GE

Grid Solutions

DS Agile C26x

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Technical Manual

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CE

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WARNING

This guide gives instructions for installation, commissioning and operation of the **DS Agile C26x**.
However, the guide cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Please contact the appropriate GE Grid Solutions technical sales office and request the necessary information.

Refer to the System Release Notes for new features.

Any agreements, commitments, and legal relationships and any obligations on the part of GE Grid Solutions, including settlement of warranties, result solely from the applicable purchase contract, which is not affected by the contents of the guide.

PC OPERATING SYSTEM COMPATIBILITY

GE Grid Solutions has conducted compatibility and performance tests with the version of Microsoft's Windows operating system indicated at the beginning of the Introduction chapter of this manual.

Depending on when the system is installed or upgraded, some of the hardware components described in this manual may be no longer available. Please check currently approved hardware in the latest release.

Although the software may run with other versions of Windows, GE Grid Solutions does not take any responsibility in possible malfunctions and may not be able to provide support for problems occurring when running our software on an unapproved operating system.

INTRODUCTION

C26X/EN IT/D40

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1 TECHNICAL MANUAL OVERVIEW

This manual provides some general information about the technical manual and an introduction to the DS Agile C26x units described in this technical document.

1.1 CHAPTER DESCRIPTION

Introduction Chapter (IT)

This is this document containing the description of each chapter of the DS Agile C26x guides. It is a brief introduction to DS Agile C26x controller's capabilities.

Safety Chapter (SA)

This chapter contains the safety instructions, handling and reception of electronic equipment, packing and unpacking parts, Copyrights and Trademarks.

Functional Description Chapter (FT)

This chapter contains a description of the product. It describes functions of the C26x.

Hardware Description Chapter (HW)

This chapter contains the hardware product description (product identification, case, electronic boards, operator interface, etc.).

Connection Chapter (CO)

This chapter contains the external wiring connections to the DS Agile C26x.

Communications Chapter (CT)

This chapter provides the companion standard of all supported protocols toward SCADA (Telecontrol BUS) and IED on LBUS. This is the list of protocol functions that the C26x uses.

Network Monitoring Chapter (NM)

This chapter contains instructions on how to set the networks for SNMP protocol.

Installation Chapter (IN)

This chapter contains the installation procedures.

Applications Chapter (AP)

This chapter contains instructions on how to configure the features of the DS Agile C26x using SCE, ISaGRAF ….

Settings Chapter (ST)

This chapter contains the list of the user functions on-line settings with default values and range.

Human Interface (HI)

This chapter contains the operator interface description, Menu tree organisation and navigation, LEDs description, Setting/configuration software.

Commissioning Chapter (CM)

This chapter contains instructions on how to download onto the sub-system the databag describing the configuration.

Maintenance Chapter, Fault finding and repairs (MF)

This chapter helps identify failure modes, fault codes and describes the recommended repair actions.

Record Sheet Chapter (RS)

This chapter contains record sheet to follow the maintenance of the C26x.

Technical Data Chapter (TD)

This chapter contains the technical data including, accuracy limits, recommended operating conditions, ratings and performance data.

It also describes environment specification, compliance with technical standards.

Current Transformer Technical Data (CD)

This chapter contains information on the current transformers used for protection applications.

Glossary Chapter (LX)

This chapter contains lexical description of acronyms and definitions.

2 FOREWORD

This technical manual provides a functional and technical description of General Electric's DS Agile C26x controller, as well as a comprehensive set of instructions for using the device. The level at which this manual is written assumes that you are already familiar with substation control, monitoring, protection, automation and have experience in this discipline.

We have attempted to make this manual as accurate and comprehensive as possible. However, we cannot guarantee that it is free from errors. Nor can we state that it cannot be improved. We would therefore be very pleased to hear from you if you discover any errors or have any suggestions for improvement. Our policy is to provide the information necessary to help you safely specify, engineer, install, commission, maintain, and eventually dispose of this product. We consider that this manual provides the necessary information, but if you consider that more details are needed, please contact us.

All feedback should be sent to our contact centre via the following URL: www.gegridsolutions.com/contact

2.1 TARGET AUDIENCE

This manual is aimed towards all professionals charged with installing, commissioning, maintaining, troubleshooting, or operating any of the products within the specified product range. This includes installation and commissioning personnel as well as engineers who will be responsible for operating the product.

The level at which this manual is written assumes that installation and commissioning engineers have knowledge of handling electronic equipment. Also, system and protection engineers have a thorough knowledge of protection systems and associated equipment.

2.2 TYPOGRAPHICAL CONVENTIONS

The following typographical conventions are used throughout this manual.

- The names for special keys appear in capital letters.

  For example: ENTER

- When describing software applications, menu items, buttons, labels etc as they appear on the screen are written in bold type.

  For example: Select **Save** from the file menu.

- Filenames and paths use the courier font

  For example: `Example\File.text`

- Special terminology is written with leading capitals

  For example: Sensitive Earth Fault

2.3 NOMENCLATURE

Due to the technical nature of this manual, many special terms, abbreviations and acronyms are used throughout the manual. Some of these terms are well-known industry-specific terms while others may be special product specific terms used by General Electric. The first instance of any acronym or term used in a particular chapter is explained. In addition, a glossary is available at the end of this manual.

We would like to highlight the following changes of nomenclature however:

- The range of C264 substation and bay computers is being widened to encompass new applications such as the process bus Ethernet network. On this occasion, the name of the range becomes DS Agile. Because new models will soon be available, the name C264 is replaced by C26x in the manuals. Please note that this is a phased evolution, and where the text in the manual refers to software labels, there may still some references to the previous names until the software update is completed.
- The word 'relay' is no longer used to describe the device itself. Instead, the device is referred to as the 'IED' (Intelligent Electronic Device), the 'device', or the 'product'. The word 'relay' is used purely to describe the electromechanical components within the device, i.e. the output relays.
- The C26x units will now be referred to as "controllers" rather than "computers" in order to avoid any confusion with the PC-type computers used in other DS Agile sub-systems.
- The British term 'Earth' is used in favour of the American term 'Ground'.

2.4 COMPLIANCE

The device has undergone a range of extensive testing and certification processes to ensure and prove compatibility with all target markets. A detailed description of these criteria can be found in the Technical Data chapter.

3 INTRODUCTION TO DS AGILE

DS Agile is a comprehensive solution capable of meeting all electricity supply requirements. It comprises a range of components, systems and services from GE Grid Solutions.

Central to their concept is flexibility.

DS Agile provides the ability to define an application solution and, through extensive communication capabilities, to integrate it with your power supply control system.

The DS Agile ranges provide:

- A range: Industrial PCs
- C range: Control units
- H range: Ethernet switches
- M range: Measurement products for accurate metering and monitoring
- P range: Protection devices
- S range: Versatile PC support and substation control packages

DS Agile products include extensive facilities for recording information on the state and behaviour of the power system using disturbance and fault records. They can also provide measurements of the system at regular intervals to a control centre enabling remote monitoring and control to take place.

The DS Agile range will continue to be expanded. The general features will also be enhanced, as we are able to adopt new technology solutions.

For up-to-date information on any DS Agile product, visit our website: http://www.gegridsolutions.com/.

4 PRODUCT SCOPE

GE Grid Solutions' philosophy is to provide a range of control units, gateways and IEDs products. Each of these products can be used independently or be integrated to form a DS Agile system, a Digital Control System (DCS) or a SCADA system.

4.1 DS AGILE CONTROL UNITS

Driven by the requirements around the world for advanced applications in SCADA, Digital Control Systems, Automation, control and monitoring, GE Grid Solutions has designed and developed a complete range of DS Agile C26x control unit products, specifically for the power process environment and electric utility industry. It allows building a customised solution for Control, Monitoring, Measurement and Automation of electrical processes.

The DS Agile C26x range is designed to address the needs of a wide variety of installations, from small to large and customer applications. Emphasis has been placed on strong compliance to standards, scalability, modularity and openness architecture. These facilitate use in a range of applications from the most basic to the most demanding. They also ensure interoperability with existing components and, by providing building control units, PLC or IEDs approach, provide a comprehensive upgrade path, which allows DS Agile capabilities to meet customer requirements.

The key features of this control unit family result from it being based on an Ethernet client/server architecture, it Is a modular control unit that offers a wide variety of applications such as Bay Controller, Remote Terminal Unit, Sequence of Event Recorder, Data Concentrator and Programmable Logic Controller.

4.2 APPLICATIONS AND SCOPE

The DS Agile C26x substation controller is a sophisticated solution supporting multiple applications and functions for substation control, communication, monitoring, protection, and automation.

The DS Agile C26x modular bay control unit is used to control and monitor switch bays. The information capacity of the DS Agile C26x is designed for controlling operated switchgear units equipped with electrical check-back signalling located in medium-voltage or high-voltage substations.

External auxiliary devices are largely obviated by the integration of binary inputs and power outputs that are independent of auxiliary voltages, by the direct connection option for current and voltage transformers, and by the comprehensive interlocking capability.

This simplifies handling of bay protection and control technology from planning to station commissioning. During operation, the user-friendly interface makes it easy to set the unit and allows safe operation of the substation by preventing non-permissible switching operations.

Continuous self-monitoring reduces maintenance costs for protection and control systems.

A built-in liquid crystal display (optional front face with LCD) shows not only switchgear settings but also measured data and monitoring signals or indications.

The bay is controlled interactively by using the control keys and the display.

Adjustment to the quantity of information required is made via the DS Agile System Configurator Editor (DS Agile SCE).

The DS Agile C26x can be connected to a higher control level, local control level or lower levels by way of a built-in communications interface.

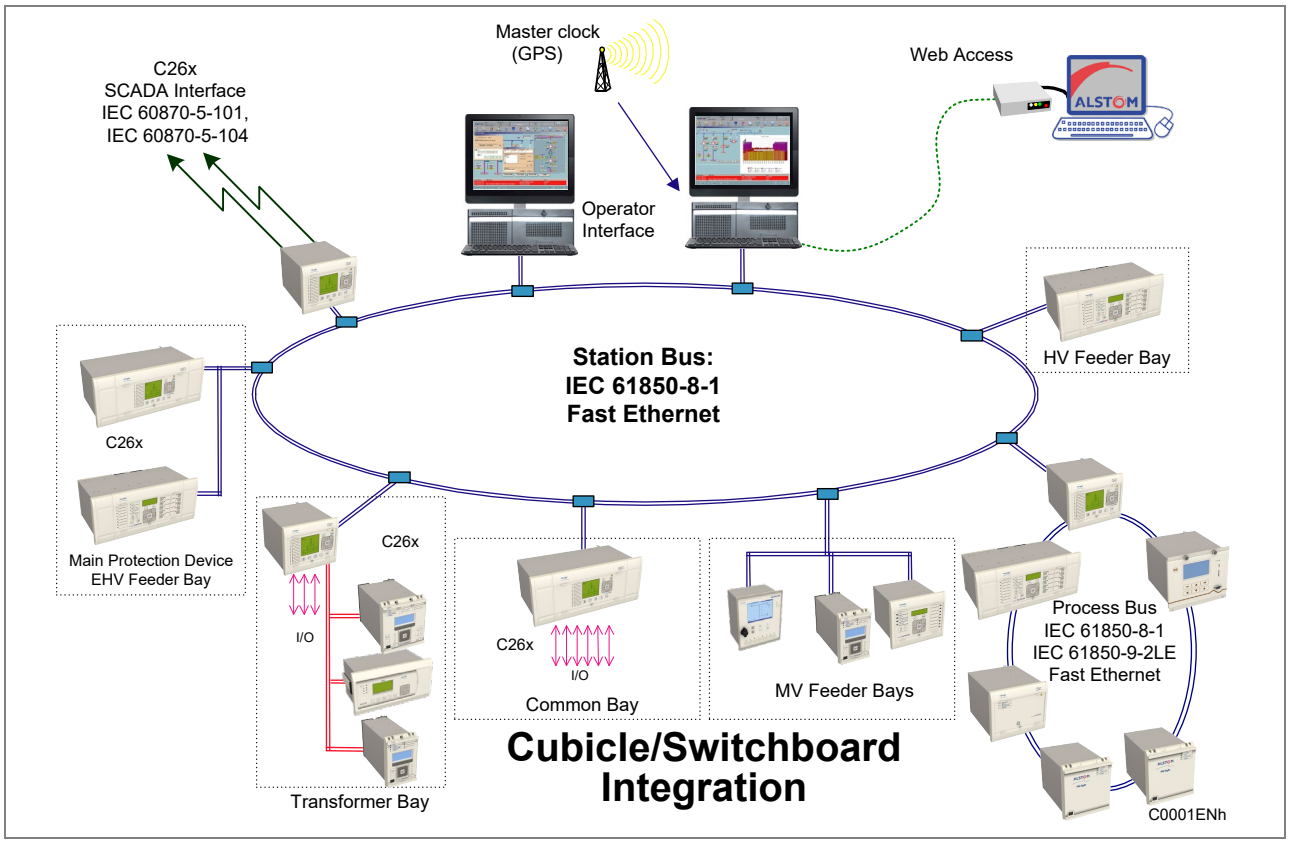


Figure 1: Typical use of a DS Agile C26x – Bay Controller

At a glance the C26x acquisition and control process is like this, based on a set of boards:

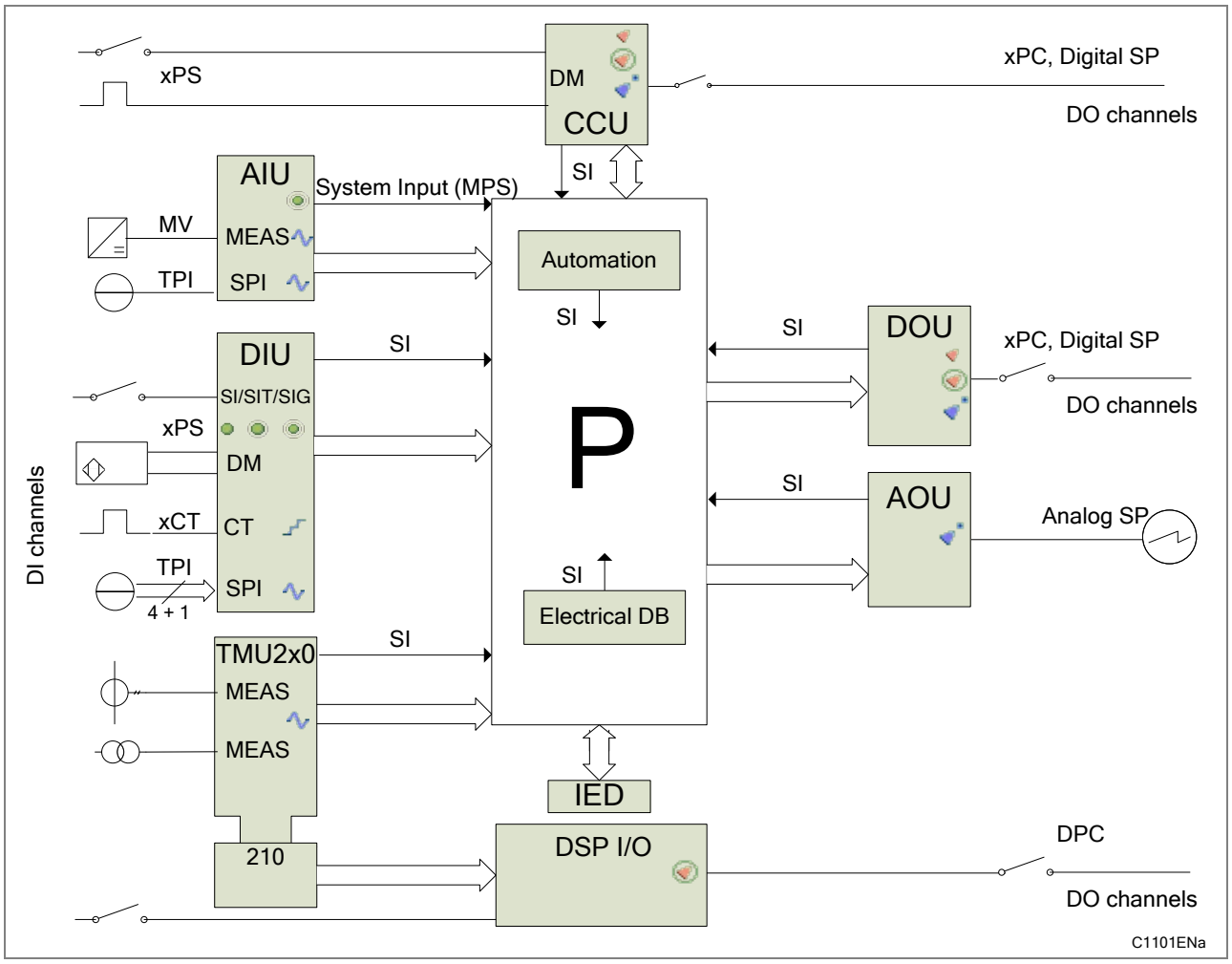


Figure 2 : Typical acquisition and control process of a DS Agile C26x

Find details on

- Boards in chapters C26x/EN HW and CO
- Processing in chapter C26x/EN FT
- Configuration in chapter C26x/EN AP

5 OPERATING SYSTEM COMPATIBILITY

Several applications may be used to configure the DS Agile C26x:

- the Computer Management Tool (DS Agile CMT)
- the setting software MiCOM S1

They are approved to run with **Windows 10 LTSC 2019 for Enterprise 64-bits edition**, with the following parameters:

Software tool	Run as administrator?	Run in XP compatibility mode?
DS Agile CMT	No	No
MiCOM S1	No	No

SAFETY INFORMATION

C26X/EN SA/D40

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1 HEALTH AND SAFETY

Personnel associated with the equipment must be familiar with the contents of this Safety Information.

When electrical equipment is in operation, dangerous voltages are present in certain parts of the equipment. Improper use of the equipment and failure to observe warning notices will endanger personnel.

Only qualified personnel may work on or operate the equipment. Qualified personnel are individuals who:

- Are familiar with the installation, commissioning, and operation of the equipment and the system to which it is being connected.
- Are familiar with accepted safety engineering practises and are authorised to energise and de-energise equipment in the correct manner.
- Are trained in the care and use of safety apparatus in accordance with safety engineering practises
- Are trained in emergency procedures (first aid).

Although the documentation provides instructions for installing, commissioning and operating the equipment, it cannot cover all conceivable circumstances. In the event of questions or problems, do not take any action without proper authorisation. Please contact the appropriate technical sales office and request the necessary information.

2 SYMBOLS

Throughout this manual you will come across the following symbols. You will also see these symbols on parts of the equipment.



Caution:
Refer to equipment documentation. Failure to do so could result in damage to the equipment



Warning:
Risk of electric shock



Earth terminal



Protective Earth terminal

3 INSTALLATION, COMMISSIONING AND SERVICING

3.1 LIFTING HAZARDS

Plan carefully, identify any possible hazards and determine whether the load needs to be moved at all. Look at other ways of moving the load to avoid manual handling. Use the correct lifting techniques and Personal Protective Equipment to reduce the risk of injury.

Many injuries are caused by:

- Lifting heavy objects
- Lifting things incorrectly
- Pushing or pulling heavy objects
- Using the same muscles repetitively

3.2 ELECTRICAL HAZARDS



Caution:
All personnel involved in installing, commissioning, or servicing this equipment must be familiar with the correct working procedures.



Caution:
Consult the equipment documentation before installing, commissioning, or servicing the equipment.



Caution:
Always use the equipment in a manner specified by the manufacturer. Failure to do so will jeopardise the protection provided by the equipment.



Warning:
Removal of equipment panels or covers may expose hazardous live parts. Do not touch until the electrical power is removed. Take extra care when there is unlocked access to the rear of the equipment.



Warning:
Isolate the equipment before working on the terminal strips.



Warning:
Use a suitable protective barrier for areas with restricted space, where there is a risk of electric shock due to exposed terminals.



Caution:
Disconnect power before disassembling. Disassembly of the equipment may expose sensitive electronic circuitry. Take suitable precautions against electrostatic voltage discharge (ESD) to avoid damage to the equipment.



Caution:
NEVER look into optical fibres. Always use optical power meters to determine operation or signal level.



Caution:
Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, discharge the capacitors by reducing the voltage to zero, before disconnecting the test leads.



Caution:
Operate the equipment within the specified electrical and environmental limits.



Caution:
Before cleaning the equipment, ensure that no connections are energised. Use a lint free cloth dampened with clean water.

4 WIRING

4.1 GENERAL WIRING

Only two wires can be screwed together on any one connector. The AC and DC signal and communication wires should use separate shielded cable.



Caution:
A high rupture capacity (HRC) fuse must be used for auxiliary supplies (for example Red Spot type NIT or TIA) with the following characteristics:

- Current rating: 16 Amps
- Minimum dc rating: 220 Vdc
- gG operating class in accordance with IEC 60269

The fuses must be connected in series with the positive auxiliary supply input connections for both primary (Pin 23) and secondary (Pin 1) BIU261D inputs.

Wires should be connected with the power supply connectors unplugged. Each wired signal has to be tested before plugging and fixing the connectors. The connectors have to be fixed on the H49 case with the screws available at each extremity of the connector.

For connection of the protective (earth) conductor, see *Connection* chapter (*C26x/EN CO*).

4.2 PROTECTIVE EARTH WIRING

This equipment requires a protective conductor (earth) to ensure user safety according to the definition in the standard IEC 60255-27: 2005 Insulation Class 1. See *Connection* chapter (*C26x/EN CO*).

5 DECOMMISSIONING AND DISPOSAL



Caution:
Before decommissioning, completely isolate the equipment power supplies (both poles of any dc supply). The auxiliary supply input may have capacitors in parallel, which may still be charged. To avoid electric shock, discharge the capacitors using the external terminals before to decommissioning.



Caution:
Avoid incineration or disposal to water courses. Dispose of the equipment in a safe, responsible an environmentally friendly manner, and if applicable, in accordance with country-specific regulations.

6 WARRANTY

The media on which you receive GE Grid Solutions' software are warranted not to fail to execute programming instructions, due to defects in materials and workmanship, for a period of 90 days from date of shipment, as evidenced by receipts or other documentation. GE Grid Solutions will, at its option, repair or replace software media that do not execute programming instructions if GE Grid Solutions receives notice of such defects during the warranty period. GE Grid Solutions does not warrant that the operation of the software shall be uninterrupted or error free.

A Return Material Authorization (RMA) number must be obtained from the factory and clearly marked on the package before any equipment will be accepted for warranty work. GE Grid Solutions will pay the shipping costs of returning to the owner parts which are covered by warranty.

GE Grid Solutions believes that the information in this document is accurate. The document has been carefully reviewed for technical accuracy. In the event that technical or typographical errors exist, GE Grid Solutions reserves the right to make changes to subsequent editions of this document without prior notice to holders of this edition. The reader should consult GE Grid Solutions if errors are suspected. In no event shall GE Grid Solutions be liable for any damages arising out of or related to this document or the information contained in it.

Except as specified herein, GE Grid Solutions makes no warranties, express or implied, and specifically disclaims any warranty of merchantability or fitness for a particular purpose.

Customer's rights to recover damages caused by fault or negligence on the part of GE Grid Solutions shall be limited to the amount therefore paid by the customer. GE Grid Solutions will not be liable for damages resulting from loss of data, profits, use of products or incidental or consequential damages even if advised of the possibility thereof.

This limitation of the liability of GE Grid Solutions will apply regardless of the form of action, whether in contract or tort, including negligence. Any action against GE Grid Solutions must be brought within one year after the cause of action accrues. GE Grid Solutions shall not be liable for any delay in performance due to causes beyond its reasonable control.

The warranty provided herein does not cover damages, defects, malfunctions, or service failures caused by owner's failure to follow the GE Grid Solutions installation, operation, or maintenance instructions; owner's modification of the product; owner's abuse, misuse, or negligent acts; and power failure or surges, fire, flood, accident, actions of third parties, or other events outside reasonable control.

7 WARNING REGARDING THE USE OF GE GRID SOLUTIONS PRODUCTS

GE Grid Solutions products are not designed with components and testing for a level of reliability suitable for use in or in connection with surgical implants or as critical components in any life support systems whose failure to perform can reasonably be expected to cause significant injuries to a human.

In any application, including the above reliability of operation of the software products can be impaired by adverse factors, including -but not limited- to fluctuations in electrical power supply, computer hardware malfunctions, computer operating system, software fitness, fitness of compilers and development software used to develop an application, installation errors, software and hardware compatibility problems, malfunctions or failures of electronic monitoring or control devices, transient failures of electronic systems (hardware and/or software), unanticipated uses or misuses, or errors from the user or applications designer (adverse factors such as these are collectively termed "System failures").

Any application where a system failure would create a risk of harm to property or persons (including the risk of bodily injuries and death) should not be reliant solely upon one form of electronic system due to the risk of system failure to avoid damage, injury or death, the user or application designer must take reasonably steps to protect against system failure, including -but not limited- to back-up or shut-down mechanisms, not because end-user system is customised and differs from GE Grid Solutions testing platforms but also a user or application designer may use GE Grid Solutions products in combination with other products.

These actions cannot be evaluated or contemplated by GE Grid Solutions; thus, the user or application designer is ultimately responsible for verifying and validating the suitability of GE Grid Solutions products whenever they are incorporated in a system or application, even without limitation of the appropriate design, process and safety levels of such system or application.

8 MANUFACTURER

General Electric Grid Solutions

Worldwide Contact Centre

St Leonards Building,

Red Hill Business Park,

Stafford ST16 1WT, United Kingdom, UK

Tel: +44 (0) 1785 25 00 70

Fax: +44 (0) 1785 27 09 40

www.gegridsolutions.com/contact/

FUNCTIONAL DESCRIPTION

C26X/EN FT/D40

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1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. This chapter contains the functional description of this device. The hardware description can be found in the Hardware Description (HW) chapter. All the connection diagrams are shown in the Connection Diagrams (CO) chapter. The technical data for this device, such as the capabilities, performance, and environmental limits, can be found in chapter C26x/EN TD.

1.1 SOFTWARE FEATURES

The C26x is a modular product at the hardware, software and functional levels. All its functions are fully configurable in accordance with the customer's needs and requirements. The C26x offers the following features:

- Direct processing interface through Digital Inputs (DI), Digital Outputs (DO), Analogue Inputs (AI), Analogue Outputs (AO) and Current Transformer (CT)/Voltage Transformer (VT) boards
- Embedded parameters to control all common plants or devices
- High communication abilities to IED, Ethernet, and SCADA
- Settable automation modules
- Events, alarms, measurement display, printing and archiving
- Enhanced inner management with database management, self-test controls and the capability to synchronize all of the devices.

The components of the software management include:

- Input/Output boards: DI, DO, AI, AO
- Analogue Inputs: AI, and from the optional CT/VT board
- Communications with the Telecontrol Bus (TBUS), Station Bus (SBUS) and Legacy Bus (LBUS). Please refer to chapter C26x/EN CT.
- Communication with peripherals such as:
- Local Operator Interface: LCD, front panel
- Local Printer: local sequence of events (SOE)

There are three ways to perform automation functions:

- Programmable Scheme Logic (PSL) for all C26x units except the C26x-Standalone unit
- Programmable Logic Control (PLC) for all C26x devices
- Built-in automation functions, such as:
  - Auto-Recloser (AR)
  - xPS/xPC Association
  - Pole Discrepancy
  - Automatic Voltage Regulation (AVR)
  - Automatic Tap Change Control (ATCC)
  - Synchrocheck
  - Synchrocheck Bypass
- Phase-to-Phase Synchrocheck with the TMU210

Depending on whether the Main Rack is redundant or not, the software features are different for a redundant main 1 rack and for a non-redundant main rack.

1.2 C26X CONFIGURATIONS

The DS Agile C26x is the base module of the DS Agile architectures.

Each C26x includes an internal rack. The controller's boards are mounted on this rack. "Rack" is the general technical name, but there can be different functional names.

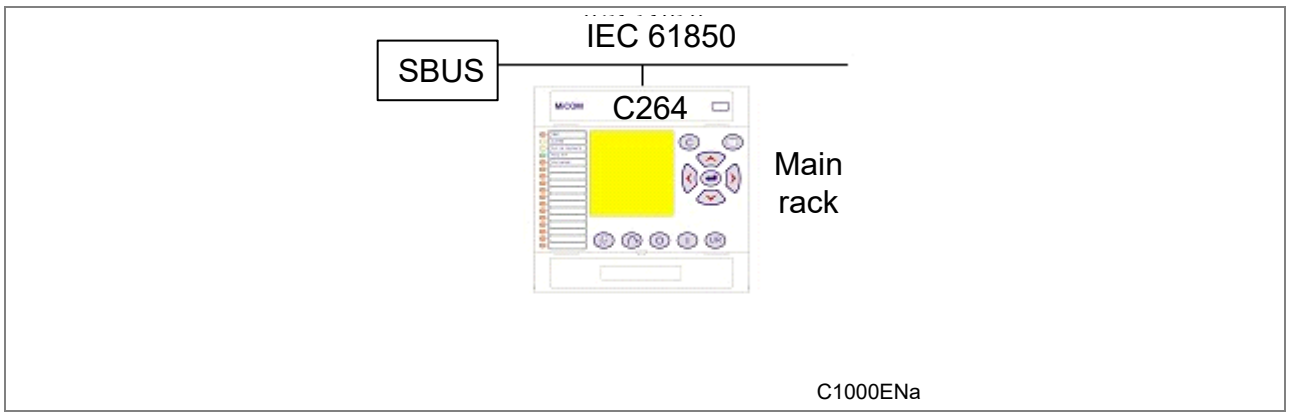
The functional name depends on the C26x's location in a system. The functional names for the rack are as follows:

- Main rack: In a standalone system, the first (and only) rack
- Main 1 rack: In a redundant system, the active rack
  In a multirack system, the active rack
- Main 2 rack: In a redundant system, the standby rack
- Extension rack: In a multirack system, one or more extension racks that cascade from the active Main 1 rack or the standby Main 2 rack
- Multirack system: A system that includes a Main rack and one or more extension racks
- Redundant system: A system that includes an active Main 1 rack and a standby Main 2 rack

The family of C26x units discussed in this chapter includes the following devices and configurations:

1.2.1 SBUS - C26X WITHOUT IED

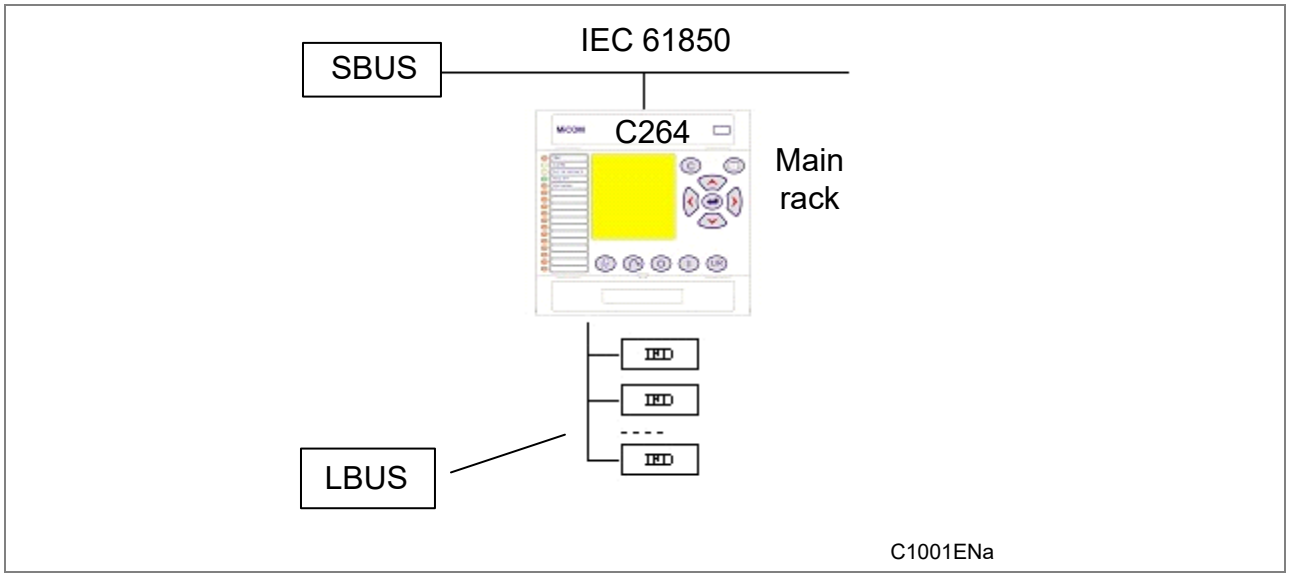
The C26x is connected to the SBUS through the Ethernet Port and uses the IEC 61850 protocol.



1.2.2 SBUS - C26X WITH IEDS

The C26x is connected to the SBUS through the Ethernet Port and uses the IEC 61850-8-1 protocol.

The C26x is connected to the IEDs through the LBUS.

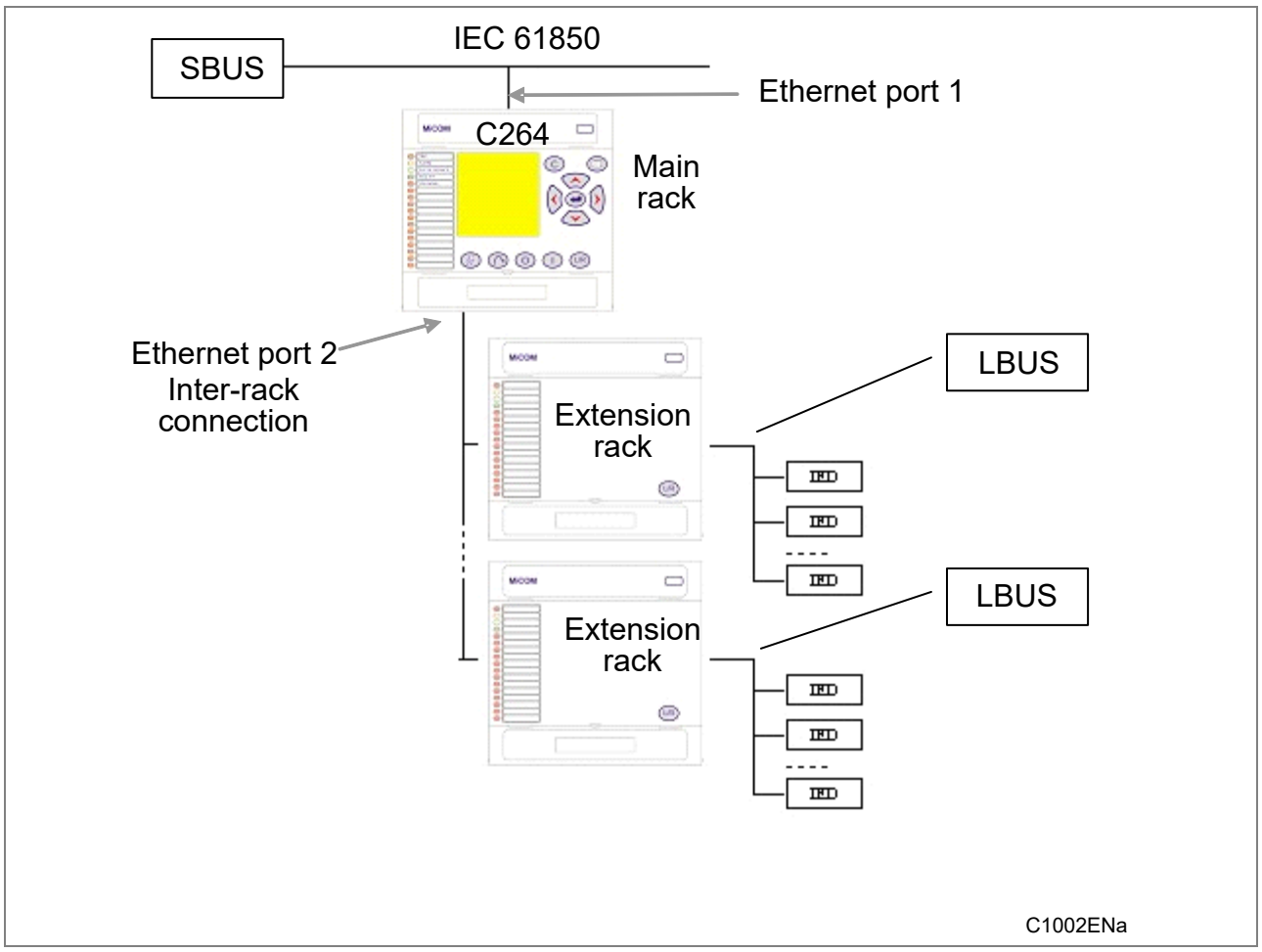


1.2.3 SBUS - C26X WITH TWO EXTENSION RACKS AND WITH IEDS

The C26x is connected to the SBUS through Ethernet Port 1 and uses the IEC 61850-8-1 protocol.

The C26x is connected to the two extension racks through Ethernet Port 2

Each extension rack is connected to the IEDs through the LBUS. The C26x includes a CPU 270 board.

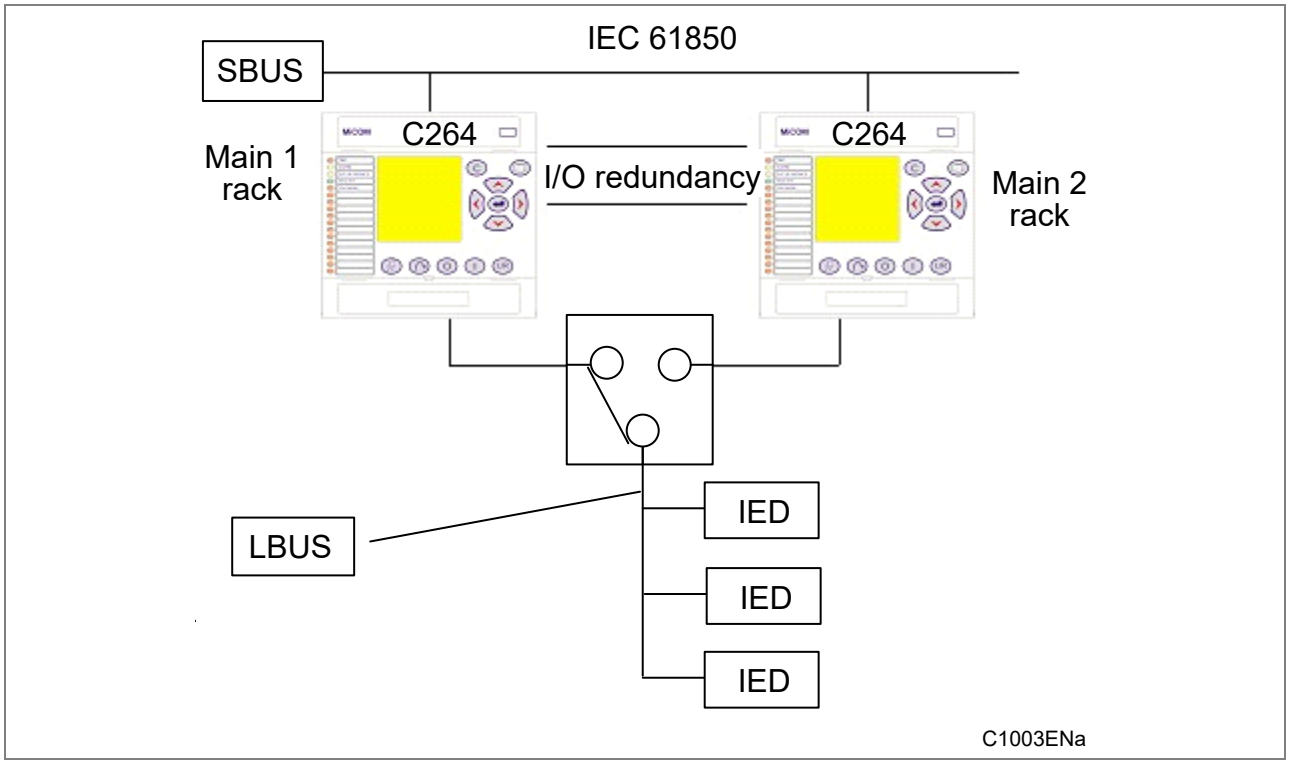


For more technical data about the C26x with two extension racks and with IEDs, please refer to chapter C26x/EN TD.

1.2.4 SBUS - TWO REDUNDANT C26XS WITH IEDS

Each C26x is connected to the SBUS through Ethernet Port 1 and uses the IEC 61850-8-1 protocol.

Each C26x is connected to the IEDs through the LBUS.

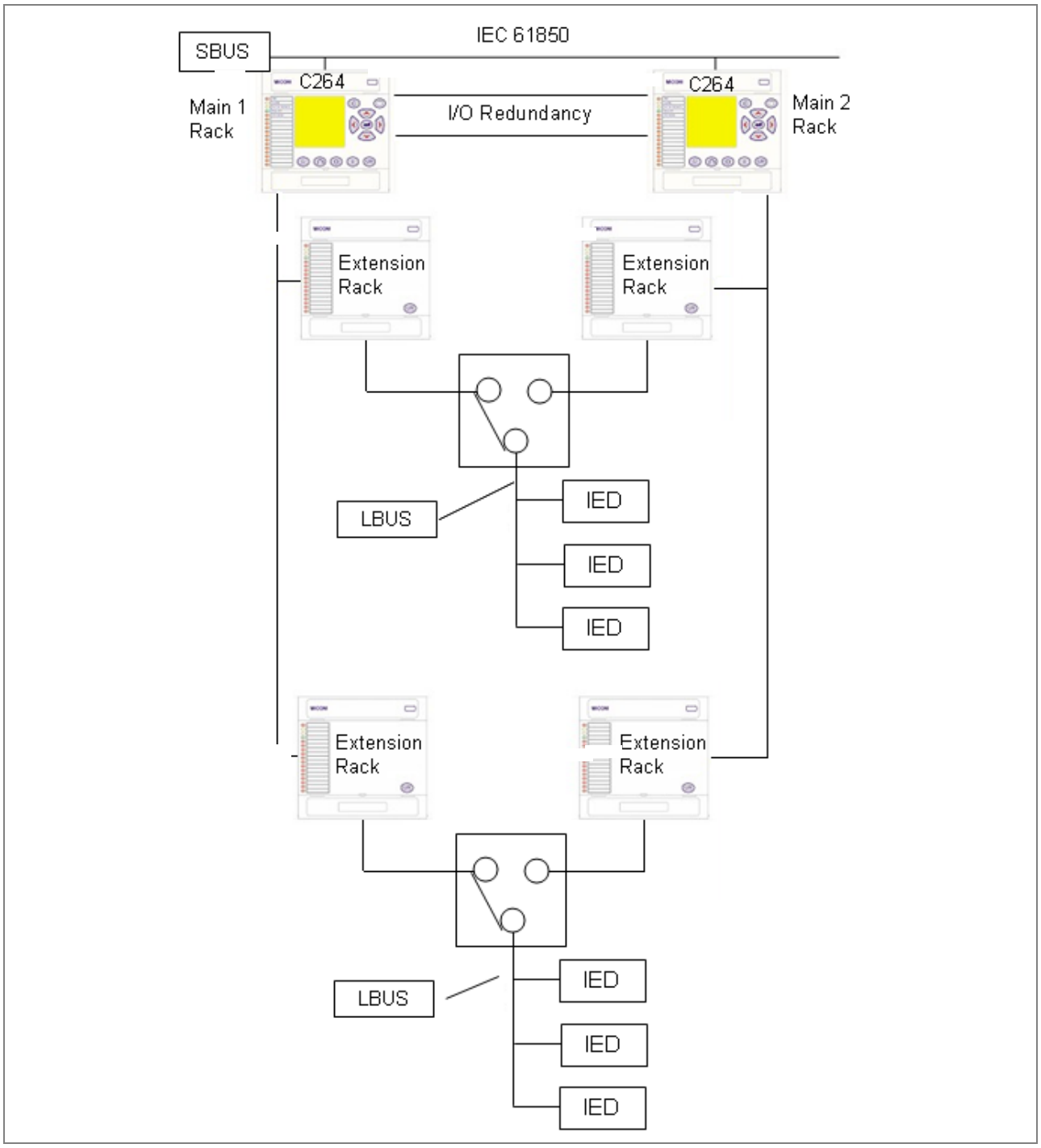


1.2.5 SBUS - TWO C26X REDUNDANT CONTROLLERS WITH TWO EXTENSION RACKS AND WITH IEDS

Each C26x is connected to the SBUS through Ethernet Port 1 and uses the IEC 61850-8-1 protocol.

Each C26x is connected to the two extension racks through Ethernet Port 2.

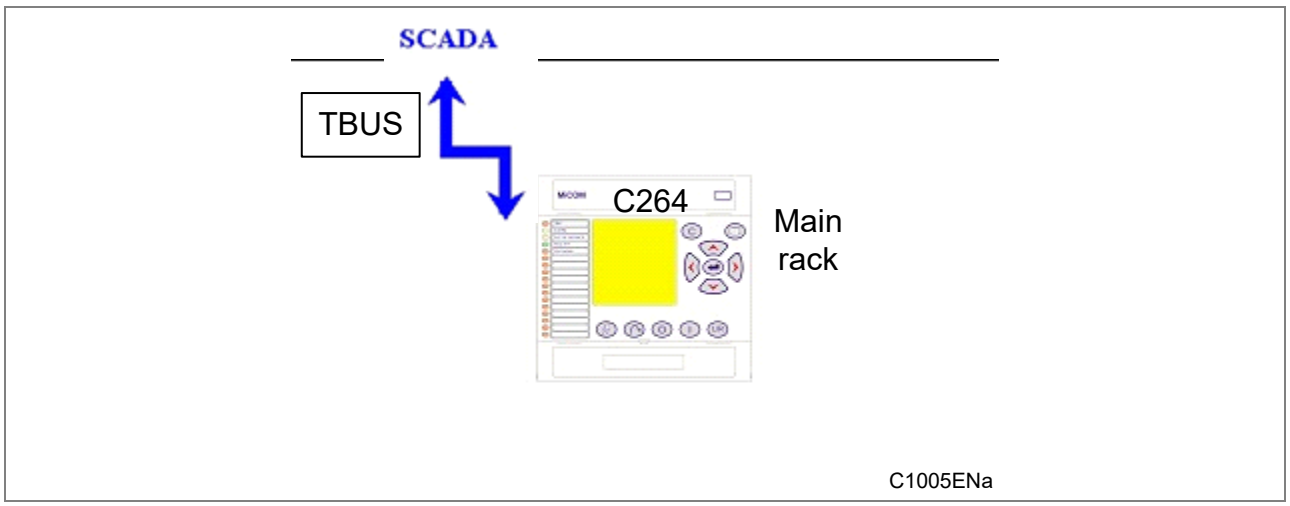
Each extension rack is connected to the IEDs through the LBUS. These C26x units each include a CPU 270 board.



For more technical data about the two redundant C26x units with two extension racks and with IEDs, please refer to chapter C26x/EN TD.

1.2.6 SCADA – TBUS - C26X-STANDALONE RTU WITHOUT IEDS

The C26x is connected to the SCADA through the Ethernet port and the TBUS.



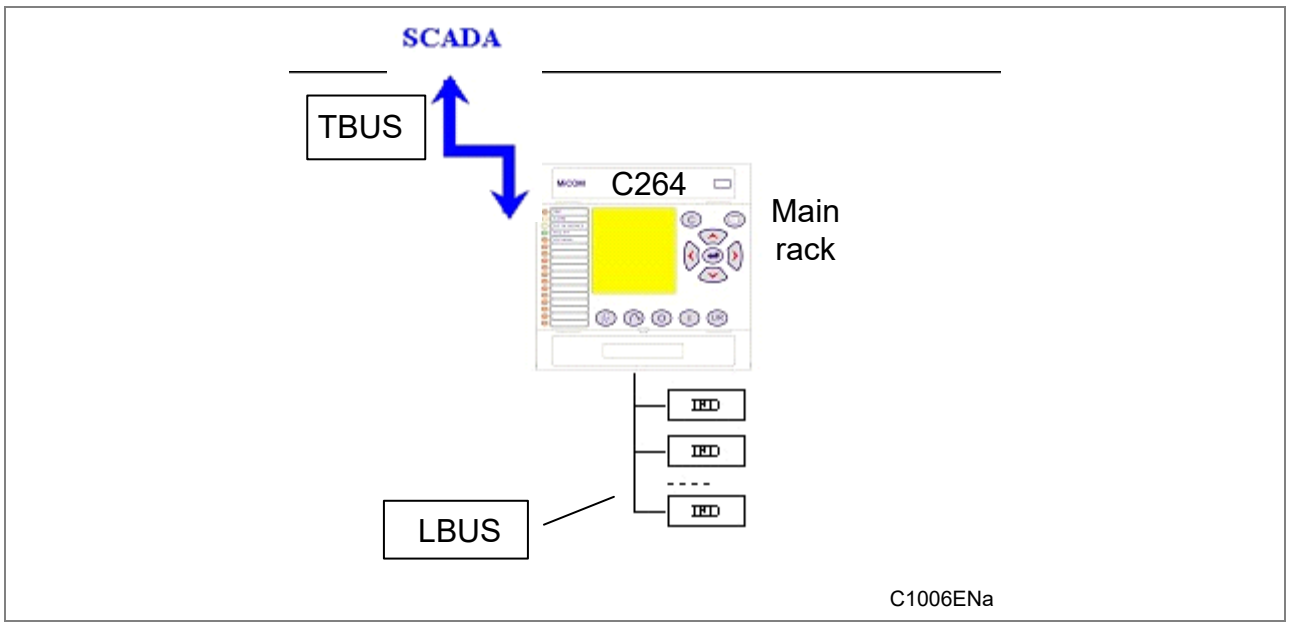
In the C26x-Standalone RTU configuration, there is no C26x redundancy nor any multi-rack. Only one C26x-Standalone unit is provided. The main rack (not redundant) manages the direct acquisitions and controls. The C26x-Standalone RTU's main rack:

- Manages communications with the SCADA
- Receives all the data from the IO boards on the rack and updates the archives (SOE and waveform)
- Manages the database downloads through the SCADA connection
- Manages the controls received through the active SCADA connection and forwards them to the extension racks
- Manages digital input and measurement acquisition. If the main 1 rack and main 2 rack are in a redundant configuration, this function is not available.
- Manages the controls. If the main 1 rack and main 2 rack are in a redundant configuration, this function is not available.

1.2.7 SCADA – TBUS - C26X-STANDALONE RTU WITH IEDS

The C26x is connected to the SCADA through the Ethernet port and the TBUS.

The C26x is connected to the IEDs through the LBUS.



In the C26x-Standalone RTU configuration, there is no C26x redundancy nor multi-rack configuration. Only one C26x-Standalone unit is provided. The main rack (not redundant) manages direct acquisitions and controls. The C26x-Standalone RTU's main rack:

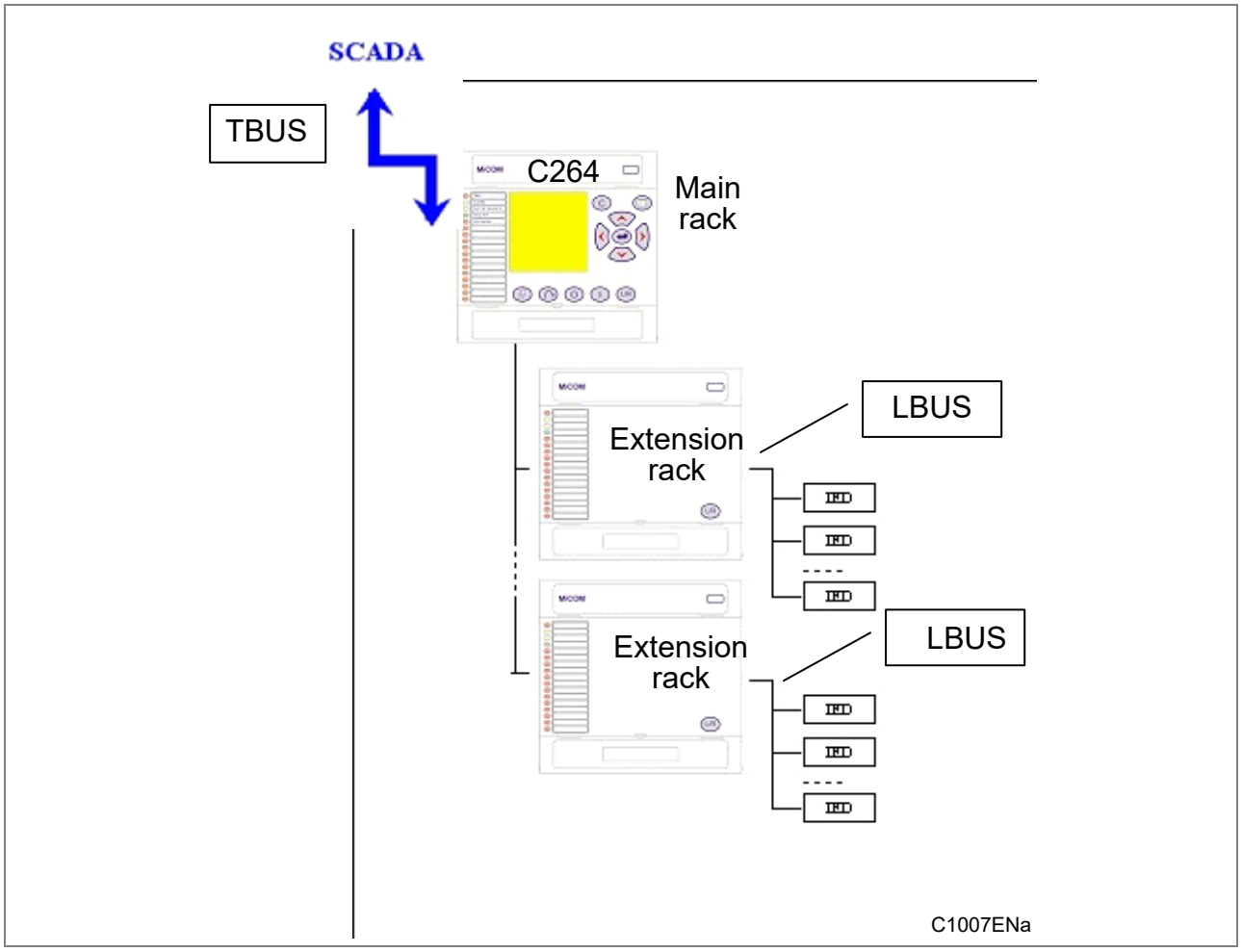
- Manages communications with the SCADA
- Receives all the data from the IO boards on the rack and updates the archives (SOE and waveform)
- Manages the database downloads through the SCADA connection
- Manages the controls received through the active SCADA connection and forwards them to the extension racks
- Manages digital input and measurement acquisition. If the main 1 rack and main 2 rack are in a redundant configuration, this function is not available.
- Manages the controls. If the main 1 rack and main 2 rack are in a redundant configuration, this function is not available.
- Manages communications with the IEDs, as well as the acquisition of the real-time data. if the main 1 rack and main 2 rack are in a redundant configuration, this function is not available.

1.2.8 SCADA – TBUS - C26X-STANDALONE RTU WITH TWO EXTENSION RACKS AND WITH IEDS

The C26x is connected to the SCADA through Ethernet Port 1 and the TBUS.

The C26x is connected to the two extension racks through Ethernet Port 2.

Each extension rack is connected to the IEDs through the LBUS. This C26x includes a CPU 270 board.



The main rack centralises all the data acquired by all the extension racks, and manages the SCADA interface. In this configuration, you can configure as many as 16 extension racks. The main rack (not redundant) manages direct acquisitions and controls. The main rack:

- Receives all the data acquired from the extension racks and updates the archives (SOE and waveform)
- Transmits all this data to the SCADA interface
- Manages communications with the SCADA
- Manages the database downloads through the SCADA connection and distributes the new configuration to all the other extension racks
- Receives the controls through the SCADA connection, manages the controls, and forwards the controls to the extension racks

- Manages digital input and measurement acquisition. In the case of a redundant configuration, this function is not available
- Manages the controls directly handled by the main rack. In the case of a redundant configuration, this function is not available
- Manages communications with the IEDs, as well as real-time data acquisition. In the case of a redundant configuration, this function is not available.

The extension racks

- Send all the acquired data to the main rack
- Manage the controls that they receive from the main rack
- Manage digital and measurement acquisition
- Manage IED communications and real-time data acquisition
- If there are no serial ports available on the main rack, the extension rack can manage the printer.

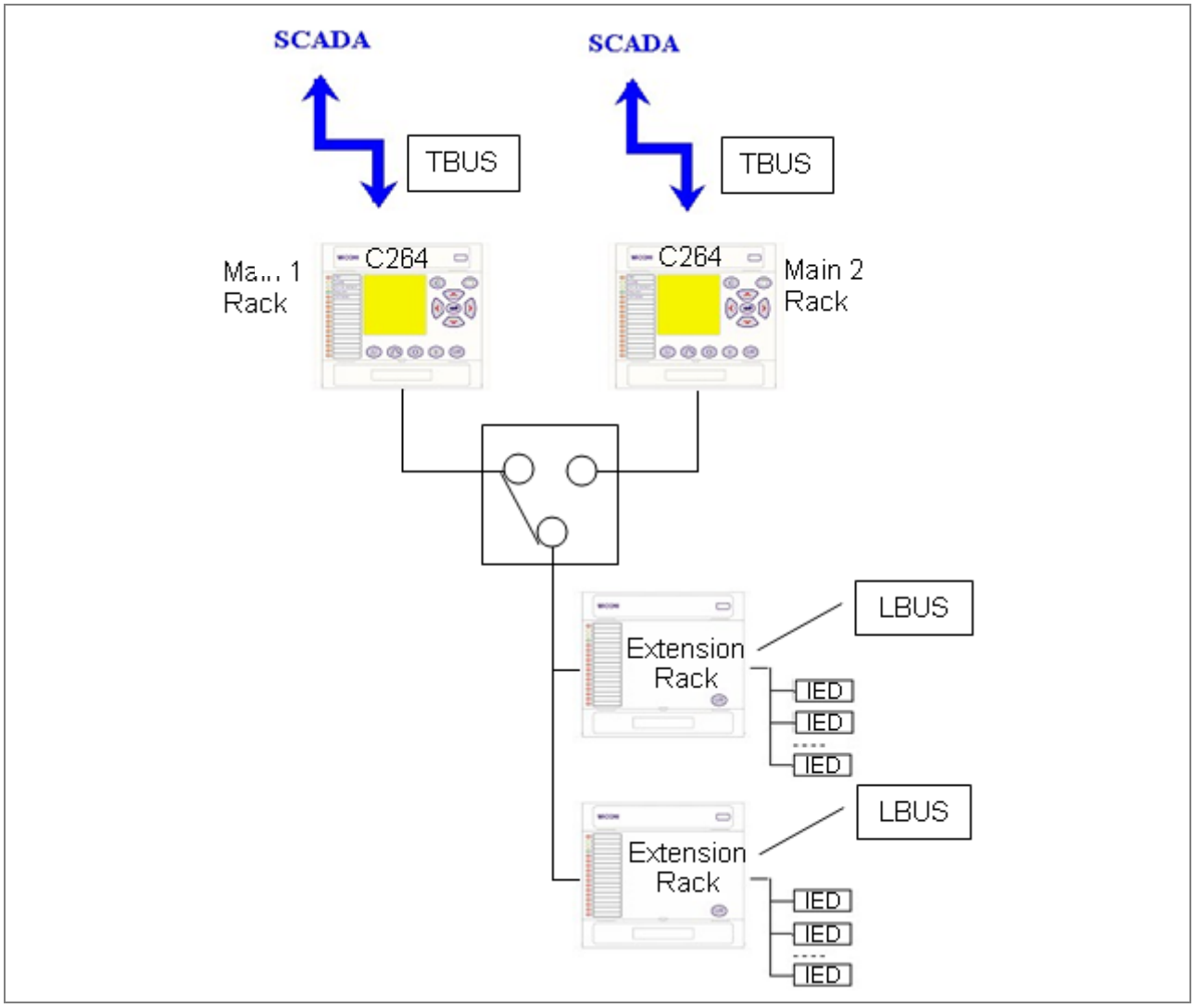
There is no rack dedicated to managing the Automation functions: Auto-recloser, Synchrocheck, AVR, ATCC. You can install a CPU270 board on the main rack and on the extension rack.

1.2.9 SCADA – TBUS - TWO C26X-STANDALONE UNITS, REDUNDANT

Each C26x connects through the Ethernet Port 1 through the TBUS to the SCADA

Each C26x connects through Ethernet Port 2 to two extension racks

Each extension rack connects through the LBUS to the IEDs. This C26x includes a CPU270.



The main 1 rack and the main 2 rack centralise all the data acquired by the extension racks and manage the SCADA interface. In this redundant C26x configuration:

- There are no I/O boards installed in the main 1 rack or in the main 2 rack
- There are no PSL nor ISaGRAF functions available
- There are no IEDs connected to the serial ports of the main 1 rack and main 2 rack

The SCADA selects which controller will be designated main 1 rack and the other controller will be designated main 2 rack.

- Neither the main 1 rack nor the main 2 rack manage these Automation functions: PSL, PLC, Auto-recloser, Synchrocheck, AVR, ATCC.
- The main 1 rack and the main 2 rack have identical hardware.

The main 1 rack

- Manages communications with the SCADA
- Receives all the data acquired by the extension racks and updates the archives (SOE and waveform)
- Forwards all this data to the SCADA
- Manages the database downloads through the SCADA connection and distributes new configurations to all the other extension racks and to the main 2 rack
- Receives the controls through the SCADA connection, manages the controls, and forwards them to the extension racks.

The main 2 rack

- Receives all the data acquired by the extension racks and updates the archives (SOE and waveform)
- Freezes all transmissions on the SCADA link: Reset of the Link: Function 0
- In the event of a SCADA General Interrogation (GI Request) to the main 2 rack, the main 2 rack takes over the main 1 rack's functions
- Receives the configuration database from the main 1 rack and updates it
- Communicates the status of the main 1 rack and main 2 rack to the SCADA. The watchdog relays can be assigned to the standard DI of an extension rack.

1.3 C26X-STANDALONE

The C26x-Standalone unit includes the following functions:

- ISaGRAF
- PSL
- Load Shedding

The above does not apply to a redundant C26x-Standalone RTU.

1.4 FIREWALL USAGE (IP FILTERING ON CPU270 BOARD)

A firewall usage parameter, i.e. IP filtering between Ethernet ports 1 and 2 of the CPU270 board, may be enabled in the configuration database. When this parameter is set to *Yes*, the Station Bus is separated from the maintenance PC (CMT, Telnet/SSH, MiCOM S1):

- The maintenance PC can only be connected to Ethernet port 2
- The Station Bus is connected to Ethernet port 1.

When this parameter is set to *No,* or not present at all (C26x-Standalone RTU), both the Station Bus and the Maintenance PC are connected to Ethernet port 1, i.e. the Maintenance PC is connected to the Station Bus.

Depending on whether that parameter is present and enabled in the active database, some connection restrictions may apply to the configuration described above.

Note:
The Firewall usage parameter is not available for C26x-Standalone databases.

This function has no impact on redundancy management.

The firewall feature is disabled in the maintenance database. However, if the C26x is switched to Maintenance mode using the SMT, for instance during a database switch, the enabling (*Yes*)/disabling (*No*) in the previously current database remains in effect until the setting included in the new database can be implemented and store in non-volatile memory.

While the C26x is in "Boot Mode", the firewall usage feature remains enabled.

After a reboot, the C26x checks its non-volatile memory and applies the stored firewall setting.

See *Installation* chapter for details.

2 DS AGILE C26X MANAGEMENT

The C26x manages its own mode, configuration (Databases), and time.

2.1 OPERATING MODE MANAGEMENT

2.1.1 DEFINITIONS

C26x modes

The C26x operates in the following modes:

- Initialisation mode
- Operational mode
  - Normal mode
  - Downgraded mode
- Maintenance mode
- Test mode (redundant C26x) or IEC 61850-compliant Test/blocked mode (non-redundant C26x)
- Faulty mode
- Halt mode

C26x faults include

- **Anomaly**: a fault that causes a downgrade in the behaviour of the C26x. There are hardware and/or software anomalies, as follows:
  - Board failure
  - Loss of synchronization
  - Loss of communications
- **Software fault**: a major software error causes a software fault, which causes the C26x to go into the **Faulty** mode.
- **Vital hardware fault**: a fault that causes a software halt which causes the C26x to stop the application software. Vital hardware faults include:
  - CPU fault
  - Power supply fault
  - Bus fault
  - Permanent interruption fault

2.1.2 INITIALIZATION MODE

After a power on or a manual reset event occurs, the C26x goes into the initialization mode. The initialization mode does not exceed one minute. The C26x performs different types of tests and checks, as follows:

Vital hardware tests

Flash memory test: in the event of a problem, the C26x tries to repair this flash memory. If a vital hardware test fails, the C26x exits the initialization mode and enters the Halt mode.

Non-vital hardware tests

The C26x performs non-vital hardware tests only on the boards installed in the C26x, and on the peripheral devices connected to the C26x:

- Input and output boards:
  - To determine the number and the type of the installed input and output boards
  - To check for the presence of previously installed input and output boards and to determine whether a board is absent
  - To check the serviceability of the installed input and output boards and to determine whether a board is unserviceable
- Communication boards: the C26x performs this test using the communication protocol
- Displays, such as the LCD screen and the LEDs: the C26x performs a single test for the presence of the HMI board
- Peripheral devices, such as the printer, external clock, and so on: the C26x uses timeouts to check for the presence of the peripheral devices.

If one of these non-vital hardware tests fails, the C26x goes into the relevant **downgraded** mode.

- **Software tests (database consistency tests)**

  Upon each restart, the C26x performs database consistency tests. These tests ensure that the database is compatible with the hardware and software of the C26x, and that the database does not contain inconsistent configuration data. The database consistency tests include:

- **Check for the presence of a database**
- **Check of the DB/ software compatibility**

  This check ensures that the C26x's software and the database are consistent and compatible. The C26x contains in its static data a database version number and a revision number that indicate which version of the database it can interpret. The database must have the same version and revision numbers for the C26x to accept it.

- **Check of the DB/ equipment compatibility**

  This check ensures that the database is compatible with the device into which it was downloaded. The C26x compares the type and the number of the device contained in the heading of the database with the type and the number of the device contained in the static data of the software.

- **Check of the validity of the database's data**

  This check ensures that the configured inputs and outputs are present and that the number of devices and signals, such as bays, digital inputs, and so on, remains within acceptable limits.

If any one of these checks fails, the C26x enters the **Maintenance** mode.

2.1.3 OPERATIONAL MODE

This mode includes two sub-modes: **Normal** mode and **Downgraded** mode.

2.1.3.1 NORMAL MODE

This is the nominal operating mode of the active C26x. In this mode the C26x energises the watchdog relay and all the C26x's functions are available. Depending on the the cause and severity of the failure, an error detection can cause the C26x to enter the relevant **Downgraded** mode, **Faulty** mode or **Halt** mode.

In Normal mode, you can use the local Human Machine Interface (HMI) or an upper level maintenance request to order a transition into **Maintenance** mode.

In Normal mode, you can use the local (HMI) or an upper level simulation request to order a transition into **Test** mode.

In Normal mode, you can perform the following database operations:

- Download a standby database
- Swap the databases: the C26x automatically restarts
- Modify a database
- Display database information.

The C26x transmits the results of the Test mode to the local HMI and to the upper level remote control point (RCP).

2.1.3.2 DOWNGRADED MODE

In the event of an anomaly, the C26x enters **Downgraded** mode. In this mode, the C26x's operation is not very disturbed because only a few functions are downgraded. The C26x energises the watchdog relay.

The type of downgraded mode depends on the C26x's hardware configuration. The various events that cause a downgraded mode include:

- Operation without DO on a board
- Operation without DI on a board
- Operation without AI on a board
- Operation without communications with some relays
- Operation without communications with some plant devices
- A combination of two or more of these events.

When you or the C26x resolve the cause of the transition into **Downgraded** mode, the C26x returns to **Normal** mode.

2.1.4 MAINTENANCE MODE

In **Maintenance** mode, the station bus (SBUS) operates: you can communicate on the SBUS to manage the database. The Maintenance mode is shown on the local HMI (LED and LCD) and on the upper level.

The C26x deenergizes the watchdog relay.

In this mode, you can manage the database:

- Download a database
- Swap the databases
- Modify a database
- Show database information

In Maintenance mode, you can use the local Human Machine Interface (HMI) or an upper level active request to request a transition into **Operational** mode. The **Operational** mode includes the Normal mode and the Downgraded mode.

2.1.5 TEST MODE

In order to simulate the operation of distributed automatic events, such as interlocks, the C26x must be switched to Test mode.

The table below shows the behaviour of the CPU and the DSP according to the C26x mode. This table is true only if there is no Programmable Scheme Logic (PSL), managed by the CPU, between the start/operate BI and the DSPIO trip relay.

Command received by the CPU / Mode CPU	Request to switch to Test mode	Request to switch to Active mode	Request to switch to Maintenance mode	Following a problem the C264 switch to Faulty mode	Following a problem the C264 switch to HALT mode	Request to switch the Database	Request to change Setting which requires protection function restart. i.e.: restart the computation. Thresholds Evaluations with the new parameters	Request to change Setting which does not require protection function restart. i.e.: Thresholds evaluations with the new parameters
CPU in Test Mode (1) **WD active**	NA: because already in test Mode	Tasks re-initialised (clean-up). The C264 switch by the intermediate maintenance Mode (between 3 to 4 sec => The DSP stops). Then the C264 switch to Active Mode and the DSP restarts. The WD falls while, CPU in Maintenance. Go to (3)	NA: Not allowed	NA: not possible to send a control from the CPU.	C264 CPU switch to Halt mode – DSP remains in maintenance mode:No trip because the DSP is in maintenance mode.	The CPU switch to Active mode at the end of the database switch then go to (3).	No Change	No Change
CPU in Test Mode (2) **WD active** **The conditions of trip are present** **i.e.: (trip relay is not activated but the start and operate BI + trip are send to the CPU)**	NA: because already in test Mode. (9575 ?)	Tasks re-initialised (clean-up). The C264 switch by the intermediate maintenance Mode (between 3 to 4 sec => The DSP stops). Then the C264 switch to Active Mode and the DSP restarts. The WD falls while, CPU in Maintenance. Go to (4)	NA: Not allowed	NA: not possible to send a control from the CPU.	C264 CPU switch to Halt mode – DSP remains in maintenance mode: No trip because the DSP is in maintenance mode.	The CPU switch to Active mode at the end of the database switch then go to (4).	Because of restart computation. The start and operate BI + trip will be temporary reset.	No Change
Active Mode (3) **WD active**	DSP switch to maintenance Mode. Go to (1). (9575 ?)	NA: because already in Active Mode.	DSP stops No more trip possible	DSP remains active TRIP is possible	DSP remains active TRIP is possible	Trip not possible while database is switching	No Change	No Change
Active Mode (4) **The conditions of trip are present** **WD active**	Switch to test mode is refused. =>TRIP	NA: because already in Active Mode. => TRIP	Switch to maintenance mode is refused. => TRIP	DSP remains active => TRIP (9483)	DSP remains active => TRIP (9483)	Database Switch Refused => TRIP (9483)	The TRIP is stops while the computation restarts. The start and operate BI + trip will be temporary reset,then re-evaluations and Trip	No Change => TRIP
Maintenance Mode (5) **WD fallen**	NA: Not allowed	DSP restarts go to (3).	NA: because already in Maintenance Mode	NA: not possible to send a control from the CPU.	C264 CPU switch to Halt mode – DSP remains stopped. No trip possible	Trip not possible while database is switching Go to (3)	No setting change possible	No setting change possible
Maintenance Mode (6) **The conditions of trip are present** **WD fallen**	NA: Not allowed	DSP restarts go to (4).	NA: because already in Maintenance Mode	NA: not possible to send a control from the CPU.	C264 CPU switch to Halt mode – DSP remains stopped. No trip possible	Trip not possible while database is switching Go to (4)	No setting change possible => NO TRIP	No setting change possible => NO TRIP
Faulty Mode (7) **WD fallen**	NA : CPU faulty, DSP active	NA : CPU faulty, DSP active	NA : CPU faulty, DSP active	NA : CPU faulty, DSP active	NA : CPU Halted, DSP remains active	Trip not possible while database is switching Go to (3)	No setting change possible	No setting change possible
Faulty Mode (8) **The conditions of trip are present** **WD fallen**	=>TRIP	=>TRIP	=>TRIP	=>TRIP	=>TRIP	Database Switch Refused =>TRIP	No setting change possible =>TRIP	No setting change possible =>TRIP
Halt Mode (9) **WD fallen**	NA : CPU halted, DSP active	NA : CPU halted, DSP active	NA : CPU halted, DSP active	NA : CPU halted, DSP active	NA : CPU halted, DSP active	Trip not possible while database is switching Go to (3)	No setting change possible	No setting change possible
Halt Mode (10) **The conditions of trip are present** **WD fallen**	=>TRIP	=>TRIP	=>TRIP	=>TRIP	=>TRIP	Database Switch Refused =>TRIP	No setting change possible =>TRIP	No setting change possible =>TRIP

2.1.5.1 IEC 61850 TEST/BLOCKED MODE FOR NON-REDUNDANT C26X

An IEC 61850-compliant test/blocked mode is implemented in non-redundant C26x units.

An IEC 61850-compliant device:

- manages a “test” quality in the GOOSE control blocks that it publishes and in the reports that it transmits,
- filters received GOOSE control blocks and reports according to the state of their “test” quality.

When it is in *test* or *test/blocked* mode:

- it sets the “test” quality in the GOOSE control blocks that it publishes and in the reports that it transmits,
- it accepts only GOOSE control blocks and reports in which the “test” quality is set.

When it is in *on* or *on-blocked* mode:

- it does not set the “test” quality in the GOOSE control blocks that it publishes and in the reports that it transmits,
- it accepts only GOOSE control blocks and reports in which the “test” quality is not set.

Note:
The “test” quality associated with operating mode indications is never set so that they are always accepted by operational devices.

Communications with the system HMI

When the C26x is in *test/blocked* mode, DS Agile OI/aView displays it as being in test mode.

Because the DS Agile OI/aView is always in operational mode, a C26x is in *test/blocked* mode always refuses commands sent from the system HMI with a “KO-mode” negative acknowledgement.

Conversely, messages sent by a C26x while in *test/blocked* mode are not displayed by the DS Agile OI/aView (provided the SBUS agency has been configured to block the test frames on the server PC).

GOOSE exchanges with IEDs

A C26x in *test/blocked* mode:

- sets the “test” quality in the GOOSE control blocks that it publishes, except for system datapoints (“DIAG” brick),
- filters received GOOSE control blocks:

  It only processes GOOSE frames with the “test” quality and discard any other frames.

When in operational mode, the C26x processes all the GOOSE frames without the “test” quality, i.e. untagged frames and frames in which the “test” quality is not set.

Note:
When the C26x switches from operational *mode to* test-blocked *mode and vice-versa, GOOSE input data will be considered only when a data state changes inside the GOOSE (GOOSE repetition is ignored).*
For example, if, while the C26x is in operational *mode, an IED publisher switches to* test *mode and publishes a data state change, the C26x will ignore it because it is not itself in test mode. Then if the C26x switches to* test/blocked*, all the GOOSE frames received without any data state change will be considered as repeated frames and the C26x will thus ignore the data state because the change was first published while the IED and C26x were in opposite modes.*

Report exchanges with other C26x units

A C26x in *test/blocked* mode sets the “test” quality in the Reports that it transmits, except for system datapoints (“DIAG” brick).

Communications with legacy IEDs

If the C26x receives messages from legacy IEDs while it is in *test/blocked* mode, it forwards those messages to the IEC 61850 network with the ”test” quality set.



Caution:
Test quality tagging only applies to IEC 61850 communications. THE TEST QUALITY IS NOT TRANSMITTED OVER LEGACY PROTOCOLS: Test commands could be sent to legacy devices as if they were valid and cause unwanted output operations.

2.1.5.2 TEST/BLOCKED MODE FOR REDUNDANT C26X

In **Test/blocked** mode, the redundant C26x operates normally but the output relays are not active. When the operator sends a command, the C26x does not energise the output relay: Instead, if the command is valid, the C26x sends a TEST OK message to the substation control point (SCP). If the command is not valid, the C26x sends a TEST NOK message to the SCP.

Note:
To perform the tests, you must manually force BI or Measurements on different C26x units to create the test conditions. When the test conditions are established, you can send a command. Look at the SCP level (HMI) to check whether the result is as expected.

The Test/blocked mode is shown on the local HMI (LED and LCD) and on the upper level.

In Test/blocked mode, you can use the local HMI or the SMT to order a transition into **Operational** mode. The **Operational** mode includes the Normal mode and the Downgraded mode.

2.1.6 FAULTY MODE

In any mode, when a fault occurs to prevent the proper operation of the software, the C26x goes into the **Faulty** mode.

When the C26x detects a failure on the DO boards, and if the configuration allows it, the C26x enters Faulty mode. Each time the C26x switches to Faulty mode, an internal counter is incremented.

There are only two ways to exit the Faulty mode:

- A transition to **Initialisation** mode and an automatic reset of the counter
- A transition to **Halt** mode.

If the value of the internal counter remains lower than the Max_Fault parameter defined during the configuration stage, the C26x switches to **Initialisation** mode. When the elapsed time since the last increment of the internal counter equals the value Fault_Detection_Lasting parameter defined during the configuration stage, the value of the counter automatically resets.

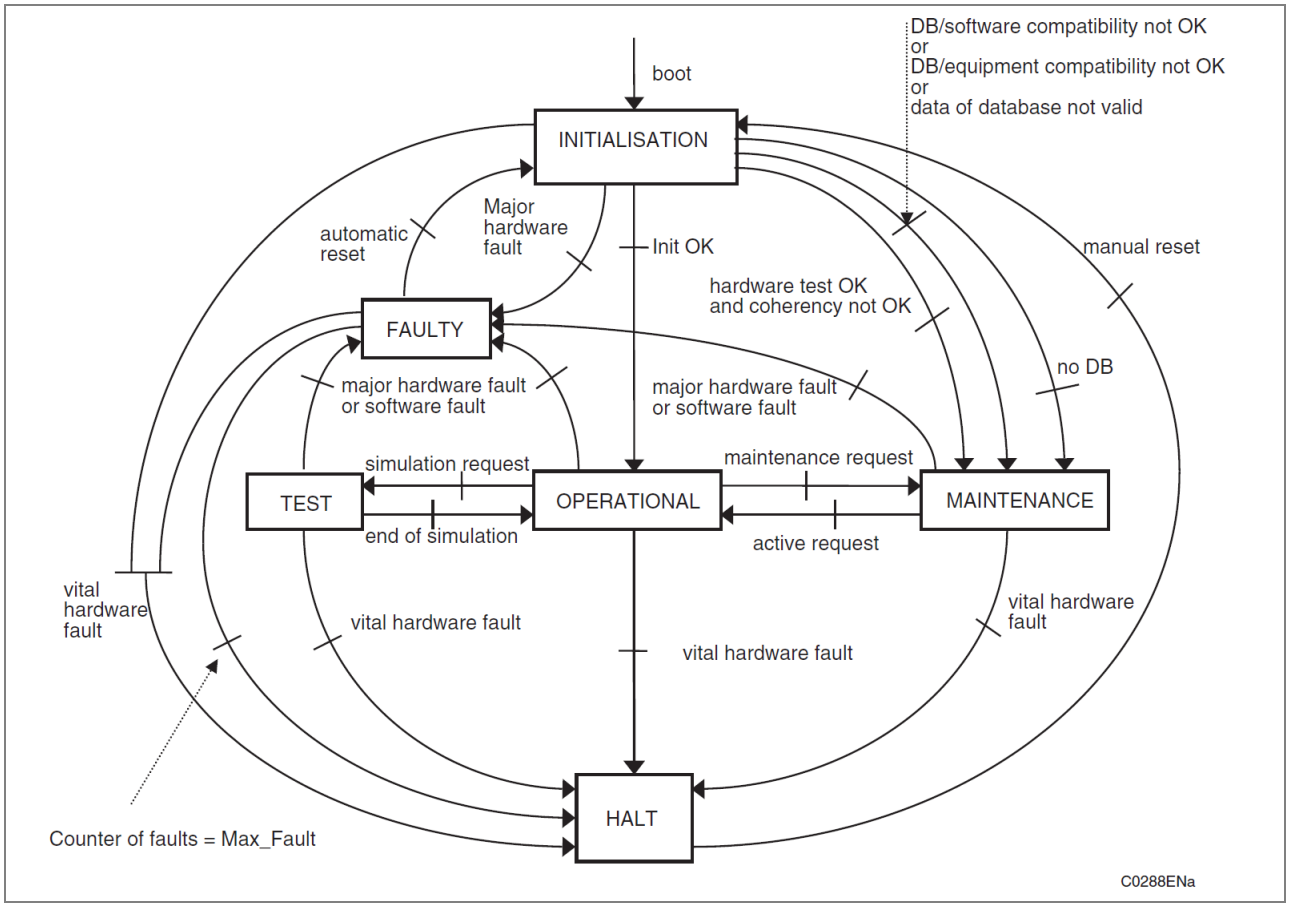
When the value of the internal counter reaches Max_Fault, the C26x goes into the **Halt** mode.

2.1.7 HALT MODE

In this mode, the C26x deenergises the watchdog relay and all the output relays. The C26x does not operate anymore. The only way to exit this mode is to perform a manual reset.

2.1.8 SUMMARY OF MODES, TESTS, TRANSITIONS, AND FAULTS

The different modes, tests, transitions, and faults of the C26x show in the figure that follows:



2.1.9 REDUNDANCY MODE MANAGEMENT

Two identical controllers with the same hardware and the same database versions manage the main 1 rack redundancy.

Note:
The redundancy mode is not compatible with the TMU210 acquisition board.

2.1.9.1 FOR THE C26X-MULTIRACK SYSTEM

The two SCADA connections, one to the main 1 rack and one to the main 2 rack, are completely independent of each other. For these two connections, there is no synchronization of protocols, and each of these racks can have its own address in the substation's Ethernet network ("station bus"). The principle here is different from the standard redundant function, where the sequence of the messages on each connection is synchronized and where both racks have the same address in the substation's Ethernet network.

In the redundant configuration, the main 1 rack does not manage direct acquisition, controls, or IED connections.

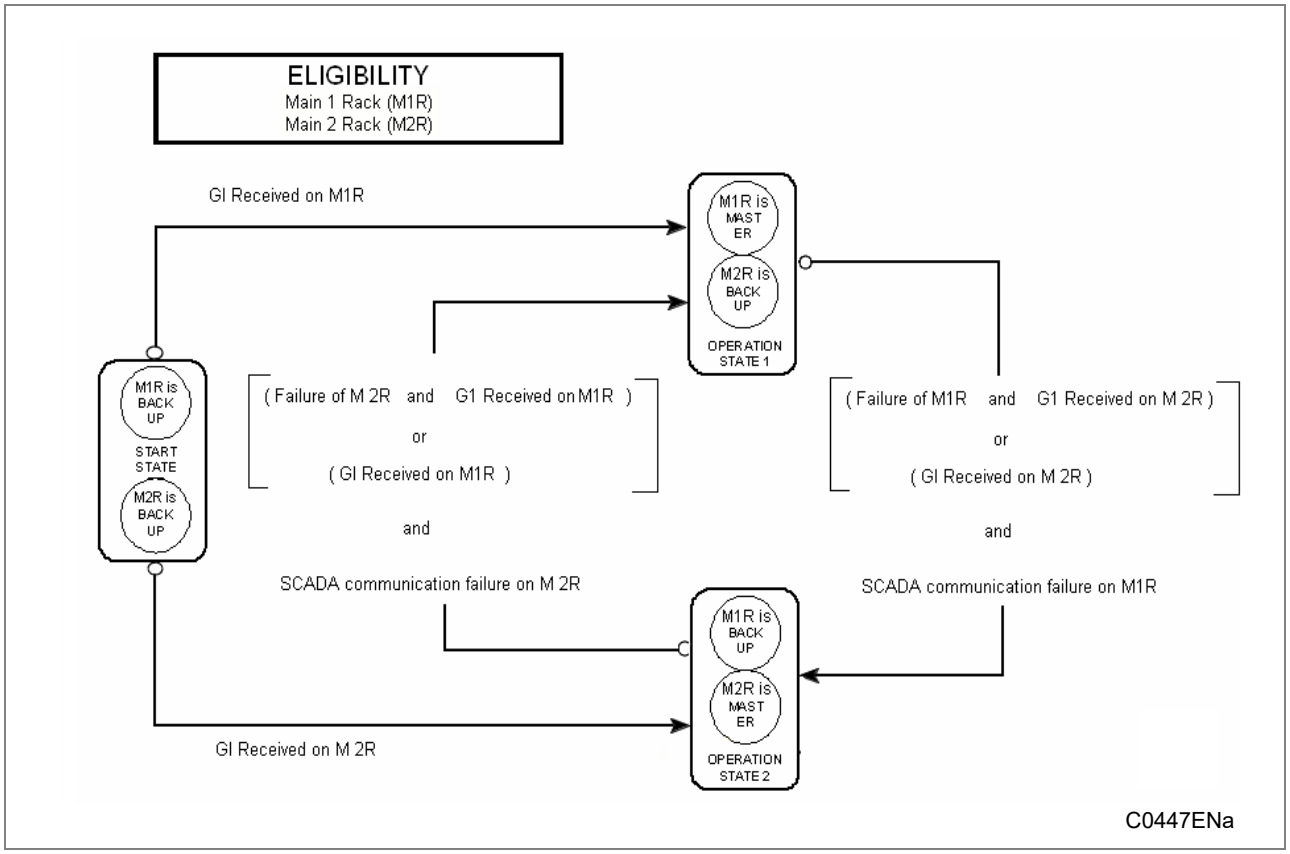
The main 1 rack and the main 2 rack have a single address on one of the two SCADA connections. This allows the main 1 rack and the main 2 rack to manage two different networks.

The main 1 rack is in operation when:

- The communication was set up on the main 1 rack connection to the SCADA. The GI request (ASDU 100) message confirms the connection set-up .
- The main 2 rack was in operation, a failure occurred, and the main 1 rack received a GI request.

When the SCADA detects a communication failure, the main 1 rack in operation becomes the main 2 rack. The SCADA must stop communicating with one rack when it decides to communicate with the other rack.

For more details, please refer to the figure below:



The main 1 rack:

- Manages the communications with the SCADA
- Receives all of the data acquired on the extension rack and updates the archives (SOE, slow waveform)
- Transmits all of the data acquired by the extension rack to the SCADA
- Manages the database downloads through the SCADA connection
- Receives the database through the SCADA connection or from the CMT and distributes the new configuration to all the other racks, including the main 2 rack
- Manages the controls received through the active SCADA connection and sends them to the extension racks

The main 2 rack:

- Receives all of the data acquired on the extension rack and updates the archives (SOE, slow waveform)
- In the event of a SCADA connection reset (GI Request), the main 2 rack performs the functions of the main 1 rack
- Receives the configuration database from the main 1 rack and updates its own configuration database

To communicate the status of the main 1 rack and main 2 rack to the SCADA, you can wire the watchdog relays to the standard DI of one extension rack.

2.1.9.2 FOR THE C26X SYSTEM

The two redundant controllers are the main 1 C26x and the main 2 C26x. The C26x that manages the bay is the **active** C26x; the other one is the **standby** C26x. In this configuration, the redundant C26x can be:

- Main 1 C26x in active mode
- Main 1 C26x in standby mode
- Main 2 C26x in active mode
- Main 2 C26x in standby mode.

During the boot time, and if both controllers are in operation, the **main** 1 C26x is the **active** controller.

The two controllers perform the same functions simultaneously: inputs acquisition and processing, archiving and automation, but at any given time, only the active C26x sends controls to the electrical process or on the SBUS. A DS Agile IEC 61850 client receives data from the two controllers: This client processes only the data it receives from the C26x in **active** mode. Only the C26x in **active** mode manages the communications with the IEDs or the SCADA.

This switch from **active** mode to **standby** mode, as well as from **standby** mode to **active** mode, is performed automatically as follows (for BCU controllers only, not standalone controllers):

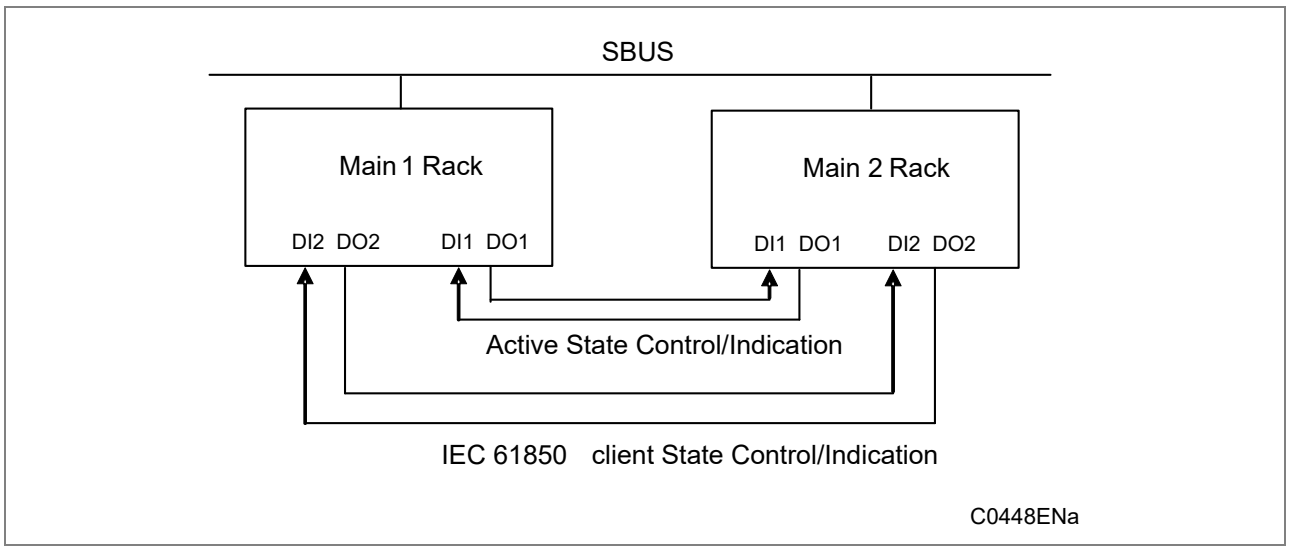


Figure 1: Redundancy management

The two controllers exchange data with:

- The SBUS, to provide their internal status (IS)
- 2 pairs of DI/DO of the BIU board:
  - DI1/DO1 to indicate the Active Status: DO1 is closed if the C26x is Active
  - DI2/DO2 to indicate a Station Bus failure: DO2 is open in the event of a failure

Note:
In order for the standby C26x to become active when the active C26x loses it communications with the station bus, it is necessary that there is at least one mms client connected or that GOOSE frames are exchanged with the two C26x.

A value is assigned to each type of C26x board failure: the controller's IS is the sum of all the failure values. The healthiest C26x is the one with the lowest internal status value. The healthiest C26x becomes the active C26x.

Board type	Failure value for each type of board
AIU	0x01
BIU	0x02
DIU	0x04
CT/VT	0x08
AOU	0x10
CCU	0x20
DOU	0x40
HBU	0x80

The initial state is "Initialisation" (state 0) and the "DI1≠1" event is generated.

"L_IS" is the internal status of the C26x, "R_IS" is the internal status of the redundant one.

The "confirmed DI2 ≠ 1" event is the detection of a Station Bus failure by the other C26x (DI2 = 0) which has been **confirmed during 20 seconds**.

T1 is the timer of the Active status confirmation during the C26x initialisation (default value: 5 seconds for the Main 1 C26x, defined during the configuration process, 30 seconds for the Main 2 C26x). T2 is the timer of the master election (default value: 5 seconds).

The switching time is less than 30 seconds.

	State 0: Initialisation	State 1: Awaiting end of initialisation / T1 timer running	State 2: Standby	State 3: Standby / T2 timer running	State 4: Active	State 5: Standby mode selected
DI1≠1	≠ T1 timer launching ≠ go to state 1	/	≠ close DO1 ≠ go to state 4	≠ stop T2 timer ≠ go to state 4	/	/
DI1=1	go to state 2	≠ stop T1 timer ≠ go to state 2	/	≠ open DO1 ≠ stop T2 timer ≠ go to state 2	go to state 5	/
"confirmed" DI2≠1	/	/	≠ T2 timer launching ≠ close DO1 ≠ go to state 3	/	/	/

	State 0: Initialisation	State 1: Awaiting end of initialisation / T1 timer running	State 2: Standby	State 3: Standby / T2 timer running	State 4: Active	State 5: Standby mode selected
Remote IS	/	/	If (L_IS<R_IS) then ≠ T2 timer launching ≠ close DO1 ≠ go to state 3	If (L_IS>R_IS) then ≠ stop T2 timer ≠ open DO1 ≠ go to state 2	/	/
End of T1 timer	/	If DI1≠1 then: ≠ T2 timer launching ≠ close DO1 ≠ go to state 3 else: ≠ go to state 2	/	not possible	not possible	/
End of T2 timer	/	/	/	go to state 4	/	/
End of standby mode going-on	/	not possible	not possible	not possible	not possible	open DO1 if conditions to enter standby mode are not true anymore then ≠ T2 timer launching ≠ go to state 3 else ≠ go to state 2

2.2 DATABASE MANAGEMENT

2.2.1 GENERAL

The C26x uses structured databases to manage data. The main principle is that the C26x will only function with other DS Agile devices if their database versions are identical.

A database (DB) is a file that includes the description of the whole electrical process, and of all the devices that the C26x is likely to communicate with: IEDs, HMI, and so on. The database also includes some parameter settings for the software and for the transmission protocols. Use a separate DS Agile tool, the System Configuration Editor (SCE), to create and version the databases. Each database has a related VDBS (System Baseline Version).

You can download a standby database even if the C26x is in operation: use the filename .adb format.

You can download a database into the flash memory of the C26x in two ways:

- Use the DS Agile tool, the System Management Tool (SMT) to download the database through the IEC 61850-8-1 station bus (SBUS).
- Use GE Grid Solutions' DS Agile tool, the Computer Maintenance Tool (CMT), to download the database directly over the Ethernet network. Operators generally use the CMT only to download the first database. During the download, the CMT sends the database to all the other racks. This database becomes the new Standby database. Upon receipt of the Switch command, the C26x cascades the switch operation to the other racks.

The C26x-Standalone RTU receives the database file from the SCADA and saves it in RAM memory, but does not forward it to the other racks.

On the C26x-Standalone RTU, the database status shows only on the main rack on the LCD.

The main 1 rack checks the compatibility between its database and the databases installed in the main 2 rack and in the extension racks. It the databases are different, the main 1 rack has the most recent version and deletes the databases on the other racks.

If the main database on the main 1 rack is compatible with the standby database on the other rack(s), the C26x switches the database.

At any moment, the C26x stores as many as two DBs in its flash memory. The two DBs and their related VDBS have the labels DB1, VDBS1; and DB2, VDBS2.

Each database in the C26x, DB1 and DB2, has one of the following states:

- **Missing**: the DB is not present in the controller's flash memory
- **Standby**: the DB was downloaded into the controller's non-volatile memory of, but the software does not acknowledge this version
- **Current**: the software acknowledges the downloaded DB
- **Current Modified**: a parameter setting was changed in the DB and the software currently acknowledges the DB
- **Standby Modified**: a parameter setting was changed in the DB and the software does not acknowledge the DB.

In the unit, the life cycle of the DBs is shown in the figure below:

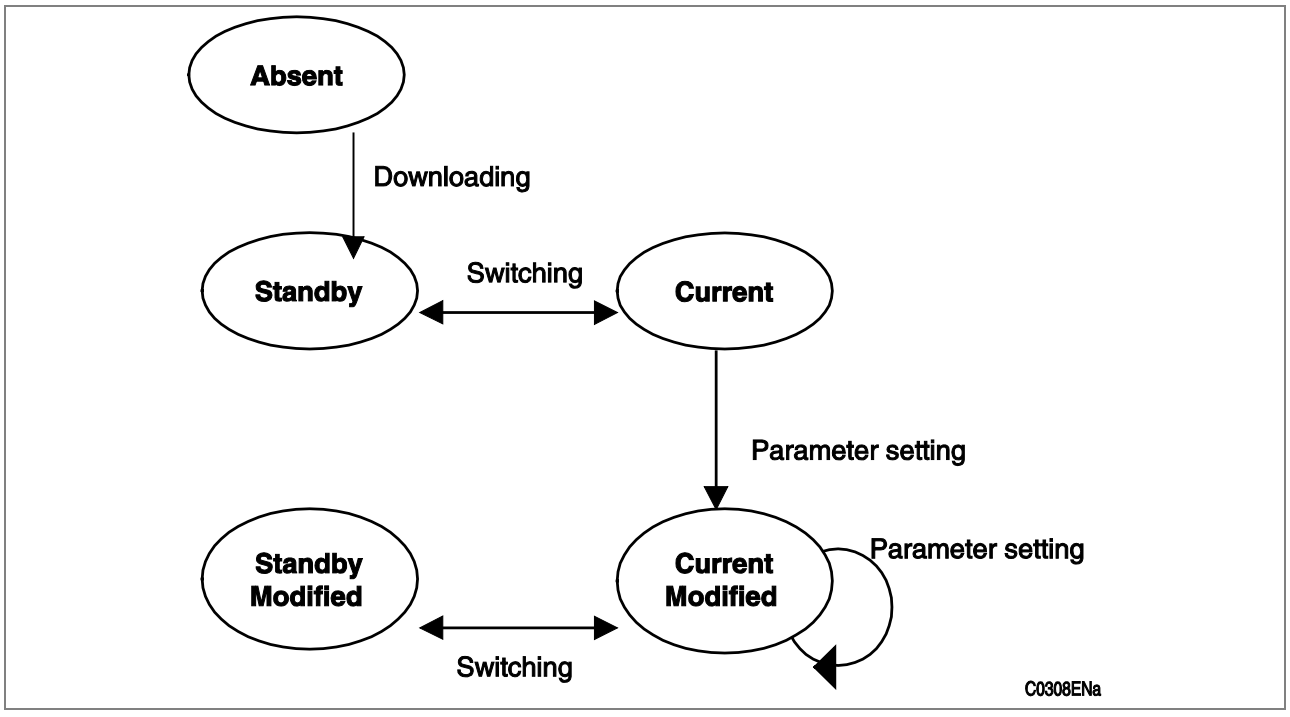


Figure 2: The different states of a database

At any moment, there is only one DB either in **Current** state or in **Current Modified** state. Similarly, there is only one DB either in **Standby** state or in **Standby Modified** state.

For the two downloaded DBs, DB 1 and DB 2, the four possible states are shown in the table below:

Database	State 1	State 2	State 3	State 4
DB1 and VDBS1	Current	Current Modified	Current	Current Modified
DB2 and VDBS2	Standby	Standby	Standby Modified	Standby Modified

A file descriptor with the label DB context, stored in the flash memory of the C26x, includes the configuration of the DB installed on the device. This file descriptor, that includes the state of each of the two databases and their related VDBS (for example, DB1 and VDBS1; DB2 and VDBS2), indicates the configuration of the databases when the C26x boots up (initialisation mode), and to start again with the **Current** database, if it exists. To update the file descriptor DB Context, use these functions:

- Download a database
- Switch the databases
- Check a database
- Modify a Database.

2.2.2 HOW TO DOWNLOAD A DATABASE THROUGH THE ETHERNET

Connect the C26x to the station bus (SBUS). Use the SMT tool to download the first DB.

The first time that you download the DB and the related Vdbs, make sure that the C26x is in maintenance mode.

Once the C26x is running with the first DB, and it is either in operational mode or in maintenance mode, you can download the standby DB and its related Vdbs.

The sequence to download the DB is as follows:

1 Use the DS Agile SMT tool to send a request to start the database transfer.

2 The receiver, the PC, returns a positive response.

3 Transmit the response to the calling device. If another request on the same DB is already in progress, the device will refuse your request.

4 Download the DB file and the related Vdbs. The C26x checks the integrity of the files: it calculates the checksum and control of the DB.

5 In the event of a fault, the C26x sends a signal to inform the calling device of the transfer.

6 After a successful transfer of the DB, the C26x checks the DB's compatibility

7 In case of an invalid DB, the C26x sends a signal to inform the calling device of the DB installation failure.

8 In case of a valid DB, the C26x:

   a Removes any **standby** DB and related Vdbs already installed in the C26x

   b Assigns the **standby** state to the downloaded DB and related Vdbs installed with it in the C26x

   c Sends a signal to inform the calling device of the success of the DB installation.

9 The C26x updates the file descriptor, Context DB, in flash memory.

2.2.3 HOW TO SWITCH THE DATABASES

The SBUS sends a request to switch the DB. **This request specifies the Version of the standby DB and related Vdbs** which are to become **current**. Please refer to *Figure 4: Database download* and to *Figure 5: Database Switch*.

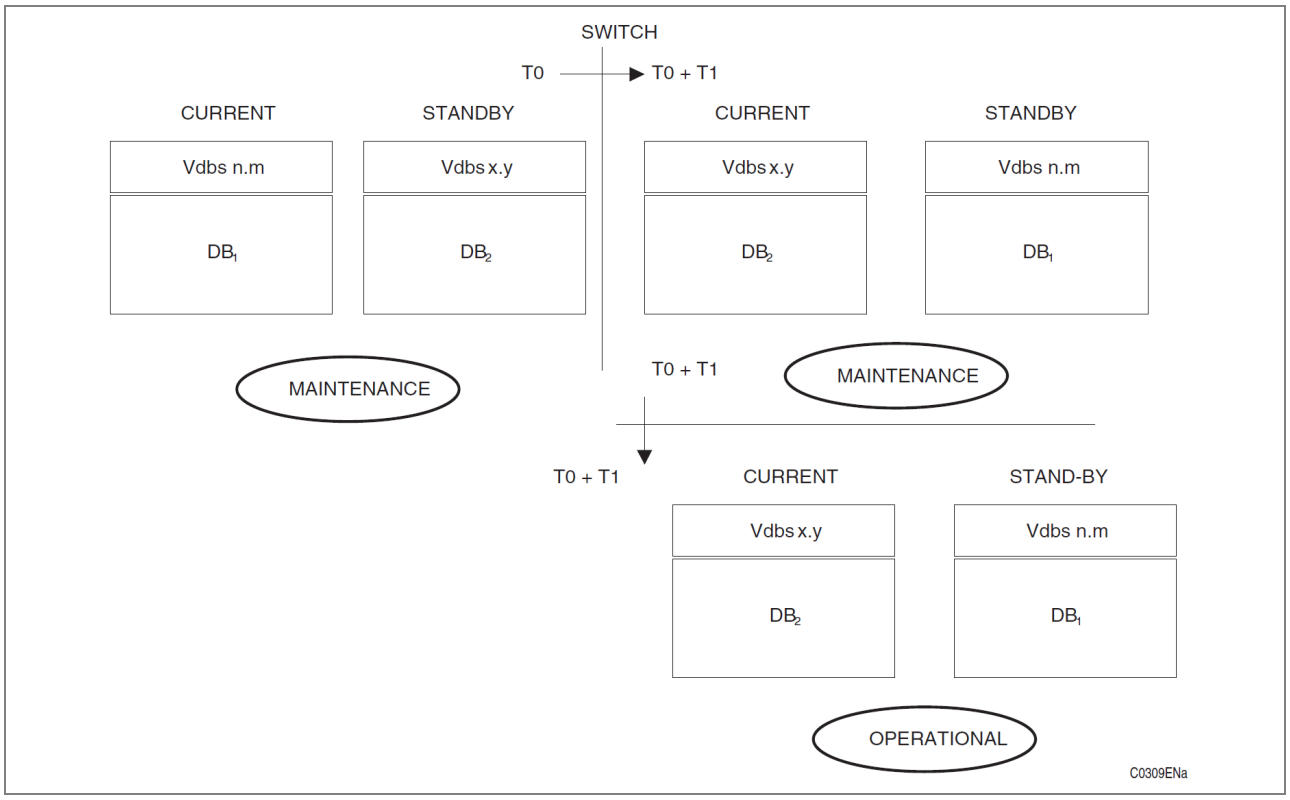


Figure 3: Switching databases

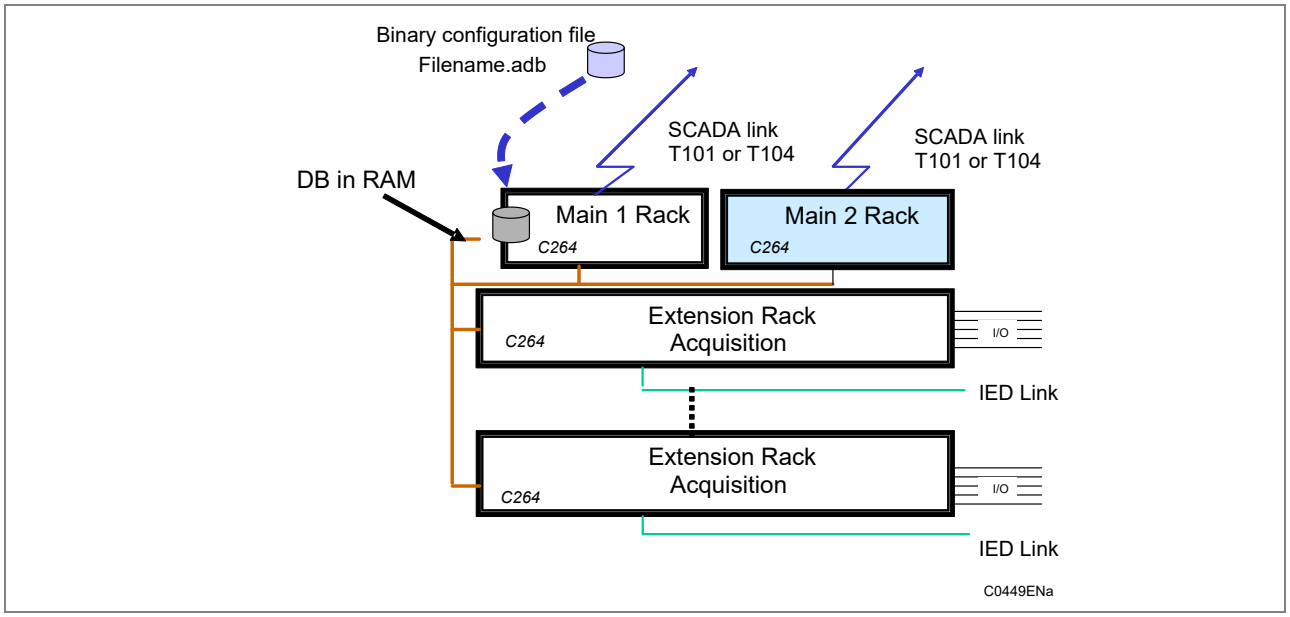


Figure 4: Database download

After a successful database download, the SCADA sends the switch command with the “Reset process command” standard message (ASDU 105) to the C26x.

When the C26x receives the switch command, the C26x downloads the database into the other racks. Please refer to *Figure 5: Database Switch*.

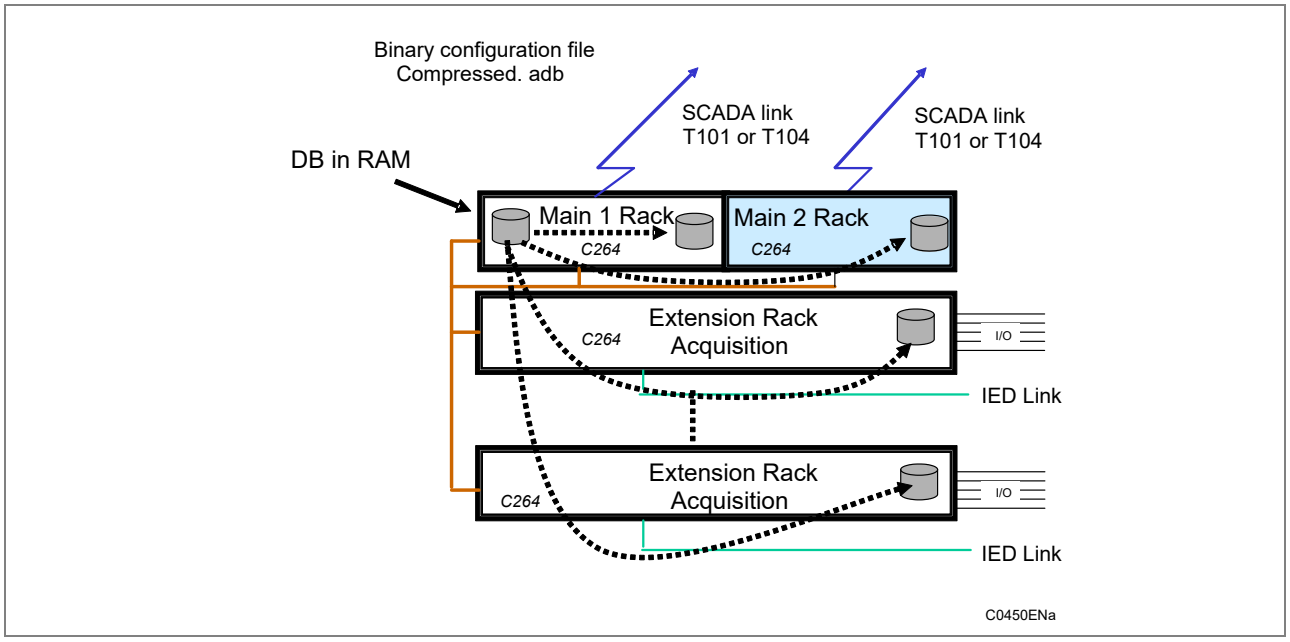


Figure 5: Database Switch

When this series of downloads is successful, the C26x switches the databases in all the racks.

After a DB switch, and if the DB is consistent with the software, the C26x automatically reboots and switches to Operational Mode.

2.2.4 HOW TO PERFORM A CHECK OF THE DATABASE

Upon each reboot, the C26x checks the DB.

2.2.5 HOW TO MODIFY THE DATABASE

With the local HMI, you can only modify a parameter setting in the current DB, i.e., the *Current* or *Current Modified* DB. You can only modify some data parameters. In order to be able modify the parameters in the settings file, they need to be defined in the DB as “editable”. The modified DB stores the new parameter settings. The C26x increments the internal version number of the parameter setting file and calculates again the checksum of the file. The database takes the *Current Modified* state.

2.2.6 HOW TO MODIFY A PARAMETER SETTING IN THE CURRENT DB

To modify the parameter setting in the current DB, use the C26x to:

1 Check the consistency of the request:

   a Is the object known to the C26x, i.e., is the object really present in the database?

   b Can the C26x set the data?

   c Is the value of the parameter setting compatible with the type of data conveyed: is the value within the range of acceptable variations?

2 Return a negative report to the device that sent the request if it is inconsistent.

3 Write the current value of the data in the DB

4 Write the date at which you modified the data in the DB

5 Compute the checksum and to write it in the DB

6 Assign the state *Current Modified* to the DB

7 Send a positive report to the device that sent the request

8 Update the file descriptor, that is the Context database, in the flash memory

2.2.7 HOW TO READ OUT A PARAMETER SETTING

To effect a request to read out a parameter setting in the current DB from the Operator Station, use the C26x to:

1 Check the consistency of the request:

   a Is the object known to the C26x, i.e., is the object really present in the database?

   b Can the C26x set the data?

   c Is the value of the parameter setting compatible with the type of data conveyed: Is the value within the range of acceptable variations?

2 Return a negative report to the device that sent the request if it is inconsistent.:

3 Expand the response to include the parameter setting and send it to the device that sent the request

For the C26x–Standalone unit, you can use the Computer Maintenance Tool (CMT) to upload and store a DB as large as 20 MB in the flash memory.

2.3 SELF-TESTS

The C26x performs the following self-tests:

- Hardware (hardware fault) at start-up and cyclically.
- Software (software fault) cyclically to ensure that software tasks are active and do not take up all the CPU time
- Database consistency at start-up
- Acquisition and output at start-up and cyclically.

2.4 FIRMWARE INTEGRITY TESTING

Firmware integrity is protected by SHA256 hash encryption. The CMT installation package contains 2 files used to manage hash encryption:

- "hashListAppFiles" for bootinstall files
- "hashListBooFiles" for bootrom files

2.4.1 BOOTINSTALL TEST

It is first tested when the firmware is downloaded, during the “bootinstall” operation.

When a new firmware version download is initiated, the "hashListAppFiles" file is downloaded first.

- If its SHA256 hash code is valid, the download is permitted.
- If it is not valid, "hashListAppFiles" file is deleted and the download is prevented. An error message is displayed.

The downloaded files are first stored in flash memory with temporary names until each of them has been checked against the SHA256 hash code.

If any file fails the hash code test, the bootinstall process is terminated and all previously validated temporary files are destroyed. An error message is displayed.

The last file to be transferred and checked is the VxWorks file. Once validated, this file is stored in place of the previous VxWorks file. The associated temporary files are then renamed and stored in place of their previous versions.

2.4.2 UPDATE BOOTROM TEST

The Update bootrom function is used to update the bootrom part of the C26x flash memory (software executed after a restart). The C26x must be in stopped mode to allow this function.

The "hashListBooFiles" file is downloaded first.

- If its SHA256 hash code is valid, the update is permitted.
- If it is not valid, the "hashListBooFiles" file is deleted and the download is prevented. An error message is displayed.

The “bootrom.flh” file is then downloaded and checked against the SHA256 hash code.

- If it is valid, it is transferred from the RAMDEV memory to the boot section of the flash memory. The bootrom update is then completed successfully.
- If it is not valid, both the "hashListBooFiles" and “bootrom.flh” files are deleted and the process is aborted. An error message is displayed.

2.4.3 CYCLICAL TEST

The C26x cyclically tests the bootinstall and bootrom files, in the following order:

1 Bootinstall files
   a Check the "hashListAppFiles" file
   b If this check is successful, check each of the pre-defined files in the flash memory (by default all the files in the list).
   c If a discrepancy is detected, a fault is logged in the syslog file and cyclical bootinstall check is stopped until the next reboot.
2 Bootrom files
   a Check the "hashListBooFiles" file
   b If this check is successful, check the “bootrom.flh” file.
   c If a discrepancy is detected, a fault is logged in the syslog file and cyclical bootrom check is stopped until the next reboot.
3 Read Only Memory
   a Read the header area of the VxWorks file stored in the Flash memory to extract information on the program running in RAM.
   b Byte per byte check of the main RAM area of code size against the reference file stored in the Flash memory (the reference file was confirmed as trusted during the previous cyclical integrity test).
   c If a fault is detected, it is inserted into the security log (sent to the Syslog server if one is used). The cyclical test of the RAM code area is suspended until the next reboot.

The complete test process takes less than 10 minutes.

2.5 TIME MANAGEMENT

The main purposes of time management include:

- To synchronize the internal clock in the C26x (referred to as the local clock) with:
  - The external clock for all C26x devices
  - SCADA for all C26xdevices
  - SBUS or LBUS for all C26x devices except C26x-Standalone RTUs
  - Operator for all C26x devices except C26x-Standalone RTUs
- To update the local clock
- To synchronize other devices through the SBUS with the local clock

You can synchronize the local clock with an external time reference from 4 sources:

- The external clock sends an IRIG-B signal Note 1
- The SCADA sends a clock message through the TBUS and the gateway Note 1
- The system's master clock sends a clock message through the SBUS - SNTP Note 2
- An operator sets the time Note 2

Note 1: For all C26x devices

Note 2: For all C26x devices except C26x-Standalone RTUs

There is a priority rule for these four external time references. If the external clock operates, it locks out changes from the three other sources: you cannot make modifications to the local clock in these cases:

- Locked out: The SCADA sends a clock message through the TBUS and the gateway
- Locked out: The system master clock sends a clock message through the SBUS
- Locked out: An operator sets the time

For the C26x-Multirack system, the main 1 rack delivers time synchronization to the main 2 rack and to the extension racks.

In case an external clock disconnects or does not operate, there is a priority order for the three external time references that remain:

- The SCADA sends a clock message through the TBUS and the gateway

  or

- The system master clock sends a clock message through the SBUS

  have priority over

- An operator who sets the time

Just after the local clock is synchronized, and if it is the master system clock of the LBUS, the controller synchronises the Intelligent Electronic Devices (IEDs) in accordance with the synchronisation procedure of the protocol. If the local clock is not synchronised, the controller synchronises periodically the IED all together.

When the local clock is synchronized, all events and measurements include a time tag with a synchronized attribute. If the synchronization is lost, or was never achieved, the attributes indicate that the time tag is not synchronized.

For a substation, the DS Agile architecture can synchronize as many as 120 devices, such as the C26x, system HMI, gateways, IED Relays, IEC 61850-8-1 Relays, and so on.

Time management is organised as follows:

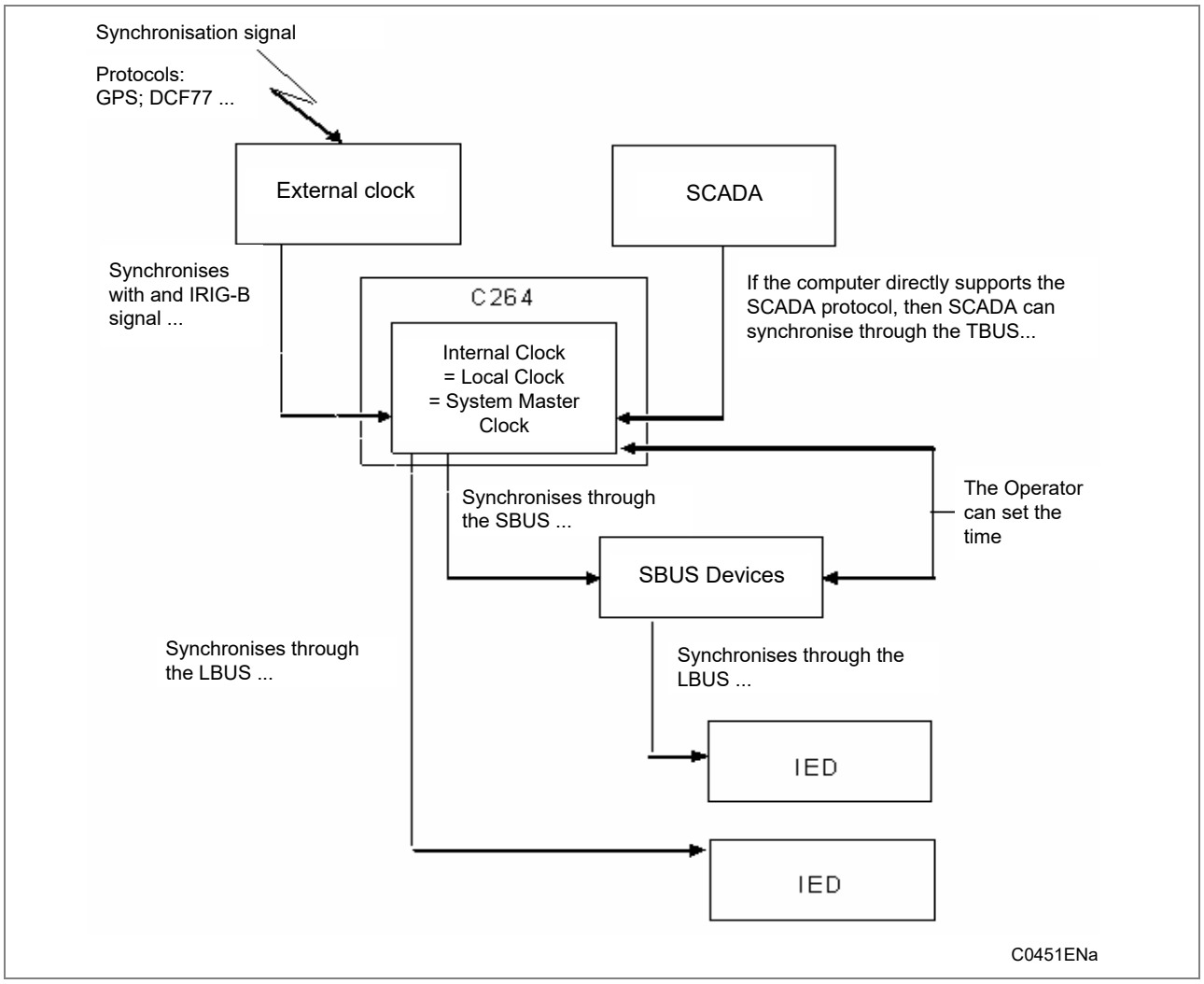


Figure 6: Time management

2.5.1 EXTERNAL CLOCK

The external clock receives the synchronization signal through one of several protocols: GPS, DCF77, and so on. Periodically, the external clock sends the synchronization signal, which includes the time and date, to the dedicated IRIG-B input of the DS Agile C26x.

Each controller has its own local clock. The local clock synchronizes with the signal from the external clock. In this system architecture, the local clock operates as the System Master Clock.

In the event of the loss of the radio signal from the external clock, two events can occur:

1 Some external clocks include a very accurate oscillator. After a loss of radio signal, these external clocks can synchronize the controller for 8 hours. The external clock sends two messages through the protocol. The text of the messages complies with the manufacturer's specifications. For example:

- no radio received
- radio signal lost for more than 8 hours

2 The local clock remains synchronised with the external clock until the message **radio signal lost for more than 8 hours** is issued. The status of the local clock now shows as **not-synchronised**.

3 Some external clocks do not have the internal accuracy to support the radio signal. In this event, when the confirmation of a **lost radio signal** occurs in a few minutes, the status of the local clock shows as **not-synchronised**

If the controller operates as the system's master clock for the other devices in the substation, then it continues to send the clock synchronisation message to the other devices, even if the local clock, or system master clock, is not synchronised with an external time reference. A binary input is dedicated to monitoring the status of the external clock.

2.5.2 CLOCK SYNCHRONISATION MESSAGE FROM A SCADA GATEWAY

The acquisition of a SCADA clock synchronisation message is a SCADA gateway specification.

The SCADA clock synchronisation depends on the protocol. The clock synchronisation message goes directly through the SCADA link to the C26x.

The clock synchronisation message from the SCADA gateway is in Universal Time Coordinated (UTC) time.

From the SCADA, the clock synchronisation message goes to the "local clock update" function in the controller. The controller checks the frame of the clock synchronisation message, removes the control fields, and transmits the clock synchronisation message.

When the SCADA gateway operates as the external time reference according to the priority, the controller receives the clock synchronisation messages from the SCADA. An interruption relates to the arrival of the frame: the controller can acquire the clock synchronisation message from the SCADA gateway. The delay in the transmission from the SCADA gateway is compensated.

The clock synchronisation message from the SCADA gateway must contain:

Day / month / year / hour / minutes / seconds / milliseconds

To update the controller local clock, please refer to *2.5.6 Local clock update*.

2.5.3 SNTP CLIENT AND SERVERS

On an IEC 61850-8-1 network, the clock synchronization uses the Simple Network Time Protocol (SNTP). In a DS Agile system, you can define as many as two controllers as the System Master Clock: they become SNTP servers. All other devices installed on the IEC 61850-8-1 become SNTP clients. In event that one SNTP server fails, for example a controller is unserviceable, or an external clock fails, the SNTP clients automatically connect to the second SNTP server.

Use the DS Agile tool, the System Configuration Editor (SCE), to configure a C26x as an SNTP server; to have redundancy, define two IP addresses. These IP addresses must be in the same range as the C26x Ethernet addresses.

In this event, no C26x is the Master Clock: all C26x devices are SNTP clients.

The synchronization performance of the system depends on the accuracy of the third-party SNTP server.

You can connect one C26x, which is configured as an SNTP server, to a second C26x SNTP server to make a C26x redundant system.

2.5.4 PTP SYNCHRONISATION

PTP synchronisation is available only if an SRP28x switch board is present. Refer to SRP28x description in Network Monitoring chapter, C26x/EN NM for details.

2.5.5 TIME SET BY AN OPERATOR

If an external time reference operates, such as the external clock, the SCADA clock or the system master clock, you the operator cannot set the time.

If the system master clock synchronises any other device in a DS Agile system architecture, you cannot set the time for that device. However, in event the system master clock is unserviceable or the connection fails, you can set the time for the device.

If the controller does not receive the clock synchronisation messages from the external clock, from the SCADA gateway, or from the system master clock, you are allowed to set the time manually.

Normally, you must manually set only the system master clock. You must use the correct tool for the specific system master clock.

With the Computer Maintenance Tool (CMT), you can set the time and date.

You use two commands:

- One to modify the time: hour/minutes/seconds
- One to modify the date: year/month/day

You can reserve a third command to do a check on the date and hour values.

You must raise a manual time-set-indication. The controller makes a record of all operator actions.

2.5.6 LOCAL CLOCK UPDATE

Each controller has its own local clock. Each local clock has its own quartz shift: a deviation of the internal oscillator of the controller. You must synchronise the local clock periodically to agree with an external time reference.

The time data includes:

- Loss of the external clock; loss of SCADA gateway clock synchronisation message; or loss of the system master clock
- An indication that the local clock was roughly synchronised. This indication shows any time difference, between the local clock and the clock synchronisation message that is greater than the fixed value: Δthreshold = 20 milliseconds. The controller sends a message about the discrepancy, prints the message, and archives the event.
- Indication that the operator performed a manual time set. This “manual time set” indication is required to time-tag the events that occur.

The internal time format for the local clock is Universal Time Coordinate (UTC). The time difference between UTC and the local time is set during configuration.

The local clock operates automatically:

- For all dates including leap years up to 2037.
- For seasonal time changes: it uses the values for Daylight Savings Time (DST) as shown in the Time Zone Adjustment Table (TZTAB) file. The TZTAB file shows the differences between UTC and local time.

If the DST rules change, you can set the new rules in the controller.

The controller manages the milliseconds with its own quartz.

The Local Clock Update function manages the synchronisation status of the controller as follows:

- Not synchronized: this is the status at initialization, the controller has never been synchronized since booting or rebooting. **Date and time are invalid**.
- Synchronized: the controller receives periodically the date and time. **Date and time are valid**. Or the controller is master clock on the Ethernet network for other equipment.

At initialisation, the controller shows the external clock as not-synchronised with the local clock. This status remains the same until you send a control message to the initialisation driver to receive synchronisation frames from an external time reference. When the control is OK and at the reception of the first external

clock message, the synchronisation upon external clock is declared valid and the external clock is considered connected.

This synchronisation with the external clock could fall back to invalid: for example, in event the controller did not receive an external synchronisation message for N minute(s). This can indicate an external clock failure, such as a disconnection or a message that contains invalid data. The value of this timing is 300 seconds.

In the event of an external clock failure, the local clock maintains the frequency in effect before the external clock failed. The controller generates an internal signal or alarm and declares the system master clock invalid. When this occurs, the controller makes a non-synchronisation mark against each event, for as long as the synchronisation with the external clock remains invalid.

When a device on the SBUS does not receive a clock synchronisation message in 180 seconds, it raises an alarm. The events processed by this device are tagged with a special mark and with the time, and the device stops the transmission of the synchronization frame to the IEDs.

2.5.7 MANAGEMENT OF LOSS OF EXTERNAL TIME REFERENCE

As the local clock update function receives the external time reference, it manages a loss of the external time reference as follows:

- If the external clock is lost, then the local clock update shows the loss of the external clock
- If the clock message from the SCADA gateway is lost, then the local clock update shows the loss of the SCADA gateway clock message
- If the system master clock is lost, then the local clock update shows the loss of the system master clock

2.5.8 UPDATE METHOD

When the controller validates the external clock acquisition, the controller manages the synchronisation of the internal system master clock to the external time reference as follows:

If a difference between the local clock value and the external time reference value transmitted exists, [C Local – C External] $\neq 0$:

- If [C Local – C External] < 1 ms, the local clock is not modified
- If [C Local – C External] > 1ms, two different events are processed:

1 If [C Local – C External] $\leq \Delta$ Threshold (20 ms), the value of the local clock is progressively corrected (reduced or increased). This compensation is performed in a set time (t_1=60 s).

2 If [C Local – C External] $\geq \Delta$ Threshold (20 ms), the hour in the local clock is updated roughly.

If an operator gets the external clock time, the operator must update the local clock.

2.5.9 LIMITS AND PERFORMANCE

The controller local clock has a small shift per day. This quartz shift, that is the deviation of the internal oscillator of the controller, is less than 0.5 s/day (that is, $\leq$ 5.8 µs/s). This quartz shift is the same through the entire operating temperature range of the controller. The operator must set the time periodically or synchronize the local clock with a master clock.

2.6 CYBER-SECURITY

Note:
In remote authentication all parameters, user profiles and roles are same as local authentication.

Access to the C26x is protected by several mechanisms:

- Operators use individual, password-protected login accounts, which have different access permissions depending on their functional roles.
- Sessions have a time-out to prevent unattended open sessions.
- A password policy can be implemented to ensure that strong passwords are always used.
- Security-relevant operations such as user connection attempts and disconnections, account modifications, database switch, etc. are logged in a secure file. The log file can be transmitted to a central repository ("Syslog" server). For details, see section **2.6.3 Security Log**.

2.6.1 USER ACCOUNTS ROLES AND PERMISSIONS

The C26x supports and stores a list of permissions.

Available permissions depend both on the roles associated with the user account and on the tool being used to access the C26x. Some roles may not have sufficient permission levels for particular tools, for instance only accounts with a System Engineer or System Administrator role may access the MiCOM S1 setting software.

CMT Permissions

Permissions	Viewer	Engineer	System Administrator	Security Administrator
Steal Session (force a connection)				R/W
View Computer information (version of the C26x and of its components, database name and version, running mode)	R/W	R/W	R/W	
Manage parameters (IP address, boot mode…)		R	R/W	
Manage Databases			R/W	
Manage Date & Time		R	R/W	
View System Errors		R/W	R/W	
File Explorer (ramdev, read flash memory & format)			R/W	
Install (bootrom, bootinstall)			R/W	
Open SSH port	Root account only			
Open MiCOM S1 port		R/W	R/W	
Manage Event Logs (archive state, etc.)	R	R	R/W	
Manage Printer Info	R	R/W	R/W	
Stop/Reboot		R/W	R/W	
Manage Board status	R	R/W	R/W	
Manage IED status	R	R/W	R/W	
Manage Statements	R	R/W	R/W	
Manage Disturbances	R	R/W	R/W	
Change Comtrade directory		R/W	R/W	
Modify own password	R/W	R/W	R/W	R/W
Manage Local Security Policy				R/W

Permissions	Viewer	Engineer	System Administrator	Security Administrator
Configure Radius server				R
Configure Syslog server				R
View Local Security Logs				R/W
Open console to send commands through SSH	Root account only			

MiCOM S1 Permissions

Permissions	Viewer	Engineer	System Administrator	Security Administrator
Manage Settings		R/W	R/W	
Download/Upload Settings		R/W	R/W	

C26x Front Panel LHMI Permissions

Permissions	Viewer	Engineer	System Administrator	Security Administrator
View Data	R/W	R/W	R/W	
Manage Settings	R	R/W	R/W	
Send Command		R/W	R/W	

Boot Mode Restrictions

When the C26x is in boot mode, the CMT permissions are restricted to the following list:

Permissions	Viewer	Engineer	System Administrator	Security Administrator
Steal Session (force a connection)				R/W
View Computer information (version of the C26x and of its components, database name and version, running mode)	R/W	R/W	R/W	
Manage parameters (IP address, boot mode…)		R	R/W	
Manage Date & Time		R	R/W	
View System Errors		R/W	R/W	
File Explorer (ramdev, read flash memory & format)			R/W	
Install (bootrom, bootinstall)			R/W	
Stop/Reboot		R/W	R/W	

2.6.2 AUTHENTICATION

There are two types of Authentication for the CMT:

- Local Authentication

  Local authentication is used when the user profiles and roles are configured on the local device.

- Remote Authentication

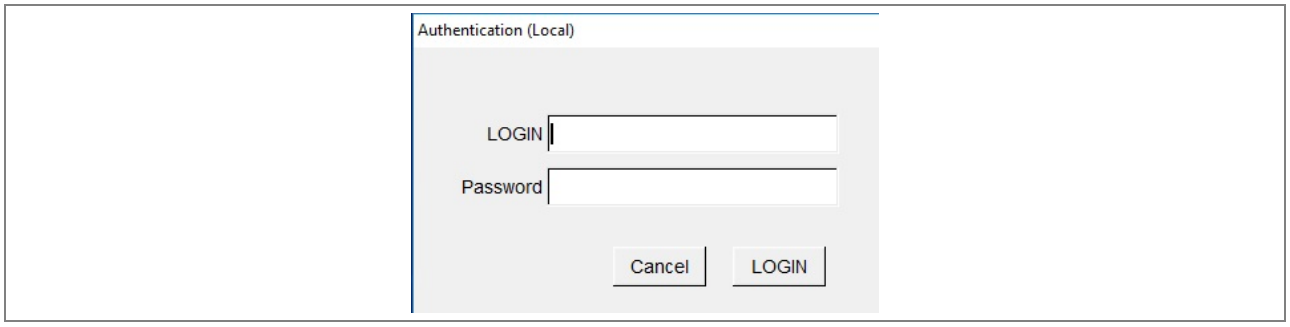
  Remote authentication is used when the user profiles and roles are configured centrally using RADIUS Server.

  If the RADIUS Server is not connected to the Station Bus network or is offline, the CMT switches to local authentication.

Note:
Login priority will be given to local / server as displayed on CMT login window.

2.6.2.1 LOCAL AUTHENTICATION

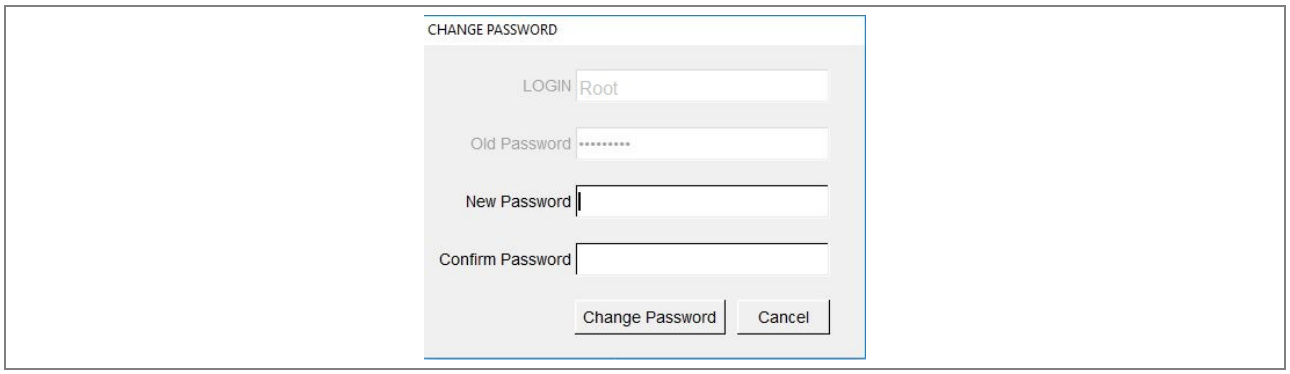
When the user starts the CMT a login popup is displayed.



The installer automatically created an administrator user account:

User Accounts	Default Password	Roles
Root	Root1234#	VIEWER OPERATOR ENGINEER RBACMNT

The first time a user attempts to log on to the CMT after its installation, a pop-up is displayed prompting to change the password.



2.6.2.1.1 Local Authentication Parameters

The local user account database and the security settings are managed using the CMT. However, they are stored locally in each C26x unit in a hidden file.

The local user account database and the security settings are common for all access points (CMT, front panel LHMI, MiCOM S1).

They are stored in non-volatile flash memory, are separate from the configuration database, and therefore are not lost after a reboot.

Inactivity Timer

A timer can be configured in the CMT to automatically close a session when the user is inactive. Depending on the user interface, the definition of "inactive" can vary:

- CMT: Only effective actions, such as clicking a button or selecting a field are considered activity. Cursor movements are not.
- MiCOM S1: Only communications with the C26x unit, i.e. upload and download of settings, are considered activity. Actions that do not involve communicating with the C26x unit, including changing settings in MiCOM S1 are not considered activity.
- LHMI: Pressing any key is considered activity.

The user is disconnected when the timer elapses.

Disclaimer

A legal disclaimer can be automatically displayed after every successful login. Its activation state and text are configured using the SCE and included in the configuration database.

In **boot** or **maintenance** mode (no active database), the CMT displays the following disclaimer, regardless of any database configuration:

“Access to this system is limited to specifically authorized users having received all trainings required by applicable laws, regulations, and by policies and procedures implemented by the legal entity hosting this system. Unauthorized users may face criminal or civil liabilities and/or penalties. The use of this system may be recorded and monitored for system operations, security policy and intellectual property compliance related purposes and any information related to the use of this system may further be disclosed to third parties or law enforcement officials as necessary. Disconnect now if you are not an authorized user or do not agree with the above terms.”

Login

Login to the C26x is password-protected for all access points: CMT, front panel LHMI and MiCOM S1.

The password is not displayed.

When a user logs out from a C26x in the CMT, he is also disconnected from the connected C264 in MiCOM S1. Logging out in the CMT does not end an SSH connection (root account only).

Session

The C26x supports only one user session at a time. However, on the maintenance PC, the same user can be connected to the C26x from both the CMT and MiCOM S1 (and also the SSH terminal for the Root account).

When a local session expires, the front panel LHMI reverts to the default start panel. On the maintenance PC, there is no disconnection warning when a session expires: The user is informed of the disconnection when he/she tries to perform an action and the login popup is displayed.

2.6.2.2 REMOTE AUTHENTICATION

Remote authentication to the C26x can be done through a RADIUS server.

RADIUS server supports 3 communication protocols:

- PAP (insecure, but used for compatibility reasons)
- PEAPv0 (EAP-MSCHAPv2)
- EAP-TTLS (server certification verification)

Note:
The PAP protocol is insecure, it is an old standard (RFC 1334 was published in 1992). PAP protocol is available for compatibility reasons but, when possible, it should not be used.

Pre-requisites

- **DCS_Master** and **DCS_User** provided by the Active Directory Server PC when you connect to the domain.

3 The C264 profiles are provided by the Active Directory Server PC.

4 Database has been downloaded by SMT.

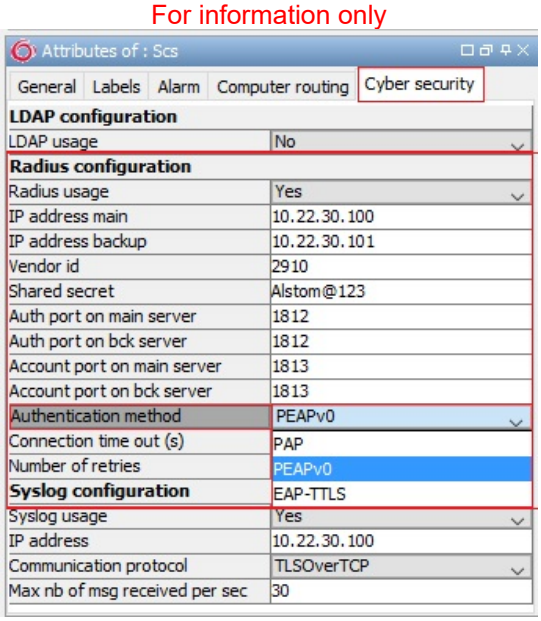
Note:
Remote Authentication user profile rights are the same as Local Authentication user profile rights.

2.6.2.2.1 Remote Authentication Configuration in SCE

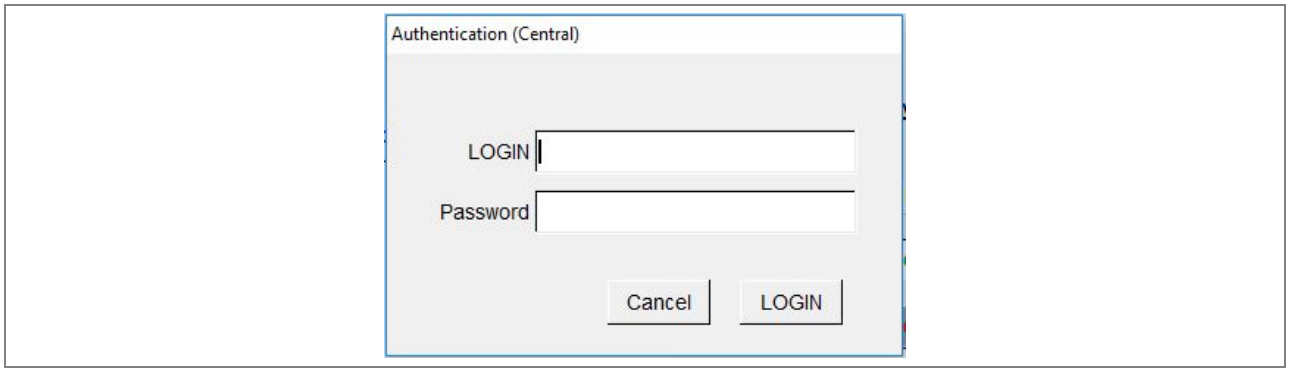
CMT remote login supports three protocols for authentication on RADIUS Server. They must have been configured in the SCE database.

See AAA/EN AP for details for database configuration regarding RADIUS Configuration.

For information only



Start the CMT with a centrally authenticated user's login and password.

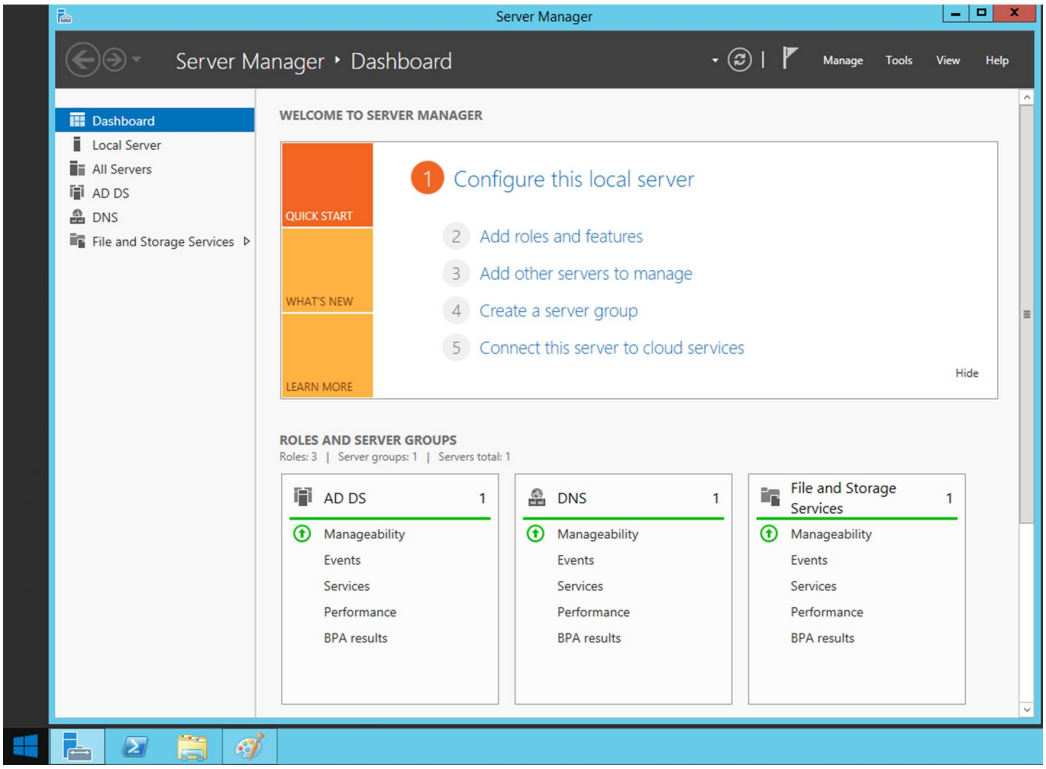


The process for creating a centrally authenticated user in the AD server is described in the following section.

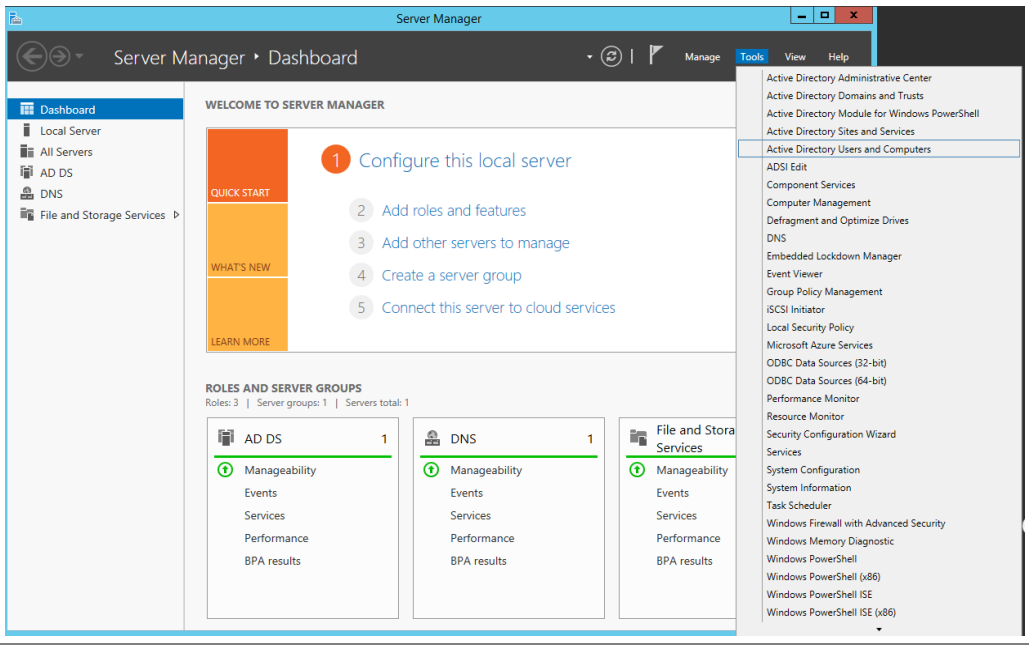
2.6.2.2.2 How to create a new centrally authenticated user in the Active Directory Server

1 Log in to the Active Directory Server PC with an **Administrator** account.

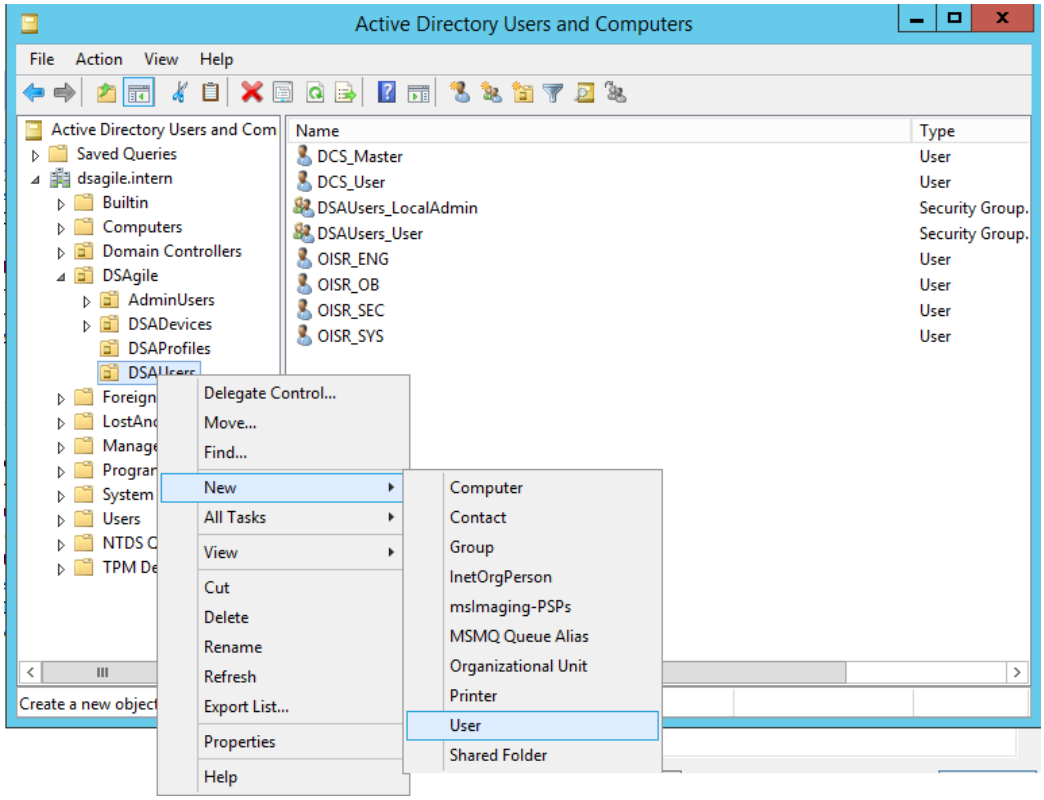
2 Click on the **Server Manager** icon, in the status bar:



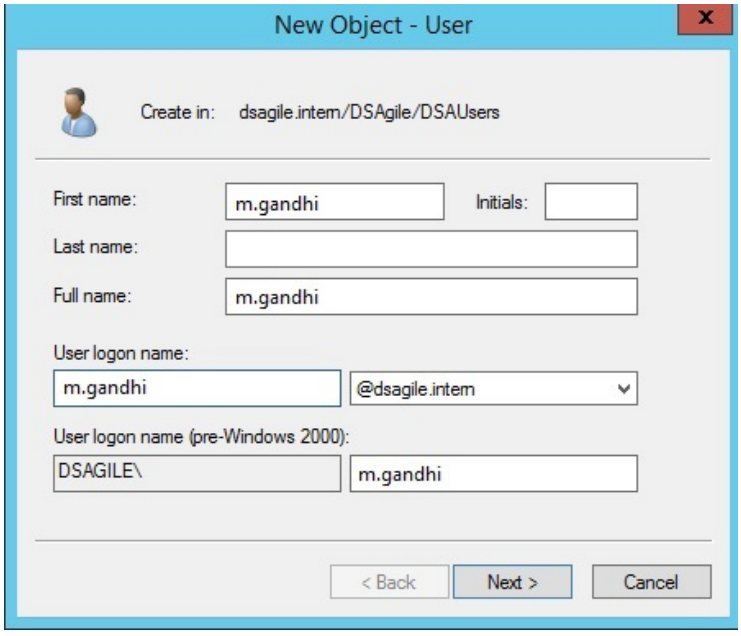
3 In the **Tools** menu select **Active Directory Users and Computers**:



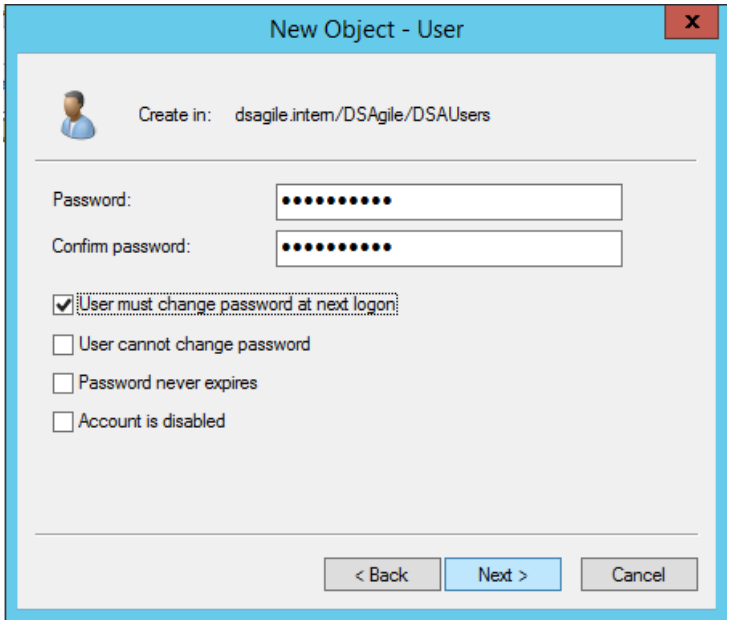
4 In the navigation tree, right-click on **Users** and then select **New** → **Users**:



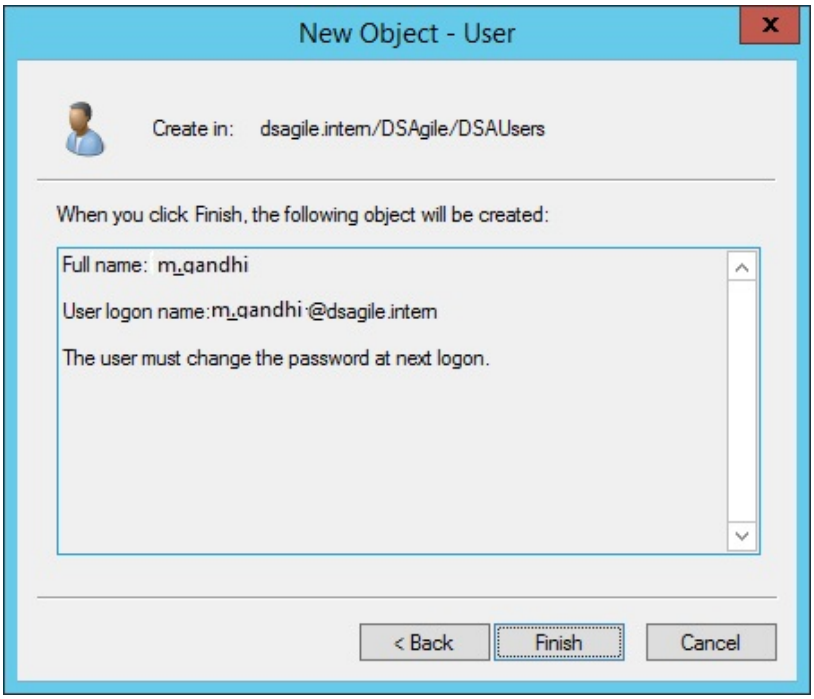
5 Provide the required user profile information to create a new user as shown below and then click **Next**.



6 Set the user's password and check the **Users must change password at next logon** option. Click on **Next**.



7 Click **Finish**.

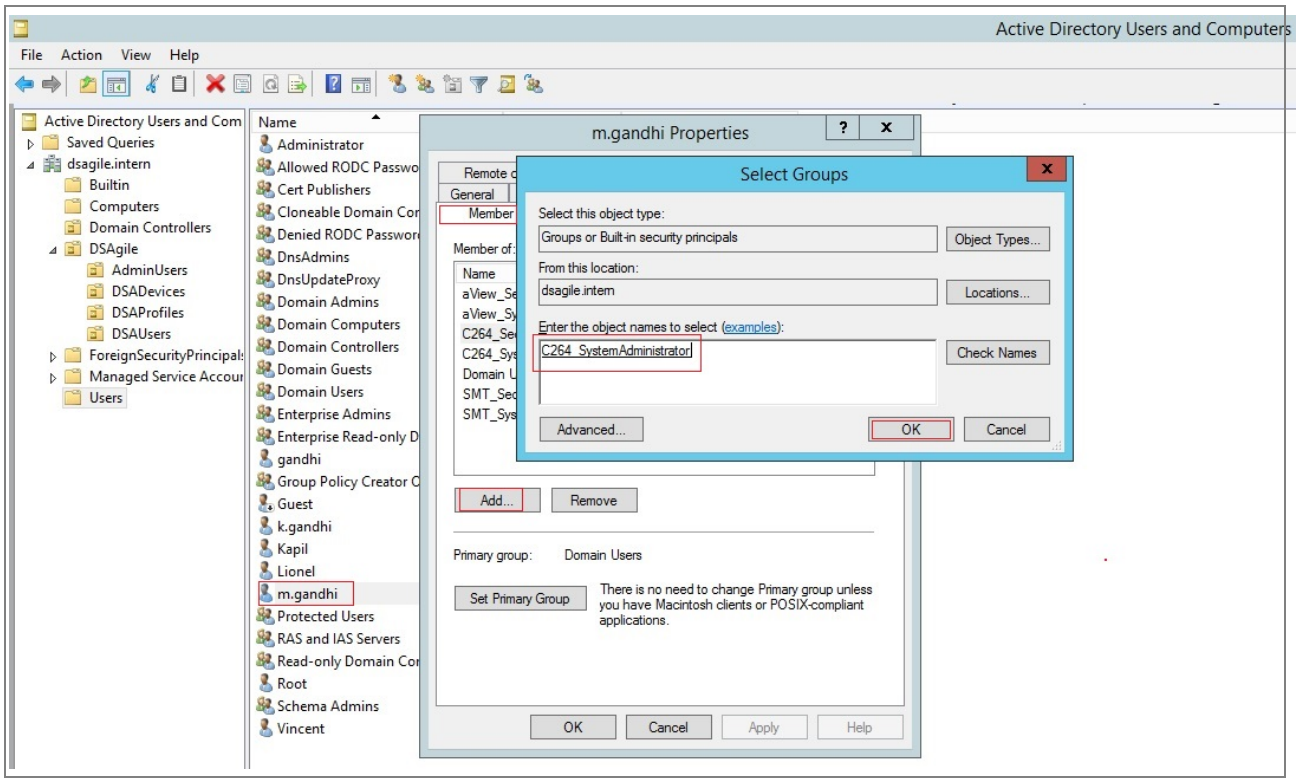


8 Right click on the newly created user and in the user properties, click on the **Member of** tab.

d Click on the **Add** button and search for pre-defined user profiles.

e Click **OK**.

f Click **Apply** and **OK**.



Note 1:

*When the Active Directory Server PC is not connected to the station bus network, or if it is offline, CMT login automatically **switches to local authentication**.*

Note 2:

User accounts with C264 profiles should also be added to DSA_LocalUser group to allow them opening a windows session.

2.6.2.2.3 Remote Authentication Parameters

Note:
In remote authentication all other parameters, user profiles and roles are the same as those defined in local authentication.

The RADIUS server or backup RADIUS server are configured in the Cyber Security tab of the SCE.

If the device is configured to use RADIUS, the device will use RADIUS authentication instead of local authentication.

By default, the device uses the RADIUS for both remote access over IP (Ex-configuration tool) or local access (Ex-front panel)

When the user login is successfully authenticated through remote authentication, the roles of the connected user will be provided by the RADIUS server.

While establishing the user connection, if the RADIUS server is unavailable, then the configuration tool will tag it as “down”.

While establishing the user connection, if the RADIUS server is unavailable and the backup RADIUS server is configured then the device will use the backup RADIUS server. Backup RADIUS server is optional.

If both RADIUS server and the backup RADIUS server are down, authentication will fall back to the local authentication and the message will be displayed on the tool “The RADIUS server cannot be reached, switching to local authentication”. Login window will automatically be changed from Authentication (Central) to Authentication (Local).

Once the authentication falls back to the local authentication, the device will check the availability of the RADIUS server every minute. If the RADIUS server or backup RADIUS server are up again, then the authentication will switch back to the central authentication.

2.6.3 SECURITY LOG

The C26x logs the following user-related operations:

- Start/Stop/Reboot
- Login attempts (successful and failed: wrong password, account locked, existing session)
- Logout
- Add/Remove a user account
- Modify a user account password
- Lock/Unlock a user account
- Add/Remove a role to/from a user account
- Database switch
- Firmware update
- Syslog server down
- Certificate expiration
- Bootloader updated
- Enable/Disable SSH port
- Enable/Disable MiCOM S1 port
- Enable/Disable Webserver port
- Syslog message lost (buffer full)
- MiCOM S1 Settings updated

The security log is displayed in the CMT and can be sent to a central repository (Syslog server) if it is defined in the configuration database.

Whether logs occurring during a communications loss are received depends on the communications protocol:

- **UDP**: The C26x is not informed of the communications loss, therefore it continues to send the logs during the downtime. These logs are stored locally but are not received by the Syslog server.
- **TLS/TCP**: The C26x is informed of the communications loss. It stores its date and time and sends the intervening logs when the communications are restored.

2.6.4 SYSLOG EVENTS

The list of Syslog event logs available for the C26x is detailed in the tables below.

2.6.4.1 AUTHENTICATION EVENT LOGS

Category	Messages	Severity
Authentication	Login successful	Informational (6)
	Login failed > Invalid user account	Warning (4)
	Login failed > Wrong password *(consecutive Number)*	Warning (4)
	Login failed > Account locked	Notice (5)
	Login failed > Session already active	Notice (5)
	Logout > User disconnection	Informational (6)
	Logout > Timeout	Informational (6)

2.6.4.2 LOCAL SECURITY (USER MANAGEMENT & SETTINGS) EVENT LOGS

Category	Messages	Severity
Security	The user account @login was created	Notice (5)
	The user account @login was removed	Notice (5)
	The user account @login was locked	Notice (5)
	The user account @login was unlocked	Notice (5)
	The role @role was added to the user account @login	Notice (5)
	The role @role was removed from the user account @login	Notice (5)
	The password of the user account @login was changed	Notice (5)
	Security settings modified	Notice (5)

2.6.4.3 SYSTEM EVENT LOGS

Category	Messages	Severity
System	System @sysVersion started	Notice (5)
	System stopped	Warning (4)
	System rebooted	Warning (4)
	Client started (can be optional)	Informational (6)
	Client stopped (can be optional)	Informational (6)
	System updated > @sysVersion to @newSysVersion	Notice (5)
	System could not be updated > @sysVersion to @newSysVersion	Error (3)
	Database switched > @dbVersion to @newDbVersion	Notice (5)
	Database could not be switched > @dbVersion to @newDbVersion	Error (3)
	Date & time modified	Informational (6)
	System settings modified	Informational (6)
	Database settings modified	Informational (6)
	Bootroom updated	Informational (6)
	Enable SSH port	Informational (6)
	Disable SSH port	Informational (6)
	Enable MiCOM S1 port	Informational (6)
	Disable MiCOM S1 port	Informational (6)
	Enable Webserver port	Informational (6)
	Disable Webserver port	Informational (6)
	Syslog message lost (buffer is full)	Warning (4)
	MiCOM S1 Settings updated	Informational (6)
	Firmware updated > @firmVersion to @newFirmVersion	Notice (5)
	Firmware update failed > @firmVersion to @newFirmVersion > (optional) @FailureExplanation	Error (3)
	User @login accessed log file	Informational (6)
	Application software integrity failure	Error (3)
	Bootroom software integrity failure	Error (3)
	C264 Network boot	Warning (4)
	RAM corruption detected	Warning (4)
	Bitstream update	Informational (6)
	Bitstream software integrity failure	Error (3)
	Configuration changed	Informational (6)
	User @login successful login with ssh	Notice (5)

2.6.4.4 CENTRAL SECURITY (LOG, AD, SECURE COM.) EVENT LOGS

Category	Messages	Severity
Security	The Active Directory server cannot be reached	Warning (4)
	The Syslog server cannot be reached	Warning (4)
	The certificate @certificateName will expire in @remainingMonths months	Notice (5)
	The certificate @certificateName will expire in @remainingDays days	Warning (4)
	The certificate @certificateName is expired	Error (3)

2.6.5 SECURE COMMUNICATIONS

The C26x supports the SSH protocol for communications with a terminal emulator.

2.6.6 CERTIFICATES

To guaranty firmware integrity, all firmware uploaded into the C26x is digitally signed.

The C26x verifies the integrity of new firmware upon download. It also checks its firmware periodically, at intervals of less than 10 minutes to verify its integrity.

3 COMMUNICATIONS

The C26x includes different types of communications:

- Telecontrol Bus (TBUS)
- Legacy Bus (LBUS)
- Station Bus (SBUS)
- Inter-rack Ethernet communications

For the C26x, the possible combinations of protocols are as follows:

For this number of Protocols on the TBUS	You can have this number of Protocols on the LBUS	Total number of protocols permitted
2	0 or 1 or 2	4 or less
1	0 or 1 or 2 or 3	4 or less
0	0 or 1 or 2 or 3 or 4	4 or less

The basic communications are as follows:

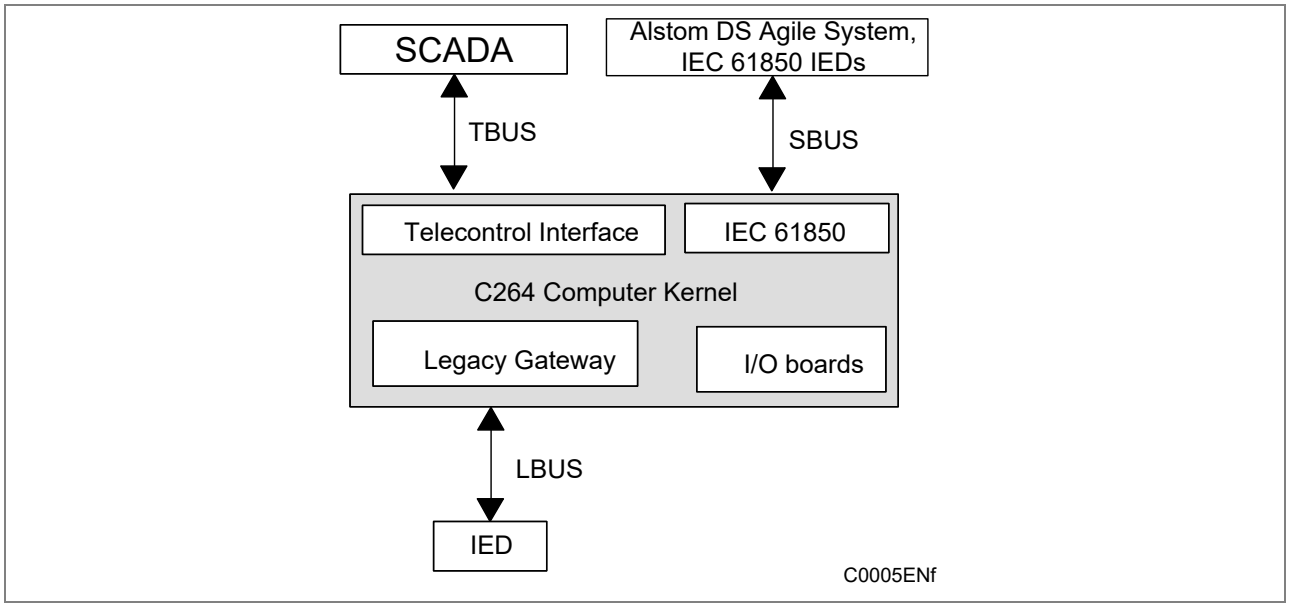


Figure 7: Communications

3.1 TELECONTROL BUS - TBUS

You can connect a C26x through the TBUS to the SCADA. The TBUS can use a maximum of two of these protocols:

Protocol	Protocol Type	C26x behaves as	C26x BCU	C26x-Standalone
DNP 3.0	Master-slave	Slave	Serial & over IP	–
MODBUS	Master-slave	Slave	Serial	–
T101	Master-slave/balanced	Slave	Serial	Serial
T104	Balanced	Slave	Over IP	Over IP
HNZ	Master-slave	Slave	–	Elenas (Indonesia)
HNZ	Master-slave	Slave	–	Yemen

The C26x behaves as a slave in:

- Master/slave protocols: DNP3, DNP3 over IP, MODBUS, T101, HNZ-Elenas, HNZ-Yemen
- Balanced protocols: T101, T104.

The C26x connects directly or through a modem with SCADA.

On the C26x, you can configure as many as 2 different serial telecontrol protocols and as many as 4 Ethernet protocols.

Each T104 protocol supports up to 4 independent client channels (SCADA front end ports), but these clients cannot simultaneously communicate with the C26x: while one channel is active, the other channels of the same T104 protocol can only perform TESTFR (no control).

Physical layer

- DNP 3.0, MODBUS, T101, HNZ-Elenas, HNZ-Yemen: RS232, RS422, RS485
- DNP3 oIP, T104: Ethernet 10/100 MB: RJ45 connector/optical fibre (multi-/single-mode)

Caution:
When you use the serial ports on the CPU board, make sure that the baudrate is the same for both CPU serial ports: com3 and com4.

Redundancy is not available for DNP3 over IP and for MODBUS.

Arbitration in a multi-SCADA architecture

If, for instance, a C26x is connected to a SCADA in T101, but also to another one in T101 or T104 (or to one of each type),

Other conditions

- substation and bay in remote mode
- control uniqueness

When the C26x is executing a command (selection or direct execution) issued by one of them, the C26x raises an internal alarm to any SCADA that places another command. Exception: if the second SCADA switches for any reason to a redundant C26x, this alarm is not sent.

3.2 LEGACY BUS - LBUS

C26x behaves as a master.

Protocols

- IEC 60870-5-103 (T103)
- IEC 60870-5-101 (T101)
- ModBus
- DNP 3.0

Devices connected to

- IEDs

Physical layer

- RS422, RS485
- Optical fibre

Caution:
When you use the serial ports on the CPU board, make sure the baudrate is the same for both CPU serial ports com3 com4

Caution:
If the main 1 rack is redundant, there is no LBUS connected to the main 1 rack

Caution:
There is no redundancy for the LBUS

On the C26x, as many as four serial ports are available to make four networks with as many as four different protocols.

3.3 STATION BUS - SBUS

The SBUS Protocol is used for communications between GE Grid Solutions' DS Agile subsystems but it is also available for other devices.

A C26x behaves mainly as a server but it can be also a client of other C26x devices (distributed automations) or IEC 61850-8-1 IED.

Protocol

- IEC 61850

Devices connected to

- DS Agile devices (system HMI, SMT, Gateway)
- Other C26x devices
- IEC 61850-8-1 IEDs

Link layer

Ethernet 10 or 100 Mb/s

Physical support

- Copper twisted pair (RJ45 connector)
- Optical fibre (single/multi-mode)
- The optical port is an option. To increase the number of Ethernet ports, several types of Ethernet switch boards are available:
- SWU with 4 RJ45 ports and 0 or 2 optical ports (single/multi-mode)
- SWD with 4 RJ45 ports and 2 optical ports for dual homing start (single/multi-mode)
- SWR with 4 RJ45 ports and 2 optical ports for a redundant ring (single/multi-mode)
- SWT with 4 RJ45 ports and 2 optical ports for teaming hot standby redundancy (single/multi-mode)
- SRP28x with 3 RJ45 ports and 2 optical ports for a PRP redundant star (single/multi-mode)
- SRP29x with 3 RJ45 ports and 2 optical ports for a PRP redundant ring (single/multi-mode)

3.3.1 EXCHANGES

The C26x acquires and sends data on an IEC 61850 network using REPORT/GOOSE.

The GOOSE is a short message (data value and quality) sent in multicast to all the IEDs on the SBUS; it is faster than the REPORT.

The REPORT is sent by a server to one client.

By default, reports are of URCB class, hence lost in the event of a communications loss.

For details on BRCB, refer to DS Agile/EN FT.

Each memory buffer is circular (FIFO). In the following example, the oldest event has been overwritten due to overflow:

96	97	98	99	100	101	2	3	
				END	↥ START	↥		

When the buffer capacity (100) is overrun, a Buffer overflow SPS is raised and is signalled when the communication is recovered.

C26x behaviour in abnormal modes

- Initialization: all the buffered data are lost
- Maintenance: all the buffered data prior to switching to maintenance mode are retained
- Test: data are buffered on as in operational mode

3.3.2 SUPPORTED COMMON DATA CLASSES

The C26x exchanges data using Common Data Classes. The table below lists the implemented classes:

Common Data Class	Description	Client support	Server support
Status			
SPS	Single input status	Yes	Yes
DPS	Double input status	Yes	Yes
INS	Integer input status	Yes	Yes
ACT	Protection activation information	Yes	Yes
ACD	Directional protection activation information	Yes	Yes
Measurement			
MV	Measurement value	Yes	Yes
CMV	Complex measurement value	Yes	Yes
WYE	3 phase + N measurement	Yes	Yes
DELTA	Phase to phase measurement	Yes	Yes
Counter			
BCR	Binary counter reading	Yes	Yes
Control			
SPC	Single point control	Yes	Yes
DPC	Double control output	Yes	Yes
BSC	Binary step control	Yes	Yes
APC	Analogue setpoint	Yes	Yes
INC	Integer control output	Yes	Yes
ISC	Integer step control output	Yes	Yes
Description			
LPL	Logical node name plate	Yes	Yes
DPL	Device name plate	Yes	Yes
Report Control Block			
URCB	Unbuffered report control block	Yes	Yes
BRCB	Buffered report control block	No	Yes

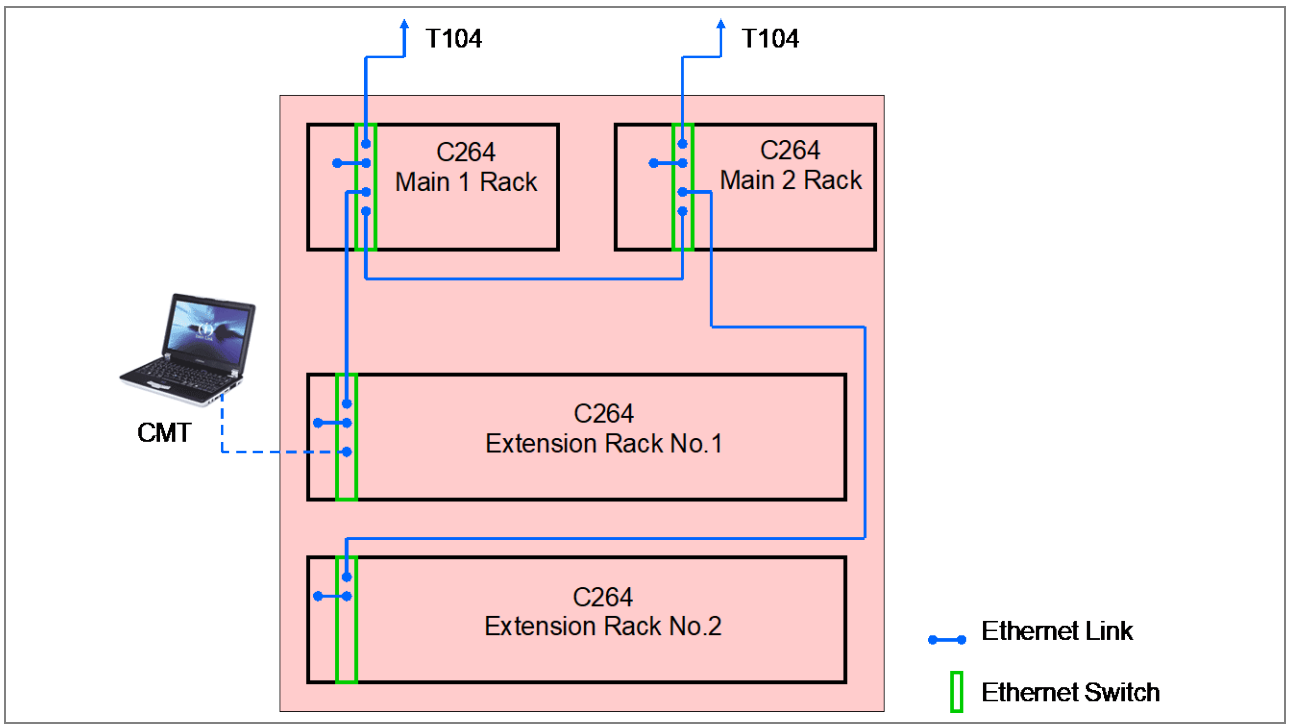
Table 1: Data management

3.3.3 CONTROLS

The C26x supports Common Data Classes control expressed with SPC, DPC, INC and APC configured as *Direct Execute* or *SBO*.

3.4 INTER-RACK ETHERNET COMMUNICATION

3.4.1 INTERNAL ETHERNET ARCHITECTURE



The internal communication on the Ethernet C26x network uses proprietary protocol with unicast messages. Consecutively all messages used by the C26x for internal data exchanges remain inside it. These messages do not pollute the external network reserved for the SCADA interface.

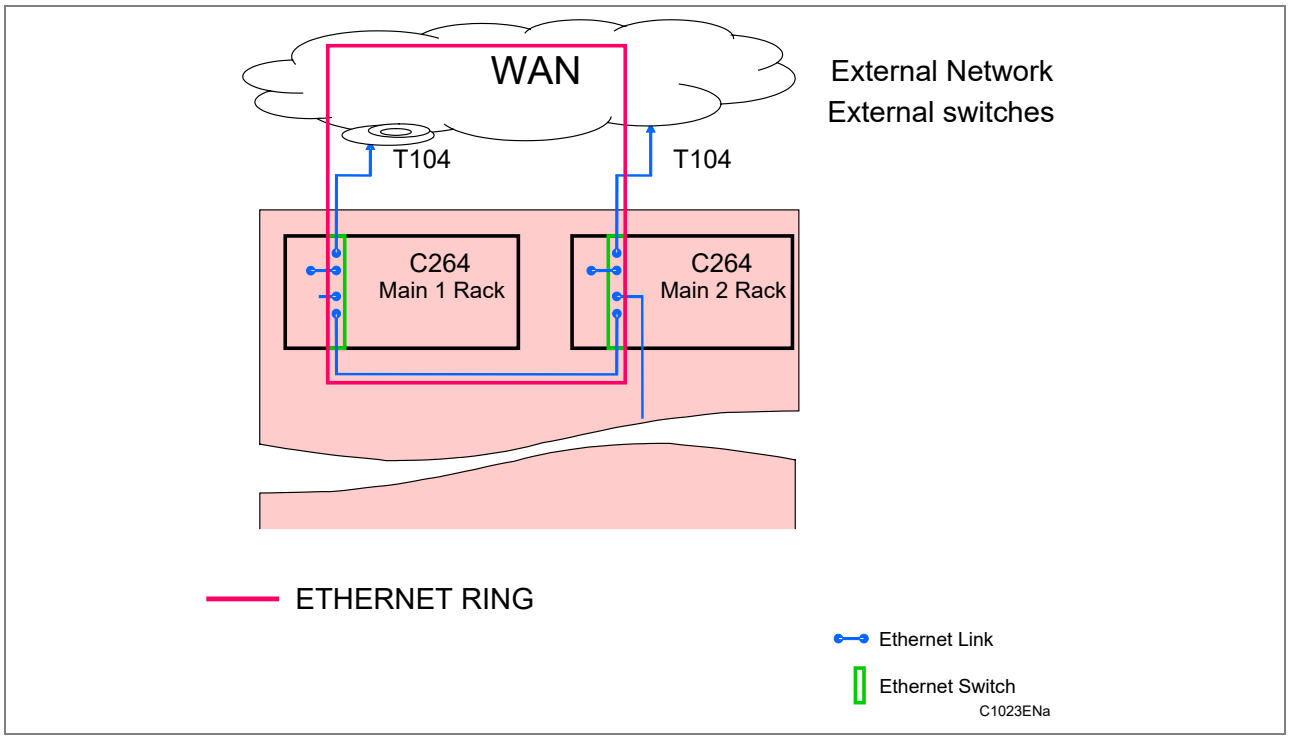
Furthermore, the CMT tool uses also the Ethernet broadcast to identify racks. This tool is used only for maintenance purpose (Software and configuration downloading)

Acquisition and main racks must have the same group number when they are attached to the same C26x. This group number is defined using the CMT and is limited to 16.

3.4.2 EXTERNAL NETWORK BEHAVIOUR

Due to the connection of the C26x with the external network for the SCADA communication (T104) a precaution shall be taken in order to avoid Ethernet loops. External switches of the upstream communication must be able to use the spanning tree algorithm to prevent Ethernet loops.

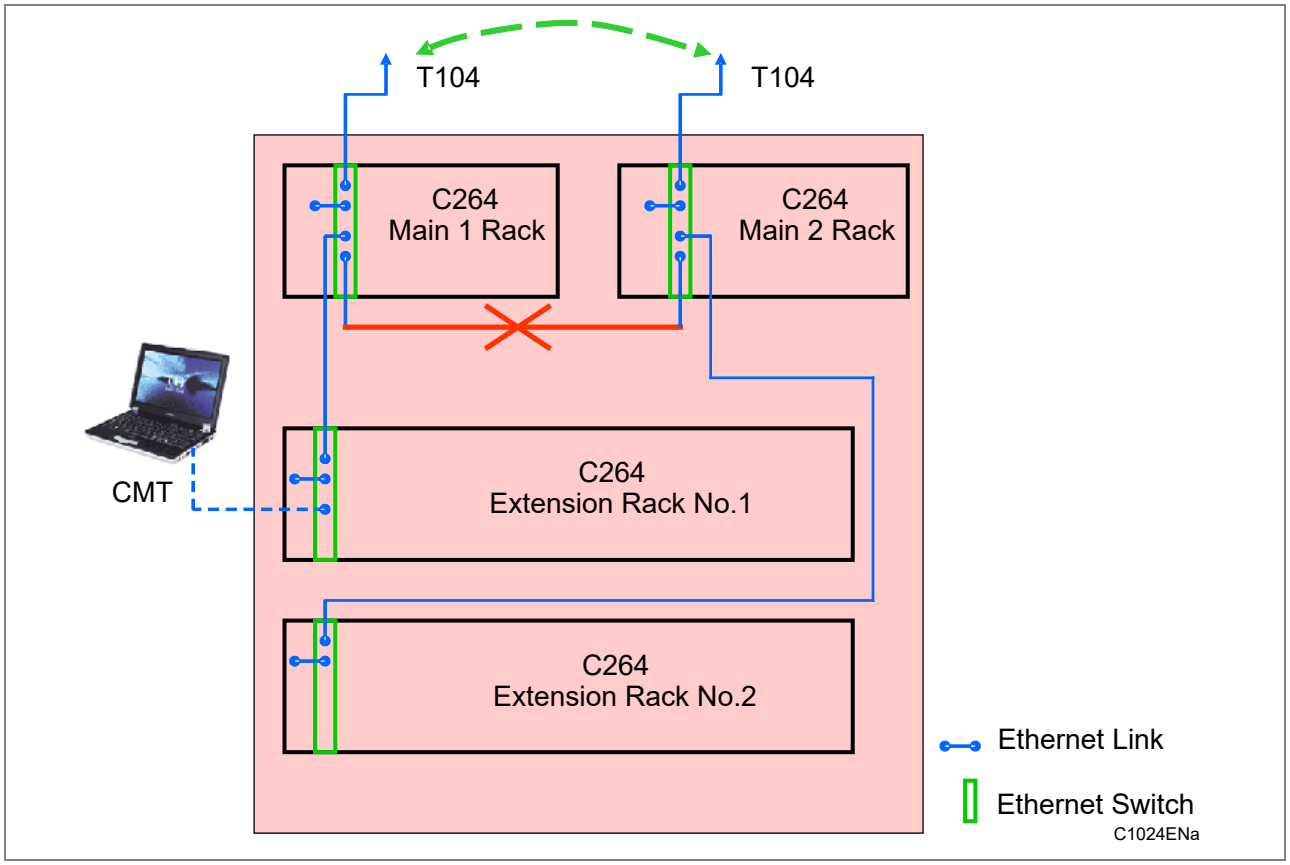
The Spanning Tree (802.1D) or the Fast Spanning Tree (802.1W) algorithm of the external switches identifies the Ethernet ring created with the external and internal Ethernet infrastructure and computes the appropriate path avoiding Ethernet Loops.



The computation of the network tree is done only one time by the spanning tree algorithm of External switches.

3.4.3 ETHERNET FAILURE

Ethernet ring opening

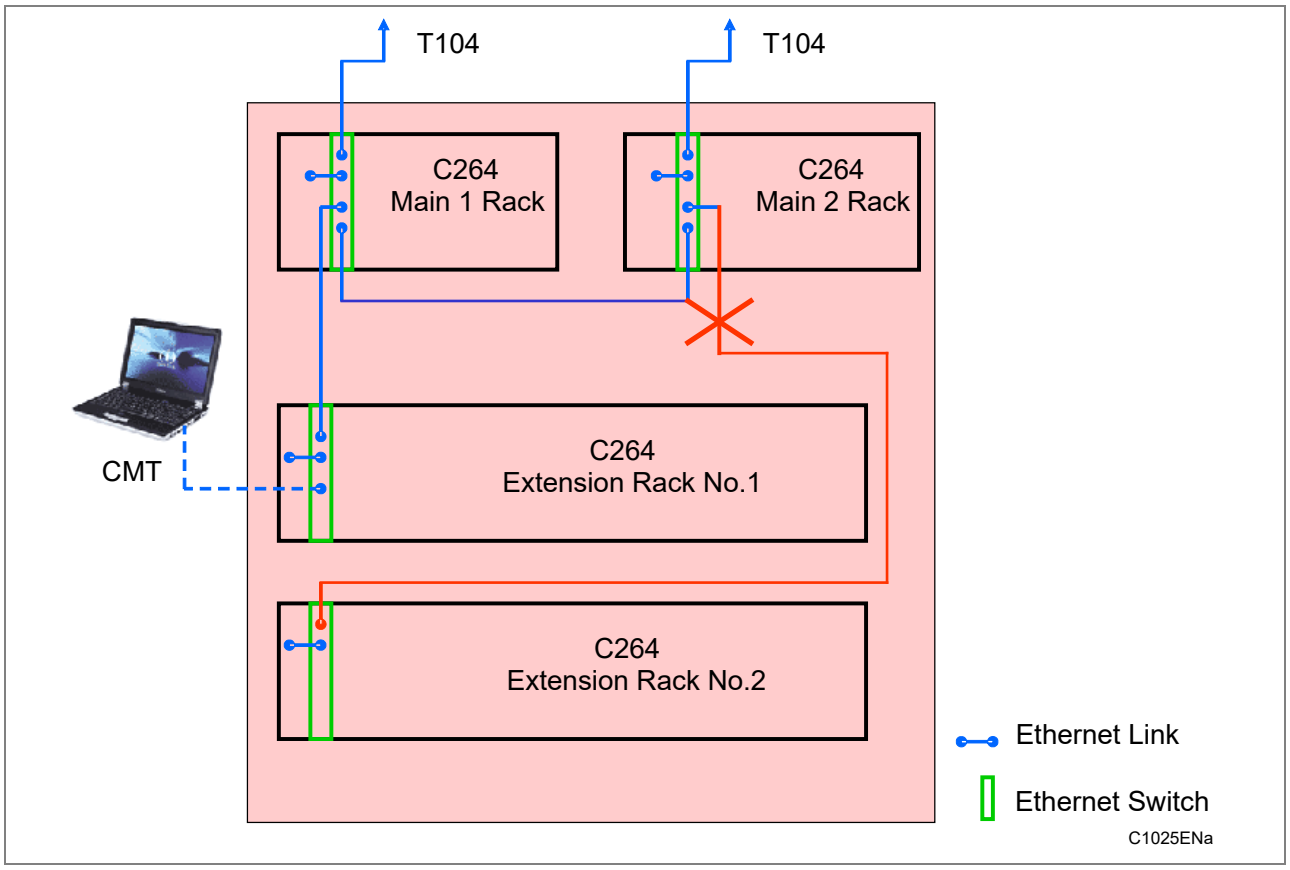


As a consequence of the ring opening, communication between the Main 1 rack and the Main 2 rack is lost.

Consecutively we have:

- Data transfer from extension rack #1 through the External Ethernet infrastructure (outside the C26x's Ethernet network) to the Main 2 rack.
- Ethernet ring opening and rebuilding of routine table ordered by the spanning tree algorithm (> 30 s if 802.1D used)

3.4.4 OTHER ETHERNET LOSS



The other events of loss of the C26x's Ethernet network do not involve:

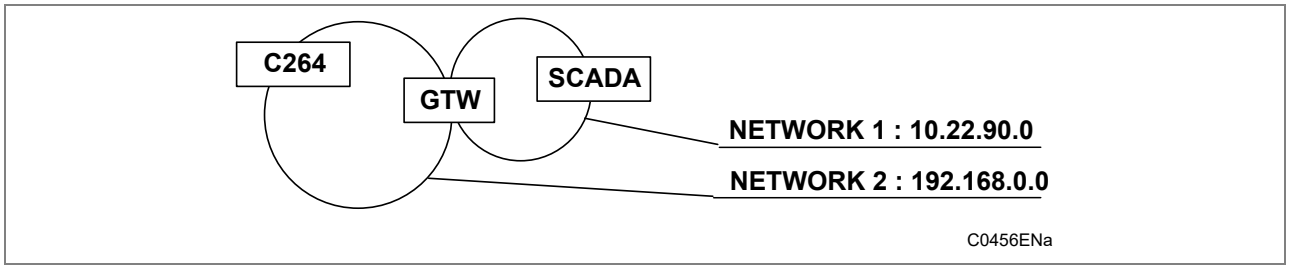
- Data Routine outside of the internal network of the C26x-Standalone RTU
- Starting of the spanning tree algorithm (Ethernet ring maintained)

All data produced by the insulated rack are defined in an unknown state.

The other racks of the C26x (remaining on Ethernet continuity) are fully operational. Data transferred to the Main racks through the Standalone private communication do not use the external Ethernet infrastructures.

3.4.5 ETHERNET ROUTING TABLE

C26x connects to a router and a remote IEC104 SCADA



3.5 ETHERNET PORT MANAGEMENT ON CPU270 ("CPU3")

A C26x can manage up to 4 protocols and up to 2 channels per protocol, i.e. it can support 4 different SCADA masters with a redundant port per master.

The 2 Ethernet ports on the CPU270 can be configured as follows:

N°	Port 1	Port 2	Comments
1	IEC 61850-8-1 SBUS + SCADA IP 1	SCADA IP 2	4 independent SCADA protocols with different database
2	SCADA IP 1	SCADA IP 2	4 independent SCADA protocols with different database
3	IEC 61850-8-1 SBUS	SCADA IP	

Table 2.

IEC 61850 Station Bus, if configured, is always on Port 1.

Up to 4 IP SCADA protocols can be configured on Port 1 and/or Port 2.

The available SCADA protocols are DNP3 and T104. DNP3 is single-client (i.e. only one SCADA front end port can be configured). T104 is multi-clients (as many as 4 clients, i.e. SCADA front end ports, can be configured) with only one active client at a time. Bind each protocol to a single Ethernet port on the CPU270. If you use both Ethernet ports, make sure that the IP addresses of the Ethernet ports are on two different sub-networks. The two Ethernet ports can share the same physical network. Use the CMT tool to configure the Ethernet ports.

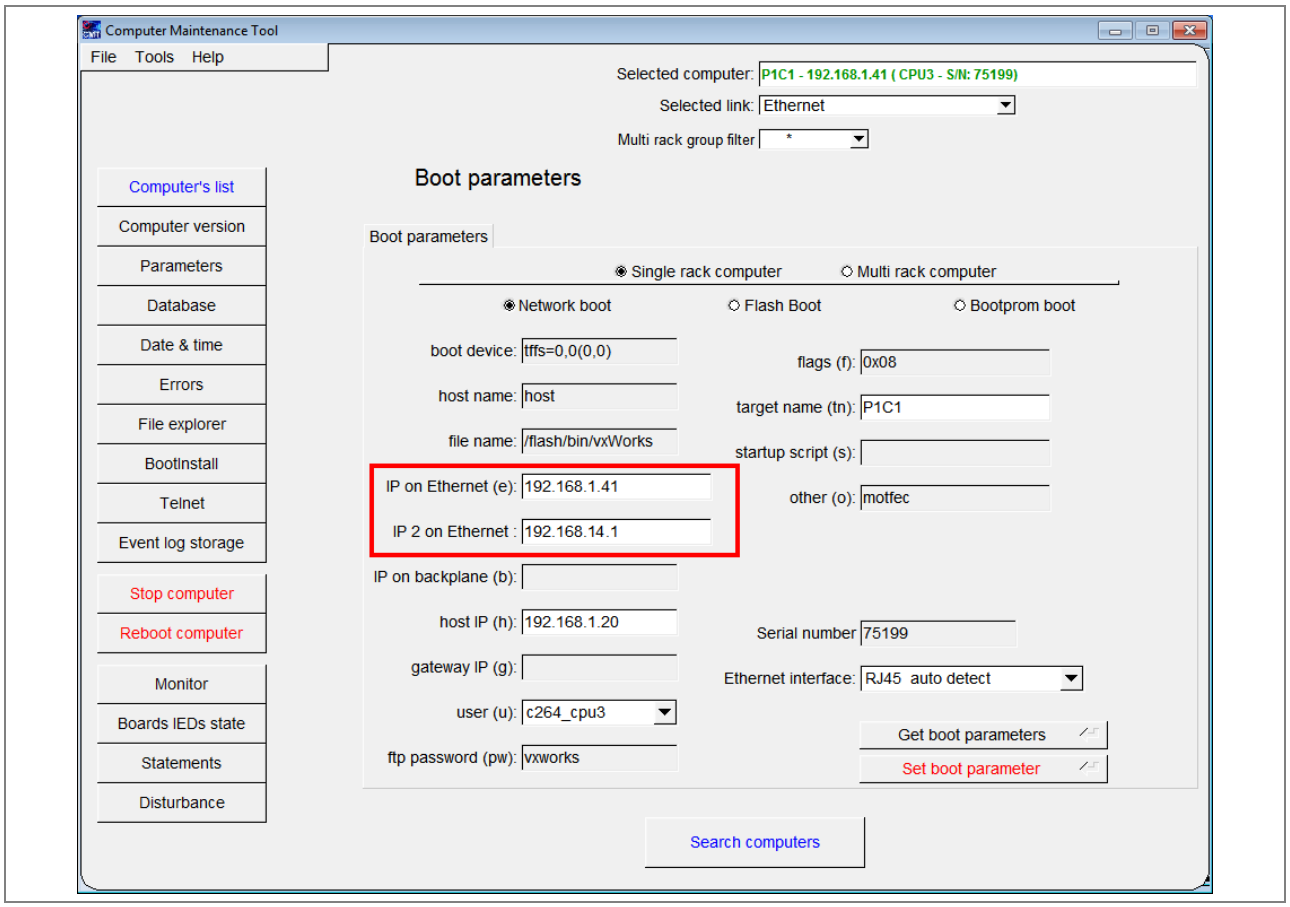


Figure 11: CMT showing the two Ethernet ports

4 DIRECT PROCESS ACCESS

Several kinds of boards can be used in C26x and extension racks. Digital Input & Outputs, Measurement acquisitions are checked to validate information/action and time tagged on any change of state or value.

The C26x acquires digital and analogue input, counters, digital measurements. Configuration parameters, filtering and triggering are applied to these inputs and depend on their type.

4.1 INPUT CHECK

Input data coming from the physical DS Agile C26x boards or from the different communication networks are periodically checked.

Invalidity status of these data is internally fixed for:

- Self-test (DI, AI, board self test failure)
- Unknown (DI, AI, communication failure to remote acquisition like IED)
- Toggling (DI, X change of state in given time)
- Over-range (AI, saturation of its transducer, or Counter value reaching limits)
- Open circuit (AI kind 4-20 mA with current value under 4mA)
- Undefined (Digital Measurement or Counter with invalid DI coding)

4.2 OUTPUT CHECK

Digital Output boards are periodically checked at their logical level. In the event of a logical circuit test fail the board is set faulty, controls on this board or upon disconnected IEDs are refused.

4.3 TIME TAGGING

All physical input data are time tagged at 1 ms accuracy. All internal logic data are time stamped at 1 ms accuracy.

Analogues acquisition time tagging is done but driven by periodic polling of this kind of board. Periods are based on multiple of 100ms.

Information coming from IED are time tagged by IED itself if it has this facility otherwise it is performed at C26x level when receiving the data.

4.4 DIGITAL INPUT ACQUISITION (DI)

4.4.1 ACQUISITION

The DIU200/DIU210/DIU211 (16 DIs) or CCU200, CCU211 (8 DIs + 4 DOs) boards acquire the binary data.

Digital Input (DI) can have the value 1 or 0. The value 1 shows the presence of an external voltage. The value 0 shows the absence of the external voltage.

When the external voltage is above or below a threshold, the hardware writes the value 1 or 0. The hardware specification document shows the value of the threshold.

A transition from the value 0 to 1 or from 1 to 0 is usually followed by a succession of transitions (bounces) before the value stabilises. The software must filter these bounces.

Each change-of-state of a digital input is time-stamped with a resolution better than 1 ms.

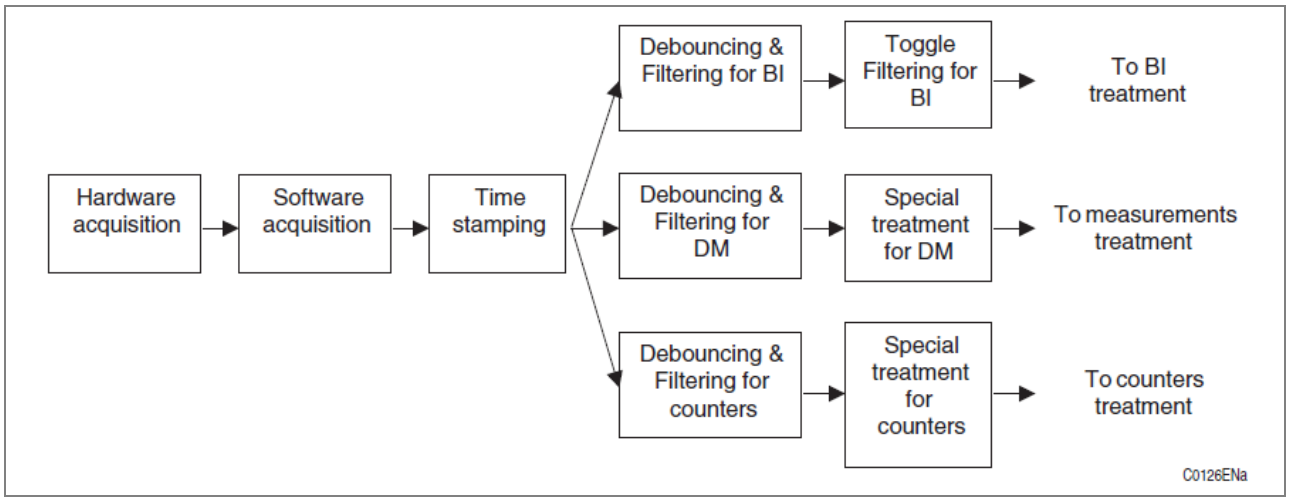


Figure 12: Digital input processing

4.4.2 DEBOUNCING AND FILTERING

A filter is applied on the digital inputs as follows:

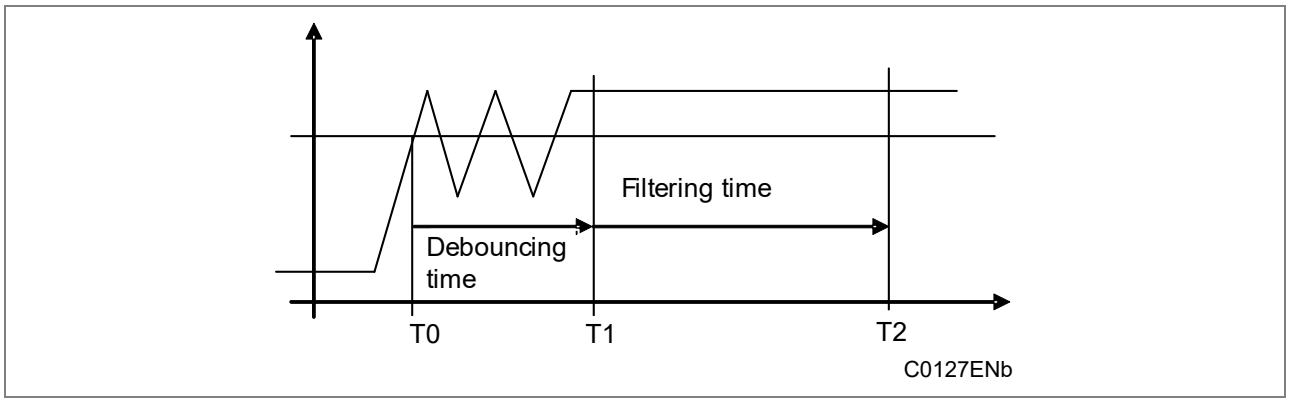


Figure 13: Digital input filtering and debouncing

T0 is the instant of detection of the first transition.

T1 is the instant of validation of the change of state.

T2 is the end of the filtering: the signal remained stable from T1 to T2). The change of state is time stamped at T0.

A value of 0 means that no filter is applied: a change of state is validated as soon as it is detected.

Three pairs (debouncing / filtering) of delays are defined:

- one for all DI that will be used as BI
- one for all DI that will be used as DM
- one for all DI that will be used as counters

4.4.3 TOGGLING

A digital input is said to be toggling if its state has changed more than N times in a given time-period T_1.

A toggling DI returns in the normal state if its state has not changed within another time-period T_2.

N, T_1 and T_2 are parameters determined at configuration time on a per system basis (same parameters for all the DS Agile controllers of a system).

The toggle filtering applies only on DI that will be used as BI (there is no toggle filtering on DI that will be used for counters or DM).

4.5 COUNTERS ACQUISITION (CT)

The counters are acquired on the same boards as the DIs. There are two types of counters SCT (Single counter) and DCT (Double counters).

4.5.1 SINGLE COUNTER (SCT)

An SCT is acquired on a single contact. The value of the accumulator is incremented after a low to high transition, confirmed after a filtering time (T_{count}). T_{count} is defined for the whole system, with a step of 5 ms: the chosen value must be coherent with the pulse frequency (that is, all counters of a system use the same T_{count}).

A subsequent pulse can be taken into account only after a high to low transition.

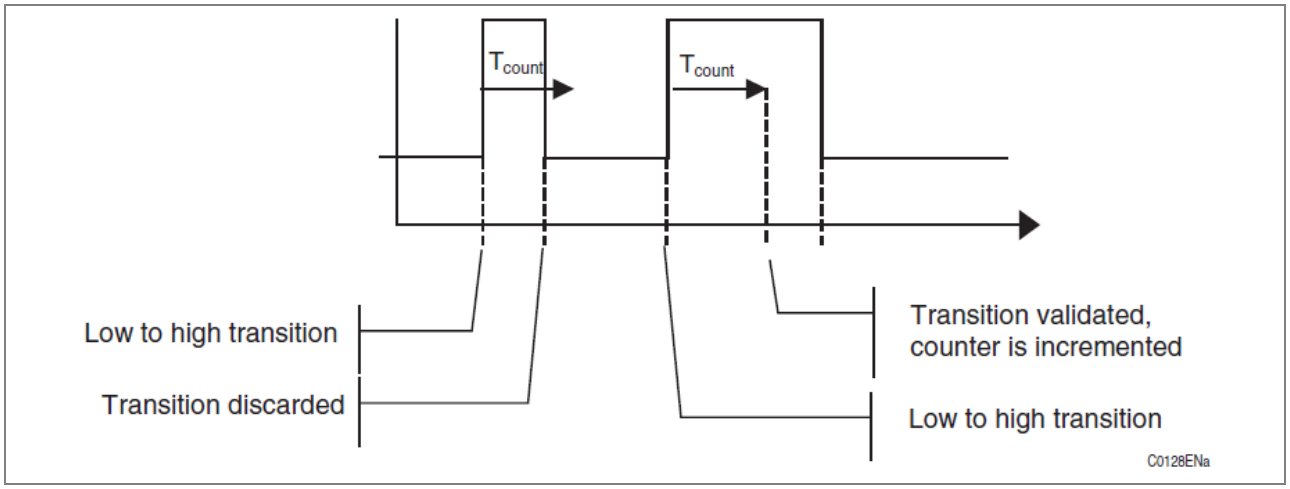


Figure 14: Single counter timing diagram

4.5.2 DOUBLE COUNTER (DCT)

A double counter is acquired on two contacts. One is called the true contact (TC), the other is the complemented contact (CC). Normally these contacts have complementary states.

Pulses are detected in the same manner as for SCT, on the TC variations, using the T_{c0unt} delay (the same T_{c0unt} value is used for SCT and DCT).

A subsequent pulse can be taken into account only after a high to low transition on TC (and so a low to high transition on CC).

The difference is that both contacts must be in opposite states for transitions to be detected and validated. The counter is invalid if there exists a non-complementarity between the 2 contacts during a delay T_{def}. This delay is defined for the whole system (that is, all DCT use the same delay).

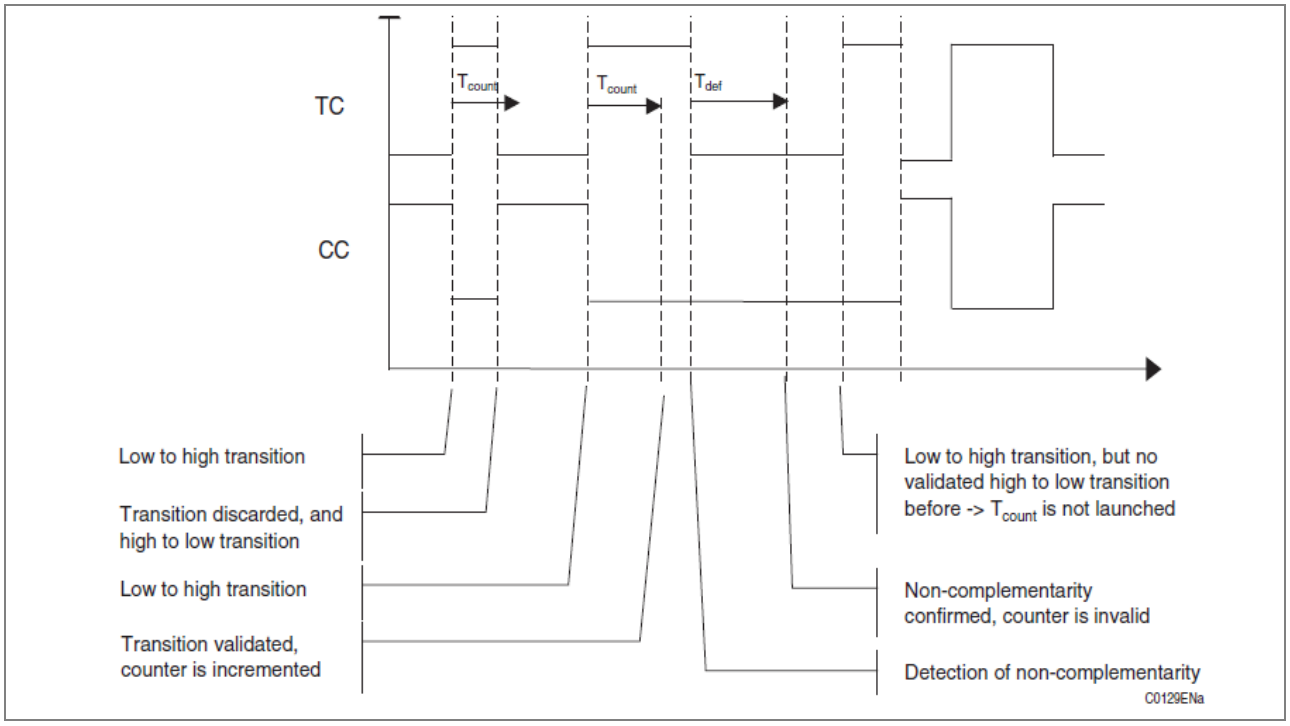


Figure 15: Double counter timing diagram

4.6 DIGITAL MEASUREMENT (DM)

The digital measurements (DM) are derived from the Digital Inputs. They are acquired on the same boards as the DIs. This interface, allowing acquisitions of a digital measurement, is a digital value coded on N wired inputs. Each wired input represents a bit of the value and can take only one of two values: low or high.

Digital Measurements are used to process the **measurements and tap position indications**. A Digital Measurement can be associated to a Read Inhibit (RI) signal. The acquisition process is different depending of the presence of this signal.

4.6.1 ACQUISITION WITHOUT READ INHIBIT SIGNAL

The DM is calculated at each change of state of one of its bits.

A stability processing is applied at each calculation to confirm the value:

- if the difference between the current value and the previous confirmed value is less or equal than V_{stab} (value defined in configuration), then the current value is confirmed

- if the difference is greater than V_{stab}, then the T_{stab} delay is launched (value defined in configuration, from 0 to 60s, with a 10 ms step). If a T_{stab} delay is already launched, this one is cancelled. At the end of the delay, the DM value is confirmed.

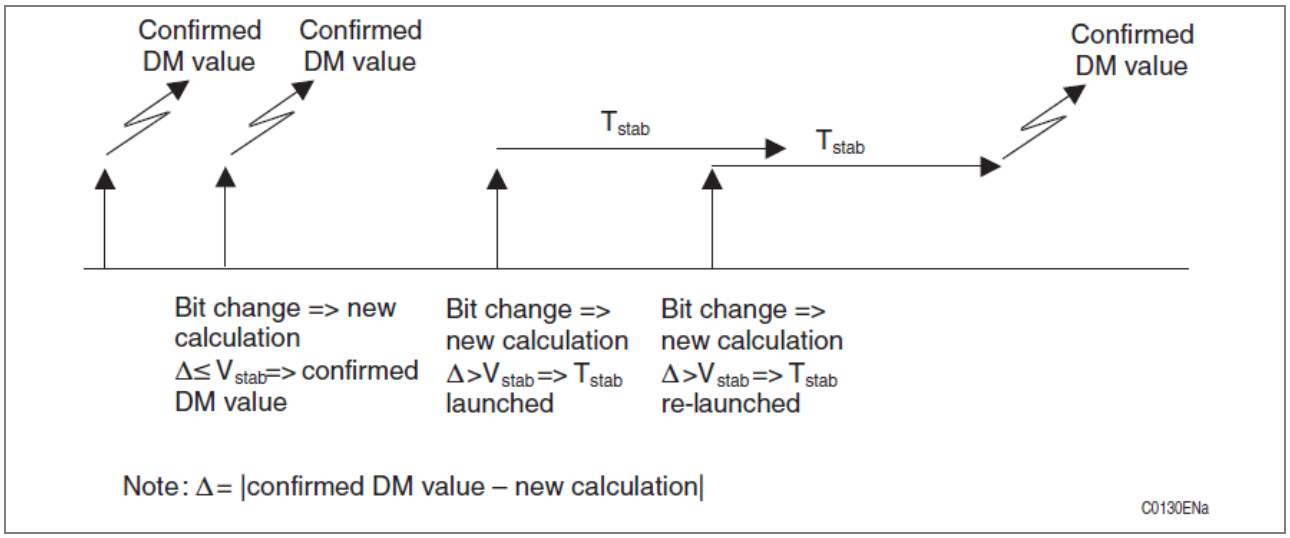


Figure 16: DM value confirmed

Furthermore, an invalidity processing is applied: at the first change of state of one bit following a confirmed DM value, the TI_{nv} delay is launched (value defined in configuration, from 0 to 300s, with a 10 ms step). If the value is not confirmed at the end of this delay, the DM is declared UNDEFINED.

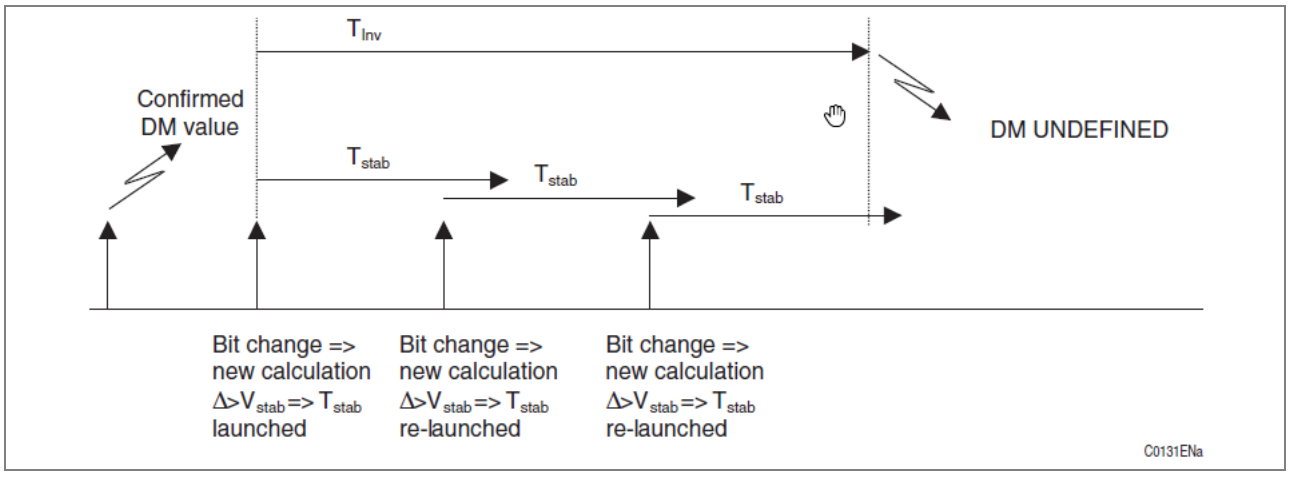


Figure 17: DM undefined

If V_{stab} is equal to 0, there is no stability processing: all DM values are sent at each calculation.

4.6.2 ACQUISITION WITH READ INHIBIT SIGNAL

When the RI signal changes to set state, the T_{inh} delay is launched. If the signal is always set at the end of the delay, the DM is declared UNDEFINED. Otherwise, if the RI signal changes to reset state before the end of the delay, the current DM value is transmitted.

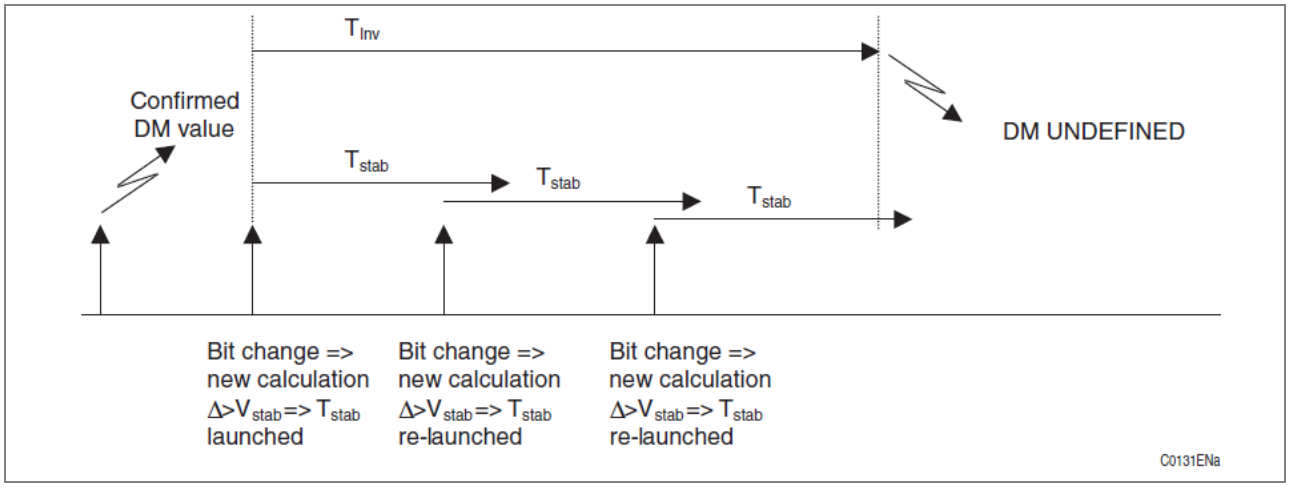


Figure 18: Acquisition with RI

If the RI signal is invalid, the DM will be invalid.

4.6.3 ENCODING

The following codes are allowed for DM:

Code	Number of bits (max. 64)	Range of value
BCD	4 (1 BCD decade)	0 to 9
	8 (2 BCD decades)	0 to 99
	12 (3 BCD decades)	0 to 999
	16 (4 BCD decades)	0 to 9 999
	32 (8 BCD decades)	0 to 99 999 999
	64 (16 BCD decades)	0 to 9 999 999 999 999 999
Binary	n	0 to 2n-1
Gray	n	0 to 2n-1
Decimal	16 (1 bit among 6 for the tens, 1 bit among 10 for the units)	0 to 69
	32 (1 bit among 4 for the thousands, 1 bit among 9 for the hundreds, 1 bit among 9 for the tens, 1 bit among 10 for the units)	0 to 4 999
	64 (1 bit among 9 for the millions, 1 bit among 9 for the hundreds of thousands, 1 bit among 9 for the tens of thousands, 1 bit among 9 for the thousands, 1 bit among 9 for the hundreds, 1 bit among 9 for the tens, 1 bit among 10 for the units)	0 to 9 999 999
1 among N	n	0 to n

You can use one extra bit for the sign (0 = positive value, 1 = negative value).

Capability extension for the Tap Position Indication only:

CODE	Number of bits	Range of value
1 among N	2 to 64	0 to 2 to 0 to 64

4.7 ANALOGUE INPUT ACQUISITION (AI)

The TMU2xx board acquires AC voltages and currents coming from the electrical network.

The AIU201 (4 AIs) or AIU211 (8 AIs) boards acquire DC voltages or currents signals. For them an input range and an acquisition cycle are configured (refer to C26x/EN AP).

4.7.1 INPUT RANGES

For voltage inputs (AIU201 only):

- [–1.25 V .. +1.25 V]
- [–2.5 V .. +2.5 V]
- [–5 V .. +5 V]
- [–10 V .. +10 V]

For current inputs:

- [–1 mA .. +1 mA]
- [–5 mA .. +5 mA]
- [–10 mA .. +10 mA]
- [–20 mA .. +20 mA]

(see C26x/EN AP for settable sensor ranges)

The saturation value depends on the selected range (see C26x/EN TD).

4.7.2 ACQUISITION CYCLE

The analogue inputs are acquired on a periodical basis. Each channel on a board can be assigned one of these cycles independently of the other channels.

There exist two acquisition cycles:

- a short cycle (N_{sc} x 100 ms, N_{sc} settable from 1 to 10, default value: 1)
- a long cycle (N_{lc} x 500 ms, N_{lc} settable from 1 to 20, default value: 2)

4.7.3 SELF-CHECKS

Two kinds of self-checks are performed:

- the board address coherency
- the complementarity control of the measured value

These self-checks are performed at each scan (defined during the configuration phase).

4.7.4 TIME TAGGING

An AI is time stamped with the date/time of the scanned value.

4.8 DIGITAL OUTPUTS (DO)

Digital outputs are used to apply a switching voltage to an external device in order to execute single or dual, transient or permanent commands. The applied voltage is fed from an external power supply. The external voltage is connected to the controlled device by a relay, thus isolating the logic part of the board from the external power supply.

Two types of Digital Outputs are available for the C26x:

- CCU200 boards for controls (8 DIs+4 normal open DOs), this board allows double pole switching controls.
- DOU200 boards for alarms (8 normal open DOs + 2 normal open/normal close DOs).

4.9 DIGITAL SETPOINTS

Digital setpoints are digital values sent on multiple parallel wired outputs. Each wired output represents a bit of the value. Digital setpoints are used to send instruction values to the process or to auxiliary devices.

The Digital Setpoints are processed on the same boards as the Digital Outputs. The Digital Outputs characteristics described above apply on Digital Setpoints. Use only standard DO boards with single pole N/O relays.

4.9.1 ENCODING

The codes that follow are allowed:

CODE	Number of bits (max. 48)	Range of values
BCD	4 (1 BCD decade)	0 to 9
	8 (2 BCD decades)	0 to 99
	12 (3 BCD decades)	0 to 999
	16 (4 BCD decades)	0 to 9 999
	32 (8 BCD decades)	0 to 99 999 999
	48 (12 BCD decades)	0 to 999 999 999 999
Binary	n	0 to 2n-1
Gray	n	0 to 2n-1
Decimal	16 (1 bit among 6 for the tens, 1 bit among 10 for the units)	0 to 69
	32 (1 bit among 4 for the thousands, 1 bit among 9 for the hundreds, 1 bit among 9 for the tens, 1 bit among 10 for the units)	0 to 4 999
	48 (1 bit among 2 for the hundreds of thousands, 1 bit among 9 for the tens of thousands, 1 bit among 9 for the thousands, 1 bit among 9 for the hundreds, 1 bit among 9 for the tens, 1 bit among 10 for the units)	0 to 299 999
1 among N	n	0 to n

A supplementary bit is for the sign (0 indicates a positive value, 1 indicates a negative value).

4.9.2 READ INHIBIT

A dedicated binary output allows/forbids reading the value by the external device.

There is one (or none) read inhibit (RI) output per value.

If the RI output is a logical one (external polarity applied), the reading is permitted.

The procedure used to output a value with a RI output is:

- Reset the RI output to a logical 0: read forbidden.
- Wait for N ms.
- Output the value.
- Wait for N ms.
- Set the RI output to a logical 1: read permitted.

The 0 to 1 transition on the RI output can be used by the external device as a trigger, indicating that a new value is available.

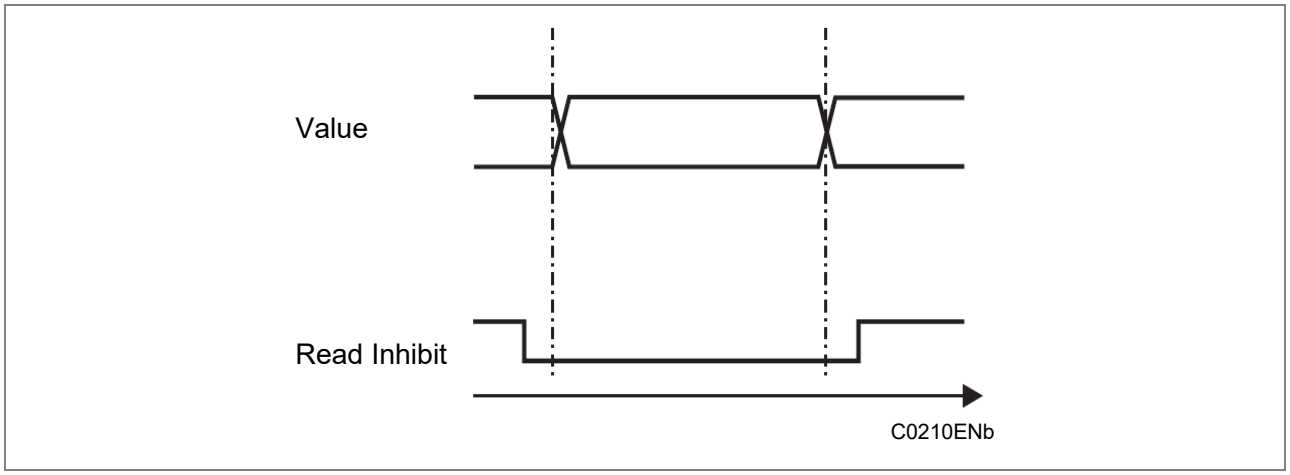


Figure 19: Read inhibit signal for a digital setpoint

4.9.3 OPEN / CLOSE SELECT ORDER

An option includes the order-running-SPS: one for the open order control, and one for the close order control.

The order-running-SPS are available only for Double Point Control (DPC).

When the C26x receives the Select (for SBO control) or the Execute (for DE control) order, and before the checks, it sets the order-running-SPS to the SET position.

When the C26x receives the control acknowledgement, the C26x sets the order-running-SPS to the RESET position

In the event of a direct negative acknowledgement, the C26x may set the order-running-SPS to the SET position and to the RESET position with the same time-stamp.

4.10 ANALOG SETPOINTS

Analog setpoints are measurement values sent on the Analog Osutput board.

These setpoint commands (with analog indication) are received from the Station Control Point (SCP), Remote Control Point (RCP), or from the local HMI (with LCD).

Analog Setpoints are used to interface auxiliary devices requiring analog inputs (ex: measurement viewers, Generator)

The Analog Output values are secured with an external power supply that allows you to keep the analog output value in the event of a C26x shutdown or power off.

A quality indication is available with the additional Read Inhibit output relays (NO) associated to each analog output.

4.10.1 OUTPUT RANGES

± 5 mA, 0 - 5 mA

± 10 mA, 0 - 10 mA

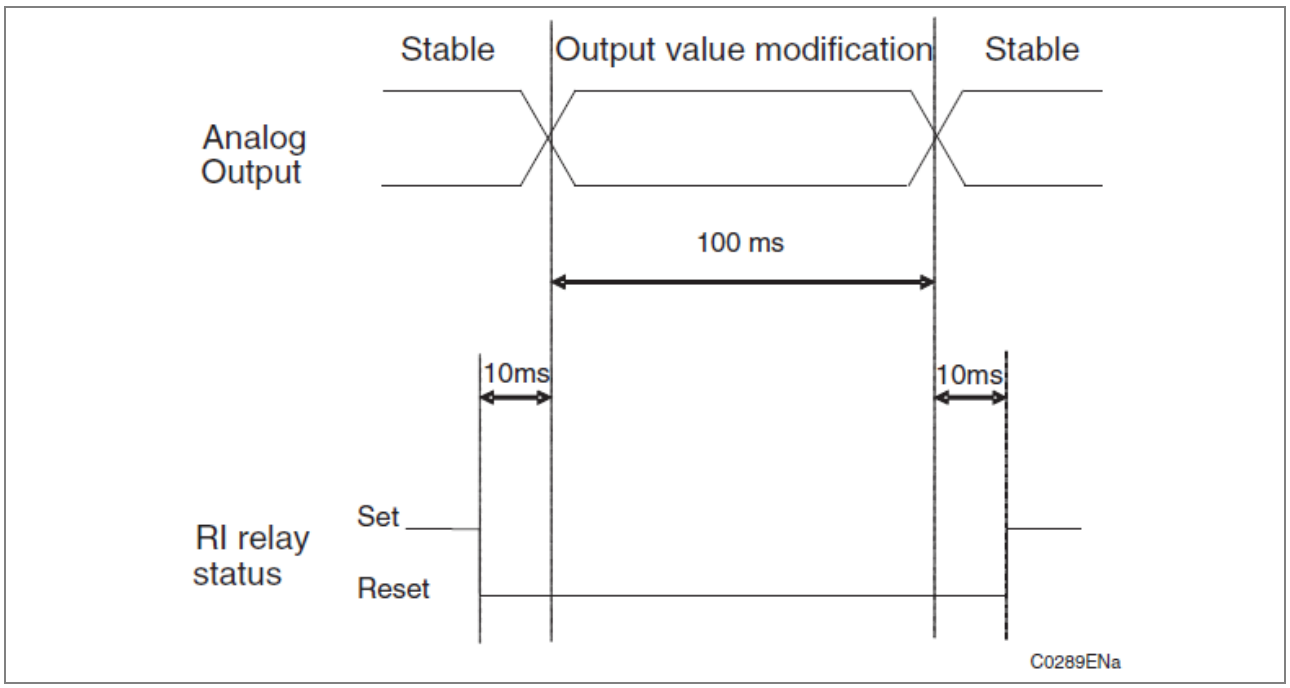
4 - 20 mA, 0 - 20 mA, ± 20 mA

4.10.2 OUTPUT MANAGEMENT

Each current output is individually managed in 2 modes:

- Maintained mode: in the event of a controller shut down or power off, the output level is maintained (and the Read inhibit relay is set). Only the reception of a new setpoint leads to an output value modification.
- Un-maintained Mode: in the event of a C26x shutdown or power off, the output is set to 0

The AO is stable 100ms after the order. During Analog output value modification, the “Read Inhibit” relay is reset (Open) and indicates that the analog output value is not to be used.



4.10.3 AOU WATCHDOG MANAGEMENT

The AOU board is monitored and the AOU Watchdog (NO relay) resets when:

- The external power supply is off
- The C26x is not operational or powered off (no communication with the CPU board)
- An AOU internal fault is present

Otherwise, the analog output function is valid, the AOU watchdog relay is set.

5 DATA PROCESSING

C26x treatment entries can be Binary Inputs or Analogue Inputs. They are issued from

- IO boards
- C26x internal data: System Input, automation
- Communication acquisition: IED or another controller from LBUS or SBUS

5.1 BINARY INPUT PROCESSING

5.1.1 BINARY INPUT DEFINITION

The five types of Binary Inputs (BI) include:

- Single Point (SP): derived from one BI
- Double Point (DP): derived from two BIs
- Multiple Point (MP): derived from multiple BIs
- System Input (SI): information related to the system, to configurable and built-in automations or to electrical process but without acquisition possibilities
- Group: logical combination of BIs

SP, DP and MP are acquired with digital input boards or with IEDs connected with a serial link.

After the acquisition on the digital input boards, the controller performs toggle filtering. When an input has a hazardous behaviour, such as more than N state changes during a given duration, toggle filtering prevents the input to load into the controller or into other devices.

5.1.1.1 TOGGLING INPUT

A binary input is said to be toggling if its state has changed more than N times within a given time-period T.

After the acquisition on digital inputs boards, the controller performs toggle filtering, this avoids loading the controller itself or other equipment when an input has a hazardous behaviour

An SP associated with a toggling Binary Input is in the TOGGLING state.

A DP or an MP whose one of the associated DI is toggling ist in the TOGGLING state.

5.1.1.2 SUPPRESSION

A binary input can be suppressed by an order issued from an operator. No subsequent change of state on a suppressed BI can trigger any action: for example, display, alarm, transmission. The BI takes the “SUPPRESSED” state. When the operator un-suppresses the BI, this one takes its actual state.

5.1.1.3 SUBSTITUTION

A BI can be substituted to a manual set state by an operator (state “SUBSTITUTED xxx”). The BI stays in the state determined by the operator until s/he un-substitutes it. When a BI is substituted, no changes of state are transmitted, and computations, for instance groupings, are made with the substituted state. When the BI is un-substituted, the actual state is transmitted to higher control levels and subsequent changes of state are transmitted again.

5.1.1.4 FORCING

When data is invalid: that is, SELFCHECK FAULTY, TOGGLING, UNDEFINED or UNKNOWN; it can be manually forced by an operator (state “FORCED xxx”). This feature is similar to the substitution but the data is automatically updated when valid data is available again. A SUPPRESSED or SUBSTITUTED datapoint

cannot be forced. The forcing could also be automatic: in this event, the invalid data is automatically replaced by the state defined in configuration.

5.1.1.5 TRANSMISSION

By configuration, a BI could be transmitted on a client-server basis on the station bus using the two modes:

- Report based mode: in this mode, a confirmed change of status is spontaneously transmitted to the subscribers with the time stamping and the reason for change. The Report mode is used to transmit filtered data for displaying, printing and archiving.
- GOOSE based mode: in this mode, the change of status is transmitted in multicast to the configured receivers. On an IEC 61850-8-1 network, all types of BI can be transmitted using GOOSE. Only the BI unfiltered states are transmitted with their time stamping, the reason for change is not. The GOOSE mode is used to transmit data as soon as possible after their acquisition and as quickly as possible, for automation purpose.

5.1.2 PROCESSING OF SINGLE POINT STATUS

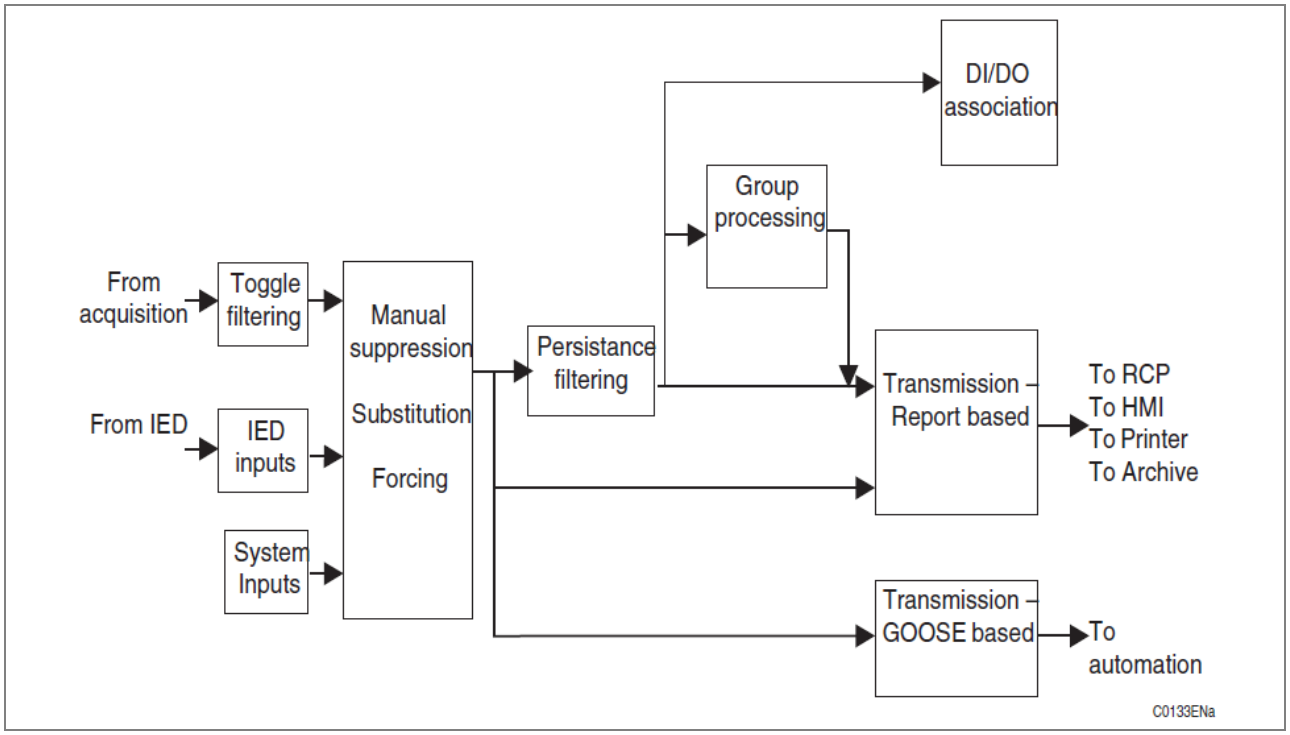


Figure 20: single point status processing

A preliminary treatment (filtering) is applied to specific Single Points (SP) in order to confirm the state.

The choice of these SPs and the filtering time are fixed by the C26x configuration. If the opposite transition occurs before this delay, both transitions are discarded.

This treatment is called persistent filtering.

- The status is stamped with the time of the transition.

The SP resulting states include:

States (Report)	Goose
RESET	01
SET	10
TOGGLING	11
SELFCHECK FAULTY	11
UNKNOWN	11
SUPPRESSED	11
FORCED RESET	01
FORCED SET	10
SUBSTITUTED RESET	01
SUBSTITUTED SET	10

For automation (interlock, PSL, PLC, and built in functions), GOOSE are used. Each valid state (01, 10 and 00) can be set so as to be seen by the automation as a False, True or Invalid state.

5.1.2.1 PERSISTENCE FILTERING

For some SP, a transition must be confirmed on a given time-period. If the opposite transition occurs before this time, both transitions are discarded.

Two time-out values can be associated with each SP:

- T_S: delay for the SET state confirmation
- T_R: delay for the RESET state confirmation

Both delays are in the range 0 to 300 s in steps of 100 ms. A value of 0 means that no filter is applied.

The time tag is user-selectable:

- Mode 1: the status is stamped with the time of the transition.
- Mode 2: the status is stamped at the end of the persistent filtering.

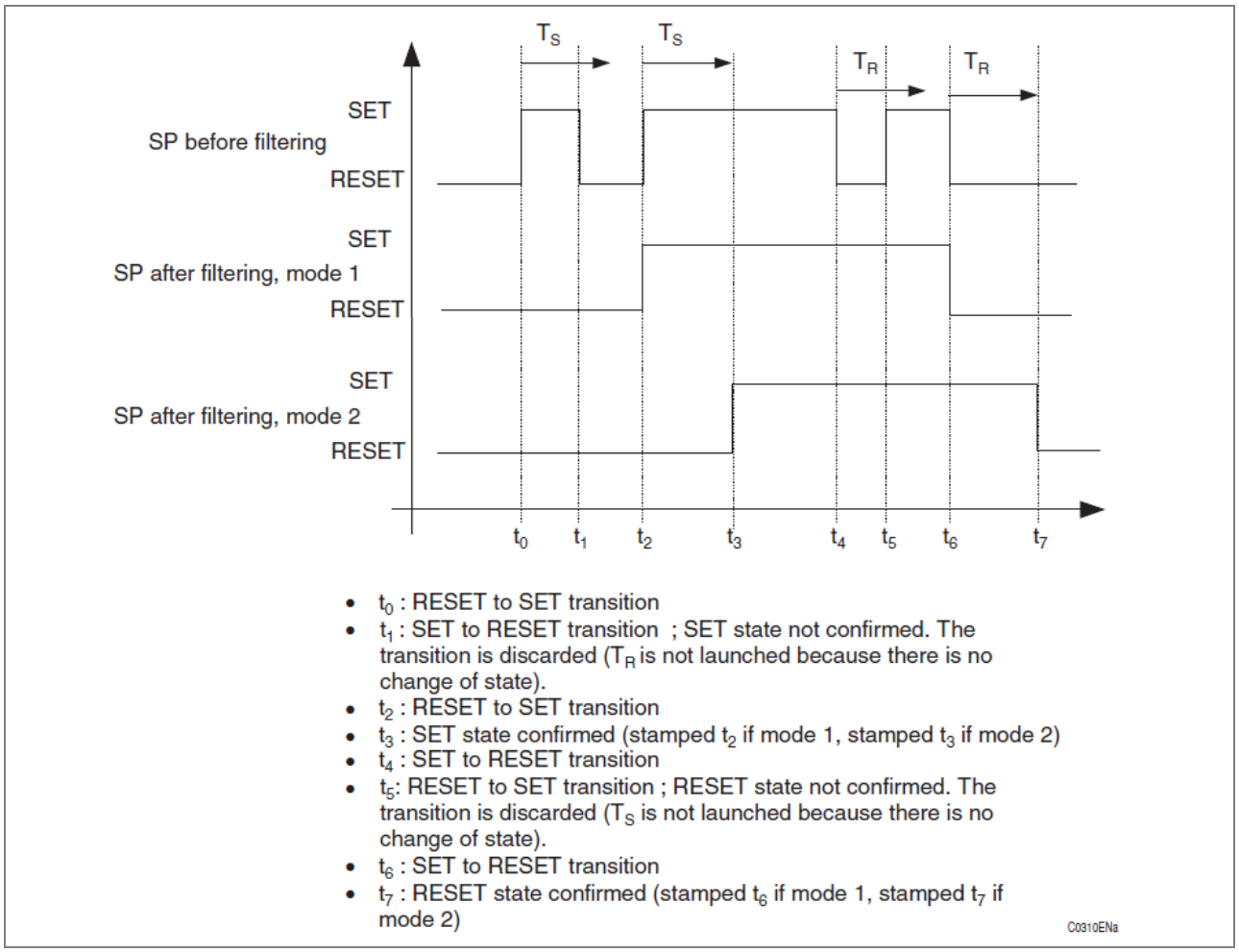


Figure 21: persistence filtering

5.1.2.2 DI/DO ASSOCIATION FOR SP

The aim of this automation is to create a direct association between a Single Point and a Digital Output: a state change on the input produces the opening of the closure of the output.

The relation between the state and the order is defined during the configuration phase.

5.1.3 PROCESSING OF DOUBLE POINT STATUS

A DP is derived from two Digital Inputs. One is called the Closed contact, the other one is the Open contact.

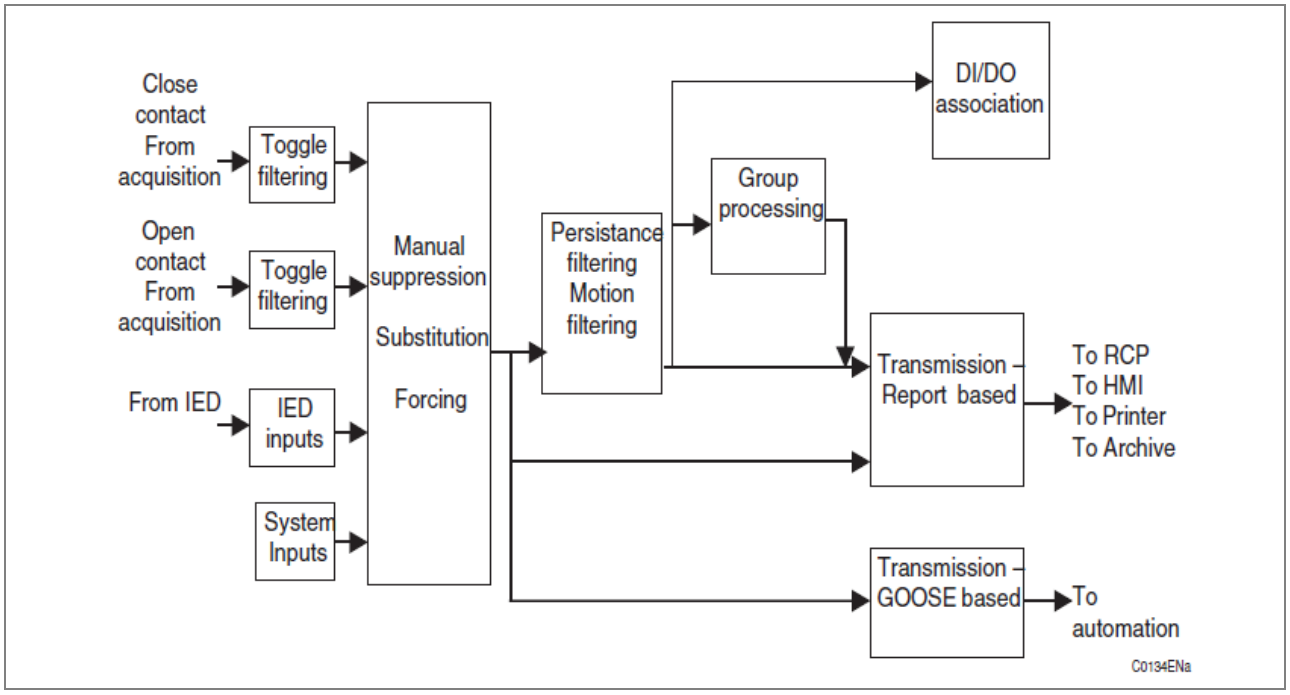


Figure 22: Double point status processing

DPS are commonly used for all switchgears position. From board valid acquisition the two contacts are Close and Open (set by configuration when voltage is present). The position of the switch is:

Close Contact	Open Contact	DPS State
0	0	Below motion delay, the state is valid motion. For REPORT no transmission of the transitory state. After Motion filtering, state is invalid JAMMED
0	1	OPEN
1	0	CLOSE
1	1	UNDEFINED after a permanent filtering

Preliminary treatment (filtering) for some DPs is applied to filter the MOTION state on a given time-period. This avoids the transmission of this (normally) transient state.

This treatment is called motion filtering.

The time tag is user-selectable:

- Mode 1: the valid state (OPEN or CLOSE) is stamped with the time of the beginning of the MOTION state
- Mode 2: the valid state (OPEN or CLOSE) is stamped with the time of this valid transition

This time stamping can be superseded if a persistence filtering applies.

If the MOTION state is confirmed, it is always stamped with the time of the beginning of the MOTION state. Furthermore, the BI takes the state JAMMED (in the event of a confirmed MOTION00 state) or UNDEFINED (in the event of a confirmed MOTION11 state). In this event, the following valid state (OPEN or CLOSE) is always time-stamped with the time of this valid transition (depending on the persistence filtering feature).

5.1.3.1 MOTION FILTERING

For some DP, the MOTION state must be filtered during a given time-period in order to avoid the transmission of this (normally) transient state.

Two time-out values can be associated with each DP:

- T_{00}: delay for the MOTION00 state filtering
- T_{11}: delay for the MOTION11 state filtering

Both delays are in the range 0 to 300 s in steps of 100 ms. A value of 0 means that no filter is applied.

The time tag is user-selectable:

- Mode 1: the valid state (OPEN or CLOSE) is stamped with the time of the beginning of the MOTION state
- Mode 2: the valid state (OPEN or CLOSE) is stamped with the time of this valid transition

This time stamping can be superseded if a persistence filtering applies.

If the MOTION state is confirmed, it is always stamped with the time of the beginning of the MOTION state. Furthermore, the BI takes the state JAMMED (in the event of a confirmed MOTION00 state) or UNDEFINED (in the event of a confirmed MOTION11 state). In this event, the following valid state (OPEN or CLOSE) is always time-stamped with the time of this valid transition (depending on the persistence filtering feature).

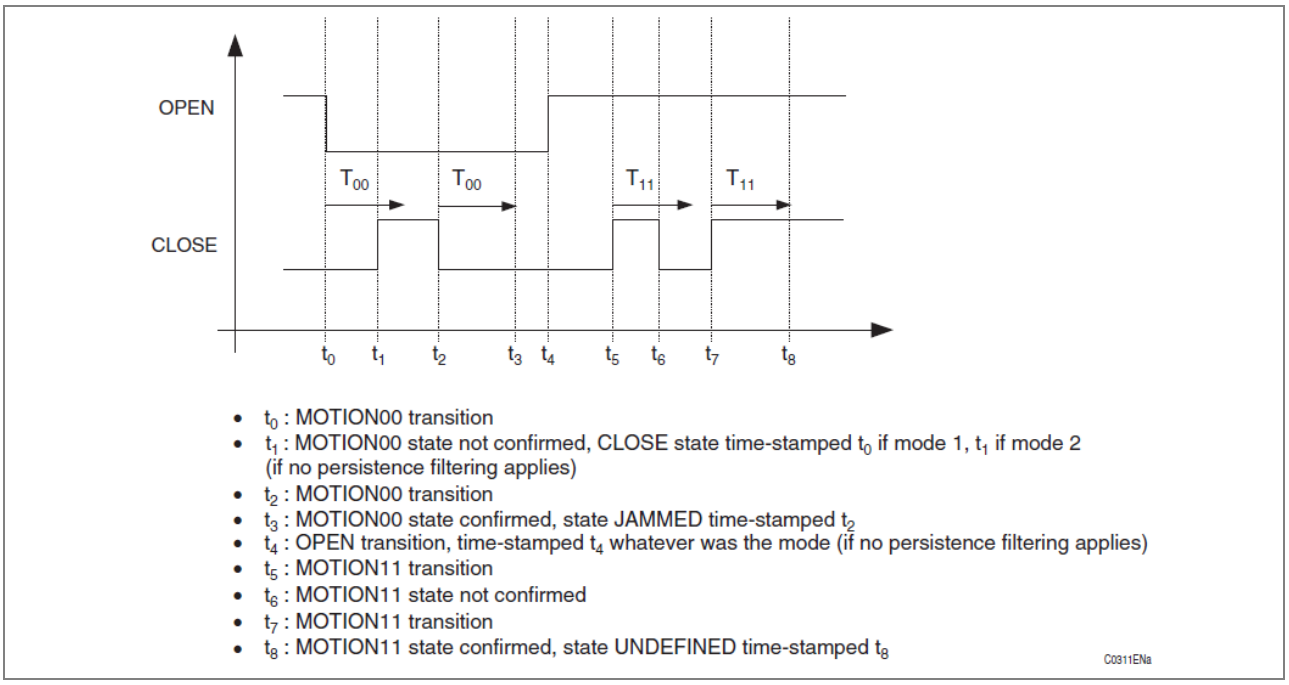


Figure 23: Motion filtering

5.1.3.2 DP PERSISTENCE FILTERING

For some DP, a valid state (OPEN or CLOSE) must be confirmed on a given time-period. If a transition occurs before this delay, the state is discarded.

Two time-out values can be associated with each DP:

- T_C: delay for the CLOSE state confirmation
- T_O: delay for the OPEN state confirmation

Both delays are in the range 0 to 300 s in steps of 100 ms. A value of 0 means that no filter is applied.

The time tag is user-selectable:

- Mode 1: the status is stamped with the time of the transition
- Mode 2: the status is stamped at the end of the delay.

Note:
If persistence filtering is applied, the OPEN or CLOSE state cannot be time-stamped from the beginning of non-complementarity: that is, mode 1 of motion filtering cannot apply.

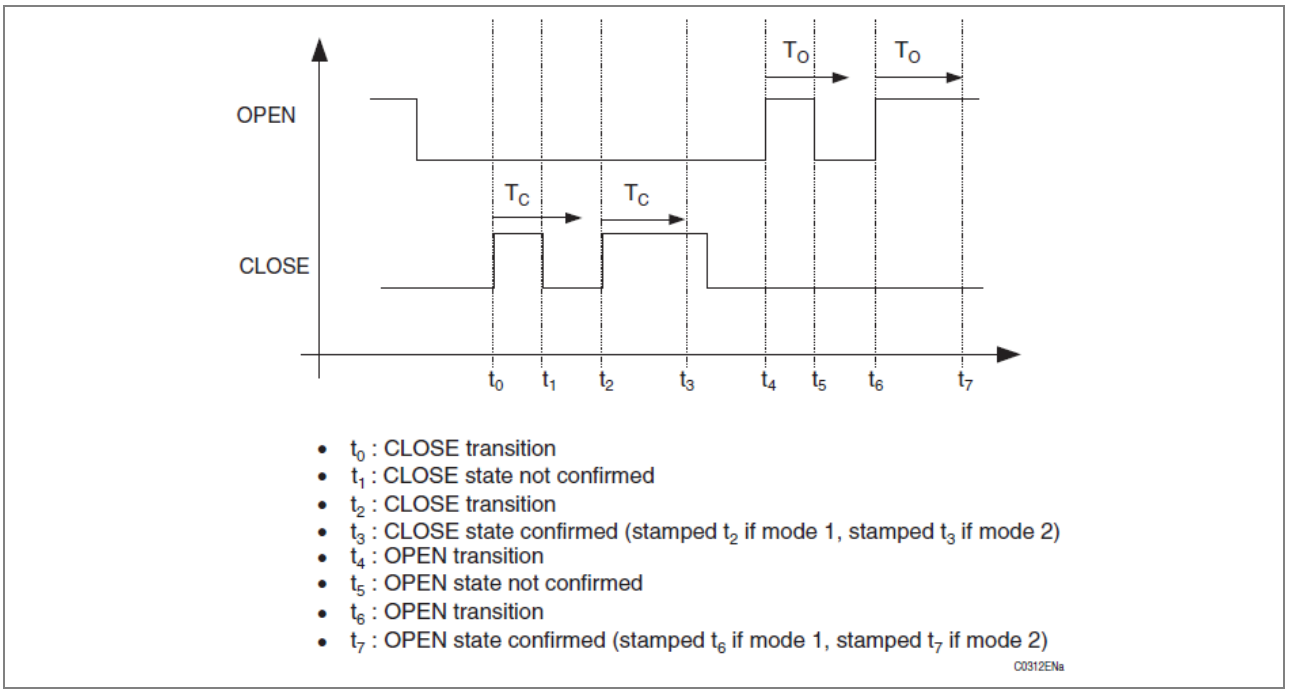


Figure 24: DP persistence filtering

The DP resulting states are:

States (report)	Goose
JAMMED	11
MOTION	00
OPEN	10
CLOSE	01
UNDEFINED	11
TOGGLING	11
SELFCHECK FAULTY	11
UNKNOWN	11
SUPPRESSED	11
FORCED JAMMED	11
FORCED OPEN	10
FORCED CLOSED	01
SUBSTITUTED JAMMED	11
SUBSTITUTED OPEN	10
SUBSTITUTED CLOSED	01

5.1.3.3 DI/DO ASSOCIATION FOR DP

The aim of this automation is to create a direct association between a Double Point and a Digital Output: a state change on the input produces the opening or the closure of the output.

The relation between the state and the order is defined during the configuration phase.

5.1.3.4 MOTION STATES MANAGEMENT

MOTION state are the valid intermediate state of the Double Point Status (DPS), when the DPS state changes from OPEN to CLOSE or from CLOSE to OPEN. The codes for the DPS data on the C26x server, on IEC 61850-8-1, and on DS Agile clients show in the table that follows:

Server	Server	Data on IEC 61850-8-1		DS Agile Client
DI acquired C26x	Resulting state C26x	stVal	quality	Resulting state C26x/aView/OI/Gateway PC
0-0 (time< complementarity delay jammed)	MOTION00	Intermediate-state 0x00	valid q= 0x00	MOTION00
0-0 (time> complementarity delay jammed)	JAMMED	bad-state 0xC0	valid q= 0x00	JAMMED
0-1	OPEN	off 0x40	valid q= 0x00	OPEN
1-0	CLOSE	on 0x80	valid q= 0x00	CLOSE
1-1 (time< complementarity delay undefined)	MOTION11	bad-state 0xC0	invalid q= 0x40	UNDEFINED
1-1 (time< complementarity delay undefined)	UNDEFINED			

5.1.4 PROCESSING OF MULTIPLE POINT STATUS

A Multiple Point (MP) is derived from N Digital Inputs. It could be also called “1 among N” BIs. Transient filtering is also added on acquisition for the events where no Digital Inputs is SET or more than one Digital Inputs are SET. After this delay, the MP becomes UNDEFINED.

N is fixed by C26x configuration from 2 to 32. There is no GOOSE transmission mechanism.

You can use an MP in two ways

- As a status (MPS): in this event, N is as many as 16
- As a value, only for TPI: in this event, N is as many as 64

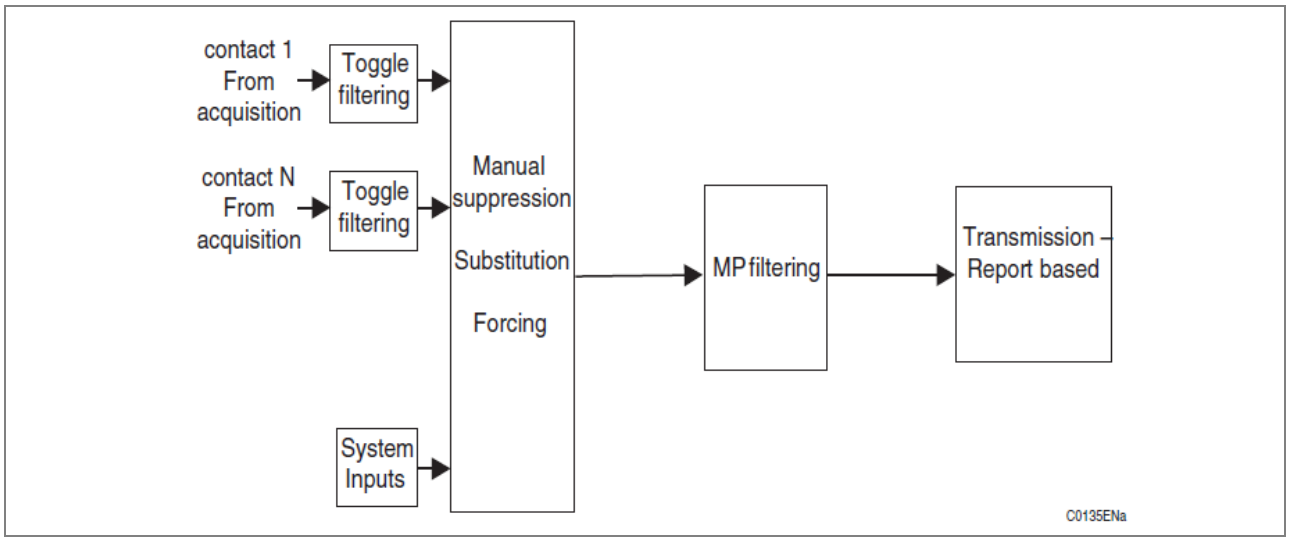


Figure 25: Multi point status processing

5.1.4.1 MULTIPLE POINT RESULTING STATES

The MP resulting states, following the various filters that can be applied, are:

- STATE1 to STATE32
- UNDEFINED
- TOGGLING
- SELFCHECK FAULTY
- UNKNOWN
- SUPPRESSED
- FORCED STATE1 to FORCED STATE32
- SUBSTITUTED STATE1 to SUBSTITUTED STATE32

Note 1:
State names that will be displayed at the user interface are defined at configuration time.

Note 2:
For TPI states, refer to TPI section.

5.1.4.2 MULTIPLE POINT FILTERING

MP is not being considered in the UNDEFINED state if the position has changed by more than one step.

MP is UNDEFINED after a user selectable time filtering (from 0 to 60 seconds, step 100 ms) when no DI is in the SET state (all RESET) or if more than one is in the SET state:

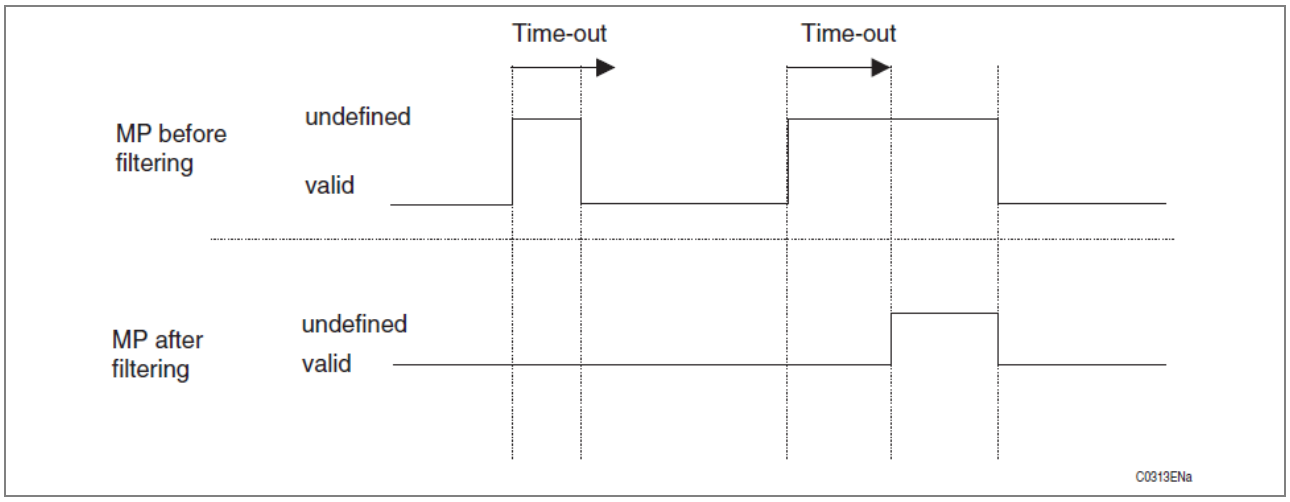


Figure 26: multiple point filtering

The MP is time-tagged with the date of the last BI change.

5.1.5 COUNTING

Counter pulses can be acquired through digital inputs or received from IEDs.

The counter accumulators are stored in non-volatile memory.

There are two types of counter processes:

1 With reset after an accumulation cycle.

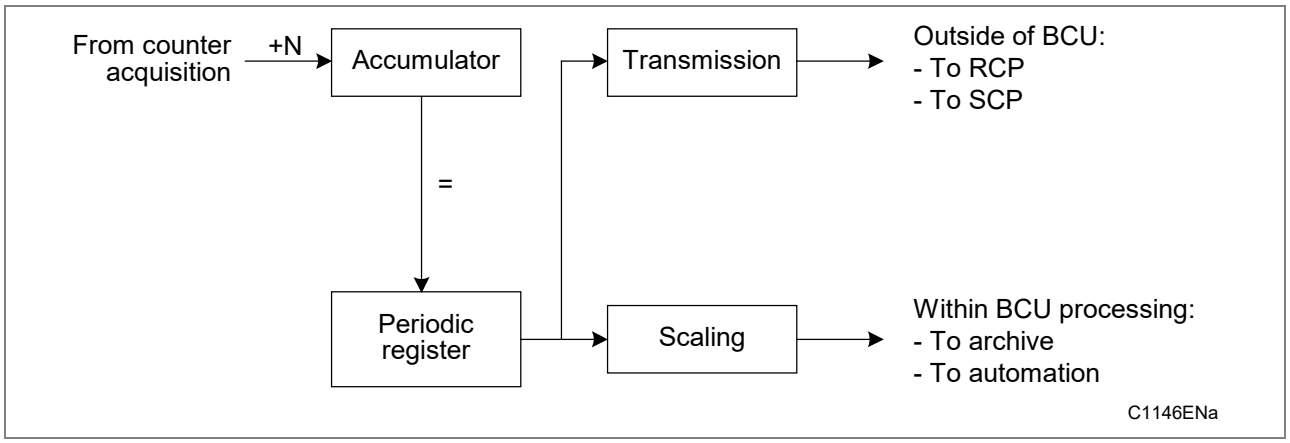


Figure 27: Counter processing with reset after an accumulation cycle.

2 Without reset after an accumulation cycle.

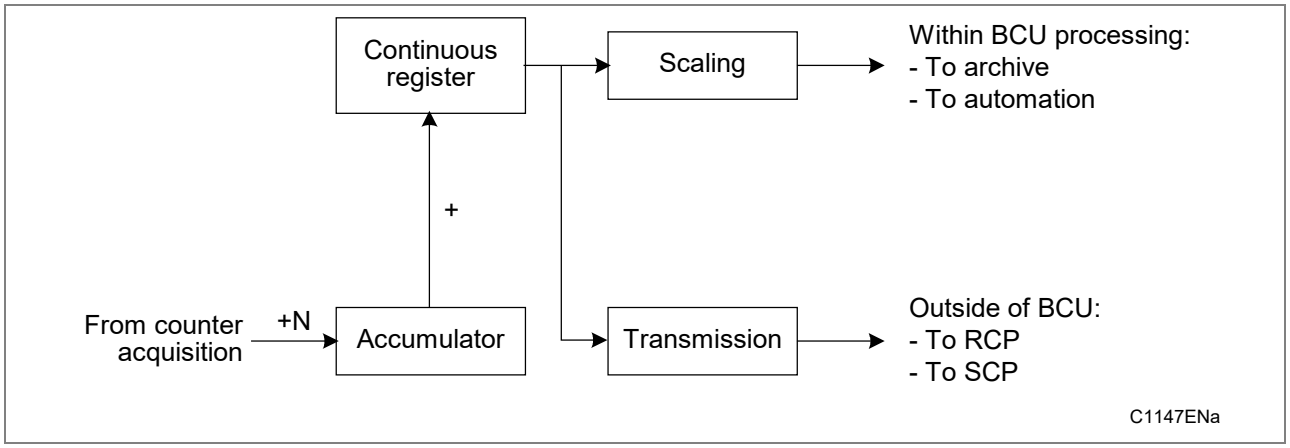


Figure 28: Counter processing without reset after an accumulation cycle.

The accumulator is incremented for each valid counter pulse.

Note: For an already totalized counter, the accumulator's value is equal to value reported by the IED.

Registers

- The periodic register is used to store the accumulator's value of each periodic cycle.
- The continuous register is used to store all the accumulator's values since the beginning of the acquisition.

Periodic processing

A periodic cycle is defined by the internal clock:

- the period duration is settable: 10', 15', 30', 1h up to 24h
- Each period is set to begin at a precise time, on a regular basis (12:00 , 12:30 , 13:00 ...).

This choice is set during the configuration phase.

For each periodic cycle:

- The content of the accumulator is added to the continuous register.
- The content of the accumulator is transferred to the periodic register.
- The accumulator is reset to 0 immediately after it has been transferred to the periodic register and added to the continuous register (a pending pulse is not lost).
- Either the continuous register or the periodic register is transmitted. The choice is made by configuration and is applicable to each accumulator.

If the chosen transmitted register exceeds its maximum value (2^{31}), the counter status is set to OVERRANGE. Only a counter modification can re-validate the counter.

Counter initialisation

Counter acquired through a digital input: The accumulator value stored in non volatile memory is used.

Counter received from an IED: The accumulator data received during the IED's General Interrogation (GI) is transmitted.

Invalidity management in case of DI acquisition failure

In case of acquisition failure (SELFCHECK FAULTY or UNDEFINED states), the counters coming from the accumulator as well as from the continuous register and the periodic register are immediately transmitted as INVALID states with their current values.

At the end of the period, they will be re-transmitted as INVALID. In the following periods, they will be sent as INVALID with their value set to 0 (if configured to '**reset after cumul period**').

When the acquisition state becomes VALID, the accumulator + the continuous and the periodic registers are immediately sent as VALID with the current value (if configured to '**reset after cumul period**').

Invalidity management in case of IED disconnection

In case of an IED's disconnection, the accumulator + the continuous and the periodic register are immediately transmitted as UNKNOWN with their current values.

At a period's expiration, they will be re-transmitted as UNKNOWN.

In the following periods, they will be sent as UNKNOWN with the value set to 0 (if configured to **'reset after cumul period**').

When the acquisition becomes valid, the accumulator and the continuous and the periodic registers are immediately transmitted as VALID with the current value set to 0.

Time Change management

In case of time change, the accumulator, as well as both the continuous and periodic registers, are immediately transmitted as INVALID with their current values and the period re-calculated.

At a period's expiration, the accumulator, as well as both the continuous and periodic registers, are transmitted as VALID with their cumulative value (before & after time modification).

Synchronisation changes have no impact on the counter process.

Scaling

Scaling is used to print or display a counter.

EPI is a parameter giving the amount of energy in KW-h or KVAR-h equivalent to a pulse.

The value displayed is: **N x EPI KW-h** (where N is the value of a counter).

Counter resulting states

The state of a counter can be:

State	Description
VALID	Not in one of the states below listed below
SELFCHECK FAULTY	Due to the SELFCHECK FAULTY of the DI
UNKNOWN	If the counter is received via a transmission link, the information is unknown when the link is disconnected
UNDEFINED	Due to a counting failure of double-counter (non-complementarity of the 2 contacts)
OVERRANGE	When the value exceeds the set maximum value

Transmission

The counters are transmitted on a Client-Server basis on the Station Bus using same mechanisms as for the measurements.

During a loss of communication between a client and a server, the states of all the server counters are set to UNKNOWN on the Client.

The counter's information transmitted in a report comprises:

- the '**Continuous register**' or '**Periodic register**' value (depending on the configuration)
- the time stamp (using UTC time) and time quality
- the resulting state (mapped on the quality field on Station Bus)
- the reason for change, which could be one of the below values:
  - cyclical change (*SET* if the value has changed)
  - change of quality (*SET* if the quality has changed)
  - change due to control (*SET* if the value or quality change is due to a control)

The counter data transmitted through a GOOSE is the same as in a report, except for the "**Reason for change**" and the time-stamp.

Counter combinations and modifications

The following table indicates the various combinations a counter can be found in, with the resulting status on the devices.

SERVER	DATA OVER IEC61850		CLIENT		
Current Status C264	actVal	Quality	C26x/OI/Gateway	aView	
			Resulting status	Validity	Quality
VALID	X	All bits at 0(0x0000)	VALID	0-Valid	
SELFCHECK FAULT	X	b1=1, b6=1, other bits at 0(0x4200)	SELFCHECK FAULT	1-Invalid	SELFCHECK FAULT
N/A	X	b1=1, other bits at 0(0x4000)		N/A	
UNKNOWN	X	b1=1, b7=1, other bits at 0(0x4100)	UNKNOWN	1-Invalid	UNKNOWN
OVERRANGE	X	b1=1, b2=1, other bits at 0(0x6000)	OVERRANGE	1-Invalid	OVERRANGE
UNDEFINED	X	b1=1, b8=1, other bits at 0(0x4080)	UNDEFINED	1-Invalid	UNDEFINED

All other stVal/q combinations are managed as UNKNOWN by IEC61850 clients.

X: any value.

N/A: Not Applicable: The data transmitted over IEC 61850 does not match the current status of a C26x. These stVal/q values can be transmitted by another type of IEC61850 Server).

Counter Modification

When an accumulator's value is modified, the request is immediately taken into account.

The continuous register is set with the accumulator's value found at the end of the cycle.

The modification can result from a counter reset.

Note:
As the counters are transmitted as 32-bit floating points for IEC 61850 compliance, if a counter value is greater than 21474836.0 (or lower than -21474836.0 for negative values), the accuracy is no longer guaranteed for the floating point values.

5.1.6 SYSTEM INPUTS (SI)

System inputs (SI) are binary information related to:

- An equipment or system internal state, such as hardware faults or system faults
- A configurable or built-in automation (status of the automation, binary input created by the automation, …)
- Electrical process data that have no acquisition possibilities: no acquisition through DI or through serial communication. However, they must be managed by the C26x. The states of this data are saved in non-volatile memory.

An SI is of SP, DP or MP type and can belong to any type of group.

The processing of a SI is given in the SP / DP / MP data flow.

5.1.7 IED INPUTS

These inputs are acquired from IEDs or protective relays via serial links.

If they are not time tagged by the IED, they are by the controller at the time of reception. This must be configured for each IED.

An IED input is of SP, DP or MP type.

Double inputs can be processed in IEDs. If they are not, the controller must receive each individual input and perform the DP processing. This must be configured for each IED.

The processing of an IED input is given in the SP / DP / MP data flow.

5.1.8 GROUP PROCESSING

A group is a logical OR, AND, NOR or NAND combination of Binary Inputs (BIs) or groups.

A group component can be an SPS, a DPS (direct or via IED), an SI or another Group. A component can belong to several groups.

A group is processed as an SPS. It is time-stamped with the date / time of the last data-point that changed the group status.

A group is calculated with filtered BIs (persistent filtering or motion filtering if configured). BIs from other BCUs are received in reports.

The binary inputs states are taken into account as follows:

Single Point Status	treated in a group as
SET, FORCED SET, SUBSTITUTED SET	Set
RESET, FORCED RESET, SUBSTITUTED RESET	Reset
SELFCHECK FAULTY, TOGGLING, UNKNOWN	Invalid
SUPPRESSED	Suppressed

Double Point Status	treated in a group as
CLOSE, FORCED CLOSE, SUBSTITUTED CLOSE	Set
OPEN, FORCED OPEN, SUBSTITUTED OPEN	Reset
JAMMED, FORCED JAMMED, SUBSTITUTED JAMMED, UNDEFINED, SELFCHECK FAULTY, TOGGLING, UNKNOWN	Invalid
SUPPRESSED	Suppressed

OR	SET	RESET	INVALID	SUPPRESSED
SET	Set	Set	Set	Set
RESET	Set	Reset	Invalid	Reset
INVALID	Set	Invalid	Invalid	Invalid

OR	SET	RESET	INVALID	SUPPRESSED
SUPPRESSED	Set	Reset	Invalid	Suppressed

AND	SET	RESET	INVALID	SUPPRESSED
SET	Set	Reset	Invalid	Set
RESET	Reset	Reset	Reset	Reset
INVALID	Invalid	Reset	Invalid	Invalid
SUPPRESSED	Set	Reset	Invalid	Suppressed

NOT	
SET	Reset
RESET	Set
INVALID	Invalid
SUPPRESSED	Suppressed

SP and SI from different hierarchical levels can be mixed, for instance a group at substation controller level can be composed of SP acquired at bay controller level or at substation controller level.

A group is time stamped with the date / time of the last datapoint that has modified the group status.

5.1.9 SBMC MODE PROCESSING

When a Bay is in Site Based Maintenance Control (SBMC) mode, the Binary Inputs (related to this Bay and defined as “SBMC-dependent”) take the forced state defined in the configuration.

This forced information is delivered to the Remote Control Point (RCP) as long as the SBMC mode is active on the Bay.

For a group a special feature is implemented: a BI belonging to a group, that is dependent of SBMC bay state, is not taken into account in group computation if the bay is set in SBMC mode. If all the BI of a group belong to one or more bays, that are all in SBMC mode, the group is then in the suppressed state. At the end of a bay SBMC mode, all groups owning BI of this bay are re-computed.

5.1.10 BI SENT TO AUTOMATISM FEATURES

In event that an automatism operates on a client controller, with BI information coming from a server controller, BI are generally transmitted in the GOOSE based mode. In some events where the GOOSE based mode is not used, BI information received by IEC 61850-8-1 reports must be used in automatism features.

In any events where GOOSE based mode and report based mode are used at the same time, the BI information used is the one receive by GOOSE (faster transmission than reports).

5.2 MEASUREMENT INPUT PROCESSING

Measurement Value can be Analogue Measurement, or Digital Measurement.

Analogue Measurements are acquired from communication or from controller boards:

- For DC: AIU201 or AIU211
- For AC: TMU2xx.

Digital Measurement comes from Digital input boards.

5.2.1 MEASUREMENT INPUT PROCESSING - FOCUS

We examine four areas of focus, as follows:

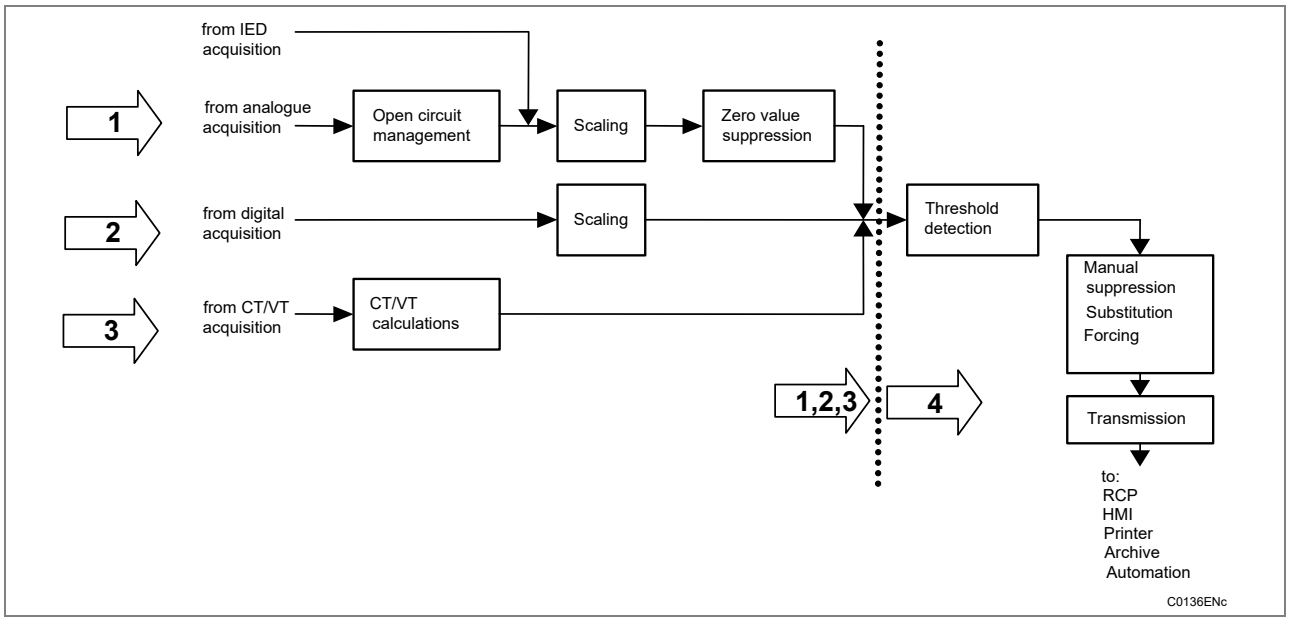


Figure 29: Measurement value processing

- Focus 1: Analogue measurement processing as far as threshold detection
- Focus 2: Digital measurement processing up to threshold detection
- Focus 3: CT / VT measurement processing up to threshold detection
- Focus 4: All measurement values, from threshold detection to transmission

5.2.2 FOCUS 1: ANALOGUE MEASUREMENT PROCESSING UP TO THRESHOLD DETECTION

A measurement value is processed as shown below:

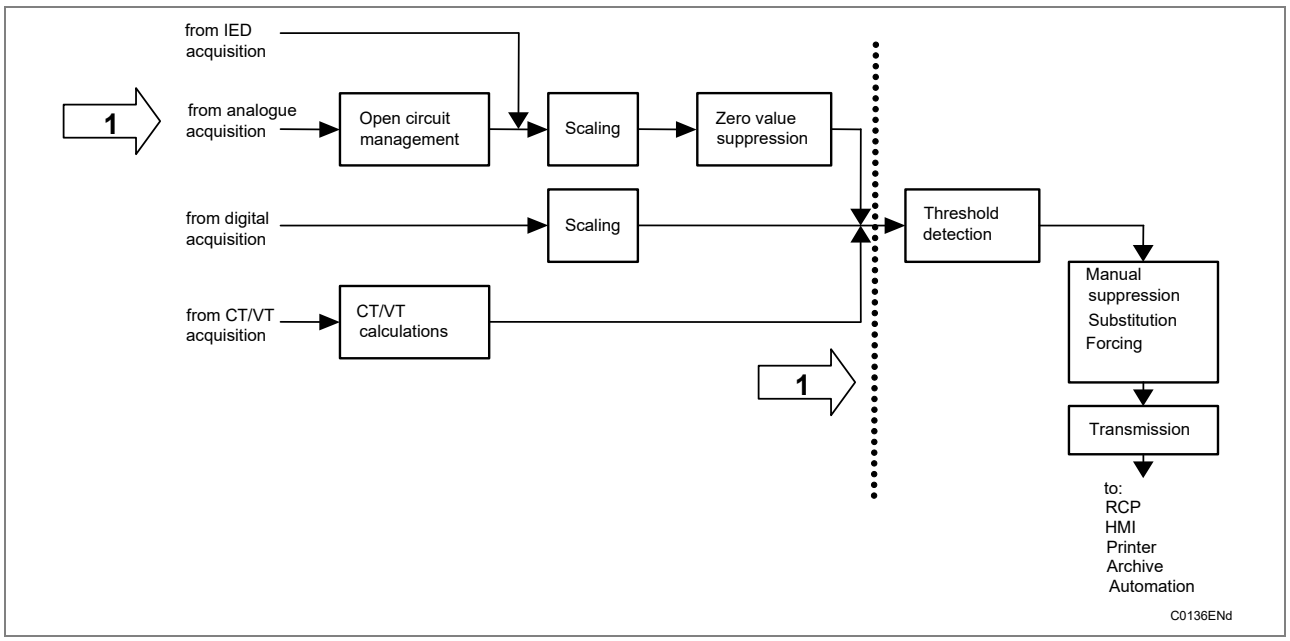


Figure 30: Process of a measurement value

5.2.2.1 OPEN CIRCUIT MANAGEMENT

For 4-20 mA transducers, a special feature is implemented to avoid fleeting values around 4 mA:

- in the range [0 .. 3 mA], the measurement value is set to 0 and the status is set to OPEN CIRCUIT,
- in the range [3 .. 4 mA], the analogue input is considered to be equal to 0 mA.

5.2.2.2 SCALING

The real value represented by the measurement can be computed by a linear or a quadratic transformation:

- Linear, single slope

  Value = A*X + B

- Linear, multi-segment

  Value = A_i*X + B_i with $X_i \leq X < X_{i+1}$.

  As many as 20 configurable segments [X_i .. X_i+1]

- Quadratic

  Value = $A\sqrt{X} + B$ or with offset:

  Value = $\sqrt{AX + B}$

Transformation law and A / B coefficients are defined in configuration.

5.2.2.3 ZERO VALUE SUPPRESSION

The function Y=f(X) representative of this processing is defined as follows:

if $X \in$ [-deadband/2, +deadband/2] $\Rightarrow$ Y=0 and state = VALID

if $X \notin$ [-deadband/2, +deadband/2] $\Rightarrow$ Y=X and state = VALID

Notes

X is an analogue measurement

deadband is a percentage of the full scale value of the measurement. These two parameters have to be set during the configuration of the controller.

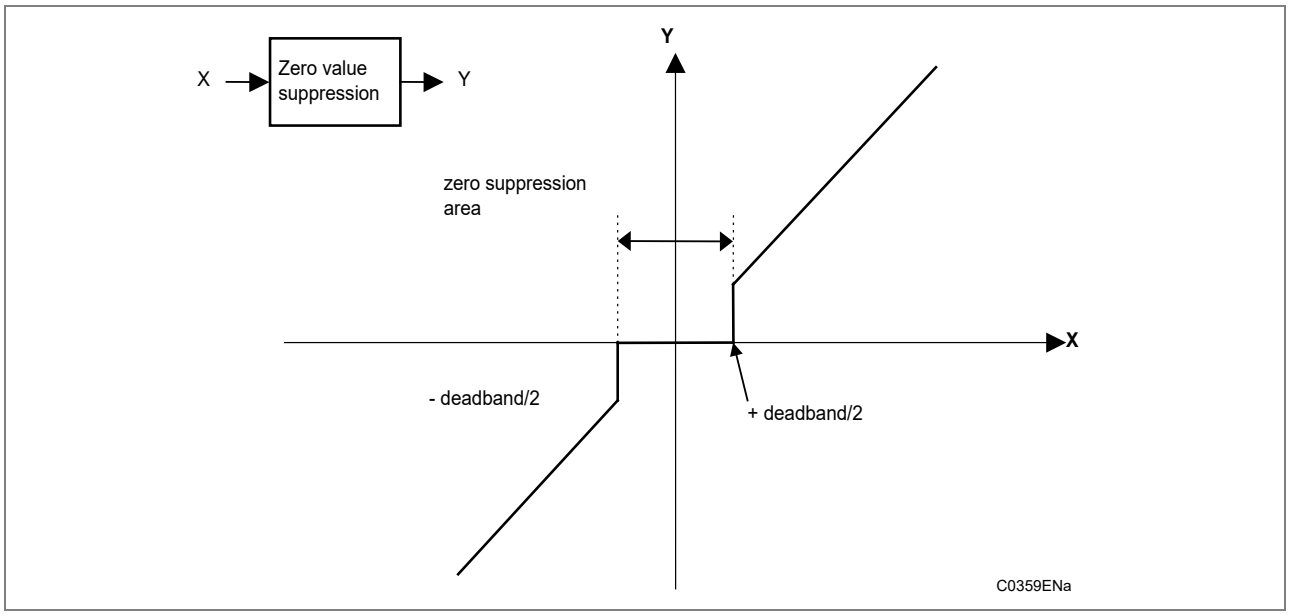


Figure 31: Zero value suppression

5.2.3 FOCUS 2: DIGITAL MEASUREMENT PROCESSING UP TO THRESHOLD DETECTION

A Digital Measurement is derived from a Digital input. Digital Measurements are used for process measures or Tap indications.

A measurement value is processed as shown below:

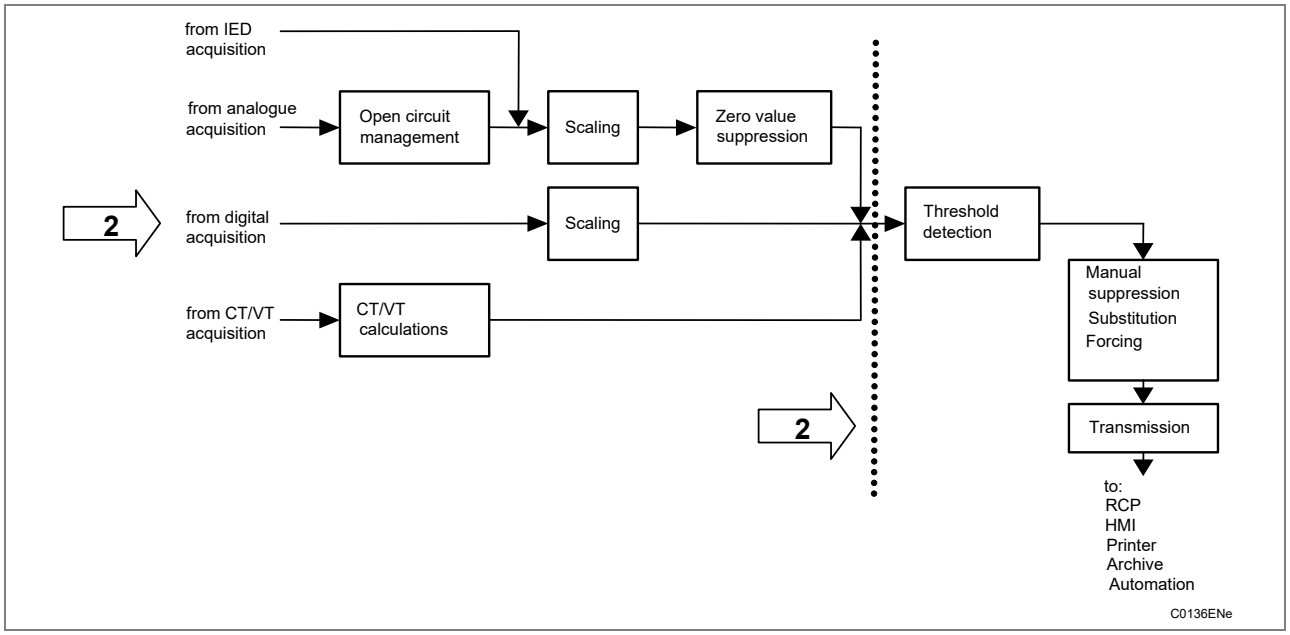


Figure 32: Process of a measurement value

For the conditions that follow, the DM is UNDEFINED:

- The value is not stable.
- BCD: a quartet is more than 9
- Decimal: no bit is set or more than one for tens or unit.

Two others bits can be used:

- For read inhibit: in this event, the DM is acquired when the Read Inhibit bit is set.
- For the sign.

5.2.4 FOCUS 3: TMU2XX - CT/VT MEASUREMENT PROCESSING UP TO THRESHOLD DETECTION

A measurement value is processed as shown below:

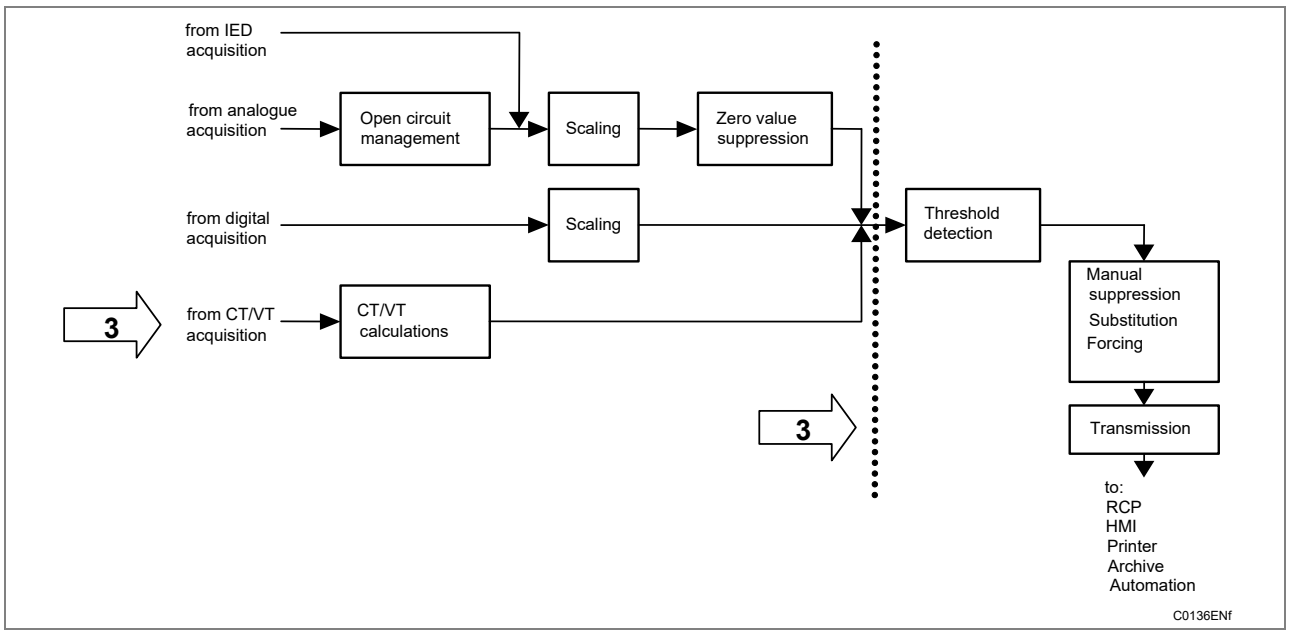


Figure 33: Process of a measurement value

It is impossible to connect the controllers directly to the high voltage electrical network. The controllers receive the data from the Current Transformers (CT) and from Voltage Transformers (VT) installed on the TMU2XX boards.

The purposes of the CT and VT include:

- To deliver current and voltage data that gives a reliable picture of what happens in the high voltage part of an electrical substation
- To make the galvanic insulation between the high voltage part and the measurement and protection circuits,
- To protect the measurement circuits against damage when a fault comes onto the high voltage network.

A given electrical network sends voltage (V) and current (I) data to a CT / VT inputs acquisition function installed on a TMU2XX board.

From the output of the CT / VT inputs acquisitions function, these samples become inputs of the CT / VT calculation function

The CT / VT calculation function performs basic mathematical processing on the stored samples and gives this set of computed measurements, such as power, frequency, and so on, to the C26x main CPU, the Power PC (PPC).

These measurements are used for the protection function and for the Internal Synchrocheck, Type 1, 2, 4 and 3.

Please refer to:

- Figure 34: Overview: TMU220 Board – CT / VT Calculations
- Figure 35: Overview: TMU210 Board – CT / VT Calculations

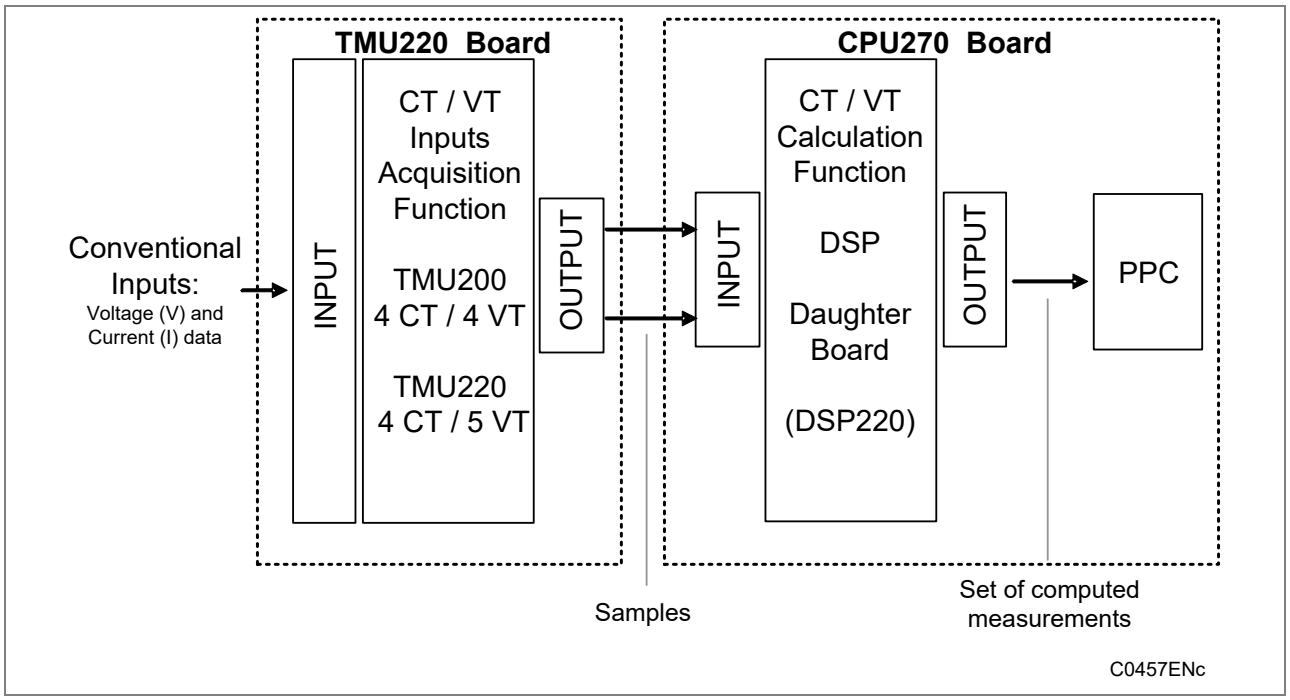


Figure 34: Overview: TMU220 board - CT / VT calculations

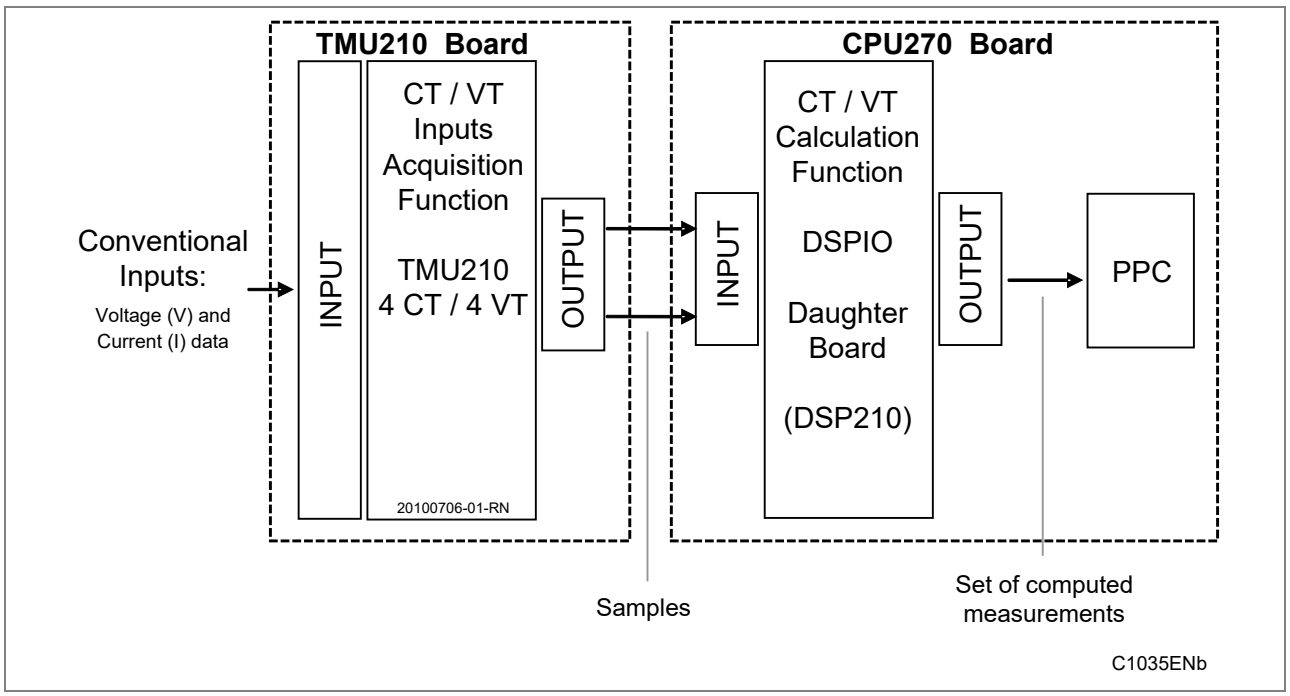


Figure 35: Overview: TMU210 board – CT / VT calculations

5.2.5 FOCUS 4: TMU2XX - CT / VT CALCULATIONS - GENERAL

The voltage measurements come from the VT installed on the TMU2XX boards. There are 3 possibilities for the number of busbar voltages and protection attributes of the controller.

CTVT Board	Wired Busbar voltage number	Protection attributes	Busbar selection	Synchrocheck (SC)
TMU210	1	Yes	External	Type 2
TMU220	2	No	Internal	Type 1 /3 / 4

CT / VT measurements are provided by 3 pairs, or combinations, of boards:

- TMU210 (4 CT and 4 VT) + DSPIO (DSP210 daughter board mounted on the CPU270 board)
- TMU220 (4 CT and 5 VT) + DSP (DSP220 daughter board mounted on the CPU270 board)

For the TMU220

The DSP board computes the samples from the TMU220 and sends the set of computed measurements to the PPC processor on the CPU270 board.

Please refer to Figure 36: Detail: TMU220 Board – CT / VT Calculations

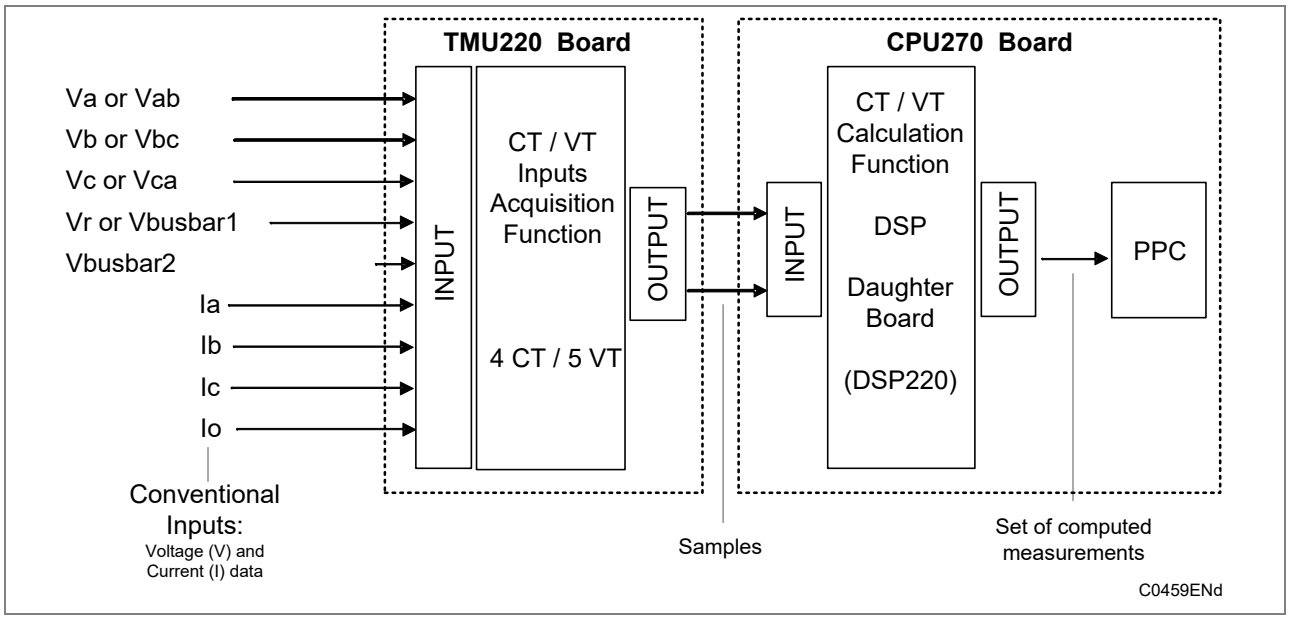


Figure 36: Detail: TMU 220 board - CT / VT calculations

TMU220 board – Signals, Ratings, and Range

Signals	Ratings	Range
V_{AN}, V_{BN}, V_{CN}, $V_0/V_{busbar1}$, $V_{busbar2}$		57 V to 270 V
I_A, I_B, I_C, I_0	1 A or 5 A	

For the TMU210

The hardware attributes of the TMU210 are different and oriented towards protection.

The DSPIO board computes the samples from the TMU210 analogue inputs, and from the digital inputs and digital outputs located on the DSPIO board. The DSPIO Board sends the set of computed measurements to the C26x-PowerPC (PPC) – CPU270.

Please refer to: Figure 37: Detail: TMU210 Board – CT / VT Calculations

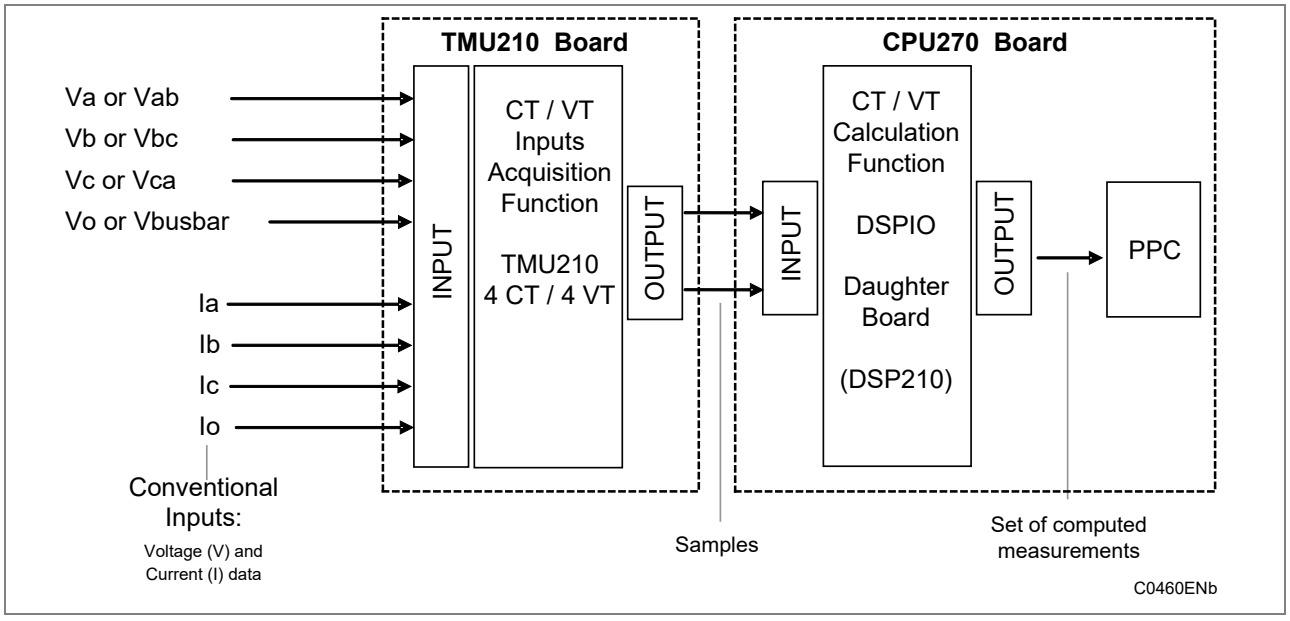


Figure 37: Detail: TMU210 board - CT / VT calculations

Signals	Ratings	Range
V_{AN}, V_{BN}, V_{CN}, V_0/V_{busbar}	NA	57 V to 130 V
I_A, I_B, I_C	1 A or 5 A	0.1 to 40 In
I_0 nomimal:	1 A or 5 A	
I_0 nomimal: Normal		0.1 to 40 I0n
I_0 nomimal: Sensitive		0.01 to 8 I0n
I_0 nomimal: Very sensitive		0.002 to 1 I0n

CT / VT Functions

These functions use the measurements from the TMU2XX boards:

- Internal synchrocheck: Type 1, Type 2, Type 3 and Type 4
- Protection
- Waveform

The CT/VT measurements can be included in the waveform function.

2 types of waveform are defined: Fast waveform and Slow waveform.

Board	Internal S/C Type 1	Internal S/C Type 2	Internal S/C Type 3	Internal S/C Type 3	Protection	Fast wave-form (Dist. rec.)	Slow wave-form
DSPIO + TMU210 or DSP210	X	X			X	X	X
DSP + TMU220 or DSP220	X		X	X		X	X

The measurements available as slow waveforms depend on the TMUxxx board used.

5.2.6 TMU220: CT / VT CALCULATIONS – INPUTS: CONFIGURATION

In agreement with the electrical system configuration, these parameters are defined:

- Nominal Network frequency: 50 or 60 Hz
- Nominal voltage of the VT: 57-130 V
- Nominal current of the CT: 1 A or 5 A
- Connection type: wye (star) or delta
- Reading cycle measurement: from the UC
- Measurement quality when missing: FAULTY or VALID value 0
- Reference voltage
- Phase reference side, for synchrocheck
- Voltage ref change mode for frequency tracking: current or default.

5.2.7 TMU220: CT / VT CALCULATIONS - INPUTS: SAMPLES

The inputs of the CT / VT Calculation function (issued from the Conventional CT/VT inputs) include:

In the event of a star (wye) coupling:

- Samples of I_A
- Samples of V_{AN}
- Samples of I_B
- Samples of V_{BN}
- Samples of I_C
- Samples of V_{CN}
- Samples of I_N
- Samples of $V_{busbar1}$ (or of V_0) if the synchrocheck function is enabled
- Samples of $V_{busbar2}$ if the synchrocheck function is enabled
- Validity of each sample.

In the event of a delta coupling:

- Samples of I_A
- Samples of I_B
- Samples of I_C
- Samples of I_N
- Samples of V_{AB}
- Samples of V_{BC}
- Samples of V_{CA}
- Samples of $V_{busbar1}$
- Samples of $V_{busbar2}$
- Validity of each sample.

64 samples per period are available.

5.2.8 TMU220: CT / VT CALCULATIONS – OUTPUTS: SET OF MEASUREMENTS

The CT / VT calculation function provides the following values:

- RMS currents and voltages
- Frequency
- Active power P (Watts – total and on a per phase basis)
- Reactive power Q (Vars – total and on a per phase basis)
- Apparent power S (VA – total and on a per phase basis)
- Power factor pf (total and on a per phase basis) – pf = P / S
- Sequence components: I1, I2, I0, V1, V2
- Phase angles
- Total Harmonic Distortion (THD, sum of all voltage harmonics) & Total Demand Distortion (TDD, sum of all current harmonics referenced to a rated current In) – Harmonics are evaluated through to the 15^{th} order.
- Fundamental (H1 harmonic) of phase A current
- Fundamental (H1 harmonic) of phase B current
- Fundamental (H1 harmonic) of phase C current
- Fundamental (H1 harmonic) of phase A voltage
- Fundamental (H1 harmonic) of phase B voltage
- Fundamental (H1 harmonic) of phase C voltage
- Fundamental measurements
- Synchrocheck data: ΔF ΔV ΔΦ
- With the synchrocheck option, the values that follow are computed:
  - Slip frequency
  - Amplitude
  - Phase difference
  - Synchrocheck voltage

These measurements are available to the PPC at every measurement reading cycle defined by the configuration.

A configuration option [meas quality when missing] allows to choose 2 different behaviours when all the Input signals disappear: all below the minimum thresholds, 10 V for voltage and 100 mA for current:

- Behaviour 1: the measurements associated with the acquired signals are set to value 0 and state VALID
- Behaviour 2: the measurements associated with the acquired signals are set to value 0 and state FAULTY

5.2.9 TMU220: MEASUREMENTS - GENERAL

Whatever the signal frequency, 64 samples are available for all the input signals.

All these samples are gathered in a revolving list stored in active memory.

A timer is adapted permanently to the frequency of the signal and provides the frequency measurement

The primary measurements that follow are derived from sample values:

- RMS Current and Voltage
- P: Active Power (Watts)
- Q: Vars (using Active Power calculation method with the voltage samples delayed by 90°)

The measurements that follow are obtained from the Fourier of sample values or the Fourier values of the above-derived measurements (DFT).

- Sequence Components (I1, I2, I0, V1, V2, V0)
- Fundamental and harmonics
- Phase angles
- Power Factor
- SVA
- THD and TDD
- Specials (for products with synchrocheck)

5.2.10 TMU220: LIST OF MEASUREMENTS

Measurements	Star	Delta	Accuracy (TMU220)	Unit
RMS phase currents I_A I_B I_C I_N "Ibusbar" (I_N)	 measured measured measured derived measured	 measured measured measured derived measured	F < 70Hz: I < In: 0.2% In I > In: 0.2% In F>70Hz: I < In: 4% In I > In: 4% In	Amps
RMS phase volts V_{AN} V_{BN} V_{CN} V_0 $V_{busbar1}$ $V_{busbar2}$	 measured measured measured derived measured measured	Not available	F < 70Hz V < 45V: 0.3% 45 V 45V < V < 200V: 0.2% Vn V>200V: 0.3% Vn F>70Hz V < 45V: 4% Vn V > 45V: 4% Vn	Volts
RMS phase volts V_{AB} V_{BC} V_{CA} V_0 $V_{busbar1}$ $V_{busbar2}$	 derived derived derived derived	 measured measured measured derived measured measured	F < 70Hz V < 45V: 0.3% 45 V 45V < V < 200V: 0.2% Vn V > 200V: 0.3% Vn F>70Hz V < 45V: 4% 45 V V > 45V: 4% Vn	Volts
Frequency	derived	derived		Hertz

Measurements	Star	Delta	Accuracy (TMU220)	Unit
Phase A power Active power (P) Reactive power (Q) Apparent power (S) Cos phi angle	 measured measured derived derived derived	Not available		 Watts Vars V_A Deg.
Phase B power Active power (P) Reactive power (Q) Apparent power (S) Cos phi angle	 measured measured derived derived derived	Not available		 Watts Vars V_A Deg.
Phase C power Active power (P) Reactive power (Q) Apparent power (S) Cos phi angle	 measured measured derived derived derived	Not available		 Watts Vars V_A Deg.
Power Active power (P) Reactive power (Q) Apparent power (S) Cos phi angle	 measured measured derived derived derived	Not available		 Watts Vars V_A Deg.
Total power Active power (P) Reactive power (Q) Apparent power (S) Cos phi angle	 derived	 derived		 Watts Vars V_A Deg.
V Sequence components Direct (V1) Inverse (V2) Homopolar (V_0) ratio	 DFT derived	 Not available		 volts
I Sequence components Direct (I1) Inverse (I2) Homopolar (I_0) ratio	 DFT derived	 DFT derived		 Amps
Harmonics for V_{AN} Fundamental 15 Harmonic distortion ratio	 DFT	 DFT		 Volts
Harmonics for V_{BN} Fundamental 15 Harmonic distortion ratio	 DFT	 DFT		 Volts
Harmonics for V_{CN} Fundamental 15 Harmonic distortion ratio	 DFT	 DFT		 Volts
Harmonics for V_{AB} Fundamental 15 Harmonic distortion ratio	 DFT	 DFT		 Volts

Measurements	Star	Delta	Accuracy (TMU220)	Unit
Harmonics for V_{BC} Fundamental 15 Harmonic distortion ratio	DFT	DFT		Volts
Harmonics for V_{CA} Fundamental 15 Harmonic distortion ratio	DFT	DFT		Volts
Harmonics for I_A Fundamental 15 Harmonic distortion ratio	DFT	DFT		Amps
Harmonics for I_B Fundamental 15 Harmonic distortion ratio	DFT	DFT		Amps
Harmonics for I_C Fundamental 15 Harmonic distortion ratio	DFT	DFT		Amps
Delta F	derived	derived		Hertz
Delta phi	derived	derived		Deg.
Delta V	derived	derived		Volts

5.2.11 TMU220: ALGORITHMS

Frequency

The frequency is directly computed through the timer frequency.

The reference phase used to set the timer frequency is chosen in the configuration (“reference phase”).

Frequency tracking is performed according to the following order:

1 on reference voltage defined in configuration (highest priority)

2 V_{busbar}

3 $V_{busbar2}$ (if a TMU220 board is used and the 5th VT is configured)

4 V_{BN} (V_{BC}) then V_{CN} (V_{CA}) if the reference voltage is V_{AN} (V_{AB})
V_{CN} (V_{CA}) then V_{AN} (V_{AB}) if the reference voltage is V_{BN} (V_{BC})
V_{AN} (V_{AB}) then V_{BN} (V_{BC}) if the reference voltage is V_{CN} (V_{CA})

5 I_1

6 I_2

7 I_3

8 I_4 (lowest priority)

A configuration option (“voltage ref change mode”) allows choosing between 2 different behaviours for frequency tracking:

- Behaviour 1 – Default Voltage Reference (default value):
  - When the signal with the highest priority disappears, frequency tracking is performed on the signal with next priority.
  - When a signal with a higher priority appears, frequency tracking is performed on this signal, even if the current reference signal is still present.

- Behaviour 2 – Current Voltage Reference:
  - When the signal with the highest priority disappears, frequency tracking is performed on the signal with next priority.
  - Even when a signal with a higher priority appears, frequency tracking remains on the current reference signal.

In both cases, during the reference change computation (about 3 seconds), all the measurements are considered INVALID (SELFCHECK FAULT).

Main principle of the frequency tracking algorithm

The value of the phase angle and the magnitude of the fundamental component of the selected signal are computed for each period, in order to match the frequency of the internal timer to the signal frequency and obtain exactly 64 samples per fundamental period and preserve that sampling frequency by keeping the phase difference between true samples and theoretical samples inside a +/-4° band. The timer frequency is adapted using a relaxation factor in order to avoid frequency overshoots or undershoots and thus adapt the loopback convergence speed.

The loopback is considered correct after 30 correct signal periods with the phase difference inside the target band have been acquired. Conversely, if the phase difference goes outside the target band for 30 periods, the loopback state becomes incorrect.

As a result, establishing the loopback process takes approximately 1.5 seconds.

Signal measurements can start as soon as frequency tracking is considered established.

Limitation

The maximum sudden gap in the signal frequency that can be tolerated without momentary loss of frequency control (i.e. momentarily causing the state of the computed measurements to become invalid) is about 50 mHz.

The maximum frequency drift that can be tolerated without momentary loss of frequency control (i.e. momentarily causing the state of the computed measurements to become invalid) is about 40 mHz/s.

A sudden gap in a phase signal can cause a momentary loss of frequency control (loss of around 3 s of valid measurements).

Validity of the measurements after filtering and stabilisation

After frequency tracking is established, all the measurements are computed, then filtered. The measurements is considered valid after a stabilisation time of 75 signal periods, i.e. about 1.5 seconds after the frequency tracking process.

Fourier Transform

The DFT (Discrete Fourier Transform) is calculated for each electrical period. This gives (among other things) the value of the phase angle and the magnitude of the fundamental.

RMS values

$$Vrms = \sqrt{\frac{1}{64}\sum_{i=0}^{63} V_i^{\,2}}$$

Phase powers in wye coupling

Active power: Pa, Pb, Pc

$$P = \frac{1}{64}\sum_{i=0}^{63} V_i I_i$$

Reactive power: Qa, Qb, Qc

$$Q = \frac{1}{64}\sum_{i=0}^{63} V_i I_{i-16}$$

Note:
The reactive power is computed by taking the values of the current a quarter of period before [sin(x) = cos (x – pi/2)]

Total power

Wye coupling: Total Power

$$P = Pa+Pb+Pc$$

$$Q = Qa+Qb+Qc$$

Delta Coupling: Total Active Power

$$P = \frac{1}{64}\sum_{i=0}^{63} U_{BC}(i).I_B(i) - U_{CA}(i).I_A(i)$$

Delta Coupling: Total Reactive Power

$$P = \frac{1}{64}\sum_{i=0}^{63} U_{BC}(i).I_B(i-\pi/2) - U_{CA}(i).I_A(i-\pi/2)$$

Note:
The reactive power is computed by taking the values of the current a quarter of period before [sin(x) = cos (x – pi/2)]

Apparent power: $S = \sqrt{P^2+Q^2}$

Power factor: $\cos(\varphi) = \frac{P}{S}$

Angle: $\varphi = \tan^{-1}(\frac{Q}{P})$

Harmonics

Harmonic values are directly issued from the DFT.

Sequence components

The sequence component computation is based on the fundamental values of phase and magnitude (from the DFT): that is its imaginary part and real part.

- Positive-sequence component

$$\mathrm{Re}(pos) = \frac{1}{3}\times\left(\mathrm{Re}(A)+\mathrm{Re}(B)\times\cos(120)-\mathrm{Im}(B)\times\sin(120)+\mathrm{Re}(C)\times\cos(120)+\mathrm{Im}(C)\times\sin(120)\right)$$

$$\mathrm{Im}(pos) = \frac{1}{3}\times\left(\mathrm{Im}(A)+\mathrm{Im}(B)\times\cos(120)+\mathrm{Re}(B)\times\sin(120)+\mathrm{Im}(C)\times\cos(120)-\mathrm{Re}(C)\times\sin(120)\right)$$

- Negative-sequence component

$$\mathrm{Re}(neg) = \frac{1}{3} \times \left(\mathrm{Re}(A) + \mathrm{Re}(B) \times \cos(120) + \mathrm{Im}(B) \times \sin(120) + \mathrm{Re}(C) \times \cos(120) - \mathrm{Im}(C) \times \sin(120)\right)$$

$$\mathrm{Im}(neg) = \frac{1}{3} \times \left(\mathrm{Im}(A) + \mathrm{Im}(B) \times \cos(120) - \mathrm{Re}(B) \times \sin(120) + \mathrm{Im}(C) \times \cos(120) + \mathrm{Re}(C) \times \sin(120)\right)$$

- Zero-sequence component

$$\mathrm{Re}(0) = \frac{1}{3} \times \left(\mathrm{Re}(A) + \mathrm{Re}(B) + \mathrm{Re}(C)\right)$$

$$\mathrm{Im}(0) = \frac{1}{3} \times \left(\mathrm{Im}(A) + \mathrm{Im}(B) + \mathrm{Im}(C)\right)$$

Synchrocheck measurements

$\Delta F = | F_{line} - F_{busbar} |$

$\Delta V = | V_{line} - V_{busbar} |$

$\Delta\varphi = | \varphi_{line} - \varphi\ V_{busbar} |$

5.2.12 TMU210: CT / VT CALCULATIONS - INPUTS: CONFIGURATION

In agreement with the electrical system configuration, the following parameters are defined:

- Nominal Network frequency (50 or 60 Hz)
- Nominal phase voltage of the VT (57-130V)
- Nominal earth voltage of the VT (57-130V)
- Nominal phase current of the CT (1A or 5A)
- Nominal earth current of the CT (1A or 5A)
- Earth current origin (computed or wired)
- Sensitivity of the earth CT (normal, sensitive, very sensitive)
- Transformer ratio of the EPATR core balance CT
- Connection type ($3V_{PN}$, $3V_{PN}+V_0$, $2V_{PN}+V_0$, $2V_{PP}+V_0$, $3V_{PP}+V_0$, $3V_{PN}+V_{busbar}$, $3V_{PP}+V_0$)
- Reading cycle measurement (from the PPC)

5.2.13 TMU210: CT / VT CALCULATIONS - INPUTS: SAMPLES

With the TMU210 board with respect to the type of connection, some restrictions exist because of the fourth VT.

At this time, please refer to the topic Phase-to-Phase Synchrocheck with the TMU210 – General and to the Table: TMU210 Type of Connection: Direct or Indirect.

The inputs of the CT / VT Calculation function (issued from the Conventional CT/VT inputs) include:

In case of star coupling:

- CI#1: samples of I_A
- CI#2: samples of I_B
- CI#3: samples of I_C
- CI#4: samples of I_N
- VI#1: samples of V_{AN}
- VI#2: samples of V_{BN}
- VI#3: samples of V_{CN}
- VI#4: samples of V_N or V_{busbar}
- Validity of each sample.

In case of delta coupling:

- CI#1: samples of I_A
- CI#2: samples of I_B
- CI#3: samples of I_C
- CI#4: samples of I_N
- VI#1: samples of V_{AB}
- VI#2: samples of V_{BC}
- VI#3: samples of V_{CA}
- VI#4: samples of V_N or V_{busbar}
- Validity of each sample.

32 samples per period are available.

5.2.14 TMU210: CT / VT CALCULATIONS – OUTPUTS: SET OF MEASUREMENTS

The CT / VT calculation function produces:

- RMS currents and voltages (phase in star wiring, phase-to-phase in delta wiring)
- Instantaneous voltages (phase in star wiring)
- Frequencies (line or busbar if V4 is connected to a busbar)
- Fundamental measurements and Derived values
- Current – voltage angles
- Total Active power P
- Total Reactive power Q
- Total Apparent power S
- Cos φ power factor
- Thermal status
- With the synchrocheck option, the values that follow are computed:
  - Synchrocheck data: ΔF ΔV ΔΦ
  - Slip frequency
  - Amplitude
  - Phase difference
  - Synchrocheck voltage

These measurements are made available to the controller and refreshed upon each measurement reading cycle defined in the configuration.

5.2.15 TMU210: MEASUREMENTS - GENERAL

Whatever the signal frequency, 32 samples are available for all the input signals.

All these samples are gathered in a revolving list stored in active memory.

A timer is adapted permanently to the frequency of the signal and provides the frequency measurement

The primary measurements that follow are read directly from sample values:

- RMS: Currents and Voltages
- Thermal status

The following measurements are obtained from the Fourier of sample values or from the Fourier values of the derived measurements (DFT):

- DFT: Currents and Voltages
- DFT Sequence Components: Current and Voltage (positive and negative)
- Current - voltage angle
- Active phase Power
- Active earth Power
- Reactive phase power
- Power Factor
- Synchrocheck measurements

5.2.16 TMU210: LIST OF MEASUREMENTS

Measurements	Accuracy	Unit
RMS phase currents Rms_I_A Rms_I_B Rms_I_C Rms_I_N	2%	In
RMS phase voltages Rms_V_{AN}_V_{AB} Rms_V_{BN}_V_{BC} Rms_V_{CN}_V_{CA} Rms_V_0 Rms_V_{busbar}	2%	Volts
Frequency F: frequency tracking F81: frequency used by 81 Index of F Index of F81 Rate of frequency_81	0.01Hz 0.03Hz/sec	 Hertz Hertz Hertz/sec
DFT phase currents I_A I_B I_C I_0 I_0_computed EPATR I_0	2%	 In In In I0n I0n Amps
DFT phase voltages V_{AN} V_{BN} V_{CN} V_{AB} V_{BC} V_{CA} V_0 V_{busbar}	2%	Volts
DFT Sequence voltages V1 V2		Volts

Measurements	Accuracy	Unit
DFT Sequence currents I1 I2		 In
Total power Active phase power (P) Active earth power(P0) Reactive power (Q) Cos phi (power factor)	 <3% <3%	 Watts Watts Vars
Thermal status		%
Synchrocheck Delta F Delta V Delta phi Line frequency Busbar frequency Phase angle between line and busbar Anticipation angle Frequency shift Frequency shift acceleration		 Hertz Volts Degree Hertz Hertz Degree Degree % %

5.2.17 TMU210: ALGORITHMS

5.2.17.1 CALIBRATION

3 calibration parameters are stored in EEPROM for each input:

- Amplitude
- Phase
- offset

The offset correction has to be re-evaluated in real time and not in a static way.

The offset correction is made by a low-pass filter (0.5 Hz). The offset parameter stored in EEPROM is not used.

The amplitude offset is used at each acquisition cycle.

5.2.17.2 FREQUENCIES

5.2.17.2.1 Frequency tracking

The frequency is tracked by calculating the frequency of a voltage or current channel. For each channel a minimum threshold is used to validate the signal (1 volt for VT, 0.1 A for CT).

If a tracking is done on a channel, there is no change until the value of this channel becomes lower than the threshold. There is no hysteresis on them. The channel change follows this list:

1 V1 (first)

2 V2

3 V3

4 I1

5 I2

6 I3 (last)

5.2.17.2.2 Frequency computation

The first phase voltage channel over minimum threshold (Umin_F_enable) is selected, then a filter FIR is applied to reject harmonic. On result, we calculate period by cross zero method, on leading edge and on trailing edge, average result of this both measurement generated frequency used.

Between 2 computations of the frequency, if the frequency change is more than 20Hz/s (equals to a brutal step 400mHz at 50Hz), then the frequency calculation will be frozen and INVALID during 7 cycles (for example, at 50Hz the frequency will be frozen during 120ms)

5.2.17.2.3 Frequency [81] and frequency rating computation

According to the configuration parameter “VT_connection”, there are 2 events:

- VT_connection = $3V_{PN}$ or $3V_{PN}+V_0$ or $2\ V_{PN}+V_0$ or $2V_{PP}+V_0$ or $3V_{PP}+V_0$

➔ Frequency81 computation **without** priority

- VT_connection = $3V_{PN}$ $+V_{busbar}$ or $3V_{PP}+V_{busbar}$

➔ Frequency81 computation **with** priority

Frequency [81] computation without priority

The first voltage upper than the threshold (Umin_F_enable, SEE GPS 8) is given as reference. When this voltage goes down the threshold, the next voltage is tested as reference.

The cycle of reference test is V1, V2, V3, V1, V2 …etc

Frequency [81] computation with priority

In priority, V4 (busbar voltage) is used for reference comparing to the threshold. If this voltage goes down the threshold, a valid line voltage is searched. When the busbar voltage is detected back over the threshold, the busbar VT is reassigning to be the frequency tracking reference.

5.2.17.3 RMS MEASUREMENTS

The RMS measurement of the last period recorded is calculated as the square root of the square sum of the samples in the period divided by the number of samples examined.

The square sum is calculated every period (32 samples recordings).

$$Vrms = \sqrt{\frac{1}{32}\sum_{i=0}^{31} V_i^{\,2}}$$

	3VPN	3VPN+V0	2VPN+V0	2VPP+V0	3VPP+V0	3VPN+Vbusbar	3VPP+Vbusbar
Rms_I_A	Rms_I_A						
Rms_I_A	Rms_I_B						
Rms_I_C	Rms_I_C						
Rms_I_0	Rms_Io						
Rms_V_A_V_{AB}	Rms_V_A	Rms_V_A	Rms_V_A	Rms_V_{AB}	Rms_V_{AB}	Rms_V_A	Rms_V_{AB}
Rms_V_B_V_{BC}	Rms_V_B	Rms_V_B	Rms_V_B	Rms_V_{BC}	Rms_V_{BC}	Rms_V_B	Rms_V_{BC}
Rms_V_C_V_{CA}	Rms_V_C	Rms_V_C	NOT VALID	NOT VALID	Rms_V_{CA}	Rms_V_C	Rms_V_{CA}
Rms_V_0	NOT VALID	Rms_Vo	Rms_Vo	Rms_Vo	Rms_Vo	NOT VALID	NOT VALID
Rms_V_busbar	NOT VALID	NOT VALID	NOT VALID	NOT VALID	NOT VALID	Rms_u_busbar	Rms_u_busbar

5.2.17.4 FUNDAMENTAL MEASUREMENTS

5.2.17.4.1 General

The instantaneous direct effective fundamental measurement, to be used by the protection devices, is supplied every samples reception frame, in terms of both module and phase as well as that for the real part and the imaginary part of the current vector. This is calculated using the **Fourier transform (DFT)**, applied to the samples of the last period recorded (32 samples) and expressed in ADC points.

So a multiplier coefficient is necessary to scale them in the appropriated unit.

	3VPN	3VPN+V0	2VPN+V0	2VPP+V0	3VPP+V0	3VPN+Vbusbar	3VPP+Vbusbar
Mod_I_A	Measured						
Mod I_B	Measured						
Mod I_C	Measured						
Mod I_0	Measured						
Mod_V_A	Measured	Measured	Measured	Derived	Derived	Measured	Not valid
Mod _V_B	Measured	Measured	Measured	Derived	Derived	Measured	Not valid
Mod _V_C	Measured	Measured	Derived	Derived	Derived	Measured	Not valid
Mod _V_{AB}	Derived	Derived	Derived	Measured	Measured	Derived	Measured
Mod _V_{BC}	Derived	Derived	Derived	Measured	Measured	Derived	Measured
Mod _V_{CA}	Derived	Derived	Derived	Derived	Measured	Derived	Measured
Mod _V_0	Derived	Measured	Measured	Measured	Measured	Derived	Not valid
Mod _V_busbar	Not valid	Not valid	Not valid	Not valid	Not valid	Measured	Measured
Mod_I1	Derived						
Mod_I2	Derived						
Mod_V1	Derived						
Mod_V2	Derived						
Ioc	Derived						

5.2.17.4.2 Conversion

- KU_{ADC} is the number of ADC points corresponding to a phase voltage of 1V to the secondary side.
- KUo_{ADC} is the number of ADC points corresponding to an earth voltage of 1V to the secondary side.
- KI_{ADC} is the number of ADC points corresponding to the nominal phase current to the secondary side.
- KIo_{ADC} is the number of ADC points corresponding to the nominal earth current to the secondary side.
- X is the value of the module expressed in ADC points (X = I, Io, Uxy, Uo)
- X" is the effective value of the module expressed in voltage or ampere to the primary side (X = I, Io, Uxy, Uo).

$$I" = \frac{I}{KI_{ADC}} * CT_In$$

$$Io" = \frac{Io}{KIo_{ADC}} * CT_Ion$$

$$U_{xy}" = \frac{U_{xy}}{KU_{ADC} \cdot Un} * VT_Un$$

$$Uo" = \frac{Uo}{KUo_{ADC} \cdot Uon} * VT_Uon$$

5.2.17.4.3 Direct measurements

The real and the imaginary part are determined using the DFT method.

$$\mathrm{Re}(G) = \sum_{i=1}^{N} sample_i * \cos\left(\frac{2\pi * i}{N}\right)$$

$$\mathrm{Im}(G) = \sum_{i=1}^{N} sample_i * \sin\left(\frac{2\pi * i}{N}\right)$$

The real part and the imaginary part of every received valid sample are calculated.

Derived measurements

Voltages

	$3V_{PN}$	$3V_{PN}+V_0$	$2V_{PN}+V_0$	$2V_{PP}+V_0$	$3V_{PP}+V_0$	$3V_{PP}+V_{busbar}$	$3V_{PN}+V_{busbar}$
V_A	V_{L1}	V_{L1}	V_{L1}	$(kV0+2V_{L1}-V_{L2})/3$	$(kV0+V_{L1}-V_{L3})/3$	Not valid	V_{L1}
V_B	V_{L2}	V_{L2}	V_{L2}	$(kV0+V_{L2}-V_{L1})/3$	$(kV0+V_{L2}-V_{L1})/3$	Not valid	V_{L2}
V_C	V_{L3}	V_{L3}	$kV0-V_{L1}-V_{L2}$	$(kV0-V_{L1}+2V_{L2})/3$	$(kV0-V_{L3}+V_{L2})$	Not valid	V_{L3}
V_{AB}	V_{L1}-V_{L2}	$V_{L1}-V_{L2}$	$V_{L1}-V_{L2}$	V_{L1}	V_{L1}	V_{L1}	$V_{L1}-V_{L2}$
V_{BC}	V_{L2}-V_{L3}	$V_{L2}-V_{L3}$	$2V_{L2}+V_{L1}-kV0$	V_{L2}	V_{L2}	V_{L2}	$V_{L2}-V_{L3}$
V_{CA}	V_{L3}-V_{L1}	$V_{L3}-V_{L1}$	$kV0-2V_{L1}-V_{L2}$	V_{L1}-V_{L2}	V_{L3}	V_{L3}	$V_{L3}-V_{L1}$
V_0	$k-1*(V_{L1}+V_{L2}+V_{L3})$				$k-1(V_{L1}+V_{L2}+V_{L3})$	Not valid	$k-1(V_{L1}+V_{L2}+V_{L3})$
V_{busbar}	$k-1*(V_{L1}+V_{L2}+V_{L3})$	Not valid	Not valid	Not valid	Not valid		

- k the earth to phase adaptation coefficient - (necessary for expressing the earth ADC points in phase ADC points) amounting to:

$$k = \frac{Un \cdot KU_{ADC}}{U0n \cdot KU0_{ADC}} \cdot \frac{VT_U0n}{VT_Un}$$

5.2.17.4.3.1 Positive and negative sequence current

The definition of positive sequence current, I1, indicates the current vector obtained by the sum of the phase A vector, plus the phase B vector rotated by 120° in advance plus the phase C vector rotated by a lag of 120°.

The definition of the negative sequence current, I2, indicates the current vector obtained by the sum of the phase A vector, plus the phase B vector rotated by a lag of 120° plus the phase C vector rotated by 120° in advance.

Derived vectors

Positive sequence current	I1	IA+(IB-120°)+(IC+120°)
Negative sequence current	I2	IA+(IB+120°)+(IC-120°)

Where the label <$I_{B/C}$+/-120°> indicates that the vector is considered rotated of +/- 120°

5.2.17.4.3.2 Positive and negative sequence voltage

Derived vectors

		3VPN, 3VPN+V0, 2VPN+V0 3VPN+Vbusbar	3VPP+V0, 2VPP+V0, 3VPP+Vbusbar
Positive sequence voltage	V1	(V_A+(V_B+120°)+(I_C+240°))/3	(V_A+(V_B+240°)+(I_C+120°))/3
Negative sequence voltage	V2	(V_A-(V_B-120°))/3	(V_A-(V_B+120°))/3

Where the label <$U_{B/C}$+/-alpha> indicates that the vector is considered rotated of +/- alpha

5.2.17.4.3.3 Computed zero-sequence current

In order to use the protective function 67N in several specific conditions, the zero-sequence current must be computed from the values of the 3 phase currents:

$\vec{I}$ The generic current vector

Re(…) the operator that returns the real part of a generic vector;

Im(…) the operator that returns the imaginary part of a generic vector;

k the earth to phase adaptation coefficient - (necessary for expressing the earth ADC points in phase ADC points) amounting to:

$$k = \frac{In \cdot KI_{ADC}}{I0n \cdot KI0_{ADC}} \cdot \frac{CT_I0n}{CT_In}$$

The real and imaginary part of the derived current vectors, expressed in ADC points, will be given by:

I0c	**Error! Objects cannot be created from editing field codes.**

5.2.17.5 PHASE AND EARTH CURRENT - VOLTAGE ANGLE MEASUREMENT

The instantaneous angle between the generic phase current and the phase-phase quadrature voltage, to be used for protection purposes is obtained as the relative angle between the involved vectors.

The formulas are:

$$I_A \hat{} U_{BC} = \text{arctg}\left(\frac{\text{Re}(\vec{I}_A)}{\text{Im}(\vec{I}_A)}\right) - \text{arctg}\left(\frac{\text{Re}(\vec{U}_{BC})}{\text{Im}(\vec{U}_{BC})}\right)$$

$$I_B \hat{} U_{CA} = \text{arctg}\left(\frac{\text{Re}(\vec{I}_B)}{\text{Im}(\vec{I}_B)}\right) - \text{arctg}\left(\frac{\text{Re}(\vec{U}_{CA})}{\text{Im}(\vec{U}_{CA})}\right)$$

$$I_C \hat{} U_{AB} = \text{arctg}\left(\frac{\text{Re}(\vec{I}_C)}{\text{Im}(\vec{I}_C)}\right) - \text{arctg}\left(\frac{\text{Re}(\vec{U}_{AB})}{\text{Im}(\vec{U}_{AB})}\right)$$

Where:

I^U is the angle between the generic phase current and the phase-phase quadrature voltage;

$\vec{I}$ is the generic current vector;

$\vec{U}$ is the generic voltage vector (phase-phase);

Re(…) is the operator that returns the real part of a generic vector;

Im(…) is the operator that returns the imaginary part of a generic vector;

5.2.17.6 ACTIVE EARTH POWER

With any type of phase voltage insertion it is always possible to derive the vectors of the earth voltage's fundamentals that, together with the earth current, allow the active earth power calculation.

$$Po = \mathrm{Re}(\vec{I}o)\cdot\mathrm{Re}(\vec{U}o) + \mathrm{Im}(\vec{I}o)\cdot\mathrm{Im}(\vec{U}o)$$

Where Po is the active earth power expressed in ADC points.

5.2.17.7 ACTIVE THREE-PHASE POWER

With any type of phase voltage insertion it is always possible to derive the vectors of the phase-phase voltage's fundamental.

Therefore, it is quite easy to calculate the 3 phase active power by using the Aaron method:

$$P = \mathrm{Re}(\vec{I}_A)\cdot\mathrm{Re}(\vec{U}_{AB}) + \mathrm{Im}(\vec{I}_A)\cdot\mathrm{Im}(\vec{U}_{AB}) - \mathrm{Re}(\vec{I}_C)\cdot\mathrm{Re}(\vec{U}_{BC}) - \mathrm{Im}(\vec{I}_C)\cdot\mathrm{Im}(\vec{U}_{BC})$$

$$P'' = \frac{P}{\sqrt{3}\cdot KI_{ADC}\cdot KU_{ADC}\cdot Un}$$

$$P' = InTA\cdot UnTV\cdot P'' = \frac{CT_In\cdot VT_Un}{\sqrt{3}\cdot KI_{ADC}\cdot KU_{ADC}\cdot Un}P$$

P is the active three phase power expressed in ADC points;

Pn is the nominal three phase power to the secondary side, amounting to: $Pn = \sqrt{3}\cdot In\cdot Un$

Since In and Un are respectively the nominal current and the voltage to the secondary side;

P" is the active three phase power to the secondary side, expressed in Watt;

P' is the active three phase power to the primary side expressed in Watt;

5.2.17.8 REACTIVE THREE-PHASE POWER

With whatever type of phase voltage insertion, it is always possible to draw the vectors of the phase-phase voltage's fundamental.

Therefore, it is easy to calculate the reactive three-phase power by using the Aaron method; the formulas are:

$$Q = \mathrm{Im}(\vec{I}_A)\cdot\mathrm{Re}(\vec{U}_{AB}) - \mathrm{Re}(\vec{I}_A)\cdot\mathrm{Im}(\vec{U}_{AB}) - \mathrm{Im}(\vec{I}_C)\cdot\mathrm{Re}(\vec{U}_{BC}) + \mathrm{Re}(\vec{I}_C)\cdot\mathrm{Im}(\vec{U}_{BC})$$

$$Q'' = \frac{Q}{\sqrt{3}\cdot KI_{ADC}\cdot KU_{ADC}\cdot Un}$$

$$Q' = InTA\cdot UnTV\cdot Q'' = \frac{InTA\cdot UnTV}{\sqrt{3}\cdot KI_{ADC}\cdot KU_{ADC}\cdot Un}Q$$

Where:

Q is the three phase reactive power expressed in ADC points;

Qn is the nominal three phase active power to the secondary side, amounting to: $Qn = \sqrt{3}\cdot In\cdot Un$

Since In and Un are respectively the nominal current and the voltage to the secondary side;

Q" is the active three phase power to the secondary side, expressed in Qn;

Q' is the active three phase power to the primary side expressed in VAR;

5.2.17.9 POWER FACTOR

The power factor is an instantaneous value, used only for visualising purposes. Indicated by:

P the three-phase active power expressed in ADC points;

Q the three-phase reactive power expressed in ADC points;

The power factor, or three phase cosϕ, is calculated according to the following algebraic function:

$$\cos\phi = \frac{|P|}{\sqrt{P^2 + Q^2}}$$

The sign of three phases cosϕ is determined according to the following conventions:

	P positive	P negative
Q positive	+L	-C
Q negative	+C	-L

5.2.17.10 THERMAL STATUS

It can be demonstrated that, for dt=0.02s, the thermal status can be estimated according to the following equation:

$$\theta(t+dt) = \theta(t) + \left(\frac{IMAX}{I_\theta}\right)^2 \frac{dt}{\tau} - \theta(t)\frac{dt}{\tau}$$

Where:

IMAX is the highest of the three instantaneous values of the three phase RMS currents.

τ is the thermal constant of the device to be protected.

Iθ is the base current of the device to be protected (ratio between the device's nominal current – in other words the current that, at full operation, implies over-temperature by 100% - and the nominal current of the TA).

Iθ = K * Ith

θ is the thermal status or over-temperature of the device (over-temperature in p.u. in relation to the temperature reached by the device at full operation, when subjected to a current equal to the base current).

The thermal status must reside in a non-volatile variable (SRAM) to allow its recovery in the event of an auxiliary voltage loss.

To avoid the unwanted trip of the thermal protection, on power-on, the thermal status is reinstated up to a maximum equalling 90% of the greater between the thermal thresholds to then evolve normally according to the above equation.

The thermal status can be reset (θ(t) = 0) through a PPC CO.

5.2.18 FOCUS 4: ALL MEASUREMENT VALUES: THRESHOLD DETECTION THROUGH TRANSMISSION

The process of a measurement value shows as follows:

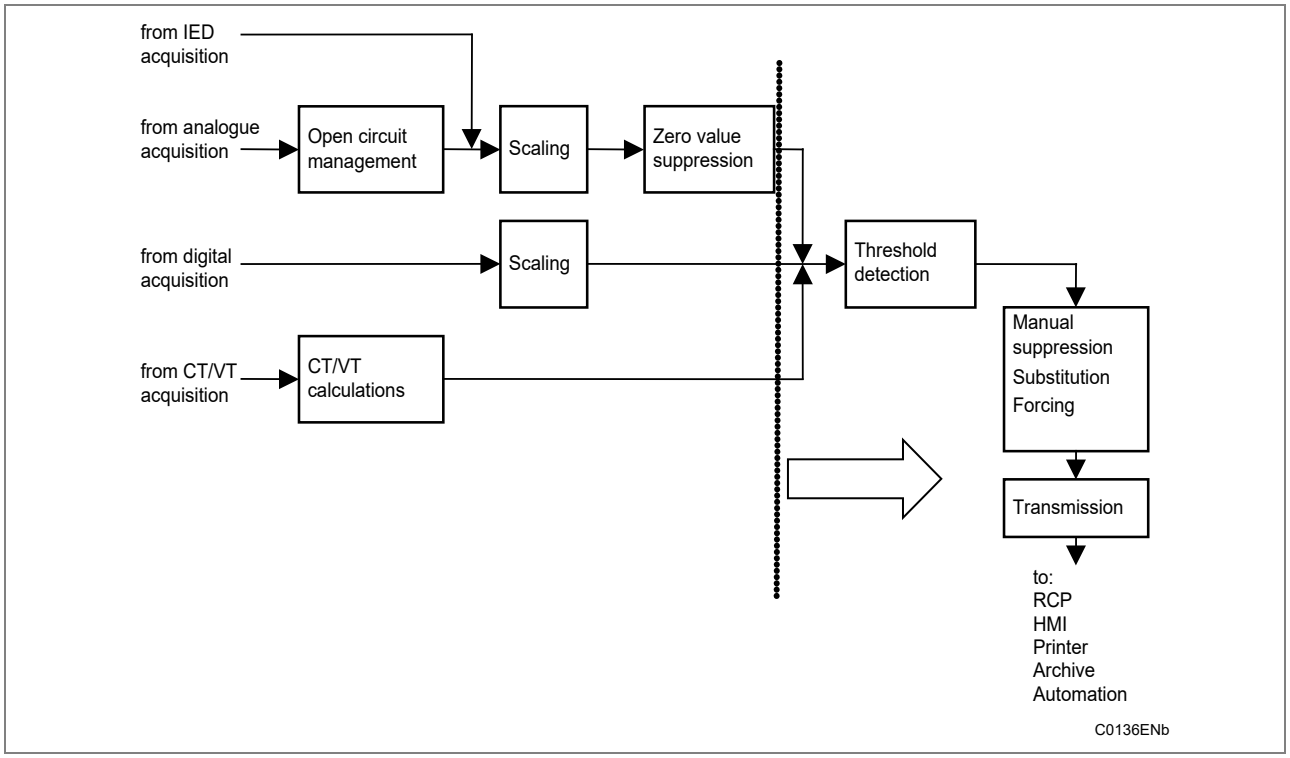


Figure 38: Process of a measurement value

Six thresholds can be defined for each measurement: 3 upper thresholds and 3 lower thresholds.

A hysteresis value configured on a per measurement basis is associated to the threshold management. This value is a percentage of the full scale value of the measurement.

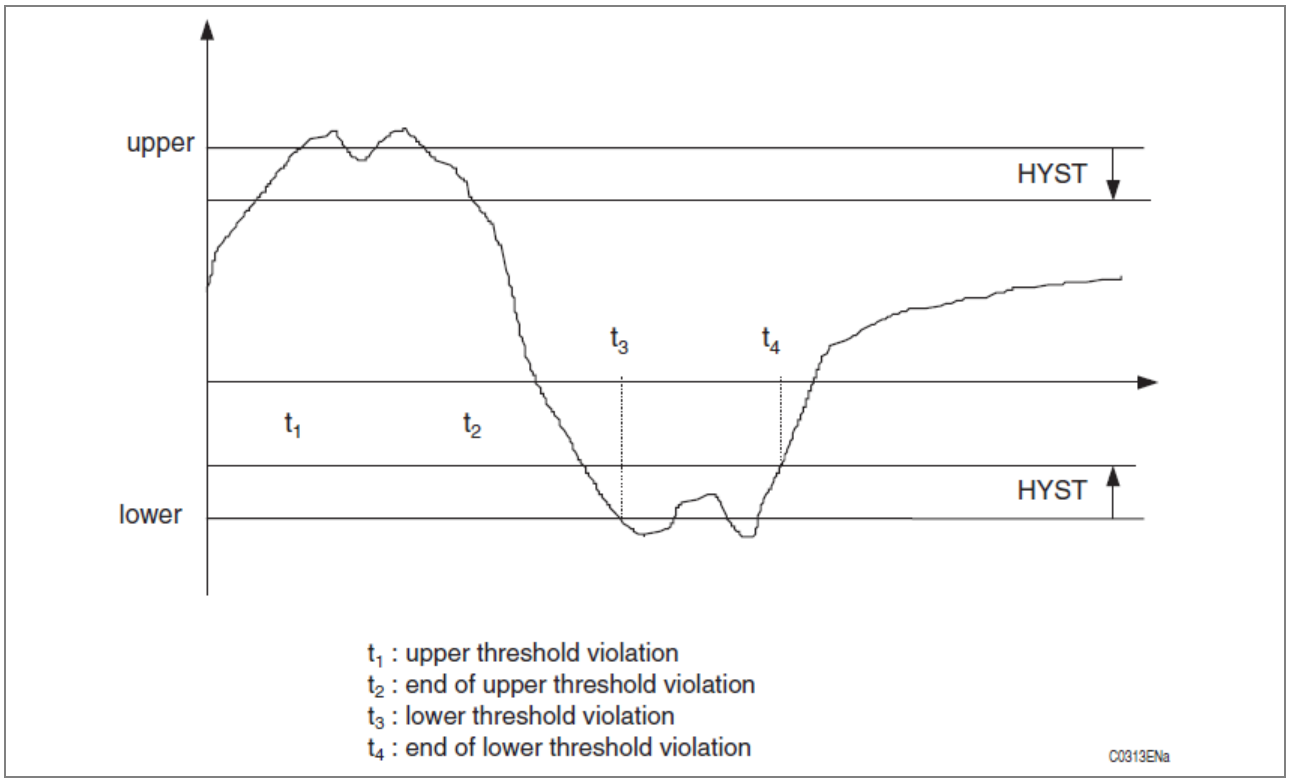


Figure 39: Threshold detection

5.2.19 MANUAL SUPPRESSION

A measurement can be assigned to the SUPPRESSED state by an order issued from an operator. No subsequent change of value or state on a "SUPPRESSED" measurement can trigger any action: for example, display, alarm, transmission. The measurement takes the SUPPRESSED state. When the operator "un-suppresses" the measurement, this one takes its actual state.

5.2.20 SUBSTITUTION

The value of a measurement can be substituted by an operator (state “SUBSTITUTED”, value defined by the operator). The measurement stays in this state until he un-substitutes it.

When a measurement is substituted, no change of value nor state is transmitted, and computations are made with the substituted state. When the measurement is un-substituted, the actual state and value are transmitted to higher control levels and subsequent changes of state and value are transmitted again.

5.2.21 FORCING AN INVALID MEASUREMENT

When a measurement is invalid: that is, SELFCHECK FAULTY, UNDEFINED, OPEN CIRCUIT, SATURATED or UNKNOWN); it can be manually forced by a user (state “FORCED”, value defined by the operator). This feature is similar to the substitution but the information is automatically updated when valid information is available again.

The forcing could also be automatic: in this event, the invalid information takes automatically the FORCED state and the value defined in configuration.

The forced/substituted data are saved in SRAM (kept for minimum 48h without C26x power supply).

The modified states are not reset by a C26x reboot.

A database switch (or evolution) reset the forced/substituted data.

5.2.22 MEASUREMENT RESULTING STATES

The Measurement resulting states, following the various filters, that you can apply include:

State	Meaning
VALID	Not in one of the following states
SELFCHECK FAULTY	AI, DI board fault
SUBSTITUTED	Operator action set MV value as valid state
FORCED	Automatic valid state and configured value when AI is invalid
SUPPRESSED	Operator set MV in this invalid state
UNKNOWN	MV is acquired via a transmission link, and the link is disconnected
SATURATED	MV is beyond its nominal input range
UNDEFINED	MV is Digital Measurement with invalid coding or computation on analogue leads to error
OPEN CIRCUIT	MV is DC 4-20 mA with input value under 4mA
OVERSHOOT[1..3]	One of the 3 overshoot values has been crossed
UNDERSHOOT[1..3]	One of the 3 undershoot values has been crossed

5.2.23 TRANSMISSION

The measurement value and state are transmitted on the Ethernet IEC 61850 network, using two modes:

- **Report based mode** (client-server): the measurement is transmitted to the subscribers with its value, its status, its time stamping and the reason for change.
- **GOOSE based mode (only on IEC 61850-8-1 network)** (subscriber-publisher): the measurement is transmitted in multicast to the configured receivers.

Notes

- A C26x client can have 32 numbers of IEC 61850-8-1 servers and a C26x server can have 16 numbers of IEC 61850-8-1 clients
- GOOSE size is restricted to 128 binary inputs and 64 measurements

During a loss of communication between a client and a server, all server measurements are set to UNKNOWN on the client.

The measurement information transmitted in a report include:

- The real value: that is, after scaling
- The resulting state: mapped on the quality field on IEC 61850-8-1
- The time stamping: in GMT time; and time quality
- The reason for the change:
  - Change of quality: set if the measurement resulting state has changed
  - Cyclic change: set if the measurement value has changed, without modification of the resulting state

A Measurement value can be transmitted periodically or upon variation (% of nominal), and anyway on state change.

5.2.23.1 PERIODIC TRANSMISSION

Two periods are defined in database, independently for each C26x:

- a short period, settable from *0* to *60* seconds (step 0.1 second),
- a long period, defined as an integer multiple of the short period, from *0* to *600* x the short period's duration.

Setting a period to *0* means periodic transmission is disabled:

- for both short and long periods if it is the short period
- for the long period only if it is the only one set to *0*

Each measurement is associated with either one of the two periods. All the measurements associated with a period are transmitted at the beginning of each cycle.

All the measurements values transmitted within one transmission cycle are the most recently acquired values.

5.2.23.2 TRANSMISSION UPON VARIATION

Measurements can be transmitted upon variation: a value is sent if the acquired value (Vacq) is different from more than a specified amount **ΔV** from the previously transmitted value (**Vt**) (i.e |Vacq-Vt| > ΔV).

ΔV is computed either from the last transmitted value (mode 1) or from the full scale value (mode 2):

ΔV = (p/1000) * |Vt| where **p** is a value in the range 0 .. 255 and **Vt** is the last transmitted value.

or

ΔV = (p/1000) * |Vmax| where **p** is a value in the range 0 .. 255 and **Vmax** is the full scale value.

5.2.23.3 TRANSMISSION UPON TRIGGER

One or more measurements can be associated to a single or double BI “trigger”. When the BI goes to the state SET / CLOSED (or FORCED SET, SUBSTITUTED SET, FORCED CLOSED / SUBSTITUTED CLOSED) all associated measurements are transmitted immediately. The same behaviour if the BI is in this state at the initialisation of the controller. As much the BI is in this state the associated measurements are transmitted after change of state or according to the configuration (periodically, upon variation, threshold variation)

5.3 TAP POSITION INDICATION (TPI) MEASUREMENT PROCESSING

5.3.1 ACQUISITION FROM DIGITAL INPUTS

The tap position is acquired on digital input boards. It could be:

- A Multiple Point , if so, the resulting states are considered as values
- A digital measurement using one of the following encoding:
  - Decimal
  - Gray
  - BCD

5.3.2 ACQUISITION FROM ANALOGUE INPUTS

The tap position is acquired by measuring a current input.

A minimum value, Imin (mA), corresponds to the lowest position, 1, of the tap, and a maximum value, Imax, corresponds to the highest value, N.

The input current should take only discrete values: Ik =Imin + (K -1)(Imax-Imin)/(N-1) , where K is the position of the tap.

However the tap is assumed in position K if the current is in the range [Ik-ΔI/2 .. Ik+ΔI/2], with ΔI = N% of (Imax – Imin). The N percentage is defined in configuration.

The tap position is considered UNDEFINED outside of this range.

5.3.3 MANUAL SUPPRESSION

A TPI can be suppressed by an order issued from an operator. No subsequent change of value or state on a suppressed TPI can trigger any action: for example, display, alarm, transmission. The TPI takes the “SUPPRESSED” state. When the operator unsuppresses the TPI, the latter takes its actual state.

5.3.4 SUBSTITUTION

The value of a TPI can be substitute by an operator (state “SUBSTITUTED”, value defined by the operator). The TPI stays in this state until he unsubstitutes it.

When a TPI is substituted, no changes of value nor state is transmitted, and computations, for instance groupings, are made with the substituted state. When the TPI is unsubstituted, the actual state and value are transmitted to higher control levels and subsequent changes of state and value are transmitted again.

5.3.5 FORCING AN INVALID TPI

When a TPI is invalid: that is, SELFCHECK FAULTY, UNDEFINED or UNKNOWN; it can be manually forced by a user (the “FORCED” state value is defined by the operator). This feature is similar to substitution but the indication is automatically updated when valid information is available again.

The automatic forcing function is not provided for TPI.

5.3.6 TPI RESULTING STATES

The state of a tap position can be:

State	Comment
VALID	NOT in one of the following states:
SELFCHECK FAULTY	Results from a fault on an AI board or on a DI board
SUBSTITUTED	See section Substitution above
FORCED	See section Forcing an invalid TPI above
SUPPRESSED	See section Manual suppression above
UNKNOWN	If the tap position is acquired via a transmission link, the information is “unknown” when the link is disconnected.
UNDEFINED	Results from the erroneous encoding of a digital acquisition, a saturation, an open circuit or an out-of-range value for an analogue acquisition.
OVERSHOOT[1..3]	There are 3 “Overshoot” states, one for each high threshold crossing. Only one may be set at any one time
UNDERSHOOT[1..3]	There are 3 “Undershoot” states, one for each low threshold crossing. Only one may be set at any one time

5.3.7 SCALING

The TPI value is transmitted as a scaled value rather than as a direct measurement.

The true value of the measurement is computed using a linear, single-slope transform:

TPI value = **ax + b**

where:

- x = measured tap position
- a and b = integer numbers, settable using DS Agile SCE (see chapter C26x/EN AP).

The scaled value is transmitted to the substation's control point (system HMI: OI or aView) and to the SCADA.

5.3.8 TRANSMISSION

The TPIs are transmitted on a client-server basis over the IEC 61850-8-1 network using the report mechanism.

During a loss of communication between a client and a server, all server TPIs are set to UNKNOWN on the client.

A TPI is transmitted as soon as a value change or a status change is detected. The TPIs transmitted in a report are:

- TPI value
- Resulting state: mapped on the quality field for IEC 61850-8-1
- Time-stamping: in GMT time; and time quality
- Reason for the change:
  - Change of data: set if the value changed
  - Change of quality: set if the quality changed
  - Change due to control: set if the state or quality change is due to a control

The TPI information transmitted in a GOOSE is the same as in a report, except for the "reason for change" and time-stamping.

5.4 ACCUMULATOR INPUT PROCESSING

The accumulator stores its current value in a static memory volatile memory (secured with a capacitor, >48h autonomy). At configured sample an accumulated value is extracted for inner computation and transmission (Common Data Class BCR on IEC 61850-8-1).

Digital Inputs are used to count pulses. There is Single counter (SCT) based on one DI and Double Counter (DCT) based on two DIs that count complementary states.

At processing level special persistent and complementary filters eliminate non-stable pulses. The integer counter (also transmitted) can be scaled (among of energy of valid pulse).

5.5 ENERGY COUNTING

The energy counting function aims to calculate exported and imported active energy (in kWh) and exported and imported reactive energy (in kVarh) from active and reactive power issued from CT/VT calculation, digital, analogue boards measurements or IEDs measurements.

Calculation of the energy is done periodically. The period is defined by the internal clock of the controller. The choice of the origin of the periodic signal is defined during the configuration phase on a per controller basis.

Whatever is the origin of an integrated measurement, the integration is done after scaling with a step of one second.

The trapezium integration method is used:

$$E = \sum E_i$$

$$E_i = S_f * \left(\frac{(M_i + M_{i-1})}{2} * \frac{(t_i - t_{i-1})}{3600} \right)$$

Where:

E = total Energy counter value (continuous register)

E_i = Integration result at time t_i

S_f = Scaling Factor (defined during the configuration phase)

M_i = absolute value of the Measurement at time t_i

$t_i - t_{i-1}$ = 1 second

For a given measurement, the integration can be done only after receiving two consecutive valid values with the same sign of the measurement. The integration result (E_i) is added to the associated export or import counter according to the sign of the measurement.

The integration is stopped as soon as the power measurement becomes invalid or changes of sign. The integration is restarted as soon as two consecutive valid measurement values with the same sign are received.

Current values of energy counters are stored in secured memory (48h autonomy when power supply is off). Current values of energy counters can be modified by an operator.

Values of energy counters are transmitted on a client-server basis on the IEC 61850-8-1 network using mechanism through the LN MMTR.

During a loss of communication between a client and a server, all server energy counters are set to UNKNOWN state on the client.

Note:
Do not use the energy counter values for the billing application.

5.6 BASIC DATA HANDLING

5.6.1 TEST MODE ENHANCEMENTS

The C26x Test Mode allows you to deactivate the DOU/CCU/HBU relays output in the event of a control sequence.

The enhancements allow to:

- manage the Test Mode in the event of a C26x redundancy (Test Mode is managed only if the controller is in active mode, so a controller in standby mode cannot be switched to Test Mode)
- manage the control feedback datapoints

In the event of a controller redundancy, the Test Mode activation is performed independently for each C26x (Main 1 rack and Main 2 rack) from SMT. If the Active C26x is set in Test Mode, it remains Active. A Standby C26x cannot be switched to Test Mode.

If the control is related to a datapoint: that is, feedback datapoint defined in configuration; this one takes the control value in Test Mode:

- Open / Reset order => Open state for DPS, Reset state for SPS
- Close / Set order => Close state for DPS, Set state for SPS

To leave the Test mode, the user, through the SMT, changes the C26x mode to Operational. The C26x automatically goes in Maintenance mode (transient) before going in Operational mode.

The user of the Test Mode owns all responsibility of controls performed during the Test Mode, and before leaving the Test Mode, he owns all responsibility to restore the system. In Test Mode, all controls performed may impact IsaGRAF programs or PSL automatisms.

Note 1:
Digital and Analogue Setpoint with measurement feedback are not managed in Test Mode: that is, they are managed as in Operational mode.
Note 2:
IEC 61850-8-1 exchanges (reports, gooses) are not impacted by the C26x Test Mode. That means that a control done in Test Mode, that is sent to another controller - that is not in test mode - or to an IED (legacy or not) may be fully and physically executed on the device.

5.6.2 DEVICE ORDER RUNNING

An "order running" SPS is managed on a per module basis. The “bay order running” is still managed.

In the event of a Direct Execute control, this SPS is:

- SET as soon as the C26x accepts the control: that is, after the control checks
- RESET when the final control acknowledgement is sent

In the event of an SBO control, this SPS is:

- SET as soon as the C26x accepts the control selection: that is, after the selection checks
- RESET when the final control acknowledgement is sent

5.6.3 CURRENT EXECUTION STATUS SPS FOR OPEN/CLOSE CONTROL COMMANDS

Optional SPS datapoints are available to indicate the current execution status of switchgear open and close **DPC** control commands: **Open ctrl SPS** for open commands and **Close ctrl SPS** for close commands.

In the event of a Direct Execute control, this SPS is:

- SET as soon as the execute control is received by the C26x: that is, before the checks
- RESET when the final control acknowledgement is sent

In the event of an SBO control, this SPS is:

- SET as soon as the control selection is received by the C26x: that is, before the checks
- RESET when the final control acknowledgement is sent

In the event of a direct negative acknowledgement, these SPS may be SET, then RESET with the same time stamp.

5.6.4 OPEN/CLOSE COMMAND STATE SPS DATAPOINTS FOR C26X OUTPUT CONTACTS

Output contacts used to transmit SPC commands

One SPS is available to indicate the open and closed states of a contact. It can be assigned to SPC controls.

on/off order SPS:

- SET when the contact to which the operate command is wired is in closed position
- RESET when the contact to which the operate command is wired is in open position

Output contacts used to transmit DPC commands

Two SPS are available to indicate the open and closed states of contacts. They can be assigned to DPC controls.

Close order SPS:

- SET when the contact to which the close command is wired is in closed position
- RESET when the contact to which the close command is wired is in open position

Open order SPS:

- SET when the contact to which the open command is wired is in closed position
- RESET when the contact o which the open command is wired is in open position

Note:
These SPS datapoints reflect their associated SPC/DPC states only if the latter are "wired" to output contacts on a C26x.

5.6.5 CONTROLS MANAGEMENT FROM PSL

A control issued from a PSL (or a DI/DO association) will be accepted even if another control is already running on the same output. In this event, the previous control is stopped and the new control is launched (except if the new one is the same command as the previous one: in that case, the new control is refused).

There are three ways to manage this. PSL refers to FBD or DI/DO association, and Operator refers to IEC 61850-8-1 / ISAGRAF / local front panel HMI:

- Control 1 from PSL and Control 2 from Operator
- Control 1 from Operator and Control 2 from PSL
- Control 1 from PSL and Control 2 from PSL

The event "Control 1 from Operator and Control 2 from Operator" is already managed: in this event, the control 2 is rejected.

Events – Control 2 different from Control 1

Control 1	Control 2	Action	Acknowledgement
PSL	Operator	Control 1 cancelled	n/a (no ack managed in PSL)
Operator	PSL	Control 1 cancelled	Ack “Operator cancel”
PSL	PSL	Control 1 cancelled	n/a (no ack managed in PSL)
Operator	Operator	Control 2 ignored	Ack “Control in progress”

Events – Control 2 identical to Control 1

Control 1	Control 2	Action	Acknowledgement
PSL	Operator	Control 2 ignored	Ack “Control in progress”
Operator	PSL	Control 2 ignored	n/a (no ack managed in PSL)
PSL	PSL	Control 2 ignored	n/a (no ack managed in PSL)
Operator	Operator	Control 2 ignored	Ack “Control in progress”

5.6.6 CAVEAT: PSL AND REDUNDANT OPERATION

C26x A is in active mode and C26x B is in standby mode. On the system HMI, the operator uses C26x DI operation mimics and applies input to the PSL. After the Timer time (T-ON is equal to 20 seconds), these events occur:

The FBD output, an SPS on C26x A/B, goes to the SET position

- FBD output 1, an SPC wired on DO of A/B and looped to DI for feedback, goes to the SET position
- FBD output 2, an SPC wired on DO of A/B and looped to DI for feedback, goes to the SET position

When C26x B goes into active mode and C26x A goes into standby mode, these events occur:

- The FBD output 1 (SPC) and the FBD output 2 (SPC) stay in the SET position
- The FBD Output (SPS) goes to the RESET position for the Timer time (T-ON is equal to 20 seconds).

After this time, the FBD Output (SPS) goes to the SET position.

When you use DS Agile S1 to modify the time of the timer, the FBD Output (SPS) goes to the RESET position. It stays in the RESET position for the modified time and then goes to the SET position.

When C26x A goes into the Faulty mode and C26x B goes into the active mode, the FBD Output (SPS) goes to the RESET position for the duration equal to the Timer time. Then the FBD Output (SPS) goes to the SET position. The FBD Output 1 (SPC) and FBD Output 2 (SPC) stay in the SET position.

6 CONTROL SEQUENCES

6.1 DESCRIPTION

A Control Sequence is a basic built-in function on a module (switch, relay, and function). It receives control order, sending back acknowledgement. After checks, control sequence sends control (protocol or DO), and check correct execution with feed back from protocol or from DI.

6.1.1 GENERAL

The C26x allows the following functions:

- Control of switching devices (circuit-breaker, disconnector, …)
- Control of transformers
- Control of secondary devices
- Locking of switching devices
- Control of IEDs
- Control of automatisms

These types of controls are allowed:

- Select control request
- Execute control request
- Unselect control request
- Cancel control request

Upon reception of one of these requests, the controller's behaviour varies according to:

- The configuration of the device control,
- The type of the device,
- The controller operating mode.

6.1.1.1 DEVICE CONTROL CONFIGURATION

By configuration, at SCE level, a control may be executed in one of the following modes:

- "**Direct Execute**" mode: usually for ancillary devices a control may be performed directly without the selection phase.
- "**Select Before Operate once**" mode" (**SBO once**): usually for circuits breakers and disconnectors. The device must be selected before allowing the execution. In that event the device is managed in two phases: selection and execution. Device unselection is done automatically by the controller.
- "**Select Before Operate many**" (**SBO many**): usually for transformers. The device must be selected before execute one or more controls before reaching the expected position (low/raise). In that event the device is managed in three phases: selection, execution and unselection. The execution phase is repeated for every new control. To end the controls sequence, the initiator of the request must send an "unselection" request.
- By configuration, each DPC order (close order or open order) and each SPC can activate simultaneously two DO contacts.

6.1.1.2 TYPES OF DEVICES

Every control sequence may be different according to the type of the device to control. The complexity of the control sequence may be more or less important depending on the device:

- Synchronised or non synchronised circuit-breakers, disconnectors and earthing switches: They are managed in **"Direct execute"** mode or **"SBO once"** mode with optional hardware selection of the device in SBO mode.
- Transformers: They are managed in the three modes: **"Direct Execute"**, **"SBO once"** and **"SBO many"** mode with optional hardware selection of the device in SBO mode.
- Ancillary devices: they are usually managed in **"Direct Execute"** mode but can be managed also in **"SBO once"** mode.
- System Controls: System outputs are used to activate or inactivate automatic functions on the controller: for example, Auto-recloser ON/OFF; change operating modes; and so on.
- Controls via Setpoints: are managed in **"Direct Execute"** mode and in **"Direct Execute with SBO popup"** mode.

6.1.2 CONTROL SEQUENCE PHASE MANAGEMENT

According to the configuration of the device control, a control sequence is performed in one, two, or three phases. Each phase of a control sequence (selection, execution and unselection) may have a normal or abnormal termination and positive or negative acknowledgement is sent to the IEC 61850-8-1 clients subscribed during the configuration process.

- **One phase – "Direct Execute" mode:**
  - **Execution phase**: If the execution phase ends normally the controller generates a positive acknowledgement and the control sequence ends. In the event of an abnormal termination, the control sequence is aborted and the controller generates a negative acknowledgement. The hardware selection of the device in "Direct Execute" mode is not permitted.
- **Two phases – "SBO once" mode:**
  - **Selection phase**: In the selection phase for a normal termination the controller generates a positive acknowledgement and proceeds to the next phase of the sequence (execution phase).
  - **Execution phase**: If the execution phase ends normally the controller generates a positive acknowledgement and the control sequence ends. In the event of an abnormal termination, the control sequence is aborted and the controller generates a negative acknowledgement.
- **Three phases – "SBO many" mode:**
  - **Selection phase**: In the selection phase for a normal termination the controller generates a positive acknowledgement and proceeds to the next phase of the sequence (execution phase)
  - **Execution phase**: If the execution phase ends normally the controller generates a positive acknowledgement and waits a new execution request. In the event of an abnormal termination, the control sequence is aborted and the controller generates a negative acknowledgement.
  - **Unselection phase**: The controller proceeds to the deselection of the device and ends control sequence sending positive acknowledgement. In the event of a failure, deselecting the device the controller sends a negative acknowledgement.

The following figures show the three control modes of the controller:

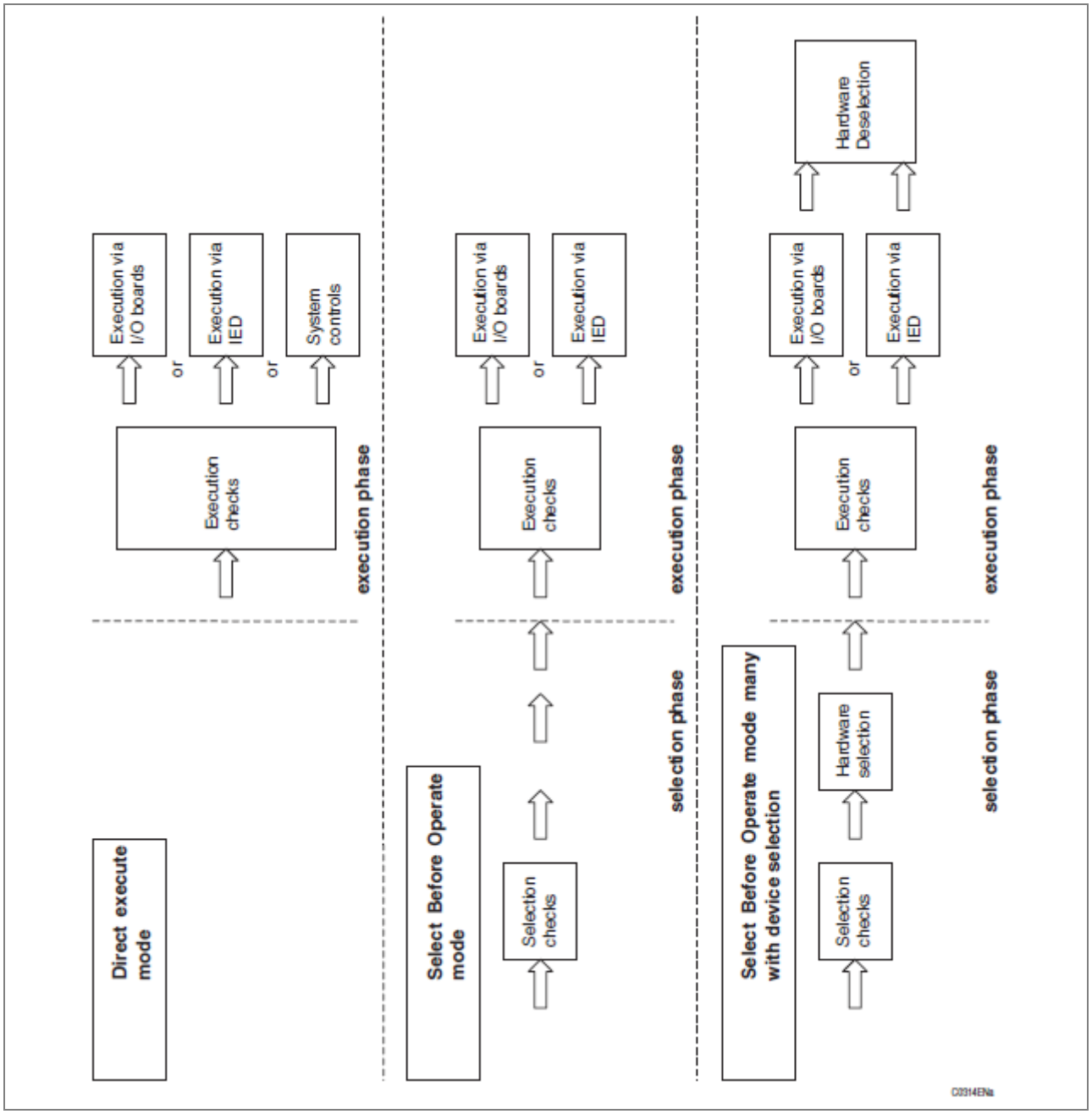


Figure 40: Control modes of the controller (1)

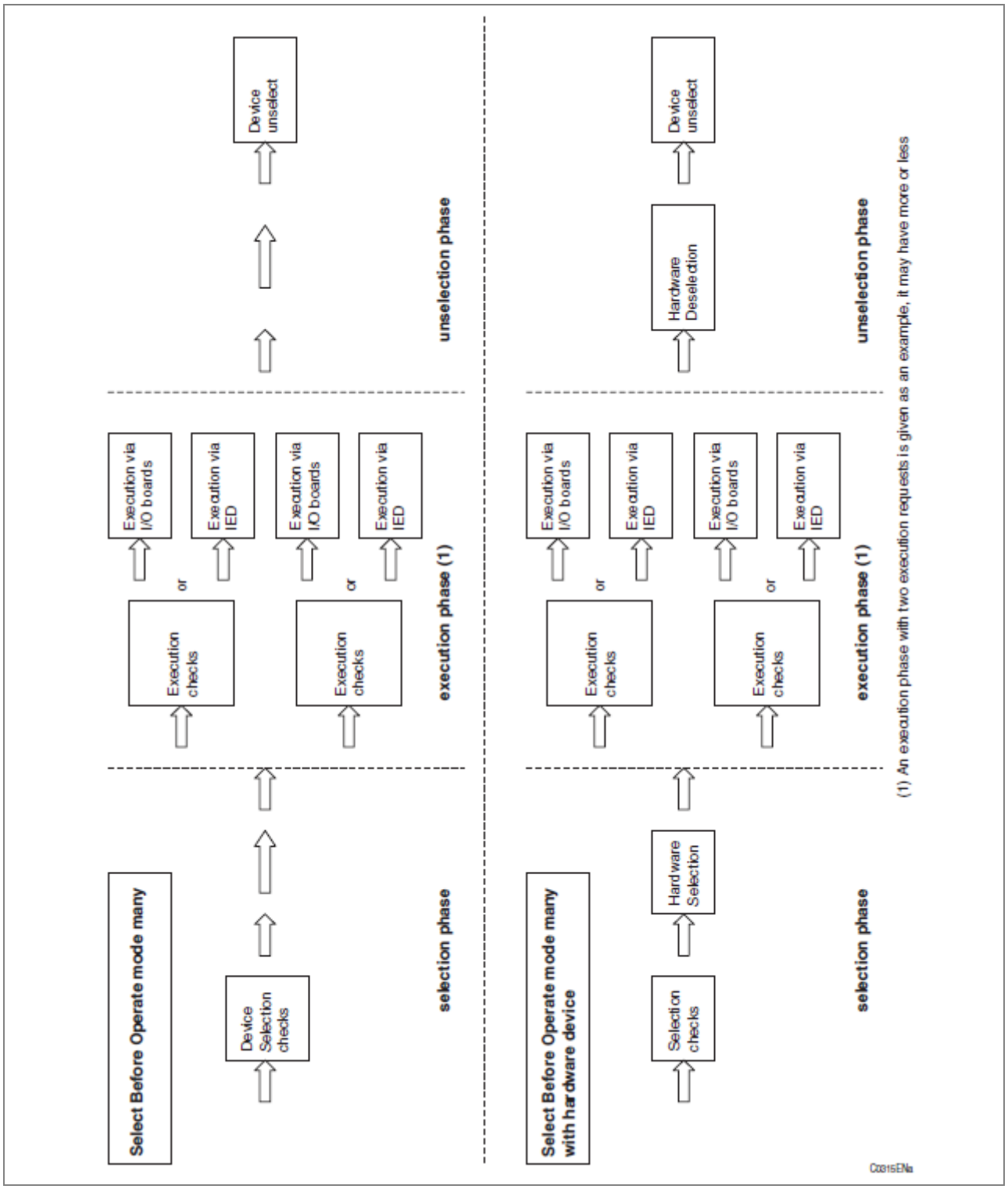


Figure 41: Control modes of the controller (2)

6.1.3 DIRECT EXECUTE MODE

In this mode a control of device is directly executed without need to be previously selected. Usually concerns ancillary devices managed via I/O boards (SPC, DPC, and Setpoints) or via IED.

The **"Direct Execute"** sequence ends normally after reception of the expected position information of the device or correct value (if setpoint control). Abnormally if the received position or value is unexpected, or not received in the predefined delay by configuration.

Note that a **"cancel"** request in **"Direct Execute"** mode has no guarantee to be performed before the execution of the request. An **"unselect"** request has no meaning in **"Direct Execute"** mode.

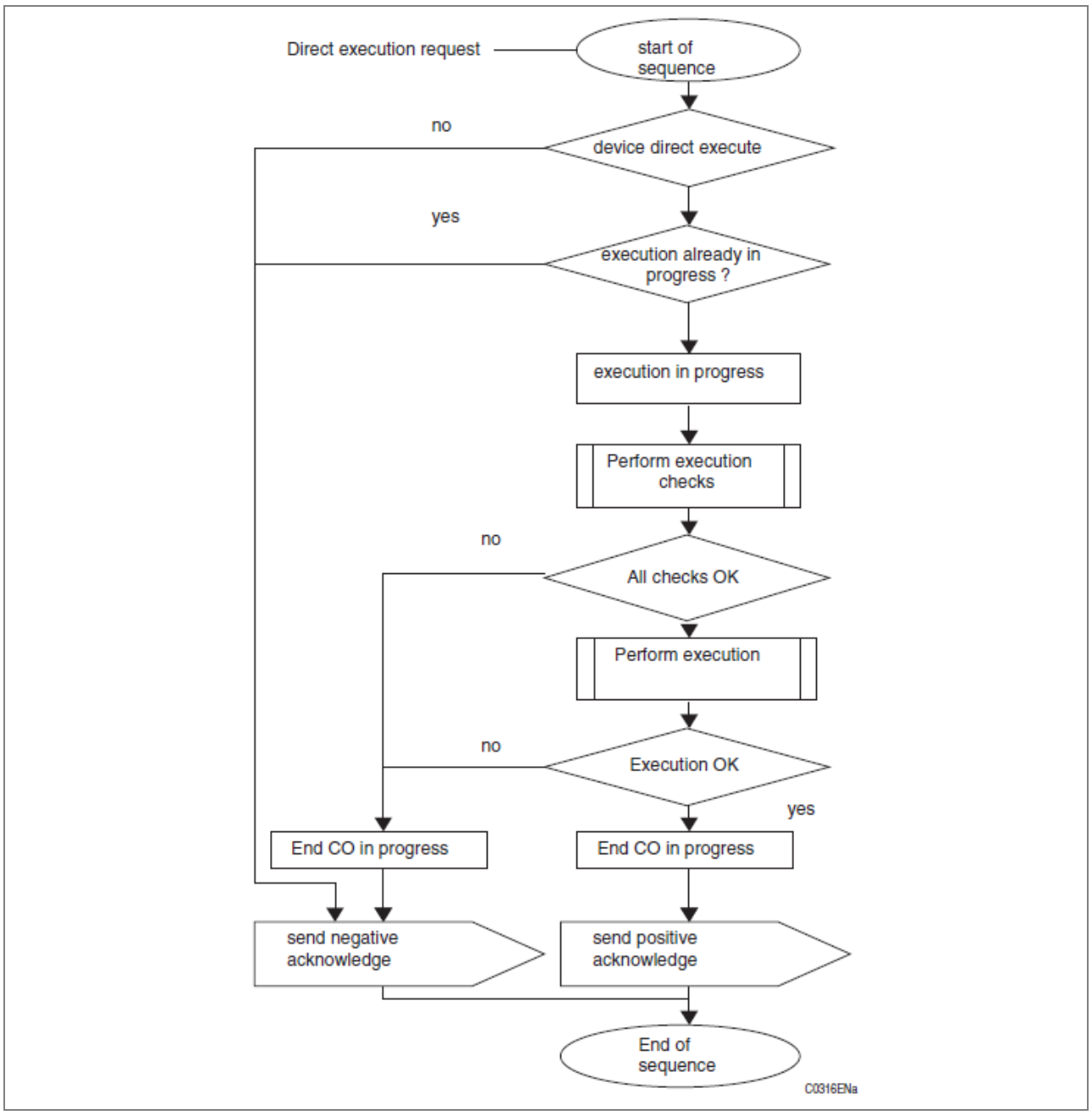


Figure 42: Execution phase for direct execute mode

6.1.4 SBO ONCE MODE

6.1.4.1 SELECTION PHASE IN “SBO ONCE” MODE

During the selection phase initialised by a selection request of the control, the controller performs selection checks in order to check whether the device is selectable or not.

If no fail occurs during these checks, the device is selected and positive acknowledgement is sent. Otherwise the selection request is refused and a negative acknowledgement is sent giving fails cause. If the selection of the device is accepted, the controller starts a delay and waits for:

- An execution request: open/close, low/raise
- A cancel of the selection request.

At the end of this delay if the execution or the cancel request is not sent, the device is automatically unselected and a negative acknowledgement is sent. The selection delay is defined during the configuration step.

Note that only one selection is permitted at a time for a device. When a device is already selected any other selection is not taken into account (none acknowledgement is sent) whichever of the initiator.

The diagram that follows shows the selection phase of a device configured in SBO once mode.

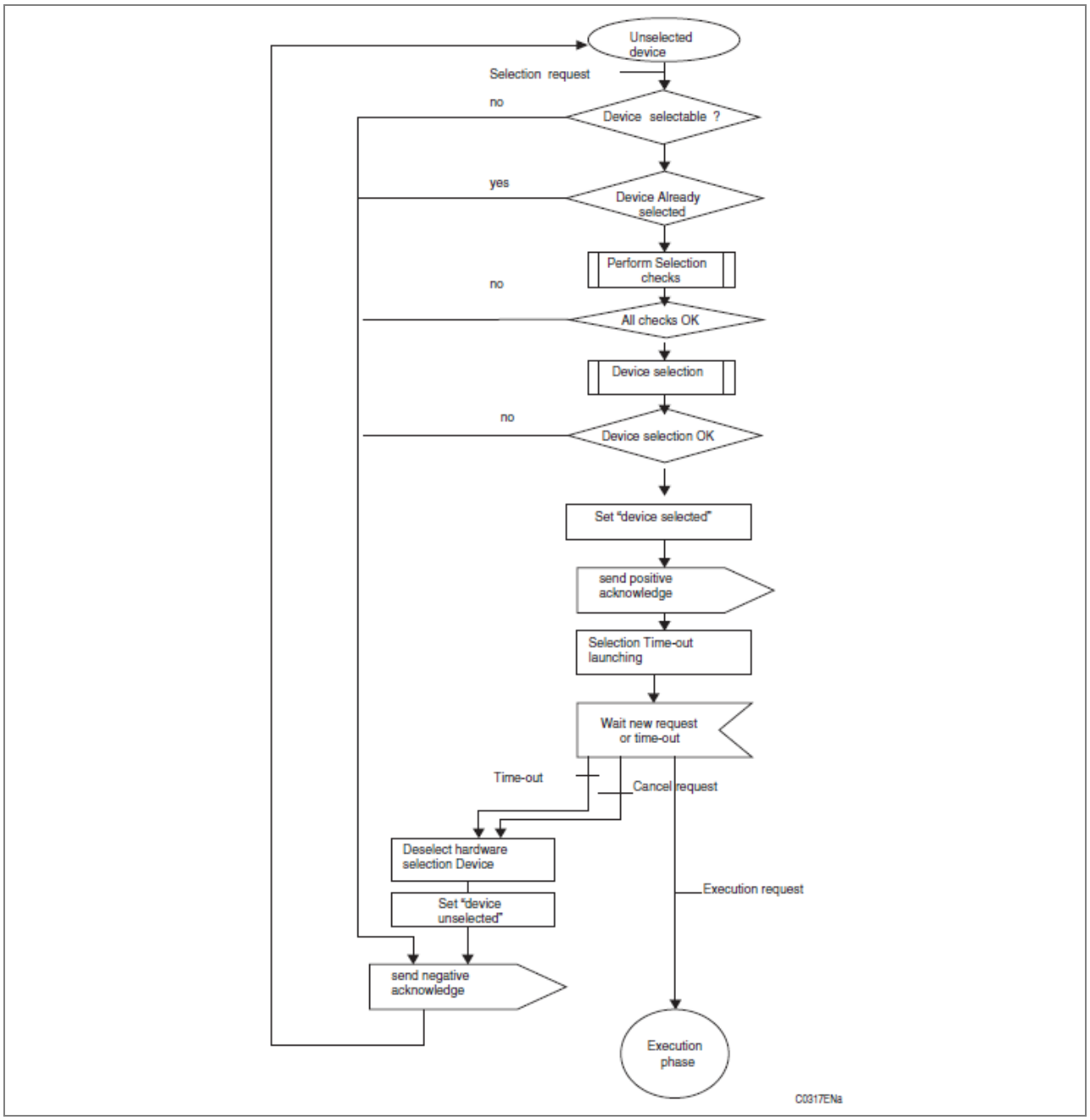


Figure 43: Selection phase in SBO once mode

6.1.4.2 EXECUTION PHASE IN "SBO ONCE" MODE

The execution phase can start only after reception of an execution request and if the device has been selected before.

In this phase, the controller performs the execution checks, and if no fail, it proceeds to the execution according to the configuration, via the IO boards or IED communication.

If the execution ends normally, a positive acknowledgement is sent, and the control sequence ends. In the event of a failure, the control sequence is aborted and the controller sends a negative acknowledgement.

During this phase a **"cancel"** request is not guaranteed except for synchronised circuit-breakers devices (refer to specifics treatments for synchronised circuit-breakers below).

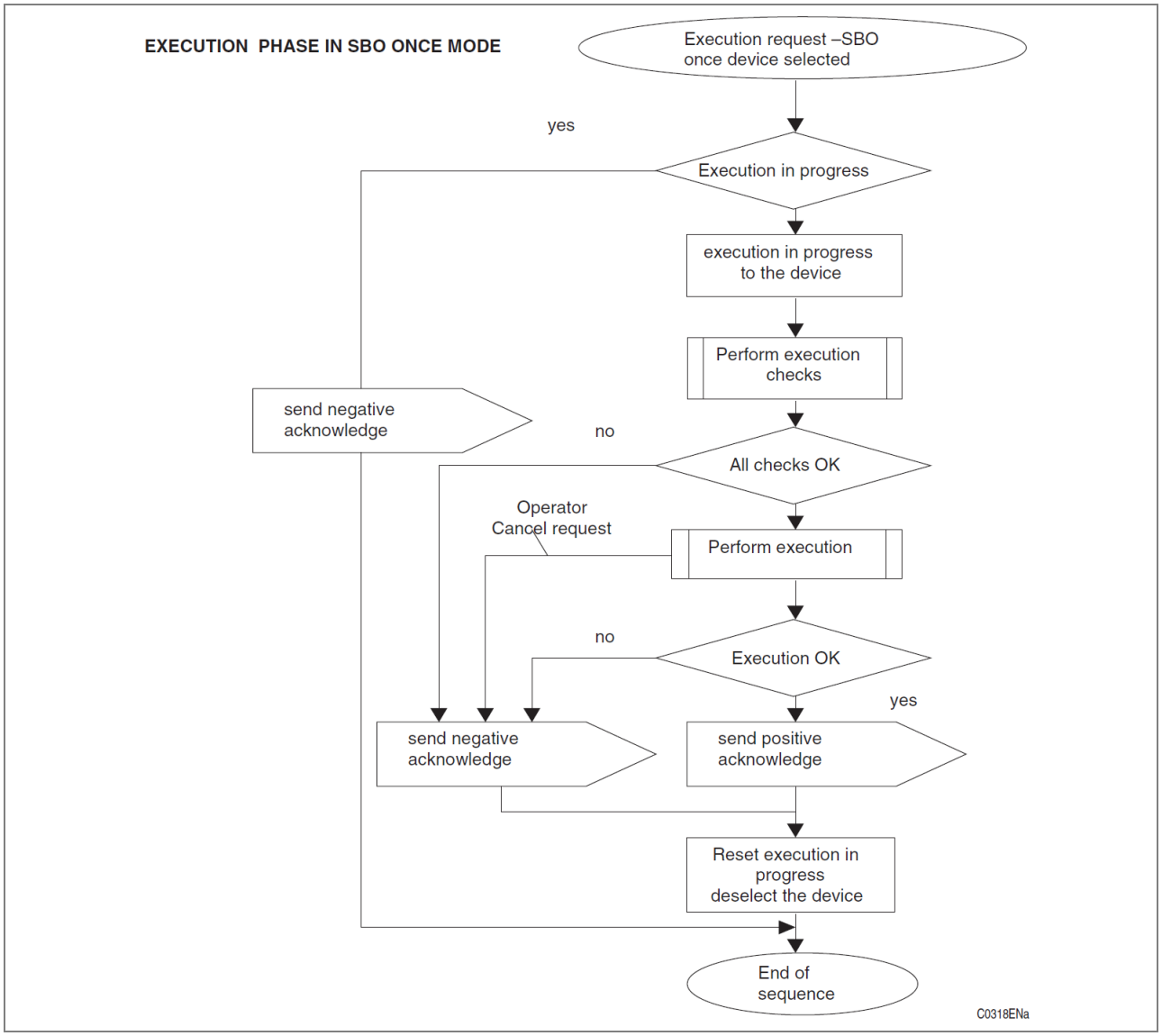


Figure 44: Execution phase on SBO once mode

6.1.5 SBO MANY MODE

This mode allows you to perform one or more control executions after the selection phase. It is usually used for the tap positioning process in where many controls are sent before reaching the desired position.

6.1.5.1 SELECTION PHASE IN SBO MANY MODE

The selection phase is identical to the “SBO once” mode selection phase.

6.1.5.2 EXECUTION PHASE IN SBO MANY MODE

The difference with the SBO once mode is that after having performed an “execution request”, the controller stays in execution phase waiting a new execution order or an **“unselect**” request. The execution phase ends only after an **“unselect**” request or **“cancel**” request by the initiator.

Upon reception of an **“unselect**” request the controller ends the execution phase and goes to the selection phase.

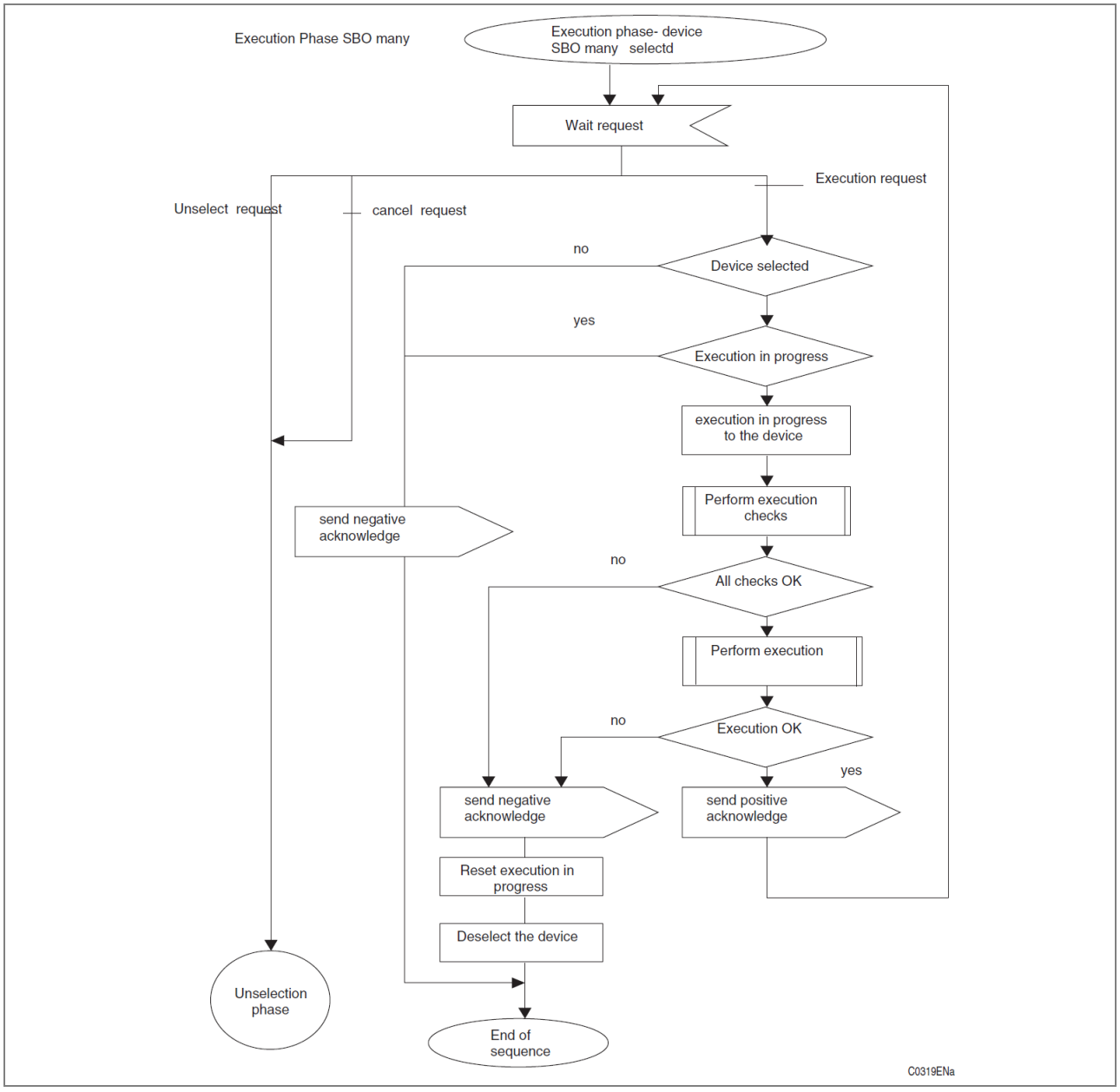


Figure 45: Execution phase in SBO many mode

6.1.5.3 UNSELECTION PHASE IN SBO MANY MODE

The controller deselects the device and sends a positive acknowledgement.

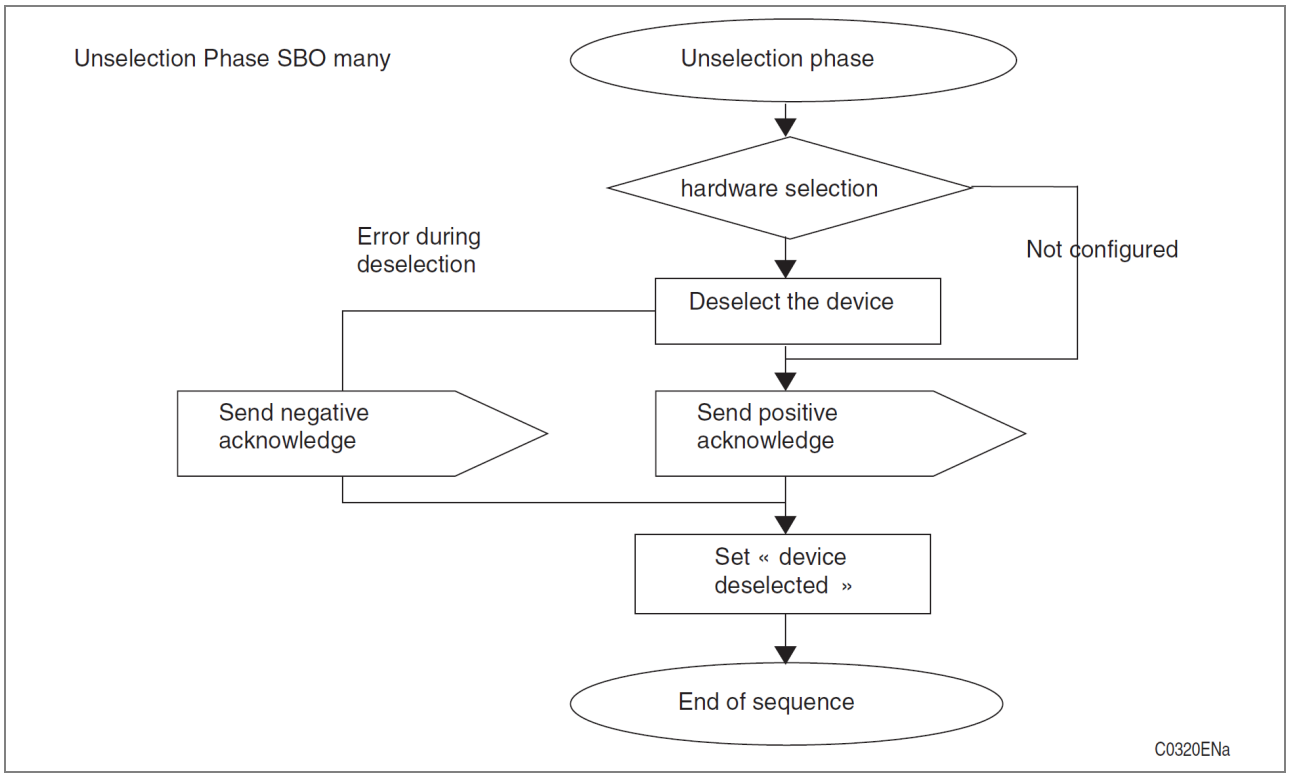


Figure 46: Unselection phase in SBO many mode

6.1.6 GENERIC SELECTION CHECKS

Checks performed during the selection phase Include:

- Inter-control delay
- controller mode
- Substation and bay mode states
- Interlock and topological interlocking states
- Automation running control
- Device selectable
- Locked device state
- Status of the device
- Uniqueness

In the event of a failure, if the rights have been granted to him/her through SCE, the initiator of the request may bypass the checks that follow:

- Substation and bay mode states
- Interlock and topological interlocking states
- Automation running control
- Locked device state
- Uniqueness

The diagram below sketches the checking process.

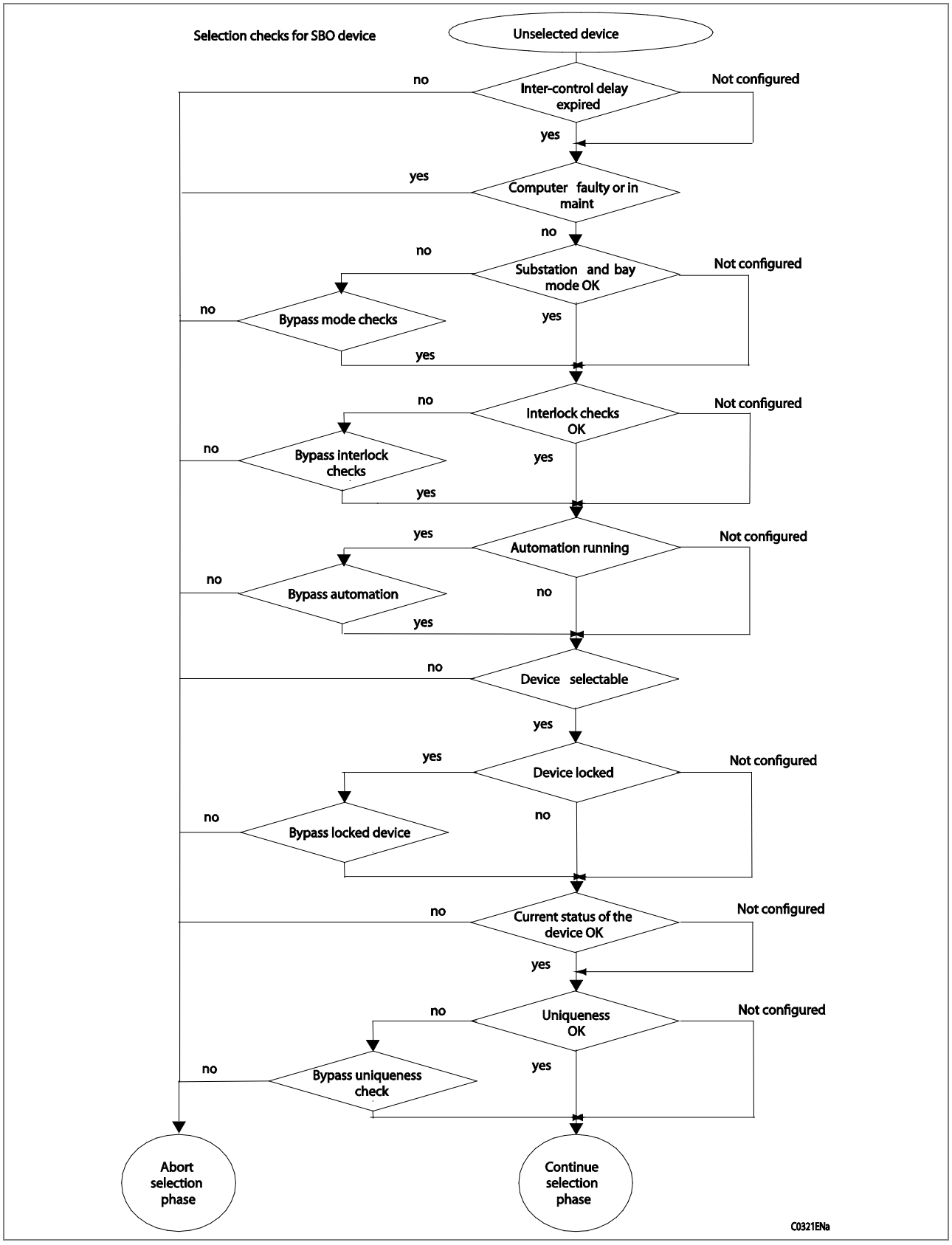


Figure 47: Selection checks for SBO device

6.1.6.1 INTER-CONTROL DELAY

For wired commands only, it is possible to define a user-selectable time-delay during which no new command to the same device is permitted. If this time-delay is set and has not elapsed when the new command is received, that command is not executed and a negative acknowledgement is sent.

6.1.6.2 C26X MODE

Control requests are accepted or not depending on the operating mode of the controller.

- **Maintenance mode**: control requests are not accepted if the controller is in **maintenance** mode except system controls concerning control mode or database management.
- **Faulty mode**: no control is accepted when the controller is in this mode.
- **Changing mode**:
  - From **"operational"** mode to **"test"** mode: the specific control **"test"** mode is refused if at least one control is in progress.
  - From **"test"** mode to **"operational"** mode: the specific control **"test"** mode is refused if at least one control is in progress.
  - From **"operational"** mode to **"maintenance"** mode: all device controls in progress are aborted and no acknowledgement is sent.

6.1.6.3 SUBSTATION AND BAY MODE CONTROL

A device control may be dependent or not on the substation mode and bay mode. Every device control command can be configured to be dependent or not on any number of the following modes:

- **Bay mode dependency** (Local/Remote mode at controller level):

  When the bay they apply to is in remote mode, L/R-dependent commands will be:
  - actuated when they originate from a level higher than the BCP (RCP or SCP)
  - ignored when they originate from the BCP

  When the bay they apply to is in local mode, L/R-dependent commands will be:
  - ignored when they originate from a level higher than the BCP (RCP or SCP)
  - actuated when they originate from the BCP

  If a command is refused the selection sequence is aborted with a negative acknowledgement.
- **Substation mode dependency** (Local/Remote mode at Station Bus level), either applicable globally to the whole substation ("global substation L/R mode") or independently bay per bay ("substation L/R mode per bay").

  A C26x performs this dependency check only if it is enabled in its database (**Local/remote substation bypass** set to *No*).

The following combinations are available for datapoints that depend on the substation L/R mode:

Datapoint dependency	Remote mode		Local mode	
	Cmd from RCP	Cmd from SCP	Cmd from RCP	Cmd from SCP
Remote-dependent DP i.e. L/R dependency settings: *Command from OI is refused* & *Command from SCADA is accepted*	✓	×	✓	✓
Local-dependent DP i.e. L/R dependency settings: *Command from OI is accepted* & *Command from SCADA is refused*	✓	✓	×	✓
Local+Remote-dependent DP i.e. L/R dependency settings: *Command from OI is refused* & *Command from SCADA is reused*	✓	×	×	✓
Independent DP i.e. L/R dependency settings: *Command from OI is accepted* & *Command from SCADA is accepted*	✓	✓	✓	✓

✓: command let through, ×: command blocked

Note:
The Global Substation L/R mode and the Substation L/R mode per Bay are mutually exclusive: Both dependencies CANNOT be used concurrently.
When the L/R mode per bay is declared in a database, the global L/R mode MUST be set to REMOTE *by default and must not be switchable.*

Note:
The C26x accepts commands from the SMT, such as a database switch or a switch to maintenance mode, only if:
- the ***global substation L/R mode*** *is set to* Local*, or*
- at least one bay managed by the C26x has its ***substation L/R mode per bay*** *set to* Local*.*

- **Bay mode dependency/Substation mode dependency truth tables**

  The following combinations are available for controls depending on their originator and whether the L/R dependency check is enabled or bypassed:

  L/R substation dependency check is enabled

L/R substation mode	Local		Remote	
L/R bay mode	**Local**	**Remote**	**Local**	**Remote**
Command from RCP	×	×	×	✓
Command from SCP	×	✓	×	×
Command from C26x LHMI	✓	×	✓	×
Command from SMT	✓	✓	✓	×/✓(1)

✓: command let through, ×: command blocked
(1) command accepted only if at least one bay managed by the C26x has its **substation L/R mode per bay** set to *Local*.

L/R substation dependency check is bypassed

L/R substation mode	Local		Remote	
L/R bay mode	**Local**	**Remote**	**Local**	**Remote**
Command from RCP	×	✓(2)	×	✓
Command from SCP	×	✓	×	✓(2)
Command from C26x LHMI	✓	×	✓	×
Command from SMT	✓	✓	✓	✓

✓: command let through, ×: command blocked
(2) command accepted only because the L/R substation dependency check is bypassed

- **Substation L/R per bay mode dependency truth tables**

Subst L/R		Remote							
Subst L/R bay		Local				Remote			
Bay L/R		Local		Remote		Local		Remote	
SBMC		Yes	No	Yes	No	Yes	No	Yes	No
Control	**RCP**	×	×	×	×	×	×	×	
	SCP	×	×	✓	✓	×	×	✓	×
	BCp	✓	✓	×	×	✓	✓	×	×
Signals	**RCP**	×	✓	×	✓	×	✓	×	✓
	SCP	✓	✓	✓	✓	✓	✓	✓	✓
	BCp	✓	✓	✓	✓	✓	✓	✓	✓
✓: Allowed, ×: Denied									

- **Substation L/R per bay mode limitations:**

  An electrical bay managed by other than C264 (eg. GTW, IED, ...) cannot integrates a "Substation L/R per bay" data point.

  The "Substation L/R per bay" data point will be used only for DS Agile system with single SBUS network.

  No SCE check is done to forbid the "Substation L/R per bay" data point on multiple rings architectures.

  "Taking control" from Scada isn't performed when "Substation L/R per bay" is used. (Substation L/R is set only to "remote" and control from RCP will be accepted or refused directly by the BCU according to dependency configured).

  SCE does not allow to wire the DPS or DPC for SS LR/bay.

- **SBMC mode dependency** (bay in maintenance or not):

  When the bay they apply to is in SBMC mode, SBMC-dependent commands will be blocked at gateway level, whatever their origin.

  When the bay they belong to is in normal operating mode (not SBMC mode), SBMC-dependent commands will be let through, whatever their origin, unless this is prevented by a local/remote condition.

6.1.6.4 INTERLOCK CONTROL

The configuration process allows to assign or not a logical equation to each order (close and open) of the device. If configured by the user, its state (true/false) may affect the control sequence. If is false, the selection is refused, excepted if bypass is set.

In the event of a failure, the sequence is aborted with a negative acknowledgement.

6.1.6.5 AUTOMATION RUNNING CONTROL

Each device may be locked by the presence of an input information (digital input, IED input etc) assigned during configuration. A “system input information” giving automatism state (active/inactive) can be used to prevent manually control execution in event an automatism is active for device monitoring: for example, ATCC.

In this event the sequence is aborted with a negative acknowledgement, except if the user asks to bypass this check.

6.1.6.6 DEVICE SELECTABLE

A device is selectable if during configuration step its control is described to be managed in **“SBO once”** or **“SBO many”** mode and is not already selected. Otherwise the selection request is refused with negative acknowledgement.

6.1.6.7 LOCKED DEVICE CONTROL

The user may lock a device in order to avoid any wrong move. If the selection concerns a locked device the request is refused, except if the user force to this control in the selection request.

In event the device is locked the sequence is aborted with a negative acknowledgement.

6.1.6.8 CURRENT STATUS OF THE DEVICE

The status check of the device is optional. It is given by a binary input or computed using more than one binary input (event of circuit-breakers). Its behaviour can be chosen (during the configuration step) among one of the four following events: it is given by a binary input or computed using more than one binary input (event of circuit-breakers).

- The request is accepted whatever the status of the device (no check)
- The request is accepted only if the device is in the opposite state and valid
- The request is accepted only if the device is in the opposite state, jammed or undefined
- The request is refused only if the device is in the same state and valid. In any event, if the request is refused, a negative acknowledgement is sent back

6.1.6.9 UNIQUENESS

It is possible by configuration to prevent to have more than one control at a time.

- For the whole substation
- Inside a bay

The following figure describes the algorithm used between controllers.

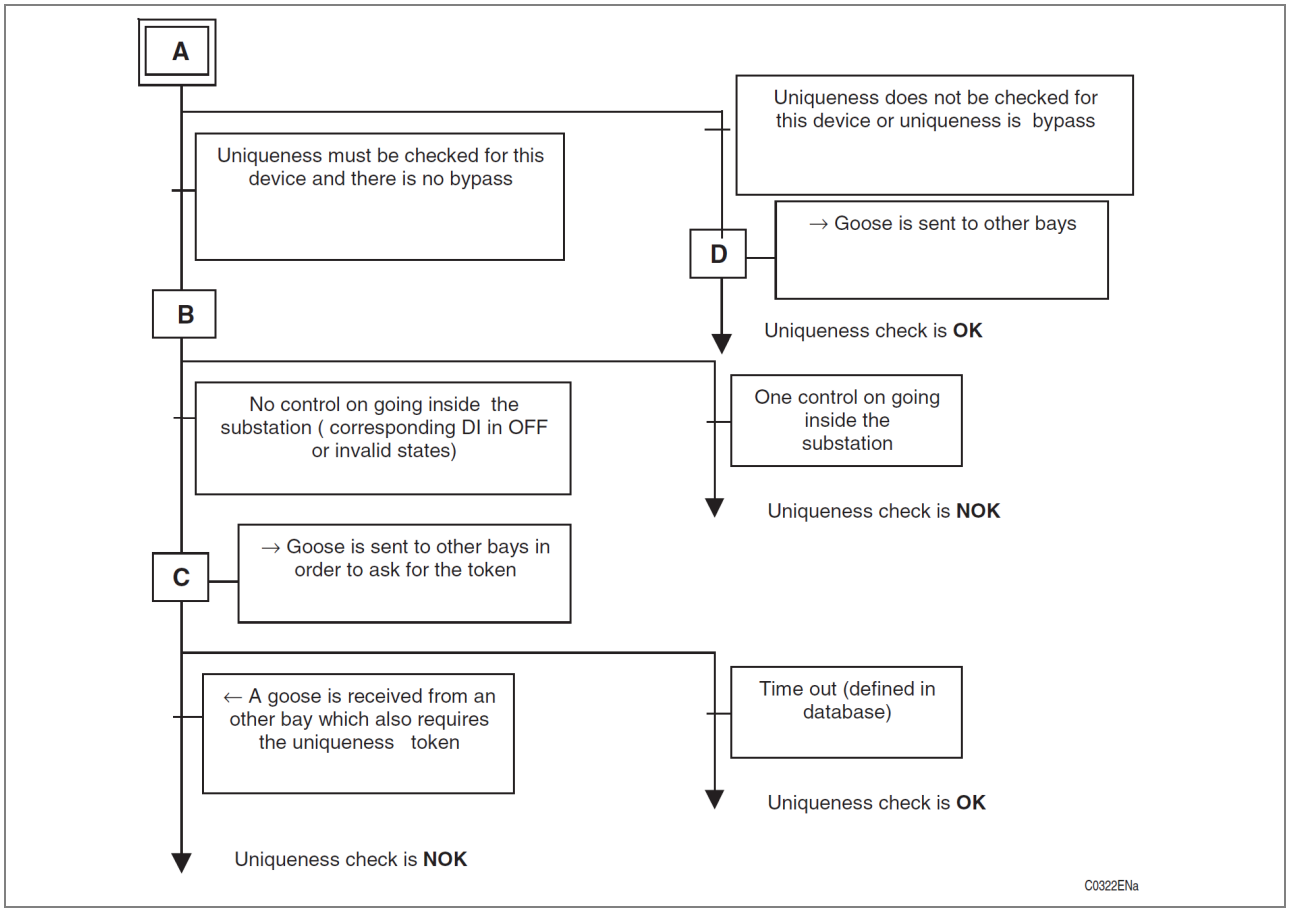


Figure 48: Check of uniqueness

If a device is under control and another control is sent on this device, the second one is ignored.

In the event of a uniqueness of the command at least to one of these levels the selection is refused, with negative acknowledgement. The user may bypass this control during selection request.

6.1.7 SELECTION BEHAVIOUR

In **SBO once** mode and **SBO many** mode, the configuration process allows to describe optionally, a device selection to control the device.

The following configurations must be considered:

- **Configuration 1**: device with a control for selection and its associated selection position information.
- **Configuration 2**: device with a control for selection (without input selection information).

Whatever the request control (select open/select close, select raise/select low) the selection of the device is performed as follows:

- **Configuration 1:**

The controller

1 verifies the selection position information, it must be open: if it is close, it is an abnormal situation, the selection sequence is stopped with a negative acknowledgement.

2 sends a “close” order of the selection control (via I/O boards or IED) and waits the selection position information in a given delay (by configuration).

If the selection control has been normally executed, and the selection position information of the device become “set” in the given delay, the selection sequence ends sending a positive acknowledgement. The controller starts its execution sequence. In the event of a failure of the execution of the selection control or if the selection position information remains open in the given delay the selection sequence ends abnormally sending a negative acknowledgement.

- **Configuration 2:**

For this configuration, in which only the output control of the selection is configured, the controller: sends a “close” order of the selection control (via I/O boards or IED). If the selection control has been normally executed, the selection sequence ends by sending a positive acknowledgement and the controller start its execution sequence.

In the event of a failure of the execution of the selection control, the sequence ends abnormally by sending a negative acknowledgement.

6.1.8 GENERIC EXECUTION CHECKS

During the execution phase, whatever the execution mode (SBO once, SBO many or Direct Execute) the controller, before proceeding to the execution of the request, performs the following checks:

- Inter-control delay
- controller mode
- Substation and bay mode states
- Interlock and topological interlocking states
- Automation running control
- Device selectable (SBO mode only)
- Locked device state
- Current status of the device
- Uniqueness

Execution checks and bypasses are identical to those of the selection phase. Moreover, In the event of an **”SBO once”** mode or **”SBO many”** mode the controller verifies that the device was previously selected.

The checks of the execution phase in **“SBO many”** mode are identical as above but they are repeated for every execution request (low/raise).

In **“Direct Execute”** mode the device selection is not verified because it is not permitted.

6.1.9 EXECUTION BEHAVIOUR

On this stage the control request is executed via:

- I/O boards
- IED communication
- System supervisor of the controller for system outputs

The execution via I/O boards is performed only if the controller is in “**operational”** mode. If the controller is in “**test”** mode, the output relay is not set. In this event the controller simulates a positive acknowledgement of hardware execution. It allows to perform control sequence safety in order to test Automatisms configuration, control sequence configuration etc. Controls to IEDs are sent if the controller is in “**operational”** mode or “**test”** mode.

6.1.9.1 EXECUTION VIA I/O BOARDS

According to the devices features the execution of the control via I/O boards may be performed using:

- Single Points Control
- Double Control Points
- Digital Setpoints
- Analogue Setpoints

Single Point Control and Double Point Control

However, the execution control sequence depends on the activation mode of the xPC. By configuration, this activation mode of SPC and DPC may be “transient”, “permanent” or “permanent until feedback”.

- **Transient**: the contact is closed and then re-opened automatically after a delay (defined during the configuration of the xPC). For a DPC, configuration gives two delays need to be configured, one for open and one for close.
- **Permanent**: For this type of output control, the contact is held in the requested position state until the a reverse order is received.
- **Permanent until feedback**: The contact is held in the requested position state until confirmation of the position of the device or after timeout awaiting the new position of the device. In this event, the input information of the device status must be configured.

Digital and Analogue Setpoints

Digital Setpoints are executed via Digital Output boards. This type of control is managed in “Direct Execute mode” only.

Analogue Setpoints are executed via Analogue Output boards. This type of control is managed in “Direct Execute mode” only.

6.1.9.2 EXECUTION VIA IED COMMUNICATION

When an execution request is performed via IED communication, the requested order is converted to a message to be sent to the IEDs, according the communication protocol.

6.1.9.3 SYSTEM CONTROLS EXECUTION

For systems outputs the controller activate/deactivate the associated function (ATCC, controller mode, etc) and if a specific system input (SPS or DPS) is configured for this control, it takes the requested state and it stored in non-volatile memory.

6.1.10 CONTROLS TIME SEQUENCING

Time sequencing of control is dependent of its configuration:

- Control mode: Direct Execute, SBO once, SBO many
- Device features: selection control wired/not wired, selection position wired/not wired, device position wired/not wired and so on
- Output control type: permanent, pulse
- Destination: I/O board, IED
- Time-out delays: selection phase time-out, selection Feedback delays, open/close Feedback delay and so on.

6.1.10.1 DIRECT EXECUTE TIME SEQUENCING

The timing diagram shows an example of normal termination on Direct Execute sequence.

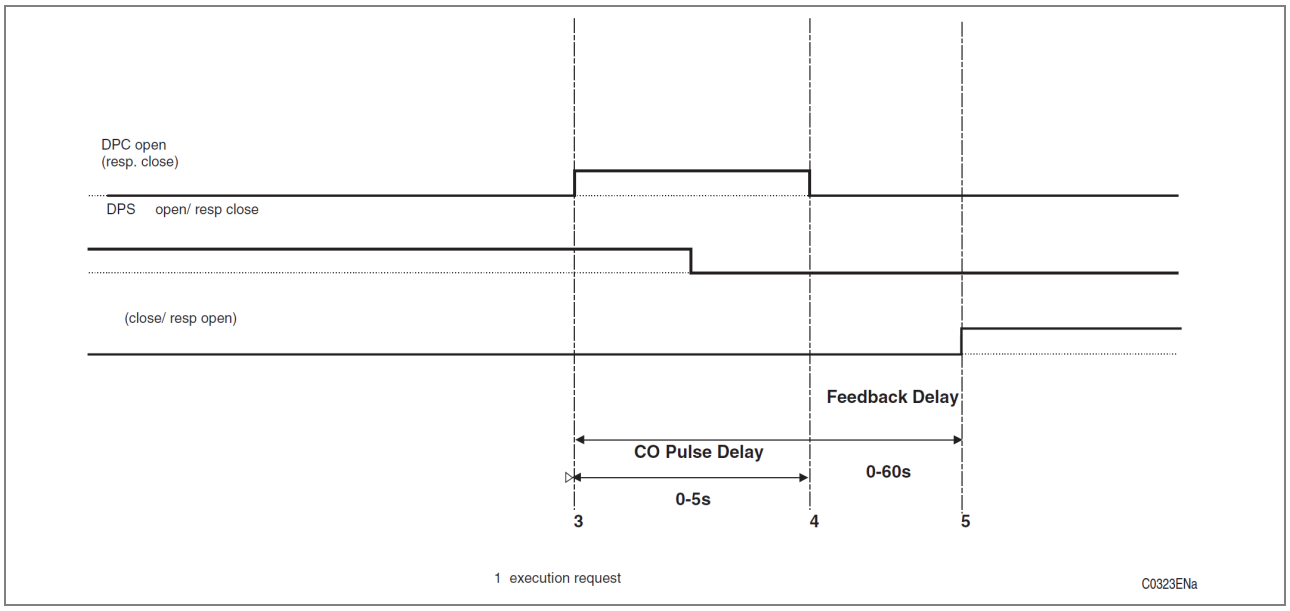


Figure 49: Normal termination of direct execute sequence

The timing diagram below shows an abnormal termination of Direct Execute sequence. The device has not taken the expected position in the given delay.

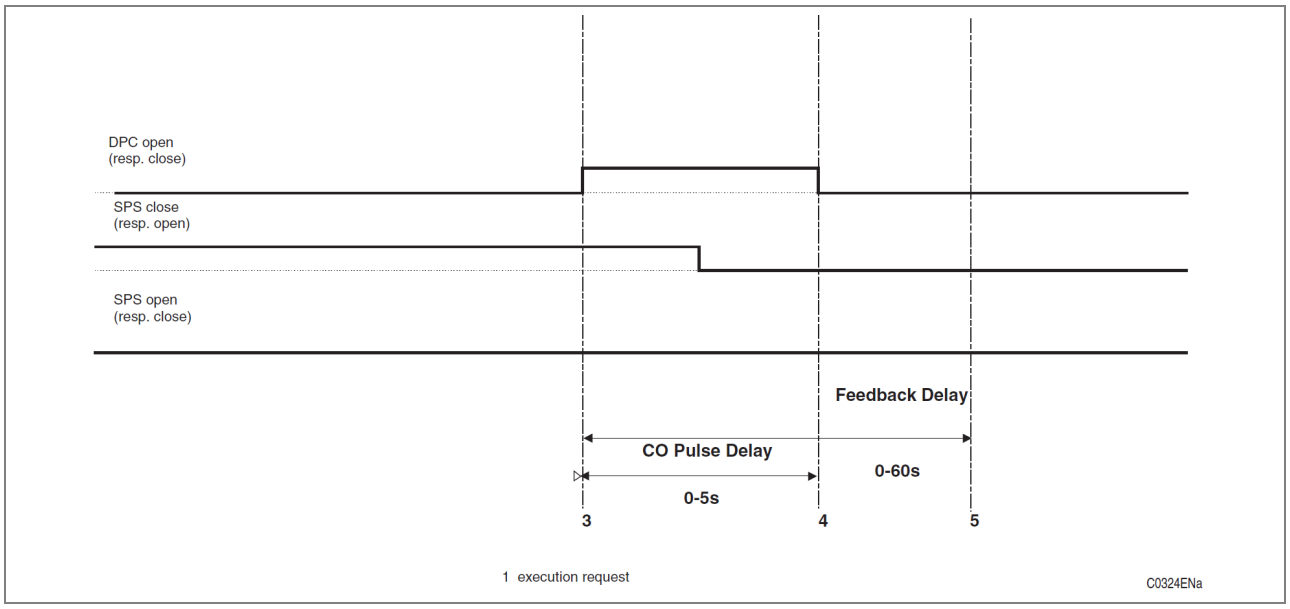


Figure 50: Abnormal termination of direct execute sequence

6.1.10.2 SBO ONCE TIME SEQUENCING

The configurations below are given as examples

Device Configuration A: the optional selection control and Selection position information are configured

The timing diagram below shows a normal termination of the control sequence.

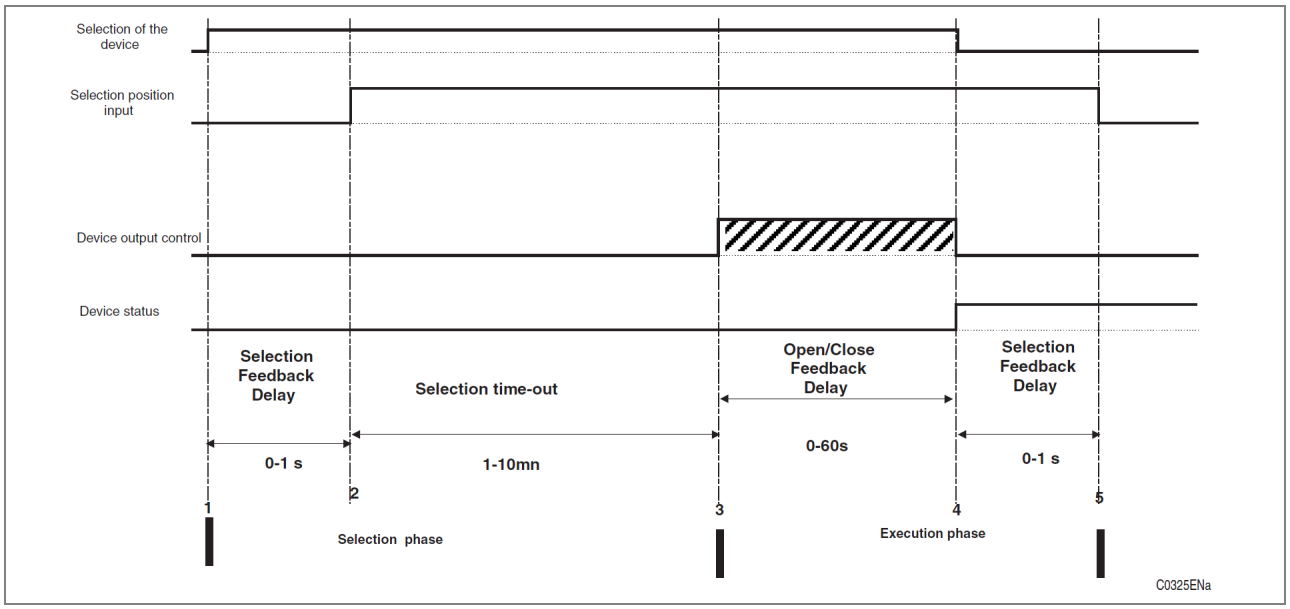


Figure 51: Normal termination of the control sequence

- Stage 1: device selection (closing the associated output control)
- Stage 2: the selection is confirmed by the associated input information in the feedback delay (0 – 1-sec user selectable)
- Stage 3: close the device before the end of the selection timeout delay (0 – 10 MN user selectable)
- Stage 4: the device has taken the expected position (close) in the feedback delay (0–60 sec user selectable). The controller deselect the device (open selection output control)
- Stage 5: confirmation of the deselecting of the device in the same given delay than stage 2.

The timing diagram below shows controls sequence that is aborted after time-out of the selection delay.

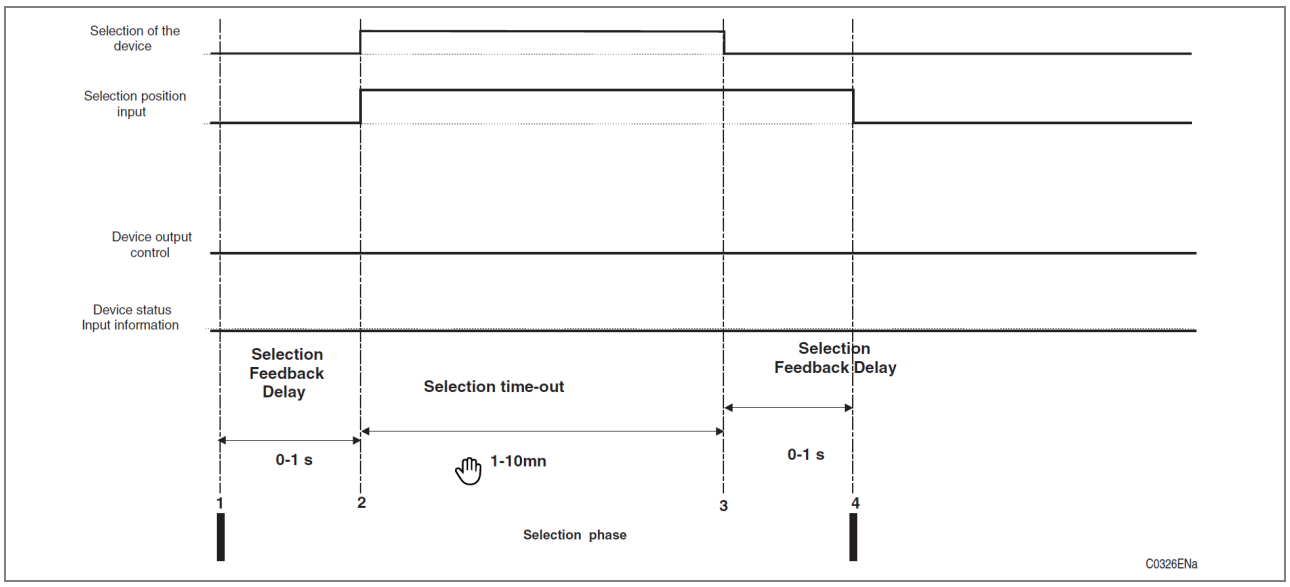


Figure 52: Aborted control sequence

- Stage 1: device selection (closing the associated output control)
- Stage 2: the selection is confirmed by the associated input information in feedback delay
- Stage 3: timeout of the delay - the device is deselected
- Stage 4: confirmation of the deselecting of the device

Device Configuration B: the optional selection control is configured and Selection position information is not configured

The timing diagram below shows a normal termination of the control sequence.

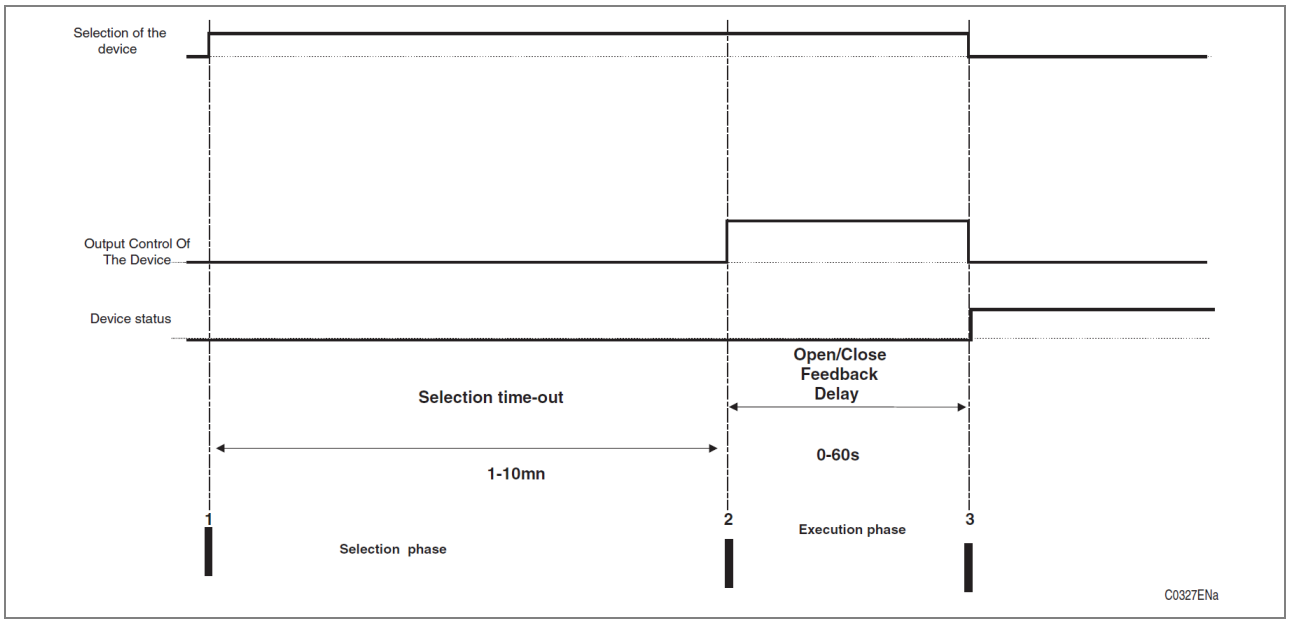


Figure 53: Normal termination of the control sequence

- Stage 1: device selection (closing the associated output control)
- Stage 2: close the device before the end of the selection timeout delay (0 – 10 MN user selectable)
- Stage 3: The device has taken the expected position (close) in the feedback delay (0–1-sec user selectable). The controller deselect the device (open selection output control)

6.1.10.3 SBO MANY TIME SEQUENCING

SBO many mode is exclusively used for control of transformers. Refer to associated section.

6.1.11 HOW AN XPS STARTS A CONTROL SEQUENCE

The supervision datapoints, referred to as xPS, include:

- Single Point Status (SPS)
- Double Point Status (DPS)
- Multi Point Status (MPS)

The xPS datapoints allow you to start a device control sequence: for example, an operator control from a hardwired mimic. These xPS datapoints start the control in the same way when the IEC 61850-8-1 or the local C26x HMI start the control. The sequence cancel command is not permitted. Only Direct Execute (DE) types of controls are permitted.

6.2 CONTROL OF NON SYNCHRONIZED BREAKERS

6.2.1 NON-SYNCHRONIZED CIRCUIT-BREAKER FEATURES

For the circuit-breakers, the table that follows gives the inputs and outputs that are controlled by the unit:

Three-pole circuit-breaker		
	Outputs to CB	**Inputs from CB**
Device control	(2) DPC, device open/close control	(3) DPS, physical position of the device (1 pole) (12) SPS (optional), pole discrepancy (ph not together) indication (1) System DPS, feedback of the control (i)
Device selection (hardware)	(10) SPC (optional), device selection control	(13) SPS (optional), device selection position indication

Single pole circuit-breaker			
	Outputs to CB 3-p operations	**Outputs to CB 1-p operations**	**Inputs from CB**
Device control	(2) DPC, device open/close control	(7) DPC, control to open phase A (8) DPC, control to open phase B (9) DPC, control to open phase C (2) DPC, control to close the device	(4) DPS, physical position of pole A (5) DPS, physical position of pole B (6) DPS, physical position of pole C (12) System SPS, "ph not together" indication (ii) (1) System DPS, control feedback (iii)
Device selection (hardware)	(10) SPC (optional), device selection control	(10) SPC (optional), device selection control	(13) SPS (optional), device selection position indication

(i) The computed value matches the state of the CB's auxiliary contacts when there is no pole discrepancy, i.e. if the value of **ph not together** is *false*, otherwise the computed value is *jammed*.

(ii) The computed **ph not together** value is *false* if all the CB poles are in the same open or closed position. It is *true* when a pole discrepancy is detected.

(iii) The computed value matches the state of phase A if the state of **ph not together** is equal to *false* (i.e. no pole discrepancy is detected), otherwise the computed value is *jammed*.

6.2.2 CONTROL SEQUENCE OF NON-SYNCHRONISED CIRCUIT-BREAKERS

Non-synchronised circuit-breakers are managed in **"Direct Execute"** mode and in **"SBO once"** mode. Refer to the generic description above.

6.3 CONTROL OF SYNCHRONISED BREAKERS

Synchronised circuit-breakers are managed in **"SBO once**" mode only. The following paragraph describes the specific features of synchronised circuit-breakers whether they are synchronised by an external or by an internal synchrocheck module.

6.3.1 SYNCHRONISED CIRCUIT-BREAKER FEATURES

For the circuit-breakers, the table that follows gives the inputs and outputs that are controlled by the unit:

Three-pole circuit-breaker with synchrocheck		
	Outputs to CB	**Inputs from CB**
Device control	(2) DPC: device open/close control (11) SPC: close with synchrocheck control	(3) DPS: physical position of the device (1 pole) (12) SPS (optional): pole discrepancy (ph not together) indication (1) system DPS: feedback of the control (i)
Device selection (hardware)	(10) SPC (optional): device selection control	(13) SPS (optional): device selection position indication
Enable/disable close with synchrocheck schemes	(14) SPC or (15) DPC (optional): synchrocheck scheme on/off control	(16) SPS or (17) DPS (optional for external S/C): synchrocheck scheme on/off indication
Enable/disable synchrocheck function (for a specific CB in CB-1/2 topology) (internal S/C only) (vi)	(18) SPC: synchrocheck function on/off control for specific CB (1 or 3)	(19) SPS: synchrocheck function on/off control for specific CB (1 or 3)

Single pole circuit-breaker with synchrocheck			
	Outputs to CB 3-p operations	**Outputs to CB 1-p operations**	**Inputs from CB**
Device control	(2) DPC: Device open/close control (11) SPC: Close control with synchrocheck	(7) DPC: open phase A control (8) DPC: open phase B control (9) DPC: open phase C control (2) DPC: close of device control (11) SPC: Close control with synchrocheck	(4) DPS: physical position of phase A (5) DPS: physical position of phase B (6) DPS: physical position of phase C (12) System SPS: ph not together indication (ii) (1) System DPS: control feedback (iii)
Device selection (hardware)	(10) SPC: (optional) device selection control	(10) SPC (optional): device selection control	(13) SPS (optional): device selection position indication
Enable/disable close with synchrocheck schemes (iv)	(14) SPC or (15) DPC: (optional) synchrocheck scheme on/off control	(14) SPC/(15) DPC: (optional) synchrocheck scheme on/off control	(16) SPS or (17) DPS: (optional for external S/C) synchrocheck scheme on/off indication
Enable/disable synchrocheck function (for a specific CB in CB-1/2 topology) (internal S/C only) (v)	(18) SPC: synchrocheck function on/off control for specific CB (1 or 3)	(18) SPC: synchrocheck function on/off control for specific CB (1 or 3)	(19) SPS: synchrocheck function on/off control for specific CB (1 or 3)

(i) The computed double signal is equal to the state of the CB auxiliary contacts when there is no pole discrepancy, i.e. if the value of **ph not together** is *false*, otherwise the computed signal is equal to *jammed*.

(ii) The computed **ph not together** signal is equal to *false* if all the poles are in the same open or closed position. It is equal to *true* when a pole discrepancy is detected.

(iii) The computed signal is equal to the state of phase A if the state of **ph not together** is equal to “false” (i.e. no pole discrepancy is detected), otherwise the computed signal is equal to “jammed”.

(iv) Wired SPC and SPS for external synchrocheck and system SPC and SPS for internal synchrocheck. If not configured, the external synchrocheck module or the internal synchrocheck function is considered as permanently disabled. DPC & DPS are used only for manual synchrocheck.

(v) **on/off main2 SPx** and **on/off main3 SPx** are only available for Synchrocheck type 3 function (breaker-and-a-half topology).

The **“Open” control sequence** of synchronised circuit-breakers remains identical to the non-synchronised circuit-breakers.

The **“Close” control sequence** is different according to the configuration the synchrocheck type:

- **External synchrocheck**: The closure of the device is assumed by an external synchrocheck module
- **Internal synchrocheck**: The closure of the device is assumed by an internal synchrocheck function

A Close control sequence can be configured with:

- **Manual set on** of the external synchrocheck module or internal synchrocheck function
- **Automatic set on** of the external synchrocheck module or internal synchrocheck function

Furthermore, waiting closes the CB by the external module the initiator of the request may:

- Cancel the request
- Close the device by forcing request

6.3.2 CIRCUIT-BREAKERS WITH EXTERNAL SYNCHROCHECK

6.3.2.1 CLOSE CB BY EXTERNAL AUTOMATIC SYNCHROCHECK

The following scheme shows a “close” control for a device in which the external synchrocheck module is enabled automatically by the controller.

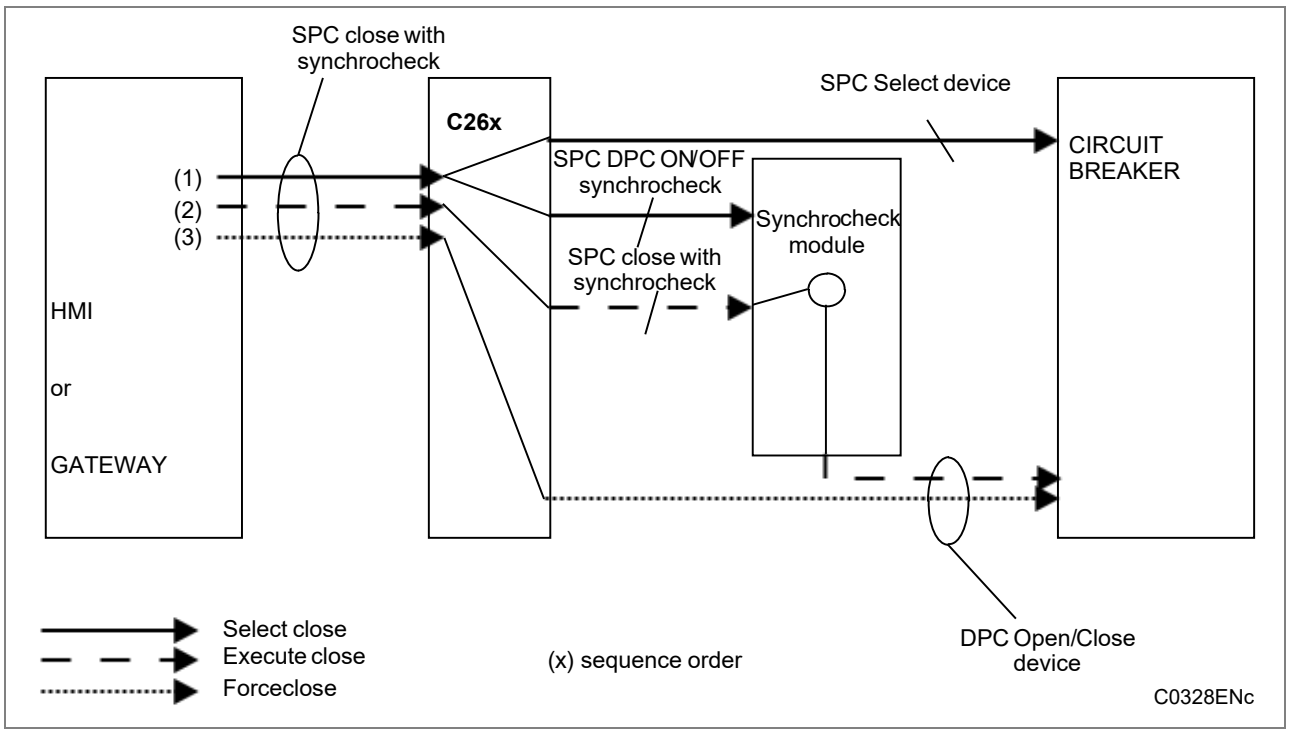


Figure 54: Close CB by external automatic synchrocheck

The “close” control sequence performed on the C26x is done as follows:

Selection phase

1 If the control is configured, enable synchrocheck module
2 If configured, check synchrocheck on/off information related to the output
3 If configured, close the device selection output to select the device
4 If configured, check selection device input information associated to the output
5 Wait for the execution request or timeout selection

In the event of a failure of one of these operations, the controls sequence is stopped with a negative acknowledgement

Execution phase

1 Close the device using synchrocheck output control
2 Check that the device position become close in the given delay
3 Disable synchrocheck module if it was previously enabled
4 Deselect the device if it previously selected

The timing diagram below shows a successful control sequence “close with synchrocheck”.

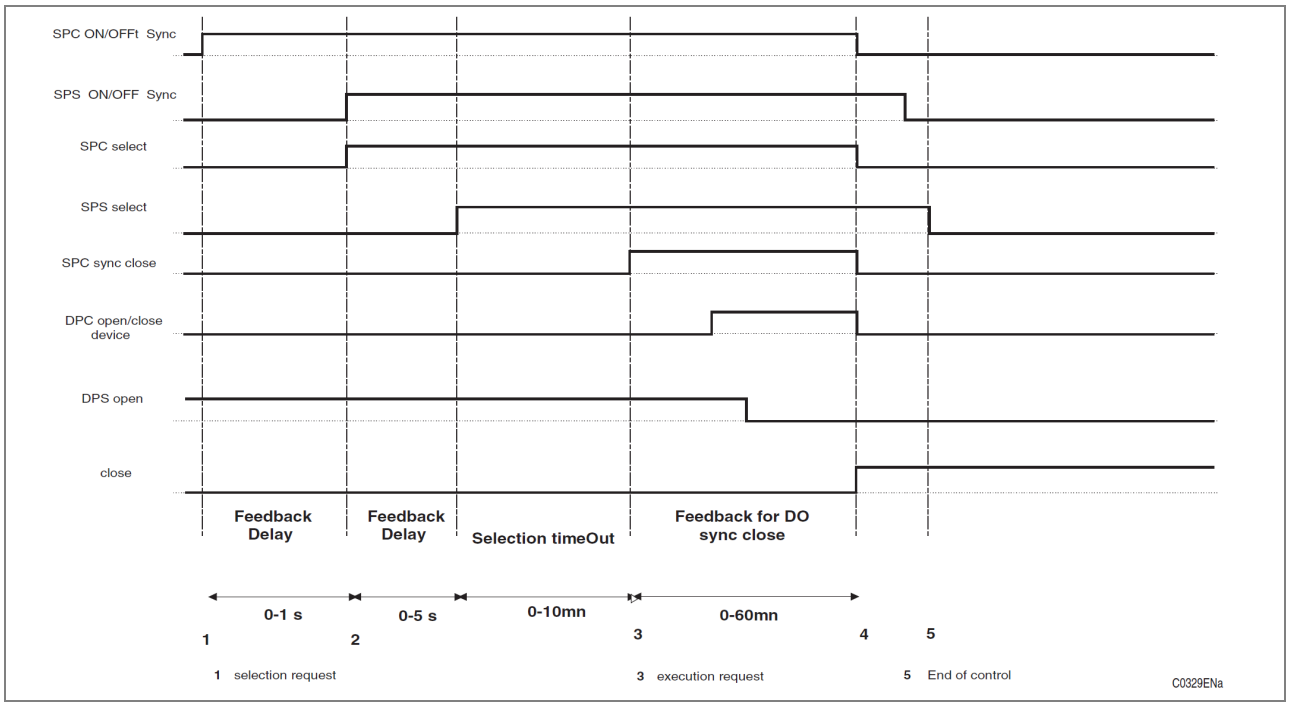


Figure 55: Timing diagram of a successful "close with synchrocheck"

The timing diagram below shows an abnormal termination of control sequence “close with synchrocheck”. The device has not taken the expected position “close” in the given delay. The control sequence is aborted with negative acknowledgement, deselecting previously synchrocheck and device.

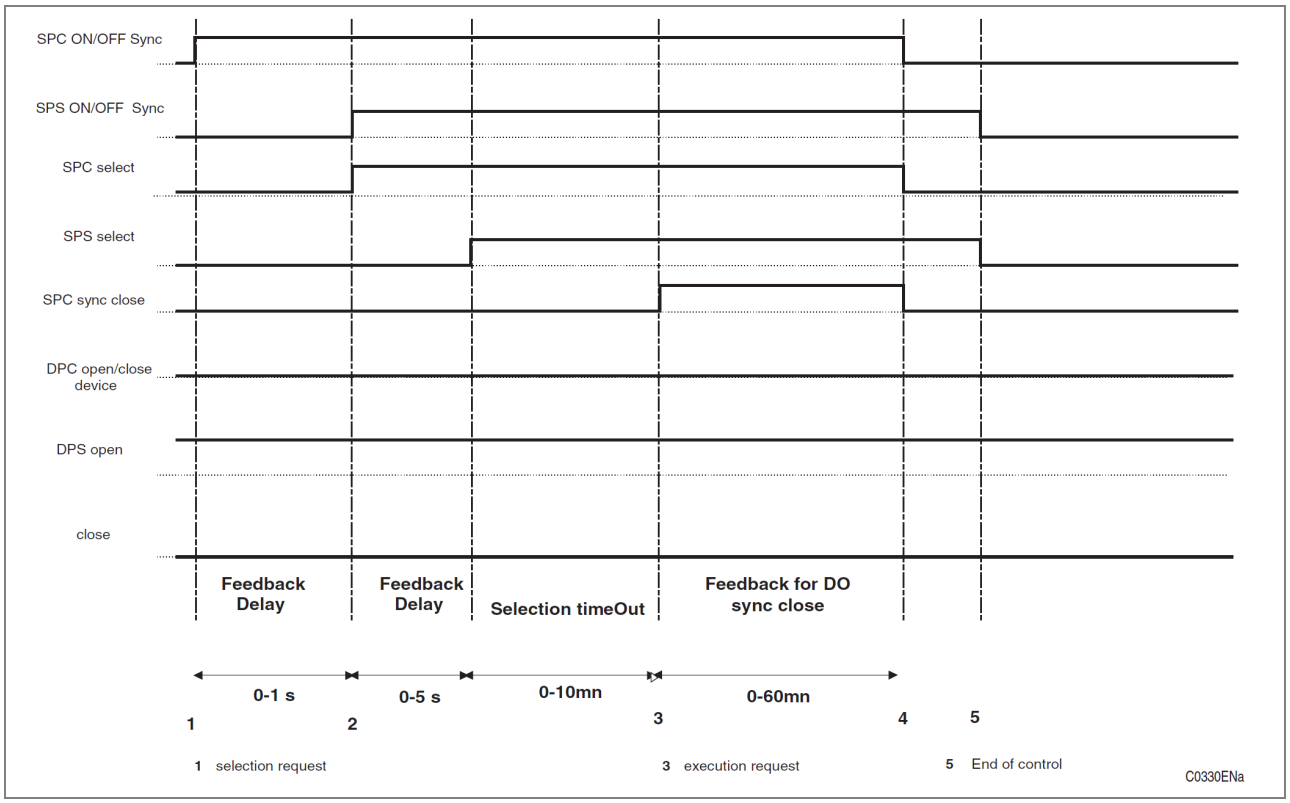


Figure 56: Abnormal termination of "close with synchrocheck"

6.3.2.2 CLOSE CB BY EXTERNAL MANUAL SYNCHROCHECK

By configuration the “close” control of the device may be done in two or three control sequences:

Two sequences

- A “Direct Execute” sequence to put in service the external synchrocheck module
- An SBO once sequence to close the CB by the synchrocheck module and put out of service the synchrocheck module

Three sequences

- A “Direct Execute” sequence to put in service the external synchrocheck module
- An SBO once sequence to close the CB by the synchrocheck module
- A “direct execute” sequence to put out service the external synchrocheck module

The scheme that follows shows a close control request where an operator manually manages the external synchrocheck module from the system HMI or through the Gateway.

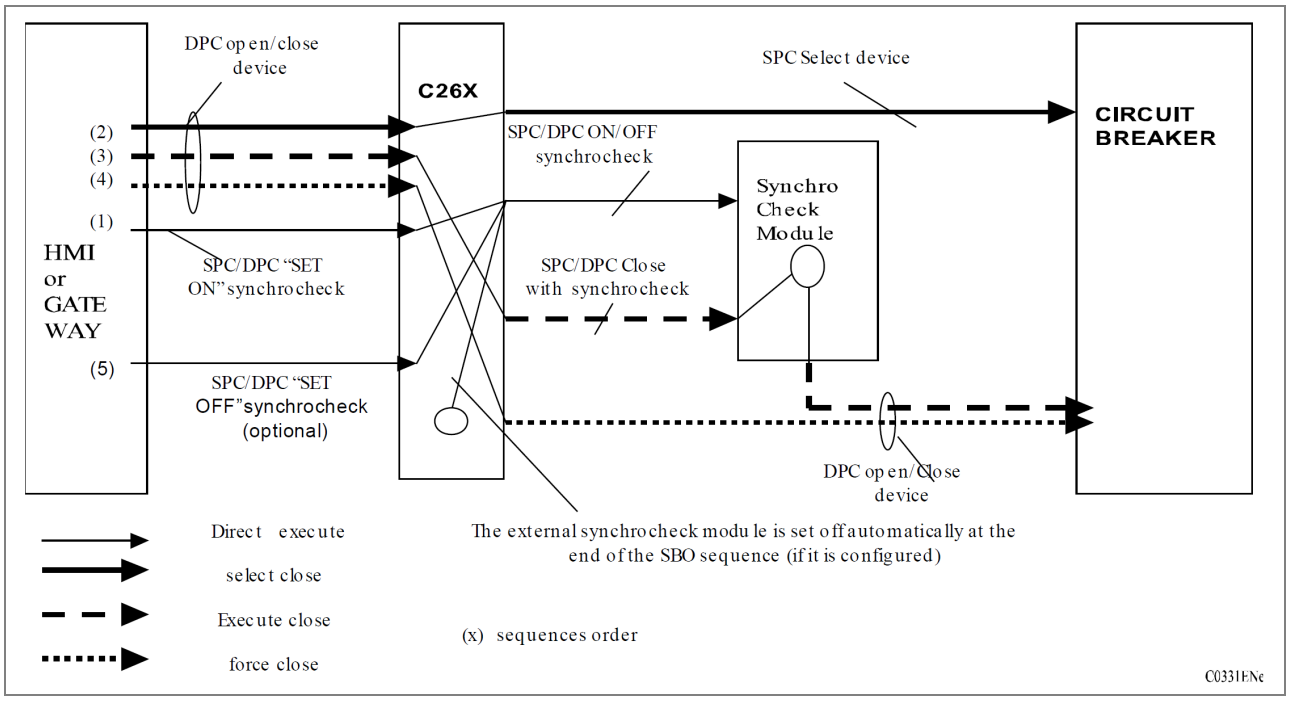


Figure 57: Close control request

First sequence (DIRECT EXECUTE): Enable the external synchrocheck module

1 Close “set on/setoff” output control of the synchrocheck module

2 Check that the synchrocheck module is set (if on/off synchrocheck input information is configured)

In the event of a failure of one of these operations, the sequence ends with a negative acknowledgement

Second sequence (SBO ONCE): Close the device with synchrocheck

Selection phase:

1 Close device selection output to select the device (if is configured)

2 Check selection device input information associated to the output (if is configured)

3 Wait for the execution request or timeout selection

4 In the event of a failure of one of these operations the controls sequence is stopped with a negative acknowledgement

Execution phase:

1 Close the device via the “close with synchrocheck” control

2 Check that the device position becomes closed within the given delay

3 Disable the synchrocheck module if is configured to be disabled automatically

4 Deselect the device if it previously selected

Third sequence (DIRECT EXECUTE): disable the external synchrocheck module

This sequence takes place only if setting the synchrocheck module off is configured to “manual”

1 Open “set on/setoff” output control of the synchrocheck module

2 Check that the synchrocheck module is enabled (if on/off synchrocheck input information is configured)

The timing diagram below shows a successful control sequence “close with synchrocheck” performed in three sequences. In the event of an automatic “setting off” of the synchrocheck module the timing diagram remain identical. It is performed at the end of the SBO sequence.

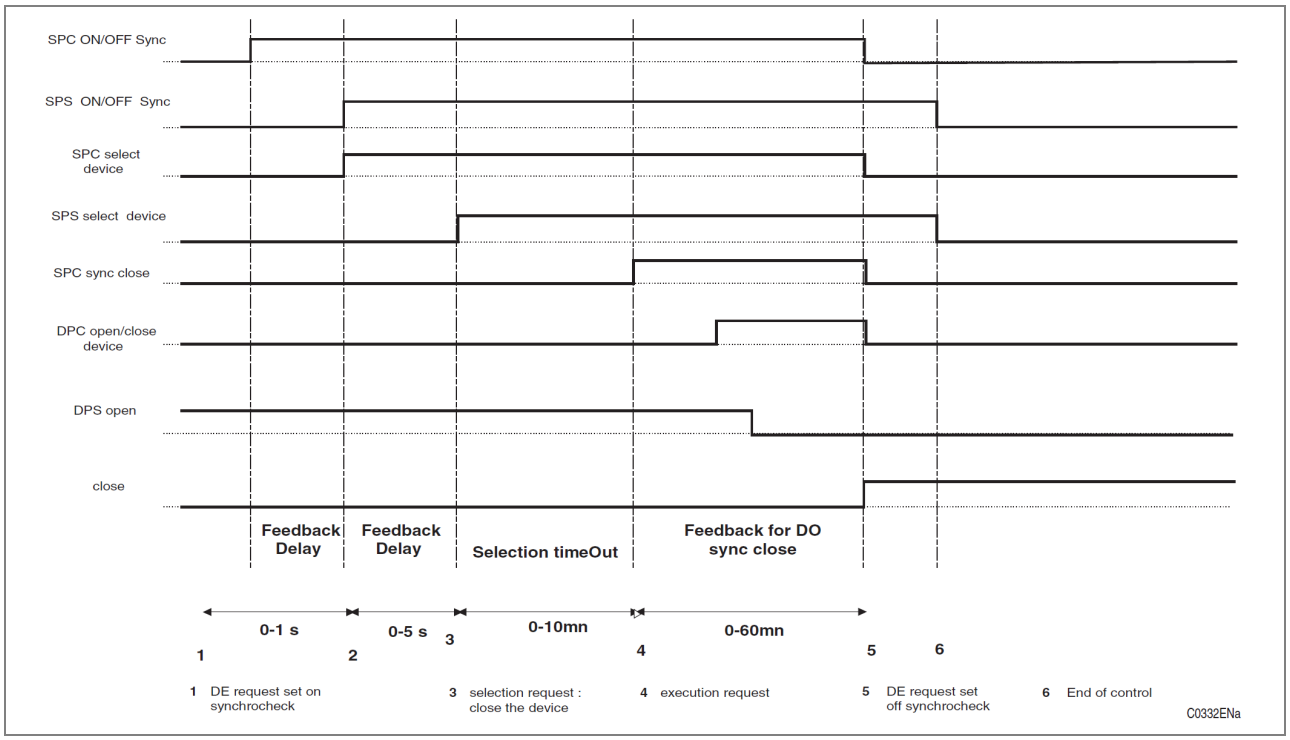


Figure 58: Successful close with synchrocheck

Note:
During SBO sequence after step 5 the initiator of the request may force the closing of the device.

6.3.2.3 CLOSE SYNCHRONIZED CIRCUIT-BREAKERS WITH FORCING

The timing diagram below shows controls sequence “close with synchrocheck” with “forcing close request”. The SBO sequence is performed in the same way whether the synchrocheck module is enabled manually or automatically.

Awaiting the device to be closed by the external synchrocheck module, the initiator of the request force to “close without synchrocheck”

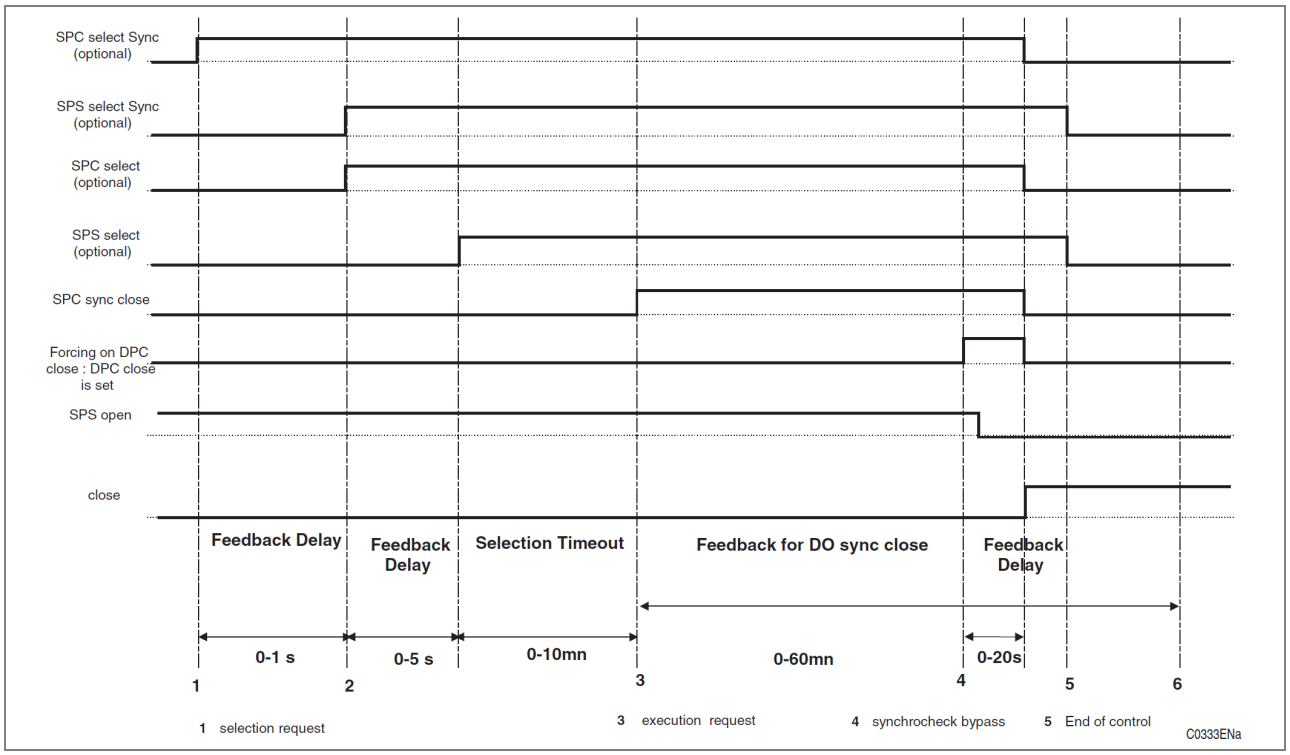


Figure 59: “Close with synchrocheck” with “forcing close request”

6.3.2.4 CANCEL CLOSE CB WITH EXTERNAL SYNCHROCHECK

While waiting to close the device (0 to 60 mn) by the external synchrocheck module, the initiator of the close request may cancel this one by a “cancel request”.

The timing diagram below shows a cancel close request awaiting to close the device by the external synchrocheck module.

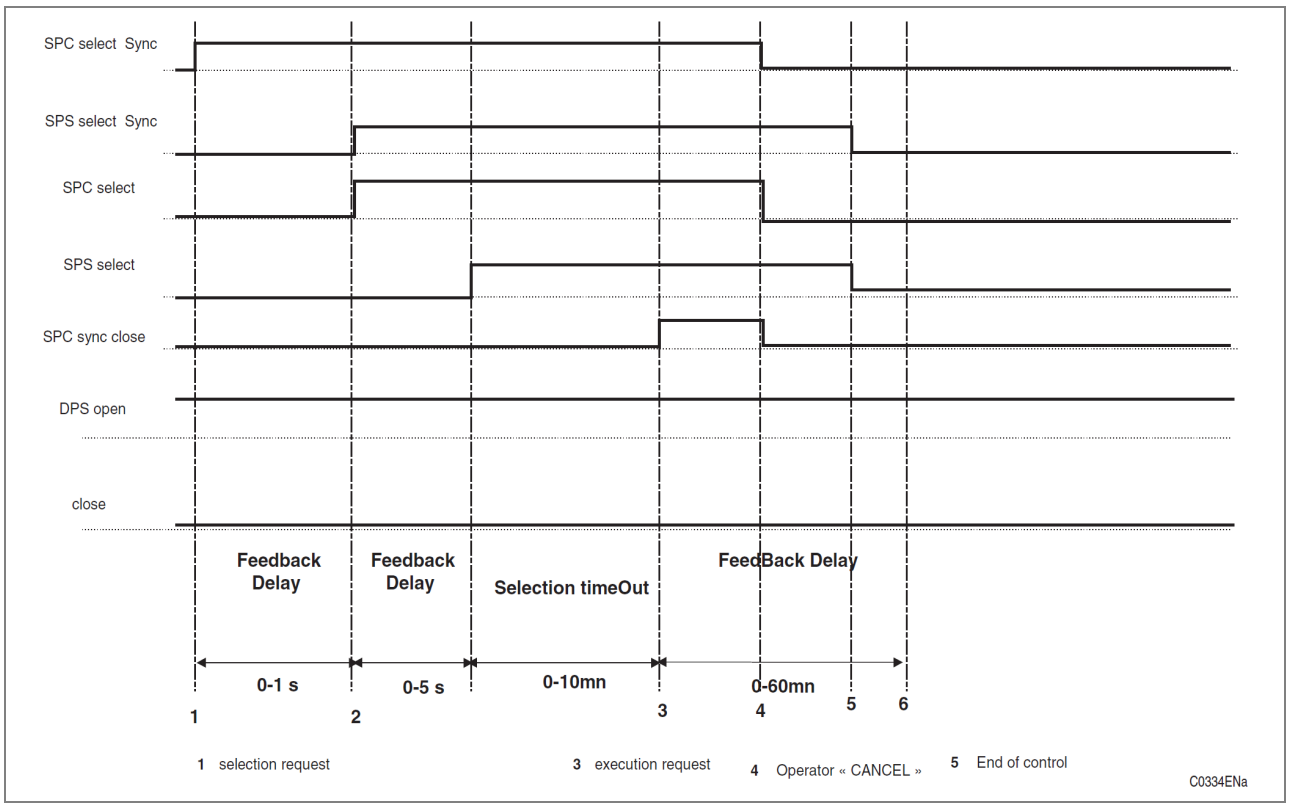


Figure 60: Cancel close request

6.3.3 CIRCUIT-BREAKERS WITH INTERNAL SYNCHROCHECK

On this configuration synchrocheck is assumed by an internal controller automatism, that proceeds to the synchrocheck voltage calculations and gives or not the closing authorisation the device.

The controls sequence remains similar with the external synchrocheck except for the setting on/off of the synchrocheck and close with synchrocheck output control that do not exist on this configuration

6.3.3.1 CLOSE CB WITH INTERNAL AUTOMATIC SYNCHROCHECK

The following sequence describes a circuit-breaker “close” request with internal synchrocheck in **“SBO once”** mode. Synchrocheck function is enabled automatically.

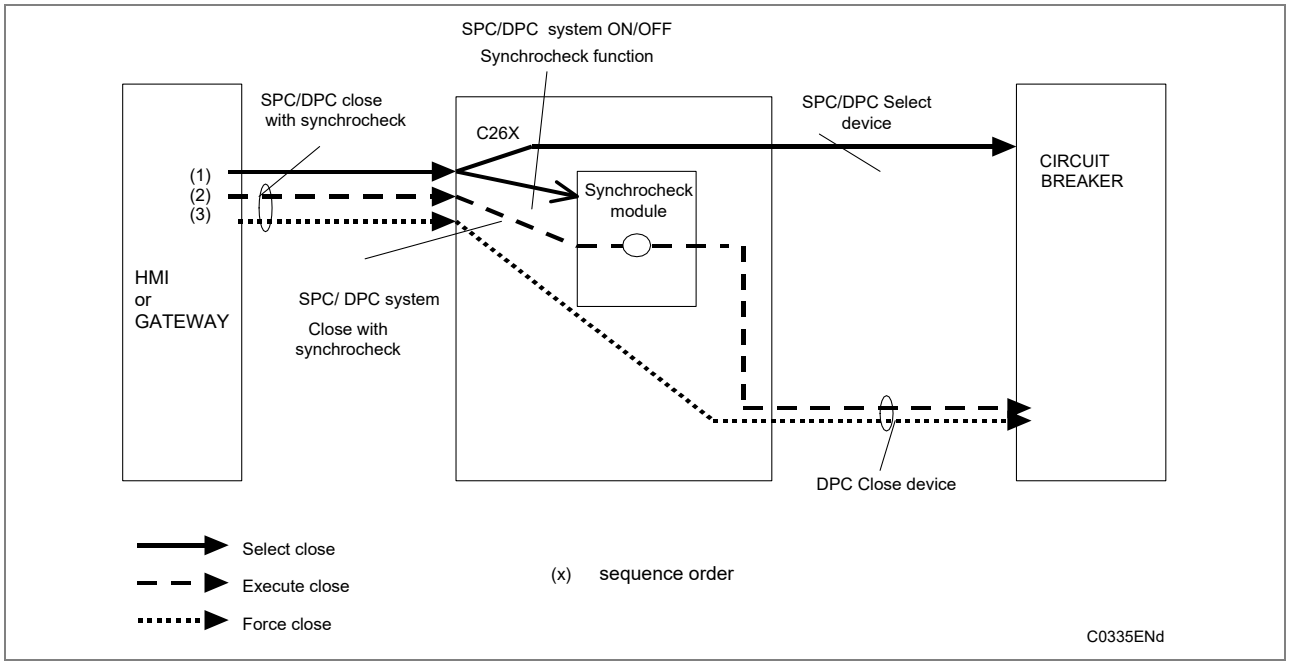


Figure 61: Close CB with internal automatic synchrocheck

Selection phase:

1 Close device selection output to select the device (if is configured)

2 Check selection device input information associated to the output (if is configured)

3 Wait for the execution close request or timeout selection

In the event of a failure of one of these operations, the device is deselected and the controls sequence is aborted with a negative acknowledgement.

Execution phase:

1 Activate the associated internal synchrocheck function for closing authorisation the device

2 Wait closing authorisation

Event 1: Synchrocheck function responds OK before the time-out of the given delay

1 Close the device

2 Deselect the device (if it was previously selected)

3 Send a positive acknowledgement

Event 2: Synchrocheck function responds NO before the time-out of the given delay

1 Deselect the device (if it was previously selected)

2 Send a negative acknowledgement

Event 3: time-out of the given delay without synchrocheck response

1 Stop the synchrocheck function

2 Deselect the device (if it was previously selected)

3 Send a negative acknowledgement

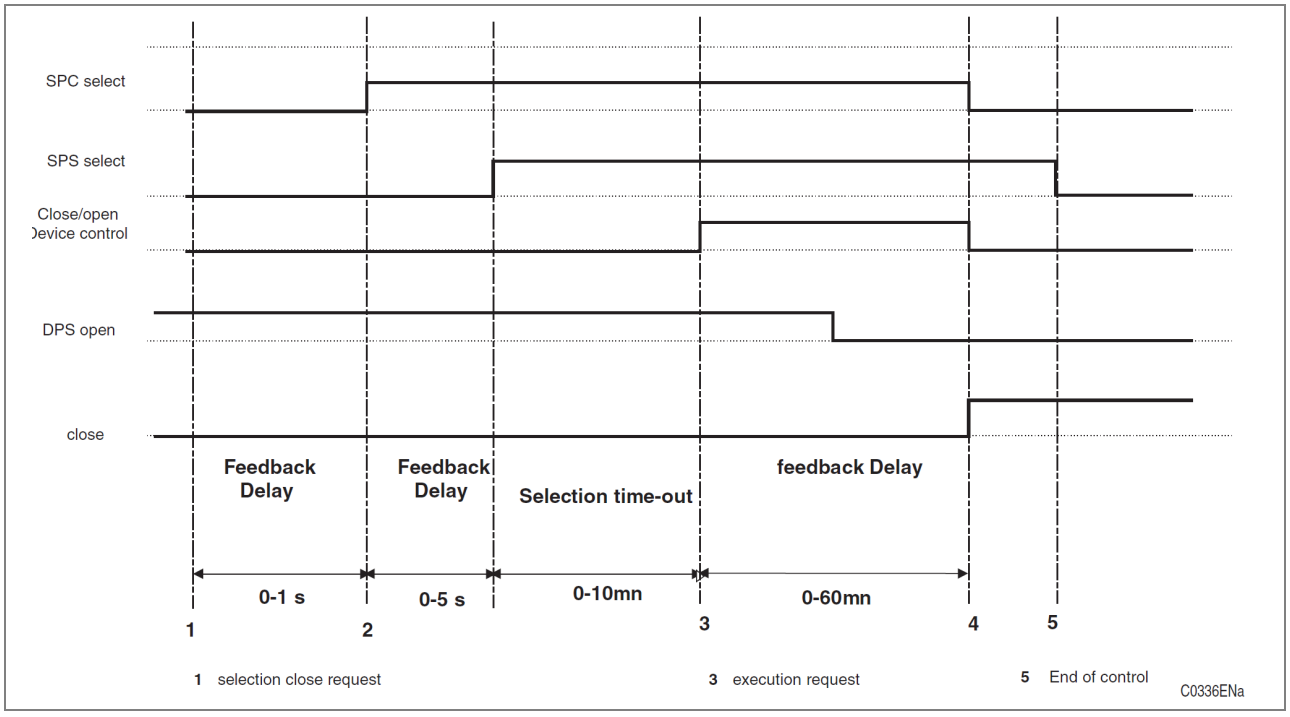
Event 4: reception of cancel request awaiting synchrocheck response

1 Stop the synchrocheck function

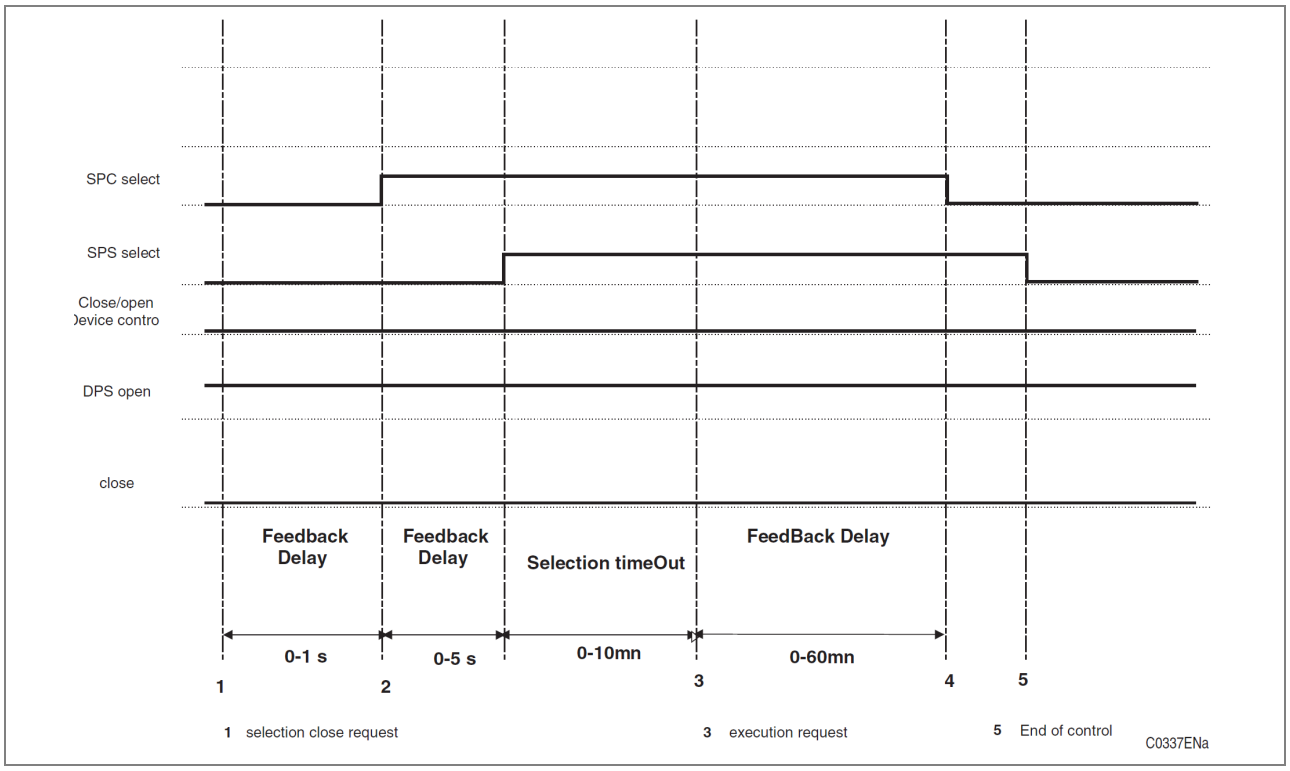
2 Deselect the device (if it was previously selected)

3 Send a negative acknowledgement

The timing diagram below shows a successful control sequence “close with internal synchrocheck”.



The timing diagram below shows an abnormal termination of control sequence “close with internal synchrocheck”.



6.3.3.2 CLOSE CB WITH INTERNAL MANUAL SYNCHROCHECK

The following sequence describes a circuit-breaker “close” request with internal synchrocheck in **“SBO once”** mode. The synchrocheck function is enabled by a separate direct execute control.

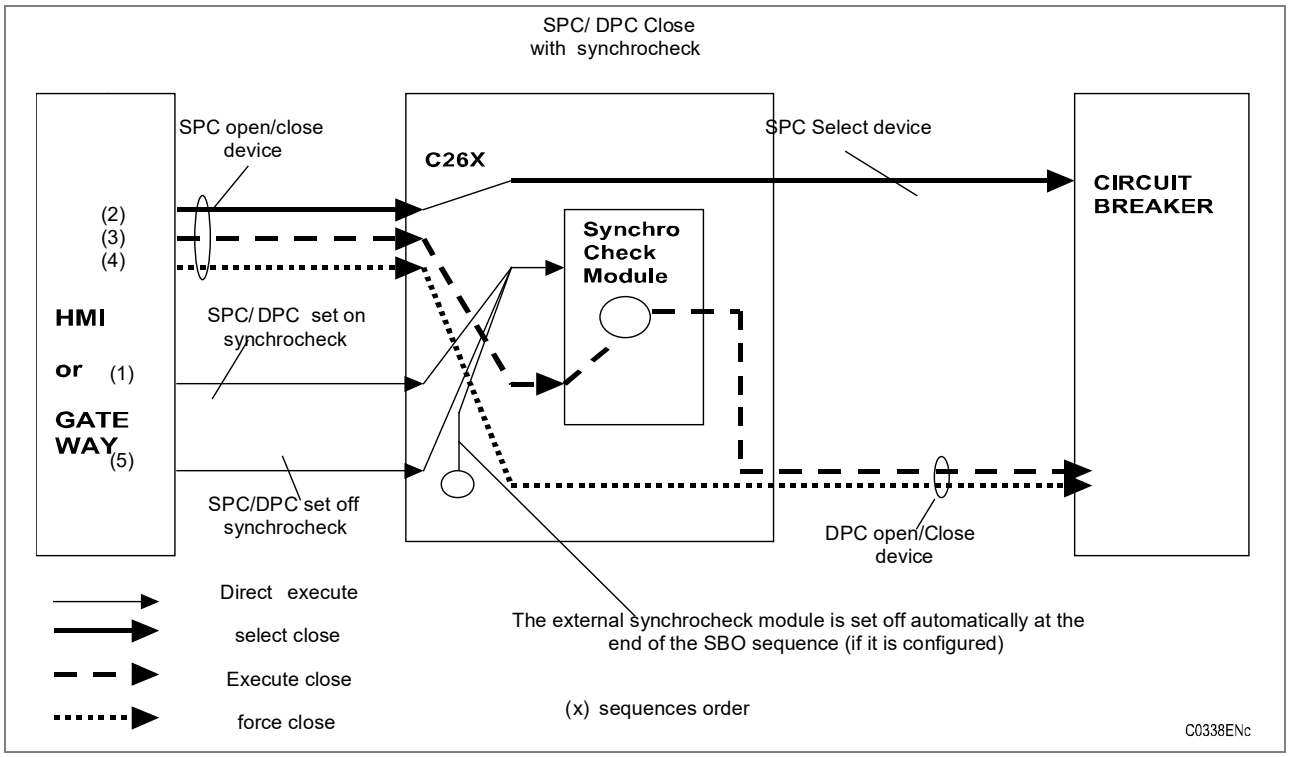


Figure 62: Close CB with internal manual synchrocheck

First sequence (DIRECT EXECUTE): Enable the internal synchrocheck function

1 Enable synchrocheck function for the device

2 Set system input “on/off synchrocheck” (if its is configured)

Second sequence (SBO ONCE): close the device with synchrocheck

Selection phase:

1 Close device selection output to select the device (if is configured)

2 Check selection device input information associated to the output (if is configured)

3 Wait for the execution request or timeout selection

4 In the event of a failure of one of these operations the controls sequence is stopped with a negative acknowledgement

Execution phase:

5 Ask to the internal automatism to close the device

Note:
The initiator of the request may force the closing of the device.

1 Check that the device's position becomes closed within the set time-delay

2 Disable the synchrocheck function if is configured to be disabled automatically

3 Deselect the device if it previously selected

Third sequence (DIRECT EXECUTE): disable the internal synchrocheck function

This sequence occurs only if the setting off of the synchrocheck function is configured “manual”

1 Disable the synchrocheck function

2 Reset system input “on/off synchrocheck” (if it is configured)

6.3.3.3 CLOSE CB WITH INTERNAL SYNCHROCHECK WITH FORCING

Awaiting authorization from the internal synchrocheck for closing the device, the initiator of the request may force the closing.

After time-out of the given delay without synchrocheck response

- Stop the synchrocheck function
- Close the device
- Deselect the device (if it was previously selected)
- Send a positive acknowledgement

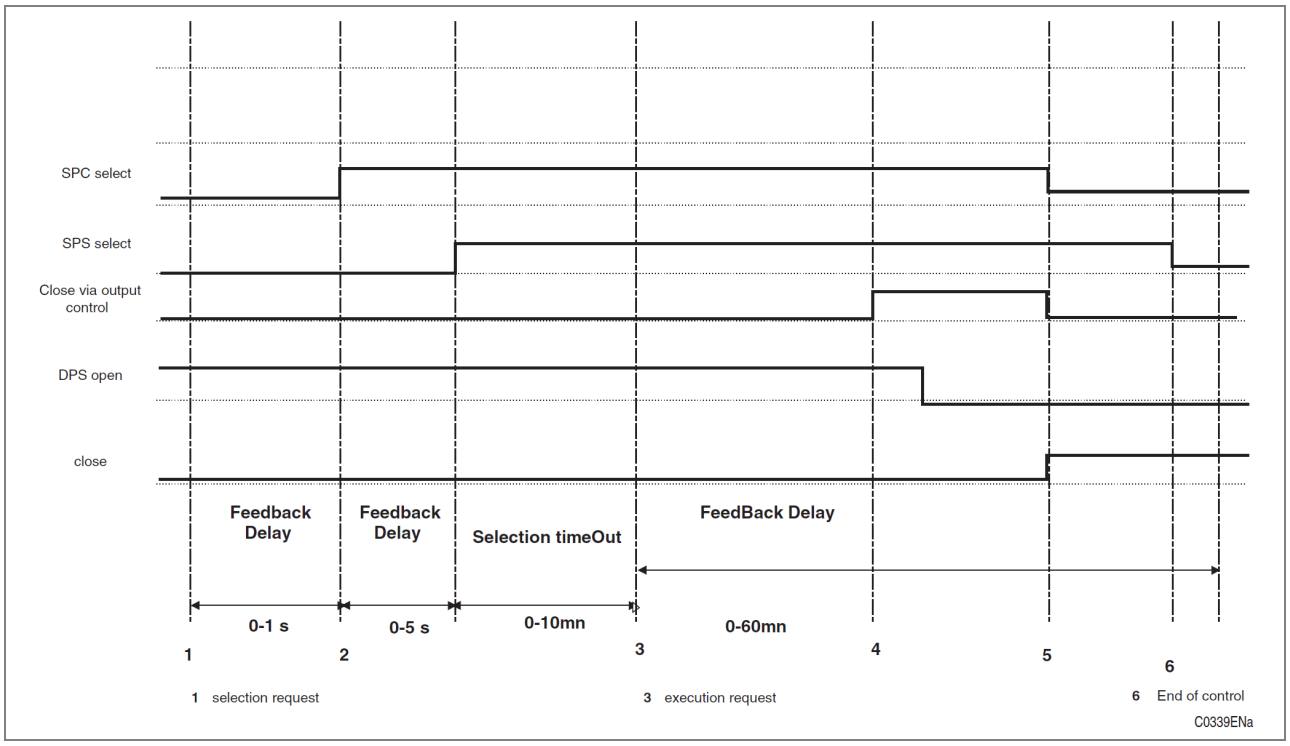


Figure 63: Close CB with internal synchrocheck with forcing

6.3.4 CIRCUIT-BREAKERS WITH INTERNAL MULTIPLEXED SYNCHROCHECK (BREAKER-AND-A-HALF TOPOLOGY)

In this configuration, the synchronism check is performed by the internal synchrocheck function. It compares the voltages of only 2 VTs at a time and gives or not the close authorisation the corresponding CB.

Note:
The multiplexed synchrocheck function can only manage manual closure (it cannot be used as part of an autoreclose sequence).

The control sequence is similar to that of internal synchrocheck Type 1 but this function the same synchrocheck can close 3 circuits breakers (one by one) using a TMU220 board wired on the first four voltage inputs.

The diagram below shows the supported electrical topology supported by the Synchrocheck Type 3 function: breaker-and-a-half diameter.

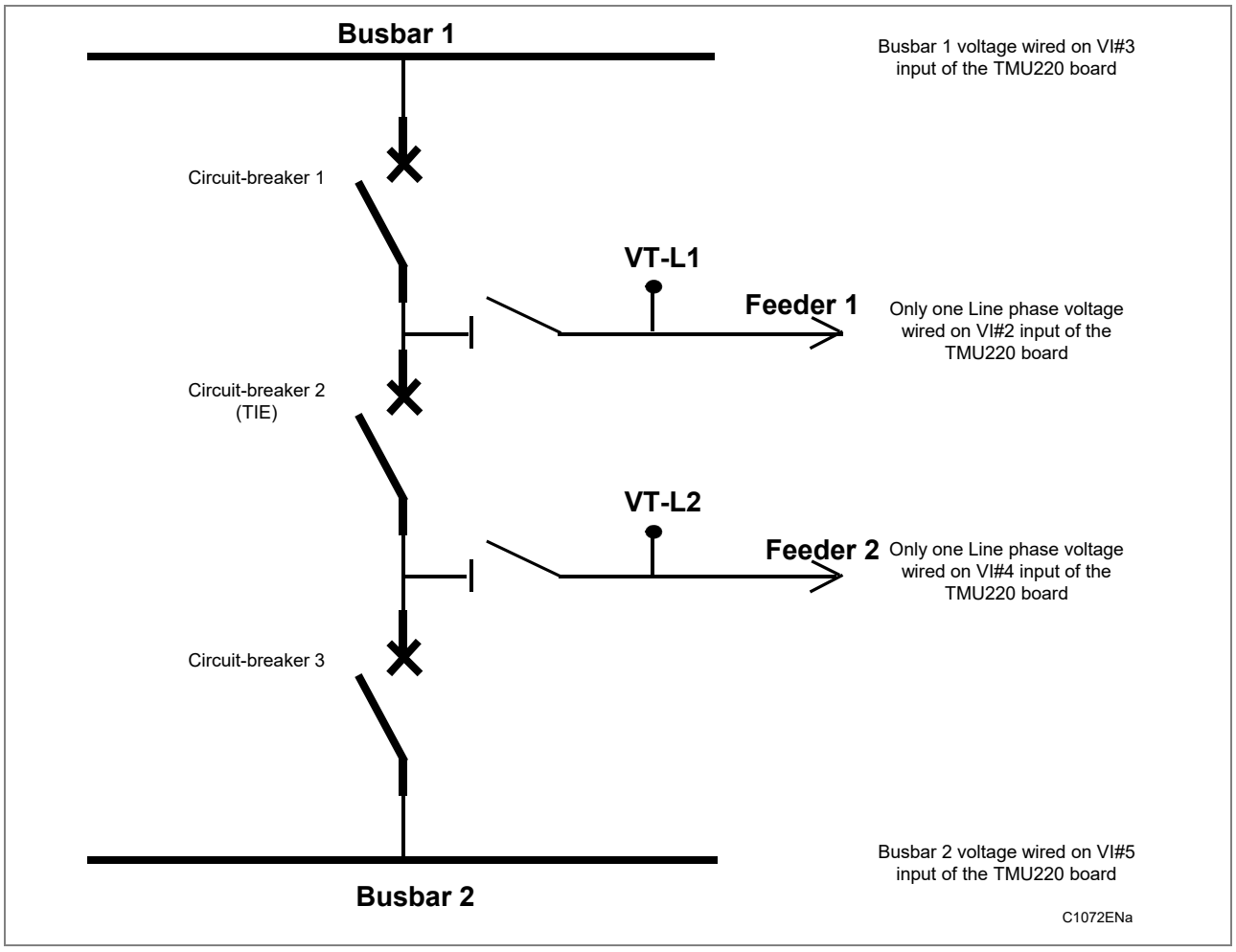


Figure 64: Circuit-breakers with internal multiplexed synchrocheck (breaker-and-a-half topology)

A fixed allocation between the measurement points (Line 1, Line 2, Busbar 1, Busbar 2) and the TMU220's voltage inputs is defined as follows:

Wiring	TMU220 inputs	VTs	Meas't points
Pins 21-22	VI#1	VT-L1	Line 1
Pins 23-24	VI#2	VT-L2	Line 2
Pins 25-26	VI#3	VT-B1	Busbar 1
Pins 27-28	VI#4	VT-B2	Busbar 2

The circuit-breakers are typed as follows:

- Line 1 circuit-breaker (CB1)
  (3 possible voltage checks: VT-B1/VT-L1; VT-B1/VT-L2; VT-B1/VT-B2)
- Tie circuit-breaker (CB2)
  (4 possible voltage checks: VT-L1/VT-L2; VT-L1/VT-B2; VT-B1/VT-L2; VT-B1/VT-B2)
- Line 2 circuit-breaker (CB3)
  (3 possible voltage checks: VT-B2/VT-L2; VT-B2/VT-L1; VT-B2/VT-B1)

For each of the 3 CBs, the following SPS datapoints are available:

The following 4 voltage selection SPSs are available:

- CBx with VT-B1
- CBx with VT-B2
- CBx with VT-L1
- CBx with VT-L2

These SPS are managed in a programmable scheme logic which checks that only 2 SPS datapoints are SET at the same time.

If there is an error on these SPS states the command will be rejected as inconsistent.

6.3.4.1 CLOSE CB WITH INTERNAL MULTIPLEXED SYNCHROCHECK, NECESSARILY SET TO "MANUAL"

The following sequence describes a circuit-breaker "close" request with internal synchrocheck in SBO once mode. The Synchrocheck function is enabled by a separate direct execute command.

First sequence (DIRECT EXECUTE) - Enable the internal synchrocheck function

1 Enable the synchrocheck function for the device

2 Set system input "on/off synchrocheck" (if it is configured)

Second sequence (SBO ONCE) - Close the device with synchrocheck"

Selection phase:

1 Close the device selection output to select the device (if it is configured)

2 Check the selection device input information associated with the output (if it is configured)

3 Wait for the execution request or timeout selection

4 If one of these operations fails the controls sequence is terminated with a negative acknowledgement

Execution phase:

1 Ask the internal automatism to close the device.

2 Check that the device's position becomes closed within the set time-delay.

3 Disable the synchrocheck function if it is configured to be disabled automatically

4 Deselect the device if it was previously selected

Third sequence (DIRECT EXECUTE) - Disable the internal synchrocheck function

This sequence takes place only if disabling of the synchrocheck function is set to "manual"

1 Disable synchrocheck function

2 Reset system input "on/off synchrocheck" (if it is configured)

Note:
During the SBO sequence, after step 1 of the Execution phase, the initiator of the request may force the CB closure.

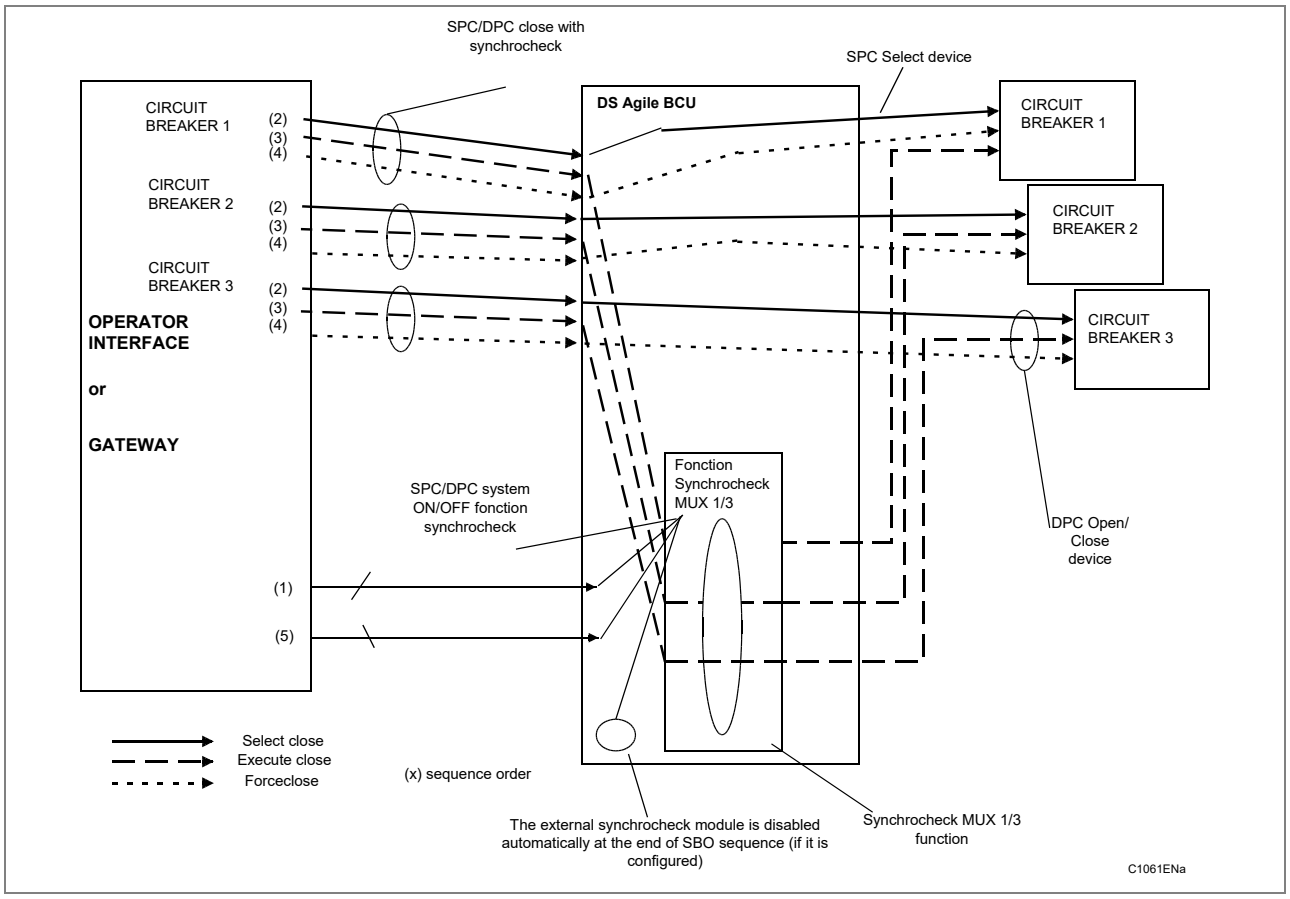


Figure 65: Close CB with internal multiplexed synchrocheck

The control sequence is similar to that of the internal synchrocheck Type 1, set to "manual".

But in this case, only SBOs are supported to close the CB so as to ensure that the synchronism is checked between the VTs corresponding to the selected CB.

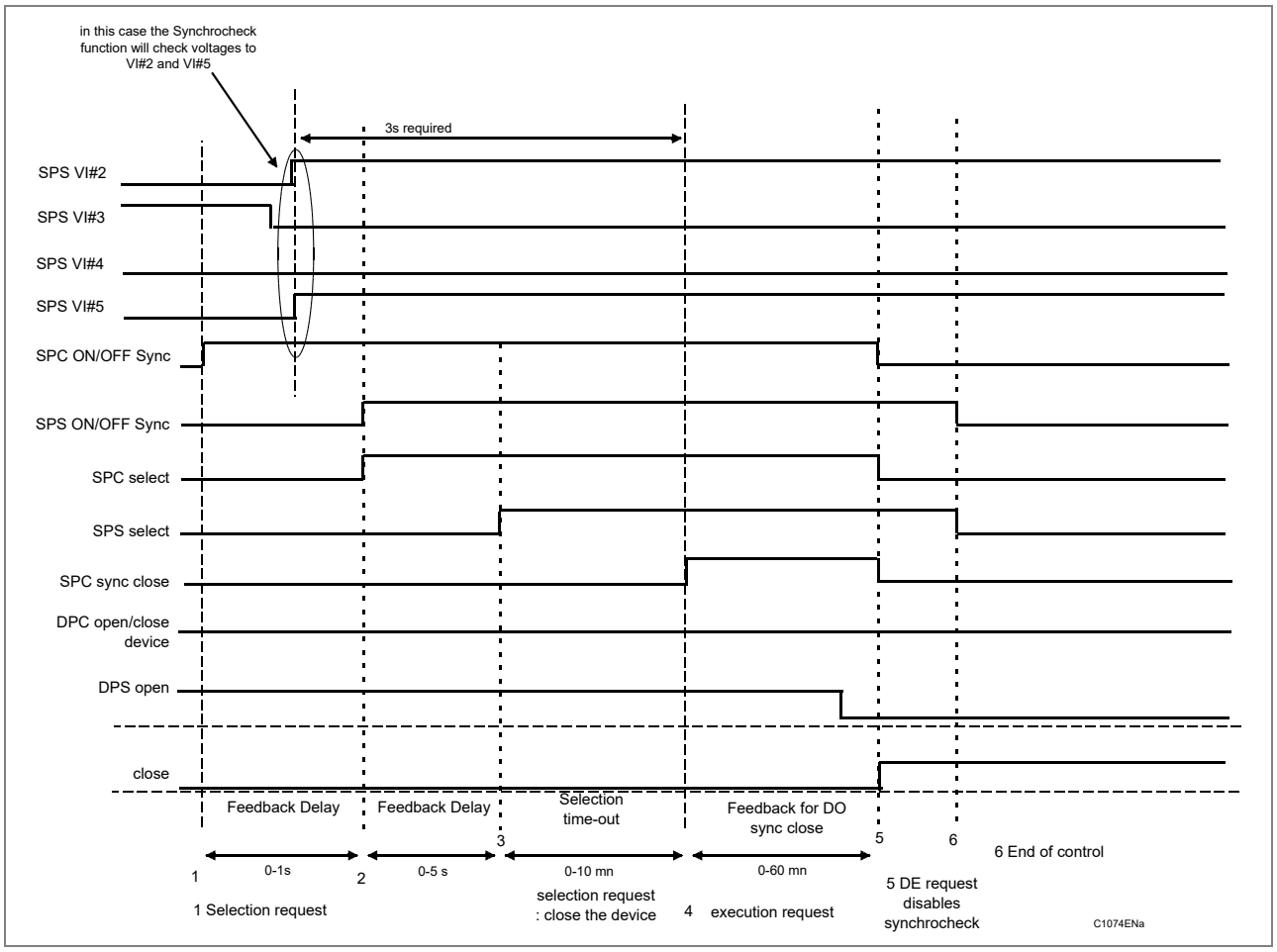


Figure 66: Close CB with internal multiplexed synchrocheck

6.4 CONTROL OF DISCONNECTORS (SWITCHGEAR)

6.4.1 DISCONNECTOR FEATURES

The C26x manages all types of disconnecting switches such as:

- Disconnectors
- Earthing switches
- Quick break switches

Disconnectors switches		
	Outputs to switchgear	**Inputs from switchgear**
Device control	DPC, control for open/close of device	DPS, physical position of the device
Device selection	SPC (optional), control of device selection	SPS (optional), device selection position information

6.4.2 CONTROL SEQUENCE OF DISCONNECTORS

The control sequence of disconnectors is identical to control sequence of the non-synchronized circuit-breakers.

6.5 CONTROL OF TRANSFORMERS

6.5.1 TRANSFORMER FEATURES

	Outputs	**Inputs**
Transformer control	DPC: raise/lower	TPI value SPS (optional) tap change in progress (TCIP)
Transformer selection	SPC (optional) transformer selection	SPS (optional) selection position information
Transformer type (see note 1)	Double wound or Auto-wound	

Note 1: Transformer type (auto-wound or double-wound) is user selectable.

Double wound (or two winding transformer) is a transformer with galvanic isolation between primary and secondary coil. Tap Changer (with additional winding) is usually located at HV-neutral side for economic reasons. Tapping-up (raise order) reduces primary winding and increases LV tension.

Auto-wound (or auto-transformer or single wound) is a transformer without galvanic isolation between primary and secondary. Secondary coil follows primary coil, (winding are serial). Tap Changer (with tap of additional winding) is serial. Increasing tap position (raise order) acts simultaneously on primary and secondary, it reduces transformer ratio then voltage at LV side.

6.5.2 CONTROL SEQUENCE OF TRANSFORMERS

You can control the transformers in the three modes **"Direct Execute"**, **"SBO once"** and **"SBO many"**.

In addition to the selection and execution checks described in the previous paragraphs the following checks are performed:

- A **"raise"** control is refused if the current tap position value corresponds to the maximum position of the tap.
- A **"lower"** control is refused if the current tap position value corresponds to the minimum position of the tap.
- In the event of a **"go to min"**, **"go to max"** or **"go to position x"** request, an internal automatism (via ISAGRAF) has to be added. This automatism generates the desired controls sequences in order to reach automatically the expected position. It may generate "Direct execute", "SBO once" or "SBO many" sequences according the configuration of the device

Note:
If the command of a transformer is configured in SBO many mode, it is impossible to configure the requests "go to min", "go to max"

TCIP feature: The TCIP input information (tap change in progress), is used to confirm the right execution of the low/raise execution. Two delays are given by the configuration for the TCIP management:

- TCIP apparition delay: The TCIP information must appear before the time-out of this delay.
- TCIP disappearance delay: The TCIP information must disappear before the time-out of this delay.

TPI feature: Because the TCIP input information is not always configured, the tap control is performed using only the Tap Position Indication (TPI) value to check the correct execution of the request. The TPI value must change in the given delay.

The following examples are given in **"SBO many"** mode that is the more complex. The main difference with the **"SBO once"** mode remains to the possibility to execute many "raise" or "low" controls before ending the sequence. Moreover, the device is not deselected automatically but only after an unselect order sent by the initiator of the control request.

6.5.2.1 CONTROL OF TRANSFORMER WITH TCIP

In this mode, when the TCIP input information is configured, the selection and execution phase are performed as follows: It is possible by configuration to prevent to have more than one control at a time.

Selection phase:

1 Close device selection output to select the device (if configured)

2 Check selection device input information associated to the output (if is configured)

3 Wait for the execution request (low/raise) or timeout selection

In the event of a failure of one of these operations, the device is deselected, the controls sequence is aborted with a negative acknowledgement.

Execution phase:

1 In agreement with the request "raise or lower" and the type of device, execute the associate control

2 Wait for the TCIP data and TIP value to confirm execution. Two events:

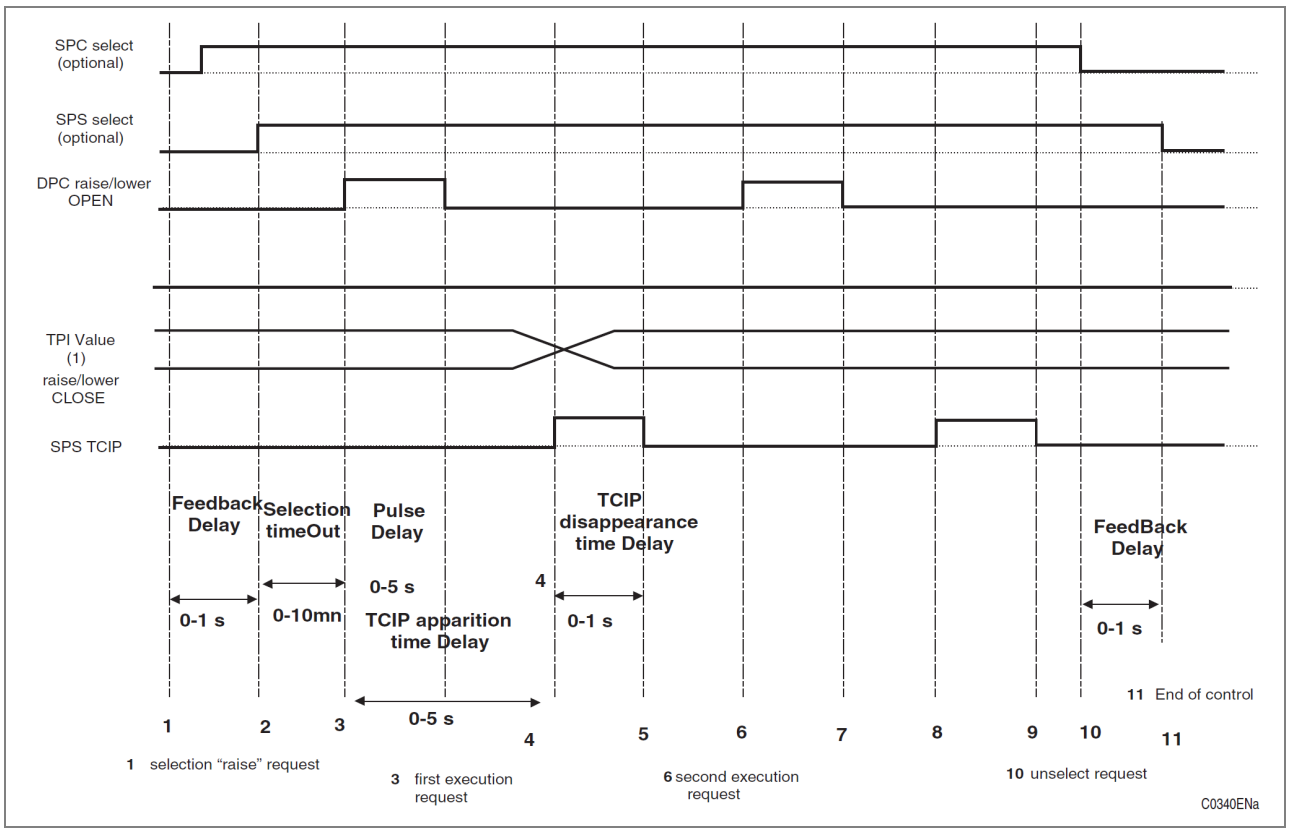
   - Event 1: The TCIP information appears and is disappears in the given delays, the TPI takes the expected value: The controller sends a positive acknowledgement and waits a new request (execution or unselection).

- Event 2: Timeout awaiting the TCIP appearance or disappearance, or the TPI value is wrong: The device is deselected (if it was previously selected), and the sequence is aborted with a negative acknowledgement.

3 Wait for the new execution request or unselection request to deselect the device

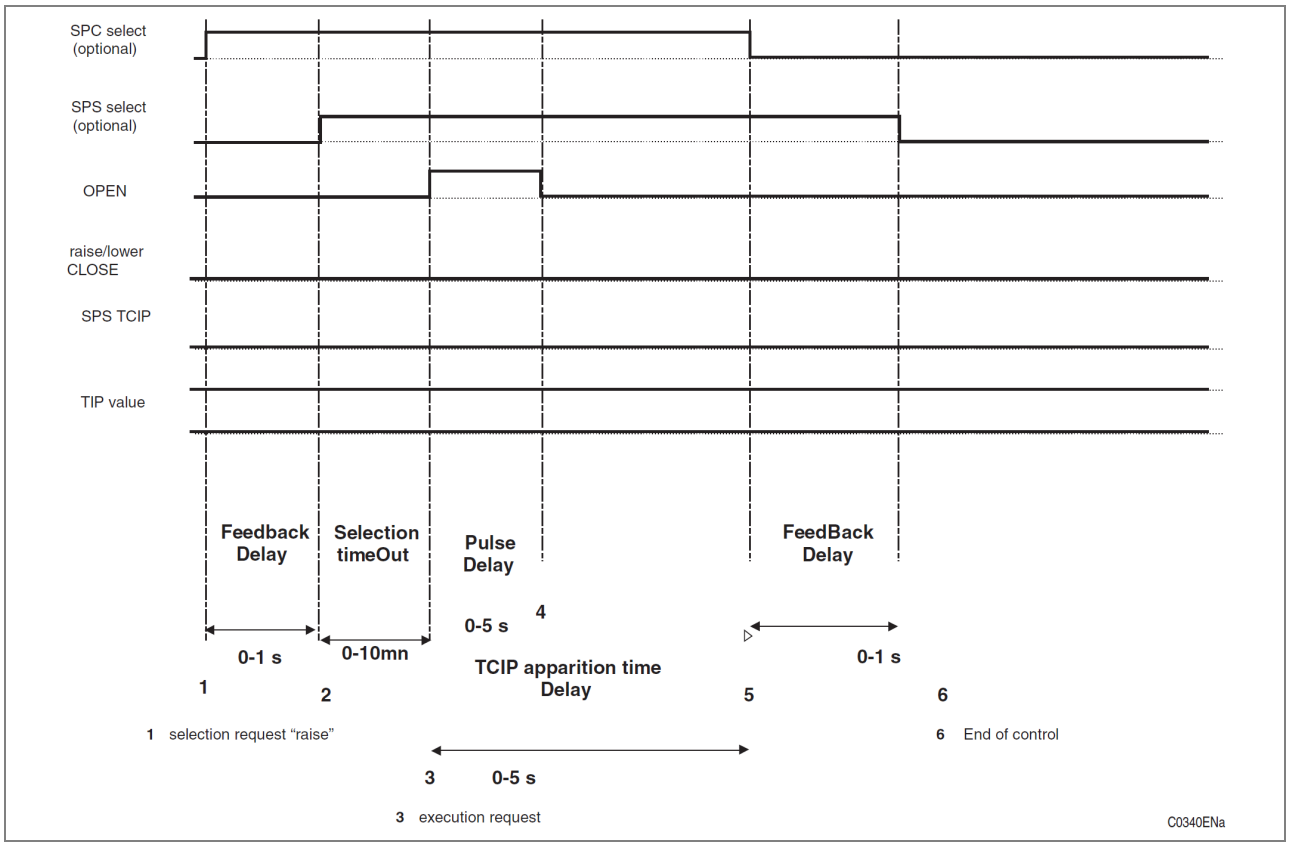
- In the event of a new request the controller repeat the steps 4 and 5.
- In the event of a deselection request the controller deselects the device (if it was previously selected), and ends the sequence with a positive acknowledgement

The timing diagram below shows a successful sequence with device selection, two “raise” controls and device unselection.



Note (1):
The TPI value must take the expected value at least at the end of TCIP disappearance

The timing diagram below shows an abnormal termination of tap changer control sequence due to absence TCIP confirmation. In this event the device is automatically deselected and the sequence ends with a negative acknowledgement.



6.5.2.2 CONTROL OF TRANSFORMER WITHOUT TCIP

In event the TCIP input information is not configured the selection and execution phase are performed as follows:

Selection phase:

1 Close the device selection output to select the device (if configured)

2 Check selection device input information associated to the output (if configured)

3 Wait for the execution close request or timeout selection

In the event of a failure of one of these operations, the device is deselected, the controls sequence is aborted with a negative acknowledgement.

Execution phase:

1 In agreement with the request "raise or lower" and the type of device, execute the related control

2 Wait for the TPI data and compare with the previous value. The difference must confirm the "low" or "raise" execution. Two events:

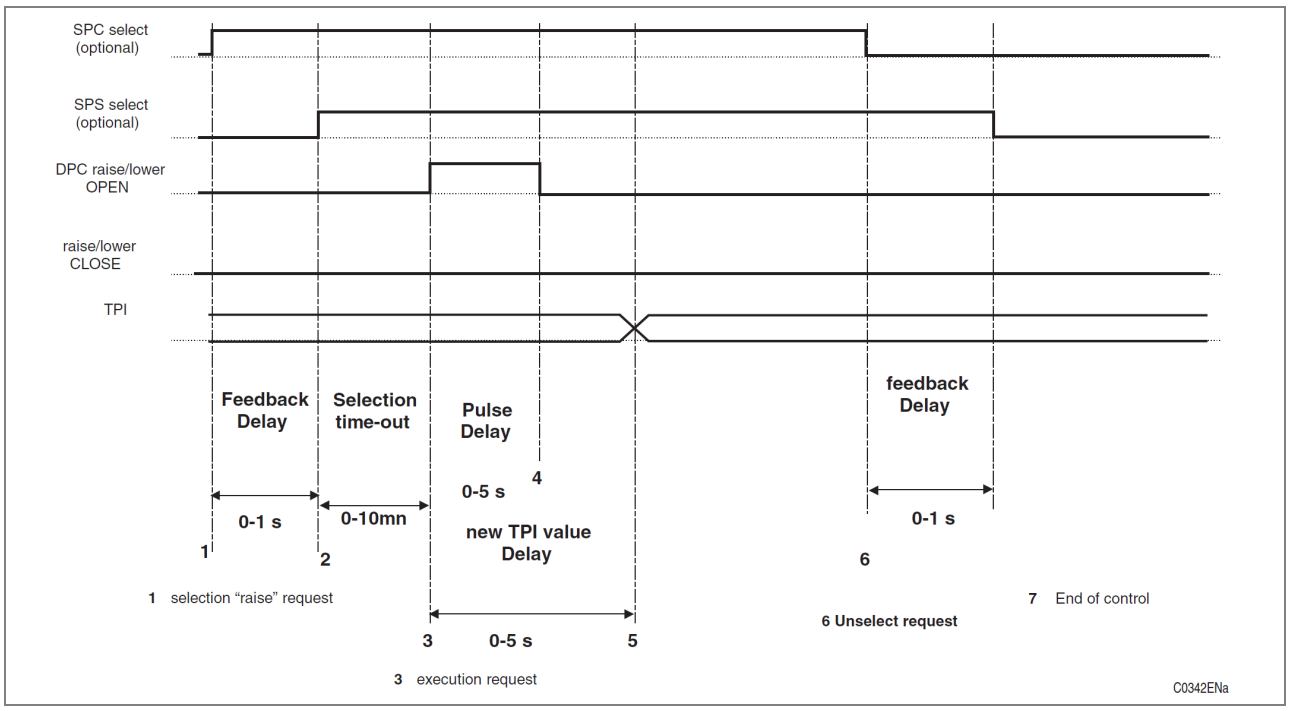
- Event 1: The TPI value confirms in the given delay the execution request: The controller sends a positive acknowledgement and waits a new request (execution or unselection) from the initiator.
- Event 2: Timeout awaiting the TPI value or unexpected TPI value: The device is deselected (if it was previously selected), and the sequence is aborted with a negative acknowledgement.

3 Wait for the new execution request or unselection request to deselect the device

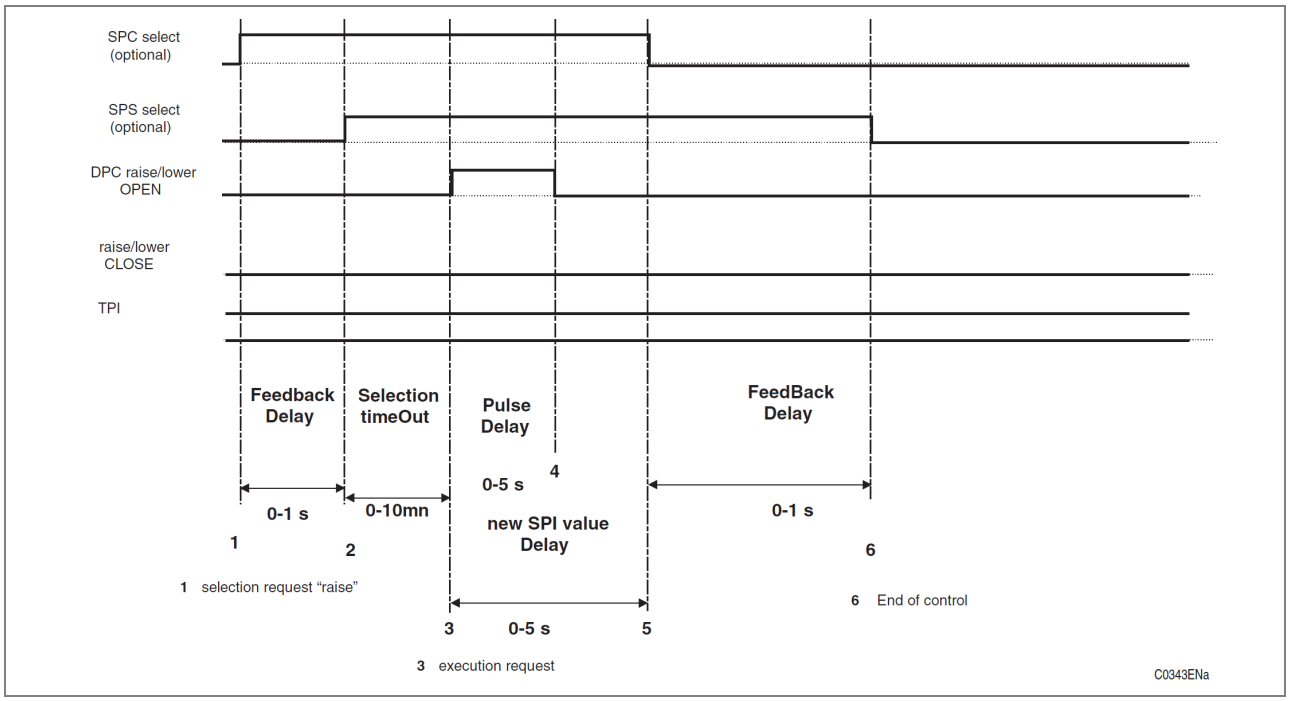
In the event of a new request the controller repeat the steps 4 and 5.

In the event of a deselection request the controller deselects the device (if it was previously selected), and ends the sequence with a positive acknowledgement.

The timing diagram below shows a successful sequence with device selection, a raise control and device unselection



The timing diagram below shows an abnormal termination due to the absence of change of the TPI value in the given delay. The device is automatically deselected, and the sequence is aborted with negative acknowledgement.



6.5.2.3 SUPPRESSION, FORCING OR SUBSTITUTION OF THE TPI

In the event of a suppress or substitution of TPI value the control sequence is aborted with negative Acknowledgement. If the Forcing of the sequence is not aborted but the value of TPI taken into account during the control sequence is the forced value.

6.6 CONTROL OF ANCILLARY DEVICES

Ancillary devices are managed in **"Direct Execute"** or in **"SBO once"** mode. Refer to generic explanations above.

6.7 CONTROL OF INTELLIGENT ELECTRONIC DEVICES (IED)

6.7.1 CONTROL TO IEDS BY XPC

A request to control equipment via IED can be performed in 3 modes: DE, SBO once, SBO many.

6.7.1.1 DIRECT EXECUTE MODE

If execution checks are successful

1 The controller sends the control (open/close, low/raise, setpoint) via the communication protocol to IED

2 The controller waits for IED's control acknowledgement in the given delay (if is supported by the protocol)

3 The controller waits for the reception of the feedback of the request (device position SPS, DPS, TPI) in the given delay (if is configured)

In the event of a failure, in step 2 or 3 the sequence ends with a negative acknowledgement. Otherwise the sequence ends with a positive acknowledgement.

6.7.1.2 SBO ONCE MODE

This mode can be configured only if is supported by the protocol.

Selection phase

After you perform the selection checks

1 The controller sends a selection request to the IED

2 The controller waits for a selection acknowledgement from IED in the given delay

3 The controller generates a positive or negative selection acknowledgement according to the result of the selection phase

4 If positive acknowledgement, the controller starts selection time-out and waits execution request, otherwise ends the controls sequence

Execution phase

1 If execution checks are successful

2 The controller sends the control, such as the open/close, low/raise, setpoint; through the communication protocol to the IED

3 The controller waits for the IED, if supported by the protocol, to send the control acknowledgement within the given delay

4 The controller waits for the reception of the feedback of the request, such as the device position SPS, DPS, TPI within the given delay, if it is configured

If successful, the sequence ends with a positive acknowledgement. In the event of a failure in step 6 or 7, the sequence ends with a negative acknowledgement

6.7.1.3 SBO MANY MODE

In comparison with the **SBO once** mode, in this mode, the execution phase is repeated till an unselection request is placed. This unselection request allows you to end the sequence in the controller, and it is not sent to the IED.

6.7.2 CONTROL TO IEDS BY DIGITAL SETTING POINT (SPC)

The available modes include: Direct Execute, Direct Execute with SBO popup (reserved to substation control point usage).

6.8 SYSTEM CONTROLS

System control is used to activate or deactivate automatic functions, change controller's mode, bay mode, database management, etc.

A system output control remains internal on the controller (has no digital or IED output) and may generate a system input information. They are managed in **Direct Execute** mode only. A hardware selection has no meaning.

For some uses, such as automatism's activation/deactivation, it is necessary to generate a system input, that gives the state of the controlled function: for example, ATCC ON/OFF. This system input may be able to be used by the control sequence or enter to an interlocking equation etc. The configuration process allows the user to assign or not a system input, that may include an SPS or DPS. System inputs generated by system outputs are stored in non-volatile memory. In the event of a the controller's initialisation, they are restored.

6.9 TYPES OF CONTROL SEQUENCES

The control sequences automation receives three kinds of input triggers (as orders from the higher level) with selection, execution and unselection. Control orders may have a normal or abnormal termination with positive or negative acknowledgement to operator and to communication.

By configuration, each DRC order (close order or open order) and each SPC can activate simultaneously two DO contacts at the same time.

6.10 CONTROL SEQUENCES CHECKS

Receiving control, the control sequence executes configured checks:

Operational conditions

- C26x mode management (Operational, Test, Maintenance..),
- IED connected,
- Substation control mode (Remote/Local),
- Bay control mode,
- SBMC mode,
- Uniqueness of control inside the substation.

Module conditions

- Inter-control delay,
- Status of the device,
- Lock condition,
- Automation already running (AR, AVR, ATCC, …),
- Interlock equations (substation, bay, local of the module).

Execution conditions

- Delays upon selection feed back, start moving, final position reached.

6.10.1 MODE MANAGEMENT

Control sequences are only performed if the controller mode is in operational mode. In test mode, control sequences are permitted but digital outputs are not set.

6.10.2 IED CONNECTED

If a control has to be sent to an IED, it is only accepted if this IED is connected to the controller.

6.10.3 CONTROL MODE

This control sequence receives requests from the various control points:

- Automation (Auto Recloser, voltage regulation, PLC),
- C26x Local HMI,
- C26x TBUS communication from SCADA,
- Station BUS (other controller in distributed automation, DS Agile system HMI, DS Agile Gateway),
- Legacy BUS (from One Box Solution IED).

To avoid conflict between the control points, substation and bay modes are checked. Each control sequence can be subjected or not to these checks. The switches Remote/Local can be hardware or software (saved in non-volatile memory).

The SBMC Site Based Maintenance Control mode allows controlling one specific bay from the Local HMI or the System HMI even if the substation is in remote mode. This feature is dedicated to commissioning or maintenance and offers also the possibility to filter data transmitted from the bay to SCADA.

6.10.4 UNIQUENESS OF CONTROL

It is possible by configuration to prevent having more than one control at a time:

- For the whole substation
- Inside a bay

If a device is under control and another control is sent on this device, the second one is ignored.

In the event of a uniqueness of the command at least to one of these levels the selection is refused, with negative acknowledgement. The user may bypass this control during selection request.

6.10.5 INTER-CONTROL DELAY

For wired commands only, it is possible by configuration to define a minimum time that must elapse between two consecutive control commands on the same device.

6.10.6 STATUS OF THE DEVICE

If the status of the device is not valid, it is possible by configuration to prevent control.

6.10.7 LOCK DEVICE

Controls are not permitted on a lock device.

6.10.8 RUNNING AUTOMATION

If there is a related automation in operation, controls are not permitted on a device.

For example controls issued from the System HMI or the Gateway are not permitted on a transformer controlled by voltage regulation.

6.10.9 INTERLOCKING

The operation of a switching device, such as circuit-breakers; traditional disconnecting switches; disconnecting switches with abrupt loss; and ground disconnecting switches; is directly related to the nature of the switch and to its environment.

To operate these devices you must respect some conditions. These conditions, called **interlocking**, are managed by **logical equations** within the C26x.

Interlocking prohibits a control sequence that may violate the device operating condition: for example, break capability, isolation, and so on; or plant operating condition.

6.11 HV CONTROL SEQUENCES

6.11.1 CIRCUIT-BREAKER

Several kind of circuit-breaker can be managed:

- Three phases or single phase circuit-breaker,
- Synchronized or non-synchronized, with internal or external synchrocheck,
- With and without Auto Recloser.

For three phase breaker each phase DPS is provided separately and it is managed globally by single (grouped) control and global DPS position. Pole Discrepancy management is available.

6.11.2 DISCONNECTOR

The control sequence of disconnectors is identical to single non-synchronized circuit-breakers.

6.11.3 TRANSFORMER

Transformer position is determined using TPI (Tap Position Indication). TPI can be a Digital Measurement or Analogue Measurement (from DC Analogue Input).

The transformer is the only device that supports the SBO Many control sequences. It is linked to voltage regulation, also its Raise and Lower controls are defined for secondary voltage (and not tap position). Except for auto wounded transformer, raise/lower voltage is also a raise/lower tap.

7 AUTOMATIONS

C26x provides three different ways to perform automation functions:

- Programmable Scheme Logic (PSL) (True for all C26x units except for the C26x-Standalone RTUs)
- Programmable Logic Controller (PLC)
- Built-in automation functions

The choice between these three solutions depends on time and complexity.

7.1 BUILT-IN AUTOMATION FUNCTIONS

Within the C26x, some built-in automation functions are available and you can set them directly:

- Auto-Recloser
- xPS/xPC Association
- Pole Discrepancy
- Automatic Voltage Regulation (AVR)
- Automatic Tap Change Control (ATCC)
- Synchrocheck

7.1.1 AUTO-RECLOSER (AR)

7.1.1.1 INTRODUCTION

80-90% of faults on the electrical network are transient, such as lightning or insulator flashover. When a fault occurs, the circuit-breaker is tripped in order to protect the system.

The Auto-Recloser function is then used to close the circuit-breaker after a set time, a time that is long enough to allow the fault to clear. This duration is called cycle delay and is defined in the database during the configuration phase.

But, as permanent fault can occur, an auto-recloser scheme has to be provided in order to allow the elimination of a transient fault by an open/close sequence (auto-reclosing cycle) and the elimination of permanent fault by, after a defined number of auto-reclosing cycle (4 cycles maximum), leaving the circuit-breaker in the open state by closing the trip relay.

A transient fault, such as a lightning strike, is one that is cleared by immediate tripping of one or more CB's to isolate the fault, and does not recur when the line is re-energized.

This means that in the majority of fault incidents, if the faulty line is immediately tripped out, and if time is allowed for the arc to de-ionise, reclosure of the CB will result in the line being successfully re-energized (Closed/Open/Closed cycle).

However, some faults will be permanent (such as a line fallen to earth). In this event the auto-recloser must be able to react to the permanent fault, and on the first reclose and detection of the permanent fault open the CB's (and, if required lock out the auto-reclose functionality). (This is a Closed/Open/Closed/Open, 4 cycle system).

Auto-recloser (AR) schemes are implemented to carry out this duty automatically.

7.1.1.2 BEHAVIOUR

The general diagram of the auto-recloser function is as follows:

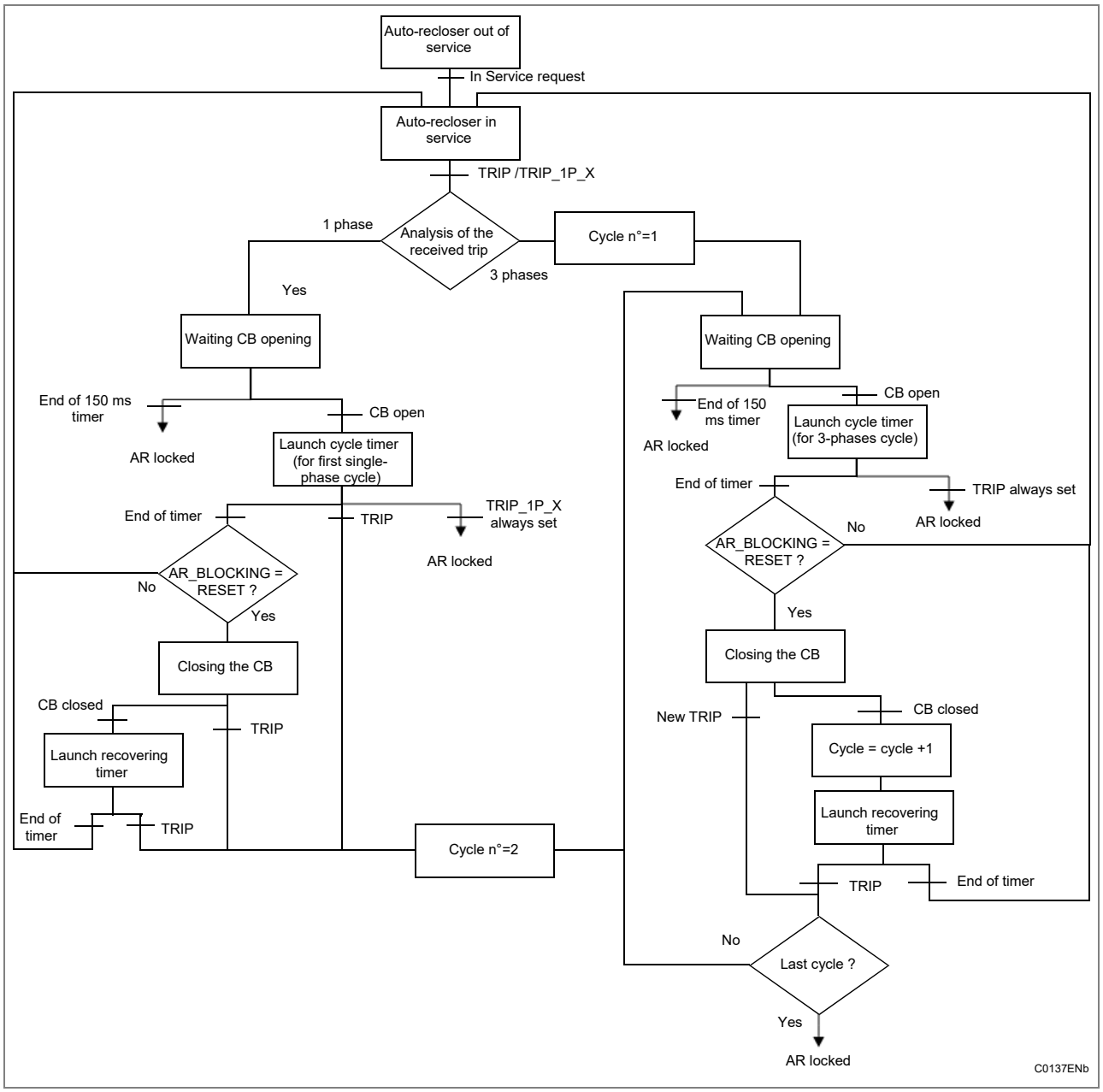


Figure 67: Auto-Recloser scheme logic

7.1.1.2.1 In Service / Out of service

The auto-recloser function can be in or out of service due to an operator control (through the station bus, the controller's local HMI or a BI).

If the auto-recloser is out of service, no cycle is authorized.

If an out of service request is received during an auto-reclosing cycle, the cycle is immediately stopped.

7.1.1.2.2 Analysis of the received trip

This analysis allows you to detect the type of auto-recloser cycle, that can be:

- The first single-phase cycle
- The first 3-phase fast cycle
- The second 3-phase slow cycle
- The third 3-phase slow cycle
- The fourth 3-phase slow cycle

This detection is done using:

- The current cycle number
- The TRIP_1P_X or TRIP signal sent by the protection relay (single-phase trip / 3-phase trip)
- The configured auto-recloser cycles

7.1.1.2.3 Waiting CB opening

As soon as the trip has been detected, a 150 ms timer is launched to wait for the circuit-breaker opening.

For a single-pole CB

- If the CB position is on a per pole basis:
  - In a single-phase cycle, only one phase position is awaited in the OPEN state (CB_STATE_1P_X)
  - In a 3-phase cycle, each one phase position is awaited in the OPEN state
- If the CB position is given globally:
  - In a single-phase cycle, the position (CB_STATE) is awaited in the MOTION00 state
  - In a 3-phase cycle, the position (CB_STATE) is awaited in the OPEN state

For a three-pole CB

- Whatever was the cycle, the 3-phase position is awaited in the OPEN state (CB_STATE)

For a 3-phase cycle, the DO “AR_TRIP_3P” is closed (if configured) as soon as the CB is detected as open.

The auto-recloser function is locked if the CB is not opened at the end of the timer.

7.1.1.2.4 Launch cycle timer

As soon as the CB is detected as open, the timer associated to the current auto-recloser phase is launched.

During the single-phase cycle, the trip signal must disappear: if not, the auto-recloser function will be locked. Furthermore, a 3-phases trip could appear. In this event, the current cycle is stopped, and the second 3-phases slow cycle is launched.

7.1.1.2.5 Closing the CB

At the end of the cycle timer, the AR_BLOCKING BI is tested: if it is in RESET state, a close order is sent to the circuit-breaker. Note that, if present, the synchrocheck function is used to control the breaker during the second, third and fourth 3-phase slow cycles. The use of the synchrocheck function during the first 3-phase fast cycle is configurable.

If the AR_BLOCKING BI is in another state, the automation is re-initialised to wait for the first cycle.

7.1.1.2.6 Launch recovery time

As soon as all concerned CB phases are closed, the Reclaimmc recovery timer is launched. If the CB remains closed during the timer, the reclosing is considered to be successful and the cycle number is set to 0. The “AR_STATE” signal is set at AR_RECLAIMC state during this timer.

If a new trip occurs during the timer, the next configured cycle is launched. If the trip occurs during the last cycle, the auto-recloser is locked.

7.1.1.2.7 Particular treatments

Reclaim time on manual close

If the CB becomes closed (through an external operation) during an auto-recloser cycle, the Reclaimmc timer is launched during which the auto-recloser function is inhibited and the “AR_STATE” signal is set at the AR_RECLAIMMC state.

CB closing failure

If the CB closing order fails, due to DO hardware failure, interlocking scheme, or synchrocheck inhibition, the AR_FAIL signal is set.

This SI is reset as soon as the CB is closed.

Lock of the auto-recloser

The conditions that lead to an auto-recloser locking are:

- A trip during the last auto-recloser cycle (in this event, the AR_STATE signal is set at the AR_BAR_SHOTS state)
- A lock signal through the AR_LOCK Binary Input at the SET state
- Trip BI state is Invalid (this BI cannot be suppressed, forced or substituted)
- CB position BI(s) state is (are) Invalid
- The Trip BI is always set at the end of the cycle timer
- There is no pole discordance at the end of the single-phase cycle: that is, the three phases are opened
- 2 phases are in an opened state at the end of the single-phase cycle without 3-phase trip signal
- The CB is not opened at the end of the 150 ms timer

The AR_STATE signal is set at the AR_BAR_LOCK state if the auto-recloser function is locked, and the cycle counter is set to 0.

There are two configurable methods to unlock the function. These methods are selected during the configuration phase and can be used separately or together:

1 A manual closing of a circuit-breaker: in this event, the Reclaimmc timer is launched.

2 An “AR_LOCK” signal at the RESET, received either through a BI or an operator order.

If none of these methods are selected, the auto-recloser is automatically unlocked if no lock condition is set and circuit-breaker is closed. In this event, the Reclaimml timer is launched. If the CB is not closed at the end of this timer, the auto-recloser is locked again.

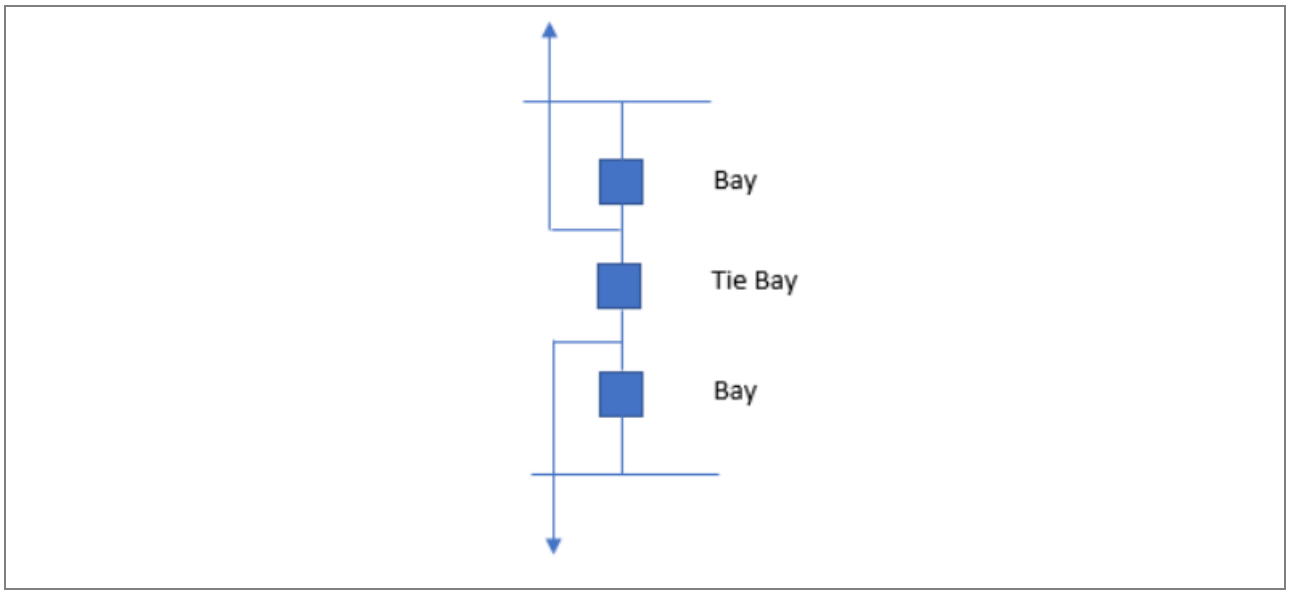
7.1.1.3 INFORMATION AND PARAMETERS

Information	Description	Type
CB_STATE_1P_x	CB status, on a per pole basis	BI (DP)
CB_STATE	CB status (global)	BI (DP)
TRIP_1P_x	Trip status, on a per pole basis	BI (SP)
TRIP	3-pole trip status	BI (SP)
AR_IS/OS	Request to put the auto-recloser in / out of service	BI (DP) or operator control
AR_LOCK	Signal to lock / unlock the auto-recloser	BI (SP, Group) or output of a configurable automation or operator control
CB_HEALTHY	Availability of the breaker to be closed	BI (SP)
AR_BLOCKING	Signal to block the closure of the circuit-breaker	BI (SP, Group) or output of a configurable automation
CB_ORDER_1P_x	CB order, on a per pole basis	DO
CB_ORDER	CB order (global)	DO
AR_TRIP_3P	Force 3-pole trip command	This information can be wired to a DO or can be used as an internal signal.
AR_IS/OS	Auto-recloser status: In / Out Of Service	SI (DP)
AR_STATE	Auto-recloser current state	SI (MP)
AR_READY	The auto-recloser is in service, unlocked and no cycle is in progress	State0
AR_WAIT_F/CB_TRP	The auto-recloser is waiting for CB opening	State1
AR_1ST_CYCLE_1P	The first single-pole shot is in progress	State2
AR_1ST_CYCLE_3P	The first 3-pole shot is in progress	State3
AR_2ND_CYCLE_3P	The second 3-pole shot is in progress	State4
AR_3RD_CYCLE_3P	The third 3-pole shot is in progress	State5
AR_4TH_CYCLE_3P	The fourth 3-pole shot is in progress	State6
AR_WAIT_F/CB_CLS	The auto-recloser is waiting for CB closing	State7
AR_RECLAIMC	The Reclaimc timer is launched	State8
AR_BAR_SHOTS	Auto-recloser locked due to reaching the max number of reclosing cycles	State9
AR_BAR_LOCK	Auto-recloser locking	State10
AR_RECLAIMML	The reclaimml timer is launched	State11
AR_RECLAIMMC	The reclaimmc timer is launched	State12
AR_FAIL	Failure of the close command	SI (MP)
AR_SYNC_NOK	Due to the synchrocheck	State0
AR_HARD_ERROR	Due to hardware failure, lock of device or another running automation linked to the device	State1
AR_ILOCK_NOK	Due to interlocking function	State2
AR_NO_FAULT	No failure	State3
AR_TYPE	Auto-recloser type cycle configuration	Mono / Tri
AR_CYCLE_NUMBER	Number of cycles	1, 2, 3 or 4
1P_CYCLE1_TIMER	Timer for the first single-pole shot	From 10 ms to 5 seconds, in steps of 10 ms

Information	Description	Type
3P_CYCLE1_TIMER	Timer for the first 3-pole shot	From 10 ms to 60 seconds, in steps of 10 ms
3P_CYCLE2_TIMER	Timer for the second 3-pole shot	From 1 to 3600 seconds, in steps of 1 s
3P_CYCLE3_TIMER	Timer for the third 3-pole shot	From 1 to 3600 seconds, in steps of 1 s
3P_CYCLE4_TIMER	Timer for the fourth 3-pole shot	From 1 to 3600 seconds, in steps of 1 s
RECLAIM_TIMER	Reclaim timer	From 1 to 600 seconds, in steps of 1 s
RECLAIMMC_TIMER	Reclaimmc timer	From 1 to 600 seconds, in steps of 1 s
RECLAIMML_TIMER	Reclaimml timer	From 1 to 600 seconds, in steps of 1 s
UNLOCKING_METHOD	Method to unlock the auto-recloser	None, manual close, unlock signal, both
SYNC_ENABLE	Use the synchrocheck function during the 3-pole first shot	Yes / No

7.1.1.4 AUTORECLOSER WITH PRIORITY HOLD

The priority hold feature is applicable only for a Breaker-and-a-half electrical topology defined as follows:



In this topology the middle bay is also known as **Tie Bay** and the end bay which are directly connected to busbar are called Main bay. The CB of the **Tie Bay** can act as a backup for any of the **Main Bay** in case the **Main Bay** CB is in maintenance as follow:

- If the main Bay autorecloser fails, then the Tie Bay autorecloser will not attempts its own autorecloser.
- In case the **Main Bay** CB is in maintenance or **Main Bay** Autorecloser is Off, then the **Tie Bay** will perform its Autorecloser as usual without any dependency on the **Main Bay.**
- This will occur at each cycle of Autorecloser if the multiple cycles are configured.

This topology can be used for both 1P or 3P autorecloser. Whenever a trip occurs, the Main Bay autorecloser starts first and only when the Main bay autoreclose is successful, the Tie Bay autoreclose will start.

7.1.1.4.1 Autorecloser's combinations topology

For any bay, in order to decide whether to autoreclose or not with the priority hold, three options are available:

1 **Standalone mode**: In this mode the Autorecloser will run as Usual. For all **Main Bays**, this mode should be chosen. This will also be the default value when the Autorecloser Module is added

2 **Line + Tie mode**: This mode is applicable for **Tie Bay** when there is only one **Main Bay** connected to the **Tie Bay** (which could be on either side)

3 **Line + Tie + Line mode**: This mode is applicable for **Tie Bay** when there are two **Line Bays** which are connected on both sides of the **Tie Bay** as follow:



7.1.2 TRIP CIRCUIT SUPERVISION (TCS)

The Trip Circuit Supervision function monitors the trip circuit wiring continuity irrespective of the position of the CB contacts but only when the trip relay is not activated. This information is received through a separate input and it inhibits the detection of continuity.

The DS Agile C26x supports two Trip Circuit Supervision schemes:

- Trip Circuit Supervision using one Digital Input and an external resistor
- Trip Circuit Supervision using two Digital Inputs and no external resistor

Both schemes are based on digital inputs being kept energised as long as the trip circuit is healthy. These inputs can then be configured to issue alarms when they are reset.

Trip Circuit Supervision using one Digital Input and an external resistor

The value of the resistor in the TCS scheme (R) should be:

1 High enough, so that once the CB is open and if the protection device's trip contact is latched, the trip coil powered via this resistor is no longer submitted to a magnetic effect and the tripping mecanism can be released (within a possible delay due to inductive effect of the coil).

2 Low enough, so that the DS Agile C26x's digital input powered through the resistor (and the tripping coil) is seen energised.

Therefore:

3 It is estimated that the magnetic effect is low enough to allow the release of the tripping mechanism when the applied voltage is equal to 0.1 Vn. Taking into account usual tolerances for the power supply, this leads to the minimum value of R being approximately 10 to 12 times the resistance of the tripping coil.

4 The DS Agile C26x's digital input was tested to operate with a series resistor of up to 40 kOhm, still leaving voltage through the input above the minimum. Taking into account tolerances, this defines a maximum value for the resistor of 20 kOhm.

The recommended value is in the middle of the range (geometrically):

R / 12 x Rc = 20kOhm / R

Where Rc = resistance of the tripping coil.

The power rating of the resistor must be such that it withstands permanent application of the maximum trip circuit voltage. Therefore:

$P = (1.2 \times Vx)^2 / R$

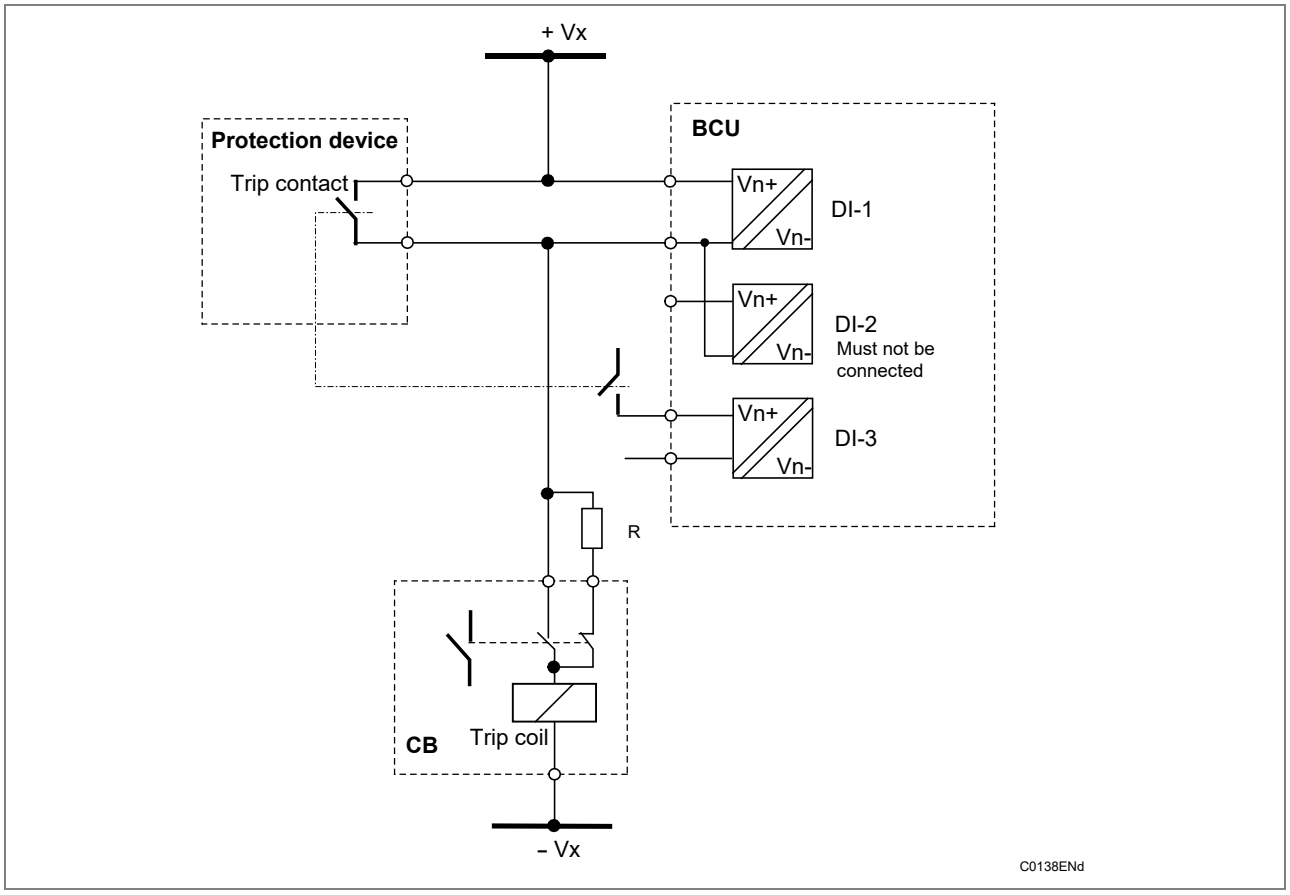


Figure 68: Trip circuit supervision using one digital input and an external resistor

Trip Circuit Supervision using two Digital Inputs and no external resistor

- When the CB is open, DI-3 is energised (SPS state: SET) while DI-1 is de-energised (SPS state: RESET).
- When the CB is closed, DI-1 is energised (SPS state: SET) while DI-3 is de-energised (SPS state: RESET).

Thus, if the trip circuit is healthy, the DPS status resulting from the two SPS datapoints is either ON (10) or OFF (01). If the trip circuit is faulty (open circuit), the DPS status is "jammed" (00).

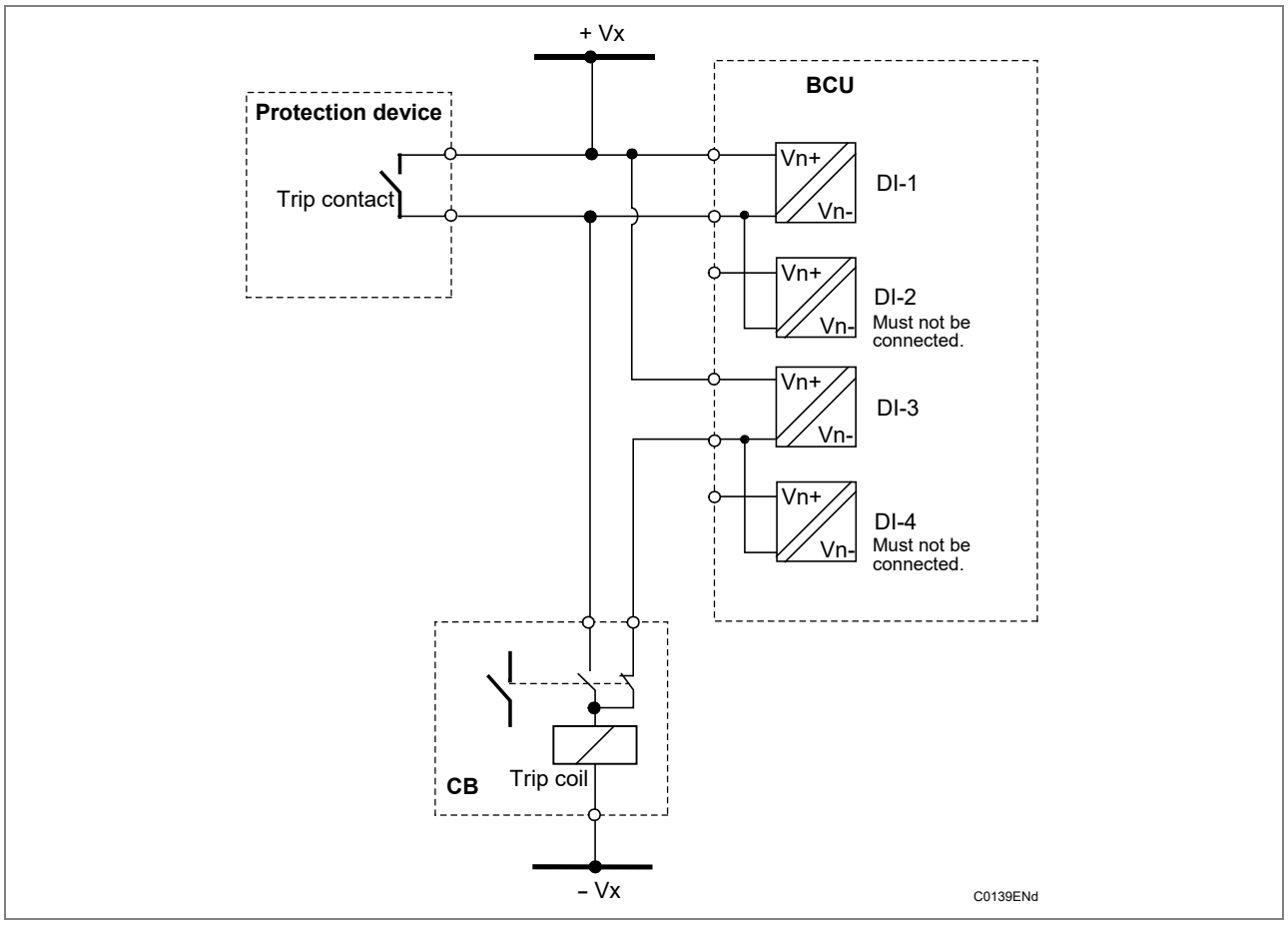


Figure 69: Trip circuit supervision using two digital inputs

Note: This scheme can be used with inputs for which the detection threshold of the "set" state is > 55% Vn (e.g. CCU200 A07).

7.1.3 AUTOMATIC VOLTAGE REGULATION–AVR

7.1.3.1 PRESENTATION

7.1.3.1.1 Role

DS Agile C26x with AVR (Automatic Voltage Regulation) is a compact Voltage Regulation solution for Electrical Substations; it automatically regulates the voltage level on the secondary side of HV/MV and/or MV/MV transformers.

It can automatically send secured commands (Raise, Lower) to the Tap Changer, fully aware of the transformer characteristics (voltage…), the Tap Changer characteristics (position number, inter tap timers,…), the voltage targets and the various transformer or tap changer alarms.

Note:
The AVR function cannot be used on one C26x together with another built-in function.

7.1.3.1.2 Topologies

Two C26x types are defined to address specific AVR issues:

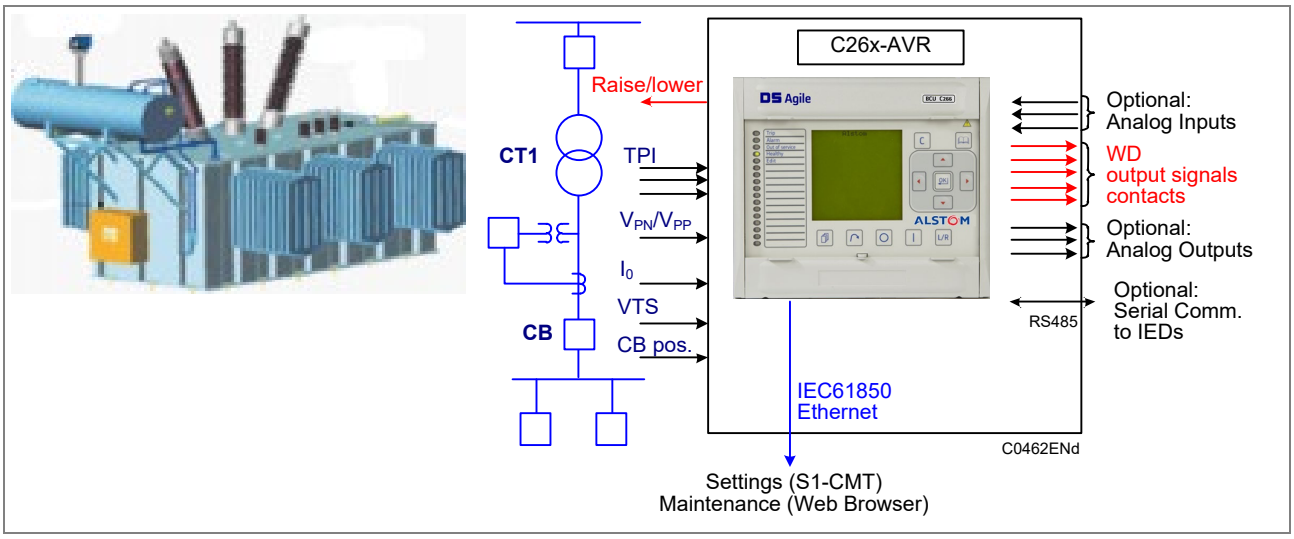
- Type 1 for a single transformer
- Type 2 for transformers in parallel (secondary poles are interconnected in pairs) – mode Master-Followers (up to 4 C26x followers with AVR)

7.1.3.1.3 Modes

The operator decides on the LHMI which way he/she wants to operate the AVR:

- “Manual” (open loop): the operator forcefully issues Raise/Lower commands to the tap changer from the LHMI
- “Automatic” (closed loop): the AVR algorithm issues Raise/Lower commands to the tap changer when the voltage is outside limits and tap changer conditions permit; the operator can still deactivate the algorithm from the LHMI.

7.1.3.1.4 Interfaces for a single transformer



7.1.3.1.5 Hardware

The DS Agile C26x includes in a 40 TE rack:

- An LCD screen, a BIU2xx board and a CPU270 board
- A DIU2xx board to acquire 16 Digital Inputs:
  - 5 Tap Position Indications (typically on 6 bits with BCD encoding, up to 64 bits with BCD, Gray, binary codes…)
  - 2 CB positions
  - 1 VT Fuse
  - 1 Tap Changer fault (option)
  - +7 customizable DIs (Bay L/R, AVR Auto/Manu, AVR on/off, alarms, external lock, voltage target selection)
- A DOU20x or HBU200 board to control 10 powerful Digital Output relays:
  - 2 Raise/Lower controls
  - 1 AVR fault (WatchDog)

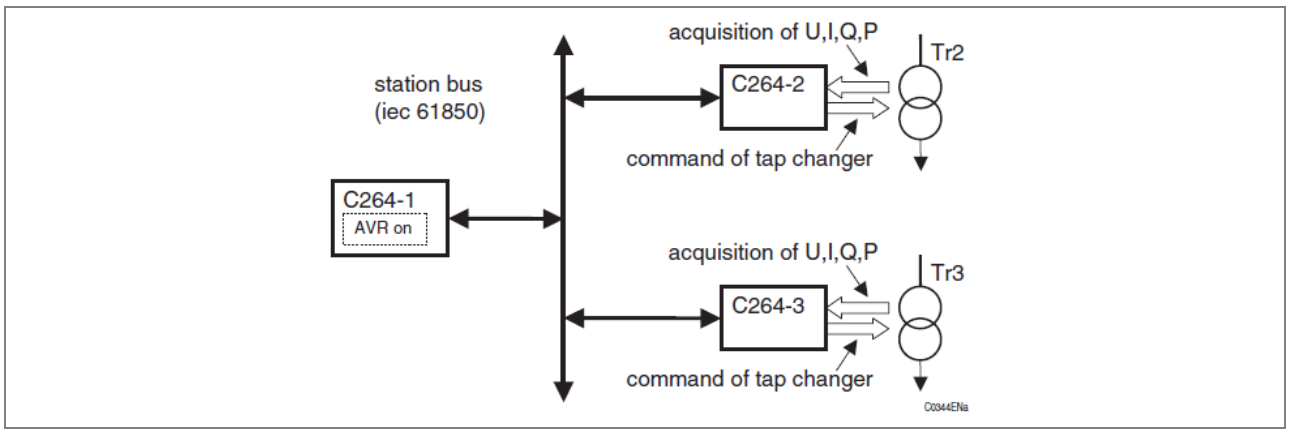
- 1 AVR Mode Auto/Manu
- 1 AVR ON/OFF
- 1 Master /Follower signal (type 2 only)
- 1 Minimize Circulating Current signal (type 2 only)
- +3 (type 1) or 5 (type 2) customizable DOs (I>, V>, alarms, locking, …)

- A TMU220 board (4 CTs / 5 VTs) for direct acquisition of currents and voltages
  - CT: 1 through 3 phases (type 1), 3 phases (type 2) + 1 earth
  - VT: 1 through 3 phases (type 1), 3 phases (type 2) + 2 customizable inputs
- An AIU board (option) to acquire Tap positions, voltages…(4-20 mA)
- An AOU board (option) for analogue outputs (4-20 mA) to repeat the Tap changer positions or measurement values (voltages, circulating currents,…)

7.1.3.1.6 Exchanges over the bus

The IEC 61850-8-1 bus can convey additional data:

- TPI and Tap changer status, “tap pulse duration”
- power factor
- target voltages and target voltage setpoint, compounding method
- topology information from IEDs (in place of serial bus) or other C26x
- settings from DS Agile S1
- measurements and commands when several transformers are involved:
- Each transformer is controlled by one controller but the AVR function is only activated on one controller. The figure exemplifies an architecture that controls two transformers:



AVR function is activated on controller C26x-1. This controller gets analogue values through the station bus from controllers C26x-2 and C26x-3 and issues tap changer commands through the station bus.

7.1.3.2 MOVING A TAP CHANGER

In this part, the settings name and values are surrounded with quote marks ("…"), while the first letters of status labels are capitalized. The former are set, the latter positioned.

7.1.3.2.1 Actual voltage

Depending on the "Regulation types", the actual (i.e. measured) voltage can be:

- either a "phase voltage Van" (V_{PN} on the first schematic)
- or a "compound voltage Ubc" (V_{PP} on the first schematic)

The actual voltage can include a Line Drop Compensation (see further).

For double wound transformer ("double wound" set to Yes), according to the setting "double wound voltage", the automatic voltage regulation applies to the:

- voltage and current of one winding (voltage 1)
- voltage and current of the other winding (voltage 2)
- average voltage and current of the 2 windings (average voltage)

If the difference between the 2 voltages is larger than a set value ("double wound voltage difference"), the signal Double wound voltage difference is positioned.

7.1.3.2.2 Target voltage

Depending on the "Target voltage management", the target voltage can be:

- Locally or Remotely defined; the AVR must be in automatic mode; the precedence order is as follows:
  - the remote target voltage comes from a remote-control point (setpoint); to be valid, it is subjected to min, max, max difference; until the end of the confirmation delay, the latest valid remote target voltage value is used
  - In the event of a confirmed loss of remote target voltage (invalidity, loss of connection with RCP), the local target voltage takes over; it is set through DS Agile S1
- Controlled: the value is one the two above, selected through controls.

In local target voltage mode, the AVR is able to treat an incoming remote target voltage value (in order to return to the remote target voltage mode). If a received remote target voltage value is valid, the remote target voltage becomes the new target voltage mode, following the transition local to remote conditions:

- At AVR start up, the local target voltage mode is active for a defined delay (end of local target voltage delay).
- If a valid remote target voltage value is received before the end of the delay, the remote target voltage mode is set at the end of the delay.
- If a valid remote target voltage value is received after the end of the delay, the remote target voltage mode is set immediately.

When the target voltage mode changes from remote to local, the same delay is launched, and the behaviour is identical.

An operator can, with a dedicated control, forcefully put the target voltage mode to Local target voltage. In this event, the mode is set immediately.

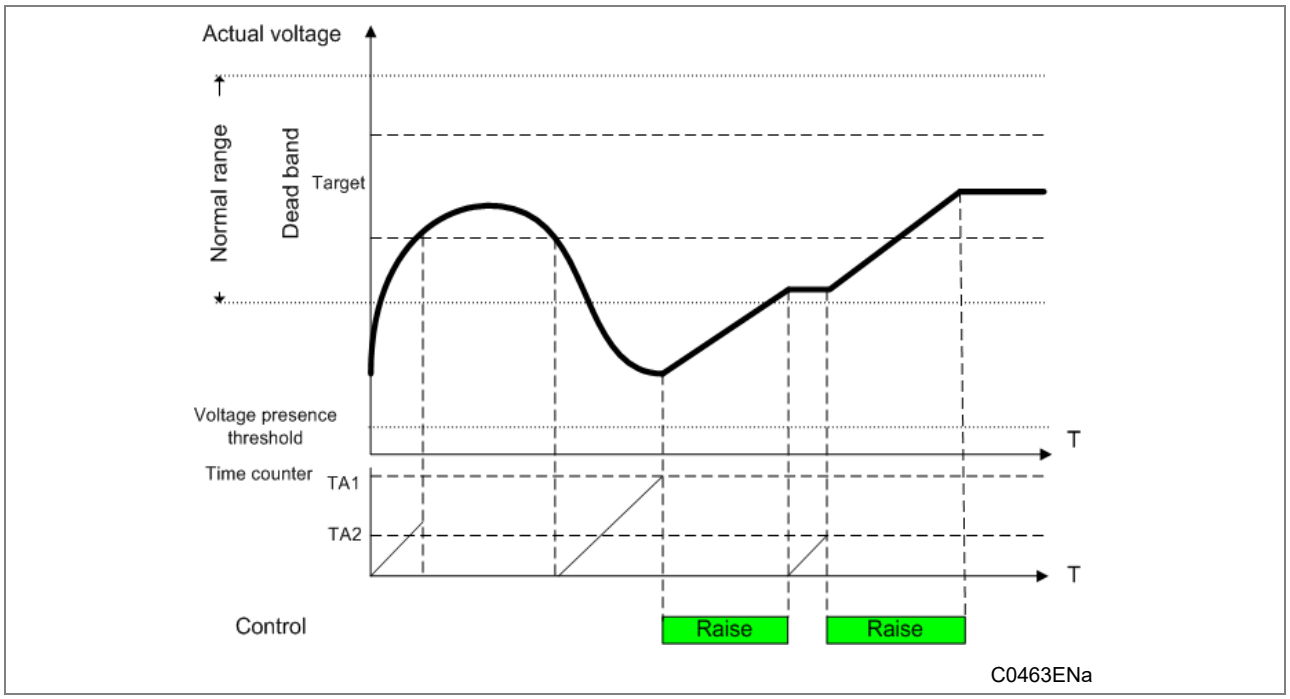
Warning:
When the current target voltage is disabled, the new target is 100% Vn.

7.1.3.2.3 Regulation

The actual voltage is compared to the target voltage.

If the actual voltage remains outside of the “regulation deadband” for an “initial tap time delay” (TA1), the C26x with AVR commands a tap change.

Any voltage swing that passes through the complete deadband, causes the “initial tap time delay” to be reset and a new time cycle to be started.



If more than one tap change is required to bring back the voltage within the deadband, the second tap changer is activated after TA2 (“inter tap time delay”). Note: TA2 < TA1.

If applicable, the last tap changing is delayed by an “end tap delay”.

The command occurs only if the following conditions prevail:

- AVR mode is automatic
- voltage is above the “voltage presence threshold”
- “Primary CB state”, circuit-breaker position on the primary side of the transformer is set to CLOSED
- No VT fuse information positioned
- No regulation locking signal (External Lock or Tap Changer fault) positioned

7.1.3.3 ADDITIONAL MONITORING FUNCTIONS

7.1.3.3.1 Tap Changer position on Voltage Loss

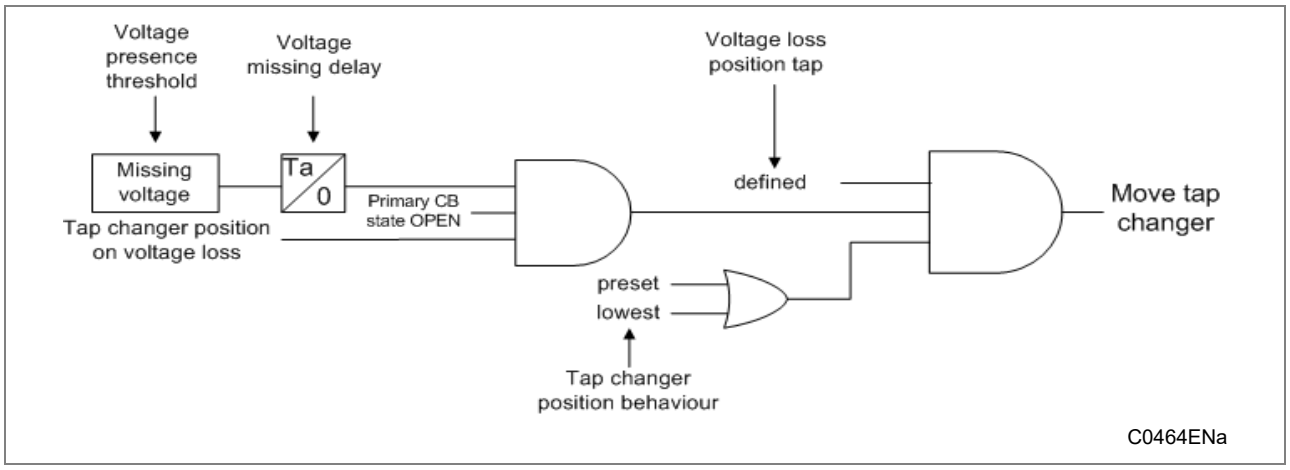
The actual voltage is present/missing (lost) whether it is above/under the “voltage presence threshold”.

According to the “voltage loss position tap”, the AVR can:

- either move the tap changer “on a defined tap”
- or “lock the automatic” regulation as long as the voltage is missing.

In the first case, the “tap changer position (on voltage loss) behaviour” can be set to:

- keep the tap changer on the “current tap” (no tap control performed)
- move the tap changer to the “preset tap”
- move the tap changer to the “lowest tap”



The function sets the tap changer on the “defined tap” position, only if the following conditions prevail:

- The AVR mode is automatic
- “Tap changer position on voltage loss” function is active
- The “Primary CB state”, circuit-breaker position on the primary side of the transformer is set to OPEN
- No other regulation locking information is set
- No VT fuse information positioned

Sequencing of commands: the subsequent command occurs not earlier than the “preset tap delay”.

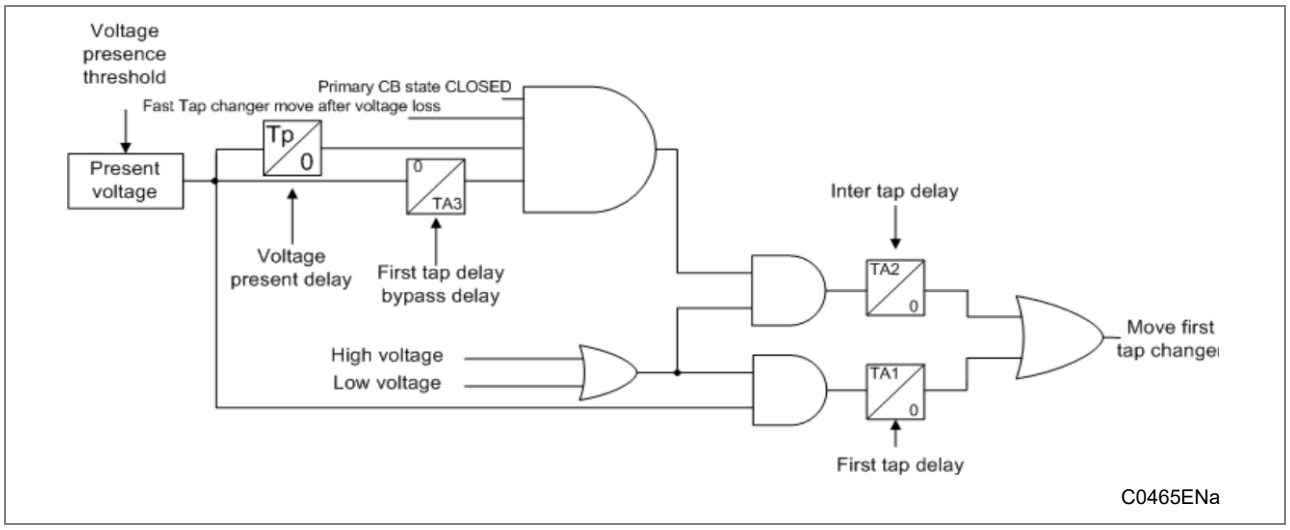
7.1.3.3.2 Fast Tap Changer move AFTER Voltage Loss and Voltage recovery

When the “Fast tap changer move after voltage loss” function is set, the AVR issues Lower/Raise commands TA3 after the voltage has overrun the “voltage presence threshold“.

The command occurs only if the following conditions prevail:

- The AVR mode is automatic
- “Fast tap changer move after voltage loss” function is active
- The “Primary CB state”, circuit-breaker position on the primary side of the transformer is set to CLOSED
- No VT fuse information positioned
- No regulation locking signal (External Lock or Tap Changer fault) positioned

If all the above conditions prevail, and the voltage is present (voltage above “voltage present threshold“) longer than the “voltage present delay” (Ta), the first tap delay is bypassed for TA3 (first tap delay bypass delay). The first tap control activation is delayed by TA2.



If the “fast tap changer move after voltage loss” function is NOT active, when the voltage is detected, the first tap control activation is delayed by TA1.

7.1.3.3.3 Abnormal Voltage signal

The voltage is considered as “abnormal” if, till the confirmation time expires, the actual voltage is moving outside the range: [Vtarget x (1- β%); Vtarget x (1+ β%)] , β% is the “abnormal voltage (threshold)“. This range is wider than the deadband. Refer to the preceding schematic.

In this event, the signal is positioned after the “abnormal voltage delay”.

Any return of the voltage into the normal range resets the delay and deactivates the abnormal voltage signal.

7.1.3.3.4 Tap Changer Failure supervision – Tap Blocking

The Tap Position Indication value may be wired on digital inputs (or optional analog inputs).

If the Current Tap value is not valid, all the functions using this information are locked.

The signal indicates the kind of problem on the tap changer.

The signal Tap Changer Fault results from one of these conditions:

- the tap value is undefined (coding error)
- after the “TCIP time out delay”, the TCIP (Tap Changer In Progress) signal is not positioned (on tap control sequence)
- after the “TCIP end time out delay”, the TCIP signaln input is not reset (on tap control sequence)
- after the TCIP signal reset, the tap has not the expected value
- after the global sequence delay (start on 1st tap control), the voltage is not normal yet

or, if the “tap changer fault function” is on,

- an external signal indicates a tap changer fault.

When the signal Tap Changer Fault is positioned, the tap control or the sequence of tap controls in progress is cancelled, and no more tap control is accepted (whether it is manual or automatic).

Depending on the “tap changer fault behaviour”, when a tap changer fault occurs, AVR can:

- position the Tap Changer Fault signal, and reset it when none of the faulty condition prevail (automatic reset)
- position the Tap Changer Fault signal, and keep it set until an operator deactivates the automatic regulation, and activates it again (manual reset).

If the “tap changer blocking activation” is on, a Tap changer Blocked is positioned in event the Tap command is issued for a time longer than the “tap changer blocking delay”. This means that the tap position is not reached during this time and this is considered abnormal.

A signal Voltage Regulation Fault is positioned with the corresponding status, when:

- a VT fuse is detected
- an abnormal voltage is detected
- a voltage or current acquisition failure is detected
- a Tap Changer is blocked

When none of the above problems is detected, the signal Voltage Regulation Fault status is OK.

7.1.3.3.5 Tap Changer Lowest/ Highest position

DS Agile C26x with AVR monitors the pair Tap changer Lowest/Highest reached position.

- When the current tap equals the “highest/lowest tap value”, the indication Highest/Lowest Tap reached is positioned.
- If the Tap Position Indication value is not valid, The Lowest / Highest Tap reached indications are not valid.

7.1.3.3.6 Run away protection

DS Agile C26x with AVR monitors if the Tap changer operates without valid commands or if tap changer operation causes Tap Changer to move further away from the set values.

If it occurs, after the “runaway tap delay”, an alarm is raised and the AVR can be blocked.

7.1.3.3.7 OverVoltage Detection

The “overvoltage detection activation” is settable; it can also be done by an operator control.

If the value of the voltage is larger than the “overvoltage threshold” for more than the “overvoltage delay”, the Overvoltage signal is positioned.

If the value of the voltage becomes lower than the “overvoltage threshold”, the Overvoltage signal is reset.

The regulation locking information can be positioned/reset depending on the Overvoltage signal.

If the voltage value is not valid, the overvoltage detection is not running.

Depending on the “Overvoltage detection behaviour” value, the AVR can:

- position/reset the Overvoltage signal
- position/reset the Overvoltage signal AND the Regulation Locking information

7.1.3.3.8 UnderVoltage Detection

“Undervoltage detection activation” is settable; it can also be done by an operator control.

If the value of the voltage is lower than the “undervoltage threshold” for more than the “undervoltage delay”, the Undervoltage signal is positioned. If the value of the voltage becomes larger than the “undervoltage threshold”, the Undervoltage signal is reset.

The regulation locking information can be positioned /reset depending on the Undervoltage signal.

If the voltage value is not valid, the undervoltage detection is not running.

Depending on the “Undervoltage detection behaviour” value, the AVR can:

- position/reset the Undervoltage signal
- position/reset the Undervoltage signal AND the Regulation Locking information

7.1.3.3.9 OverCurrent detection

“Line overcurrent detection activation” is settable.

If the value of the current is larger than the “overcurrent threshold” for more than the “overcurrent delay”, the Overcurrent signal is positioned.

If the value of the current becomes lower than the “overcurrent threshold”, the Overcurrent signal is reset.

The regulation locking information can be set/reset following the line overcurrent signal.

If the line current value is not valid, the line overcurrent detection is not running.

Depending on the “Overcurrent detection behaviour” value, the AVR can:

- position/reset the Overcurrent signal
- position/reset the Overcurrent signal AND the Regulation Locking information

7.1.3.3.10 Tap Changer Maintenance: Tap Counting

The numbers of automatic + manual tap changes are counted as follows:

Number	On the “slipping period for counting”	since C26x init	since last operator reset
Overall changes	x	up to 6 000 000	x
Raise	x	up to 3 000 000	x
Lower	x	up to 3 000 000	x
Limits reached	x	–	–
Time of use	–	For each tap as long as voltage is present	

- The date of the latest operator reset is also recorded.

Note 1: On operator reset

- the partial number of “tap changes”, “raise” and “lower” controls are reset
- the partial time of use with voltage present of each tap is reset
- the current date becomes the new “last reset date”

Note 2: The time of use is recorded, only if the voltage is present, and the Tap Position Indication and the TCIP signal are valid.

Data visualization and use

Histograms are shown on a dedicated page of the C26x Maintenance Tool. Refer to the IN chapter (Operations with buttons/Statements).

As counters, all the sums can be viewed:

- on the Station Bus (IEC 61850-8-1)
- on a SCADA line
- on the Local HMI

and be used as inputs of ISaGRAF sequences, e.g. for threshold management.

Data storage

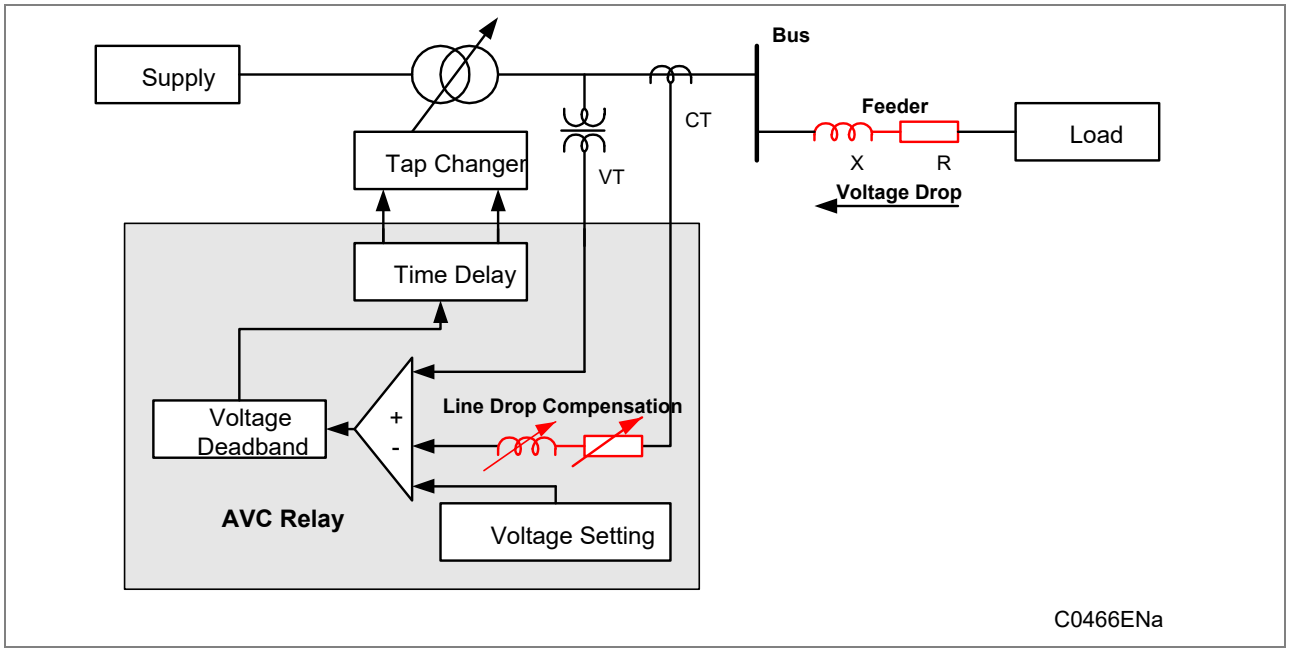
Data are stored in a secured SRAM memory and are not lost:

- on C26x restart
- on database switching (over some conditions)
- on power outage for less than 48h

7.1.3.4 LINE DROP COMPENSATION

To regulate the voltage at a remote point on the feeder, the LDC simulates voltage drop of the line and artificially boosts transformer voltage at times of high load.

The LDC is validated by the “compounding activation” and ruled by the active “compounding method”.



Vr = Vm - Vcomp

Z = R + jX, R and X are % of Vn/In

R = “Active compounding method parameter A1”, % of Vn/In (nominal voltage and current)

X = “Active compounding method parameter B1”, % of Vn/In (nominal voltage and current)

The reactive “compounding method” is used only when two transformers are in parallel.

7.1.3.5 OTHER FUNCTIONS

7.1.3.5.1 Additional Measurements (Optional)

If 3 CTs and 3 VTs are fed into the C26x, additional measurements can be computed

- Frequency
- Active power, Cos (Phi)
- Circulating current (transformers in parallel)

These calculated measurements can be viewed locally on the Local HMI (LCD Screen).

7.1.3.5.2 Raise/lower control and voltage target from external signals

Depending on “AVR mode”, additional inputs can be used:

- “Automatic”: to activate a specific target voltage:
  - Target Voltage 5 (Vn-5%)
  - Target Voltage 2, 3, 4 (Voltage Boosting)

These external commands have precedence over the Local LCD commands and are active as the external signal is positioned.

- “Manual”: to activate Raise/Lower commands from wired signals:
  - Raise Command Input
  - Lower Command Input

The activation of Raise/lower Controls also depends on the usual AVR conditions (CB status, TC fault,…).

7.1.3.6 TRANSFORMERS IN PARALLEL

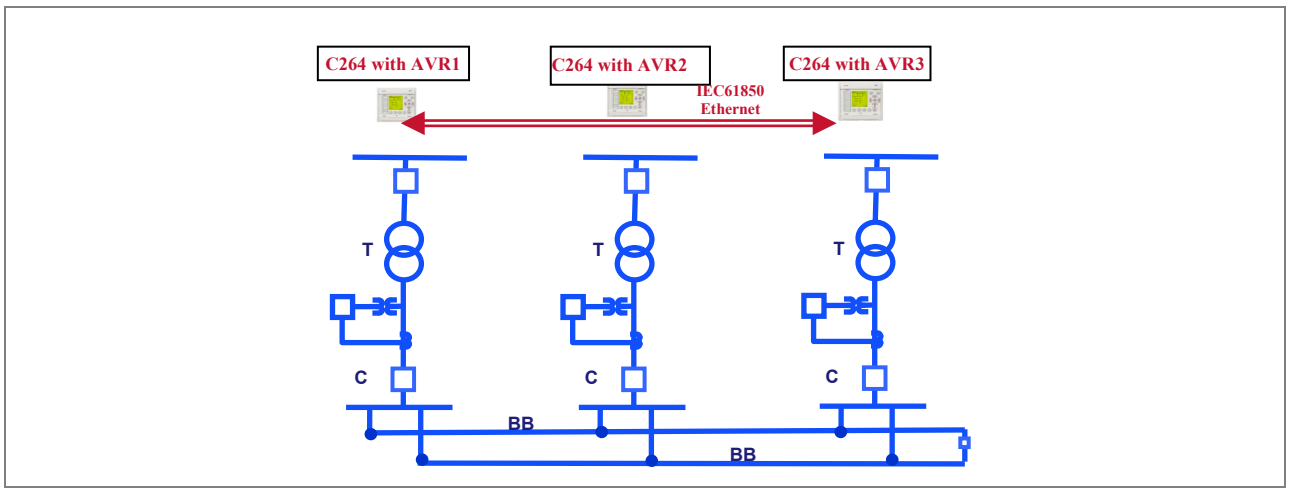
Two methods can be used whether the transformers are identical and work together or not.

7.1.3.6.1 Master/Followers method

Roles:

In a group of transformer bays, one C26x with AVR is appointed “Master”, the others “followers”. The master transmits its TPI to the followers over the Station Bus and elaborates the commands for all the transformers. All the operator controls (activation/deactivation), if any, are put on the master C26x, which in turn activates/deactivates the followers.

The followers receive the master’s TPI, offset any discrepancy with their own TPI and execute the commands coming from the master over the Station Bus.



The Master compares the tap position of the followers with its own tap position and if deviations are detected, the master put commands to bring them to its own position.

No circulation currents are evaluated; this imposes severe limitations on the network operation:

- transformers identical, with the same impedance
- same number of taps
- transformers on the same tap position

The indication of which C26x is the Master and which one is “Follower” can be viewed

- on LCD (optional Mimic Page)
- on configurable LEDs of the Front Panel

It can be available

- on an output contact
- on the Station Bus / Scada

and used in PSL/Isagraf automation.

In the event of a Master failure (reboot, disconnection, switching to maintenance mode) the “Master failure management” offers two possible fallback plans:

- a Backup Master can be selected among all the followers:
  - manually by the operator (on LCD or from Station Bus)
  - automatically to ensure a continuous service, using the configured “Follower Master Backup”.

If the master recovers, the backup master remains master. The master regulates its voltage in stand alone mode.

Note: this backup mode requires a good health network. In the event of a faulty network, the TPI received by the followers, still have the quality Unknown. Then, after the “backup mode delay”, all the followers will switch to a standalone mode.

If the mode switches automatically to standalone, returning requires a manual operation (reset process in which the master restarts all the followers).

- drop the coupled regulation: all the C26xs operate in standalone mode.

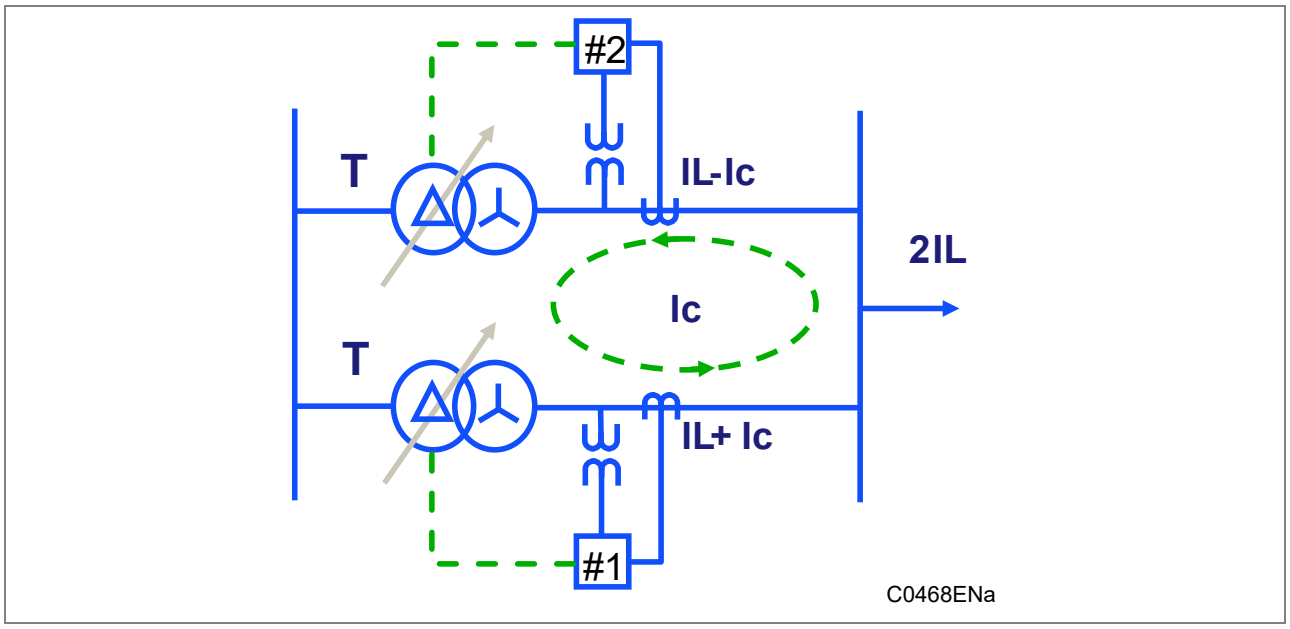
7.1.3.6.2 “Standalone regulation”

There are no restrictions on the transformers.

The differences between two transformers superimpose a current I_C in both incomers:

If the transformer #1 is on a higher tap than #2:

- Current seen by #1 = IL + I_C
- Current seen by #2 = IL – I_C

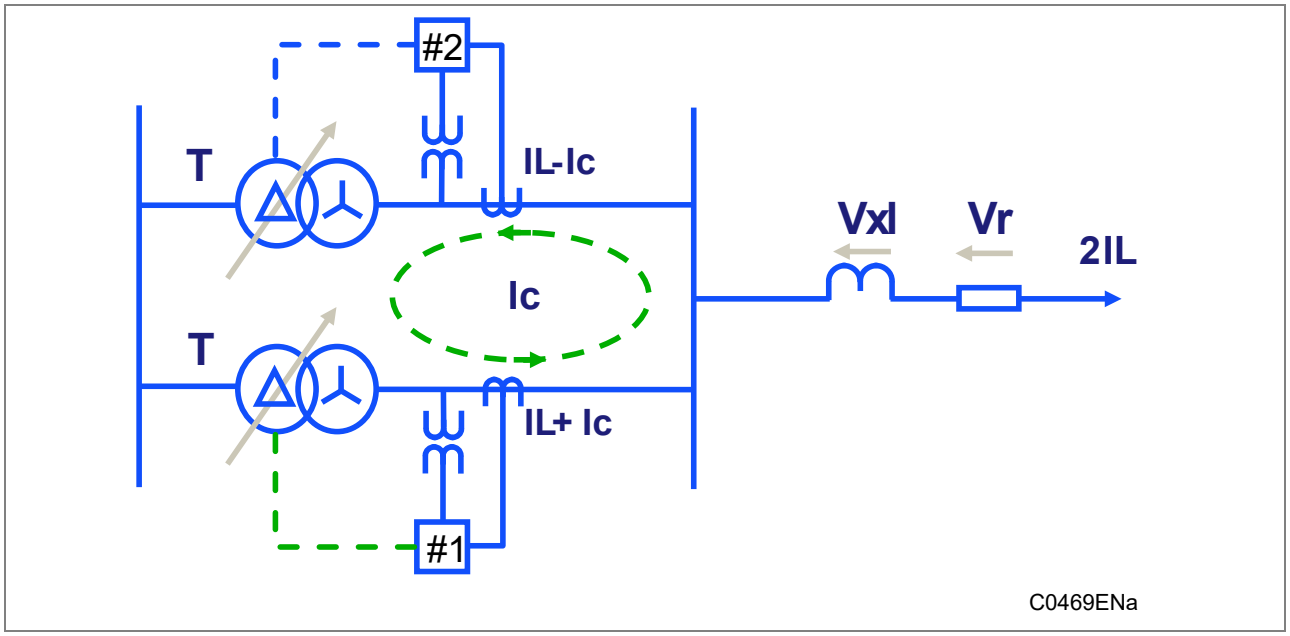


Two methods are available:

- “Minimizing circulating current”: refer to the ATCC section further

  The topology (i.e.which transformers are interconnected) is dynamically evaluated by a C26x-MCC (minimize circulating current). It computes the U,I,P,Q for all the C26x that control transformers (up to 4) and transmits the values over the Station Bus.

- “Negative reactance compensation”, in conjunction with the Reactive “Compounding method”.



As I_C is not present in the feeder, another method is needed: compensating the voltage attenuation due to currents circulating from one transformer to the other.

With reactive compounding, the voltage to be regulated (Vr) is evaluated as follows:

Vr = Vm – Vxl, where:

Vr: actual voltage to regulate

Vm: measured voltage

Vxl: Compounding voltage = Z.I where Z = R – jX

R = “Reactive compounding method parameter A2”, % of Vn/In (nominal voltage & current), this the resistive part of the load line

X = “Reactive compounding method parameter B2”, % of Vn/In (nominal voltage & current), this the reactive part of the transformer impedance (the transformer impedance is mostly a reactance)

Note:
For a power factor near 1, this negative reactance compensation has a good accuracy, but if the power factor is low, this compensation mode is no more accurate.

7.1.4 AUTOMATIC VOLTAGE REGULATION–ATCC

The Automatic Voltage Regulation–ATCC function automatically maintains a correct voltage at the lower voltage of transformers by controlling the tap changer of transformers.

7.1.4.1 PRESENTATION

7.1.4.1.1 Topologies

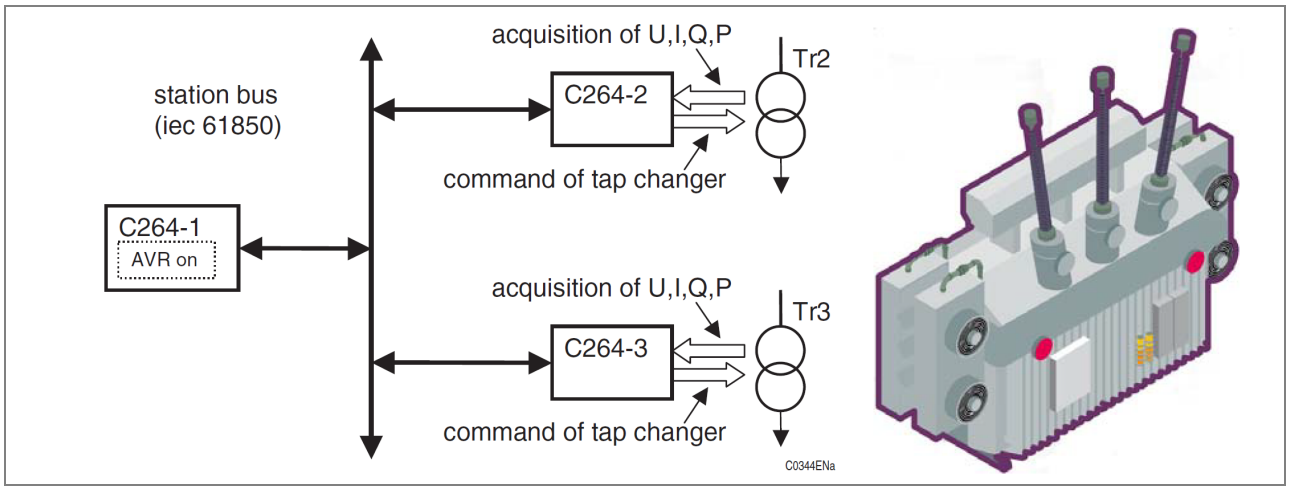
A substation includes busbars and transformers.

A group is a set of interconnected busbars. A transformer belongs to a group if it is electrically connected to a busbar of this group at the low voltage level. The voltage target is that of the highest priority busbar.

The partition is dynamic: two independent groups may be merged as a result of the closing of a circuit-breaker.

Typical topologies

- one busbar connected to one or several transformers in parallel. Transformers are in parallel if their secondary poles are interconnected.
- several coupled busbars in a group that includes one transformer or several ones in parallel (see an example further)
- Each transformer is controlled by one controller but ATCC function is only activated on one controller. The figure that follows shows an example of the architecture for the ATCC function that controls two transformers



ATCC function is activated on controller C26x-1. This controller gets analogue values through the station bus from controllers C26x-2 and C26x-3 and sends tap changer commands through the station bus.

7.1.4.1.2 Situations requiring ATCC

ATCC is activated when:

- The voltage in one group is far from the Target Voltage. This is the most common situation.
- The voltage is correct, but there is a circulating current between parallel transformers. This happens when two groups are interconnected.
- The voltage is correct, but the Tpi range and patterning may be changed when the state of any relevant switchgear changes.

7.1.4.1.3 Definitions and main attributes

For a transformer:

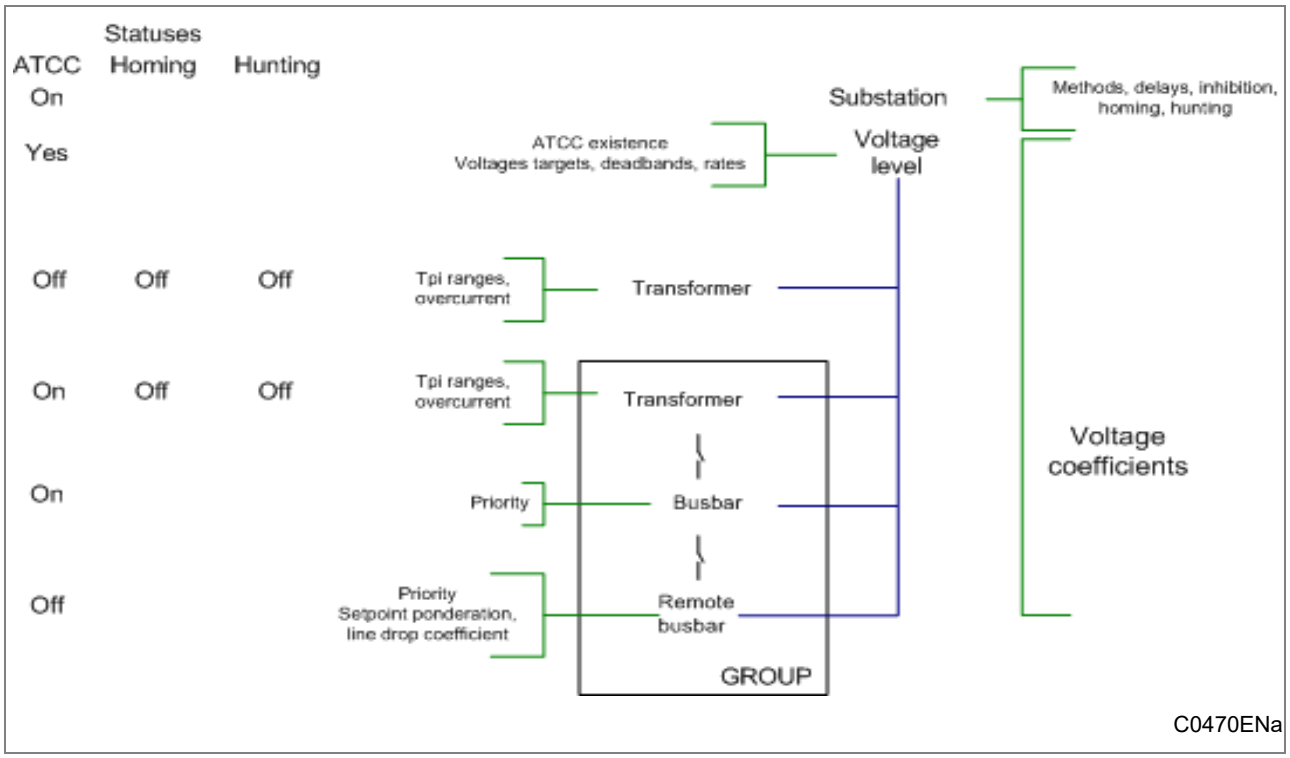
Homing (status): if a transformer is disconnected from the busbar (the “homing circuit-breaker” at the LV side of the transformer is open), it can follow the busbar voltage in order to avoid overvoltage at re-connection. This capability is selected on a global basis.

Hunting (status): if the same transformer has received more change controls than the opposite max tap changes within a time window, the ATCC is deactivated. These attributes are enabled a global basis.

For a busbar:

Line drop compensation: in case two interconnected busbars are far from each other, to compensate the resistive and reactive voltage drops across the power line, several compounding methods are available. The method is selected on a global basis and the coefficients on a per busbar basis.

Example: the main attributes to enable the various levels are as follows (bracketed)



This schematic exemplifies two independent cells:

- a stand-alone transformer operating in manual mode (ATCC status is off)
- a group operating in automatic mode (ATCC status is on)

The operator sets the global status to on.

7.1.4.1.4 Capacity

A DS Agile C26x is able to manage a maximum of:

- 7 transformers
- 4 transformers in parallel
- 8 busbars
- 4 transformers per busbar
- 2 reactances per transformer
- 2 voltage levels

7.1.4.1.5 Alarm conditions

The attribute names used in SCE are bracketed if it helps identify the datapoint.

Transformer

- MCB trip. If a transformer is in automatic control and there is an invalid evolution of the tap changer, the tap changer MCB is tripped
- Run away: if the Tap changer operates without valid commands or if tap changer operation causes Tap Changer to move further away from the set values. This alarm is reset 30 s after the group is switched to ATCC Off
- Bay disconnected (includes power failure) [disc eqt]
- Local bay: contains the tap change control: local/remote, connected/disconnected (supervision values)
- Invalid voltage [inv voltage]
- Tap changer abnormal if:
  - TCIP signal is too late [TAP bad TCIP] or too long [TAP long TCIP]
  - The tap is invalid [TAP invalid]: tap number is not the required tap; you may have this problem after a tap operation if the tap number is not the expected one.
  - This TAP bad TCIP alarm is reset 30 s after the group is switched to ATCC Off
- ATCC hunting: this alarm is reset 30 s after the group is switched to ATCC Off.
- Overcurrent, overvoltage

Busbar

- Invalid voltage (when different values for parallel transformers) [inv voltage]
- More than 4 transformers in the group [max transfo]
- A circuit-breaker or a disconnector in an invalid state in the group [inv module]

Global

- Target unreached
- ATCC defect: raised if one of these alarms is raised, and is reset if all of them are reset
- Error Log Indication: raised if one of the input is raised and is reset if the operator selects the "Clear ATCC Faults" command.
- DBI override

7.1.4.2 MONITORING LOGIC

7.1.4.2.1 Modes

From the system HMI or from a SCADA, according to the Substation control mode, the operator controls the Global ATCC mode (substation level) and the busbar ATCC modes.

Substation control mode	Control from the RCP (SCADA)	Control from the SCP (OI/aView)
Local	inhibited	allowed
Remote	allowed	inhibited

It is up to the operator to choose, on a global basis, how the mode (that is, the ATCC status) is changed:

- On group interconnection: the group resulting of the merging of two groups in different modes can be off or on
- When bay turns to local control: the bay can go off or on

7.1.4.2.2 Conditions for an active automatic voltage regulation

The following conditions are required for automatic regulation to be active:

- The ATCC mode is on
- The circuit-breaker at the other side of the transformer (primary) is closed
- No “regulation locking” information (AVR defect alarm, external lock, run away, overcurrent on a transformer)

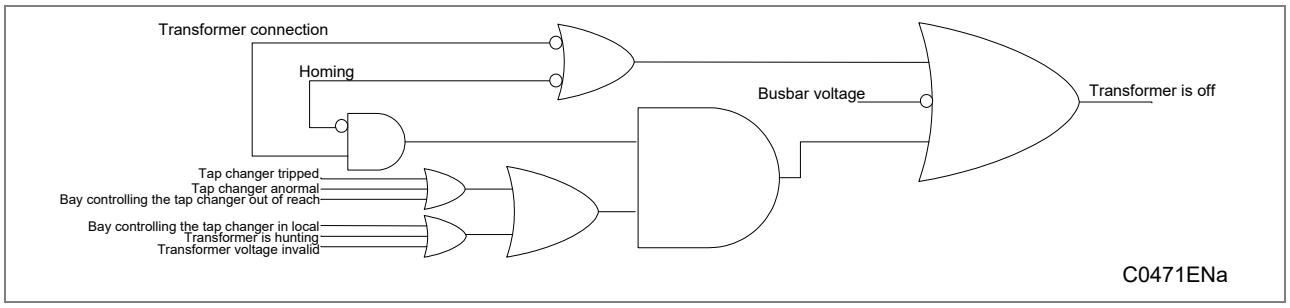
For ATCC/homing to take place:

- the measured voltage must be within tolerances set as ratios of the nominal voltage:
  - tolerable nominal under voltage
  - tolerable nominal over voltage
- the deviation to the target voltage must be lesser than a set ratio of the nominal voltage:
  - max voltage difference

Moreover, before sending a tap changer control (Raise/Lower), the following conditions are required:

- No “tap in progress“
- No “higher position” information, for a raise control
- No “lower position” information, for a lower control

7.1.4.2.3 Transformers status logic



7.1.4.2.4 Busbars status logic

The current busbar mode is equal to (busbar ATCC status) AND (Global ATCC status).

The status is Off if:

- the status of one of the transformers connected to it is Off

OR

- the busbar voltage is invalid

7.1.4.2.5 Group status logic

The average voltage is invalid if:

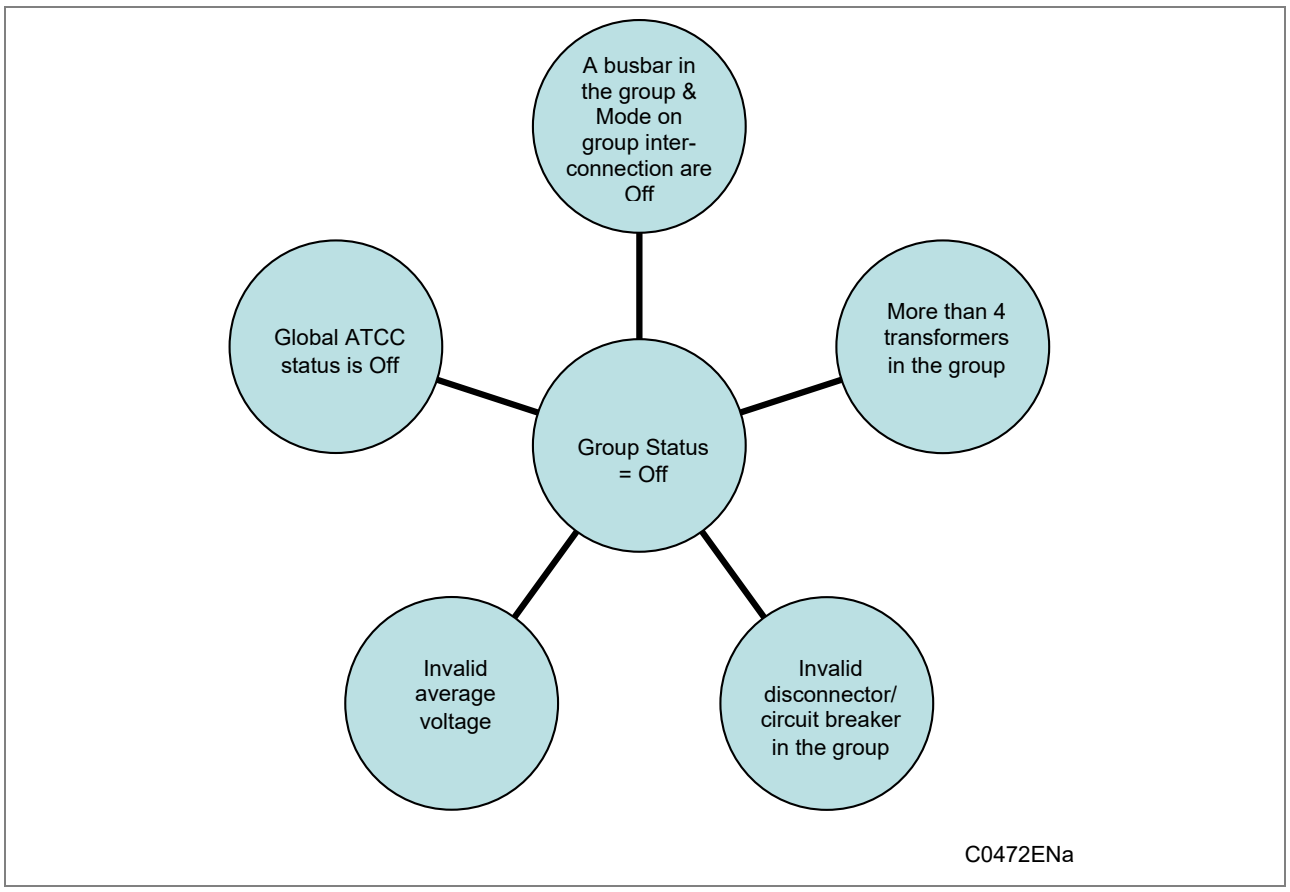
- one of the voltage differs by more than “max voltage difference” (ratio) from the average voltage

OR

- one voltage is invalid.

The status is On if at least one of the busbars in the group is On.

The status is Off if at least one of the conditions below is met:



If two busbars get disconnected, they keep their previous mode.

When a fault occurs, the related busbar ATCC turns off.

7.1.4.3 MOVING TAP CHANGERS

7.1.4.3.1 Target voltage

When the operator changes a target voltage, the new target voltage is indicated immediately. The actual target voltage cannot changed by more than the “voltage target ramping rate” if the busbar is under automatic control. If the busbar is not under automatic control the new target voltage is immediately in force.

Each voltage level has other attributes:

- 5 voltage targets, with a default target (one of the 5)
- 2 deadbands, one is coarse (DB1, to initiate tapping), the other is fine (DB2, to end tapping)
- a max tap change rate of change that cannot be exceeded when moving the tap.

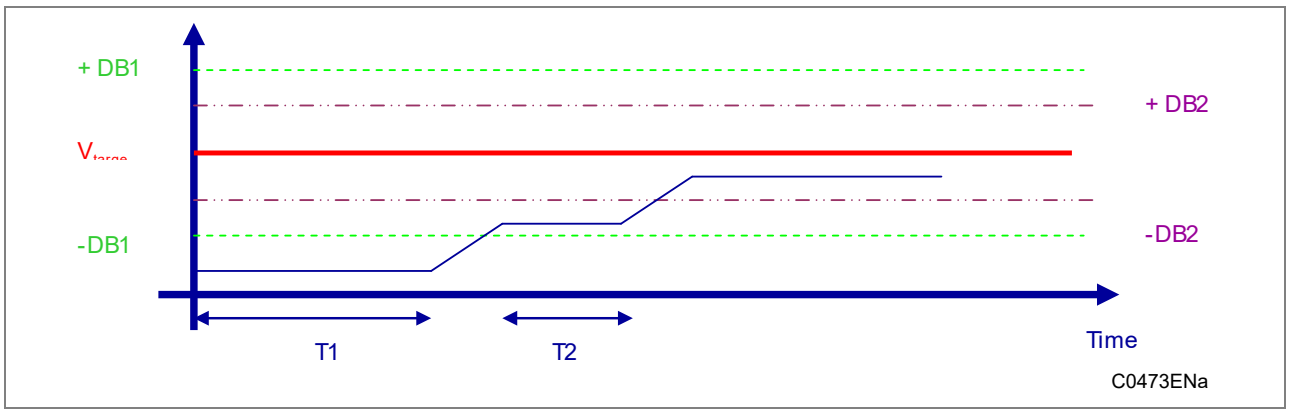
Each busbar voltage target is selected among the 5 through controls, in accordance with the voltage target ramping rate.

If the busbar is part of a group, the target in force is the one of the highest priority busbar. A single tap is changed at a time within a group but several groups may be active simultaneously.

Each group has to reach the target voltage.

If the voltage is outside DB1, then an initial timer T1 is set and the tap control is issued once the timer has elapsed.

More tap changing may be necessary in order to enter DB2: they are actuated when the second timer T2 has elapsed; the changing is subjected to the max tap change rate.



Remote busbar

The voltage target may be set for a point far from the LV transformer side.

Reference_U_{LV} = (Target_ U_{LV} + Drop_U) x set point ponderation (0.9 …1)

U_{LV} is the actual measured value

Compounding methods:

- Setpoint adjustment: Drop_U ² = P_{LV} x $R_{\%}$ + Q_{LV} x $X_{\%}$ where

P_{LV} and Q_{LV} are local measured active and reactive powers

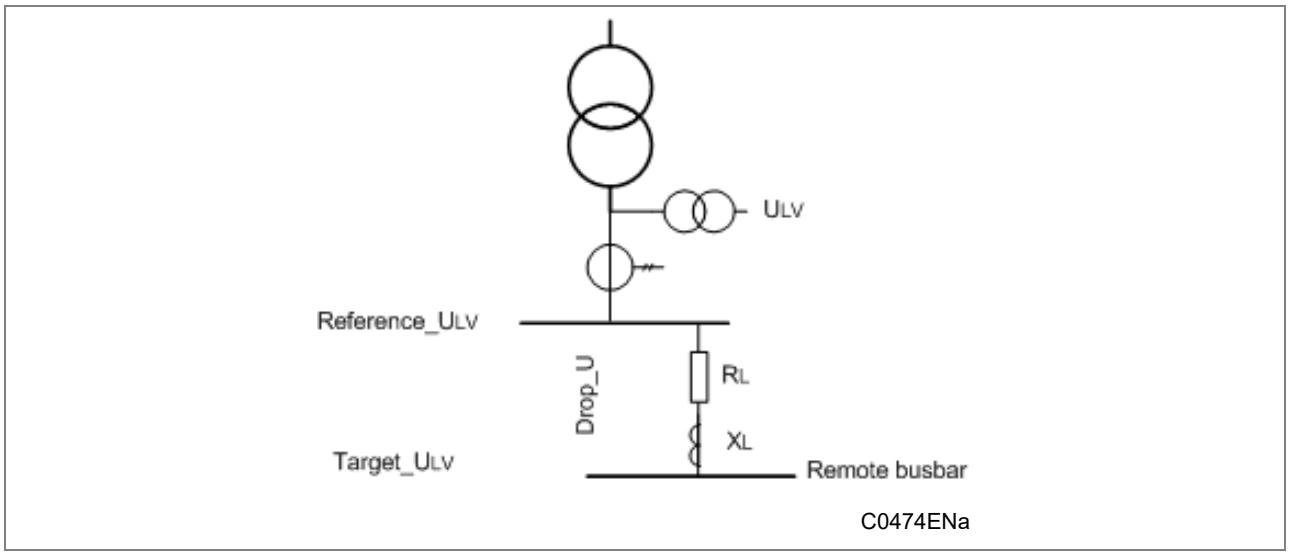
$R_{\%}$ and $X_{\%}$ are resistive/reactive coefficients

- Voltage adjustment: in place of U_{LV}, use Drop_U ² = (U_{LV} –A)² + B² where

A = (R_L x P + X_L x Q)/ U_{LV}

B = (X_L x P + R_L x Q)/ U_{LV}

X_L and R_L are transfo-busbar resistive/reactive coefficients



Note:
If line drop compensation is not used, set the resistive and reactive coefficients to the minimum.

7.1.4.3.2 Voltage is outside of the Target Voltage Deadband

When the regulated voltage moves outside of the deadband settings for a definite time, the C26x send commands to Tap Changer mechanism to bring it back within the set deadband limits.

The Voltage Deadband is expressed as a percentage of the nominal voltage. Depending on the number of transformers in a group, different set coefficients are applied.

Voltage deadband = Base Voltage deadband x voltage coefficient.

Examples:

	Example 1	Example 2
Group with 1 transformer	1	1
Group with 2 transformers	1	1
Group with 3 transformers	1	2/3
Group with 4 transformers	1	1/2

Decision to move the tap changer is made when:

- Voltage > Target Voltage + Voltage Deadband x Nominal Voltage

OR

- Voltage < Target Voltage - Voltage Deadband x Nominal Voltage for more than the time-out T1.

Dual deadbands are used to ensure that the post tapping voltage is sufficiently closed to the selected target voltage. DB1 is used to initiate tapping and DB2 is used to end tapping.

7.1.4.3.3 Timeouts

Moving the taps of the transformers is achieved with respect to some time-outs:

The "Initial tap" of a transformer is delayed by a time out T1, the next ones by a time out T2. Several taps are used if one is not enough to reach the voltage target or the optimisation of the circulating current. T2 begins after the end of the TCIP.

When the voltage shifts in and out of the deadbands, the system counts up to T1 when the voltage is outside of the deadband1. If the voltage returns within the deadband2 before T1 is reached, then the system counts down to 0.

Any voltage swing that passes from through the complete deadband from one side to the other, causes the “initial tap time delay” to be reset and a new time cycle to be started.

After an auto-recloser operation, the group (or the two new groups) keeps the same ATCC modes; however the count is reset to zero and the new time delay is T1.

- Initial tap delay T1 is adjustable between 15 and 120 s in 0.1 s increments.
- Inter tap delay T2 is adjustable between 0 and 120 s in 0.1 s increments.

To ensure that transient voltage fluctuations do not cause unnecessary tap change, the voltage must remain outside of the deadband for an “initial Tap Time Delay” (settable T1).

Any voltage swing that passes from through the complete deadband from one side to the other, causes the “initial tap time delay” to be reset and a new time cycle to be started.

If a tap changing is required after a previous tap control:

- Ti is the date when the previous tapping was performed
- T is the current time
- RateMax is max tap change rate
- T2 is the inter tap delay
- Vi was the secondary voltage at Ti
- V is the current secondary voltage

For a Tap Up (to increase voltage), tap is changed when

- T > Ti + T2 and V < Vi + RateMax x (T–Ti)

For a Tap Down (to decrease voltage), tap is changed when

- T > Ti + T2 and V > Vi – RateMax x (T–Ti)

The maximum voltage rate is achieved as described in the example below:

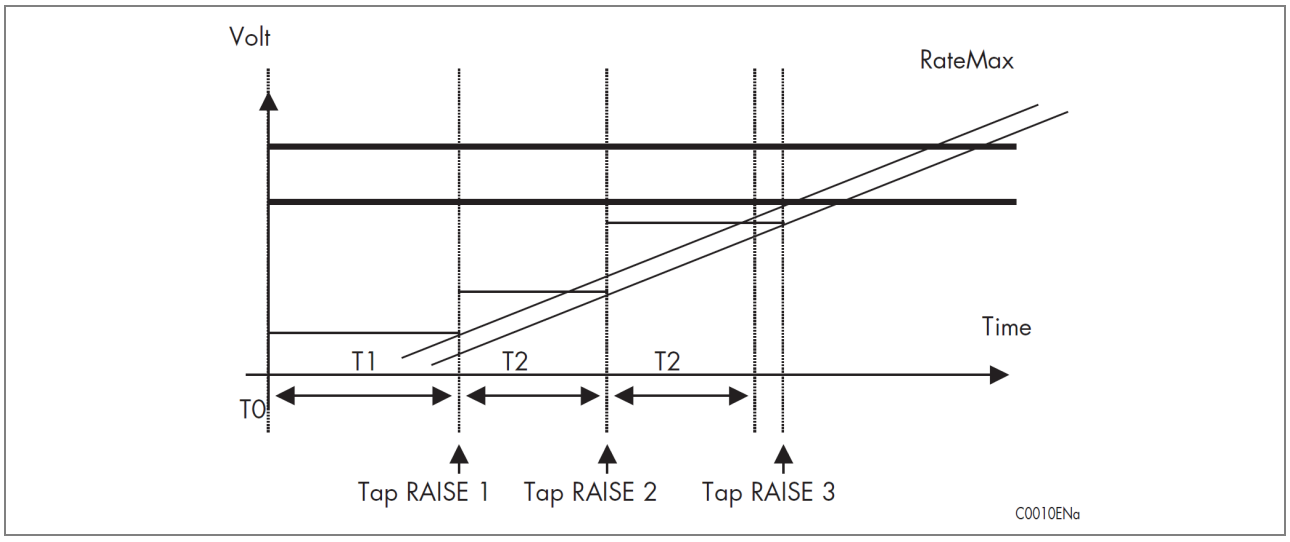


Figure 70: Voltage regulation

Tap RAISE 1 is performed after T1.

Tap RAISE 2 is performed T2 after Tap RAISE 1, at this time the voltage change rate is lower than the maximum rate.

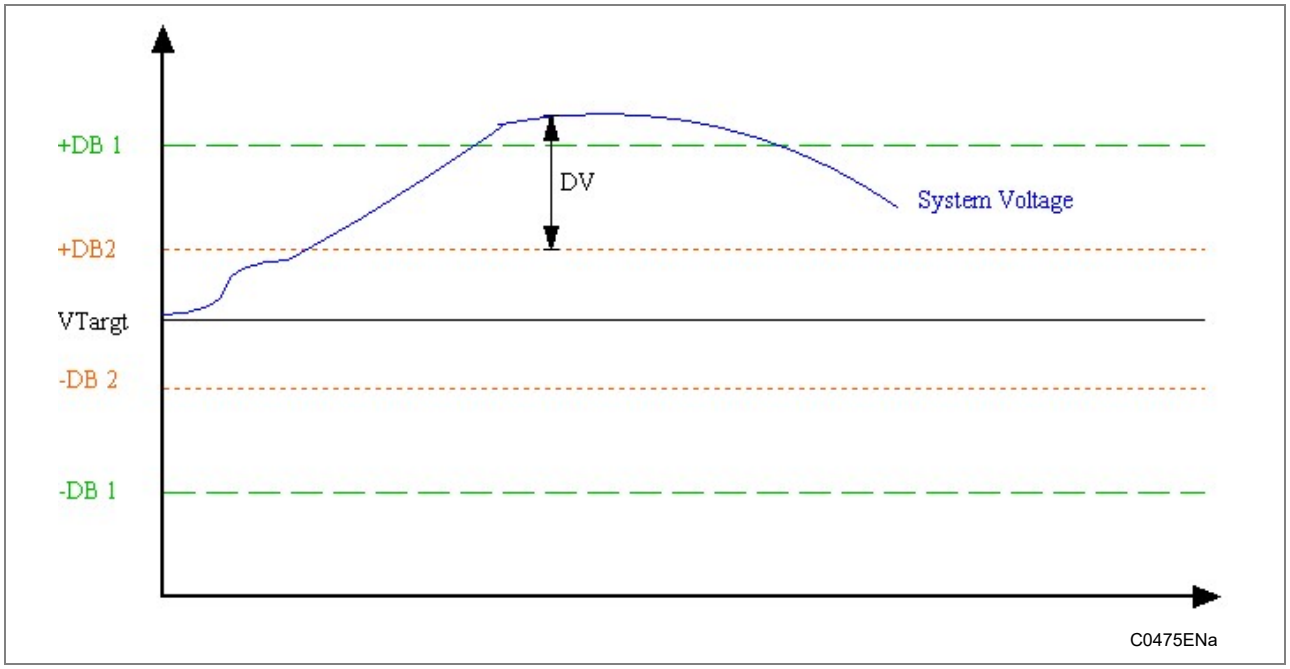
Tap RAISE 3 is NOT performed T2 after Tap RAISE 2, because at this time the voltage change rate is more than the maximum rate. It is performed when the current voltage change rate becomes lower than the maximum rate.

It is possible to choose a T1 delay as a fixed delay or not, i.e. an inverse time delay.

When inverse initial time delay is selected: the deviation is

DV = | actual group voltage - deadband limit voltage |

- IF DV < 1% target voltage THEN initial tap delay = T1.
- IF 1% ≤ DV < 10% target voltage THEN initial tap delay = T1/DV.
- IF DV ≥ 10% target voltage THEN initial tapdelay = T1/10.



Example: Target = 135.96 T1= 40.00 s DeadBand2 = 136.64

Busbar	DV = (BusBar-DeadBand)	%DV = (DV*100)/Target	Time Out	
137	0.36	0.26	40.00	%DV <1%: Timeout = T1
139.03	2.39	1.76	22.75	1% < %DV <10%: Timeout = T1/%DV
140.01	3.37	2.48	16.14	
141.01	4.37	3.21	12.44	
143.04	6.40	4.71	8.50	
145.04	8.40	6.18	6.47	
146.01	9.37	6.89	5.80	
150.01	13.37	9.83	4.07	
151.02	14.38	10.58	4.00	%DV >10%: Timeout = T1/10
152.05	15.41	11.33	4.00	

153.03	16.39	12.06	4.00	

When a transformer belongs to a group of several transformers, the time out is applied to the group. 2 different groups have separate timeout references, thus allowing simultaneous taps.

- The tap is defined as the "first one" when (logical OR):
- The group mode has changed
- The voltage comes back into the deadband2
- When the voltage crosses from one side of the deadband to the other side.

7.1.4.3.4 Homing

When the mode of the busbar is in automatic control, homing taps transformers such that their open circuit terminal volts follows the volts on the busbars that they are selected to within 3% of the busbar voltage.

Homing is active:

- If there is at least one transformer connected on the related busbar and
- If the transformer busbar disconnector is closed and
- If LV circuit-breaker open.

Homing is disabled while the busbar voltage is less than Umin (80% of nominal voltage).

If a transformer is in Homing Mode, a manual control is not accepted.

If (and only) a fault on the Tap Changer remains active, the transformer remains OUT of automatic control. As a consequence, homing ceases as long as the Tap Changer is faulty and until the operator selects "Clear AVR faults".

Homing Initial tap delay is used for the first tap in the homing mode.

Homing Inter tap delay is used between successive taps.

7.1.4.4 CALCULATION MODES FOR A BUSBARS GROUP

If a group includes more than one transformer and is in automatic control mode, then the coordination of the transformers of the group aims at minimising the circulating power. To achieve this, there exist three calculation modes depending on the substation constraint and customer requirement. By configuration one of the three is chosen.

For the three following calculation modes, if all the transformer tap-changers reach their end stop while tapping is required to go further, then the substation alarm "target unreached" is generated. When the problem is cleared, this alarm disappears.

First calculation mode: “TAP”

In this event, the assumption is:

- The primary voltages of the transformers are identical
- The number of taps and tapping ranges of the transformers are identical

Then the maximum Tpi range between the transformers will be 1 and there will be a balanced control of them when the voltage is changing.

Calculation is as follows:

- if voltage is OUT of the deadband and
  - under the deadband -> action is raise on the transformer with the lowest Tap
  - over the deadband -> action is lower on the transformer with the highest Tap

- if voltage is IN the deadband, the system sets the transformer within one tap

Second calculation mode: “Transformer ratio”

In this event, the assumption is that the primary voltages of the transformers are identical.

The calculation is as follows:

- if voltage is OUT of the deadband and,
  - under the deadband -> action is raise on the transformer with the lowest transformer ratio
  - over the deadband -> action is lower on the transformer with the highest transformer ratio
- if voltage is IN the deadband, the system sets the transformer within a percentage of the transformer ratio. This percentage P is calculated for all groups:

P = Maximum (Tpi range / (number of taps - 1))

Example

Group with 3 transformers:

- SGT1: 19 taps, Tpi range = 30 %
- SGT2: 19 taps, Tpi range = 30 %
- SGT3: 16 taps, Tpi range = 20 %

  P = Max (30 / 18; 30 / 18; 20 / 15) = 30/18 % = 1.67 %

  So, the 3 transformers stay within 1.67 %.

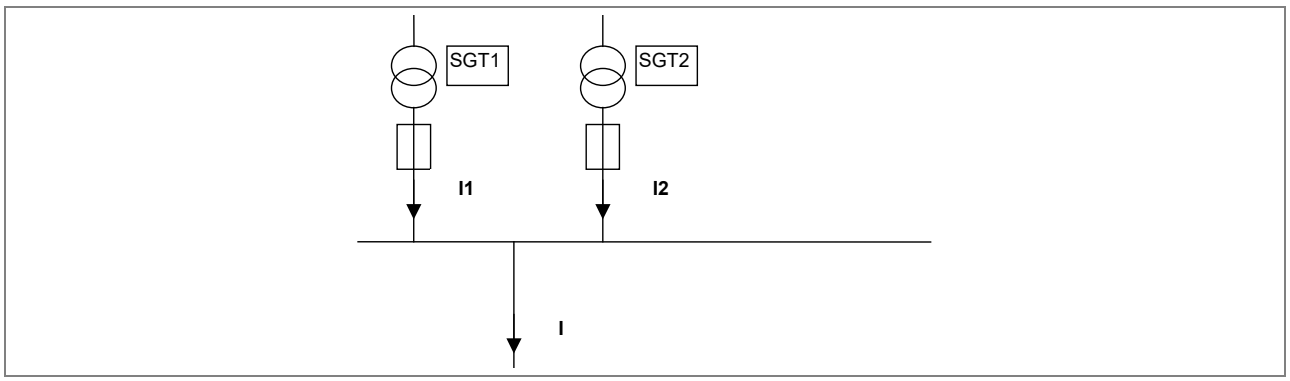
Tap operation if (ratioMax - ratioMin) > 0.0167 ratioNom, with:

- ratioMin = Minimum transformer ratio of the 3 transformers
- ratioMax = Maximum transformer ratio of the 3 transformers
- ratioNom = Nominal secondary voltage / Nominal primary voltage (defined in configuration)

Third calculation mode: “circulating current minimisation”

There is no assumption that the primary voltages of the transformers are identical.

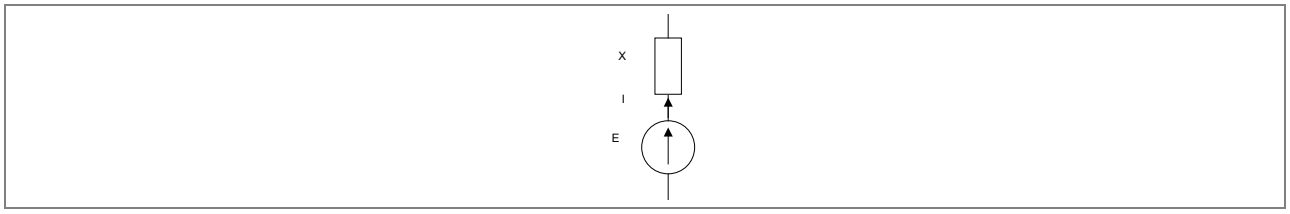
Example of two transformers:



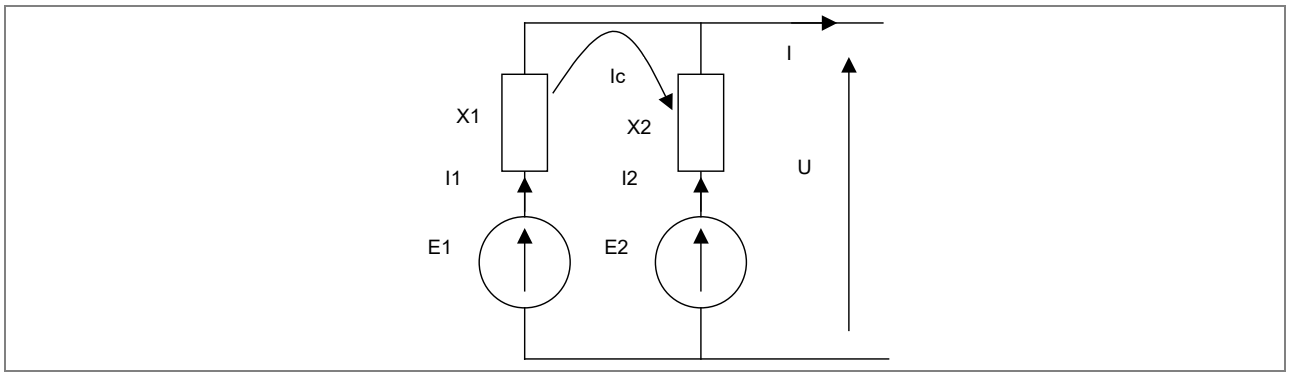
Each transformer is characterized by:

- Sn (power value)
- x (% impedance at Sbase = 100 MVA), in other words X (reactance) = x . Un² / Sbase
- U, I, P, Q
- Current tap
- Un (nominal secondary voltage)

A transformer can be presented as below:



The transformers can be presented as below:



U = E1 - X1.I1 = E2 - X2.I2 => E1-E2 = X1.I1 - X2.I2

I = I1 + I2

E1 - E2 = (X1 + X2) . I_C

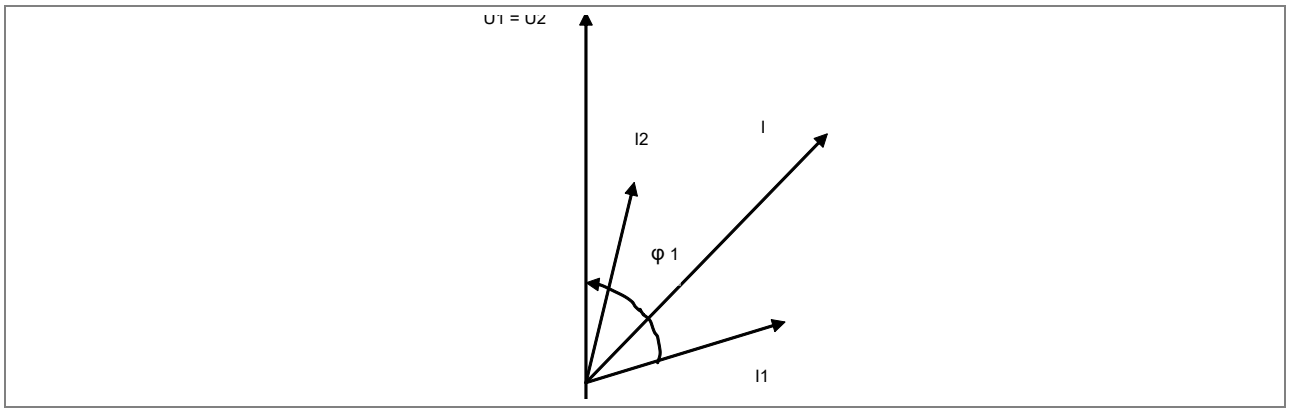
=> the circulating current **I_C = (X1.I1 - X2.I2) / (X1 + X2)**

For each transformer, we have U,I,P,Q (U1,I1,P1,Q1 and U2,I2,P2,Q2)

For i=1 or i=2, Qi/Pi = tan φi

According to the signs of Pi and Qi: $-\pi < \varphi i < \pi$

If there is a circulating current from transformer 1 to transformer 2 then $\varphi 1 > \varphi 2$.



Voltage out of the deadband

If the voltage is out of the deadband and active power > 0 ($|\varphi| < \pi/2$) then:

- If the voltage is under the target then transformer with highest $|\varphi|$ is tapped UP
- If the voltage is over the target then transformer with lowest $|\varphi|$ is tapped DOWN

If the voltage is out of the deadband and active power < 0 ($|\varphi| > \pi/2$) then:

- If the voltage is under the target then transformer with lowest $|\varphi|$ is tapped UP
- If the voltage is over the target then transformer with highest $|\varphi|$ is tapped DOWN

For three or four transformers, the same algorithm is used.

Voltage inside the deadband

If the voltage is into the deadband then the circulating current must be checked to know if it is possible to reduce it.

$\Delta U = E1 – E2 = |X1*I1 - X2*I2|$

ΔU is compared to the voltage step corresponding to one tap ($\Delta U1tap$).

Tpi range: tap span for the transformer

NbTap: number of taps for the transformer

Un: nominal secondary voltage

$\Delta U1tap$ = (Tpi range/(NbTap -1)) x Un

if $\Delta U > \Delta U1tap$ and if $\varphi i > \varphi j$ so

If the voltage is out of the deadband and active power > 0 ($|\varphi| < \pi/2$) then:

- If the voltage is under the target then transformer with highest $|\varphi|$ is tapped UP
- If the voltage is over the target then transformer with lowest $|\varphi|$ is tapped DOWN

If the voltage is out of the deadband and active power < 0 ($|\varphi| > \pi/2$) then:

- If the voltage is under the target then transformer with lowest $|\varphi|$ is tapped UP
- If the voltage is over the target then transformer with highest $|\varphi|$ is tapped DOWN

For three or four transformers, the same algorithm is used.

7.2 SYNCHROCHECK

7.2.1 GENERAL

The DS Agile C26x synchrocheck function is designed to measure voltages with respect to phase angle, frequency and magnitude on the line and on the busbar in order to safeguard against the interconnection of unsynchronised systems.

It is impossible to connect the C26x directly to the high voltage electrical network. The C26x receives the data from the Current Transformers (CT) and from Voltage Transformers (VT) connected to the TMU2xx boards.

The purposes of the CTs and VTs include:

- Delivering current and voltage data that give a reliable picture of in the phenomena occurring on the high voltage side of an electrical substation
- Providing galvanic insulation between the high voltage side and the measurement and protection circuits,
- Protecting the measurement circuits against damage when a fault occurs in the high voltage network.

The voltage measurements used by the internal synchrocheck function are provided by VTs. These measurements are used for the protection functions and for the Internal Synchrocheck, whether the latter is of Type 1 (standard set of requirements for CB closure), Type 2 (automation based on frequency shift), Type 3 ("breaker-and-a-half" arrangements) or Type 4 (Type 1 variant with “retry” timeout and overvoltage threshold).

The synchrocheck function makes it possible to couple together 2 electrical networks that can be connected to different sources (generators) and therefore not synchronised with each other:

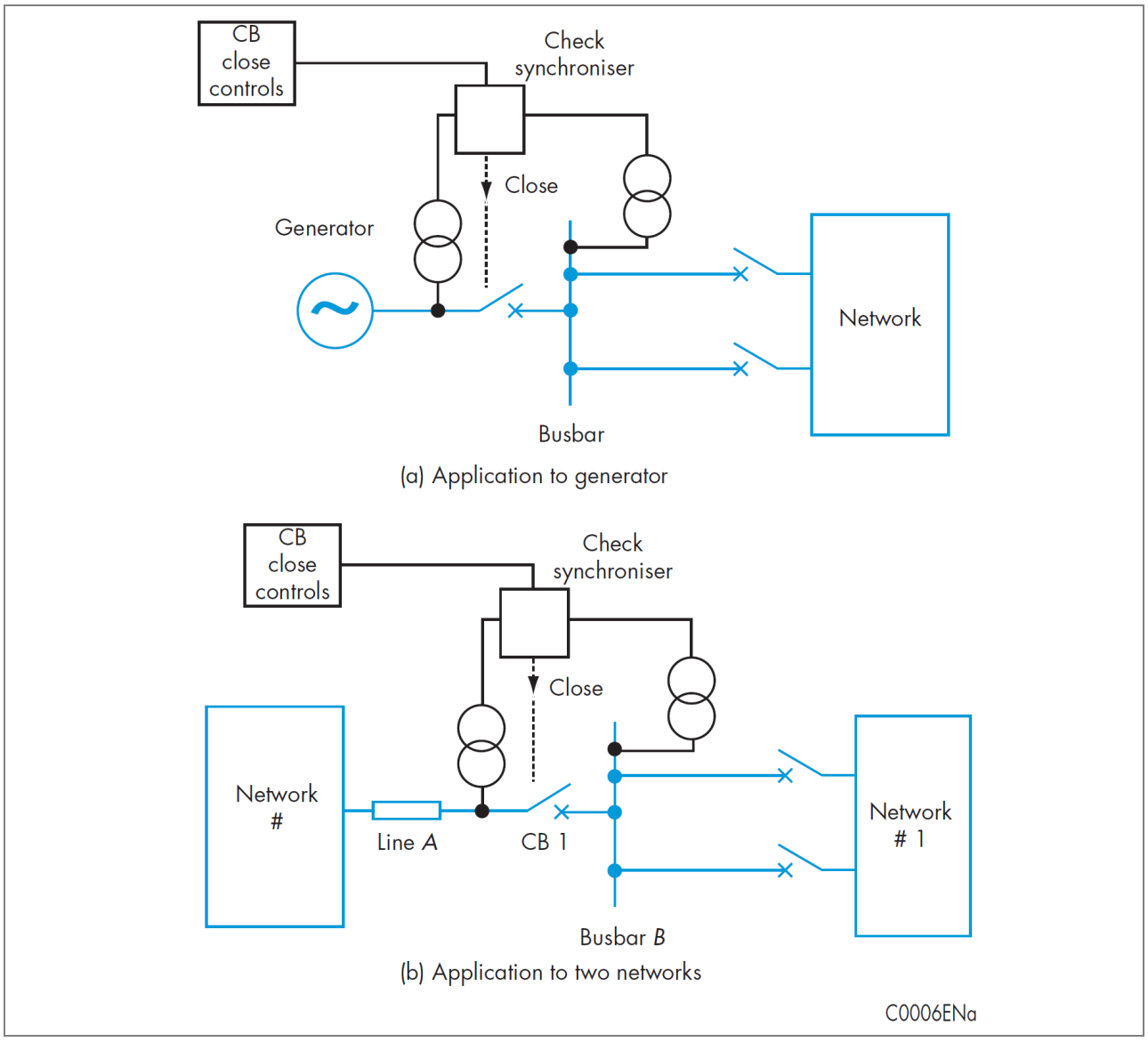


Figure 71: Synchrocheck single-breaker application examples

The Synchrocheck function measures two voltages with respect to phase angle, frequency and magnitude to safeguard the electrical network against the interconnection of two unsynchronised systems.

Synchrocheck functions types 1, 2 and 4 can manage up to 2 circuit-breakers. However, they can only control 1 circuit-breaker at a time. The set of parameters defined for the synchrocheck function applies for both circuit-breakers.

Synchrocheck function type 3 concurrently manages 3 circuit-breakers in Breaker-and-a-Half topology: 2 feeder CBs and 1 bus coupler CB.

When 2 electrical networks are synchronized with each other:

- Voltages are identical (plus or minus a dispersion)
- Frequencies are identical (plus or minus a dispersion)
- Phases are identical (plus or minus a dispersion)

ΔV, $\Delta\varphi$ and ΔF are calculated. Their values are available through the measurement module.

ΔV is derived from the RMS values of the voltages on both busbar and line side.

The value of ΔF is assumed to be constant across the period. As a result, the Δφ measurement makes it possible to determine whether the synchrocheck conditions are met (the circuit-breaker operating time can be taken into account).

time_synchro = 2 * pi *ΔF / Δφ

For more details, refer to section *5.2.4 Focus 3: TMU2XX - CT/VT measurement processing up to Threshold Detection*.

The 3 phase voltages of the line and one phase of the busbar are provided to the synchrocheck function.

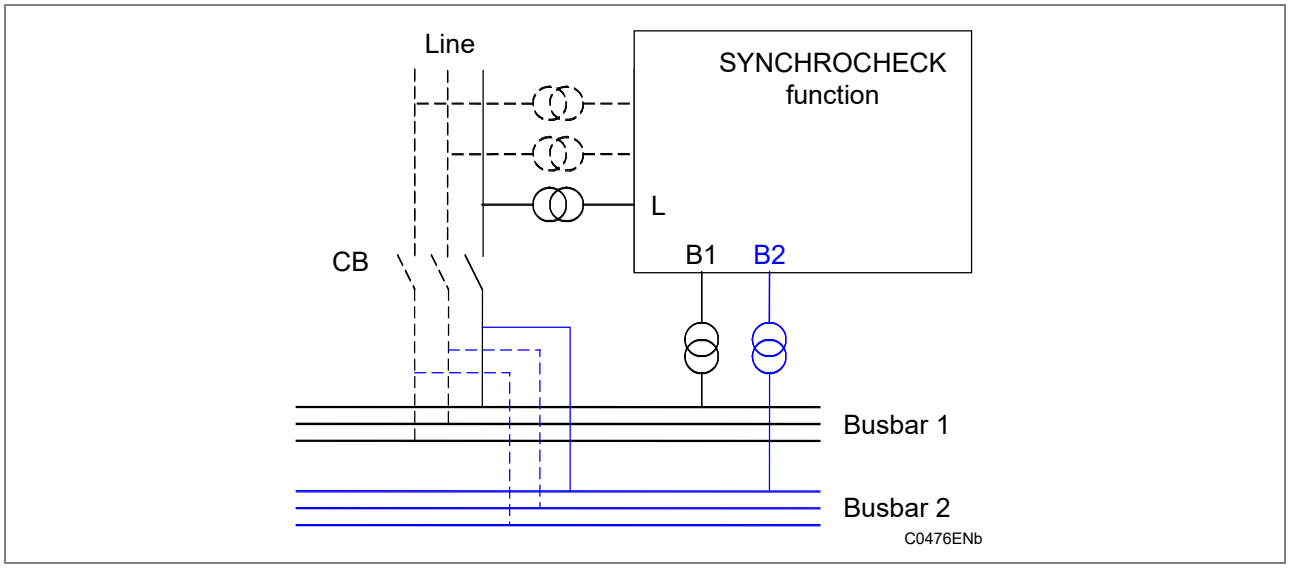


Figure 72: Standard Type1 synchrocheck scheme

The busbar reference phase is settable. If there are two busbars, the reference phase must be the same for both. The synchronism check will be applied between the line and the selected busbar for Types 1, 2 and 4. Type 3 synchrocheck (breaker-and-a-half diameter configuration) uses virtual equivalences for compatibility. They are listed later in this section.

7.2.2 FUNCTIONAL DESCRIPTION

7.2.2.1 MODES

Check synchronizing (locking)

It is performed if the ΔF value is lower than a user-defined threshold (generally less than 0.1 Hz). If so, ΔV and Δφ are calculated. If these values are under a user-defined threshold, a close command is sent to the circuit-breaker.

On the other hand, closure of the circuit-breaker is prevented if system synchronizing is not activated and one of the above conditions is not met.

System synchronizing (coupling)

When a close request is received and if the ΔF value is outside of a user-defined range, coupling is activated.

The system synchronizing function has a predictive role. This means that it calculates the time to wait before initiating the CB closure authorization by taking into account the complete command line, including the mechanical characteristics of the circuit-breaker. This time should be user-defined.

Note:
After a user-defined delay, the system synchronizing mode is reset.

Voltage presence Check

Voltage presence is checked if locking is not permitted by the set schemes or has failed, and if coupling is not permitted. The role of the voltage presence check is to control if the line and/or the busbar are “Dead” (voltage under the **line/bus voltage under threshold (%)** setting), or “Live” (voltage higher than the **line/bus voltage over threshold (%)** setting). There are four possible cases:

- Live Line and Live Bus: LL/LB
- Live Line and Dead Bus: LL/DB
- Dead Line and Live Bus: DL/LB
- Dead Line and Dead Bus: DL/DB

In the LL/DB, DL/LB, and DL/DB cases, a close command is sent to the circuit-breaker according to the configured scheme.

There are three ways to manage Locking and Coupling (LL/LB):

- Exclusive mode

  No locking is performed, only coupling. If that fails, then the closing operation is aborted.

- Evolutive mode

  This is the default mode: locking is tried first, and if it fails, then coupling is tried. If that fails too, then the closing operation is aborted.

- Split mode

  Locking is tried first, and if it fails, then coupling is tried according to special split conditions. If that fails too, then the closing operation is aborted.

The availability of these modes depends on the type of Synchrocheck: Details are provided later in this chapter.

7.2.2.2 DIFFERENT TYPES OF CLOSE REQUESTS

There are four types of circuit-breaker close requests:

- **Close with synchro** — Close request with synchrocheck: Locking, coupling and voltage presence check will be performed, according to the user configuration and selected schemes
- **Manual Close** — Close request without synchrocheck: Only locking and voltage presence check will be performed, according to the user configuration and selected schemes
- **Automatic Close** — Close request from auto-recloser: It is managed like a manual close but has a separate and different set of schemes (not available with Synchrocheck Type 3)
- **Manual override** — Synchrocheck override: No synchronisation

The Synchrocheck process replies with a positive (closing is possible) or negative (closing is not possible) acknowledgement.

7.2.2.3 BLOCK DIAGRAM

The synchrocheck diagram will vary depending on the type of synchrocheck, on the type of close request, on the locking/coupling management mode, and on the configured schemes. Nevertheless, the C26x always executes the scheme checks in the same order:

- Locking
- Coupling (this step can be skipped for a manual close command)
- Voltage presence check

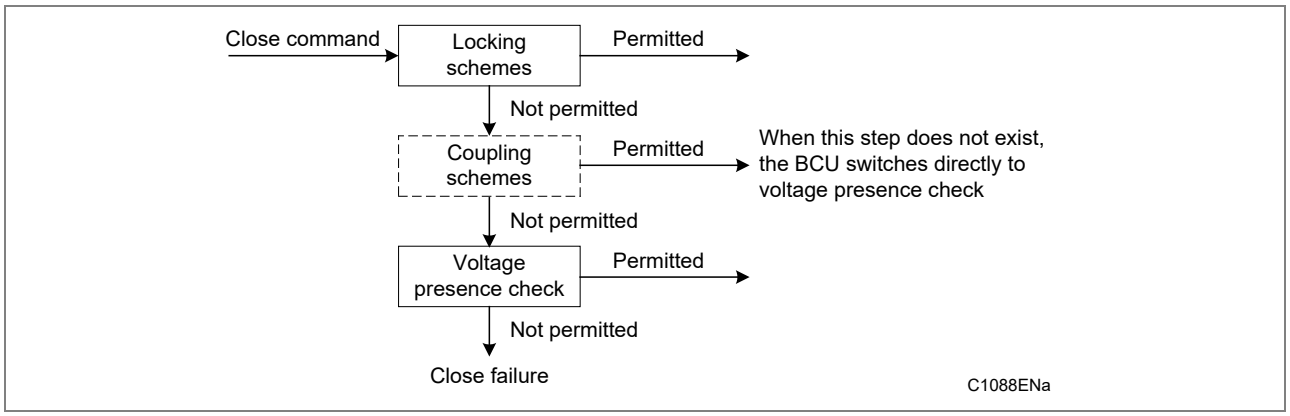


Figure 73: Synchrocheck scheme sequence

7.2.3 SYNCHROCHECK CLOSE REQUEST

When a close request is received, the schemes are tested and the close command is sent with the answer:

- OK: closing is possible
- KO: closing is impossible

When the LL/LB scheme is valid, the synchronization conditions between the 2 voltages must be checked in order to allow the breaker to close.

The locking mode is the default synchronising mode. If the requirements are valid, at least during a delay T1, closing is immediate. Otherwise the coupling mode is tried. The different coupling modes are defined according to the type of synchrocheck.

The following authorized schemes are defined during the configuration process. The synchrocheck function operates for these schemes:

	Operator manual closure	Operator Synchrocheck closure	Auto-recloser
Network locking on both voltages presence and test of deltas Automatic and manual network locking on live line / live bus	X	X	X
Network coupling on both voltages presence and test of deltas Automatic and manual network coupling on live line / live bus		X	
Presence of only the line voltage Automatic and manual network connection on live line / dead bus	X	X	X
Presence of only the busbar voltage Automatic and manual network connection on dead line / live bus	X	X	X
Absence of both voltages Automatic and manual network connection on dead line / dead bus	X	X	X

7.2.4 HARDWARE CONSTRAINTS AND USE

The voltages used are provided by the CT/VT board. There are 2 possibilities regarding the number of S/C voltages and required features for the C26x.

CT/VT board	Number of wired S/C voltages	Protection functions	Busbar selection	SC type
TMU210	1	Yes	External	1 or 2 or 4
TMU220	1 or 2* or 3**	No	Internal*	1 or 3 or 4

*: There is an extra voltage input on the TMU220 which can be connected either to a neutral voltage VT (for the line) or to a second busbar VT. The synchronism check can only use one busbar input at a time. The switch between the 2 busbar VT inputs is done using the **busbar V choice** SPS.
This feature is only available for Synchrocheck Type 1 in applications where the VT topology is identical on the line side and on the busbar side.

**: For use with Synchrocheck Type 3 only

TMU210 restrictions

There are some restrictions when the C26x is fitted with the TMU210 board because it has only 4 voltage inputs: The fourth input must be used for either the neutral (or residual) voltage or the busbar voltage, therefore the synchrocheck function cannot be available if the fourth voltage input is used to measure the neutral voltage.

Meas't	$3V_{PN}$	$3V_{PN} + V_0$	$2V_{PN} + V_0$	$2V_{PP} + V_0$	$3V_{PP} + V_0$	$3V_{PN} + V_{busbar}$	$3V_{PP} + V_{busbar}$
V_{AN}	measured	measured	measured	derived	derived	measured	n/a
V_{BN}	measured	measured	measured	derived	derived	measured	n/a
V_{CN}	measured	measured	derived	derived	derived	measured	n/a
V_{AB}	derived	derived	derived	measured	measured	derived	measured
V_{BC}	derived	derived	derived	measured	measured	derived	measured
V_{CA}	derived	derived	derived	derived	measured	derived	measured
V_0	derived	measured	measured	measured	measured	derived	n/a
V_{Busbar}	n/a	n/a	n/a	n/a	n/a	measured	measured
Protection functions	all	all	all	all	all	all	All except 59N, 67N
Internal S/C	n/a	n/a	n/a	n/a	n/a	yes	yes

Note:
For the cases 3VPN + Vbusbar and 3VPP + Vbusbar, frequency tracking is primarily based on Vbusbar.



Caution:
The TMU210 acquisition board can now allow different types of VT wiring on each side: With this board, mixed delta-star configurations are possible for type 4 synchrocheck only.

7.2.5 VT WIRING CONFIGURATION

The synchronism check is calculated by comparing the magnitudes, frequencies and phase differences between the line and busbar voltages.

A voltage input on the C26x's TMU220 or TMU210 can be wired to a Ph-N or Ph-Ph VT.

The VTs' wiring topology must be configured:

- Ph-N line side and Ph-N busbar side: *star on both sides*
- Ph-Ph line side and Ph-Ph busbar side: *delta on both sides*
- Ph-N line side and Ph-Ph busbar side: *star on line - delta on busbar*
- Ph-Ph line side and Ph-N busbar side: *delta on line - star on busbar*

The reference phase (or circuit) must be configured, whatever the type of wiring on the line side:

- If on the line side, the VT wiring is in a star configuration, AN, BN or CN can be chosen as reference.
- If on the line side, the VT wiring is in a delta configuration, AB, BC or CA can be chosen as reference.

***star on both sides* wiring**

The synchronism check is calculated using:

- ΔV = | Measured line V_{PN} – Measured busbar V_{PN} |
- ΔF = | Frequency of measured line V_{PN} – Frequency of measured busbar V_{PN} |
- $\Delta \varphi$ = | Phase angle of measured line V_{PN} – Phase angle of measured busbar V_{PN} |

The measured line V_{PN} depends on the reference circuit (AN or BN or CN). On the busbar side, the voltage can only measured since only one circuit (AN or BN or CN) is available.

***delta on both sides* wiring**

The synchronism check is calculated using:

- ΔV = | Measured line V_{PP} – Measured busbar V_{PP} |
- ΔF = | Frequency of measured line V_{PP} – Frequency of measured busbar V_{PP} |
- $\Delta \varphi$ = | Phase angle of measured line V_{PP} – Phase angle of measured busbar V_{PP} |

The measured line V_{PP} depends on the reference circuit (AB or BC or CA). On the busbar side, the voltage can only measured since only one circuit (AB or BC or CA) is available.

***star on line - delta on busbar* wiring**

The synchronism check is calculated using:

- ΔV = | Derived line V_{PP} – Measured busbar V_{PP} |
- ΔF = | Frequency of derived line V_{PP} – Frequency of measured busbar V_{PP} |
- $\Delta \varphi$ = | Phase angle of derived line V_{PP} – Phase angle of measured busbar V_{PP} |

The measured line V_{PN} depends on the reference circuit (AN or BN or CN). On the busbar side, the voltage can only be measured since only one circuit (AB or BC or CA) is available.

***delta on line - star on busbar* wiring**

The synchronism check is calculated using:

- ΔV = | Derived line V_{PN} – Measured busbar V_{PN} |
- ΔF = | Frequency of derived line V_{PN} – Frequency of measured busbar V_{PN} |
- $\Delta \varphi$ = | Phase angle of derived line V_{PN} – Phase angle of measured busbar V_{PN} |

The measured line V_{PP} depends on the reference phase (AB or BC or CA). On the busbar side, the voltage can only be measured since only one circuit (AN or BN or CN) is available.

Earth factor

The earth factor K_0 (**earth phase factor**) must be configured as it is needed in the calculation to derive the phase-phase voltages from the phase-neutral voltages and vice-versa where there are different VT topologies on the line side and on the busbar side.

Frequency

The frequency is not affected by the calculation to derive the line V_{PN} from the measured line V_{PP}. It is identical for both.

7.2.6 COMMANDS RECEIVED FROM A CONTROL SEQUENCE

A synchronism check is initiated when a close command is received for a synchronised circuit-breaker.

Depending on the configuration of the circuit-breaker and the synchrocheck, the type of request and the state of the built-in synchrocheck, the requests received and managed by the synchrocheck function are:

Synchrocheck "on/off sec" state	Control command	Origin	Request received by the synchrocheck function
OFF	Close	Operator	Manual close
ON	Close	Operator	Synchro close
ON or OFF	Close	Auto-Recloser	Automatic close
ON	Cancel	Operator	Abort
ON	Force	Operator	Abort

The requests received and managed by the synchrocheck function do not depend on whether it is automatic or manual.

7.2.7 SCHEME LL/LB: LIVE LINE, LIVE BUS

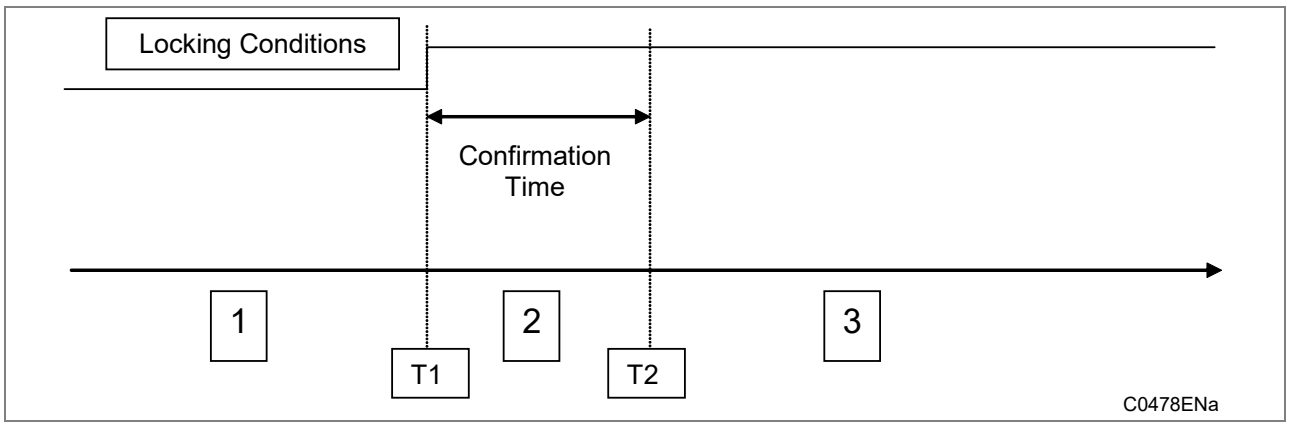
Locking (check synchronizing) is defined by specific requirements: frequency difference, etc. If the corresponding values are all below the set thresholds, closing is immediately accepted.

Generally, these requirements are very restrictive: for example, Delta F < 0.1 Hz

Coupling (system synchronizing is also defined by specific requirements: frequency difference, etc. This has a predictive mode: the C26x includes a timer "T" and calculates whether the coupling conditions will be met t seconds later. This timer is settable.

7.2.7.1 LOCKING PERMITTED / COUPLING NOT PERMITTED BY CONFIGURATION

Example 1



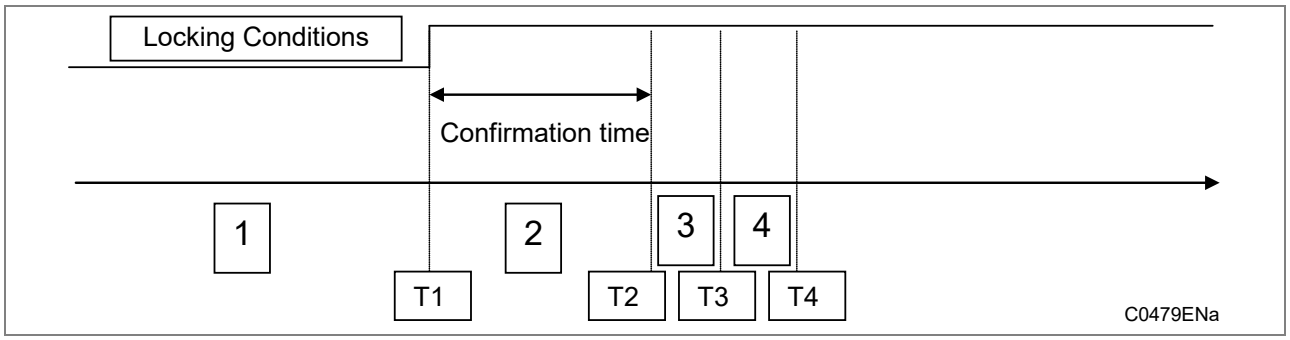
1: If a close command is received before T1 elapses, it is rejected.

2: If a close command is received after T1 has elapsed but while T2 is still running, it is executed when T2 elapses if the locking conditions are still present. If the locking conditions are lost before T2 elapses then the command is rejected

3: If a close command is received after T2 has elapsed, it is accepted.

7.2.7.2 LOCKING PERMITTED / COUPLING PERMITTED BY CONFIGURATION

Example 1

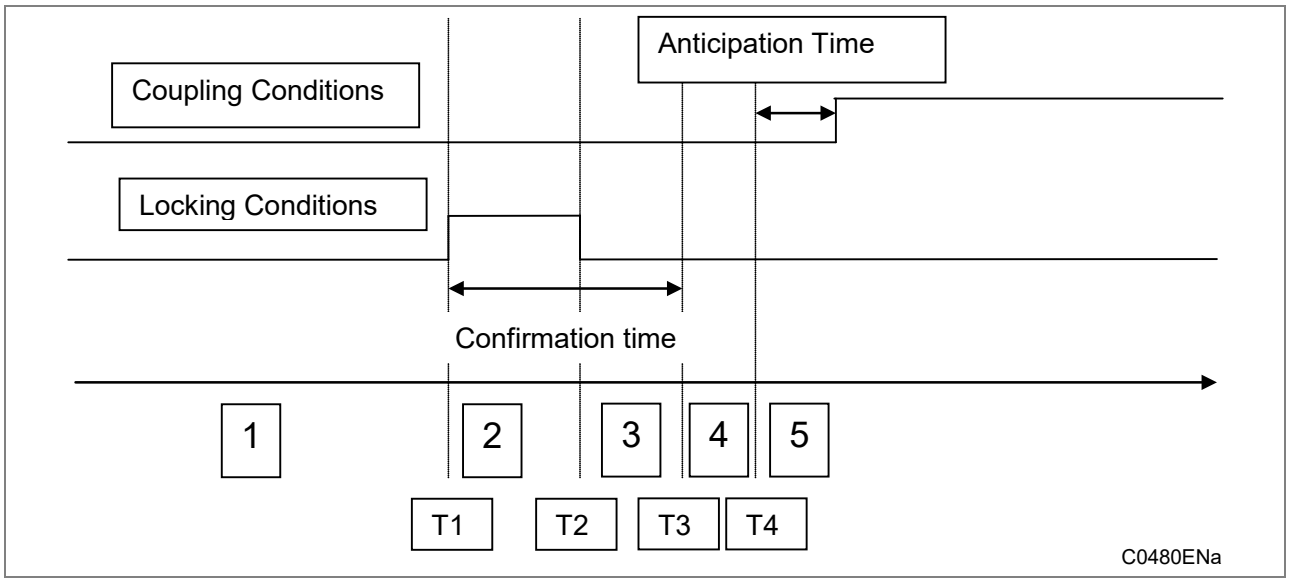


1: If a close command is received before T1 elapses, it is sent to the DSP board, and the control is executed from the DSP board when T2 elapses.

2: If a close command is received after T1 has elapsed but while T2 is still running, it is buffered until T2 elapses if the locking conditions are still present. If the locking conditions are lost before T2 elapses then the command is rejected.

3: If a close command is received after T2 has elapsed, it is accepted.

Example 2



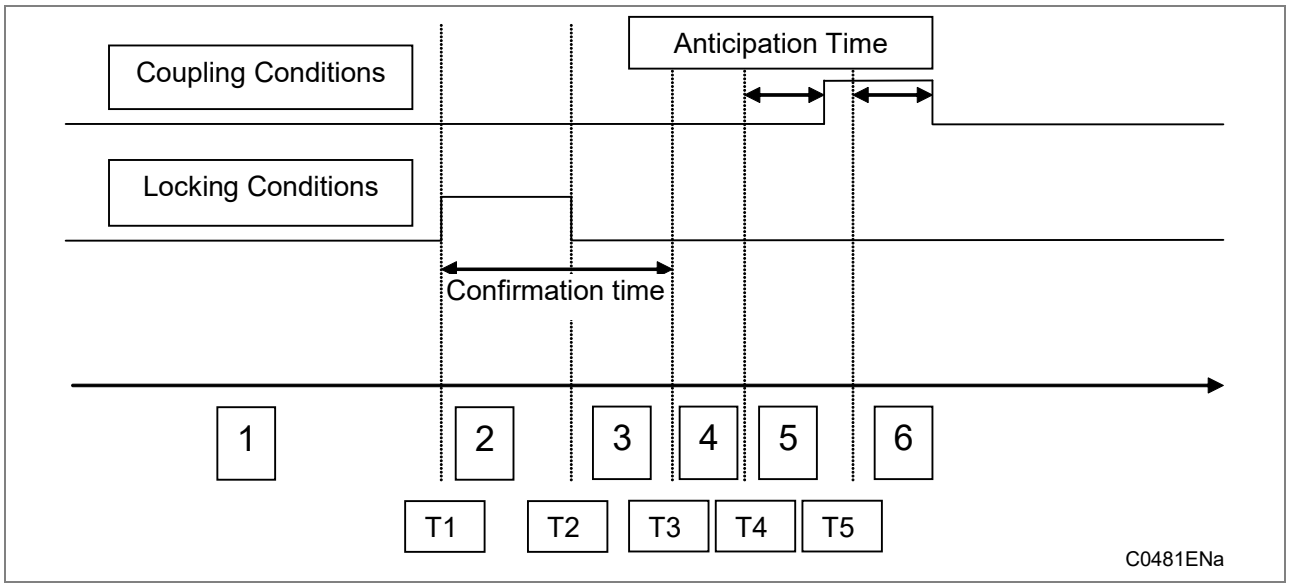
1: If a close command is received before T1 elapses, it is sent to the DSP board, and the control is executed from the DSP board when T4 elapses.

2: If a close command is received after T1 has elapsed but while T2 is still running, it is buffered. As the locking conditions are lost then the command is sent to the DSP board and executed when T4 elapses.

3, 4: If a close command is received after T2 has elapsed but while T4 is still running, it is sent to the DSP board, and the control is executed from DSP board when T4 elapses.

5: If a close command is received after T4 elapses, it is sent to the DSP board, and the control is immediately executed from the DSP board.

Example 3



1: If a close command is received before T1 elapses, it is sent to the DSP board, and the control is executed from the DSP board when T4 elapses.

2: If a close command is received after T1 has elapsed but while T2 is still running, it is buffered. As the locking conditions are lost then the command is sent to the DSP and executed at T4.

3, 4: If a close command is received after T2 has elapsed but while T4 is still running, it is sent to the DSP board, and the control is executed from the DSP board when T4 elapses.

5: If a close command is received after T4 has elapsed but while T5 is still running, it is sent to the DSP board, and the control is immediately executed from the DSP board.

6: If a close command is received after T5 has elapsed, it is sent to the DSP board, and the control is rejected after the synchrocheck waiting time (not shown in the above drawing).

7.2.8 SYNCHROCHECK TYPE 1

7.2.8.1 MANUAL AND AUTOMATIC CLOSE CONDITIONS (LOCKING LOGIC)

Voltage conditions for manual and automatic requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Voltage missing:

- Not(V_{line}): On the line VT, the voltage of the set reference circuit is lower than the set threshold **line voltage under threshold**.
- Not(V_{busbar}): On the busbar VT, the voltage (only one circuit available) is lower than the set threshold **bus voltage under threshold**.

Permitted voltage delta:

- $\Delta V \leq \Delta V_{locking}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for locking**.

Permitted frequency delta:

- $\Delta f \leq \Delta f_{locking}$: The difference between the line frequency and the busbar frequency is lower than the set threshold **frequency delta threshold for locking**.

Permitted frequency range:

- $f_{min\ locking} \leq f_{line} \leq f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **minimum frequency for locking**.
- $f_{min\ locking} \leq f_{busbar} \leq f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **maximum frequency for locking**.

Permitted phase angle delta:

- $\Delta\varphi \leq \Delta\varphi_{locking}$: the difference between the line voltage phase angle (for the configured reference circuit) and the busbar voltage phase angle is lower than the set threshold **phase delta threshold for locking**.

Dead Line / Dead Bus

The Dead Line / Dead Bus (DLDB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage missing

for the duration of the T3 time-delay at the end of which the absence of both voltages is confirmed.

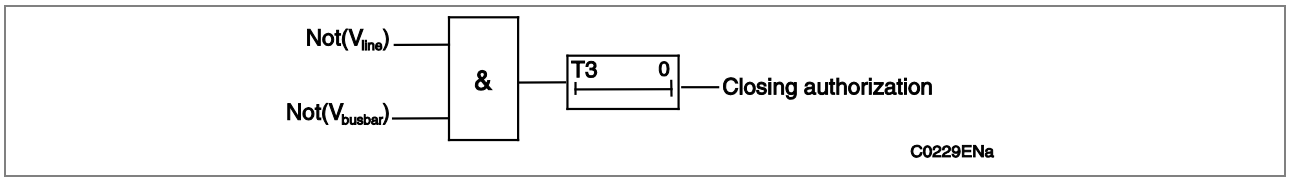


Figure 74: Not(V_{line}) and not(V_{busbar}) voltage check

When the Dead Line / Dead Bus (DLDB) closing conditions are met, CB closure is authorised.

If either DLDB condition criterion is lost while T3 elapses, the DLDB condition is no longer verified and T3 is reset. It will be restarted only upon the reappearance of both criteria.

Dead Line / Live Bus

The Dead Line / Live Bus (DLLB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage present

for the duration of the T2 time delay at the end of which the presence of only one voltage is confirmed.

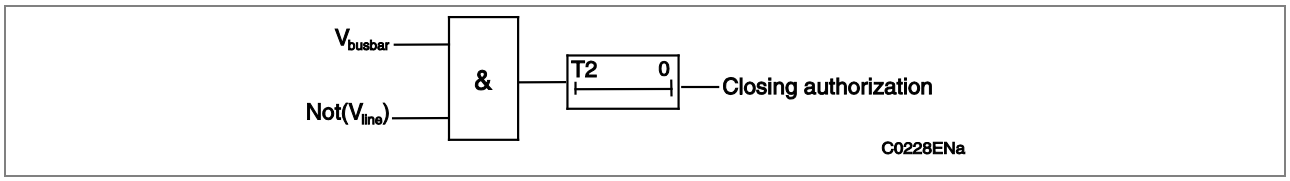


Figure 75: not(V_{line}) and V_{busbar} voltage check

When the Dead Line / Live Bus (DLLB) closing conditions are met, CB closure is authorised.

If either DLLB condition criterion is lost while T2 elapses, the DLLB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of both criteria.

Live Line / Dead Bus

The Live Line / Dead Bus (LLDB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage missing

for the duration of the T2 time delay at the end of which the presence of only one voltage is confirmed.

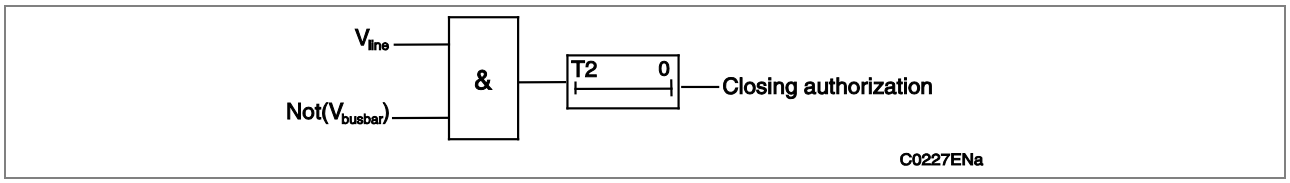


Figure 76: V_{line} and not(V_{busbar}) voltage check

When the Live Line / Dead Bus (LLDB) closing conditions are met, CB closure is authorised.

If either LLDB condition criterion is lost while T2 elapses, the LLDB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of both criteria.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK
- Phase Delta = OK

for the duration of the T1 time-delay at the end of which the presence of both voltages is confirmed and so are the locking conditions.

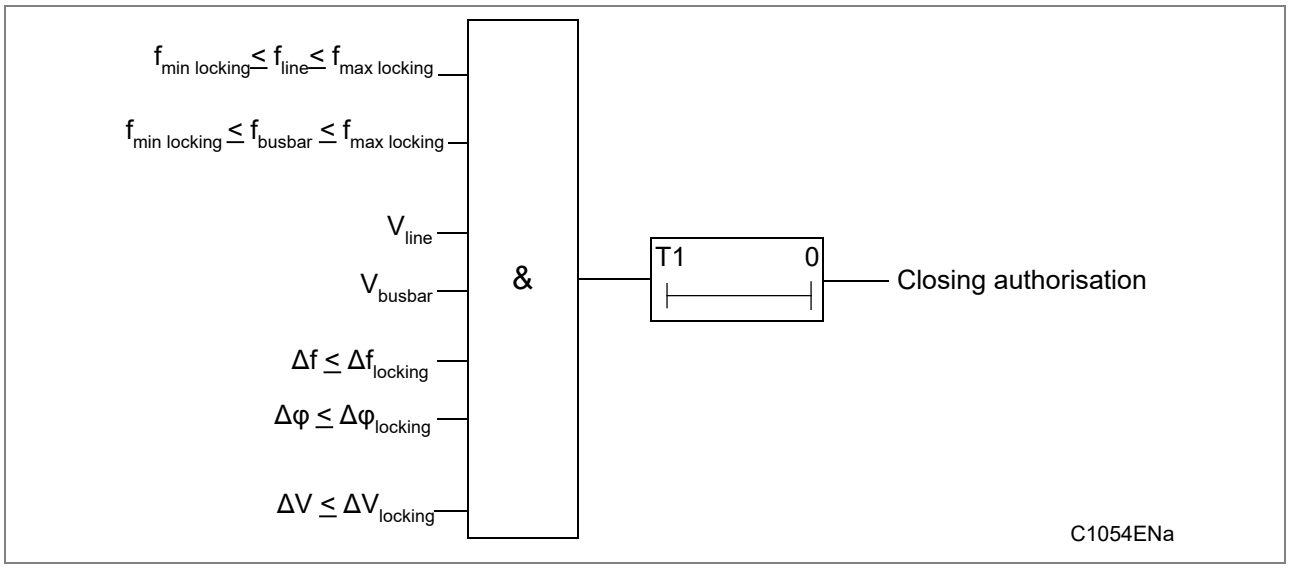


Figure 77: Locking scheme for type 1 synchrocheck

When the Live Line / Live Bus (LLLB) closing conditions are met, CB closure is authorised.

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

7.2.8.2 SYNCHRO CLOSE CONDITIONS (COUPLING LOGIC)

Voltage conditions for synchro close requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Permitted voltage delta:

- $\Delta V < \Delta V_{locking}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for coupling**.

Permitted frequency delta range:

- $\Delta f_{min\ locking} < \Delta f < \Delta f_{max\ locking}$: The difference between the line frequency and the busbar frequency is comprised between the set thresholds **minimum frequency delta threshold for coupling** and **maximum frequency delta threshold for coupling**.

Permitted frequency range:

- $f_{min\ locking} < f_{line} < f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **minimum frequency for coupling**.
- $f_{min\ locking} < f_{busbar} < f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **maximum frequency for coupling**.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK

for the duration of the T1 time-delay at the end of which the presence of both voltages is confirmed and so are the coupling conditions.

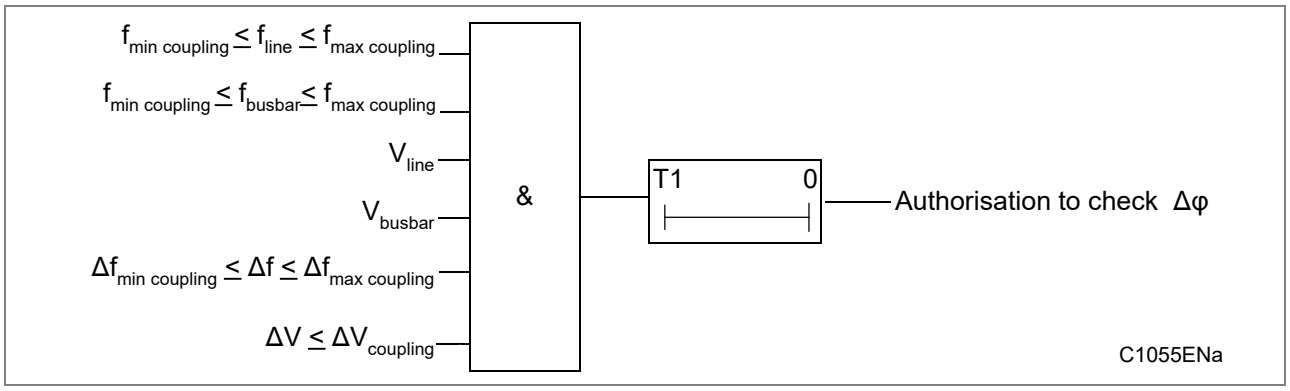


Figure 78: Coupling scheme for type 1 synchrocheck

When the Live Line / Live bus (LLLB) closing conditions are met, a synchro close request will authorise searching for min(Δφ).

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

The search for min(Δφ) is launched, in order to find the optimal phase difference between line and busbar to close the circuit-breaker. In the min(Δφ) search, the circuit-breaker's operating time must be taken into account.

min(Δφ) is reached when:

- $\Delta\varphi = \Delta f * 360 * Ta$

where Ta = circuit-breaker operating time.

Locking mode vs. Coupling mode

In order to discriminate between the locking and coupling modes, 2 separate ranges for frequency differences are configured.

- Locking range: [0 … $\Delta f_{max\ locking}$]
- Coupling range: [$\Delta f_{min\ coupling}$ … $\Delta f_{max\ coupling}$]

The 2 ranges may overlap but the following condition must be met:

- $\Delta f_{max\ coupling} > \Delta f_{max\ locking}$

7.2.8.3 CLOSING SCHEMES

In order to enable closing only when the required voltage conditions are met, separate closing schemes are configured for each type of close request:

Manual close

For the manual close request, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (locking)	YES / NO

Depending on the configuration, the following checks are performed for manual close requests:

Voltage Conditions	Closing Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected

* the voltage condition check is in progress when the manual close request is received.

Automatic close (reclosing cycle after a protection trip)

For the automatic close request, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorization
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO

Depending on the configuration, the following checks are performed for automatic close requests:

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected

* the voltage condition check is in progress when the automatic close request is received.

Synchro close

For the synchro close request, and for each voltage condition, a close scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO
Live Line / Live Bus (Locking and Coupling)	YES / NO

Depending on the configuration, the following checks are performed for synchro close requests:

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close Request Result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close Request Result
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB (locking)	Accepted
Live Line / Live Bus (Locking)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB (locking)	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking)	Accepted
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking and Coupling)	YES	≠ LLLB (locking and coupling)	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (coupling only)	Search for min(Δφ)
Live Line / Live Bus (Locking and Coupling)	NO	Any condition	Rejected

* the voltage condition check is in progress when the synchro close request is received.

7.2.8.4 CLOSING SCENARIOS

Request accepted

According to the configured closing scheme, if the close request is accepted, a close command is sent to the circuit-breaker.

Request rejected

According to the configured closing scheme, if the close request is rejected, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

Request delayed

According to the configured closing scheme, if the close request result is delayed, a configured time-delay is started (**delay (ms)**):

- When the voltage condition check is complete, if the close scheme issues a close authorization:
  - a close command is sent to the circuit-breaker
  - and the time-delay is reset.
- When the voltage condition check is complete, if the close scheme does not give a close authorization:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - no close command is sent to the circuit-breaker,
  - and the time-delay is reset.

- If the time-delay elapses with no voltage conditions having been checked:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - and no close command is sent to the circuit-breaker.

7.2.8.5 CLOSE WITH LOCKING / COUPLING

Synchro close requests can be managed according to three management modes combining Locking and Coupling logics.

The synchro close request Locking/Coupling management mode is defined in the configuration and cannot be changed without reloading a new database.

The 3 available modes are:

- Exclusive mode
- Evolutive mode
- Split mode

Exclusive mode

When a synchro close request is received, if $\Delta f_{min\ coupling} \leq \Delta f \leq \Delta f_{max\ coupling}$ the search for min(Δφ) is started and a time-delay is launched (**delay for coupling (s)**).

If min(Δφ) is found, a positive acknowledge is sent to close the circuit-breaker, and the time-delay is reset.

If the time-delay elapses without min(Δφ) being found, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

When a synchro close request is received while Δf is not within the range $[\Delta f_{min\ coupling} \ldots \Delta f_{max\ coupling}]$, a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

If Δf drifts outside of the range $[\Delta f_{min\ coupling} \ldots \Delta f_{max\ coupling}]$ during the search for min(Δφ) a negative acknowledge (*KO-Synchrocheck*) is sent when **delay for coupling (s)** elapses and no close command is sent to the circuit-breaker.

Evolutive mode

When a synchro close request is received, if Δf is within the range $[0 \ldots \Delta f_{max\ locking}]$ and the locking condition is met, a positive acknowledge is immediately sent to close the circuit-breaker.

When a synchro close request is received, if Δf is within the range $[0 \ldots \Delta f_{max\ locking}]$ and the locking condition check is in progress, the LLLB locking logic is applied.

When a synchro close request is received, if Δf is within the range $[\Delta f_{min\ coupling} \ldots \Delta f_{max\ coupling}]$, the search for min(Δφ) is started and a time-delay is launched (**delay for coupling (s)**).

When a synchro close request is received, if Δf is within neither of the ranges $[0 \ldots \Delta f_{max\ locking}]$ and $[\Delta f_{min\ coupling} \ldots \Delta f_{max\ coupling}]$, a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

If Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min(Δφ), the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic.

If Δf drifts outside of both the Coupling and Locking ranges during the search for min(Δφ), the search is aborted, the time-delay is reset, a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

The drift of Δf during the search for min(Δφ) is confirmed after a fixed time-delay of 5 s.

If Δf drifts outside of the Coupling range, the 5 s Δf drift time-delay is started. If Δf returns into the Coupling range, the Δf drift time-delay is reset.

If, when the Δf drift time-delay elapses, Δf is inside the Locking range, the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic. If Δf is outside the Locking range, the search is aborted, the search for min(Δφ) time-delay is reset, a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker..

If the Evolutive mode for synchro close request management is defined in the configuration, a SPS “Delta drift” can be defined. Whenever Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min(Δφ), the SPS “Delta drift” is transmitted in the SET state. As soon as the Δf drift during the search for min(Δφ) is over, whatever the resulting acknowledgement: OK or *KO-Synchrocheck*, the SPS “Delta drift” is transmitted in the RESET state.

Split mode

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition is met, a positive acknowledge is immediately sent to close the circuit-breaker.

When a synchro close request is received while the locking conditions are not met, the **SBO timeout (s)** time-delay configured in the *Switch Ctrl DPC* profile table (0 to 600 s, step 1 s) is started and the following condition checks are performed:

- $\Delta V_{min\ split} \leq \Delta V \leq \Delta V_{max\ split}$
- $\Delta f_{min\ split} \leq \Delta f \leq \Delta f_{max\ split}$
- $\Delta\varphi \leq \Delta\varphi_{min\ split}$ (negative value) or $\Delta\varphi \geq \Delta\varphi_{max\ split}$ (positive value)

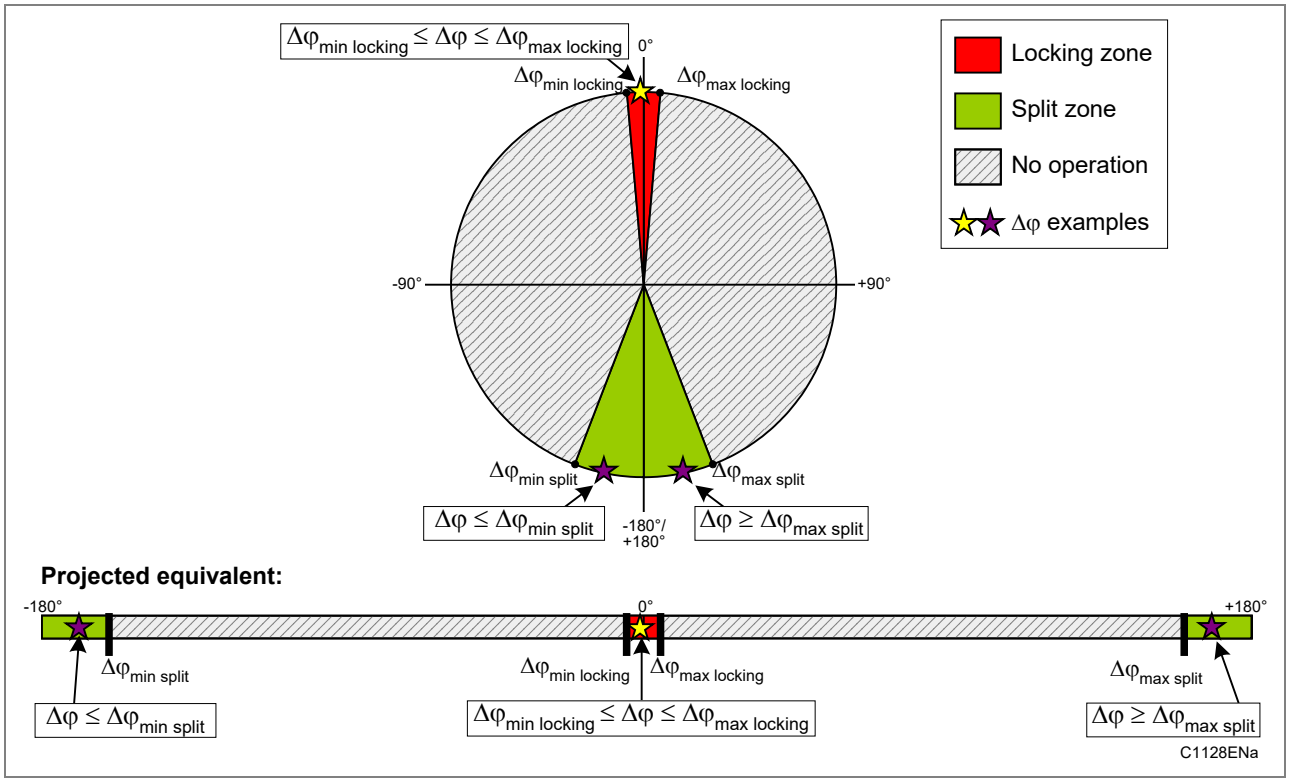


Figure 79: Angle conditions for split and locking zones

If the above split condition checks are verified, the search for min(Δφ) is started, **SBO timeout (s)** is reset and the coupling process is started:

- if
  - Δf is in the range [$\Delta f_{min\ coupling}$ .. $\Delta f_{max\ coupling}$]

  and
  - $\Delta V \leq \Delta V_{max\ coupling}$

  and
  - the coupling mode T1 time-out has elapsed,

  the search for min(Δφ) is started and another time-delay is launched (**delay for coupling**).
- if Δf is not in the range [$\Delta f_{min\ coupling}$ .. $\Delta f_{max\ coupling}$], a negative acknowledge (*KO-Synchrocheck*) is sent immediately.
- if $\Delta V > \Delta V_{max\ coupling}$, a negative acknowledge (*KO-Synchrocheck*) is sent immediately.

When **SBO timeout (s)** elapses while the split conditions are not met, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

When **SBO timeout (s)** elapses while the coupling mode is still not confirmed (T1 is running), the search for min(Δφ) is started when T1 elapses and another time-delay is launched (**delay for coupling**)..

Note:
If the three condition checks are verified when the CB close request is received, the search for min(Δφ) time-delay is started immediately.

If min(Δφ) is found, a positive acknowledge is sent to close the circuit-breaker and the time-delay is reset.

If the time-delay elapses without min(Δφ) having been found, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

If the **Split mode** is configured, 2 SPS datapoints: "**Locking mode**" and **"Split sync mode"** can be defined.

The SPS **"Locking mode"** is SET as soon as Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition is met.

The SPS **"Locking mode"** is RESET as soon as Δf is outside the range [0 ... $\Delta f_{max\ locking}$] or the locking condition is not met.

The SPS **"Split sync mode"** is SET as soon as the split conditions are verified.

The SPS **"Split sync mode"** is RESET as soon as the split conditions are not verified.

"Locking mode" and **"Split sync mode"** are managed even if there is no close request received by the synchrocheck.

7.2.9 SYNCHROCHECK TYPE 2

7.2.9.1 MANUAL AND AUTOMATIC CLOSE CONDITIONS (LOCKING LOGIC)

Voltage conditions for manual and automatic requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the three voltages are higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Voltage missing:

- Not(V_{line}): On the line VT, the three voltages are lower than the set threshold **line voltage under threshold**.
- Not(V_{busbar}): On the busbar VT, the voltage (only one circuit available) is lower than the set threshold **bus voltage under threshold**.

Permitted voltage delta:

- $\Delta V \leq \Delta V_{locking}$: The difference between the voltage of the set reference circuit and the busbar voltage is lower than the set threshold **voltage delta threshold for locking**.

Permitted phase angle delta:

- $\Delta\varphi \leq \Delta\varphi_{locking}$: the difference between the line voltage phase angle (for the configured reference circuit) and the busbar voltage phase angle is lower than the set threshold **phase delta threshold for locking**.

Locking Frequency Shift:

- $S_{filtered} \leq S_{freq\ locking}$: The difference between the line frequency and the busbar frequency is lower than the set threshold **frequency shift threshold for locking**.

Locking Frequency Shift Acceleration:

- $dS/dt < dS_{max}/dt$: The shift acceleration is lower than the set threshold **frequency shift acceleration threshold for locking**

Frequency Shift Filtering

Frequency Shift Filtering is applicable only to the synchronous mode (locking logic) of Synchrocheck type 2.

The following condition needs to be checked:

$|S_{filtered}| < S_{freq\ locking}$

where:

- |S| is defined as the instantaneous frequency shift (i.e. the difference between busbar frequency and line frequency),
- $|S_{filtered}|$ is defined as the filtered frequency shift. This value is computed using a rolling average filter. $|S_{filtered}|$ is the mean value of all sampled |S| values during the set time-period.

The filter can smooth frequency differences between 0.8 Hz and 1.6 Hz, in steps of 0.1 Hz, which corresponds to a period between 0.6 and 1.3 seconds. This is the period in which the mean value must be computed. The default value is 1.2 Hz (0.84 s).

The following condition also needs to be checked:

$|dS/dt|_{filtered} < dS_{max}/dt$

where:

- $|dS/dt|$ is defined as the acceleration of frequency shift (i.e. the derivative of the difference between busbar frequency and line frequency)
- $|dS/dt|_{filtered}$ is defined as the filtered acceleration of frequency shift. This value is computed with a rolling average filter. $|dS/dt|_{filtered}$ is the mean value of all the $|dS/dt|$ values over the set period.

The filter can smooth the acceleration of the frequency shift between 0.5 and 2 Hz, in steps of 0.1 Hz, corresponding to a period between 0.5 and 2 seconds. This is the period in which the mean value must be computed. The default value is 1 Hz (1 s).

The dS_{max}/dt value can be set between 10 mHz/s and 50 mHz/s in steps of 5 mHz/s. The default value is 25 mHz/s.

Note:
$S_{freq\ locking}$, dS_{max}/dt, $|S_{filtered}|$ and $|dS/dt|_{filtered}$ are all settable.

The "**Locking dS/dt filter enable**" parameter is defined in configuration. If this parameter is set to YES in the configuration, the following check is done, in addition to the above:

If $|dS/dt|_{filtered} > dS_{max}/dt$, closing must not be permitted.

Dead Line / Dead Bus

The Dead Line / Dead Bus (DLDB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage missing

for the duration of the T3 time-delay at the end of which the absence of both voltages is confirmed.

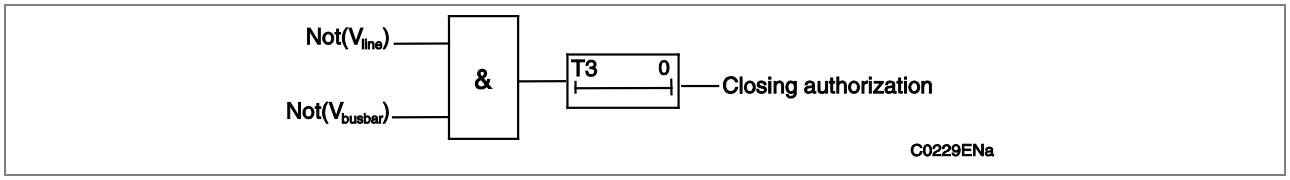


Figure 80: Not(V_{line}) and not(V_{busbar}) voltage check

When the Dead Line / Dead Bus (DLDB) closing conditions are met, CB closure is authorised.

If either DLDB condition criterion is lost while T3 elapses, the DLDB condition is no longer verified and T3 is reset. It will be restarted only upon the reappearance of both criteria.

Dead Line / Live Bus

The Dead Line / Live Bus (DLLB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage present

for the duration of the T2 time delay at the end of which the presence of only one voltage is confirmed.

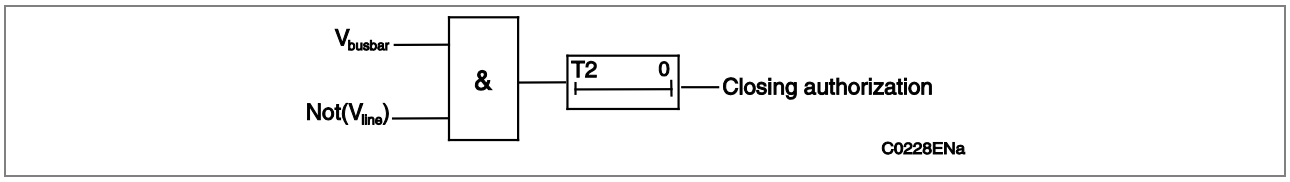


Figure 81: not(V_{line}) and V_{busbar} voltage check

When the Dead Line / Live Bus (DLLB) closing conditions are met, CB closure is authorised.

If either DLDB condition criterion is lost while T2 elapses, the DLLB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of both criteria.

Live Line / Dead Bus

The Live Line / Dead Bus (LLDB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage missing

for the duration of the T2 time delay at the end of which the presence of only one voltage is confirmed.

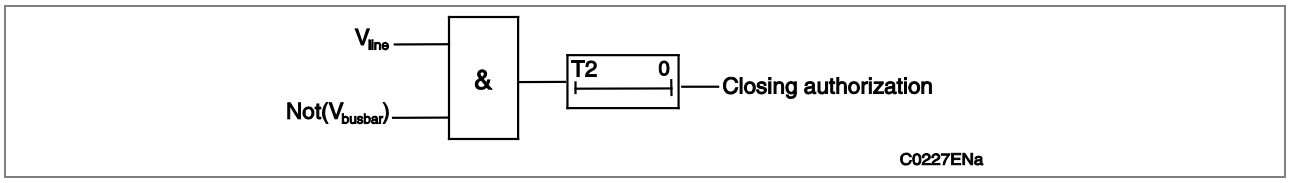


Figure 82: V_{line} and not(V_{busbar}) voltage check

When the Live Line / Dead Bus (LLDB) closing conditions are met, CB closure is authorised.

If either LLDB condition criterion is lost while T2 elapses, the LLDB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of both criteria.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Locking Frequency Shift = OK
- Locking Frequency Shift Acceleration = OK(*)
- Phase Delta = OK
- Manual/Automatic Close command in progress = OK

for the duration of the T1 time-delay at the end of which the presence of both voltages is confirmed and so are the locking conditions.

(*) This condition is taken into account only if the attribute **ds/dt filtering enable** is set to *Yes*.

Note:
This voltage condition is currently called locking mode (or synchronous mode).

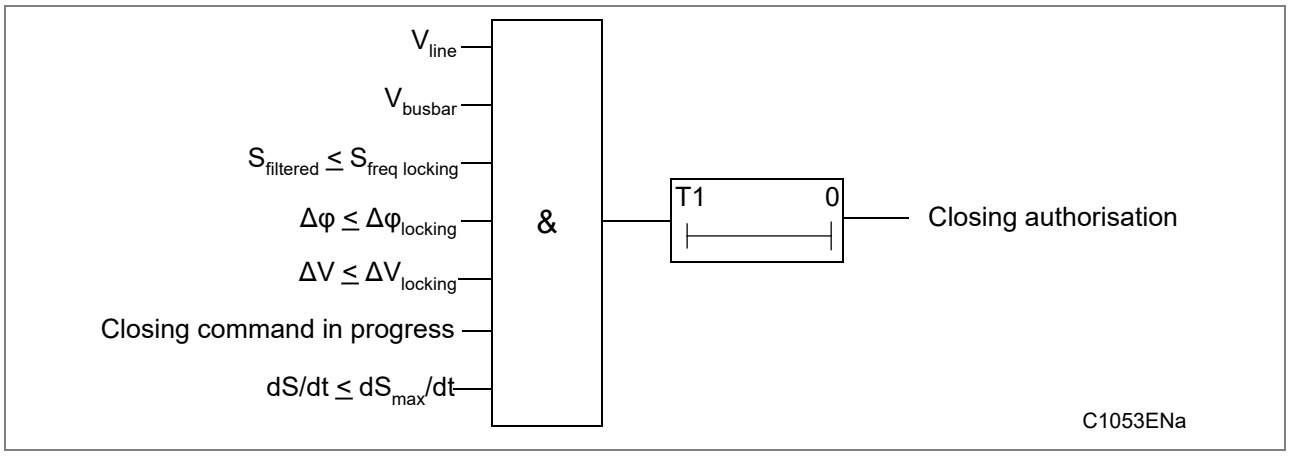


Figure 83: Locking scheme for type 2 synchrocheck

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

Even if the Live Line / Live bus (LLLB) closing conditions are met, the reception of a manual/ automatic close request would cause the LLLB voltage condition to be checked again during the T1 time-delay. When T1 elapses, the closing authorisation for the manual/automatic close request is given.

The setting for **delay (ms)** must be greater than the T1 time-delay.

7.2.9.2 SYNCHRO CLOSE CONDITIONS (COUPLING LOGIC)

Voltage conditions for synchro close requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltages of all the phases are higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltages of all the phases are higher than the set threshold **bus voltage over threshold**.

Permitted voltage delta:

- $\Delta V < \Delta V_{coupling}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for coupling**.

Locking Frequency Shift:

- $S_{filtered} \leq S_{freq\ locking}$: The difference between the line frequency and the busbar frequency is lower than the set threshold **frequency shift threshold for locking**.

Coupling Frequency Shift:

- $S_{filtered} \leq S_{freq\ coupling}$: The difference between the line frequency and the busbar frequency is lower than the set threshold **frequency shift threshold for coupling**.

Frequency Shift Acceleration:

- accShift ≤ $accS_{freq\ coupling}$: the shift acceleration is lower than the set threshold **frequency shift acceleration threshold for coupling**.

Note:
The threshold accSfreq coupling is not directly settable. It is derived from the circuit-breaker operating time (Ta):
*- if Ks * (Tk – Ta) > 0.05%/s accSfreq coupling = Ks * (Tk – Ta)*
- else accSfreq coupling = 0.05%/s
Where Ks = 1%
Tk = 0.5 s
Ta = CB operating time

Live Line / Live Bus

The Live Line / Live bus (LLLB) voltage condition is verified if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Shift for locking = Not OK
- Frequency Shift for coupling = OK
- Frequency Shift acceleration for coupling = OK
- Synchro Close request in progress = OK

No confirmation for this voltage condition is made.

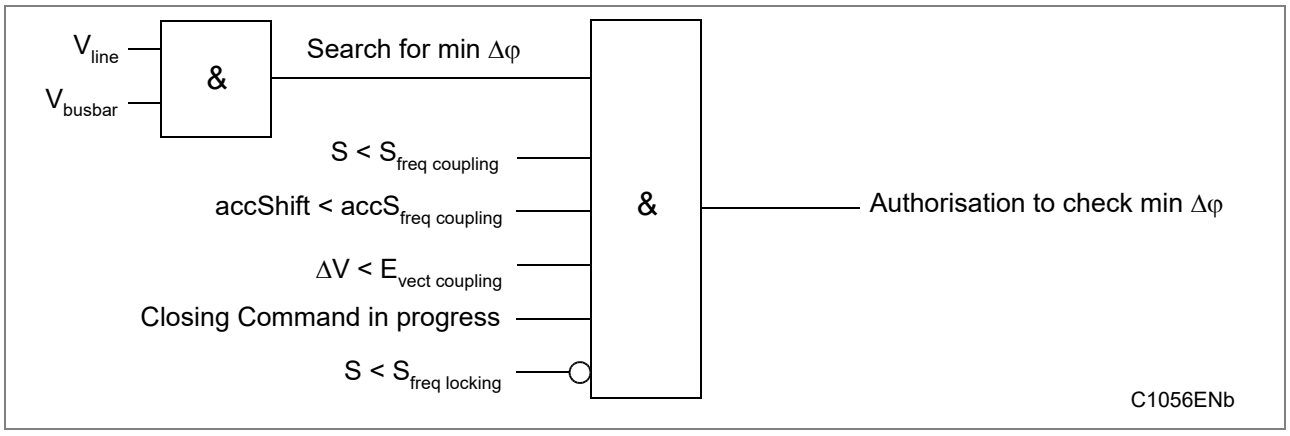


Figure 84: Coupling scheme for type 2 synchrocheck

When the Live Line / Live bus (LLLB) closing conditions are met, a synchro close request will authorise searching for min(Δφ).

The search for min(Δφ) is launched, and the closing conditions are checked, in order to find the optimal phase difference between line and busbar to close the circuit-breaker. In the min(Δφ) search, the circuit-breaker's operating time must be taken into account.

min(Δφ) is reached when:

- ΔF*360*Ta - Δ(Δφ) ≤ Δφ ≤ ΔF*360*Ta + Δ(Δφ)

where Ta = circuit-breaker operating time

and $\Delta(\Delta\varphi)$ is the acceptable margin of error on $\Delta\varphi$

For coupling, the frequency shift between signals (S) must not be lower than the settable locking threshold ($S_{freq\ locking}$), it can be represented as shown below:

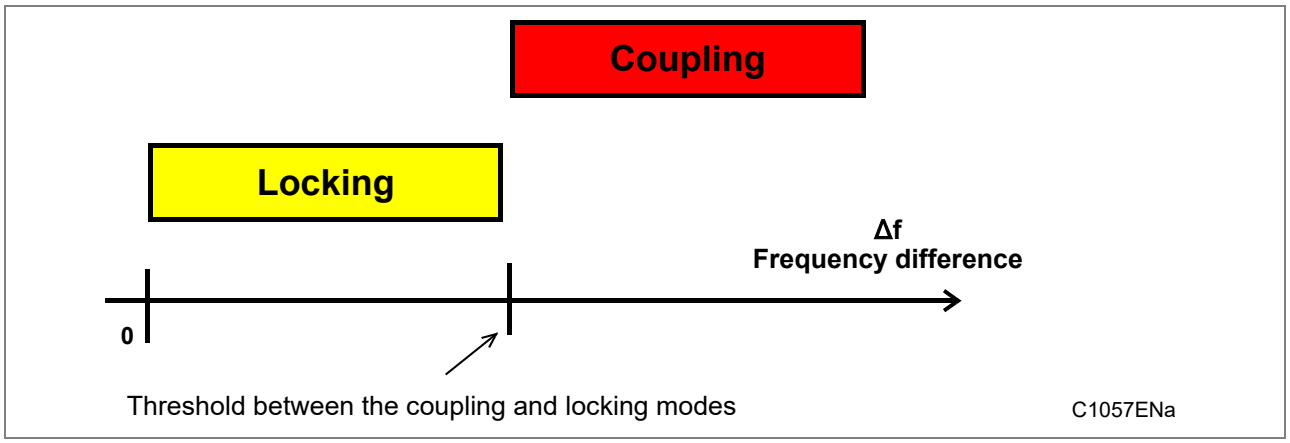


Figure 85: Locking/Coupling behaviour for type 2 synchrocheck

7.2.9.3 CLOSING SCHEMES

In order to enable closing only when the required voltage conditions are met, separate closing schemes are configured for each type of close request and also defined dynamically using SPS datapoints:

For the manual, automatic and synchro close requests, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO
Live Line / Live bus (Locking and Coupling)	YES / NO

In addition, SPS datapoints are available for each type of voltage conditions to allow (if in the SET state) or reject (if in the RESET state) CB closing. Another SPS can also be used to bypass the other SPS states. The 6 SPS datapoints are:

- Bypass
- Scheme Coupling
- Scheme DL/DB
- Scheme DL/LB
- Scheme LL/DB
- Scheme Locking

Depending on the configuration, the following checks are performed for manual close requests:

Voltage Conditions	Closing Authorisation	Closing scheme SPS state	Bypass SPS state	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	Any state	SET	DLDB or DLDB in progress*	Bypassed
Dead Line / Dead Bus	YES	SET	RESET	DLDB	Accepted
Dead Line / Dead Bus	YES	SET	RESET	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	RESET	RESET	DLDB or DLDB in progress*	Rejected
Dead Line / Dead Bus	NO	Any state	Any state	DLDB or DLDB in progress*	Rejected
Dead Line / Live Bus	YES	Any state	SET	DLLB or DLLB in progress*	Bypassed
Dead Line / Live Bus	YES	SET	RESET	DLLB	Accepted
Dead Line / Live Bus	YES	SET	RESET	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	RESET	RESET	DLLB or DLLB in progress*	Rejected
Dead Line / Live Bus	NO	Any state	Any state	DLLB or DLLB in progress*	Rejected
Live Line / Dead Bus	YES	Any state	SET	LLDB or LLDB in progress*	Bypassed
Live Line / Dead Bus	YES	SET	RESET	LLDB	Accepted
Live Line / Dead Bus	YES	SET	RESET	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	RESET	RESET	LLDB or LLDB in progress*n	Rejected
Live Line / Dead Bus	NO	Any state	Any state	LLDB or LLDB in progress*	Rejected
Live Line / Live Bus (Locking)	YES	Any state	SET	LLLB or LLLB in progress*	Bypassed
Live Line / Live Bus (Locking)	YES	SET	RESET	LLDB	Accepted
Live Line / Live Bus (Locking)	YES	SET	RESET	LLDB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	RESET	RESET	LLLB or LLLB in progress*	Rejected
Live Line / Live Bus (Locking)	NO	Any state	Any state	LLLB or LLLB in progress*	Rejected

* the voltage condition check is in progress when the manual close request is received.

Manual close requests will be rejected for any voltage conditions not listed above.

Depending on the configuration, the following checks are performed for automatic close requests:

Voltage Conditions	Close Authorisation	Close scheme SPS state	Bypass SPS state	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	Any state	SET	Any condition	Bypassed
Dead Line / Dead Bus	YES	SET	RESET	DLDB	Accepted
Dead Line / Dead Bus	YES	SET	RESET	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	RESET	RESET	Any condition	Rejected
Dead Line / Dead Bus	NO	Any state	Any state	Any condition	Rejected
Dead Line / Live Bus	YES	Any state	SET	Any condition	Bypassed
Dead Line / Live Bus	YES	SET	RESET	DLLB	Accepted
Dead Line / Live Bus	YES	SET	RESET	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	RESET	RESET	Any condition	Rejected
Dead Line / Live Bus	NO	Any state	Any state	Any condition	Rejected
Live Line / Dead Bus	YES	Any state	SET	Any condition	Bypassed
Live Line / Dead Bus	YES	SET	RESET	LLDB	Accepted

Voltage Conditions	Close Authorisation	Close scheme SPS state	Bypass SPS state	Verified Voltage Conditions	Close request result
Live Line / Dead Bus	YES	SET	RESET	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	RESET	RESET	Any condition	Rejected
Live Line / Dead Bus	NO	Any state	Any state	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	Any state	SET	Any condition	Bypassed
Live Line / Live Bus (Locking)	YES	SET	RESET	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	SET	RESET	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	RESET	RESET	Any condition	Rejected
Live Line / Live Bus (Locking)	NO	Any state	Any state	Any condition	Rejected

* the voltage condition check is in progress when the automatic close request is received.

Depending on the configuration, the following checks are performed for synchro close requests:

Voltage Conditions	Close Authorisation	Close scheme SPS state	Bypass SPS state	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	Any state	SET	Any condition	Bypassed
Dead Line / Dead Bus	YES	SET	RESET	DLDB	Accepted
Dead Line / Dead Bus	YES	SET	RESET	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	RESET	RESET	Any condition	Rejected
Dead Line / Dead Bus	NO	Any state	Any state	Any condition	Rejected
Dead Line / Live Bus	YES	Any state	SET	Any condition	Bypassed
Dead Line / Live Bus	YES	SET	RESET	DLLB	Accepted
Dead Line / Live Bus	YES	SET	RESET	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	RESET	RESET	Any condition	Rejected
Dead Line / Live Bus	NO	Any state	Any state	Any condition	Rejected
Live Line / Dead Bus	YES	Any state	SET	Any condition	Bypassed
Live Line / Dead Bus	YES	SET	RESET	LLDB	Accepted
Live Line / Dead Bus	YES	SET	RESET	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	RESET	RESET	Any condition	Rejected
Live Line / Dead Bus	NO	Any state	Any state	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	Any state	SET	Any condition	Bypassed
Live Line / Live Bus (Locking)	YES	SET	RESET	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	SET	RESET	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	RESET	RESET	Any condition	Rejected
Live Line / Live Bus (Locking)	NO	Any state	Any state	Any condition	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	Any state	SET	Any condition	Bypassed

Voltage Conditions	Close Authorisation	Close scheme SPS state	Bypass SPS state	Verified Voltage Conditions	Close request result
Live Line / Live Bus (Locking and Coupling)	YES	SET	RESET	LLLB (coupling condition)	Search for min(Δφ)
Live Line / Live Bus (Locking and Coupling)	YES	SET	RESET	LLLB in progress*	Delayed
Live Line / Live Bus (Locking and Coupling)	YES	RESET	RESET	Any condition	Rejected
Live Line / Live Bus (Locking and Coupling)	NO	Any state	Any state	Any condition	Rejected

* the voltage condition check is in progress when the synchro close request is received.

7.2.9.4 CLOSING SCENARIOS

Request accepted

According to the configured closing scheme, if the close request is accepted or bypassed, a close command is sent to the circuit-breaker.

Request rejected

According to the configured closing scheme, if the close request is rejected, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

Request delayed

According to the configured closing scheme, if the close request result is delayed, a configured time-delay is started (**delay (ms)**):

- When the voltage condition check is complete, if the close scheme issues a close authorization:
  - a close command is sent to the circuit-breaker
  - and the time-delay is reset.
- When the voltage condition check is complete, if the close scheme does not give a close authorization:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - no close command is sent to the circuit-breaker,
  - and the time-delay is reset.
- If the time-delay elapses with no voltage conditions having been checked:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - and no close command is sent to the circuit-breaker.

7.2.9.5 CLOSE WITH LOCKING / COUPLING

There are 2 types of closing schemes:

- the synchronous closing scheme (locking logic),
- the asynchronous closing scheme (coupling logic).

The asynchronous (coupling) scheme runs in parallel with the synchronous (locking) scheme during all the time allowed to wait for the close authorisation.

This means that:

- if the closing request is received while the frequency shift between the line and busbar signals (S) is lower than the settable locking threshold ($S_{freq\ locking}$) but rises above that threshold before locking is confirmed, then the coupling scheme continues to run and closing can take place in coupling mode;
- if the closing request is received while the frequency shift between the line and busbar signals (S) is higher than the settable locking threshold ($S_{freq\ locking}$) but decreases below this threshold before min(Δφ) is reached, then the locking scheme continues to run and closing can still take place in locking mode.

Logic for manual close

When a manual close request is received,

- if the LLLB conditions are met, the T1 confirmation time-delay is started. If the LLLB conditions are still met when T1 elapses, the closing authorization for the manual close request is given;
- if an LLLB condition confirmation is in progress, the T1 confirmation time-delay is reset and restarted. If the LLLB conditions are still met when T1 elapses, the closing authorization for the manual close request is given;
- if, when the T1 time-delay elapses, the LLLB conditions are not met, then no action is taken. At the end of the manual close **delay (ms)**, a negative acknowledgement is sent to prevent closing the circuit-breaker.

Logic for synchro close

When a synchro close request is received with both the locking and coupling logics permitted, if the voltage is present on both the line and the busbar, the search for min(Δφ) is started and a time-out is launched (delay for coupling). A manual close logic is also simultaneously started:

- If the synchronous (locking) close conditions are met when the T1 time-delay elapses, a positive acknowledge is sent to close the circuit-breaker and the search for min(Δφ) is terminated.
- if the synchronous (locking) close conditions are not met when the T1 time-delay elapses, the search for min(Δφ) continues while the manual close logic is suspended until locking conditions are met again or until the time-out elapses (whichever happens first).

If min(Δφ) is found, a positive acknowledge is sent to close the circuit-breaker, and the time-out is reset.

If the time-out elapses without min(Δφ) being found, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

When a synchro close request is received while voltage is present on both the line and the busbar, and that only the synchronous close scheme (locking) is permitted, a manual close is performed.

When a synchro close request is received while neither the synchronous close scheme (locking) nor the asynchronous close scheme (coupling) are permitted, a manual close is performed, but only if one of these voltage conditions is met:

- Dead Line / Dead bus,
- Dead Line / Live bus,
- Live Line / Dead bus.

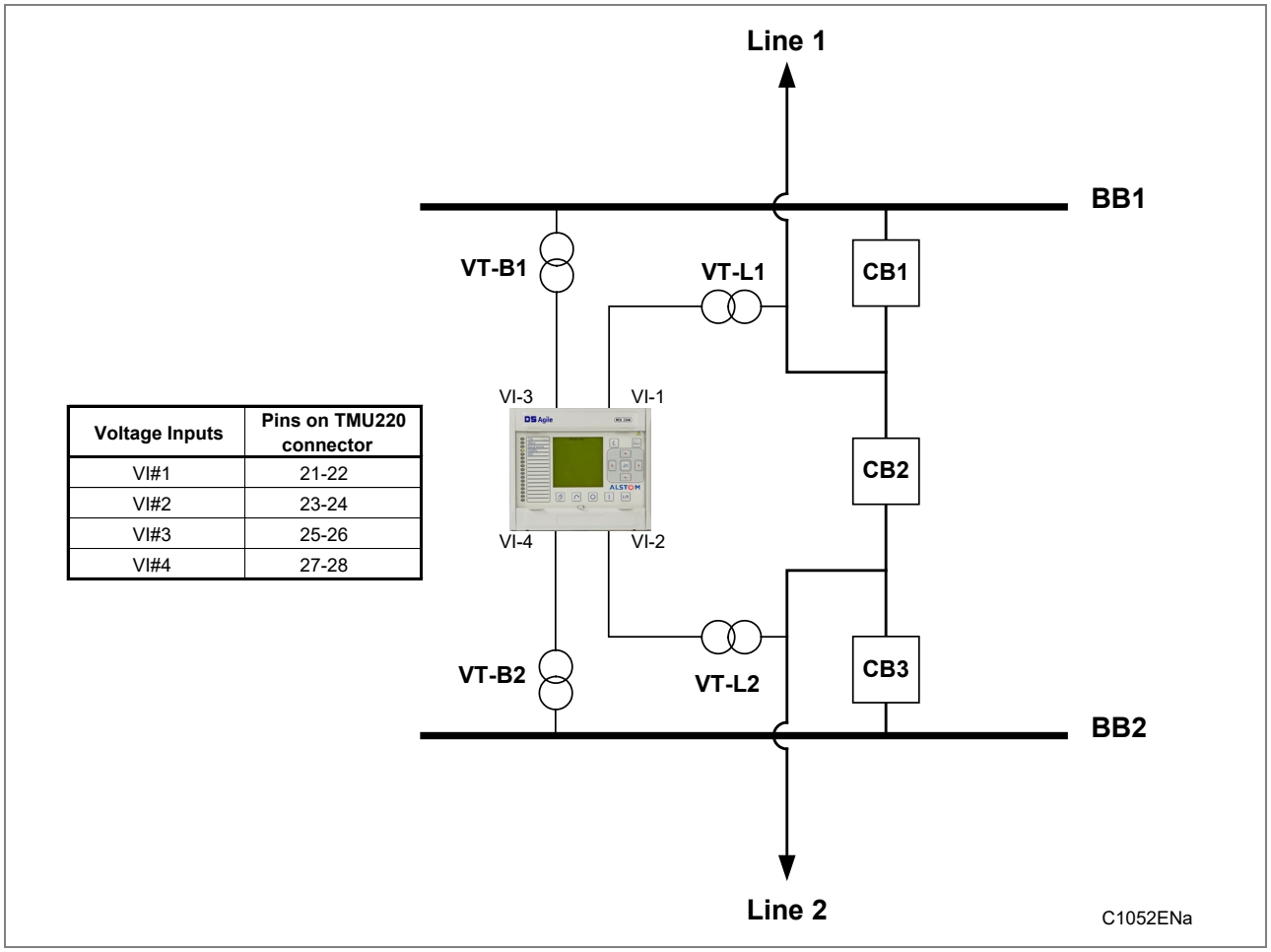
7.2.10 SYNCHROCHECK TYPE 3

7.2.10.1 MULTIPLEXED VOLTAGE SELECTION

The synchrocheck type 3 function manages 3 circuit-breakers in a breaker-and-a-half diameter topology, using dynamically-defined voltage checks.

Its operation and settings are almost identical to those for internal Synchocheck Type 1 except for the number of circuit-breakers it manages, and also the facts that its only possible locking/coupling mode is the Evolutive mode (no visible setting) and that it does not support automatic synchrocheck.

In addition, because only one line voltage per feeder will actually be connected to the TMU220 board, there is no setting for the reference phase as this will be imposed by wiring.



Voltage Inputs	Pins on TMU220 connector
VI#1	21-22
VI#2	23-24
VI#3	25-26
VI#4	27-28

Figure 86: Breaker-and-a-half single-line connection diagram

Only one TMU220 board is required, each VT is used to provide a voltage to be checked against another on the other side of the circuit-breaker. A fixed allocation between the measurement points (Line 1, Line 2, Busbar 1, Busbar 2) and the TMU220's voltage inputs is defined as follow:

Wiring	TMU220 inputs	VTs	Meas't points
Pins 21-22	VI#1	VT-L1	Line 1
Pins 23-24	VI#2	VT-L2	Line 2
Pins 25-26	VI#3	VT-B1	Busbar 1
Pins 27-28	VI#4	VT-B2	Busbar 2

The circuit-breakers are typed as follows:

- Line 1 circuit-breaker (CB1)
  (3 possible voltage checks: VT-B1/VT-L1; VT-B1/VT-L2; VT-B1/VT-B2)
- Tie circuit-breaker (CB2)
  (4 possible voltage checks: VT-L1/VT-L2; VT-L1/VT-B2; VT-B1/VT-L2; VT-B1/VT-B2)
- Line 2 circuit-breaker (CB3)
  (3 possible voltage checks: VT-B2/VT-L2; VT-B2/VT-L1; VT-B2/VT-B1)

The voltage checks to be performed by the breaker-and-a-half synchrocheck are defined in the following table:

TMU220 inputs	Meas't points	Line 1 circuit-breaker (CB1)			Tie circuit-breaker (CB2)				Line 2 circuit-breaker (CB3)		
VI#1	VT-L1	X			X	X				X	
VI#2	VT-L2		X		X		X		X		
VI#3	VT-B1	X	X	X			X	X			X
VI#4	VT-B2			X		X		X	X	X	X

For each circuit-breaker, 2 VTs must be selected, one on each side of the circuit-breaker (Line 1 / Line 2 / Tie) so as to compare the voltages provided by those VTs.

4 voltage selection SPSs are available for each circuit-breaker, each SPS represents a VT, and 2 out of 4 are to be in the SET state, which will indicate which VTs will be used to check the voltages.

Line 1 circuit-breaker (CB1)

The following 4 voltage selection SPSs are available:

- CB1 with VT-B1
- CB1 with VT-B2
- CB1 with VT-L1
- CB1 with VT-L2

Exactly 2 out of the possible 4 voltage selection SPSs must be selected at any one time for voltage checking to be possible. Synchro close requests will not be accepted if a different number of VTs are selected.

Note:
These SPS datapoints are inputs of the synchrocheck Type 3 function. The actual closing scheme must be designed using a programmable automation (FBD).

SPS positions for voltage checks:

	VT-L1/VT-B1	VT-L2/VT-B1	VT-B1/VT-B2
CB1 with VT-L1	SET	RESET	RESET
CB1 with VT-L2	RESET	SET	RESET
CB1 with VT-B1	SET	SET	SET
CB1 with VT-B2	RESET	RESET	SET

Tie circuit-breaker (CB2)

The following 4 voltage selection SPSs are available:

- CB2 with VT-B1
- CB2 with VT-B2
- CB2 with VT-L1
- CB2 with VT-L2

SPS positions for voltage checks:

	VT-L1/VT-L2	VT-L1/VT-B2	VT-L2/VT-B1	VT-B1/VT-B2
CB2 with VT-L1	SET	SET	RESET	RESET
CB2 with VT-L2	SET	RESET	SET	RESET
CB2 with VT-B1	RESET	RESET	SET	SET
CB2 with VT-B2	RESET	SET	RESET	SET

Exactly 2 out of the possible 4 voltage selection SPSs must be selected at any one time for voltage checking to be possible. Synchro-close requests will be not be accepted if a different number of VTs are selected.

Note:
These SPS datapoints are inputs of the synchrocheck Type 3 function. The actual closing scheme must be designed using a programmable automation (FBD).

Line 2 circuit-breaker (CB3)

The following 4 voltage selection SPSs are available:

- CB3 with VT-B1
- CB3 with VT-B2
- CB3 with VT-L1
- CB3 with VT-L2

SPS positions for voltage checks:

	VT-L2/VT-B2	VT-L1/VT-B2	VT-B1/VT-B2
CB3 with VT-L1	RESET	SET	RESET
CB3 with VT-L2	SET	RESET	RESET
CB3 with VT-B1	RESET	RESET	SET
CB3 with VT-B2	SET	SET	SET

Exactly 2 out of the possible 4 voltage selection SPSs must be selected at any one time for voltage checking to be possible. Synchro-close requests will be not be accepted if a different number of VTs are selected.

Note:
These SPS datapoints are inputs of the synchrocheck Type 3 function. The actual closing scheme must be designed using a programmable automation (FBD).

Confirmation time-delay

Between the SPS state change (for VT selection) and the execution of a close request on the corresponding circuit-breaker, there must be a 3 s time-delay. No close request received before this time-delay has elapses will be taken into account: a *KO-Synchrocheck* negative acknowledge will be sent back.

7.2.10.2 VOLTAGE ACQUISITION FOR BREAKER-AND-A-HALF DIAMETER ARRANGEMENTS

The TMU220 only acquires voltages via inputs VI#1, VI#2, VI#3 and VI#4,. No currents are acquired. The following measurements are available:

Actual measurement	Voltage input on TMU220	Corresponding label in SCE
Line 1	VI#1	V_{AN}, RMS value of the voltage phase A
Line 2	VI#2	V_{BN}, RMS value of the voltage phase B
Busbar 1	VI#3	V_{CN}, RMS value of the voltage phase C
Busbar 2	VI#4	V_{busbar}, RMS 1 value of the busbar voltage

Only one phase-neutral or phase-phase voltage can be connected per VT, and it must be the same for all VTs (V_{AN}, V_{BN}, V_{CN}, V_{AB}, V_{BC} or V_{CA}).

7.2.10.3 MANUAL CLOSE CONDITIONS

In each possible VT combination, one VT is considered to be on the "line" side and the other on the "bus" side in order to maintain compatibility with the existing threshold settings for standard "line VT/busbar VT" synchrocheck arrangements (Type 1 and Type 2). The tables below summarize the "line" and "bus" equivalences used by synchrocheck Type 3 for each of the three circuit-breakers in the breaker-and-a-half diameter:

Line 1 circuit-breaker (CB1)

VT combinations	Voltage equivalences	
	Line side	Bus side
VT-L1/VT-B1	VT-L1	VT-B1
VT-L2/VT-B1	VT-L2	VT-B1
VT-B1/VT-B2	VT-B2	VT-B1

Tie circuit-breaker (CB2)

VT combinations	Voltage equivalences	
	Line side	Bus side
VT-L1/VT-L2	VT-L1	VT-L2
VT-L1/VT-B2	VT-L1	VT-B2
VT-L2/VT-B1	VT-L2	VT-B1
VT-B1/VT-B2	VT-B1	VT-B2

Line 2 circuit-breaker (CB3)

VT combinations	Voltage equivalences	
	Line side	Bus side
VT-L2/VT-B2	VT-L2	VT-B2
VT-L1/VT-B2	VT-L1	VT-B2
VT-B1/VT-B2	VT-B1	VT-B2

Voltage conditions for manual requests are checked during a set "scheme" time-delay.

Voltage conditions

The voltage conditions for each CB are as follows:

Voltage present:

- V_{line}: On the line VT, the voltage is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage is higher than the set threshold **bus voltage over threshold**.

Voltage missing:

- Not(V_{line}): On the line VT, the voltage is lower than the set threshold **line voltage under threshold**.
- Not(V_{busbar}): On the busbar VT, the voltage is lower than the set threshold **bus voltage under threshold**.

Permitted voltage delta:

- $\Delta V \leq \Delta V_{locking}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for locking**.

Permitted frequency delta:

- $\Delta f \leq \Delta f_{locking}$: The difference between the line frequency and the busbar frequency is lower than the set threshold **frequency delta threshold for locking**.

Permitted frequency range:

- $f_{min\ locking} \leq f_{line} \leq f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **maximum frequency for locking**.
- $f_{min\ locking} \leq f_{busbar} \leq f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **maximum frequency for locking**.

Permitted phase angle delta:

- $\Delta\varphi \leq \Delta\varphi_{locking}$: the difference between the line voltage phase angle and the busbar voltage phase angle is lower than the set threshold **phase delta threshold for locking**.

Dead Line / Dead Bus

The Dead Line / Dead Bus (DLDB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage missing

for the duration of the T3 time-delay at the end of which the absence of both voltages is confirmed.

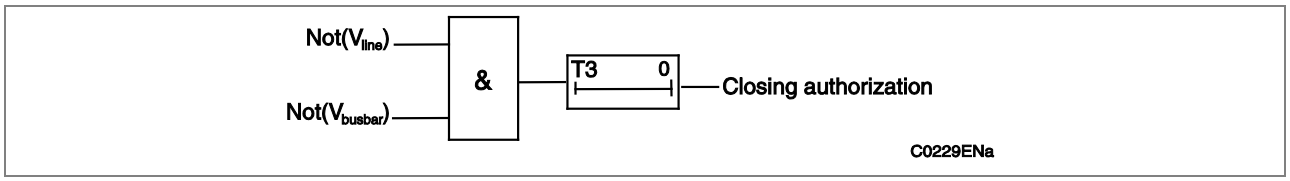


Figure 87: not(V_{line}) and not(V_{busbar}) voltage check

When the Dead Line / Dead Bus (DLDB) closing conditions are met, CB closure is authorised.

If either DLDB condition criterion is lost while T3 elapses, the DLDB condition is no longer verified and T3 is reset. It will be restarted only upon the reappearance of both criteria.

Dead Line / Live Bus

The Dead Line / Live Bus (DLLB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage present

for the duration of the T2 time delay at the end of which the presence of only one voltage is confirmed.

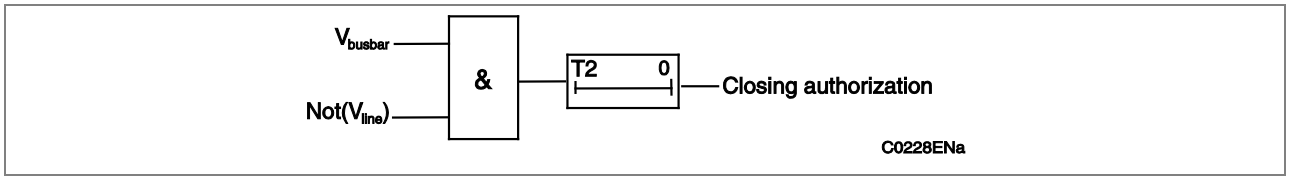


Figure 88: not(V_{line}) and V_{busbar} voltage check

When the Dead Line / Live Bus (DLLB) closing conditions are met, CB closure is authorised.

If either DLDB condition criterion is lost while T2 elapses, the DLLB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of both criteria.

Live Line / Dead Bus

The Live Line / Dead Bus (LLDB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage missing

for the duration of the T2 time delay at the end of which the presence of only one voltage is confirmed.

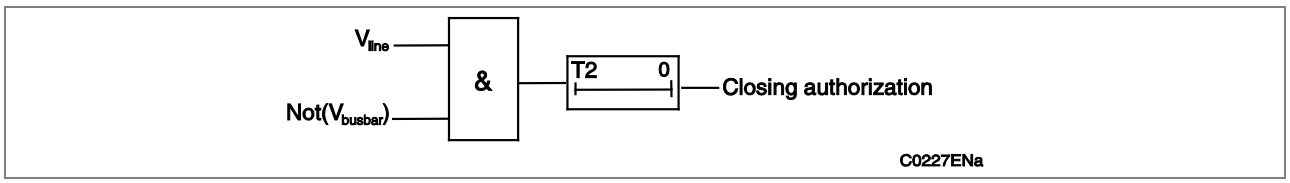


Figure 89: V_{line} and not(V_{busbar}) voltage check

When the Live Line / Dead Bus (LLDB) closing conditions are met, CB closure is authorised.

If either LLDB condition criterion is lost while T2 elapses, the LLDB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of both criteria.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK
- Phase Delta = OK

for the duration of the T1 time-delay at the end of which the presence of both voltages is confirmed and so are the locking conditions.

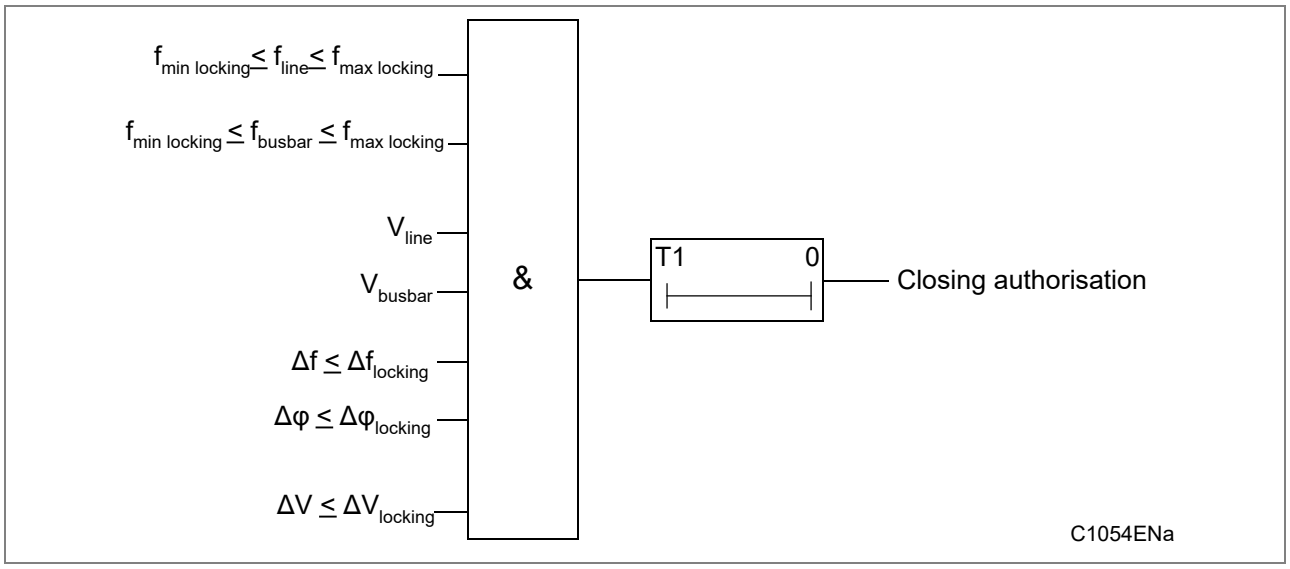


Figure 90: Locking scheme for type 3 synchrocheck

When the Live Line / Live Bus (LLLB) closing conditions are met, CB closure is authorised.

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

7.2.10.4 SYNCHRO CLOSE CONDITIONS

Note:
All the checks performed for "manual close" conditions are also identically applicable to "synchro close" conditions: "Dead Line / Dead Bus", "Dead Line / Live Bus", "Live Line / Dead Bus" and "Locking" can be selected in addition to the synchro-specific conditions described below, i.e. Coupling.

Voltage conditions for synchro close requests are checked during a set "synchro scheme" time-delay.

Voltage conditions

The voltage conditions for each CB are as follows:

Voltage present:

- V_{line}: On the line VT, the voltage is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage is higher than the set threshold **bus voltage over threshold**.

Permitted voltage delta:

- $\Delta V < \Delta V_{coupling}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for coupling**.

Permitted frequency delta range:

- $\Delta f_{min\ coupling} < \Delta f < \Delta f_{max\ coupling}$: The difference between the line frequency and the busbar frequency is comprised between the set thresholds **minimum frequency delta threshold for coupling** and **maximum frequency delta threshold for coupling**.

Permitted frequency range:

- $f_{min\ coupling} < f_{line} < f_{max\ coupling}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **maximum frequency for coupling**.
- $f_{min\ coupling} < f_{busbar} < f_{max\ coupling}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **maximum frequency for coupling**.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK

for the duration of the T1 time-delay at the end of which the presence of both voltages is confirmed and so are the coupling conditions.

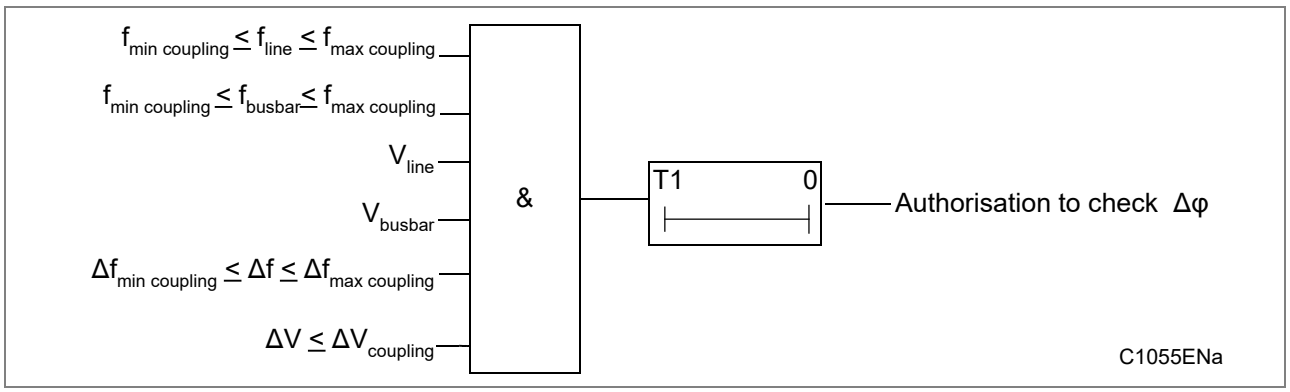


Figure 91: Coupling scheme for type 3 synchrocheck

When the Live Line / Live bus (LLLB) closing conditions are met, a synchro close request will authorise searching for min(Δφ).

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

The search for min(Δφ) is launched, in order to find the optimal phase difference between line and busbar to close the circuit-breaker. In the min(Δφ) search, the circuit-breaker's operating time must be taken into account.

min(Δφ) is reached when:

- $\Delta\varphi = \Delta f * 360 * Ta$

where Ta = circuit-breaker operating time.

Locking mode vs. Coupling mode

In order to discriminate between the locking and coupling modes, 2 separate ranges for frequency differences are configured.

- Locking range: $[0 \ldots \Delta f_{max\ locking}]$
- Coupling range: $[\Delta f_{min\ coupling} \ldots \Delta f_{max\ coupling}]$

The 2 ranges may overlap but the following condition must be met:

- $\Delta f_{max\ coupling} > \Delta f_{max\ locking}$

7.2.10.5 CLOSING SCHEMES

Note:
Contrary to types 1, 2 and 4, the closing schemes used in type 3 synchrocheck are independently configured for each of the three circuit-breakers.

In order to enable closing only when the required voltage conditions are met, separate closing schemes are configured for each type of close request:

Manual close

For the manual close request, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (locking)	YES / NO

Depending on the configuration, the following checks are performed for manual close requests:

Voltage Conditions	Closing Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected

* the voltage condition check is in progress when the manual close request is received.

Synchro close

For the synchro close request, and for each voltage condition, a close scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO
Live Line / Live Bus (Locking and Coupling)	YES / NO

Depending on the configuration, the following checks are performed for synchro close requests:

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close Request Result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB (locking)	Accepted
Live Line / Live Bus (Locking)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB (locking)	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking)	Accepted
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking and Coupling)	YES	≠ LLLB (locking and coupling)	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (coupling only)	Search for min(Δφ)
Live Line / Live Bus (Locking and Coupling)	NO	Any condition	Rejected

* the voltage condition check is in progress when the synchro close request is received.

7.2.10.6 CLOSING SCENARIOS

Request accepted

According to the configured closing scheme, if the close request is accepted, a close command is sent to the circuit-breaker.

Request rejected

According to the configured closing scheme, if the close request is rejected, a negative acknowledge (*KO-Synchrocheck*) is sent and no close command is sent to the circuit-breaker.

Request delayed

According to the configured closing scheme, if the close request result is delayed, a configured time-delay is started (**delay (ms)**):

- When the voltage condition check is complete, if the close scheme issues a close authorization, a close command is sent to the circuit-breaker and the time-delay is reset.
- When the voltage condition check is complete, if the close scheme does not give a close authorisation:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - no close command is sent to the circuit-breaker,
  - and the time-delay is reset.
- If the time-delay elapses with no voltage conditions having been checked, a negative acknowledge (*KO-Synchrocheck*) is sent, and no close command is sent to the circuit-breaker.

Synchro close request

If the voltage conditions change while a received synchro close request is being processed, a negative acknowledge (*KO-Synchrocheck*) is sent, and no close command is sent to the circuit-breaker.

7.2.10.7 CLOSE WITH LOCKING / COUPLING

The synchrocheck type 3 function only operates in Evolutive mode:

Evolutive mode

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition is met, a positive acknowledge is immediately sent to close the circuit-breaker.

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition check is in progress, the LLLB locking logic is applied.

When a synchro close request is received, if Δf is within the range [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], the search for min($\Delta\varphi$) is started and a time-delay is launched (**Delay for coupling)**.

When a synchro close request is received, if Δf is not within neither of the ranges [0 ... $\Delta f_{max\ locking}$] and [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

If Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min($\Delta\varphi$), the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic.

If Δf drifts outside of both the Coupling and Locking ranges during the search for min($\Delta\varphi$), the search is aborted, the time-delay is reset, a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

The drift of Δf during the search for min($\Delta\varphi$) is confirmed after a fixed time-delay of 5 s.

If Δf shifts outside of the Coupling range, the Δf drift time-delay is started. If Δf returns into the Coupling range, the Δf drift time-delay is reset.

If, when the Δf drift time-delay elapses, Δf is inside the Locking range, the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic. If Δf is outside the Locking range, the search is aborted, the search for min(Δφ) time-delay is reset, a negative acknowledge (*KO-Synchrocheck*) is immediately sent and no close command is sent to the circuit-breaker.

Note:
Separate sets of closing schemes and parameters are available for each of the 3 circuit-breakers managed by the Synchrocheck Type 3 function. For more information on settings, see Application chapter C26x/EN AP.

7.2.10.8 MEASUREMENTS

Due to the specific configuration, the available measurements are restricted to four voltages: one phase voltage per line/busbar plus the values that can be derived from those.

Measured values

The following **measurement types** should be added and wired to MVs:

- **VI#1** *VAN, RMS value of the voltage phase A* (VTL1)
- **VI#2** *VAN, RMS value of the voltage phase A* (VTL2)
- **VI#3** *VAN, RMS value of the voltage phase A* (VTB1)
- **VI#4** *Vbusbar RMS 1 value of the busbar voltage phase* (VTB2)

The **measurement type** labels correspond to the voltages that would be wired to those inputs in a standard wiring topology; they should not be taken literally in the breaker-and-a-half configuration.

VI#1, VI#2, VI#3 and VI#4 can acquire measurements from the voltage transformers VT-L1, VT-L2, VT-B1 or VT-B2, depending on the configuration.

Derived values

The following **measurement types** should be added and wired to MVs:

- *signed dV*, *signed dV for CB2*, *signed dV for CB3* (voltage difference between line and busbar, for each circuit-breaker): Signed value computed using the selected voltages, according to the dynamic topology and always using the line voltage as reference. This value is always computed if it is configured as a standard measurement.
- *signed dF*, *signed dF for CB2*, *signed dF for CB3* (frequency difference between line and busbar, for each circuit-breaker): Signed value computed using the selected voltages, according to the dynamic topology and always using the line voltage as reference. This value is always computed if it is configured as a standard measurement.
- *signed dPhi*, *signed dPhi for CB2*, *signed dPhi for CB3* (phase angle difference between line and busbar, for each circuit-breaker): Signed value computed using the selected voltages, according to the dynamic topology and always using the line voltage as reference. This value is always computed if it is configured as a standard measurement.

7.2.11 SYNCHROCHECK TYPE 4

Synchrocheck Type 4 is a variant of Type 1. The differences are:

- No Split mode.
- Addition of a settable overvoltage threshold, **over voltage threshold (% of Vn)**: Closing is not permitted if the line voltage, the busbar voltage, or both, are higher than this threshold.
- Addition of a settable "retry" timeout, **control rejection time out (s)**: Starting when the close or reclose command is issued, this timer allows the C26x to continue trying to reach synchronizing conditions until it expires. **Control rejection time out (s)** replaces the **close with synchro: delay** which is used only for Type 1.
- In addition to preventing the S/C function from starting when it is *SET*, if the datapoint *CS Locked* becomes *SET* while a check is in progress, it is terminated with a negative acknowledge.

7.2.11.1 MANUAL AND AUTOMATIC CLOSE CONDITIONS (LOCKING LOGIC)

Voltage conditions for manual and automatic requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Overvoltage threshold:

- V>: On both the line VT and the busbar VT, the voltage is lower than or equal to the set threshold **over voltage threshold**.

Voltage missing:

- Not(V_{line}): On the line VT, the voltage of the set reference circuit is lower than the set threshold **line voltage under threshold**.
- Not(V_{busbar}): On the busbar VT, the voltage (only one circuit available) is lower than the set threshold **bus voltage under threshold**.

Permitted voltage delta:

- $\Delta V \leq \Delta V_{locking}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for locking**.

Permitted frequency delta:

- $\Delta f \leq \Delta f_{locking}$: The difference between the line frequency and the busbar frequency is lower than the set threshold **frequency delta threshold for locking**.

Permitted frequency range:

- $f_{min\ locking} \leq f_{line} \leq f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **minimum frequency for locking**.
- $f_{min\ locking} \leq f_{busbar} \leq f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for locking** and **maximum frequency for locking**.

Permitted phase angle delta:

- $\Delta\varphi \leq \Delta\varphi_{locking}$: the difference between the line voltage phase angle (for the configured reference circuit) and the busbar voltage phase angle is lower than the set threshold **phase delta threshold for locking**.

Dead Line / Dead Bus

The Dead Line / Dead Bus (DLDB) closing conditions are met if, before **control rejection time out (s)** expires:

- Line = Voltage missing
- Busbar = Voltage missing

for the duration of the T3 time-delay at the end of which the absence of both voltages is confirmed.

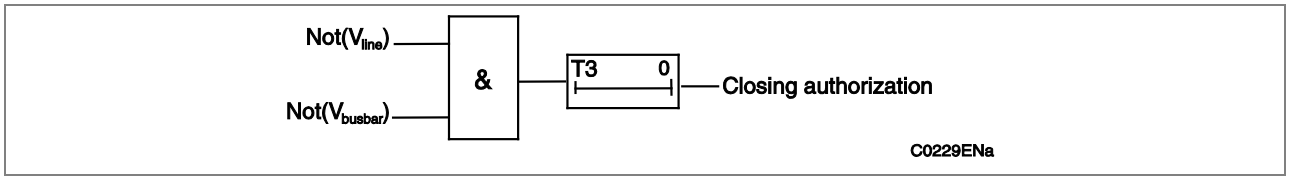


Figure 92: Not(V_{line}) and not(V_{busbar}) voltage check

When the Dead Line / Dead Bus (DLDB) closing conditions are met, CB closure is authorised.

If either DLDB condition criterion is lost while T3 elapses, the DLDB condition is no longer verified and T3 is reset. It will be restarted only upon the reappearance of both criteria.

Dead Line / Live Bus

The Dead Line / Live Bus (DLLB) closing conditions are met if:

- Line = Voltage missing
- Busbar = Voltage present
- Busbar voltage ≤ V> (overvoltage threshold)

for the duration of the T2 time delay at the end of which the presence of only one voltage not exceeding the overvoltage threshold is confirmed.

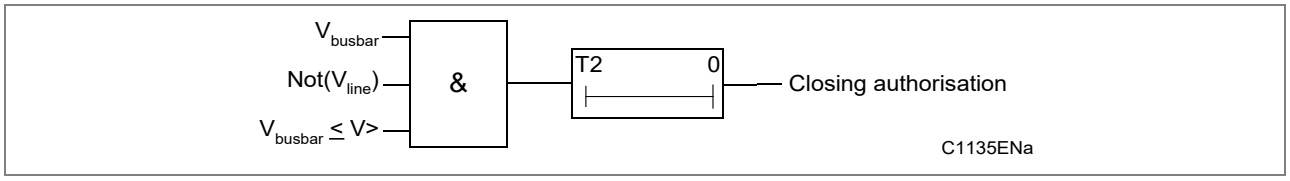


Figure 93: not(V_{line}) and V_{busbar} and not(V>) voltage check

When the Dead Line / Live Bus (DLLB) closing conditions are met, CB closure is authorised.

If either DLLB condition criterion is lost while T2 elapses, the DLLB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of all the criteria.

Live Line / Dead Bus

The Live Line / Dead Bus (LLDB) closing conditions are met if, before **control rejection time out (s)** expires:

- Line = Voltage present
- Busbar = Voltage missing
- Line voltage ≤ V> (overvoltage threshold)

for the duration of the T2 time delay at the end of which the presence of only one voltage not exceeding the overvoltage threshold is confirmed.

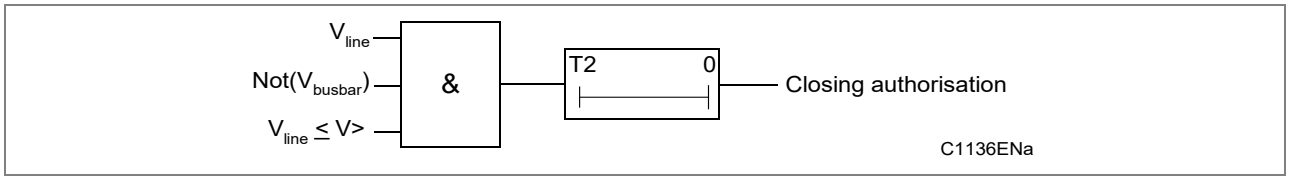


Figure 94: V_{line} and not(V_{busbar}) and not(V>) voltage check

When the Live Line / Dead Bus (LLDB) closing conditions are met, CB closure is authorised.

If either LLDB condition criterion is lost while T2 elapses, the LLDB condition is no longer verified and T2 is reset. It will be restarted only upon the reappearance of all the criteria.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if, before **control rejection time out (s)** expires:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK
- Phase Delta = OK
- Line voltage ≤ V>
- Busbar voltage ≤ V>

for the duration of the T1 time-delay at the end of which the following conditions are confirmed:

- both the line and the busbar voltages are present,
- neither voltage exceeds the overvoltage threshold,
- the locking conditions are met.

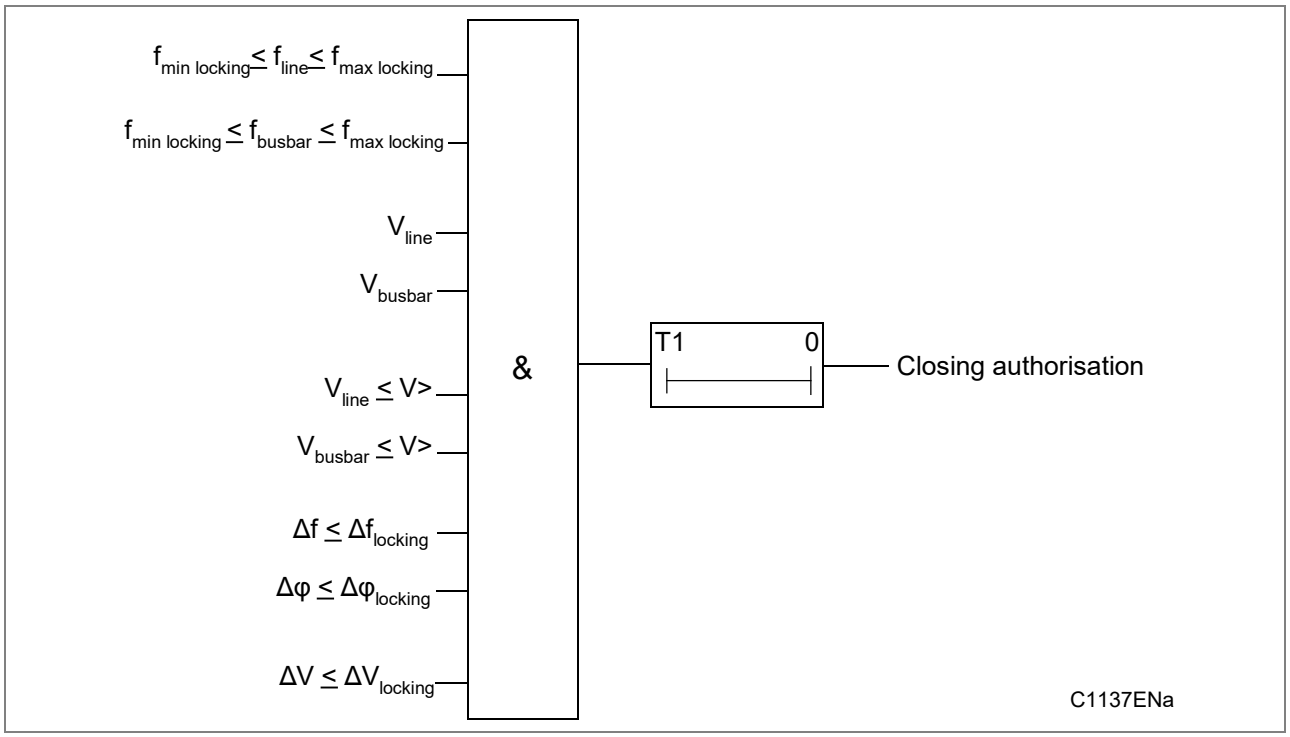


Figure 95: Locking scheme for type 4 synchrocheck

When the Live Line / Live Bus (LLLB) closing conditions are met, CB closure is authorised.

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

7.2.11.2 SYNCHRO CLOSE CONDITIONS (COUPLING LOGIC)

Voltage conditions for synchro close requests are checked during a set time-delay.

Voltage conditions

The voltage conditions are:

Voltage present:

- V_{line}: On the line VT, the voltage of the set reference circuit is higher than the set threshold **line voltage over threshold**.
- V_{busbar}: On the busbar VT, the voltage (only one circuit available) is higher than the set threshold **bus voltage over threshold**.

Overvoltage threshold:

- V>: On both the line VT and the busbar VT, the voltage is lower than or equal to the set threshold **over voltage threshold**.

Permitted voltage delta:

- $\Delta V < \Delta V_{locking}$: The difference between the line voltage and the busbar voltage is lower than the set threshold **voltage delta threshold for coupling**.

Permitted frequency delta range:

- $\Delta f_{min\ locking} < \Delta f < \Delta f_{max\ locking}$: The difference between the line frequency and the busbar frequency is comprised between the set thresholds **minimum frequency delta threshold for coupling** and **maximum frequency delta threshold for coupling**.

Permitted frequency range:

- $f_{min\ locking} < f_{line} < f_{max\ locking}$: The line voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **minimum frequency for coupling**.
- $f_{min\ locking} < f_{busbar} < f_{max\ locking}$: The busbar voltage frequency is comprised between the set thresholds **minimum frequency for coupling** and **maximum frequency for coupling**.

Live Line / Live Bus

The Live Line / Live Bus (LLLB) closing conditions are met if, before **control rejection time out (s)** expires:

- Line = Voltage present
- Busbar = Voltage present
- Voltage Delta = OK
- Frequency Delta = OK
- Line voltage ≤ V>
- Busbar voltage ≤ V>

for the duration of the T1 time-delay at the end of which the following conditions are confirmed:

- both the line and the busbar voltages are present,
- neither voltage exceeds the overvoltage threshold,
- the coupling conditions are met.

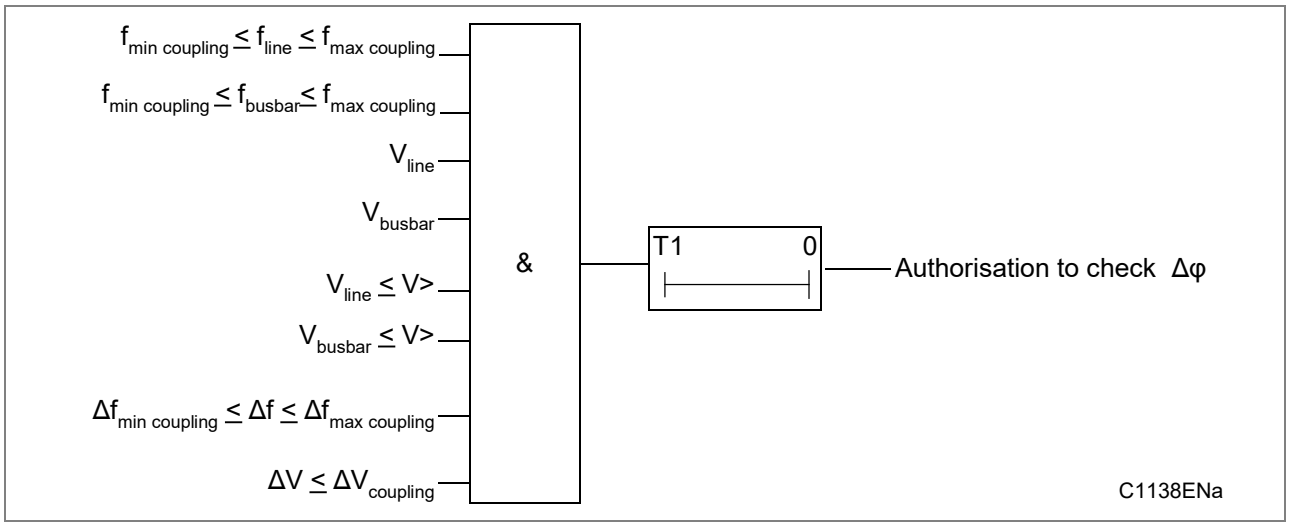


Figure 96: Coupling scheme for type 4 synchrocheck

When the Live Line / Live bus (LLLB) closing conditions are met, a synchro close request will authorise searching for min(Δφ).

If any LLLB condition criterion is lost while T1 elapses, the LLLB condition is no longer verified and T1 is reset. It will be restarted only upon the reappearance of all the criteria.

The search for min(Δφ) is launched, in order to find the optimal phase difference between line and busbar to close the circuit-breaker. In the min(Δφ) search, the circuit-breaker's operating time must be taken into account.

min(Δφ) is reached when:

- $\Delta\varphi = \Delta f * 360 * Ta$

where Ta = circuit-breaker operating time.

Locking mode vs. Coupling mode

In order to discriminate between the locking and coupling modes, 2 separate ranges for frequency differences are configured.

- Locking range: $[0 \ldots \Delta f_{max\ locking}]$
- Coupling range: $[\Delta f_{min\ coupling} \ldots \Delta f_{max\ coupling}]$

The 2 ranges may overlap but the following condition must be met:

- $\Delta f_{max\ coupling} > \Delta f_{max\ locking}$

7.2.11.3 CLOSING SCHEMES

In order to enable closing only when the required voltage conditions are met, separate closing schemes are configured for each type of close request:

Manual close

For the manual close request, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (locking)	YES / NO

Depending on the configuration, the following checks are performed for manual close requests:

Voltage Conditions	Closing Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected

* the voltage condition check is in progress when the manual close request is received.

Automatic close (reclosing cycle after a protection trip)

For the automatic close request, and for each voltage condition, a closing scheme is defined as shown below:

Voltage Conditions	Close Authorization
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO

Depending on the configuration, the following checks are performed for automatic close requests:

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close request result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB	Accepted
Live Line / Live Bus (Locking)	YES	LLLB in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected

* the voltage condition check is in progress when the automatic close request is received.

Synchro close

For the synchro close request, and for each voltage condition, a close scheme is defined as shown below:

Voltage Conditions	Close Authorisation
Dead Line / Dead Bus	YES / NO
Dead Line / Live Bus	YES / NO
Live Line / Dead Bus	YES / NO
Live Line / Live Bus (Locking)	YES / NO
Live Line / Live Bus (Locking and Coupling)	YES / NO

Depending on the configuration, the following checks are performed for synchro close requests:

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close Request Result
Dead Line / Dead Bus	YES	DLDB	Accepted
Dead Line / Dead Bus	YES	DLDB in progress*	Delayed
Dead Line / Dead Bus	YES	≠ DLDB	Rejected
Dead Line / Dead Bus	NO	Any condition	Rejected

Voltage Conditions	Close Authorisation	Verified Voltage Conditions	Close Request Result
Dead Line / Live Bus	YES	DLLB	Accepted
Dead Line / Live Bus	YES	DLLB in progress*	Delayed
Dead Line / Live Bus	YES	≠ DLLB	Rejected
Dead Line / Live Bus	NO	Any condition	Rejected
Live Line / Dead Bus	YES	LLDB	Accepted
Live Line / Dead Bus	YES	LLDB in progress*	Delayed
Live Line / Dead Bus	YES	≠ LLDB	Rejected
Live Line / Dead Bus	NO	Any condition	Rejected
Live Line / Live Bus (Locking)	YES	LLLB (locking)	Accepted
Live Line / Live Bus (Locking)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking)	YES	≠ LLLB (locking)	Rejected
Live Line / Live Bus (Locking)	NO	Any condition	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking)	Accepted
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (locking) in progress*	Delayed
Live Line / Live Bus (Locking and Coupling)	YES	≠ LLLB (locking and coupling)	Rejected
Live Line / Live Bus (Locking and Coupling)	YES	LLLB (coupling only)	Search for min(Δφ)
Live Line / Live Bus (Locking and Coupling)	NO	Any condition	Rejected

* the voltage condition check is in progress when the synchro close request is received.

7.2.11.4 CLOSING SCENARIOS

Request accepted

According to the configured closing scheme, if the close request is accepted, a close command is sent to the circuit-breaker.

Request rejected

According to the configured closing scheme and when **control rejection time out (s)** expires, if the close request is rejected, a negative acknowledge (KO-Synchrocheck) is sent and no close command is sent to the circuit-breaker.

Request delayed

According to the configured closing scheme, if the close request result is delayed, a configured time-delay is started (**delay (ms)**):

- When the voltage condition check is complete, if the close scheme issues a close authorization:
  - a close command is sent to the circuit-breaker
  - and the time-delay is reset.
- When the voltage condition check is complete, if the close scheme does not give a close authorisation, the process is repeated until **control rejection time out (s)** expires.
  If, when **control rejection time out (s)** expires there is still no close authorisation:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - no close command is sent to the circuit-breaker,
  - and the time-delay is reset.
- If the time-delay elapses with no voltage conditions having been checked, the process is repeated until **control rejection time out (s)** expires.
  If, when **control rejection time out (s)** expires there is still no close authorisation:
  - a negative acknowledge (KO-Synchrocheck) is sent,
  - and no close command is sent to the circuit-breaker.

7.2.11.5 CLOSE WITH LOCKING / COUPLING

Synchro close requests can be managed according to three management modes combining Locking and Coupling logics.

The synchro close request Locking/Coupling management mode is defined in the configuration and cannot be changed without reloading a new database.

The 2 available modes are:

- Exclusive mode
- Evolutive mode

Exclusive mode

When a synchro close request is received, if $\Delta f_{min\ coupling} \leq \Delta f \leq \Delta f_{max\ coupling}$ the search for min($\Delta\varphi$) is started and a time-delay is launched (**delay for coupling (s)**).

- If min($\Delta\varphi$) is found, a positive acknowledge is sent to close the circuit-breaker, and the time-delay is reset.
- If **delay for coupling (s)** elapses without min($\Delta\varphi$) being found:
  - a negative acknowledge (KO-Synchrocheck) is sent
  - and no close command is sent to the circuit-breaker.

When a synchro close request is received while Δf is not within the range [$\Delta f_{min\ coupling}$ … $\Delta f_{max\ coupling}$], the C26x waits for Δf to shift into the range [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$] until **control rejection time out (s)** expires.
If, when **control rejection time out (s)** expires there is still no close authorisation:

- a negative acknowledge (KO-Synchrocheck) is immediately sent
- and no close command is sent to the circuit-breaker.

If Δf drifts outside of the range [Δ $f_{min\ coupling}$ ... Δ $f_{max\ coupling}$] during the search for min(Δφ:

- a negative acknowledge (KO-Synchrocheck) is sent
- and no close command is sent to the circuit-breaker.

Evolutive mode

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition is met, a positive acknowledge is immediately sent to close the circuit-breaker.

When a synchro close request is received, if Δf is within the range [0 ... $\Delta f_{max\ locking}$] and the locking condition check is in progress, the LLLB locking logic is applied.

When a synchro close request is received, if Δf is within the range [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], the search for min(Δφ) is started and a time-delay is launched (**delay for coupling (s)**).

When a synchro close request is received, if Δf is within neither of the ranges [0 ... $\Delta f_{max\ locking}$] and [$\Delta f_{min\ coupling}$ ... $\Delta f_{max\ coupling}$], the C26x waits for Δf to shift into either range until **control rejection time out (s)** expires.
If, when **control rejection time out (s)** expires there is still no close authorisation:

- a negative acknowledge (KO-Synchrocheck) is immediately sent
- and no close command is sent to the circuit-breaker.

If Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min(Δφ), the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic.

If Δf drifts outside of both the Coupling and Locking ranges during the search for min(Δφ), the search is aborted, the time-delay is reset, and:

- a negative acknowledge (KO-Synchrocheck) is immediately sent
- and no close command is sent to the circuit-breaker.

The drift of Δf during the search for min(Δφ) is confirmed after a fixed time-delay of 5 s.

If Δf drifts outside of the Coupling range, the 5 s Δf drift time-delay is started. If Δf returns into the Coupling range, the Δf drift time-delay is reset.

If, when the Δf drift time-delay elapses,

- Δf is inside the Locking range, the search is aborted, the time-delay is reset and a synchro close request is sent according to the locking logic.
- Δf is outside the Locking range, the search is aborted, the search for min(Δφ) time-delay is reset:
  - a negative acknowledge (KO-Synchrocheck) is immediately sent
  - and no close command is sent to the circuit-breaker..

If the Evolutive mode for synchro close request management is defined in the configuration, a SPS “Delta drift” can be defined. Whenever Δf drifts from the Coupling range to the Locking range (outside of any overlap) during the search for min(Δφ), the SPS “Delta drift” is transmitted in the SET state. As soon as the Δf drift during the search for min(Δφ) is over, whatever the resulting acknowledgement: OK or KO-Synchrocheck, the SPS “Delta drift” is transmitted in the RESET state.

7.2.12 PARAMETERS OF THE TMU2XX BOARD

The parameters for the TMU220 are the same as for the TMU210:

- Reference phase: definition of the voltage reference phase for comparison
- Reference phase side: definition of the energised reference voltage

Note:
These setting are not used for Synchrocheck type 3.

7.2.13 CONFIGURATION AND SETTINGS

7.2.13.1 CONFIGURATION

The table below lists all the parameters that can only be set in the SCE configuration (not in DS Agile S1).

Configuration / Label in SCE	Setting range	SC Type
General		
SC type	type 1, type 2, type 3 or type 4	Type 1, Type 2, Type 3, Type 4
Check voltage	Yes or No	Type 1, Type 2, Type 3, Type 4
drift Management	Exclusive mode Evolutive mode Split mode (1)	Type 1, Type 4
wiring mode	star on both side delta on both side star on line - delta on busbar (2) delta on line - star on busbar (2)	Type 1, Type 4
Earth to Phase Coefficient	0 to 2, in steps of 0.01	Type 1, Type 4
Voltage condition		
S filtering value (Hz)	From 0.8 Hz to 1.6 Hz, in steps of 0.1 Hz	Type 2
dS/dt filtering enable	No or Yes	Type 2
dS/dt filtering value (Hz)	From 0.5 Hz to 2 Hz, in steps of 0.1 Hz	Type 2
dS/dt max value (Hz)	From 10 mHz/s to 50 mHz/s, in steps of 5 mHz/s	Type 2

(1) Split mode is available only for type 1 synchrocheck.

(2) for Type 1, mixed wiring (*star on line - delta on busbar* / *delta on line - star on busbar*) is available only if the acquisition board is a TMU220.

7.2.13.2 SETTINGS

The table below lists all the parameters that can be set in both the SCE configuration and using the setting software DS Agile S1.

Setting name	Setting range	Type 1	Type 2	Type 3	Type 4	Comments
Timers						
T1: presence deltas test duration	From 20 ms to 10 s, in steps of 10 ms	✓	✓	✓	✓	
T2: presence test duration	From 200 ms to 10 s, in steps of 20 ms	✓	✓	✓	✓	
T3: absence deltas test duration	From 200 ms to 10 s, in steps of 20 ms	✓	✓	✓	✓	

Setting name	Setting range	Type 1	Type 2	Type 3	Type 4	Comments
Ta: close time of the Circuit-Breaker	0 to 1 s, in steps of 10 ms	✓	✓	✓	✓	For optimal performances, Ta must be greater than or equal to 50 ms
Control rejection time out	0 to 60 s, in steps of 1 s				✓	Must be greater than T1, T2 and T3.
Voltage presence conditions / Thresholds						
Line voltage over threshold	0 to 100% Vn, in steps of 1% Vn	✓	✓	✓	✓	
Line voltage under threshold	0 to 100% Vn, in steps of 1% Vn	✓	✓	✓	✓	For type 2, defined by the fixed drop-off percent
Bus voltage over threshold	0 to 100% Vn, in steps of 1% Vn	✓	✓	✓	✓	
Bus voltage under threshold	0 to 100% Vn, in steps of 1% Vn	✓	✓	✓	✓	For type 2, defined by the fixed drop-off percent
over voltage threshold	100% to 150% Vn, in steps of 1% Vn				✓	
Locking and Coupling						
Locking parameters						
Voltage delta threshold for locking	0 to 100% Vn, in steps of 1% Vn	✓	✓	✓	✓	
Minimum frequency for locking	45 to 59.5 Hz, in steps of 0.1 Hz	✓		✓	✓	
Maximum frequency for locking	50.5 to 66 Hz, in steps of 0.1 Hz	✓		✓	✓	
Frequency delta threshold for locking	0 to 1 Hz, in steps of 0.01 Hz	✓		✓	✓	
Phase delta threshold for locking	0 to 90°, in steps of 1°	✓	✓	✓	✓	
Frequency shift threshold for locking	0.02 to 0.1 %, in steps of 0.01 %		✓			% of the present frequency of the reference signal
Split parameters						
Voltage diff. drift management split mode	No or Yes	✓				Only used if drift management=Split mode
Min voltage diff. (%)	0 to 100% Vn, in steps of 1% Vn	✓				Only used if drift management=Split mode
Max voltage diff.(%)	0 to 100% Vn, in steps of 1% Vn	✓				Only used if drift management=Split mode
Frequency diff. drift management split mode	No or Yes	✓				Only used if drift management=Split mode
Min frequency diff. (Hz)	0 to 1 Hz, in steps of 0.01 Hz	✓				Only used if drift management=Split mode
Max frequencydiff. (Hz)	0 to 1 Hz, in steps of 0.01 Hz	✓				Only used if drift management=Split mode
Phase diff. drift management split mode	No or Yes (Yes must be selected if Split mode is used)	✓				Only used if drift management=Split mode
Min phase diff.	-180° to 0, in steps of 1°	✓				Only used if drift management=Split mode

Setting name	Setting range	Type 1	Type 2	Type 3	Type 4	Comments
Max phase diff.	0 to 180°, in steps of 1°	✓				Only used if drift management=Split mode
Time out drift management split mode	0 to 10 s, in steps of 0.1 s	✓				Only used if drift management=Split mode
Coupling parameters						
Voltage delta threshold for coupling	0 to 100% Vn, in steps of 1% Vn	✓	✓	✓	✓	
Minimum frequency for coupling	45 to 59.5 Hz, in steps of 0.1 Hz	✓		✓	✓	
Maximum frequency for coupling	50.5 to 66 Hz, in steps of 0.1 Hz	✓		✓	✓	
Maximum frequency delta threshold for coupling	0 to 1 Hz, in steps of 0.01 Hz	✓		✓	✓	
Minimum frequency delta threshold for coupling	0 to 1 Hz, in steps of 0.01 Hz	✓		✓	✓	
Phase delta threshold for coupling	0 to 90°, in steps of 1°	✓			✓	
Frequency shift threshold for coupling	0.1 to 1%, in steps of 0.02%		✓			% of the present frequency of the reference signal
Delay for coupling	1 to 3600 s, in steps of 1 s	✓	✓	✓	✓	
Schemes						
Close with synchro schemes						
Coupling and locking	No or Yes	✓	✓	✓	✓	
Locking	No or Yes	✓	✓	✓	✓	
Line Dead and Bus Live	No or Yes	✓	✓	✓	✓	
Line Live and Bus Dead	No or Yes	✓	✓	✓	✓	
Line Dead and Bus Dead	No or Yes	✓	✓	✓	✓	
Delay (ms)	From 200 ms to 10 s, in steps of 10 ms	✓		✓		Replaced by control rejection timeout in Type 4
Close schemes						
Locking	No or Yes	✓	✓	✓	✓	
Line Dead and Bus Live	No or Yes	✓	✓	✓	✓	
Line Live and Bus Dead	No or Yes	✓	✓	✓	✓	
Line Dead and Bus Dead	No or Yes	✓	✓	✓	✓	
Delay (ms)	From 200 ms to 10 s, in steps of 10 ms	✓	✓	✓	✓	
AutoRecloser schemes						
Locking	No or Yes	✓	✓		✓	
Line Dead and Bus Live	No or Yes	✓	✓		✓	
Line Live and Bus Dead	No or Yes	✓	✓		✓	
Line Dead and Bus Dead	No or Yes	✓	✓		✓	
Delay (ms)	From 200 ms to 10 s, in steps of 10 ms	✓			✓	

7.2.13.3 THRESHOLD HYSTERESIS

A hysteresis is built into each threshold calculation in order to avoid multiple state changes for values close to the threshold (toggling):

- High ('over' / '>' / 'max') thresholds:

  The thresholds pick up at their set value, and drop off at their set value minus the hysteresis.

- Low ('under' / '<' / 'min') thresholds:

  The thresholds pick up at their set value, and drop off at their set value plus the hysteresis.

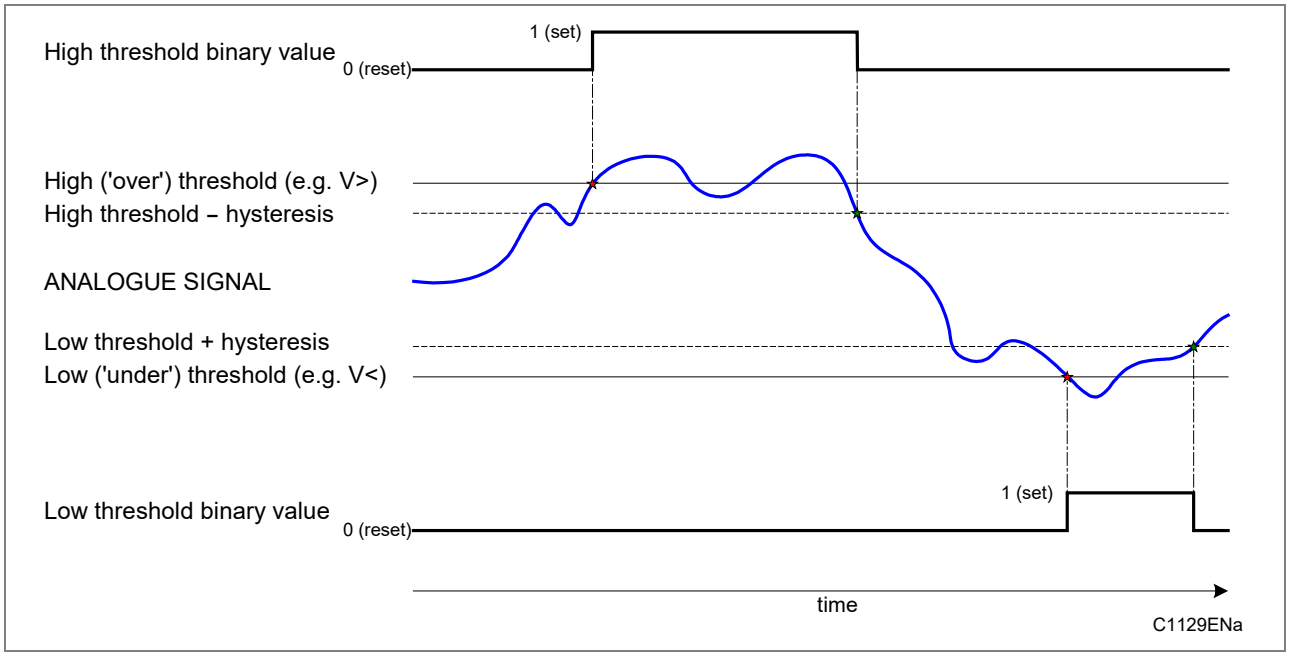


Figure 97: Pick-up/drop-off characteristics for high/low thresholds according to the relevant signal's variations

Values

- voltage thresholds: 5% of set value
- voltage delta threshold for locking and coupling:
  - 2% of nominal voltage for TMU220
  - 2% of delta voltage for TMU210
- frequency delta threshold for locking: 0.007 Hz
- frequency delta threshold for coupling: 0.014 Hz
- frequency delta threshold for split: 0.014 Hz
- over- and under-frequency thresholds: 0.1 Hz
- phase delta threshold for locking
  - +/– 1° for synchrocheck type 1/2/4
  - +/– 2° for synchrocheck type 3

7.2.14 MANAGEMENT OF THE 5TH VT INPUT ON THE TMU220 BOARD

The fifth VT input allows using 2 different synchrocheck voltages: $V_{busbar1}$ and $V_{busbar2}$

An internal SPS, defined in the SCE configuration, allows choosing either voltage to close the circuit-breaker with synchrocheck. This SPS can be directly measured or derived using a programmable scheme logic (PSL). Depending on its state, the selected busbar voltage is:

- $V_{busbar1}$ if the SPS is RESET (or FORCED RESET or SUBSTITUTED RESET)
- $V_{busbar2}$ if the SPS is SET (or FORCED SET or SUBSTITUTED SET)

If the state of this SPS changes during a synchrocheck closure, the operation is aborted, a negative acknowledgement (*KO-Synchrocheck*) is sent and the system waits for a new command.

If the SPS is SELFCHECK FAULTY (or TOGGLING or UNKNOWN or SUPPRESSED), no busbar voltage can be used (automatic forcing can be used on this SPS to pre-define a behaviour in case of invalid state)

This SPS is optional: if it is not configured, $V_{busbar1}$ is used.

The 5th voltage input is associated to an RMS measurement and can be used in the same way as the other voltage inputs. This new measurement is defined using the SCE with the TMU220 board.

Samples from the fifth voltage channel can be included in fast waveform records.

The RMS value of $V_{busbar2}$ can be included in a slow waveform record.

7.2.15 DIGITAL OUTPUT (DO) OF THE CIRCUIT-BREAKER

The DPC of the circuit-breaker can be configured on the DSPIO board or on a DOU/HBU board.

On the DSPIO, the DPC close command must be connected to the contact 1 or contact 2 of relay 3 (pins 9/10 or 11/12).

In this case, there are only 2 choices for the DPC type:

- Transient
- Permanent until feedback

If a DOU or HBU board is used, both contacts must be connected to it with same constraint.

Note:
The check sequence is detailed at the end of the Interlocking section.

7.3 INTERLOCKING: LOGICAL EQUATIONS

In an electrical substation, the switching devices include primarily:

- Circuit-breakers
- Traditional disconnecting switches
- Disconnecting switches with abrupt loss
- Ground disconnecting switches

The operation of a switching device is directly related to its nature and its environment. It can be operated only with respect of specific conditions called **interlocking** conditions; they are checked within the controller using **logical equations**.

Interlocking conditions allow blocking remote controls that are beyond the switching device standard conditions of operation. They can be applied to any module or any control.

The operation of the disconnecting switches is also checked against the topology. The topological interlocking equations are generated by independent software. This software takes in account the topology and some predefined rules.

Comparison of the interlocking schemes:

	Conventional interlock	Boolean equations	Topological interlock
Security-related interlock	Relay schemes	Boolean equations	Evaluation of potential isolating distance
Simple-operation related interlock	Additional circuits	Boolean equations	Path tracking
Zone	Selection of switchgear position indications		Complete connected area
Complex-operation related interlock	Restricted		Fully by “search of path”
Taking intermediate position into account	Restricted		Fully by “worst case” analysis
Applying set of rules	Project-specific		Generic conditions
Image of s/s topology	Ring wiring		Topological database
Testability	Restricted		Full

7.3.1 INPUTS

Interlocking function can use the following inputs:

- Digital inputs from the system digital input boards, from other system controllers, from protection relays and other IEDs via a communication network (single and double point, digital groups).
- Internal indications (e. g. system failures, equipment operation modes, ...).
- Limits derived from measured values by the systems analog input boards (CT, VT, transducers), other system controllers, protection relays and other IEDs via a communication network.

7.3.2 OUTPUTS

The result of the interlocking equation is transmitted through a system binary output and saved locally in RAM.

Any task can get the result of the computation. For example, the function managing “control of sequence” uses this output to know whether the control can be executed; then, a simple transient binary input can be set if it has been configured. The same SPS is used for the commands “open” and “close” of an xPC.

7.3.3 CONTROL

There is no control. An equation is computed whenever one of its input changes of state or of validity.

7.3.4 BEHAVIOUR

7.3.4.1 PRINCIPLE

In a C26x, a logical interlocking equation is defined as a sum of products (AB+CDE+F for example).

7.3.4.1.1 Introduction

Interlocking function uses up to two interlocking equations per switching device on bay-level and on substation-level. During configuration process the definition of the switching devices can be:

- without associated interlocking equations,
- with only one interlocking equation, e. g. for opening, while closing is not checked or vice-versa,
- with two interlocking equations (for opening and closing). The interlocking equations can be different but can also be identical.

The equation is composed of Boolean information that mainly represents the position of other switching devices.

The interlocking for a switching device might include:

- Local equation, that requires information from its own digital inputs and IEDs connected to the C26x.
- Substation equation, that requires information from its digital inputs and inputs provided by the communications network from other C26x, from bay controllers and from IED's (protection relays, etc.). Substation interlocking can also include topological interlocking.

Both types are managed by the C26x which controls the switching device.

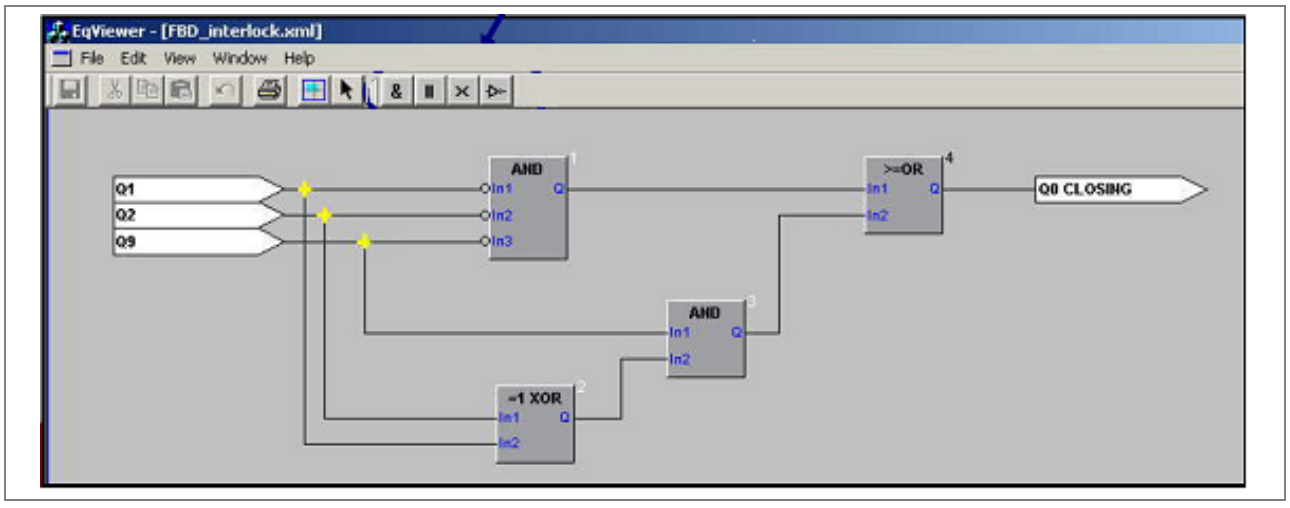
7.3.4.1.2 Local interlocking

There can be up to one equation for each switching device and for each direction (open and close). If there is no equation for a switching device for a direction, the related variable equals true.

7.3.4.1.3 Substation interlocking

The substation interlocking analyses the position of all the switching devices in the substation and calculates the substation interlocking equation to authorise control of a switching device according to the mechanical and electrical capabilities of the switching device. If there is no equation for a switching device for a direction, the related variable equals true.

Example



7.3.4.1.4 Validity of information

The interlocking equation uses not only the information value but also its validity (invalid, ...).

The evaluation of the result of the basic operators is as follows:

NOT	
True	False
False	True
Invalid	Invalid

OR	True	False	Invalid
True	True	True	True
False	True	False	Invalid
Invalid	True	Invalid	Invalid

XOR	True	False	Invalid
True	False	True	Invalid
False	True	False	Invalid
Invalid	Invalid	Invalid	Invalid

AND	True	False	Invalid
True	True	False	Invalid
False	False	False	False
Invalid	Invalid	False	Invalid

Key:

Input	Output

Note:
RS and timers are not allowed.

An Interlocking equation in the INVALID state is considered FALSE.

But the system binary input also generated can be valid (SET or RESET) or invalid.

7.3.4.1.5 Interlocking bypass

Bypass made by key switch

Interlocking can be overridden (interlocking bypass mode). Overriding of interlocking can be set from the LOCAL control point.

During configuration, optional overriding of interlocking from any other control point can be defined according to customer requirements. This includes the possibility of overriding of interlocking per switching device or per bay or per substation.

If an interlocking is overridden, the associated variable is true.

Bypass within the control

From ANY control point, the operator can bypass the interlocking check. Bypass is then an attribute of the control. If the bypass is set, the function managing the “control of sequence” does not use the service giving the current result of the interlocking equations.

7.3.4.2 SOFTWARE TASKS

A logical equation is a sum of products. Each product comprises logical data that can be complemented. Each electrical component has two logical equations at the most, and each logical equation is associated with one electrical component.

Example of Logical equation: X = A.$\underline{B}$ + $\underline{C}$.D.$\underline{E}$

In this example, the component X can be operated only if:

- (A is in the higher state) AND (B is in the lower state)

OR

- (C is in the lower state) AND (D is in the higher state) AND (E is in the lower state)

The terms of these equations can be issued from:

- Simple point status (BI)
- Double point status (BI)
- 1 among N BIs (SIG)
- Measurement (MEAS)

At configuration time, operator has to define the “interlocking profile” of each data included in an interlocking equation. It means that operator must select for each state or validity of a data a logical state (TRUE, FALSE or INVALID).

Interlocking computation

As said before, an interlocking equation

- is computed each time that one of its element changes of quality or state and
- is defined by a sum of product.

Upon reception of a new state or quality for a data

- Get logical state associated to the received state and validity of the data
- For each equation that includes the data
  - Compute the sum of product
  - Determine the result of the interlocking equation (TRUE or FALSE)
  - Send new state of the system binary input representing the result of the interlock. BI can be: SET, RESET or INVALID

Interlocking readout

On reception of an open or close request, if the logic equation associated with the switching device exists, the “control of sequence” function used the service offered by the interlocking function to get the result of the interlocking associated to the received request.

If result of the interlocking is TRUE, the check is considered as achieved, else request must be refused and a negative acknowledgement sent to the origin of the request.

Simulation and test of interlocking equations

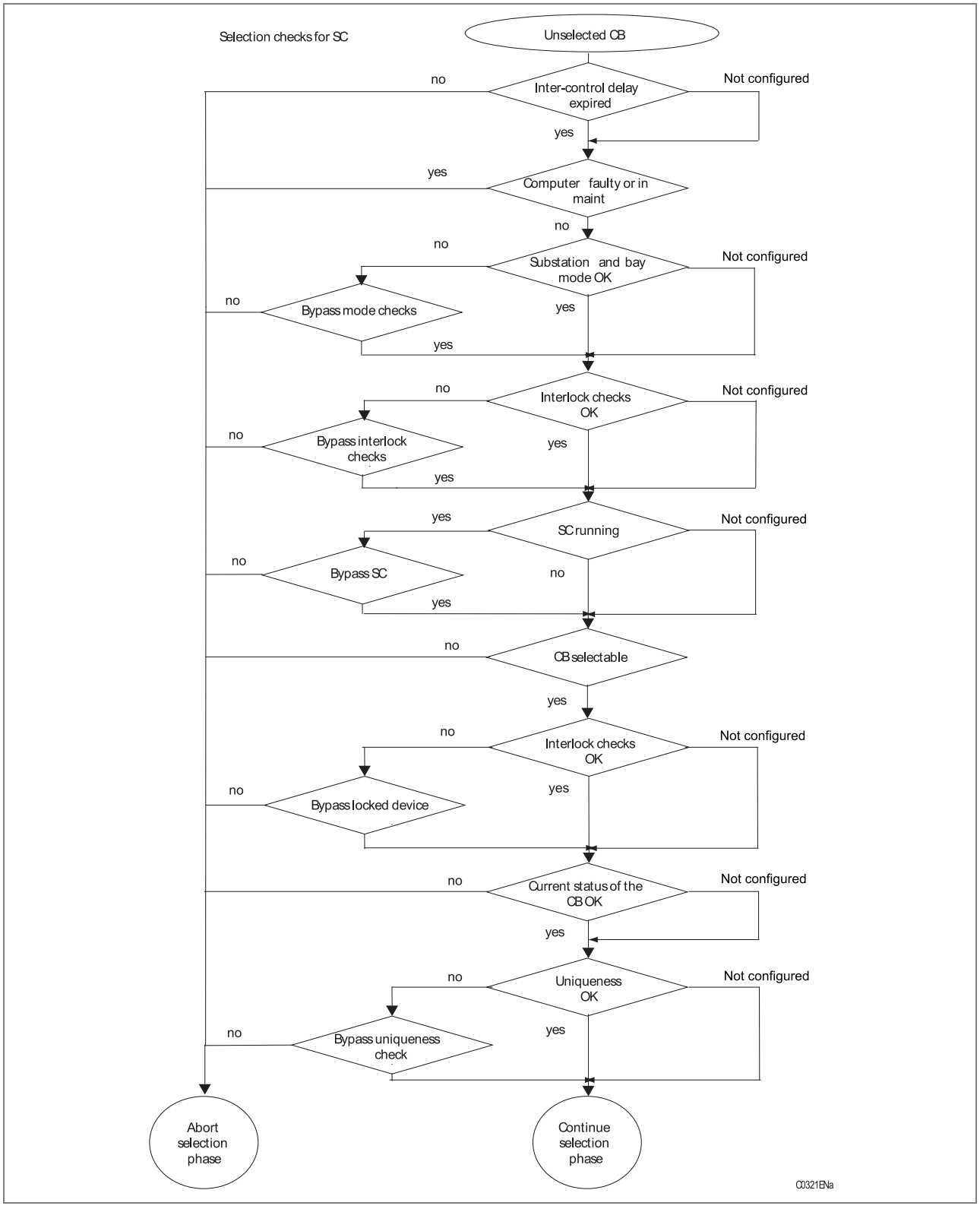
The interlocking system is checked during the factory acceptance test of the substation control system. Each interlocking equation may be checked by issuing a control to the corresponding switching device.

To check the interlocking on site, set the C26x to Test/blocked mode. In that operating mode, a valid control is sent to the output, but the contact is not closed. A positive acknowledgement message is generated.

7.3.5 INTERLOCKING AND SYNCHROCHECK

The interlocking conditions must be checked again after the Synchrocheck conditions are fulfilled.

In event the interlocking conditions are not fulfilled, a report message pops up.



7.4 SLOW AUTOMATION: PROGRAMMABLE LOGIC CONTROL (PLC)

During the substation configuration phase, the C26x allows you to configure the specific control sequences or automations: for example, the switching sequences, busbar transfer, load shedding, and GIS-pressure supervision.

You create the Programmable Logic Controls (PLC) or Configurable Automations and build them onto a logic development workbench. The real time kernel of the controller operates them.

The software logic package includes the logic development workbench. The logic development workbench is a host-based software development environment related to the SCE. Use the software logic package and the logic development workbench to create the control logic programs in the DS Agile C26x.

The logic development workbench includes a set of tools that allow you to:

- Edit
- Generate code
- Simulate
- Debug
- Project management.

The software logic package supports standard programming languages of the IEC 1131-3:

- Sequential Function Chart, SFC (GRAFCET)
- For action and transition description, you can use this language with Function Block Diagram (FBD), Ladder Diagram (LD) or Instruction List (IL).
- Structured Text, ST

The logic development workbench generates code. The code is uploaded to the controller target system that operates the code.

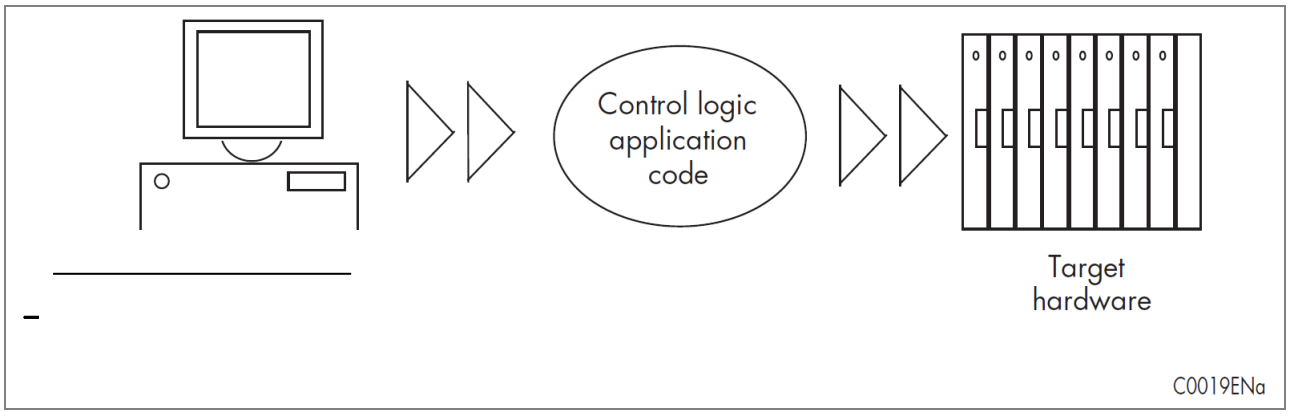


Figure 98: PLC workbench

For ISaGRAF, refer to the chapter SCE/EN AP.

7.4.1 INPUTS

All the datapoints of the C26x can be used as an input of a PLC.

7.4.1.1 DATA ACQUIRED BY C26X

- BI: non filtered change of states are transmitted to PLC kernel
- MEAS (MV or DM)
- CT
- Tap position (TPI aka SPI)

7.4.1.2 DATA MANAGED BY C26X

- CO

Note:
A CO can be used as input of a PLC function, but only through the use of 'C' function present by default with the kernel.

7.4.1.3 ACKNOWLEDGEMENT OF CONTROL

A PLC function can manage a control sequence:

- Send control
- Process acknowledgement to the sent control

7.4.2 OUTPUTS

A PLC function can:

- Generate a BI, for example. PLC is considered as source of acquisition of the data point
- Generate an MEAS
- Generate a CT
- Generate an SPI
- Generate a SIG
- Modify quality of a Binary Input defined in the controller: force, suppress or substitution request
- Modify quality of an MEAS defined in the controller: force, suppress or substitution request
- Modify quality of a SIG defined in the controller: force, suppress or substitution request
- Send binary order to controller boards or IED or to another controller
- Send digital and analogue setpoints to controller boards or IED or to another controller.

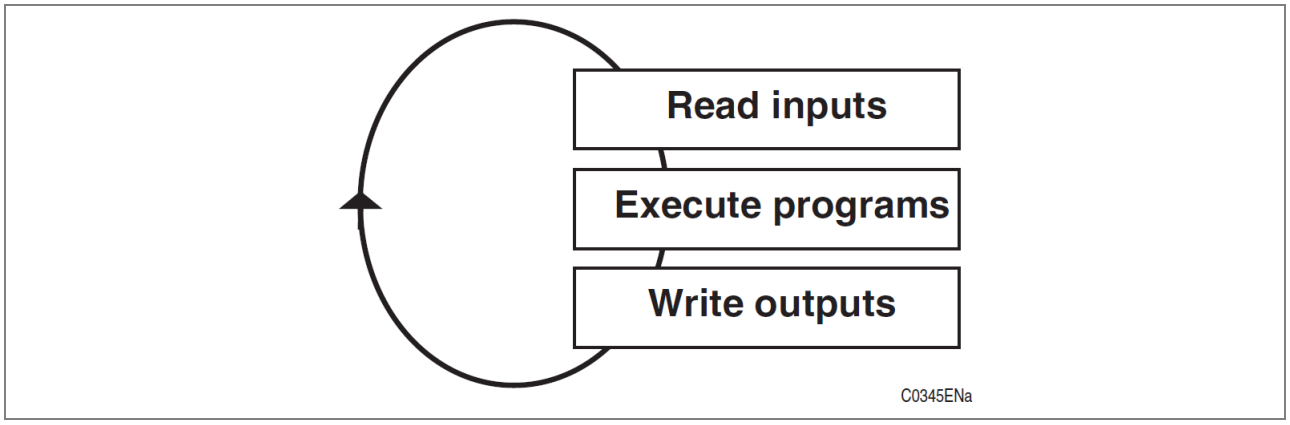
7.4.3 CONTROL

Automations can be triggered:

- By operator request,
- By events (digital or analogue input state changes),
- Cyclically (each day, each week or each month),
- At a specific date and time (e. g.: 20. 12. at 10:00).

7.4.4 BEHAVIOUR

The controller has a software execution engine that interprets the automation application code as shown in the cycle that follows:



The cycle duration depends on the number of I/O to be scanned and the complexity of the operations to be performed. Set the cycle during the configuration process.

7.4.4.1 INTERFACING WITH AN HMI OR AN RCP/SCADA

A master station on a remote site can send and receive data to and from the automation applications of C26x.

In DB, the data sent by a master station to an automation application include DO and BI entities. Conversely, the data received by a master station from automation applications include DI, Measurements, Metering (non-tariff), and Tap Changer Position entities. These data have a unique transmission address for C26x.

7.4.5 LIMITS AND SPECIFICATIONS

- The execution of the automation sequences can be cyclic and/or event-driven.
- Maximum number of cyclic PLC-programs is 32.
- The two different time cycles of a PLC-program can be set from 10 ms up to several seconds. For some specific equations a cycle less or equal to 10ms and a cycle less or equal to 100ms for the other logic equations. The time cycle for the automatic functions is less than 100ms.
- Each PLC-program operates on one controller: this means a PLC-program cannot be distributed within the system. However, it is possible to use data obtained by other controllers.
- Routing of the automatism applications to the memory must be in agreement with the memory and hardware design.
- To debug the applications, you can connect a PC to the front face. The hardware design separates the debug function and the application download function.

7.5 FAST AUTOMATION: PROGRAMMABLE SCHEME LOGIC (PSL)

7.5.1 GENERAL

As automations created through ISaGRAF are dependent on the ISaGRAF cycle whose value is about 50ms at least, it may be necessary to implement configurable automations that can be achieved in less than 50ms.

PSL is the solution for implementation of automatism to perform as quickly as possible.

Designed solution is mainly based on mechanism used for the computation of logical interlocking (see logical interlocking for details). Indeed, logical gates AND, OR, NOT, NAND, NOR or a combination of these gates can be processed as a logical equation. Some other functions (drop-off & pickup timer, bistables) are added to these logic gates.

These automations are event-driven: they are calculated each time an input changes: that is, there is no cycle time.

Only BI and measurements described are usable as inputs (controls are not). Transient SPS are transformed in permanent SPS. A reset state is created 1ms after the set state.

PSL are logical equations that use the following functions:

- AND, OR, XOR, NOT, NAND, NOR operators
- "bistable" functions
- pickup and drop-off timers (from 50 ms to 1 hour, by step of 10 ms)
- BI setting – the system BI is:
  - SET if the PSL is TRUE
  - RESET if the PSL is FALSE
  - INVALID if the PSL is INVALID
- Digital Output setting – the DO is:
  - closed if the PSL is TRUE
  - opened if the PSL is FALSE or INVALID (only in the event of a permanent DO)
  - INVALID if the PSL is INVALID

The equations management rules described for interlocking equations apply on PSL.

Digital outputs used as outputs are mandatory local hardwired DO directly managed by the controller.

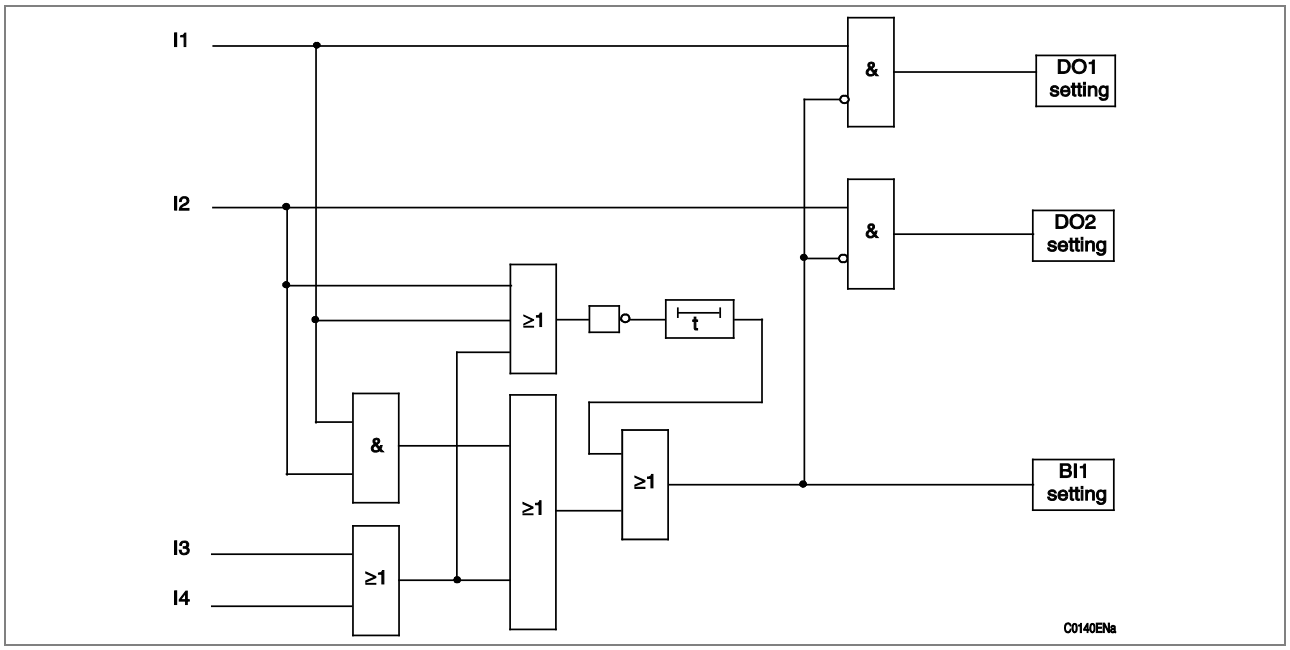
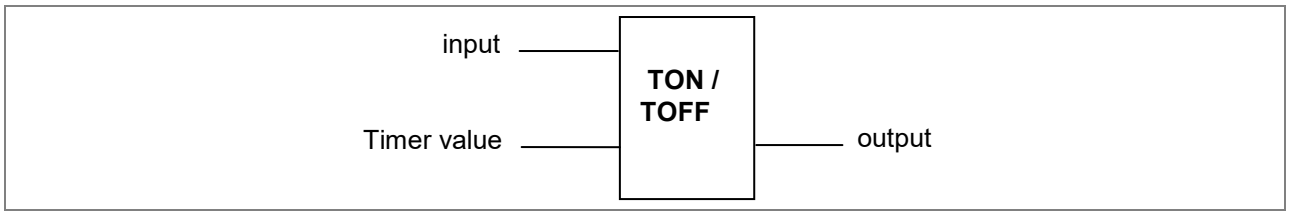


Figure 99: Example of PSL

7.5.2 TIMERS

For TON/TOFF timers, the timer value input can be associated:

- to a direct value
- to a timer setting input (FBD Timer)



In C26x, a timer setting is taken into account at the next evaluation of the TON/TOFF operator (i.e. when the input changes).

TON:

Event / State	Input = 0	Input = 1	Input = INV	T expiration
Not initialized 0	Output = 0 Goto state 1	Output = 0 Activate T Goto state 4	Output = INV Goto state 3	X
Output = 0 1	X	Activate T Goto state 4	Activate T Goto state 5	X
Output = 1 2	Output = 0 Goto state 1	X	Output = INV Goto state 3	X
Output = INV 3	Output = 0 Goto state 1	Output = 0 Activate T Goto state 4	X	X

Event / State	Input = 0	Input = 1	Input = INV	T expiration
Input = 1, Output = 0 and timer activated 4	Stop T Goto state 1	X	Goto state 5	Output = 1 Goto state 2
Input = INV, Output = 0 and timer activated 5	Stop T Goto state 1	Activate T Goto state 4	X	Output = INV Goto state 3

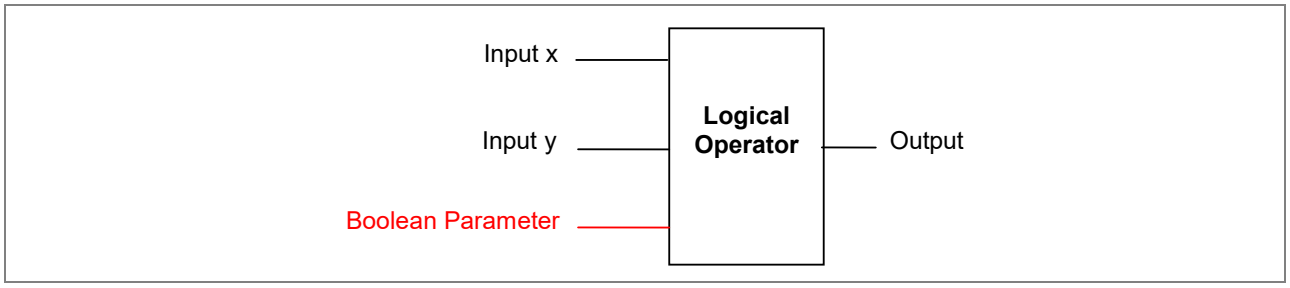
TOFF:

Event / State	Input = 0	Input = 1	Input = INV	T expiration
Not initialized 0	Output = 0 Goto state 1	Output = 1 Goto state 2	Output = INV Goto state 3	X
Output = 0 1	X	Output = 1 Goto state 2	Output = INV Goto state 3	X
Output = 1 2	Activate T Goto state 4	X	Activate T Goto state 5	X
Output = INV 3	Output = 0 Goto state 1	Output = 1 Goto state 2	X	X
Input = 0, Output = 1 and timer activated 4	X	Stop T Goto state 2	Goto state 5	Output = 0 Goto state 1
Input = INV, Output = 1 and timer activated 5	Goto state 4	Stop T Goto state 2	X	Output = INV Goto state 3

X is a forbidden action: it means the controller goes in Halt mode.

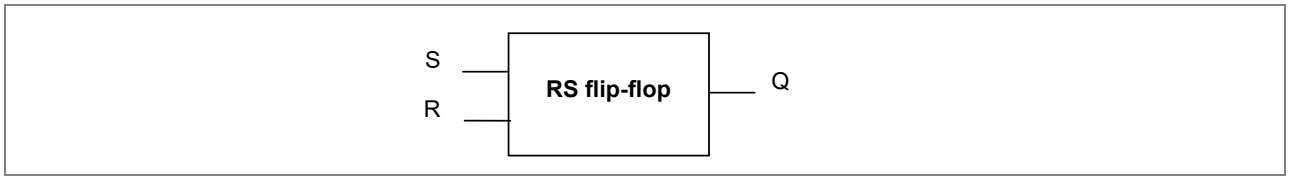
7.5.3 BOOLEAN

For one Boolean operator (i.e. AND, OR, XOR, NOT operators only), one (and only one) input can be defined as a parameter.



In C26x, the Boolean setting is taken into account immediately (i.e. managed as the modification of an operator input).

7.5.4 RS FLIP-FLOP



The Q state:

- equals to 1 when the S input is set
- equals to 0 when the R input is set
- is unchanged when both inputs are at 0
- is forced to reset when both inputs are at 1

Event / State	S = 0	S = 1	S = INV	R = 0	R = 1	R = INV	End of init
Not initialized 0	VAR= Q-1 Goto state 1	VAR=1 Goto state 1	VAR= Q-1 Goto state 1	VAR= Q-1 Goto state 2	VAR=0 Goto state 2	VAR= Q-1 Goto state 2	X
Not initialized, awaiting R init 1	X	X	X	Goto state 3	VAR=0 Goto state 3	Goto state 3	X
Not initialized, awaiting S init 2	Goto state 3	If R=1, then VAR=0, else VAR=1 Goto State 3	Goto state 3	X	X	X	X
Not initialized, awaiting end of init 3	X	X	X	X	X	X	Q=VAR If Q=0 goto state 4 else goto state 5
Q=0 4	No Action	If (R=0 or R=INV) then Q=1 Goto state 5, else no action	No Action	If S=1Q=1 Goto State 5 Else No Action	No Action	No Action	X
Q=1 5	No Action	If R=1 then Q=0 Goto state 4, else no action	No Action	No Action	Q=0 Goto state 4	No Action	X

X is a forbidden action: it means the controller would go in Halt mode.

Q_{-1} is the output value before the reinitialization (stored in the C26x); at first boot (after change of data base) Q_{-1} =0.

N.B.: A change of software without a change of database is not considered as a first boot Q_{-1} is the memorised one.

Let I1, I2 be the inputs of RS latch.

These inputs can be acquired:

- directly by C26x's BIU
- through an IED (IED legacy or IED on SBUS)

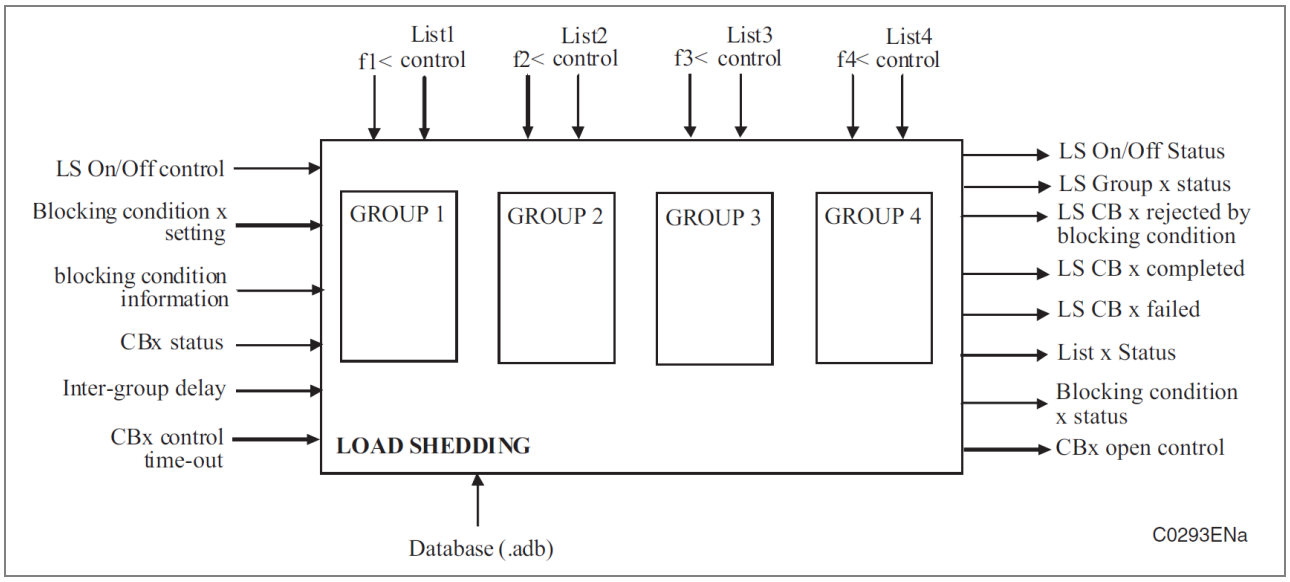
In the event of a loss of source of information, C26x can temporarily lose I1 or I2. Examples: reboot of C26x, disconnection of the IED sever of I1, I2, …

I1	I2	S	R	Q	
1	0	1	0	1	Initial state
1	1	-	-	1	source lost and I2 changed
1	1	1	1	0	source restored

I1	I2	S	R	Q	
1	0	1	0	1	Initial state
0	1	-	-	1	source lost, and I1 and I2 changed
0	1	0	1	0	source restored

I1	I2	S	R	Q	
1	1	1	1	0	Initial state
1	0	-	-	0	source lost and I2 changed
1	0	1	0	1	source restored

7.6 LOAD SHEDDING – C26X–STANDALONE



Note:
The Load Shedding function is available only on the C26x–Standalone unit.

7.6.1 INPUTS

- f1<, f2<, f3<, f4<: digital inputs, coming from frequency relay. Each input is a frequency threshold and is associated to a group.
- List1, List2, List3, List4 control: each “list” input is a set of three setpoints associated to a group. These setpoints give the list of circuit-breakers attached to a group. They can be only received from the SCADA interface. ASDU 48 (setpoint normalised value) is used for these setpoints.
- LS On/Off Control: control (DPC type) that allows you to set On or Off the Load Shedding automation. This control can be received from the SCADA interface or from the C26x local HMI.
- Blocking condition x setting (1≤x≤6): each blocking condition setting is a set of three setpoints. These setpoints give the list of circuit-breakers blocked by the condition x. It can be only received from the SCADA interface. ASDU 48 (setpoint normalised value) is used for these setpoints.
- Blocking condition data: digital inputs that blocks the CB trip is set, according to the CBx blocking condition setting. A maximum of 6 SPS / DPS can be defined as blocking condition information.
- CBx status: status of each circuit-breaker (Feedback of the CBx control).
- Inter-group delay: delay between each group when several group are activated: that is, when CB of a group have to be tripped. This delay is defined in configuration and settable through a setpoint (ASDU 48) that can be only received from the SCADA interface. The delay is stored in flash memory, but set to the value defined in configuration in the event of a database switch.
- CBx control time-out: one time-out per circuit-breaker. For a circuit-breaker, this time-out defines the authorized delay between the CB control activation and the CB position change. These time-out are defined in configuration – through DS Agile SCE – as the CB control’s Feedback time-out.
- Database: C26x database (.adb file).

7.6.2 ALGORITHM

Group definition

At configuration time (with DS Agile SCE), the operator defines the list of CB attached to each Load Shedding group. The minimum number of CBs in a group is 0, the maximum number is 40. No more than 40 CBs can be defined for the whole automation. The 40 CBs that you can use in the load shedding function are tagged in configuration with a number from 1 to 40.

When the database is downloaded and switched, the load shedding automation considers the data described in the database (last setting sent by the SCADA is lost). The Listx status information is updated and sent to the SCADA.

The assignment of CB to the groups is performed on-line through the SCADA interface, whatever was the status of the automation (On or Off). Three setpoints are defined per group, each value combination gives the allocation of a CB to the group as defined in the table below:

Breaker number/ setpoint 1	**/**	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Breaker number/ setpoint 2	/	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Breaker number/ setpoint 3	/	/	/	/	/	/	40	39	38	37	36	35	34	33	32	31
Bit	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Value		16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

If a CB is already assigned to another group, it is automatically re-assigned to the new group (a CB can be affected to only one group). After assignment, the Listx status information for group(s) that has(have) been modified is sent to the SCADA.

During CB assignment (from the reception of the Listx control up to the sending of the Listx status), the load shedding function cannot be started.

The group definition is saved in flash memory and restored after a controller reboot. It is erased in the event of a database switch.

Locally to the controller, assignments of CB to a group can be performed only through a database download.

Blocking conditions

You can define as many as 6 SPS/DPS as blocking condition: they are numbered from 1 to 6.

At configuration time (with DS Agile SCE), the operator defines the list of blocking conditions activated for each circuit-breaker.

When the database is downloaded and switched, the load shedding automation takes into account information described in the database (last setting sent by the SCADA is lost).

The use of blocking condition is also performed through the SCADA interface, whatever was the status of the automation (On or Off). Three setpoints are defined on a per blocking condition basis; each value combination gives the association between the CB and the blocking condition (refer to the table of group definition).

The usage of blocking conditions is saved in flash memory and restored after a controller reboot. It is erased in the event of a database switch.

After assignment, the Blocking condition x status information for blocking condition(s) that has(have) been modified is sent to the SCADA.

Automation

The automation is activated only if it is On. The On / Off control (DPC) is performed through the SCADA interface or the controller local HMI. The automation status is provided through a DPS.

As soon as a fx< SPS is detected in a SET state, the CB belonging to the group x are tripped, with the following constraints:

- The order to trip the first CB will be sent in less than 100ms after the fx< detection whatever was the number of CBs in the group
- If the group contains as many as 20 CBs, the order to trip the 20th CB is sent in less than 500 ms after the fx< detection
- If the group contains as many as 40 CBs, the order to trip the 20th CB is sent in less than 500 ms after the fx< detection and the order to trip the last CB is sent in less than 1 second after the fx< detection
- A blocking condition on a CB prevents its trip
- No other information than the blocking condition can prevent the CB trip, such as interlocking, control uniqueness, bad CB state (already open, jammed, and so on….)

Note:
Time constraints are given from fx< transition detection to Digital Output closure.

Any invalid state of the fx< SPS (Selfcheck faulty, toggling) is not taken into account to trig the automation.

In the event of a simultaneous fx< detection: that is, multiple fx< detection with the same time tag, the groups are activated in the order of trigger detection:

- If the "inter-group delay" is null, the time constraints given above are respected for each group
- If the "inter-group delay" is not null, all CB of one group are tripped before beginning to trip all CB of the following group.

In the event of multiple fx< detections: that is, fx detection during activation of an other group, the groups will be activated in the order of trigger detection. So, all CBs of the first group will be tripped before beginning to trip all CBs of the following group.

7.6.3 OUTPUTS

- LS On/Off Status (DPS type): status of the Load Shedding automation
- LS Group x status (SPS permanent type, 1≤x≤4): set as soon as a group is activated: that is, the fx< input is set and automation status is On. Reset when the last CB control has been performed, whatever was the control result
- LS CB x rejected for blocking condition (SPS transient type, 1≤x≤40): one piece of information on a per circuit-breaker basis. Set during 100 ms if the control is refused due to a blocking condition
- LS CB x completed (SPS transient type, 1≤x≤40): one piece of information on a per circuit-breaker basis. Set during 100 ms if the control has been correctly performed: that is, the breaker opened before the end of the control time-out.
- LS CB x failed (SPS transient type, 1≤x≤40): one piece of information on a per circuit-breaker basis. Set during 100 ms if the CB is not opened at the end of the control time-out
- Listx Status (1≤x≤4): status of the assignment of CB to a group, transmitted to the SCADA through an analogue value (ASDU 09 or 10)
- Blocking condition x Status (1≤x≤6): list of CBs for which the blocking condition is set, transmitted to the SCADA through an analogue value (ASDU 09 or 10)
- CBx open control: control for CB trip

7.6.4 HYPOTHESIS AND CONSTRAINTS

- Only one frequency relay provides frequency thresholds to the C26x
- The Load Shedding automation can manage as many as 40 circuit-breakers
- All DOU, HBU or CCU boards used for CB controls must be in the same rack
- All the configurable information used for Load Shedding function is set using DS Agile SCE
- There is no way to visualise / modify the settings from the controller local HMI or from the CMT
- Functioning in the event of a main 1 rack redundancy
  - Load Shedding must operate in the event of a main 1 rack redundancy.
  - LS function can be set On or Off from the SCADA interface. The SCADA sends this order to only one main 1 rack. The order must be automatically transmitted to other main 1 racks.
  - All settings defined on a main 1 rack are also automatically transmitted to other main 1 racks. [settings = Inter-group delay; List of circuit-breakers attached to each group; List of circuit-breakers blocked by each blocking condition]
  - In the event of a group activation (*fx*< goes in Set state), the LS automation operates in parallel on all front-end main racks.
- Management of the LS On/Off state
  - The LS On/Off state is saved in non volatile memory. This data is erased only when the controller boots with a DB without LS (so, this information is kept on DB switch).
  - After a controller reboot, if a “saved LS On/Off state” is found the LS function is set in this saved state, otherwise the LS is set in On state (default state).

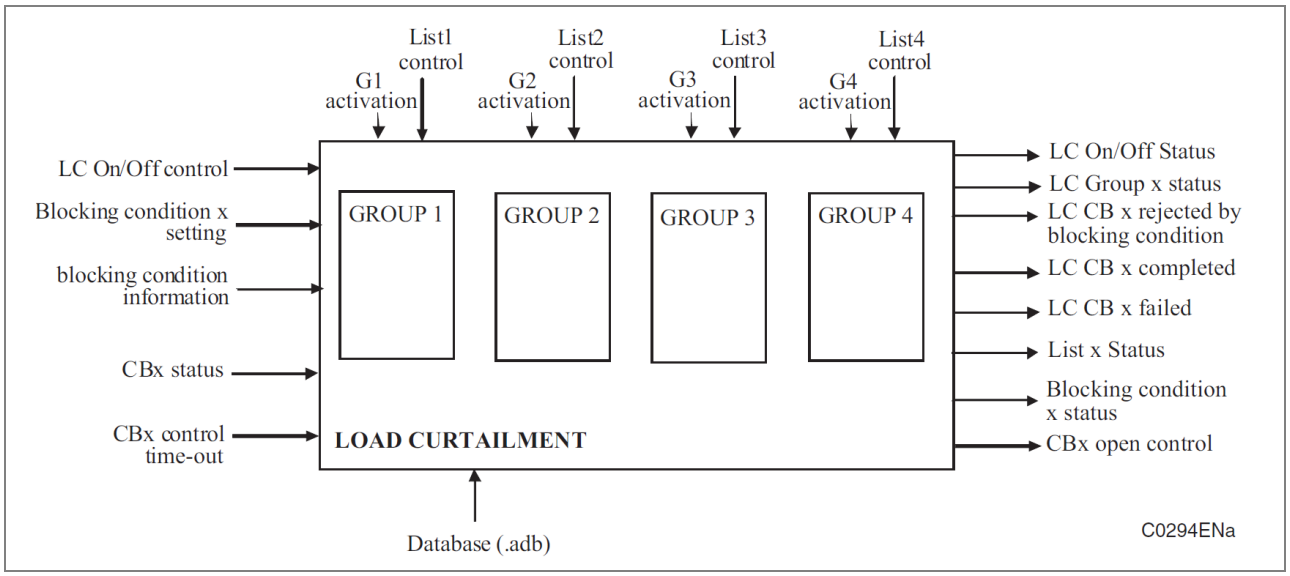
- Management of Settings
  - LS setting are saved in non volatile memory. This information is erased on DB switch.
  - After a controller reboot, if “saved LS settings” are found these settings are used, otherwise settings given by the DB are used.

7.6.5 CONFIGURABLE DATA

Attribute	Default Value	Range	Provided through S9R file	Comments
Load Shedding Automation				
Inter-group delay	100 ms	from 0 to 9999 ms	Yes	with a 100 ms step
Circuit Breaker				
Group assignment	0	[0..4]	Yes	0 = no assignment to a group
Breaker number	0	[0..40]	Yes	0 = not used in Load Shedding
control time-out	600 ms	[0..6000000]	Yes	Given by the feedback timeout on the CB control
Blocking condition n° 1	No	Yes / No	Yes	No = the blocking condition is not used for the breaker
Blocking condition n° 2	No	Yes / No	Yes	
Blocking condition n° 3	No	Yes / No	Yes	
Blocking condition n° 4	No	Yes / No	Yes	
Blocking condition n° 5	No	Yes / No	Yes	
Blocking condition n° 6	No	Yes / No	Yes	
SPS / DPS datapoint				
Blocking condition number	0	[0..6]	Yes	0 = the SPS / DPS is not used as a blocking condition
Blocking state	On	On / Off	Yes	Indicates if the blocking condition is active with the ON or OFF state

Furthermore, all datapoints described above are configured using the SCE and must be provided by the S9R file.

7.7 LOAD CURTAILMENT – C26X-STANDALONE



7.7.1 INPUTS

- List1, List2, List3, List4 control: each “list” input is a set of two setpoints associated to a group. These setpoints give the list of circuit-breakers attached to a group. They can be only received from the SCADA interface. ASDU 48 (setpoint normalised value) is used for these setpoints.
- Gx activation: SPC, for each group, that allows you to activate the Load Curtailment function for the Group x when a SET control is received (the RESET control has no effect).
- LC On/Off Control: control (DPC type) that allows you to set On or Off the Load Curtailment automation. This control can be received from the SCADA interface or from the C26x local HMI.
- Blocking condition x setting (1≤x≤6): each blocking condition setting is a set of 2 setpoints. These setpoints gives the list of circuit-breakers blocked by the condition x. It can be only received from the SCADA interface. ASDU 48 (setpoint normalised value) is used for these setpoints.
- Blocking condition information: digital inputs that block the CB trip is set, according to the CBx blocking condition setting. A maximum of 6 SPS / DPS can be defined as blocking condition information.
- CBx status: status of each circuit-breaker (Feedback of the CBx control).
- CBx control time-out: one time-out per circuit-breaker. For a circuit-breaker, this time-out defines the authorized delay between the CB control activation and the CB position change. These time-outs are defined in configuration – through DS Agile SCE – as the CB control’s Feedback time-out.
- Database: C26x database (.adb file).

7.7.2 ALGORITHM

Group definition

At configuration time (with DS Agile SCE), the operator defines the list of CBs attached to each Load Curtailment group. The CB minimum number in a group is 0, the maximum number is 5. No more than 20 CBs can be defined for the whole automation. The 20 CBs that can be used in load curtailment function are tagged in configuration with a number from 1 to 20.

When the database is downloaded and switched, the load curtailment automation takes into account information described in the database (last setting sent by the SCADA is lost). The Listx status information is updated and sent to the SCADA.

The assignment of CB to the groups is performed on-line through the SCADA interface, whatever was the status of the automation (On or Off). Two setpoints are defined per group, each value combination gives the allocation of a CB to the group as defined in the table below:

Breaker number/ setpoint 1	**/**	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Breaker number/ setpoint 2	/	/	/	/	/	/	/	/	/	/	/	20	19	18	17	16
Bit	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Value		16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

If a CB is already assigned to another group, it is automatically re-assigned to the new group (a CB can be affected to only one group). After assignment, the Listx status information for group(s) that has(have) been modified is sent to the SCADA.

During CB assignment (from the reception of the Listx control up to the sending of the Listx status), the load curtailment function cannot be started.

The group definition is saved in flash memory and restored after a controller reboot. It is erased in the event of a database switch.

Locally to the controller, assignments of CB to a group can be performed only through a database download.

Blocking conditions

You can define as many as 6 SPS/DPS as blocking condition: they are numbered from 1 to 6.

At configuration time (with DS Agile SCE), the operator defines the list of blocking conditions activated for each circuit-breaker.

When the database is downloaded and switched, the load shedding automation takes into account information described in the database (last setting sent by the SCADA is lost).

The use of blocking condition is performed through the SCADA interface, whatever was the status of the automation (On or Off). Two setpoints are defined on a per blocking condition basis; each value combination gives the association between the CB and the blocking condition (refer to the table of group definition).

The usage of blocking conditions is saved in flash memory and restored after a controller reboot. It is erased in the event of a database switch.

After assignment, the Blocking condition x status information for blocking condition(s) that has (have) been modified is sent to the SCADA.

Automation

The automation is activated only if it is On. The On/Off control (DPC) is performed through the SCADA interface or the C26x LHMI. The automation status is provided through a DPS.

When the SET control is received through the Gx Activation SPC: that is, reception by the C26x of the order, all the CB belonging to the group x must be tripped in less than 300 ms.

Notes:
- A blocking condition on a CB prevents its trip
- No other information than the blocking condition can prevent the CB trip [inter-locking, control uniqueness, bad CB state (already open, jammed, …), ….]

In the event of a multiple reception of Gx Activation controls, the groups are activated in the order of control reception. So the CBs of a group are tripped before beginning to trip those of another group. In this event, the time to trip the CB of the other(s) group(s) can be more then 300 ms.

7.7.3 OUTPUTS

- LC On/Off Status (DPS type): status of the Load Curtailment automation
- LC Group x status (SPS permanent type, 1≤x≤4): set as soon as a group is activated: that is, one Gx Activation control received and automation status is On. Reset when the last CB control has been performed, whatever was the control result
- LC CB x rejected for blocking condition (SPS transient type, 1≤x≤20): one piece of information on a per circuit-breaker basis. Set during 100 ms if the control is refused due to a blocking condition
- LC CB x completed (SPS transient type, 1≤x≤20): one piece of information on a per circuit-breaker basis. Set during 100 ms if the control has been correctly performed: that is, the breaker opened before the end of the control time-out.
- LC CB x failed (SPS transient type, 1≤x≤20): one piece of information on a per circuit-breaker basis. Set during 100 ms if the CB is not opened at the end of the control time-out
- Listx Status (1≤x≤4): status of the assignment of CB to a group, transmitted to the SCADA through an analogue value (ASDU 09 or 10)
- Blocking condition x Status (1≤x≤6): list of CBs for which the blocking condition is set, transmitted to the SCADA through an analogue value (ASDU 09 or 10)
- CBx open control: control for CB trip

7.7.4 HYPOTHESIS AND CONSTRAINTS

- The Load Curtailment automation can manage as many as 20 circuit-breakers
- All DOU or CCU board used for CB controls must be in the same rack
- All the configurable information used for Load Curtailment is set using SCE
- There is no mean of visualisation/modification of settings from the controller local HMI or from the CMT
- Functioning in the event of a main 1 rack redundancy is identical to LS except for group activation: as the '*Gi activation'* is received from SCADA interface, the LC automation operates only on the Front-end main rack that received this activation.
- Management of the LC On/Off state: identical to LS
- Management of Settings: identical to LS

7.7.5 CONFIGURABLE DATA

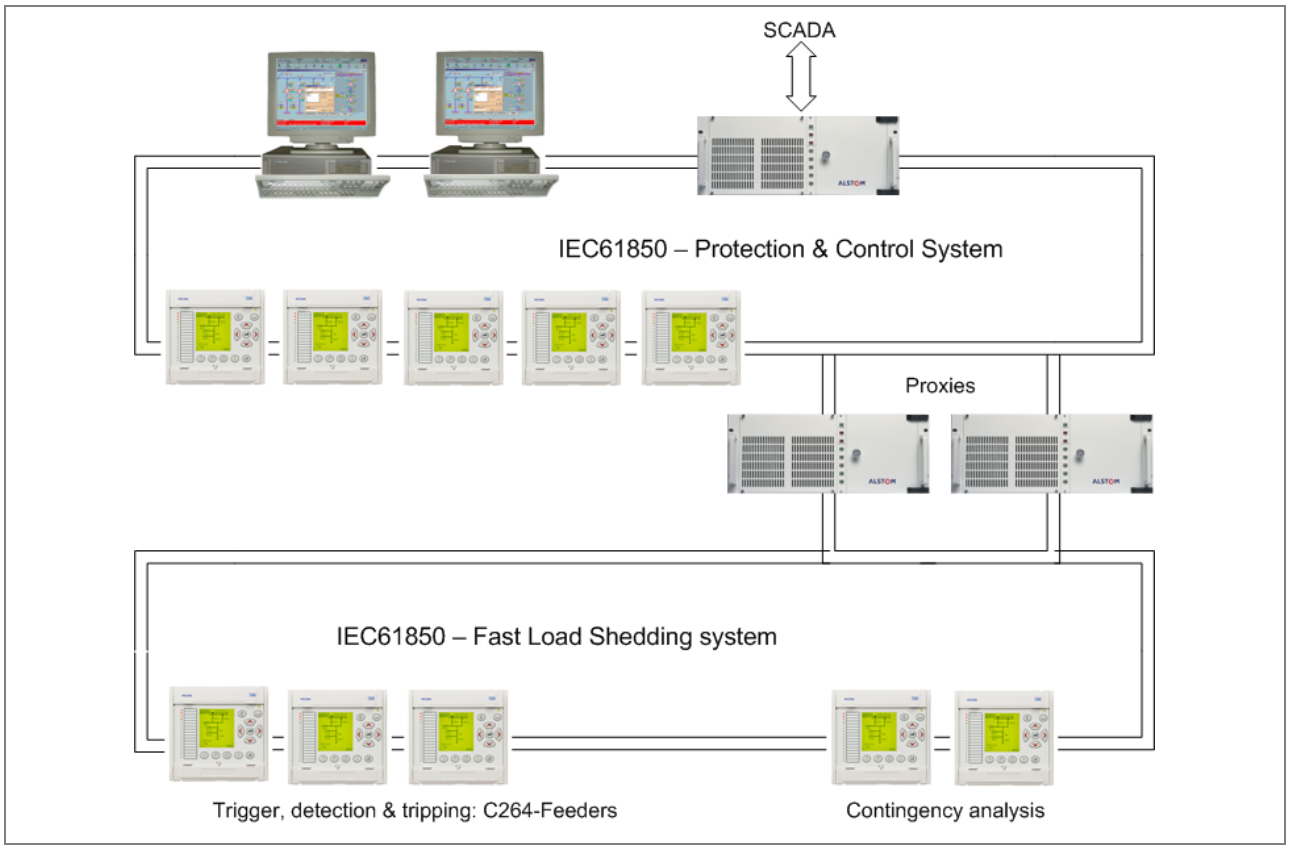
Attribute	Default Value	Range	Provided through S9R file	Comments
Circuit Breaker				
Group assignment	0	[0..4]	Yes	0 = no assignment to a group
Breaker number	0	[0..20]	Yes	0 = not used in Load Curtailment
Control time-out	600 ms	[0..6000000]	Yes	Given by the feedback timeout on the CB control
Blocking condition n° 1	No	Yes / No	Yes	No = the blocking condition is not used for the breaker
Blocking condition n° 2	No	Yes / No	Yes	
Blocking condition n° 3	No	Yes / No	Yes	
Blocking condition n° 4	No	Yes / No	Yes	
Blocking condition n° 5	No	Yes / No	Yes	
Blocking condition n° 6	No	Yes / No	Yes	
SPS / DPS datapoint				
Blocking condition number	0	[0..6]	Yes	0 = the SPS / DPS is not used as a blocking condition
Blocking state	On	On / Off	Yes	Indicates if the blocking condition is active with the ON / OFF state

Furthermore, all these datapoints are configured using SCE and must be provided by S9R file

7.8 FAST LOAD SHEDDING (FLS)

The Fast Load Shedding speeds up the Load Shedding process using GOOSE system message exchange; thus the loads are permanently compared to the available power and shed within 80 ms, according to priorities, in case of shortage.

FLS requires a dedicated architecture such as:



The proxy gateway continuously transfers the required data (measurements, loads, electrical topology) from the main application to the FLS. This information is cyclically computed to recalculate the decision matrix defining for each load and trigger if shedding is needed.

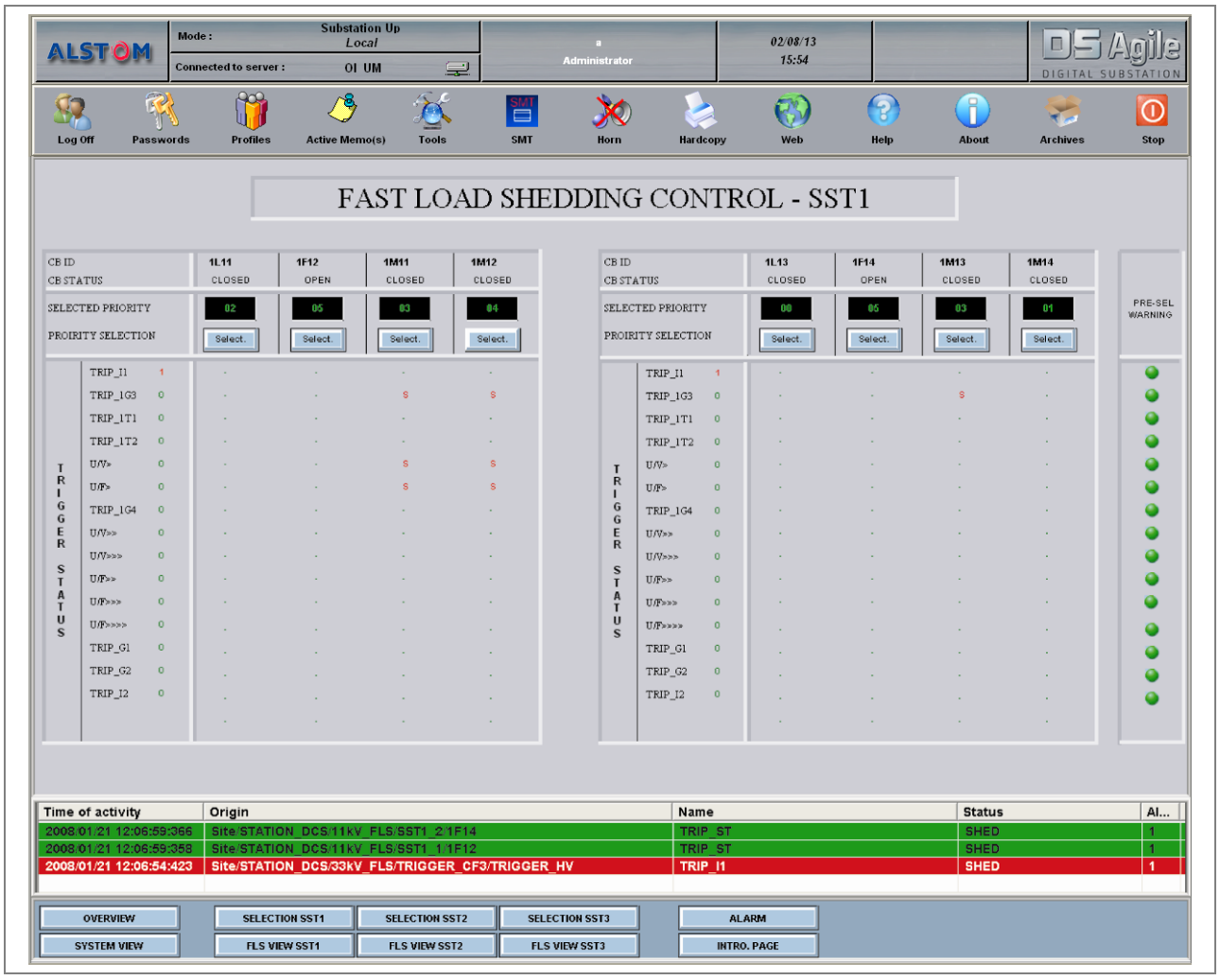
Contingency scenarios are computed to predetermine the loads to be shed if one of the triggers materializes on one or more computed networks.

The algorithm allows also to overdrive a generator to temporarily provide more power, till a process slow down.

The main C26x supports the ISaGRAF and/or PSL automations.

As many as 48 C26x Feeder controllers support the FLS Function. You can create as many as 300 output breaker commands.

Simulation allows anticipating impacts. On the OI interface that follows you can select priority and read the decision matrix:



7.9 RELAY AUTOMATISM FUNCTIONS

Note:
Relay automatism functions are associated with protection functions and are therefore only available for DS Agile C26x fitted with a TMU210 CT/VT board.

7.9.1 TRIP CURRENT MEASUREMENT INDICATION

After an overcurrent trip, this built-in function records and processes the three phase currents – and optionally the neutral current – at the time of the trip command decision.

It is available if:

- at least one standard directional/non-directional overcurrent protection function ([67/50/51] or/and [67N/50N/51N]) is defined in the SCE configuration database,
- the corresponding threshold(s) (Trip I>, Trip I>>, Trip I>>>, Trip Ie>, Trip Ie>> and/or Trip Ie>>>) are set to ON in the AUTOMAT. CONTROL column in DS Agile S1,
- the acquisition of the three phase trip currents is configured in the SCE database.

These measurements are then processed as standard MVs and can be displayed on the C26x front panel LCD or/and forwarded to the system HMI or/and the SCADA via the Ethernet network.

4 MVs are available:

- Trip.current.A
- Trip.current.B
- Trip.current.C
- Trip.current.N (optional)

Inhibition

The function is blocked by:

- the pre-defined “Blocking SPS” associated with the protection function
- the pre-defined “Blocking control” associated with the protection function
- the upload by MiCOM S1 DS Agile of a setting file (for another function)

Local HMI behavior:

The measurements' values are initially set to '0'. When an overcurrent trip occurs, the values reflect the fault conditions at the time the trip command is issued, in Amps. When a new overcurrent trip occurs, the new values will be substituted to reflect the new fault conditions.

The values are stored in volatile memory and are reset to '0' if:

- the C26x reboots,
- a new database is downloaded or switched,
- a new firmware is downloaded.

Substation system HMI (OI/aView) behavior:

The trip current measurement values corresponding to the latest overcurrent trip are displayed as MVs. They are updated when the next overcurrent trip occurs.

Note:
This function can only be configured using the SCE, it cannot be edited using MiCOM S1.

7.9.2 OVERCURRENT/BREAKER FAILURE PHASE SEGREGATION: FAULTED CIRCUIT/FAILED CB POLE INDICATION

After an overcurrent trip, this built-in function records which circuits were affected by the fault that caused the trip command: phases A, B and/or C, and, optionally, neutral for earth faults.

In addition, if a trip command issued by any internal protection function is unsuccessful, the function records which circuit-breaker pole(s) failed to trip.

Overcurrent/earth fault indication is available if:

- at least one standard directional/non-directional overcurrent protection function ([67/50/51] or/and [67N/50N/51N]) is defined in the SCE configuration database,
- the corresponding threshold(s) (Trip I>, Trip I>>, Trip I>>>, Trip Ie>, Trip Ie>> and/or Trip Ie>>>) are set to ON in the AUTOMAT. CONTROL column in DS Agile S1.

Circuit-breaker failure indication is available if the CB Fail threshold is set to ON in the AUTOMAT. CONTROL column in MiCOM S1.

There are 7 SPS datapoints available, one for each circuit and circuit-breaker pole:

- Phase A overcurrent: **Ia phase fault**
- Phase B overcurrent: **Ib phase fault**
- Phase C overcurrent: **Ic phase fault**
- Neutral for earth fault: **In earth fault**
- CB phase A pole failed to trip: **Ia ph fault 50BF**
- CB phase B pole failed to trip: **Ib ph fault 50BF**
- CB phase C pole failed to trip: **Ic ph fault 50BF**

If the function is used with overcurrent or earth fault protection, the three phase SPS datapoints must be configured. The earth fault SPS is optional. The three circuit-breaker failure SPS datapoints are automatically added and cannot be deleted.

When an overcurrent/earth fault trip occurs or a circuit-breaker pole fails to trip, the corresponding SPS datapoints are updated, i.e. their states are *SET* and the corresponding events are time-stamped. The states of the phase overcurrent and earth fault datapoints are *RESET* when all the conditions that have initiated the event have disappeared, i.e. the electrical fault is cleared. The states of the CB failure datapoints are *RESET* when all conditions that have initiated the event have disappeared, usually when the upstream circuit-breaker has tripped.

Local HMI behaviour:

The indications corresponding to the latest event can be listed in the **Events panel** as standard permanent SPS datapoints.

The datapoints are initially RESET (=0). When an overcurrent/earth fault trip or a circuit-breaker failure occurs, the values reflect the faulted circuits or failed poles at the time the trip command is issued.

For instance:

- the datapoints **Ia phase fault** and **Ib phase fault** being SET (=1) would mean that the phase A and phase B currents were above the trip threshold at the time the trip command was issued, indicating a probable A-B fault,
- the datapoints **Ia phase fault** and **In earth fault** (if configured) being SET (=1) would mean that phase A current and the neutral current were above their respective thresholds at the time the trip command was issued, indicating a probable A-N fault,
- the datapoint **Ia ph fault 50BF** being SET (=1) would indicate a failure to trip by the circuit-breaker's pole A.

Note:
The function does not discriminate between concurrent, related or unrelated, faults. For instance, an A-B fault and a separate C-N fault would cause the same display as an A-B-C-N fault.

Substation system HMI (OI/aView) behaviour:

The indications corresponding to the event can be listed in the **Events view** as standard permanent SPS datapoints.

Note:
This function can only be configured using the SCE, it cannot be edited using DS Agile S1.

7.9.3 VOLTAGE TRANSFORMER SUPERVISION (VTS)

Voltage transformer supervision is used to detect failure of the ac voltage inputs to the unit. This may be caused by internal voltage transformer faults, overloading, or faults on the interconnecting wiring to the C26x. This usually results in one or more VT fuses blowing. Following a failure of the ac voltage input, there would be a misrepresentation of the phase voltages on the power system, as measured by the C26x, which may result in mal-operation.

The VTS function in the C26x is designed to detect voltage failures, and set datapoints that can in turn be used to issue alarms or adjust the configuration of voltage-dependent protection elements whose stability would otherwise be compromised. It uses a combination of three detection methods:

- Single- or two-phase fuse failures: Voltage imbalance with no fault currents
- Three-phase fuse failures (optional): No voltages and no superimposed currents
- Miniature circuit-breaker input: Digital input from the voltage transfomer's MCB, indicating that it has tripped

Single- or two-phase fuse failure

A fuse failure is detected if either or both of the residual and negative-sequence voltages are above the settable thresholds VN> and V2> while none of the currents (phase currents, zero- and negative-sequence currents) are above the settable thresholds IA>/IB>/IC>, I0> and I2>.

Three-phase fuse failure (optional)

The 3-phase detection option can be enabled or disabled separately.

Under the loss of all three phase voltages to the C26x, there will be no negative phase sequence quantities present to operate the VTS function. However, under such circumstances, a collapse of the three phase voltages will occur. If this is detected without a corresponding change in any of the phase current signals (which would be indicative of a fault), then a fuse failure condition will be raised. In practice, the C26x detects the presence of superimposed current signals, which are changes in the current applied to the relay. These

signals are generated by comparison of the present value of the current with that exactly one cycle previously. Under normal load conditions, the value of superimposed currents should therefore be zero. Under a fault condition, a superimposed current signal will be generated which will prevent operation of the VTS function.

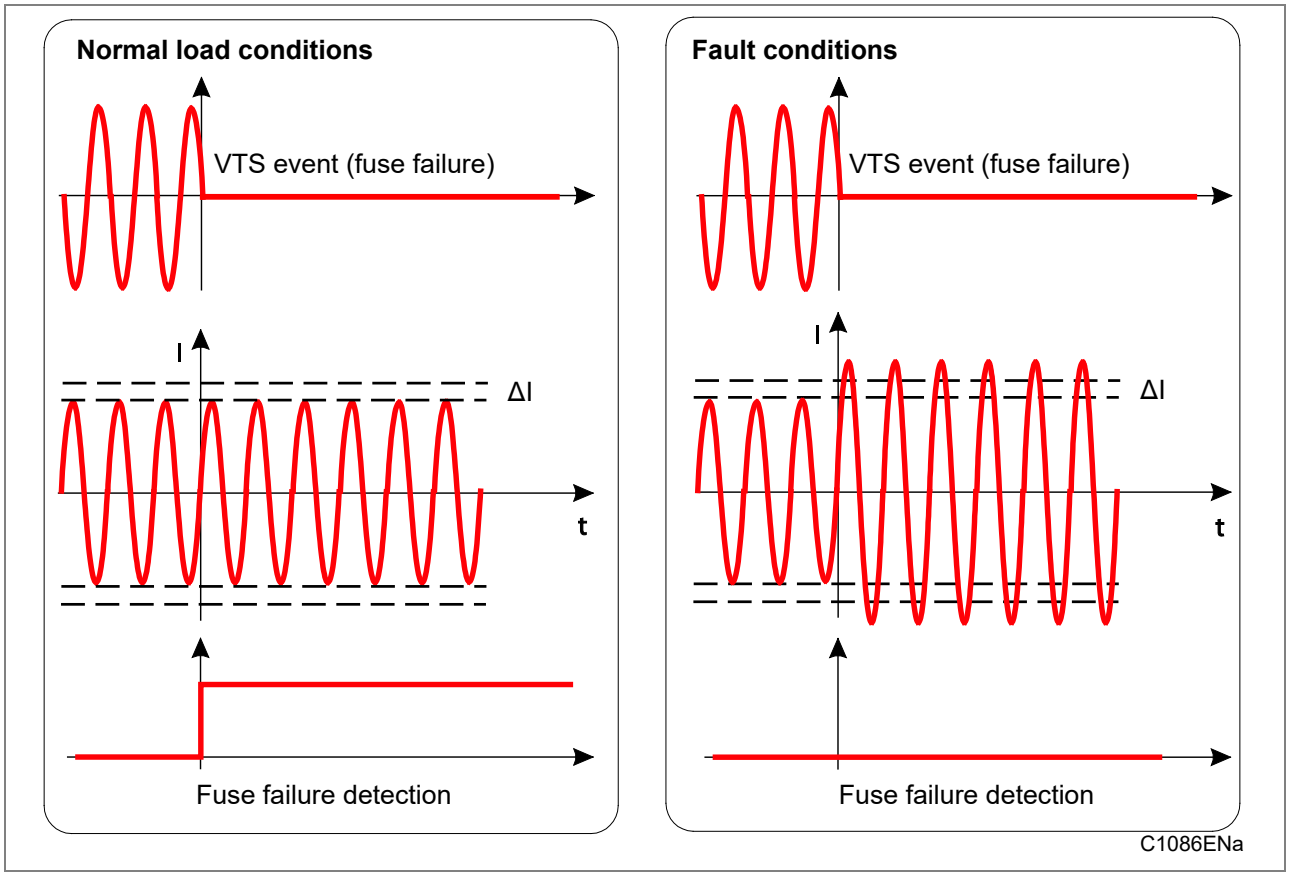


Figure 100: Superimposed current principle

A 3-phase fuse failure is detected when no line voltages are present, i.e. all phase voltages are below the settable threshold VA</VB</VC<, while none of the three superimposed currents are above a set threshold ΔIA>/ΔIB>/ΔIC> and no autoreclose cycle is in progress (NO.AR.PROG SPS input). This detection is reset by the "No voltage & No current" internal input (all phase currents under 0.1 In and all phase voltages under 0.1 Vn, meaning that the circuit-breaker has tripped).

Global logic

If either of these methods computes a fuse failure, the C26x checks that there is no indication that the circuit-breaker is open, i.e. neither the "No voltage & No current" internal input nor the ALL.POLE.DEAD SPS datapoint are SET.

An instantaneous fuse failure indication is made available (VT.FUSE.INST SPS datapoint) for information purposes.

The fuse failure detection signal is also fed through a timer, VT Fuse Delay. If the fuse failure conditions are still present when this timer elapses, a confirmed fuse failure signal is issued (VT.FUSE.TEMP SPS datapoint).

Miniature circuit-breaker input

A trip by the voltage transformer's MCB is received via a digital input and linked to the VT.FUSE.FAIL SPS. The reception of this signal immediately results in the issuance of a confirmed fuse failure signal (VT.FUSE.TEMP SPS datapoint).

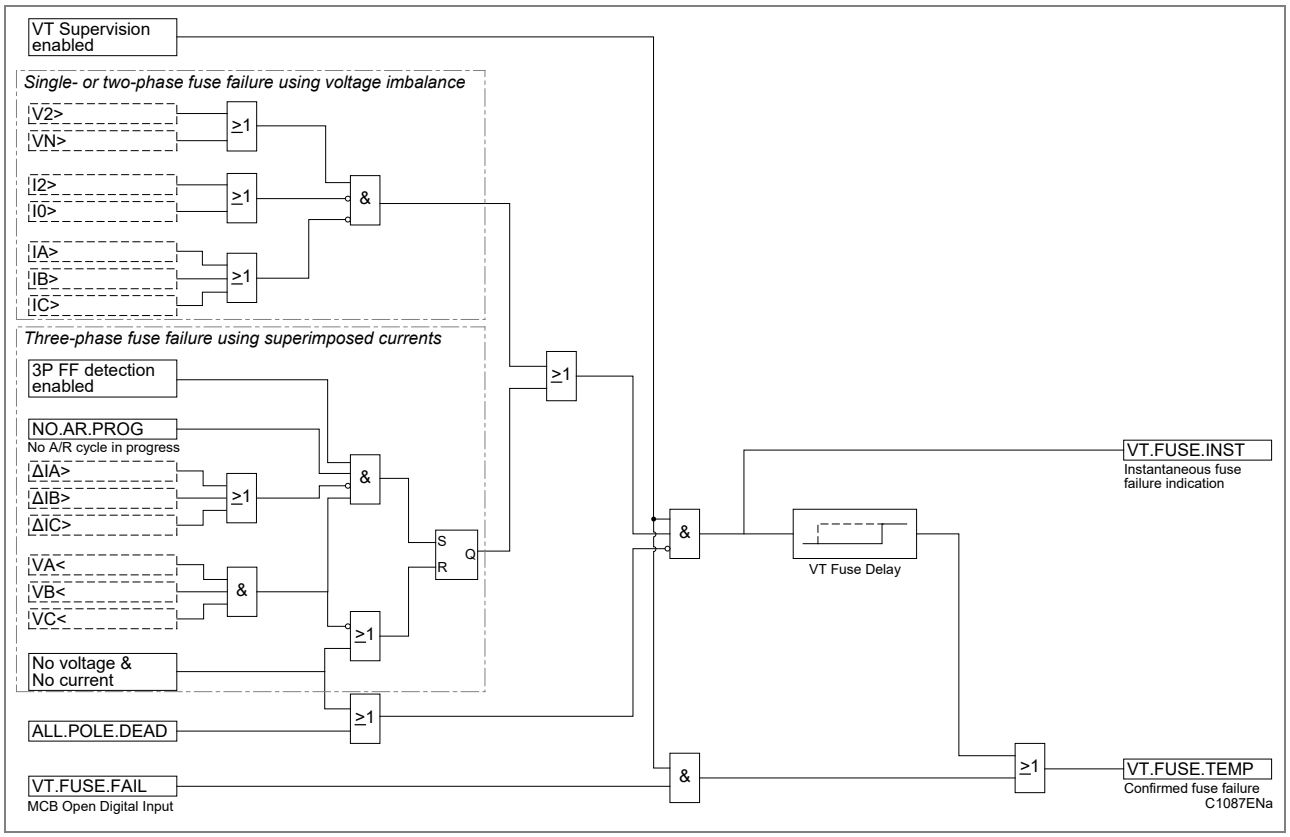


Figure 101: Fuse failure detection logic

Notes:
1. The VTS function parameters can be set using DS Agile S1 as well as DS Agile SCE.
2. Because the VTS function uses the three phase voltages and the neutral voltage, either measured or derived, the VT topology must be at least either a full "star", i.e. the three phase-neutral voltages, or a full "delta" + VN, i.e. the three phase-phase voltages + the residual voltage.
The compatible SCE settings for the TMU210's type of connection attribute are as follows:
- 3 Vpn (star)
- 3 Vpn + V0 (star)
- 3 Vpn + Vb (star)
- 3 Vpp + V0 (delta)

8 RECORDS

Several kinds of record are stored in the C26x.

8.1 PERMANENT RECORDS STORAGE

All parameters or settings that can be modified via the front panel LHMI are stored in flash memory.

Lists of system information are also stored in the flash memory.

8.1.1 EVENTS

All data change or events declared in the C26x configuration database “To be logged” are stored in a circular queue.

The event records are available for viewing either via the front panel LHMI, via a slave protocol at SCADA level or on CMT/SMT equipment. They can also be printed.

Events, depending on the C26x configuration, can typically contain the C26x description, the date of the event and the time of the event with an accuracy of 1 ms, plus specific information regarding the causes of the events.

The C26x under the following circumstances can record events:

- Quality-valid changes of state of Binary Inputs (SP, DP, Groups)
- Changes of state of Measurements
- Changes of state and value of Tap Position Indications
- Devices Control actions and acknowledgements
- Alarm acknowledgement

The size of the queue is:

- 200 data for front panel
- 2000 data for CMT
- settable for each slave protocol for SCADA.

8.1.2 WAVEFORM RECORDING: GENERAL

A waveform recording deals with the storage of measurement and logical information in order to visualise the electrical network behaviour when electrical events appear, such as the start of the generator. These types of events are called “trigger of waveform recording”.

In order to see the influence of a trigger, data are recorded before (pre trigger time) and after (post trigger time) the raise of the trigger.

Two types of waveform recording can be performed in the controller:

- Fast Waveform recording that gives access to samples. This record is useful for transient electrical events.
- Slow scan triggered recording (SST) referred to as Slow Waveform recording that gives access to RMS values. This record is useful to define load profile or power regulation.

8.1.3 FAST WAVEFORM RECORDING

For the TMU2XX Boards, the inputs for the fast waveform records follow:

	INPUTS					
TMU BOARD	CT: as many as	VT: as many as	DSP	DSPIO	Digital I&Os	Analog I&Os
TMU210	4	4	NO	DSPIO	YES	YES
TMU220	4	5	DSP	NO	NO	YES

You can capture as many as 128 digital channels. The choice of selected inputs/outputs is defined in configuration.

The waveform recorder provides as many as 8 analogue measurements and as many as 128 digital channels for extraction by a remote device.

A maximum of 480 cycles (9.6 seconds at 50 Hz) of measurements samples, with 32 samples per cycle, can be stored, divided in 1, 2, 4 or 8 files saved in flash disk.

A timer channel is also required to provide accurate timing information for each sample. The delay between each sample is assumed constant over a single cycle.

Number of Files	Number of cycles
8	60
4	120
2	240
1	480

The waveform recorder can be triggered by the following user-settable events:

- Changes in state of binary inputs (SP, DP, or Groups). The triggering is available only from a state/value with VALID quality (ex: SET/RESET; OPEN/CLOSE) to a state/value with VALID quality Changes in state of digital outputs (in case of SBO, the execution order is the trigger)
- Measurement threshold violations
- Operator request (controls)

Only one re-triggering is permitted: it means that a new trigger can only be accepted after the end of recording of the current waveform.

Waveform records are available in COMTRADE 2001 format.

8.1.4 SLOW WAVEFORM RECORDING

The inputs for the slow waveform records are:

- Analogue values coming from CT VT calculation (RMS values)
- Analogue values coming from AIU boards
- Digital inputs
- Digital outputs

The function manages as many as 24 analogue and 48 digital values.

Data from TMU220 can be chosen among:

- RMS values of phase voltages (phase-to-neutral or phase-to-phase)
- RMS values of busbar voltage
- RMS values of phase current
- RMS values of residual voltage and current
- Fundamental sequence components
- Active, Reactive, Apparent Powers (components and total)
- Frequency and Harmonics level

Data from TMU210 can be chosen among:

- Star wiring: RMS values of phase-to-neutral voltages or/and instantaneous phase-to-phase voltage
- Delta wiring: RMS values of phase-to-phase voltage
- RMS values of busbar voltage (Vbb or Vr whether V4 or VN is connected on Busbar)
- RMS values of phase current
- RMS values of residual voltage and current (Vr, Ir)
- Zero sequence voltage (V0)
- Active, Reactive, Apparent Powers (total) and Power factor (total)
- Frequency of line (or busbar if V4 is connected to the busbar)
- Standard synchrocheck data (ΔF, ΔV, $\Delta \Phi$)

The C26x stores at maximum 5000 integrated values as follows:

Number of Files	Number of integrated values
1	5000
2	2500
5	1000
10	500
20	250
50	100

The integrated value has a duration of up to one hour. It is defined in configuration.

For analogue samples, the stored value is the average value of the signal over the integration time.

For digital samples, the stored value depends on the duration of the digital signal: if the signal duration is longer than the arbitration period, the stored value is 1, if it is shorter, the stored value is 0.

The slow waveform recorder can be triggered by the following events, each of which is settable:

- Changes in state of binary inputs (SP, DP or Groups). The triggering is available only from a state/value with VALID quality (ex: SET/RESET; OPEN/CLOSE) to a state/value with VALID quality
- Changes in state of digital outputs (in case of SBO, the execution order is the trigger)
- Measurement threshold violations
- Operator request
- Periodically: e.g., every day at 00h00

8.1.5 SLOW WAVEFORM RECORDING – CONDITIONS

The conditions for slow waveform recording include the following:

1 Digital inputs are not recorded if the integration time is longer than 100 ms (i.e. 5 cycles at 50 Hz, 6 cycles at 60 Hz)

2 A digital input is recorded as “1” if it remains at “1” during x% of the integration time (x between 10 and 100%, with a 1% step)

3 The permitted cycle numbers are as follows:

- 1 to 180 000 at 50 Hz
- 1 to 216 000 at 60 Hz

4 The measurements issued from analogue inputs boards are processed as follows:

- If the integration time is less or equal to 1 second, the recorded value is the current measurement value
- Otherwise, the recorded value is equal to:

$$Record = \sum_{i=1}^{N} \frac{TMi}{N}$$

N: number of seconds in the integration time

TMi: measurement value at the “i” second of the integration time



If the integration time is longer than 1 second, it can only be set as a multiple of 1 second, i.e.:
- At 50 Hz, it should be set to 100 (2s), 150 (3s), … 179950 (3599s) and 180000 (3600s).
- At 60 Hz, it should be set to 120 (2s), 180 (3s), … 215940 (3599s) and 216000 (3600s).

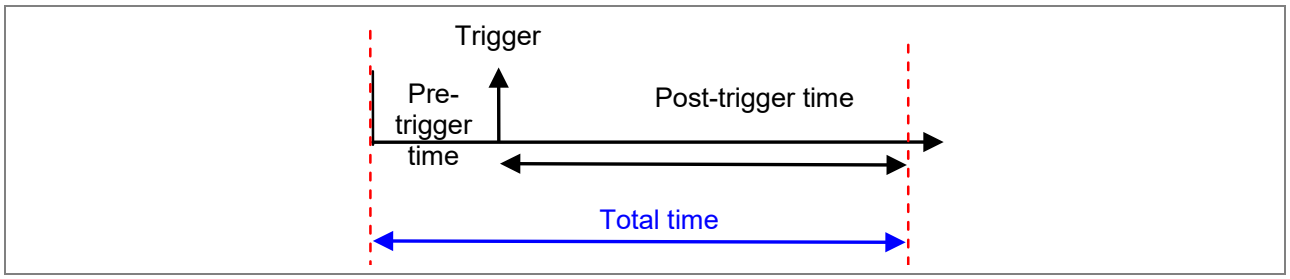
8.1.6 RECORDING – MECHANISM

The PPC sends a command, referred to as a trigger, to the DSP to start a disturbance recorder.

The DSP stores in a buffer 32 samples by period of the 8 analogue channels according to the configuration:

- Pre-trigger time
- total time
- integration time

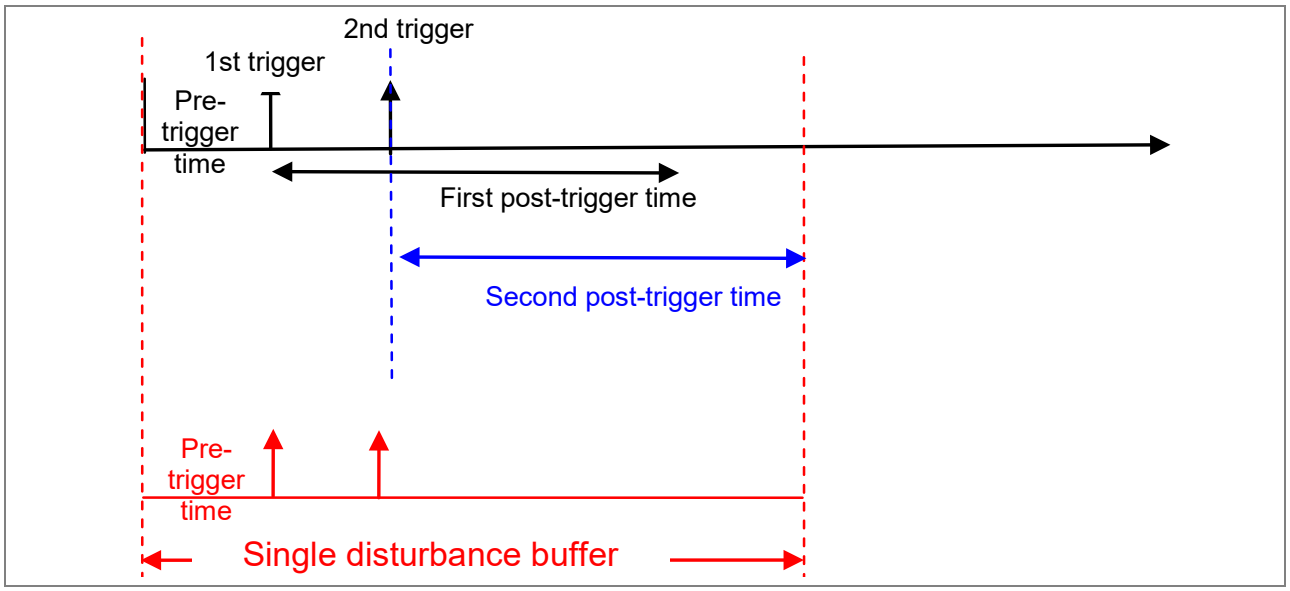
PPC converts this buffer in wave form adding binary inputs/output defined in configuration.



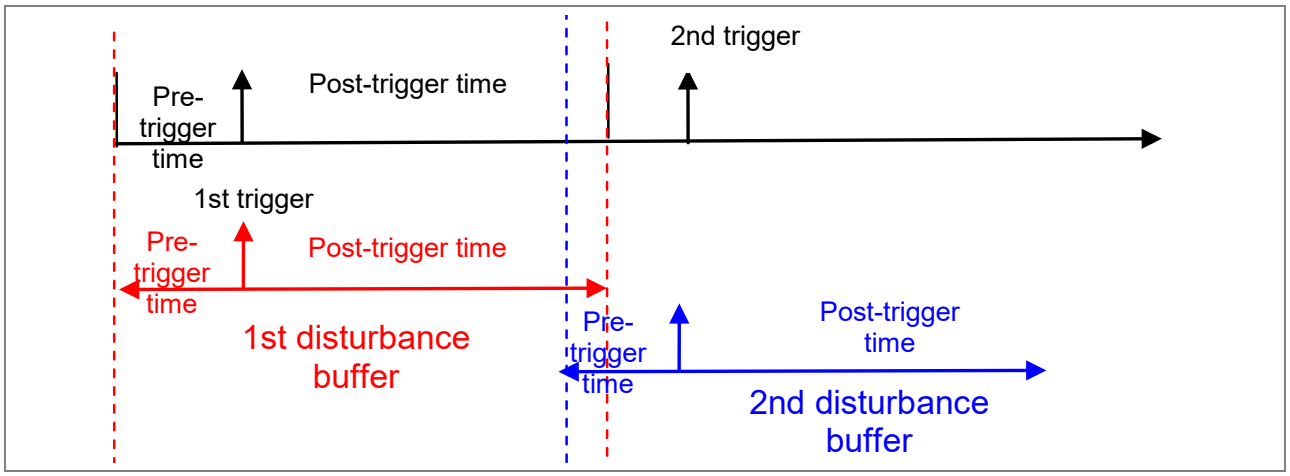
The maximum length of a disturbance buffer from the DSP is **2 * total time.**

One record contains at least one trigger and at most 2 triggers.

If a second trigger appears during the post time of the first trigger, only one buffer is generated by the DSP and split into two files by the PPC. Therefore the DS Agile C26x generates two files.



If a 2nd trigger appears after the post time of the first trigger, a second buffer is generated.



If a 3rd trigger appears, it is ignored if the previous buffer is not yet downloaded by the PPC.

8.2 NON-PERMANENT DATA STORAGE

8.2.1 ALARMS

8.2.1.1 DEFINITIONS

8.2.1.1.1 Definition of an alarm

An alarm is a visual (and optionally audible) annunciation of the appearance and/or disappearance, within the controlled electrical process or within the system itself, of an event, defined during the configuration phase as ”to be alarmed”.

These definitions, of what is to be alarmed and what it is not, are completely user relevant.

However the concept of alarms into DS Agile has been introduced to inform the operators of “abnormal” or “special” events or other miscellaneous events that you must absolutely not overlook.

8.2.1.1.2 Types of alarmed data

These events can generate an alarm:

- Each Binary Input (SP, DP, MP, SI, IED input, Groups) state related to “the reason for change” of these events
- Each Measurement state related to “the reason for change” of these events
- Each TPI state or value related to “the reason for change” of these events
- Each metering state related to “the reason for change” of these events

For example, the OPEN state of a circuit-breaker can be un-alarmed if the change is due to a control, and alarmed if the change is due to an other reason.

An alarm can be related to a control acknowledgement. In this event, the alarm is considered as “spurious”.

8.2.1.1.3 Alarm states definition

An alarm is generated by an event: for example, a particular datapoint in a state defined during the configuration phase as “to be alarmed”.

While this event is still present: for example, the previous particular datapoint is still in the same state, the alarm is “active”.

When this event disappears: for example, the previous particular datapoint is now in another not alarmed state; the previous alarm is “inactive”.

An existing alarm (active or inactive), can be acknowledged by an operator from the FP.

An alarm can have the following states:

- Inactive: no transition, no event
- Active-acknowledged: the cause is still present but the active state has been taken into account by the operator
- Active-unacknowledged: the cause is still present and the active state has not been taken into account by the operator
- Inactive-unacknowledged: the cause has disappeared but the inactive state has not been taken into account by the operator (only available for events alarmed on appearance and disappearance)
- Inactive-acknowledged: the cause has disappeared and the inactive state has been taken into account by the operator
- Inactive-active-unacknowledged: the cause has disappeared but the active state (previous state) has not been taken into account by the operator

8.2.1.1.4 Parameters associated to an alarm

The following user-selectable parameters can be associated with each alarm definition. The values are set during the configuration phase for each alarm:

- Immediate or differed:
  - an “immediate” alarm is displayed as soon it has been detected.
  - a “differed” alarm is displayed only after a user-selectable time delay following its detection (the event associated with the alarm must remain present during the delay; if not, the alarm will be not displayed); this delay is in the range of 1 to 120 seconds and can be set to particular value for each “differed” alarm.
- Gravity level: this level is defined for each alarm allowing a hierarchical classification to deal with the urgency of the events; the gravity level value can be: 0, 1, 2, 3, 4 or 5, 5 being the most grave and 0 meaning that there is no gravity level.
- Alarm generated:
  - only when the associated event appears

OR

  - when the associated event appears AND when it disappears

  In this event the “differed” parameter is taken into account only when event appears; when event disappears the new state of the alarm is displayed immediately.
- Alarm clearing mode:
  - manual: the alarm is cleared only on an operator request; this clearing command is only permitted on inactive-acknowledged alarms.
  - automatic: an alarm is automatically cleared when it reaches the appropriate state.
  - gravity basis
- Audible or not when detected.

8.2.1.2 ALARM PROCESSING

Only one alarm (the last one) associated with a state change of a data is displayed. The previous one (concerning the data) is replaced by the current one.

According to the previous example, only one from the three alarmed states can be displayed for the switching device: for example, "JAMMED" or "TOGGLING" or "OPEN" state (the last one that has appeared).

By configuration, one of the following behaviours is chosen:

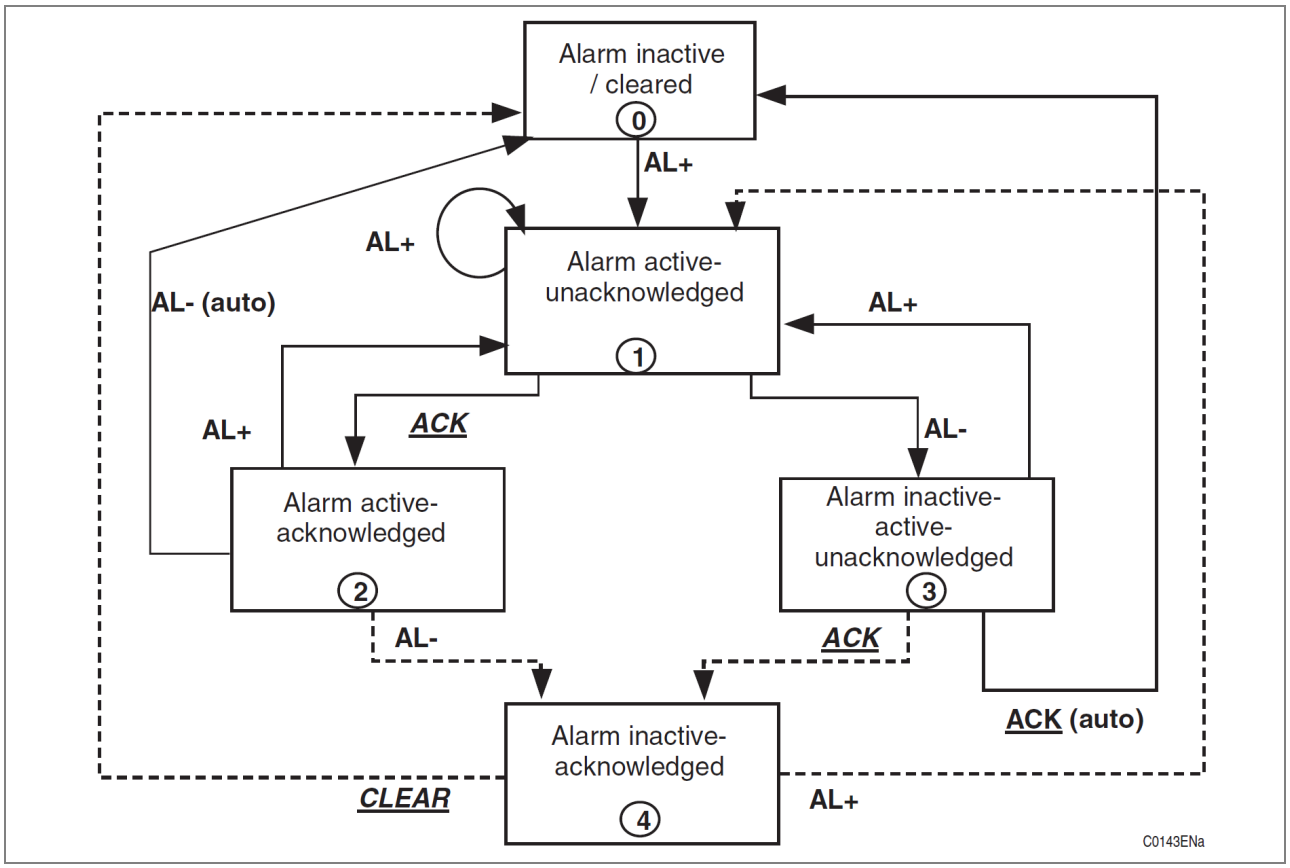


Figure 102: Event alarmed on appearance only

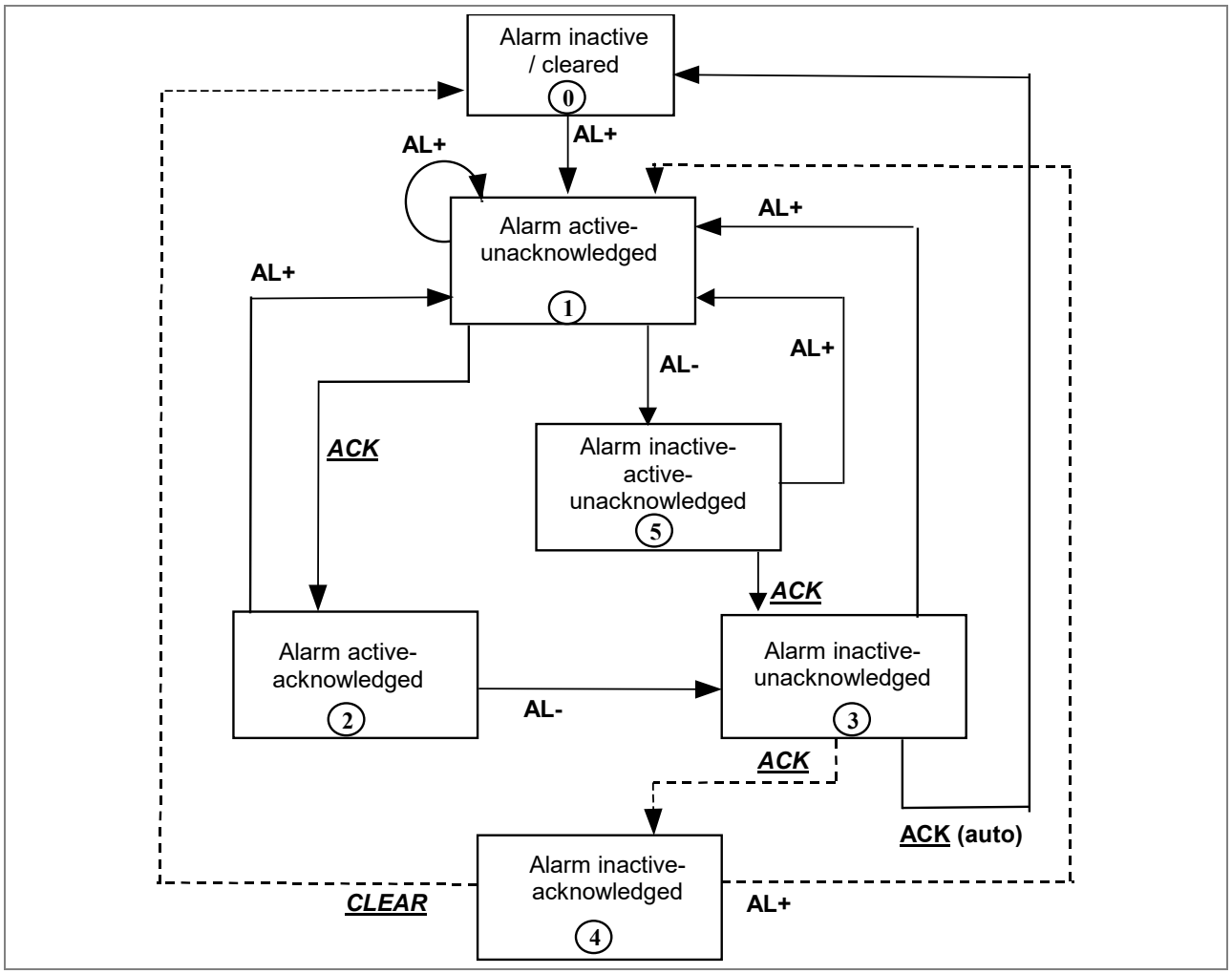


Figure 103: Event alarmed on appearance and disappearance

Transition events:

- AL+: alarmed event appearance
- AL–: alarmed event disappearance
- ACK: operator acknowledgement of the alarm
- CLEAR: operator clearing of the alarm

Note:
In that event "alarmed event disappears (AL-)" means that the associated data is now in another state that is not alarmed. The time stamp of the alarm is modified.

Transition conditions:

- (auto) means Automatic clearing

Transition description:

The transition from alarm state "0" to alarm state "1" is crossed when the alarmed event appears (AL+).

The alarm state transitions "1 → 1" and "2 → 1" are crossed when the state of the data associated with the alarm goes from a state that is flagged to be alarmed with any gravity level to another state that is also flagged to be alarmed with any gravity level (AL+). In this event the active alarm stays active but the time tagging of the alarm is changed. The new alarm time stamp corresponds to the last associated data state change. The alarm becomes unacknowledged if not already unacknowledged.

The alarm state transitions "1 → 2", "3 → 4" and “5 → 3” are crossed on operator acknowledge action. The time stamp of the alarm is unchanged.

The alarm state transitions "1 → 3" and “1 → 5” are crossed when the alarmed event disappears (AL-). The time stamp of the alarm is modified.

The alarm state transition "2 → 4" is crossed when the event disappears (AL-) the alarm being configured to be activated only "on appearance of the event". The time stamp of the alarm is modified.

The alarm state transition "2 → 3" is crossed when the event disappears (AL-) the alarm being configured to be activated "on appearance and disappearance of the event". The time stamp of the alarm is modified and the alarm will have to be acknowledged again.

The alarm state transitions "3 → 1", "4 → 1" and “5 → 1” are crossed when the previous alarmed event appears again or when another state that is also flagged to be alarmed with any gravity level appears (AL+). The alarm becomes active-unacknowledged. The time stamp of the alarm is modified.

The alarm state transition "2 → 0" is crossed when the event disappears (AL-) the alarm being configured to be activated only "on appearance of the event" and "to be cleared automatically". The alarm is removed from the alarm list.

The alarm state transition "3 → 0" is crossed on operator acknowledgement only if the alarm associated with the event is configured as "to be cleared automatically". The alarm is removed from the alarm list.

The alarm state transition "4 → 0" is crossed on operator clearing action. The alarm is removed from the alarm list.

8.2.1.2.1 Acknowledgement

Acknowledgement of an alarm can be done by two ways:

- **On operator request:** an operator can acknowledge an existing alarm from the front panel to signify that it has been taken into account.
- **Globally:** at substation level it is possible to use an SPS (named **Global alarm ack**) especially dedicated to a global acknowledgement of alarms: When this SPS is set to the SET state all alarms present in the controller are acknowledged. As long as this SPS remains in the SET state, any new alarm is inserted in the alarm list with the ACKLOWLEDGED status.

  In addition to the Global Alarm Acknowledgement SPS, a Local Alarm Acknowledgement SPS can be defined on a per C26x basis: that is, one for each C26x.
  This SPS can be wired or managed by an automation. When this SPS is configured in a C26x, the “Global Alarm Acknowledgement” SPS is no more taken into account by this C26x.
  When this SPS is SET, all C26x alarms are immediately acknowledged.
  This SPS cannot be transmitted on the Station Bus network: that is, it remains local to the C26x, so it cannot be associated to a remote – system HMI or SCADA - control.

8.2.1.2.2 Clearing

Whatever the clearing mode is, the clearing of an alarm is immediately taken into account: removal from the alarm list.

Automatic clearing

An alarm can be configured as “to be cleared automatically”. It means that when this alarm reaches the appropriate state, it is cleared automatically without any operator action. The events of “automatic clearing” are:

- the alarm is in the **active-acknowledged** state and the alarm disappears (for event alarmed on appearance only)
- the alarm is in the **inactive-active-unacknowledged** state and the operator acknowledges it (for event alarmed on appearance only)
- the alarm is in the inactive-unacknowledged state and the operator acknowledges it (for event alarmed on appearance and disappearance)

This feature can be configured on a per alarm basis.

Operator request clearing

An alarm that is not configured as “to be cleared automatically” has to be cleared by an explicit operator action (this action being only possible when it is in the “inactive-acknowledged” state). Otherwise it remains present in the alarm list.

As for an acknowledgement by an operator, clearing of alarms by an operator can be configured so as to be printed or not printed.

A global clearing procedure, that allows you to clear all “inactive-acknowledged” alarms in a single operation, will be provided.

Audible alarms

An audible alarm can be associated with the “unacknowledged” state of an alarm. This facility is configurable on a per alarm basis.

If an alarm is configured “audible” then the sound appears when the alarm is displayed.

The audible alarm is stopped when all audible alarms are acknowledged.

An audible alarm can be associated with the “unacknowledged” state of an alarm. This facility is configurable on a per alarm basis.

If an alarm is configured as “audible” then the sound appears when the alarm is displayed.

The audible alarm is stopped when all audible alarms are acknowledged.

HARDWARE

C26X/EN HW/D40

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1 HARDWARE DESCRIPTION

1.1 COMPONENTS

The DS Agile C26x is based on a modular and scalable architecture to support dedicated hardware modules adapted to the plant data interfaces.

Each DS Agile C26x rack can be equipped with the following modules:

- CPU270 (also named CPU3): **C**entral **P**rocessing **U**nit and communications board based on a PowerPC-type microprocessor (PowerQUICC II)
- **Front panel:**
  - GHU201 (for 80TE case) or GHU200 (for 40TE case): **G**raphical **H**uman machine interface **U**nit: Front Panel including 17 LEDs (13 are user-configurable) + 7 pushbuttons (L/R, Open, Close, etc) + LCD (resolution of 128 x 128 pixels /16 lines of 21 characters each) and a keypad at the front plate for local HMI management

    or
  - GHU211 (for 80TE case) or GHU210 (for 40TE case): Front Panel including 17 LEDs (12 are user-configurable) + 1 pushbutton (L/R)

    Or
  - GHU221 (for 80TE case) or GHU220 (for 40TE case): Front Panel used to connect a detachable HMI (GHU20x or GHU21x)
- **Power supply:**
  - BIU241: **B**asic **I**nterface **U**nit: this board includes the auxiliary power supply converter, the watchdog relay, 2 digital outputs/2 digital inputs for C26x redundancy and 2 isolated RS485/RS232 interfaces
  - BIU261: **B**asic **I**nterface **U**nit with universal input power supply: this board can hold a daughter board carrying a redundant power supply input, thus offering a dual-input power supply module. It also includes a watchdog relay, 2 digital outputs/2 digital inputs for C26x redundancy and 2 isolated RS485/RS232 interfaces.
- **Internal bus:**
  - FBP28x: **F**ront **B**ack**P**lane: bus for 80TE case
  - FBP24x: **F**ront **B**ack**P**lane: bus for 40TE case

Depending on the needs, additional modules may be added (optional):

- CU200: **C**ircuit breaker **C**ontrol **U**nit, each with 8 digital inputs and 4 digital outputs
- CCU211: **C**ircuit breaker **C**ontrol **U**nit, each with 8 digital inputs and 4 digital outputs (versions are jumper-selected)
- DIU200: **D**igital **I**nputs **U**nit, each with 16 digital inputs
- DIU210: **D**igital **I**nputs **U**nit, each with 16 digital inputs for voltages from 24 to 220V_{DC}
- DIU211: **D**igital **I**nputs **U**nit, each with 16 digital inputs for voltages from 24 to 220V_{DC} (versions are jumper-selected)
- DIU221: **D**igital **I**nputs **U**nit, each with 16 digital inputs for voltages from 154 to 170V_{DC}

- DOU200: **D**igital **O**utputs **U**nit, each with 10 digital outputs
- DOU201: **D**igital **O**utputs **U**nit, each with 10 digital outputs
- HBU200: **H**igh **B**reak **U**nit, each with 10 heavy duty digital outputs
- AIU211: **A**nalogue **I**nput **U**nit, each with 8 analogue inputs (direct current loops)
- TMU220: **T**ransducerless **M**easurements **U**nit board for direct CT/VT measurement used together with DSP260: Digital Signal Processing board
- TMU210: **T**ransducerless **M**easurements **U**nit board for direct CT/VT measurement used together with DSPIO: Digital Signal Processing board for protection functions
- AOU200: **A**nalogue **O**utput **U**nit, each with 4 current analogue outputs
- SWU20x: Ethernet **SW**itch **U**nit board, with 4 electrical links and x= 0 or x=2 optical links
- SWR21x: Ethernet **SW**itch board for **R**edundant Ethernet ring, with 4 electrical links and 2 optical links for the Dual ring
- SWD21x: Ethernet **SW**itch board for **D**ual Homing Ethernet star, with 4 electrical links and 2 optical links for a Dual star
- SWT21x: Ethernet **SW**itch board for **T**eaming hot standby redundancy between end nodes and a LAN (ring, star or tree), with 4 electrical links and 2 optical links
- SRP28x: Ethernet switch board for PRP (Parallel Redundancy) protocol, with 3 electrical links and 2 optical links
- SRP29x: Ethernet switch board for HSR (High availability Seamless Redundancy) protocol, with 3 electrical links and 2 optical links
- ECU200: **E**xtended **C**ommunication **U**nit board to convert non isolated RS232 into optical signal
- ECU201: **E**xtended **C**ommunication **U**nit board to convert non isolated RS232 into isolated RS485 signal



Caution:
50% of digital inputs and 50% of digital outputs may be energized simultaneously at the maximum ambient temperature (-25°C;+55°C).

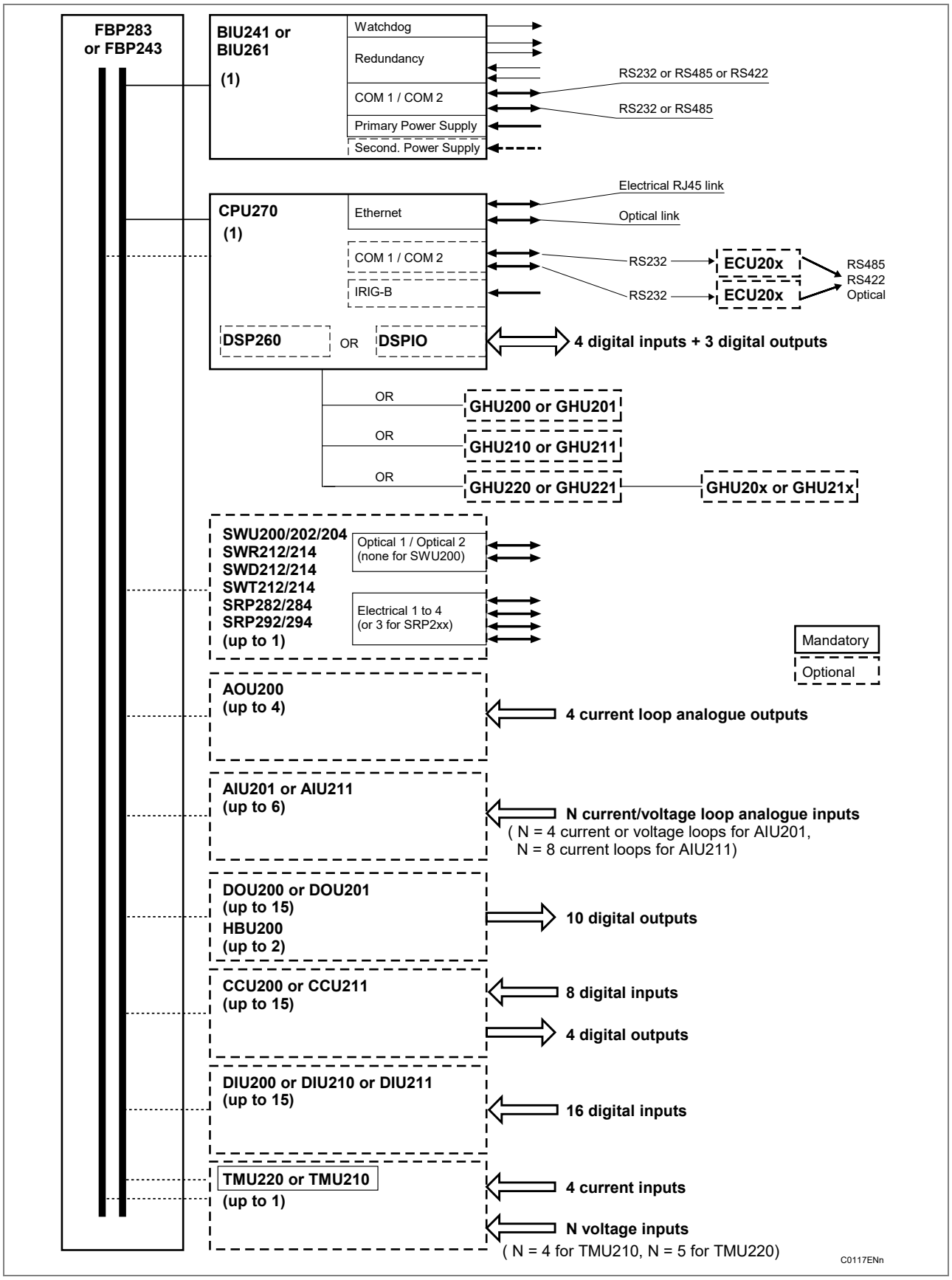


Figure 1: Standard hardware overview

1.2 RACK TYPES

The height of the mechanical rack is 4U.

Two case widths are available:

- Compact case, 40TE-wide
- Standard case, 80TE-wide

1.2.1 COMPACT 40TE CASE

1.2.1.1 OVERVIEW

The dimensions of this rack are indicated in the figure below (in mm):

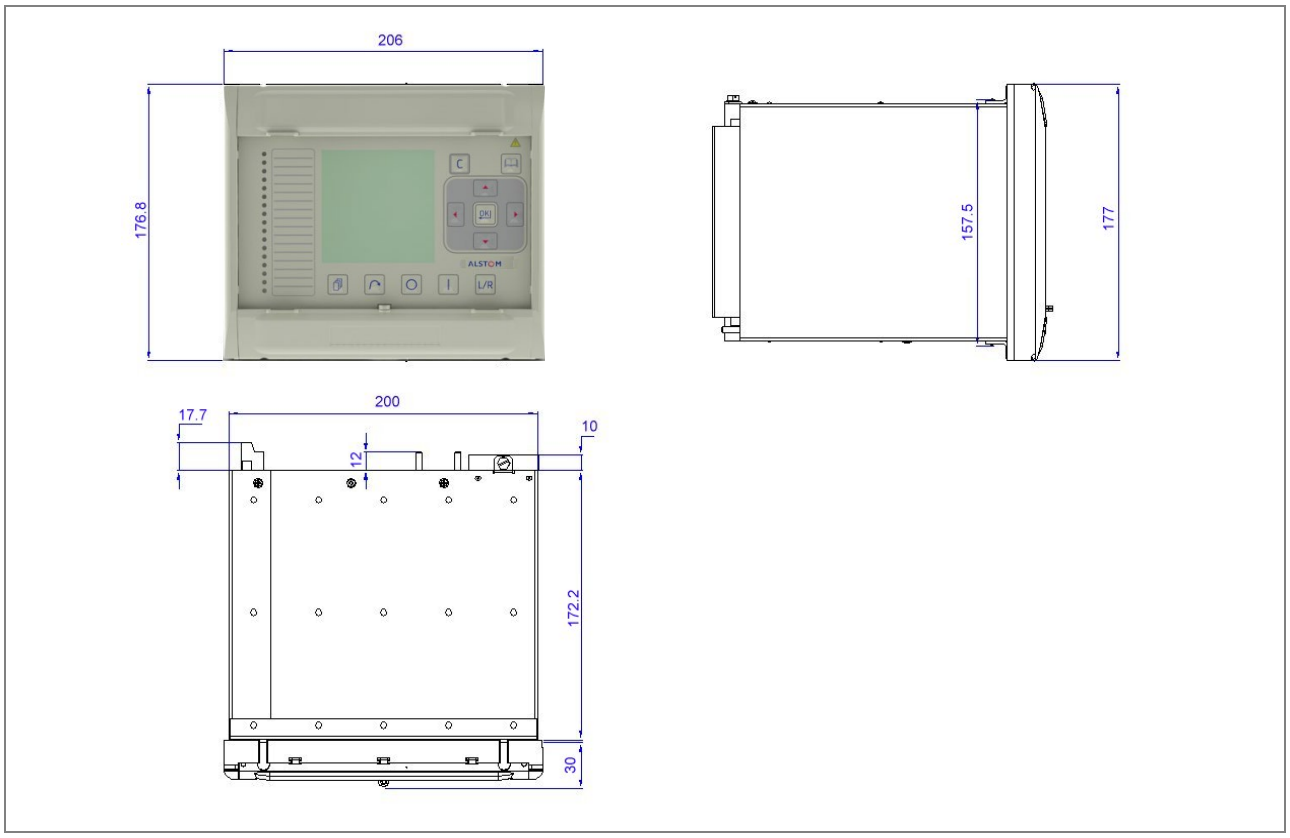


Figure 2: Compact 40TE case – Rack size

Case properties

- Degree of protection:
  - Case IP50 as standard
  - Front panel: IP52 for front panels with LEDs/LCD, IP10 for blind front panel (GHU220)
  - Rear panel: IP20 without TMU2xx board, IP10 with TMU2xx board
- Metallic case
- Mounting holes position for compact 40TE case:

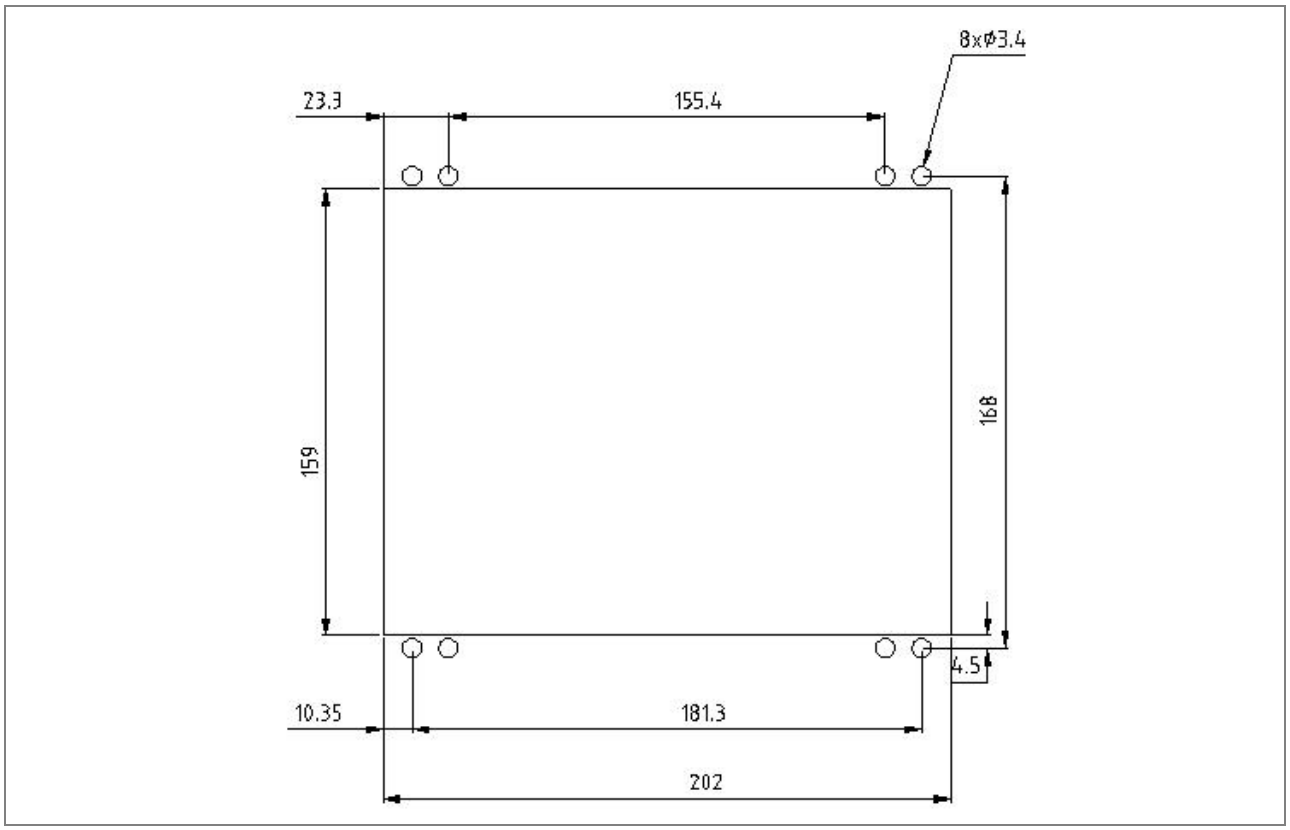


Figure 3: Mounting holes position for compact 40TE case

1.2.1.2 FRONT PANELS

1.2.1.2.1 GHU200

The GHU200 is the front panel with LCD and LEDs used for the 40TE case:

- 17 LEDs (13 are user-configurable)
- 7 pushbuttons (L/R, Open, Close, etc)
- a keypad at the front plate for local HMI management with 5 pushbuttons
- an LCD (resolution of 128 x 128 pixels /16 lines of 21 characters each)



Figure 4: Compact 40TE case – GHU200 Board

1.2.1.2.2 GHU210

The GHU210 is the front panel with LEDs used for the 40TE case:

- 17 LEDs (12 are user-configurable)
- 1 pushbutton (L/R)



Figure 5: Compact 40TE case – GHU210 Board

1.2.1.2.3 GHU220

The GHU220 is the front panel used for the compact 40TE case. This includes only an RJ11 coupler in order to connect a remote GHU20x or GHU21x.



Figure 6: Compact 40TE case – GHU220 Board

1.2.1.3 INTERNAL BUS

In conventional use, there is only one internal bus in the case, used for communications between boards and to power them.

The FBP243 board is the standard front bus of the compact 40TE case equipped with the CPU270:

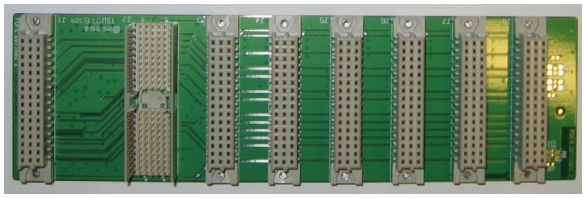


Figure 7: Compact 40TE case standard bus

Rear panel featuring the CT/VT board

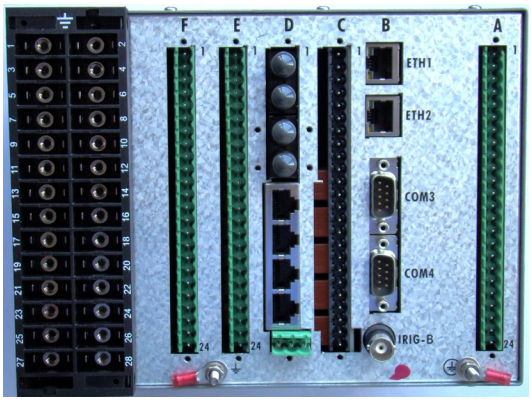


Figure 8: Compact 40TE case – Rear panel with CT/VT connector (on TMU2xx)

Rear panel without CT/VT board

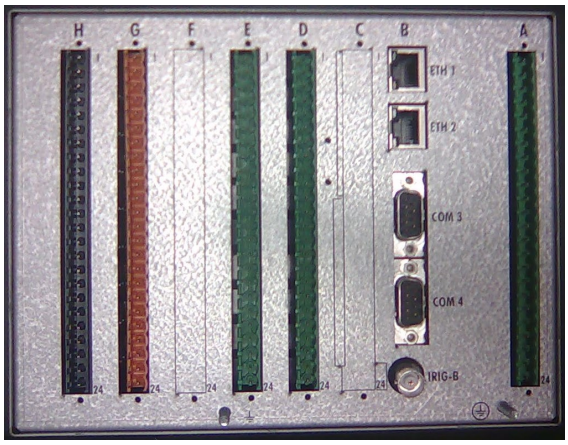


Figure 9: Compact 40TE case – Rear panel without CT/VT connector

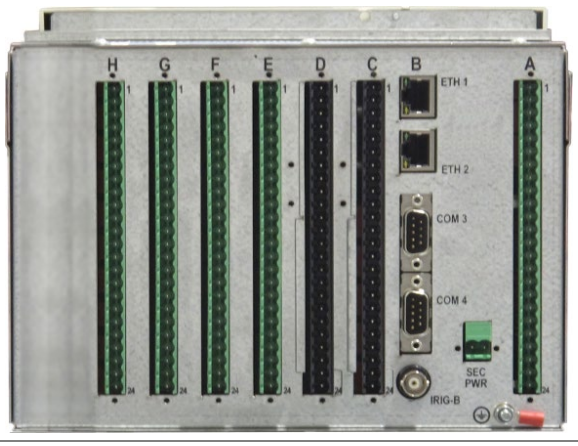
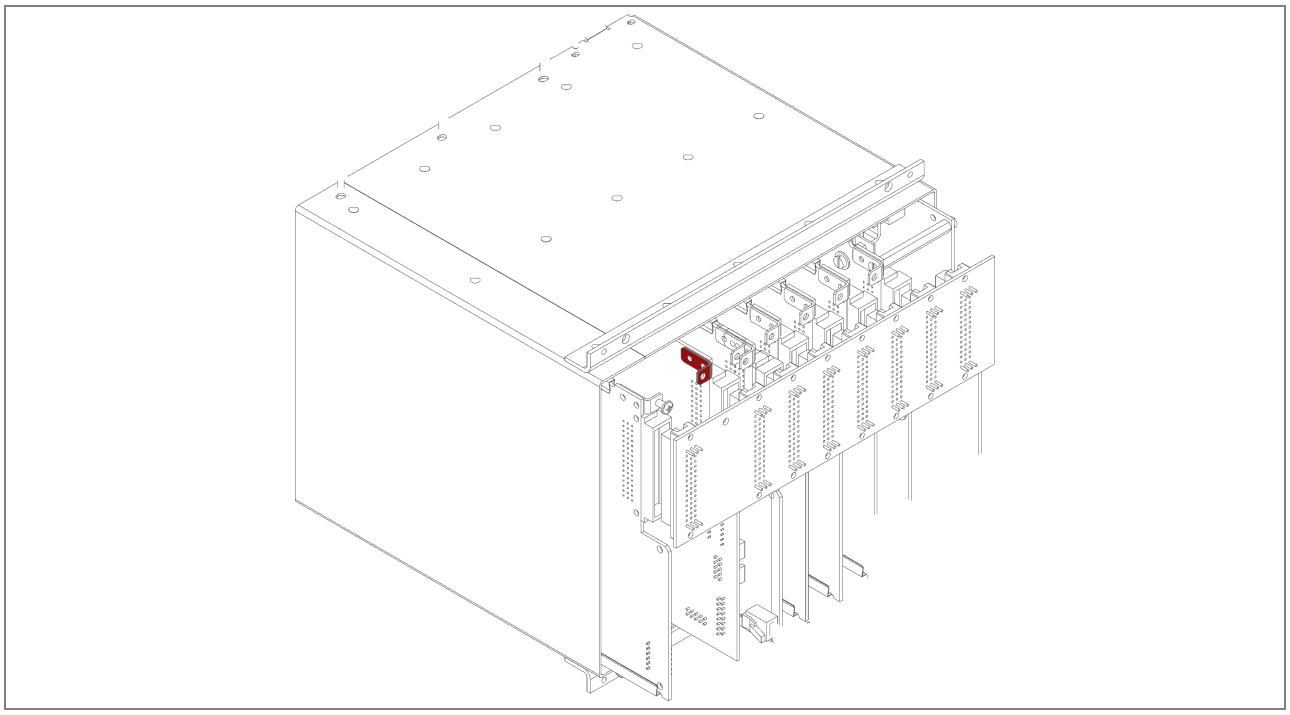


Figure 10: Compact 40TE case – Rear panel with BIU261dual power supply board (A)

1.2.1.4 BONDING

In addition to its upper and lower sides, each board is grounded through a bracket (coloured red in the figure below). A conductive screw is used to link that bracket to the case via a fixed lug:



1.2.2 STANDARD 80TE CASE

1.2.2.1 OVERVIEW

The dimensions of this rack are indicated in the figure below (in mm):

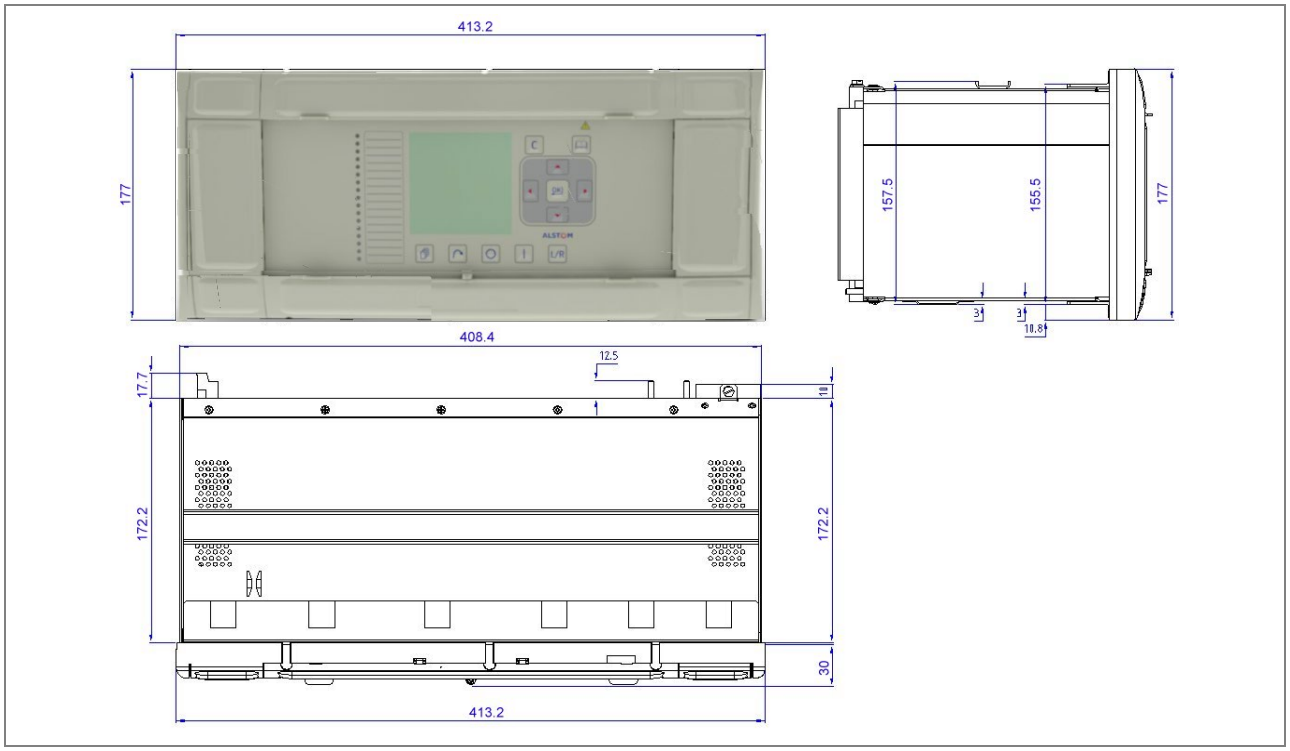


Figure 11: Front panel overview

Case properties

- Degree of protection:
  - Case IP20 as standard
  - Front panel: IP52 for front panels with LEDs/LCD, IP10 for blind front panel (GHU221)
  - Rear panel: IP20 without TMU2xx board, IP10 with TMU2xx board
- Metallic case
- Mounting holes position for the standard 80TE case:

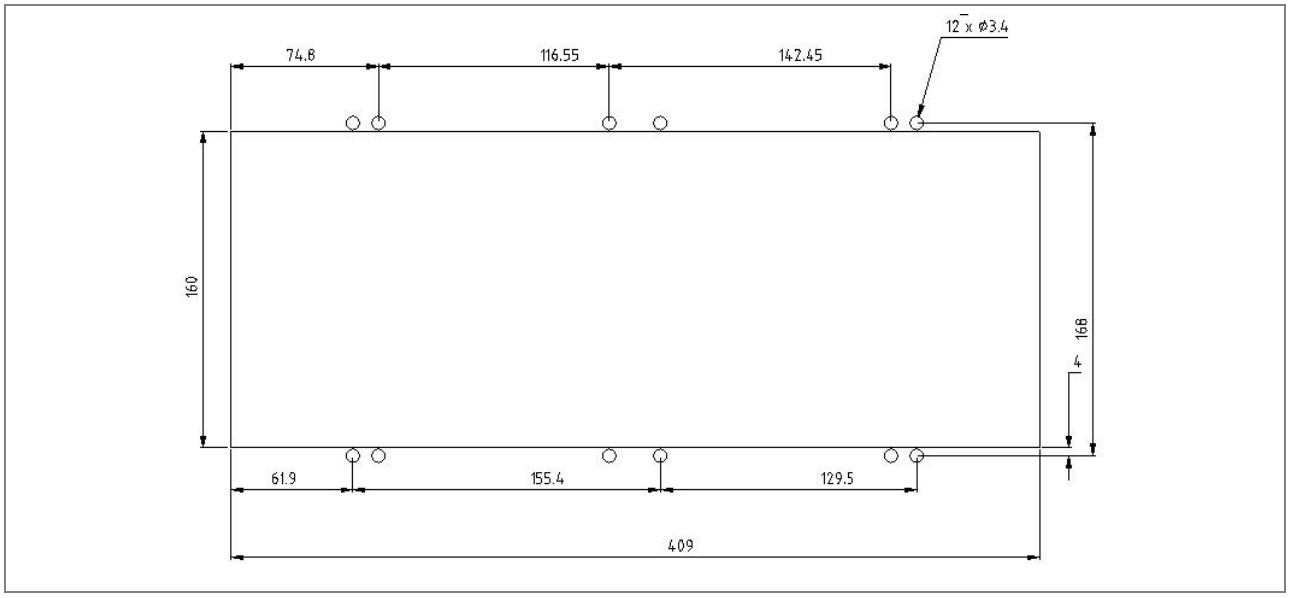


Figure 12: Standard 80TE case - Mounting holes position

1.2.2.2 FRONT PANELS

1.2.2.2.1 GHU201

The GHU201 is the front panel with LCD and LEDs used for the standard 80TE case:

- 17 LEDs (13 are user-configurable)
- 7 pushbuttons (L/R, Open, Close, etc)
- a keypad at the front plate for local HMI management with 5 pushbuttons
- an LCD (resolution of 128 x 128 pixels /16 lines of 21 characters each)



Figure 13: GHU201 Board

1.2.2.2.2 GHU211

The GHU211 is the front panel with LEDs used for the standard 80TE case:

- 17 LEDs (12 are user-configurable)
- 1 pushbutton (L/R)



Figure 14: GHU211 Board

1.2.2.2.3 GHU221

The GHU221 is the front panel used for the standard 80TE case. This includes only an RJ11 coupler in order to connect a remote GHU20x or GHU21x.



Figure 15: GHU221 Board

1.2.2.3 INTERNAL BUS

In conventional use, there is only one internal bus in the case, used for communications between boards and to power them.

The FBP283 board is the front bus of the standard 80TE case equipped with the CPU270.

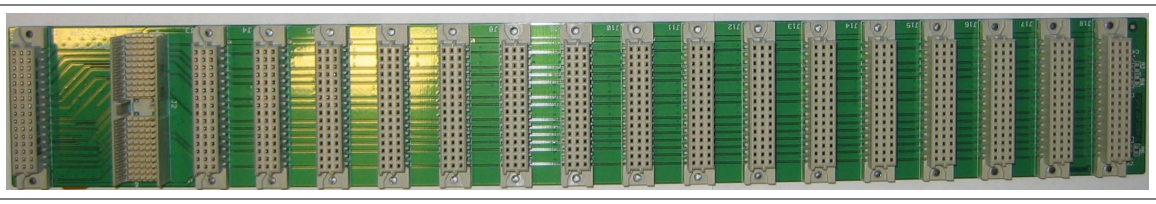


Figure 16: FBP283 Board

Rear panel of a C26x featuring the CT/VT board

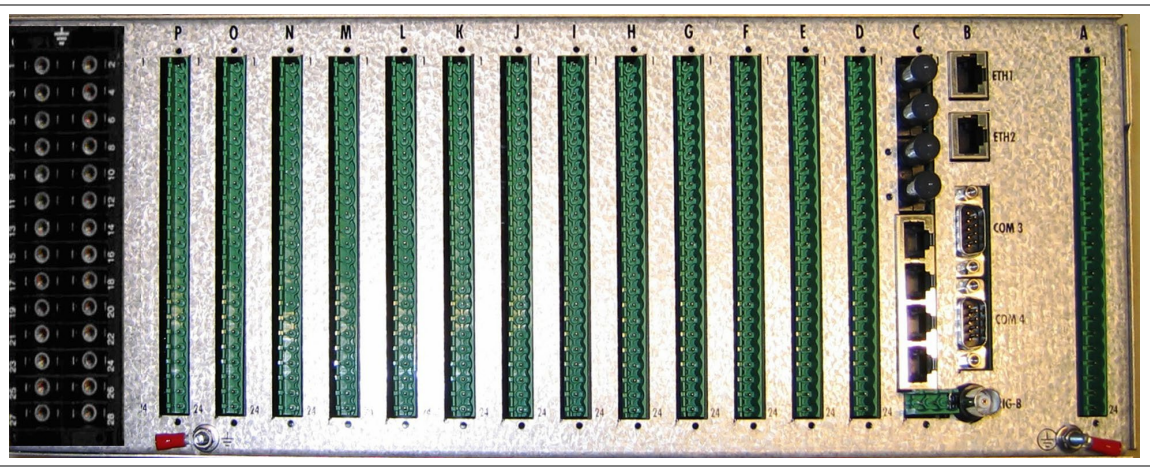


Figure 17: 80TE case – Rear panel with a CT/VT connector

Rear panel without CT/VT board

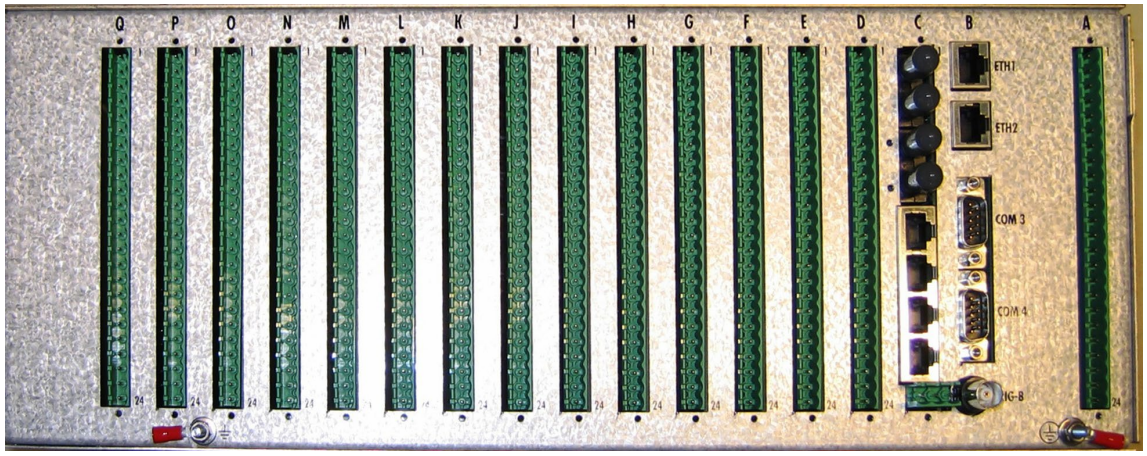


Figure 18: 80TE case – Rear panel without CT/VT connector

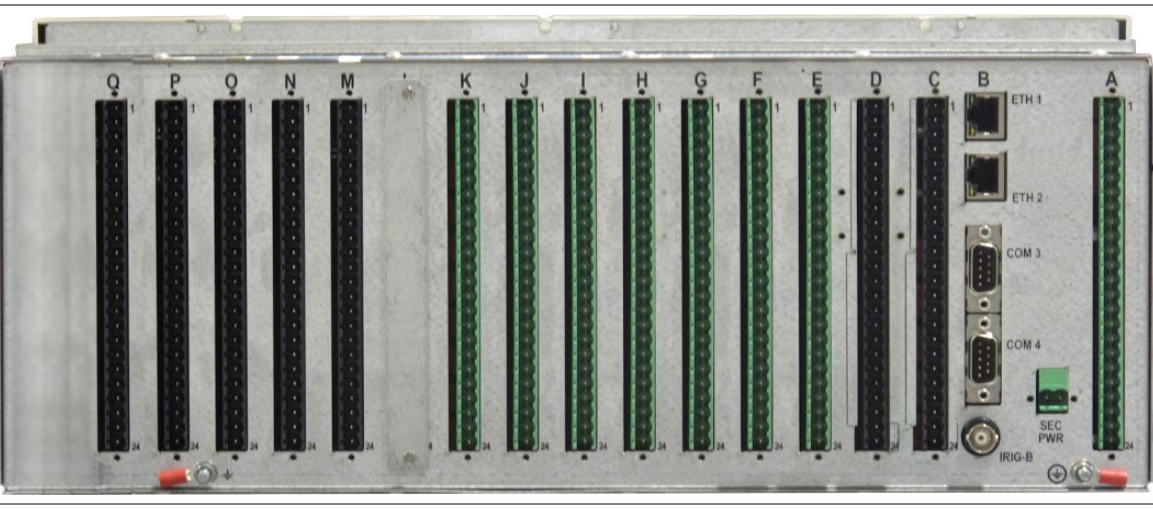
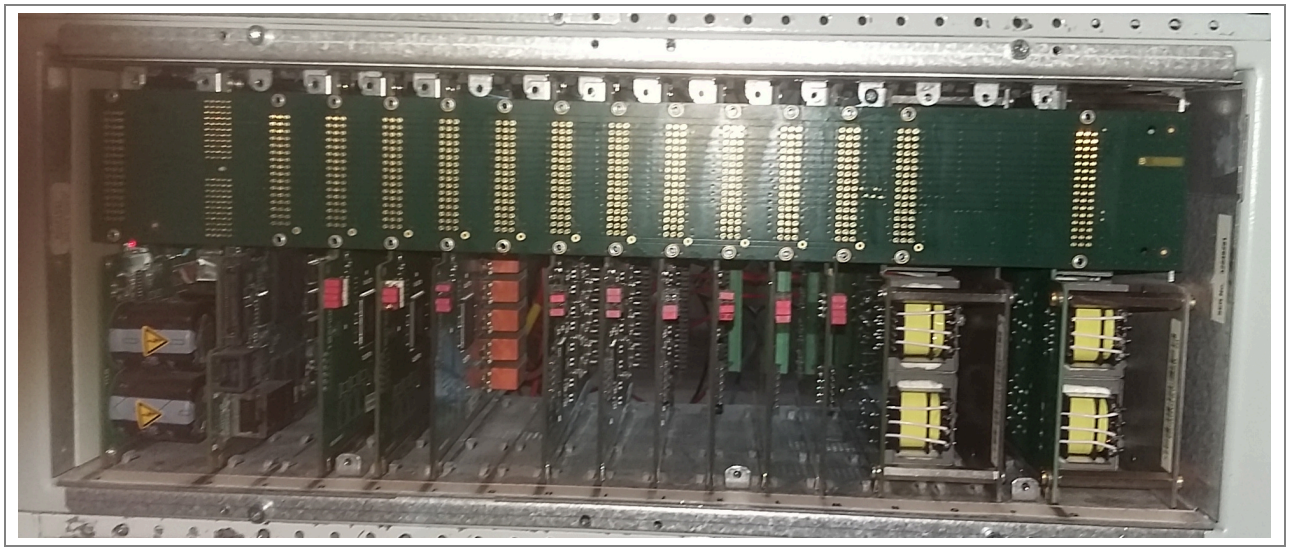


Figure 19: 80TE case – Rear panel with BIU261dual power supply board (A)

1.3 CODING OF BOARD ADDRESS

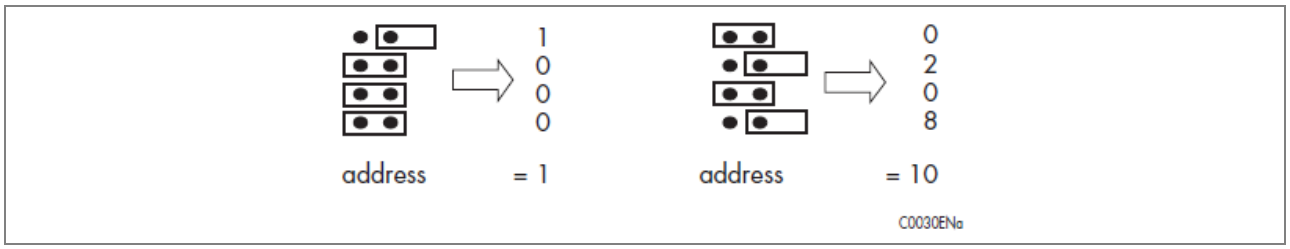
The same rule is applicable to all I/O boards (DIU200, DIU210, DIU211, AIU201, AIU211, DOU200, DOU201, HBU200, CCU200 and CCU211) controlled by the CPU board:



Binary coding from 0 to 15 based on 4 jumpers top down:

- Jumper
  - missing => 1
  - present => 0

Example



Note:
Two boards of the same type must not have the same address.

Most I/O boards have to have their address set by positioning jumpers, but a few may optionally have their address set based on slot positions in the configuration database, i.e.:

- DIU211
- DOU201
- CCU211
- HBU200

Whichever the selected address configuration mode, the boards are to be placed in the order described in the next section.

1.4 BOARD LOCATIONS

TMU210/TMU220

Whenever a CT/VT TMU2xx board is present, it is always located at the far left of the rack, from the rear (at the far right from the front):

- 40TE rack: Slots H-G
- 80TE rack: Slot Q

BIU241/BIU261S/BIU261D

The power supply BIU2xx board or module is always present and located at the far right of the rack, from the rear (at the far left, from the front):

- 40TE & 80TE: Slot A

CPU270

The CPU270 main processor board or module is always present and located next to the BIU2xx board.

Note:
If a TMU210 board is used, the CPU270 is fitted with a DSPIO daughter board, which has its connector in slot C.

Without DSPIO daughter board:

- 40TE & 80TE: Slot B

With DSPIO daughter board:

- 40TE & 80TE: Slots B-C

Switch boards

There is a maximum of 1 switch board, or none at all. If one is present, it is always located next to the CPU board or module.

Without DSPIO daughter board on the CPU270:

- 40TE & 80TE: Slot C

With DSPIO daughter board on the CPU270:

- 40TE & 80TE: Slot D

I/O boards

The location of I/O boards varies depending on which boards are present and how many of each.
The maximum number of I/O boards depends on the rack size (40TE: 8 slots, or 80TE: 17 slots) and on whether other boards such as TMU2xx, DSPIO, switch and/or process bus boards are present.

Note:
In the 40TE rack, the TMU2xx board takes up 2 slots.

- From first available slot on the left, towards the right, from the rear (on the right, towards the left, from the front):

  1 HBU200 Addresses increasing from 0 Max.: 2 boards (1)

2	DIU200 or DIU211 (do not mix)	Addresses increasing from 0	Max.: Nr of available slots
3	CCU200 or CCU211 (do not mix)	Addresses increasing from 0	Max.: Nr of available slots

- From first available slot on the right, towards the left, from the rear (towards the right, from the front):

1	AIU201	Addresses increasing from 0	Max.: 6 boards (1)
2	AIU211	Addresses increasing from 0	Max.: 6 boards (1)
3	DOU201	Addresses increasing from 0	Max.: Nr of available slots
4	AOU200	Addresses increasing from 0	Max.: 4 boards (1)

(1) if enough free slots are available in the rack.

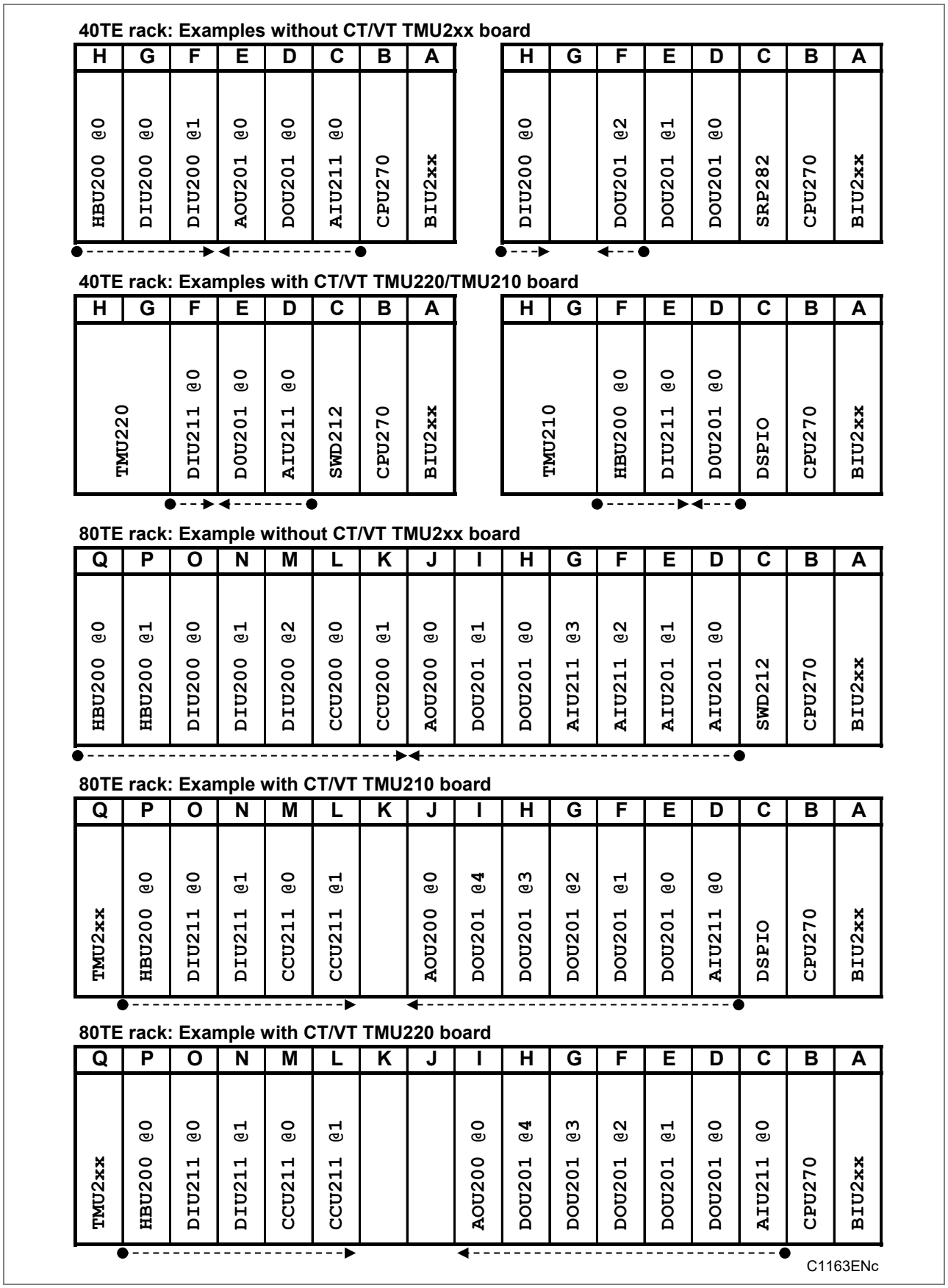


Figure 20: Examples of correct board locations in the racks

1.5 MODULES DESCRIPTION

1.5.1 SINGLE-INPUT AUXILIARY POWER SUPPLY AND LEGACY PORTS BOARD – BIU241

This board houses:

- the auxiliary power supply converter
- the watchdog relay (closed if the product is healthy)
- 2 outputs (Normally Open contacts) and 2 inputs for redundancy (BCU only)
- 2 isolated interfaces (Port 1: RS232 or RS485, Port 2: RS232, RS422 or RS485)

The power auxiliary supply board is protected against polarity reversal.

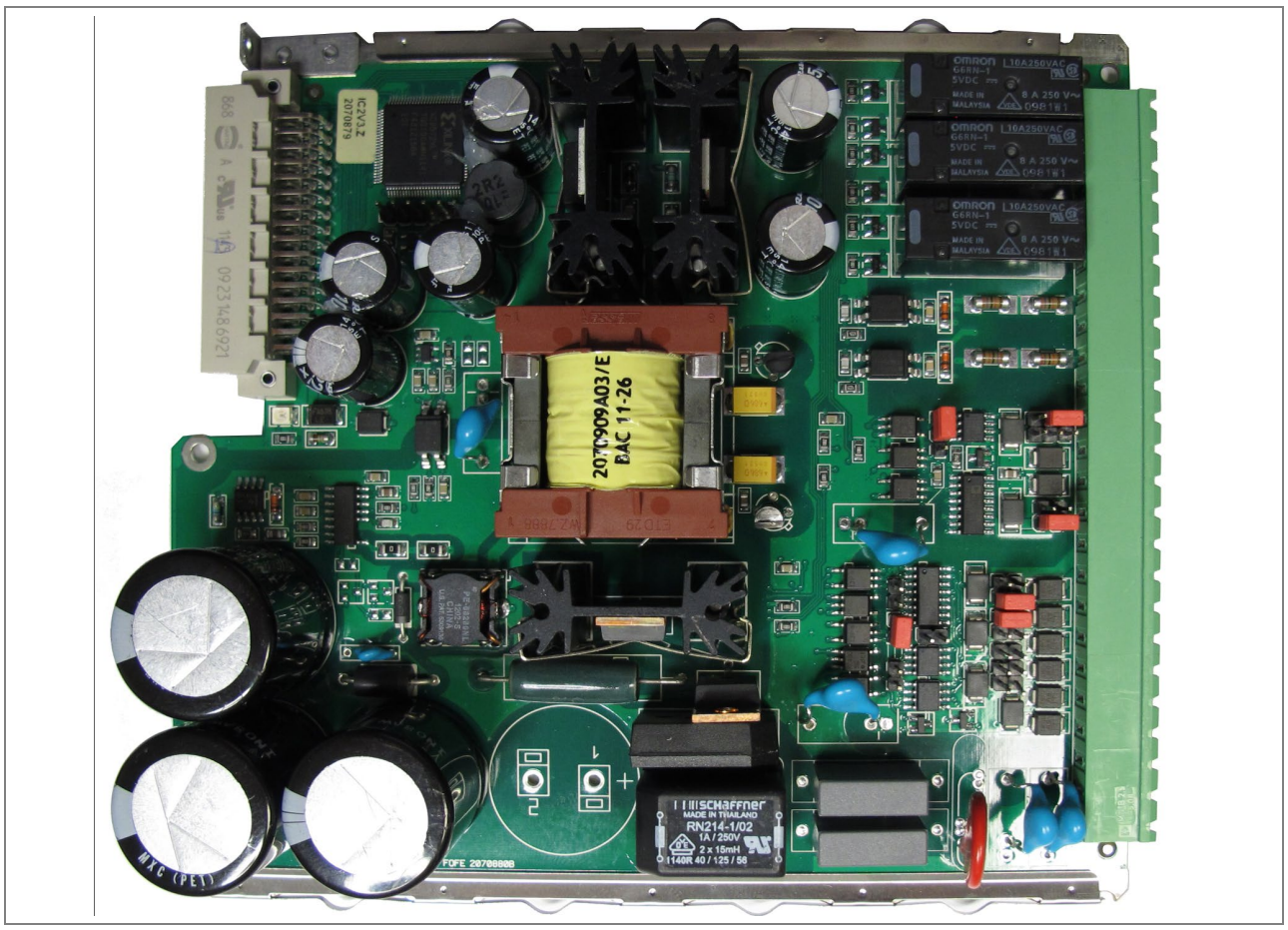


Figure 21: BIU241 board

Note:
The number of capacitors (bottom left) depends on the board variant (voltage range).

The BIU241 board provides two isolated serial links.

This figure below shows the location of the serial links' configuration jumpers:



Figure 22: BIU241 – Location of serial port jumpers

1.5.1.1 CONFIGURABLE COMMUNICATIONS PORT 1 - RS232/485

The communication link characteristics are:

- Full duplex serial protocol
- Transmission rate: 50 bps to 38400 bps (configurable in DS Agile SCE or settable on the front panel HMI)

Configuration:

The hardware jumper arrangement is as follows:

- For RS232, set the jumpers S14, S16 and between S12.1 and S12.3
- For RS485, set the jumpers S13, S15 and between S12.1 and S12.2. It is possible to terminate the line with a 124 Ω resistor by setting S17. (See CO chapter to know when the resistor is required).

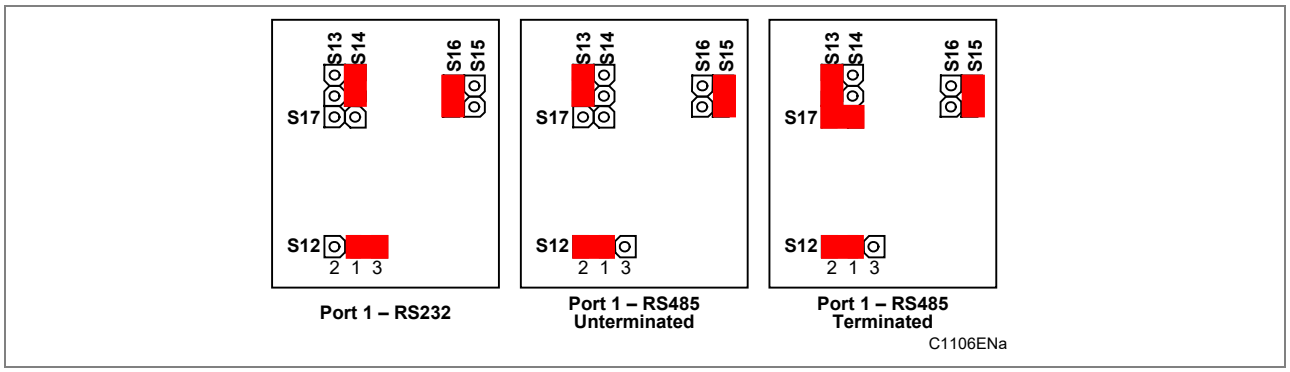


Figure 23: BIU241 – Port 1 jumper settings

1.5.1.2 CONFIGURABLE COMMUNICATIONS PORT 2 - RS232/422/485

The communication link characteristics are:

- full duplex serial protocol
- transmission rate: 50 bps to 38400 bps (configurable in DS Agile SCE or settable on the front panel HMI)

Configuration

The hardware jumper arrangement is as follows:

- For RS232, set the jumpers S5, S6, S9 and S3
- For RS485, set the jumpers S7, S8, S2. It is possible to terminate the line with a 124 Ω resistor by setting S11. (See chapter C26x/EN CO to know when the resistor is required).
- For RS422, set the jumpers S7, S8, S4 and S1. It is possible to terminate the line with a 124 Ω resistor by setting the jumpers S10 and S11. (See CO chapter to know when the resistor is required).

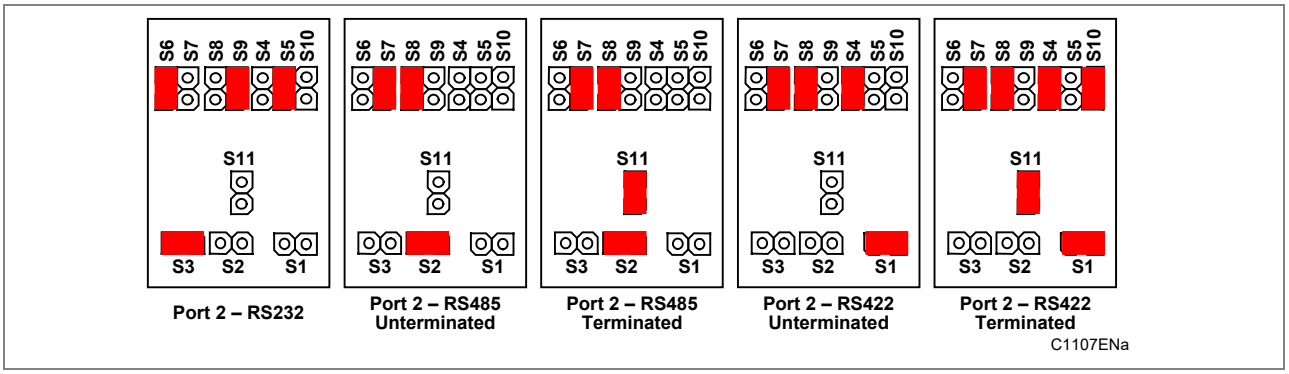


Figure 24: BIU241 – Port 2 jumper settings

1.5.2 UNIVERSAL, SINGLE OR DUAL-INPUT AUXILIARY POWER SUPPLY AND LEGACY PORTS MODULE – BIU261S/BIU261D

Depending on whether a secondary power supply is present, the BIU261 module comprises one or two boards:

- BIU261S - single board
- BIU261D - main board + daughter board offering a secondary power supply input.

The main board houses:

- the primary universal auxiliary power supply converter
- the watchdog relay (closed if the product is healthy)
- 2 outputs (Normally Open contacts) and 2 inputs for redundancy (BCU only)
- 2 isolated interfaces (Port 1: RS232 or RS485, Port 2: RS232, RS422 or RS485)

The power supply board is protected against polarity reversal.

The daughter board carries the secondary auxiliary power supply converter.

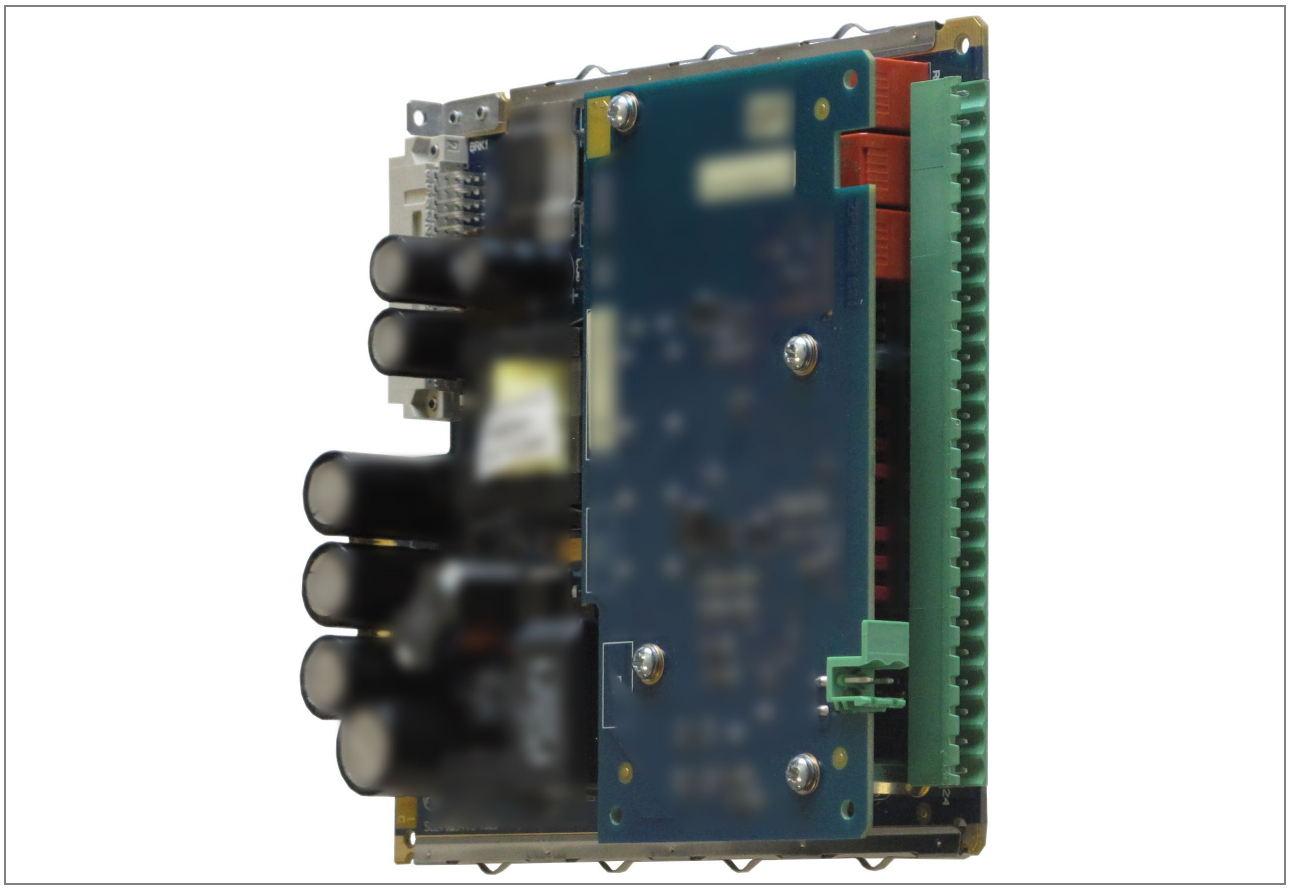


Figure 25: BIU261D module with dual-input power supply

The BIU261 mother board provides two isolated serial links.

This figure below locates the serial links' configuration jumpers.

Note:
These jumpers are not accessible if the daughter board is fitted.

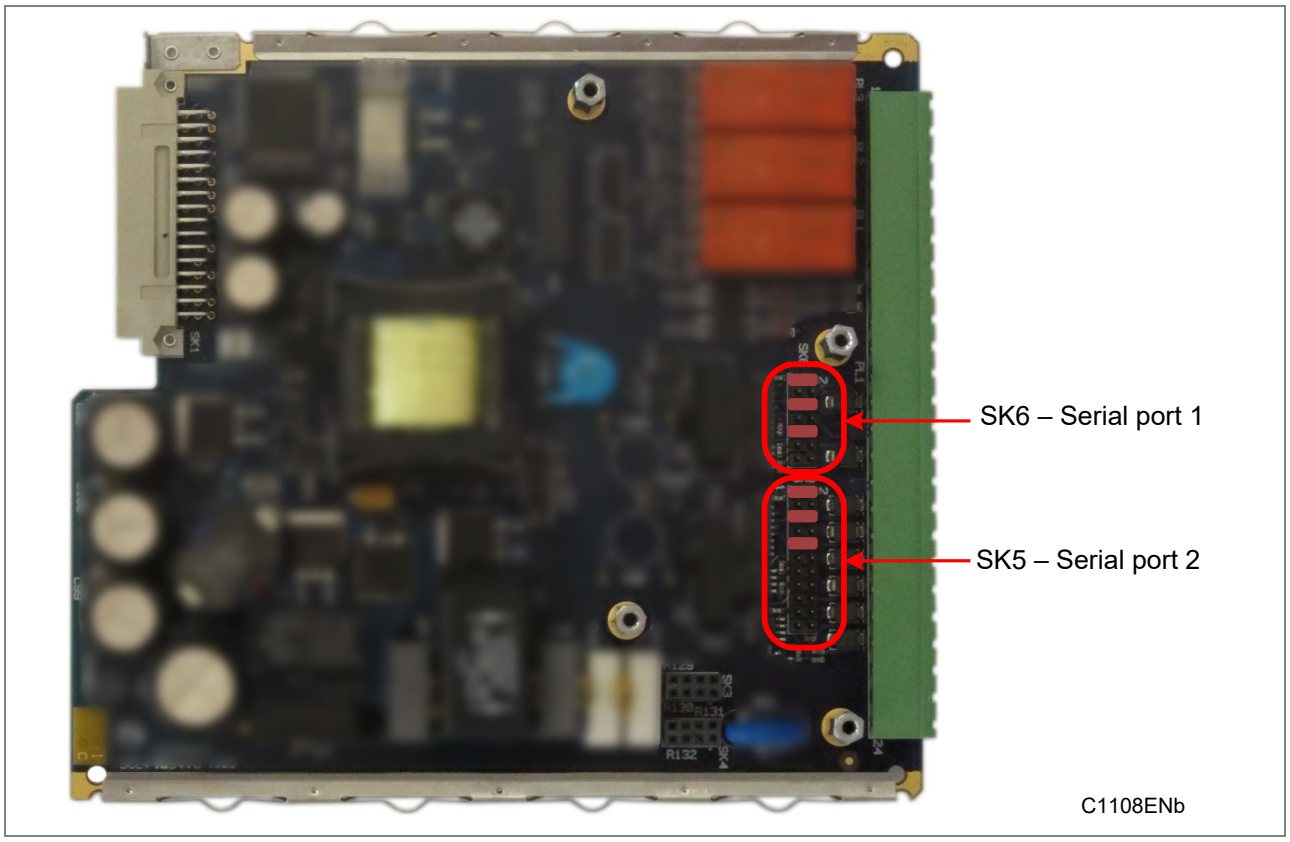


Figure 26: BIU261 without daughter board – Serial port jumpers visible

1.5.2.1 CONFIGURABLE COMMUNICATIONS PORT 1 - RS232/485

The communication link characteristics are:

- Full duplex serial protocol
- Transmission rate: 50 bps to 38400 bps (configurable in DS Agile SCE or settable on the front panel HMI)

Configuration

The hardware jumper arrangement is as follows (jumper block SK6):

- For RS232, set the jumpers 1-2, 5-6 and 9-10
- For RS485, set the jumpers 3-4, 7-8 and 11-12. It is possible to end the line with a 124 Ω resistor by setting 13-14. (See Connection chapter C26x/EN CO for information on when the resistor is required).

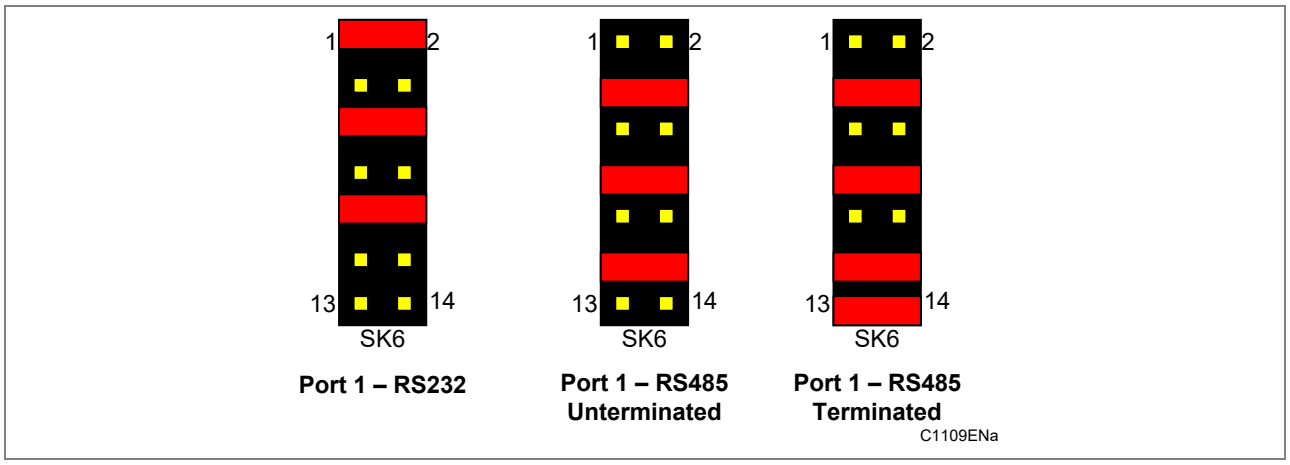


Figure 27: BIU261 – Port 1 jumper settings

1.5.2.2 CONFIGURABLE COMMUNICATIONS PORT 2 - RS232/422/485

The communication link characteristics are:

- full duplex serial protocol
- transmission rate: 50 bps to 38400 bps (configurable in DS Agile SCE or settable on the front panel HMI)

Configuration:

The hardware jumper arrangement is as follows (jumper block SK5):

- For RS232, set the jumpers 1-2, 5-6 and 9-10
- For RS485, set the jumpers 3-4, 7-8 and 11-12. It is possible to terminate the line with a 124 Ω resistor by setting 13-14. (See chapter C26x/EN CO to know when the resistor is required).
- For RS422, set the jumpers 3-4, 7-8, 11-12, 15-16, 17-18 and 19-20. It is possible to terminate the line with a 124 Ω resistor by setting 13-14. (See CO chapter to know when the resistor is required).

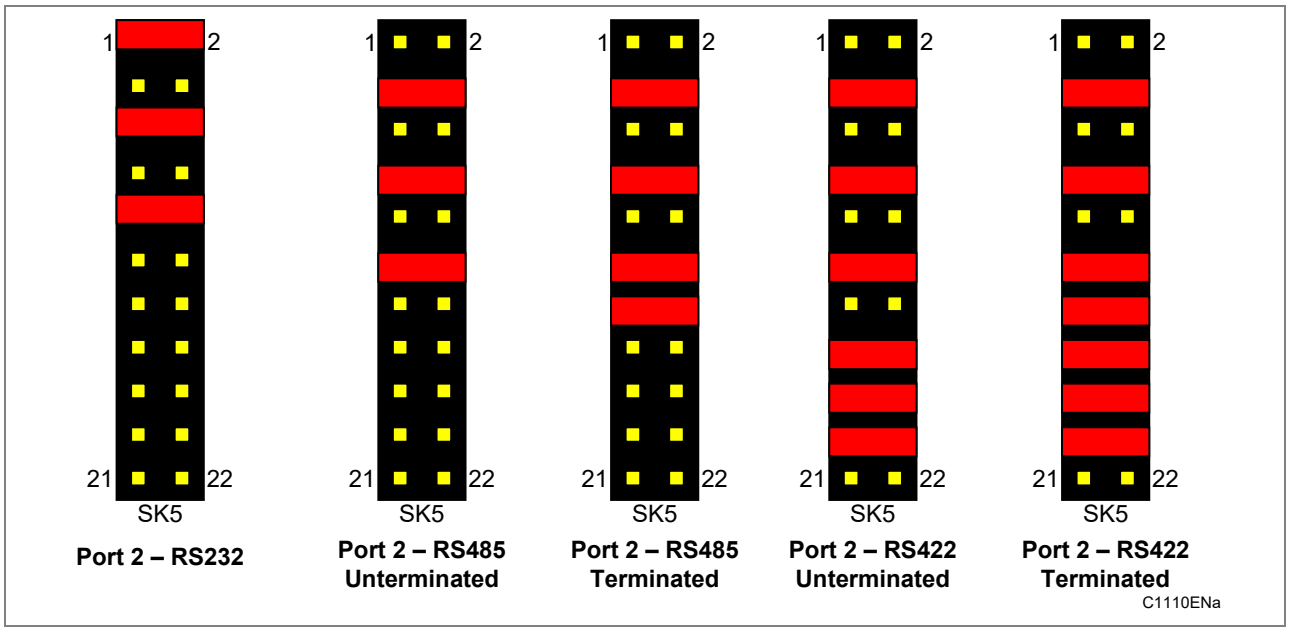


Figure 28: BIU261 – Port 2 jumper settings

1.5.3 CENTRAL PROCESSING UNIT AND BASE COMMUNICATIONS BOARD – CPU270

The CPU270 board is based on a PowerPC processor including 10/100BaseT Ethernet communications.

- Two 10/100BaseTx Ethernet ports. The ports are half/full duplex and auto-sense the transmission speed. They auto-negotiate with the connected device to determine the optimal transmission speed: 10Mbps or 100Mbps depending on the connected device's capability.
- One IRIG-B input
- Optional daughter board (DSPIO) for CT/VT management

Caution:
The RS232 port on the CPU270 board shall not be connected. In the event the RS232 port should be used, please contact GE Support service at Stafford beforehand (Tel: +44 (0) 1785 25 00 70, www.gegridsolutions.com/contact/)

The CPU270 board is interfaced with all I/O boards and the front panel HMI.

The CPU270 board has the following key features:

- 32-bit Power PC-based microprocessor with 64-bit memory data bus (MPC8270VR), clocked at 266 MHz (theoretical frequency, effective frequency at serial link is 262 MHz)
- 128 MB SDRAM
- 64 MB Flash memory
- 128 kB static memory SRAM
- Calendar saved

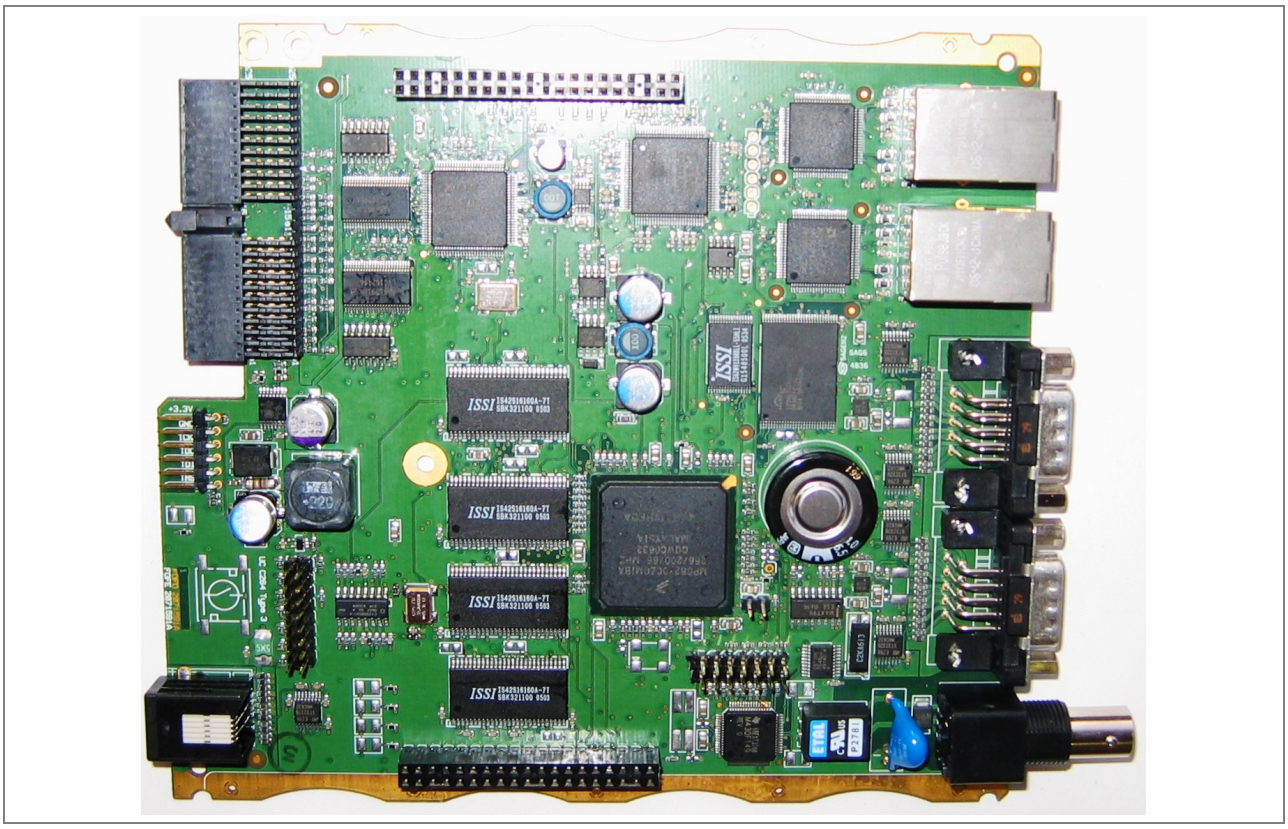


Figure 29: CPU270 board

Counter values are stored in static memory (secured with a capacitor, > 48h autonomy). The counters are kept for more than 48h when the C26x power supply is disconnected.

1.5.4 DSP BOARD

The DSP board is mounted on the CPU270 board. It is used in conjunction with the TMU220 board.

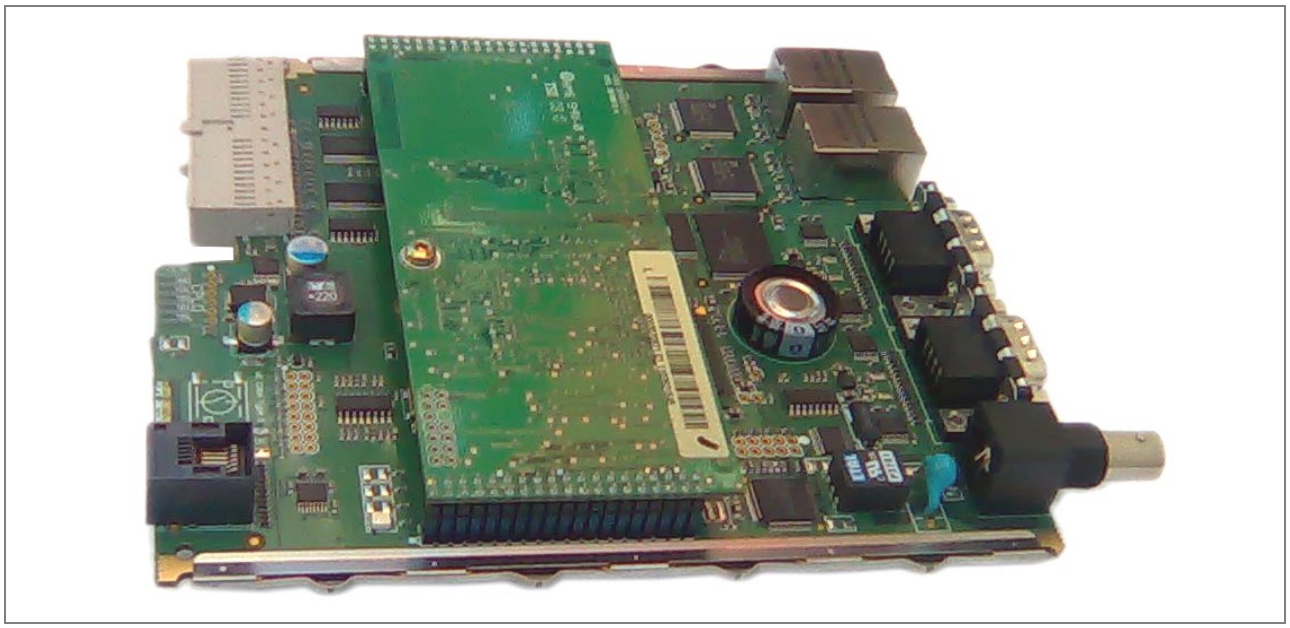


Figure 30: DSP daughter board mounted on CPU270

1.5.5 DSPIO BOARD

The DSPIO board is mounted on the CPU270 board. It is used in conjunction with the TMU210 board.

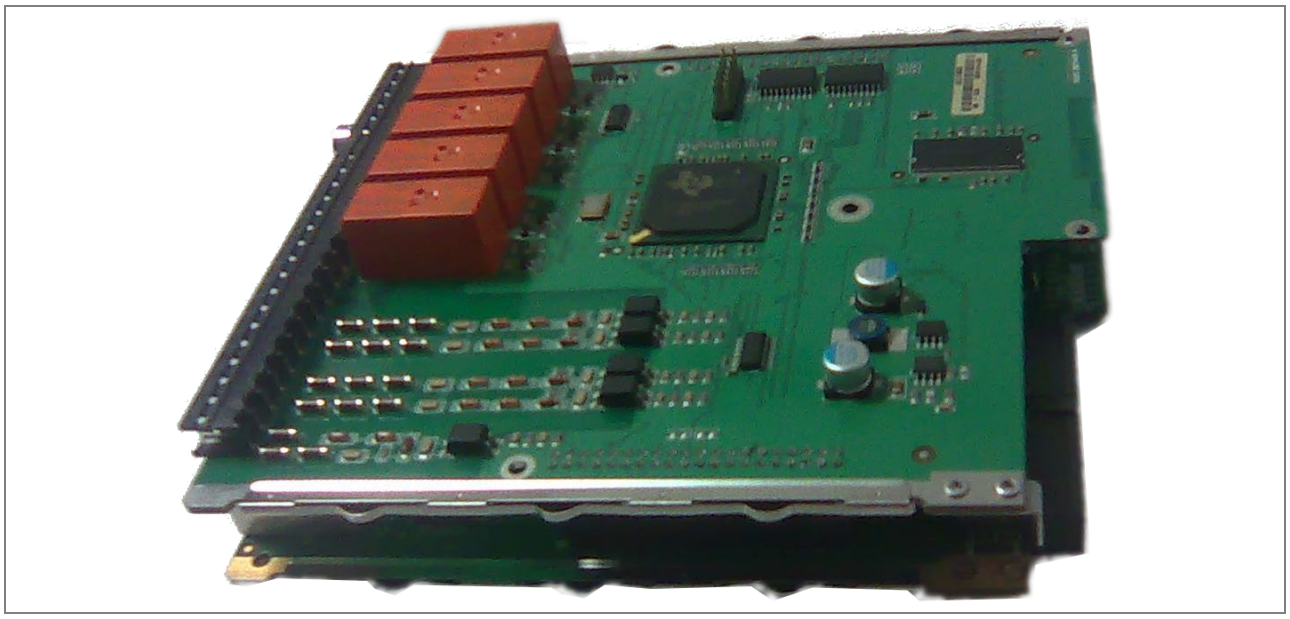


Figure 31: DSPIO daughter board mounted on CPU270

1.5.6 CIRCUIT BREAKER CONTROL UNIT - CCU200

The Circuit breaker Control Unit (CCU200) board provides 8 digital inputs and 4 double pole outputs using integrated relays.

The digital input (DI) capabilities of the CCU200 boards are:

- 8 optically isolated digital inputs
- 1 common contact for 2 inputs
- Protection against polarity reversal

The digital inputs can be configured in single or double remote signalling inputs on the same module.

The digital output (DO) capabilities of the CCU200 boards are:

- 4 double pole switching relays with normally open (NO) contacts
- 1 common + and 1 common - contacts per 2 relays

A self-monitoring device for the output control chain is provided (address check, state monitoring)

The +5V voltage is monitored to avoid issuing unwanted signals.

The digital outputs can be configured in double remote signalling only.

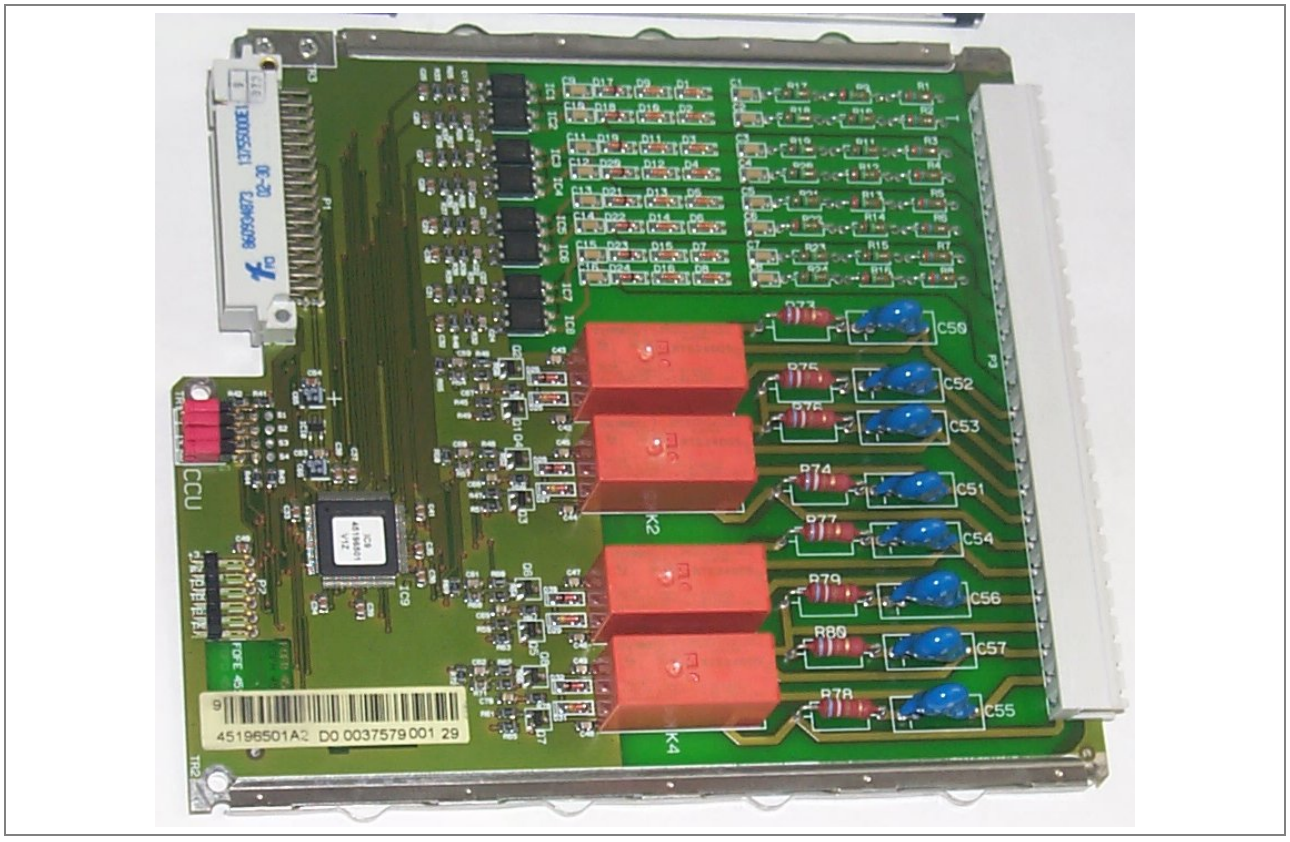


Figure 32: CCU200 board

1.5.7 CIRCUIT BREAKER CONTROL UNIT - CCU211

The CCU211 board provides 8 digital inputs and 4 digital outputs using integrated relays.

The Digital Input capabilities of the CCU211 board are:

- 8 optically isolated digital inputs
- 1 common contact for 2 inputs (positive or negative)
- The digital inputs can be used for single or double remote signalling, pulse or digital measurement input on the same module.
- The input responds to negative input voltages and they are not self-controlled
- All voltages between 24 V_{DC} and 220 V_{DC} selected using jumpers
- Pre-defined triggering thresholds selected using jumpers:

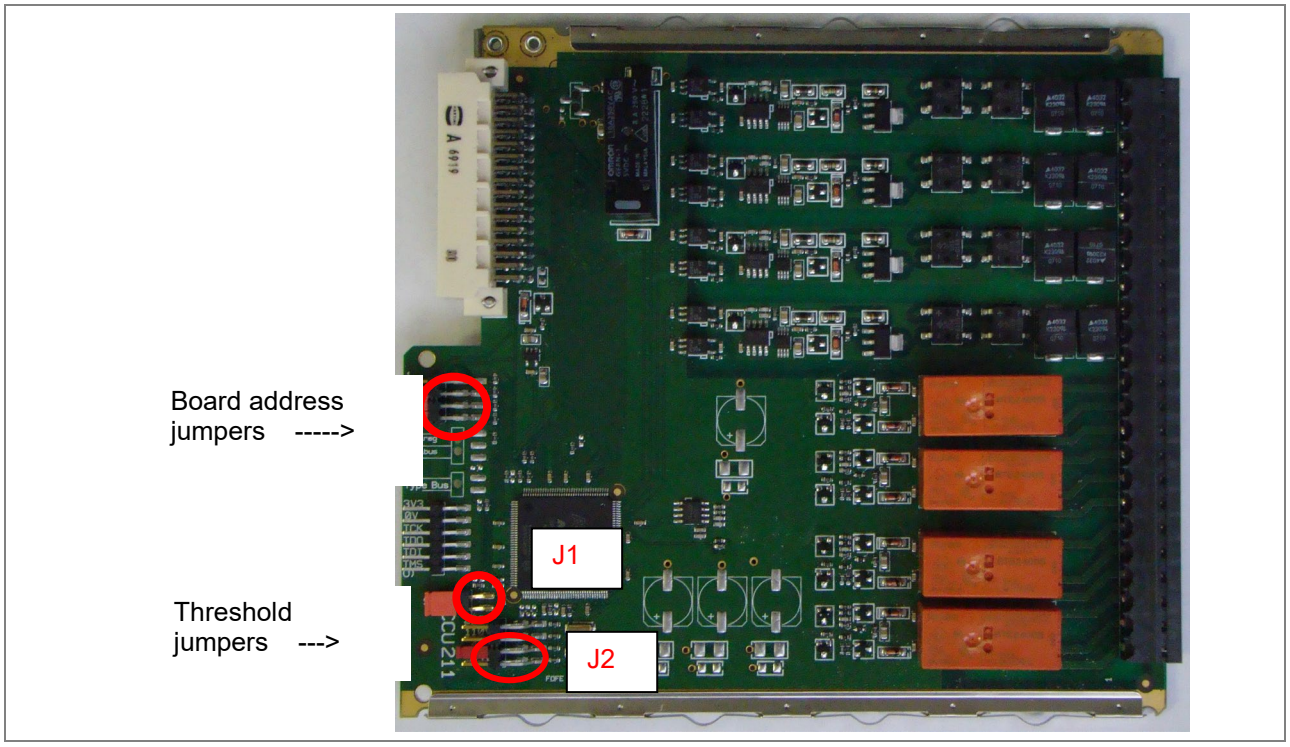
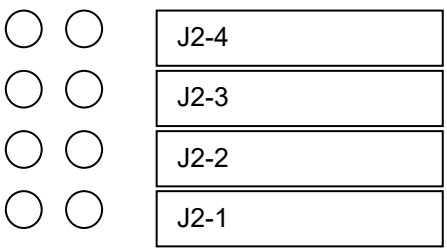


Figure 33: CCU211 board

J1 connector

Set the “jumper” on J1 for A07 and A08 VARIANTS ONLY

J2 connector



Set only one jumper on J2 connector:

Board variant	Jumper on J1	Jumper on J2
A01	No	J2-1
A02	No	J2-2
A03	No	J2-3
A04	No	J2-4
A07	Yes	J2-3
A08	Yes	J2-4

- From 24 V_{DC} to 220 V_{DC}: a peak current (>27 mA) circulates during a short time (approximately 2 ms) to clean external relays' contacts:

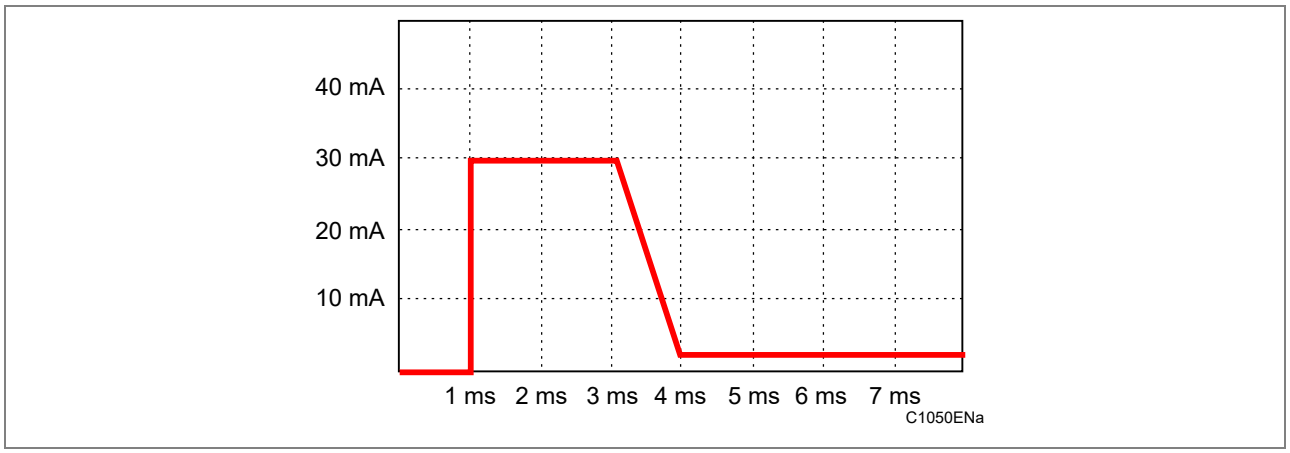


FIGURE 34: Peak current response curve

The Digital Output capabilities of the CCU211 board are:

- 4 double pole switching relays with normally open (NO) contacts
- 1 common + and 1 common - contacts per 2 relays
- Nominal operating voltage range of 24 V_{DC} to 250 V_{DC} / 230 V_{AC}

A self-monitoring device for the output control chain is provided (address check, state monitoring).

The +5 V voltage is monitored to avoid issuing unwanted signals.

The digital outputs can be configured in double remote signalling only.

Board address setting

The address of the board can be defined by the location of the CCU211 in the C26x rack (or by jumper if the board is used as spare of a previous board). This location is defined using the SCE (refer to C26x/EN AP).

1.5.8 DIGITAL INPUTS UNIT – DIU200

Depending on the applied voltage, 4 versions of the DIU200 are available.

The capabilities of the DIU200 boards are:

- 16 optically isolated digital inputs
- 1 negative common contact for 2 inputs
- Protection against polarity reversal
- The digital inputs can be used for single or double status, pulse or digital measurement input on the same module.

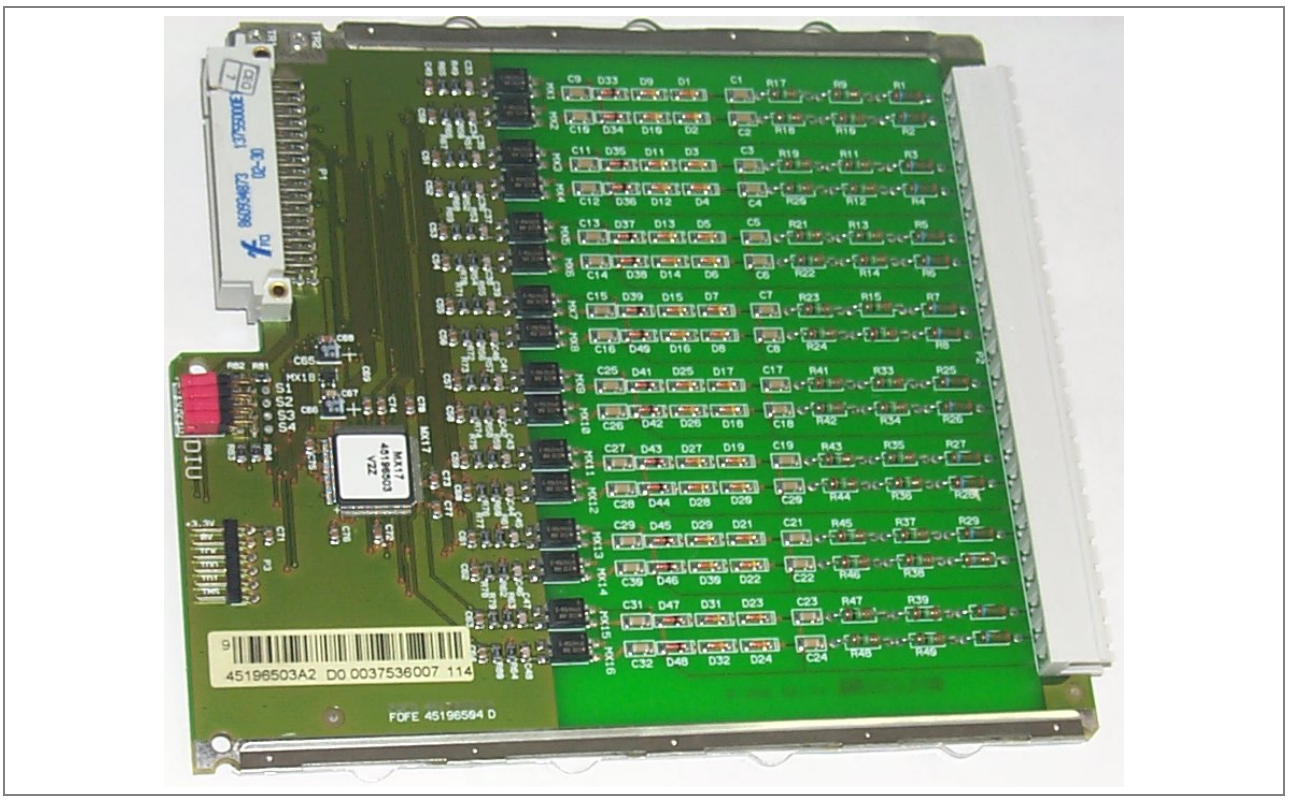


Figure 35: DIU200 board

1.5.9 DIGITAL INPUTS UNIT – DIU210

Depending on the applied voltage, 4 versions of the DIU210 are available.

The capabilities of the DIU210 boards are:

- 16 optically isolated digital inputs
- 1 negative or positive common contact for 2 inputs
- Protection against polarity reversal
- The digital inputs can be used for single or double status, pulse or digital measurement input on the same module.
- All voltages between 24 V_{DC} and 220 V_{DC}
- From 48 V_{DC} to 220 V_{DC}: High current circulation inside binary contacts inputs during a short time (to clean external contacts): see the current peak response curve
- With 24 V_{DC} voltage, the high current consumption (>25 mA) is permanent

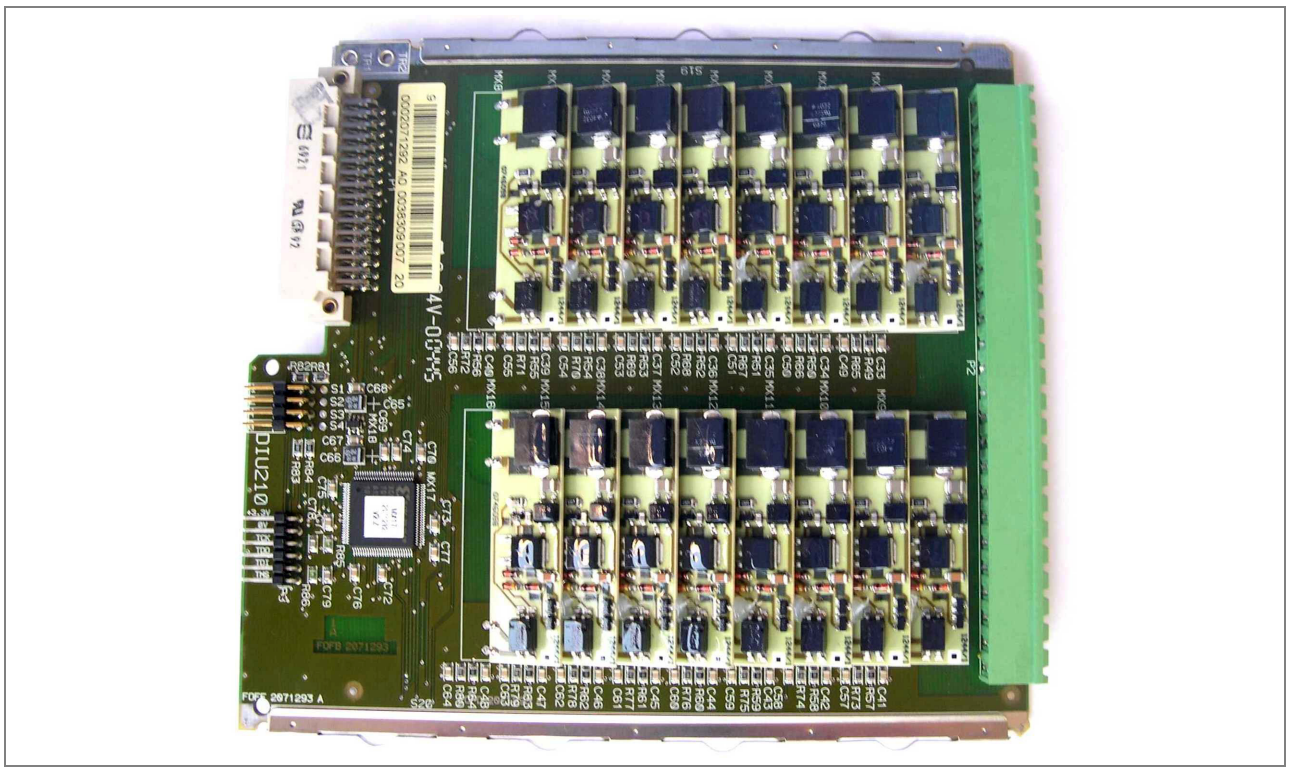


Figure 36: DIU210 board

1.5.10 DIGITAL INPUTS UNIT – DIU211

The capabilities of the DIU211 boards are:

- 16 optically isolated digital inputs
- 1 common contact for 2 inputs (positive or negative)
- The digital inputs can be used for single or double status, pulse or digital measurement input on the same unit.
- All voltages between 24 V_{DC} and 220 V_{DC}
- Pre-defined triggering thresholds selected using jumpers:

Variants

Variant	Input voltage
A01	24 V_{DC}
A02	48 V_{DC} – 60 V_{DC}
A03	110 V_{DC} – 125 V_{DC}
A04	220 V_{DC}
A07	110 V_{DC} – 125 V_{DC} with 80% threshold
A08	220 V_{DC} with 80% threshold

The board variants are determined by the position of 2 jumpers:

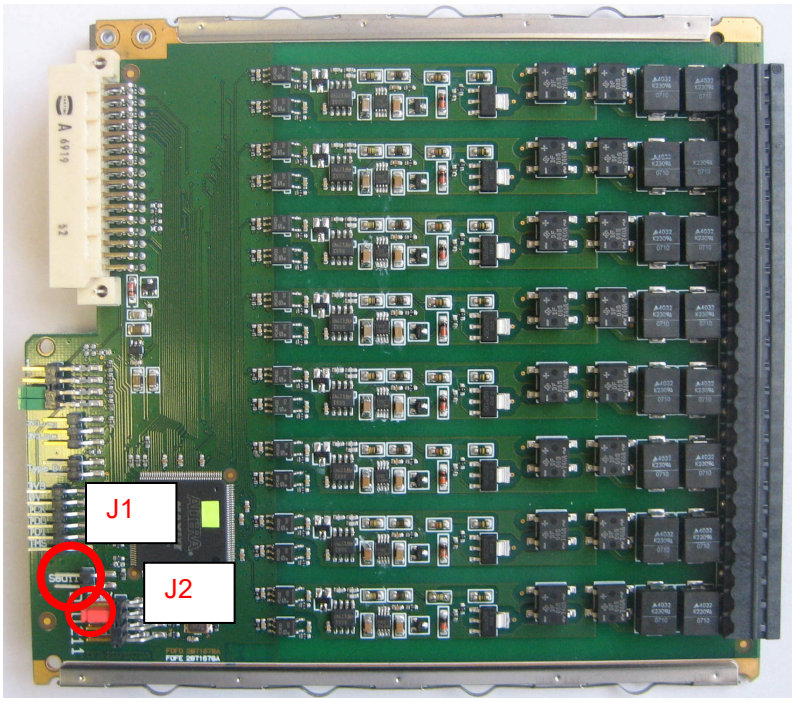
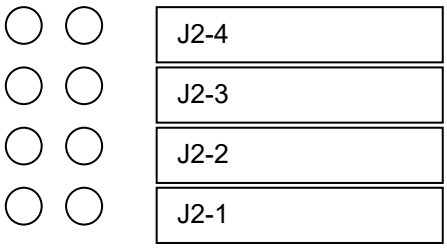


Figure 37: Voltage variant jumpers on the DIU211 board

J1 connector

Set the “jumper” on J1 for A07 and A08 VARIANTS ONLY

J2 connector



Set only one jumper on J2 connector:

Board variant	Jumper on J1	Jumper on J2
A01	No	J2-1
A02	No	J2-2
A03	No	J2-3
A04	No	J2-4
A07	Yes	J2-3
A08	Yes	J2-4

- From 24 V_{DC} to 220 V_{DC}: a peak current (>27 mA) circulates during a short time (approximately 2 ms) to clean external relays' contacts:

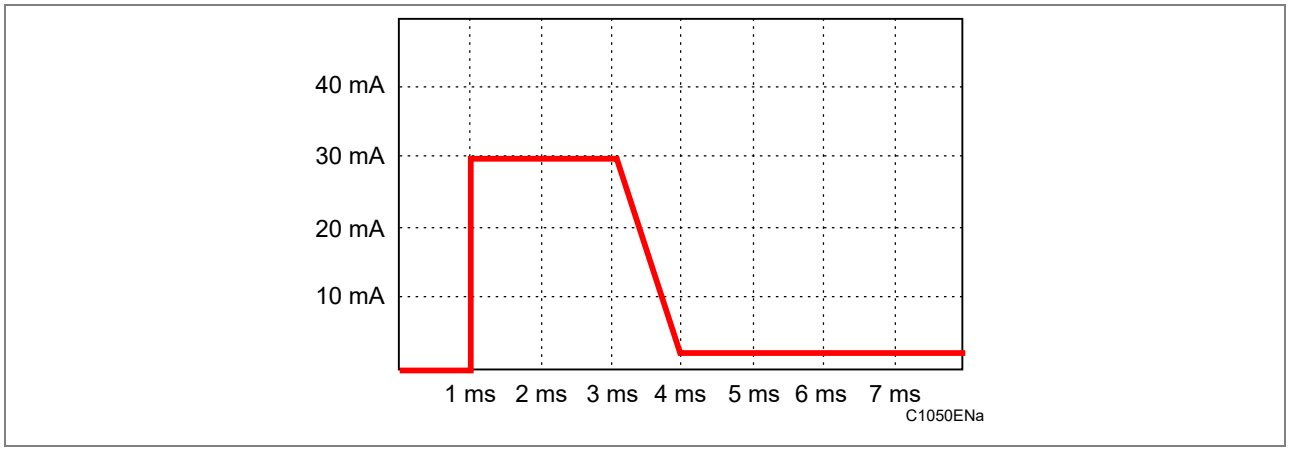


Figure 38: Peak current response curve

Settings: When used with a CPU270 board, the address of the board can be defined by the location of the DIU211 in the C26x rack (or by jumper if the board is used as spare of a previous board). This location is defined using the SCE (refer to C26x/EN AP).

1.5.11 DIGITAL INPUTS UNIT – DIU221

The capabilities of the DIU221 boards are:

- 16 galvanically-isolated (40 kΩ) digital inputs
- 1 common contact for 2 inputs (positive or negative)
- The digital inputs can be used for single or double status, pulse or digital measurement input on the same unit.
- Pre-defined triggering thresholds selected using jumpers:

Variants

Variant	Input voltage
A09	170 V_{DC}
A10	250V_{DC}

The board rated input voltage variant is determined by jumpers on the PL3 connector:

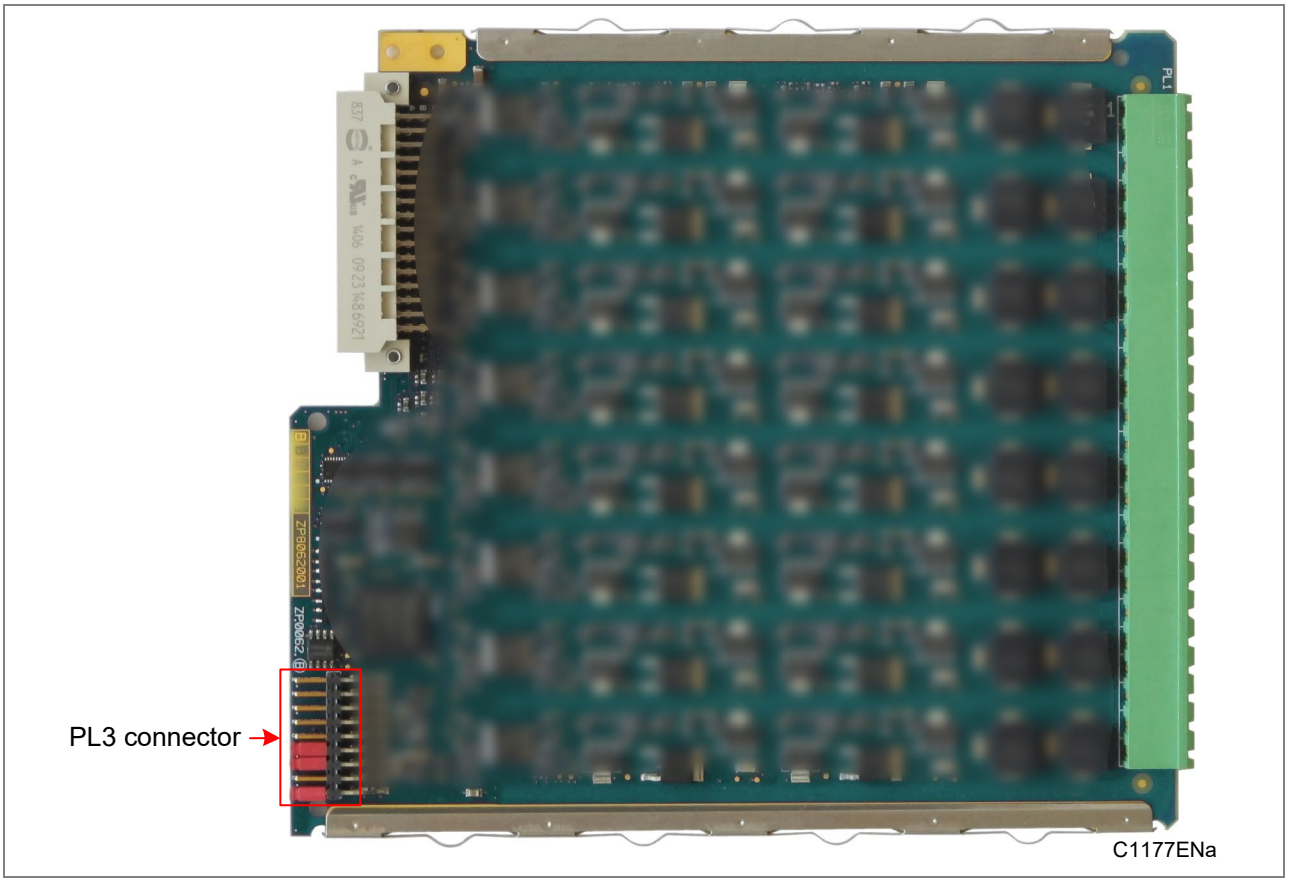


Figure 39: PL3 connector location on the DIU221 board (A09 variant)

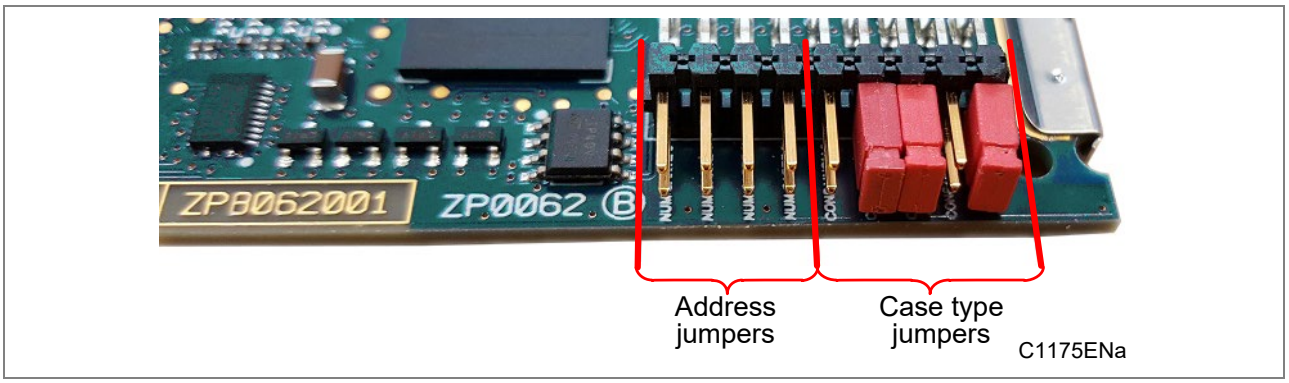
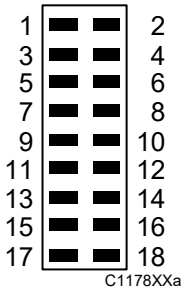


Figure 40: Voltage variant jumpers on the DIU221 board, A09 variant



At this time only the A09 and A10 variants are available. For these variants, jumpers must be fitted on pins:

A09	A10
11-12	9-10
13-14	13-14
17-18	17-18

Address configuration

When used with a CPU270 board, the address of the board can be defined by the location of the DIU221 in the C26x rack (or by jumper if the board is used as spare of a previous board). This location is set in the configuration database, using the SCE (refer to C26x/EN AP).

1.5.12 DIGITAL OUTPUTS UNIT – DOU200

The Digital Outputs Unit (DOU200) board provides 10 outputs using integrated relays.

The DOU200 board capabilities are:

- 8 single pole relays with one normally open (NO) contact
- 2 double pole relays with 1 common for 2 output contacts (NO/NC changeover)

A self-monitoring device for the output control chain is provided (address check, state monitoring)

The +5V voltage is monitored to avoid issuing unwanted signals.

The digital outputs can be configured in single or double remote control or set point outputs on the same module.

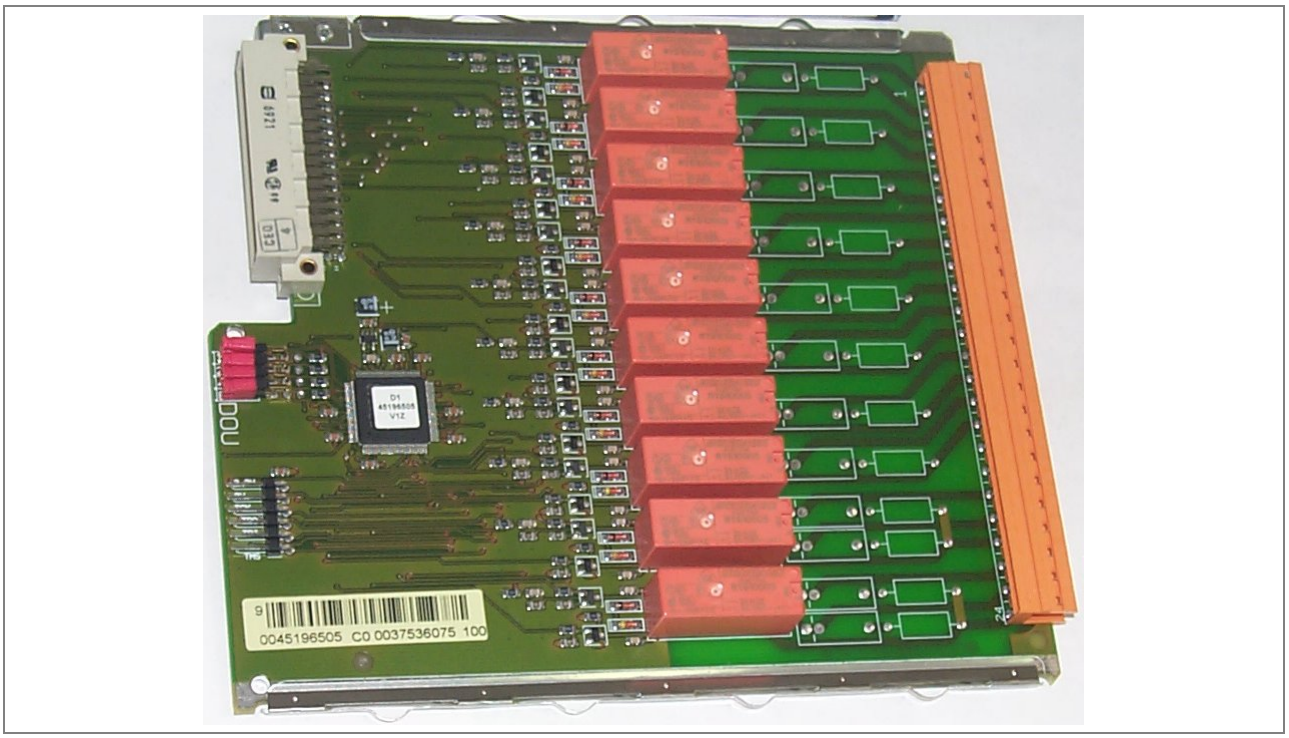


Figure 41: DOU200 board

1.5.13 DIGITAL OUTPUTS UNIT – DOU201

The Digital Outputs Unit (DOU201) board provides 10 isolated digital outputs using integrated relays.

The DOU201 board capabilities are:

- 8 single pole relays with one normally open (NO) contact
- 2 double pole relays with 1 common for 2 output contacts (NO/NC changeover)
- Nominal operating voltage range of 24 V_{DC} to 250 V_{DC} / 230 V_{AC}

The DOU201 has 8 single pole contacts that are normally open and 2 double pole contacts in which one pole contact is normally open and one pole contact is normally close.

The address of the board can be defined by the location of the DOU201 in the C26x rack (or by jumper if the board is used as spare of a previous board). This location is defined using the SCE (refer to C26x/EN AP).

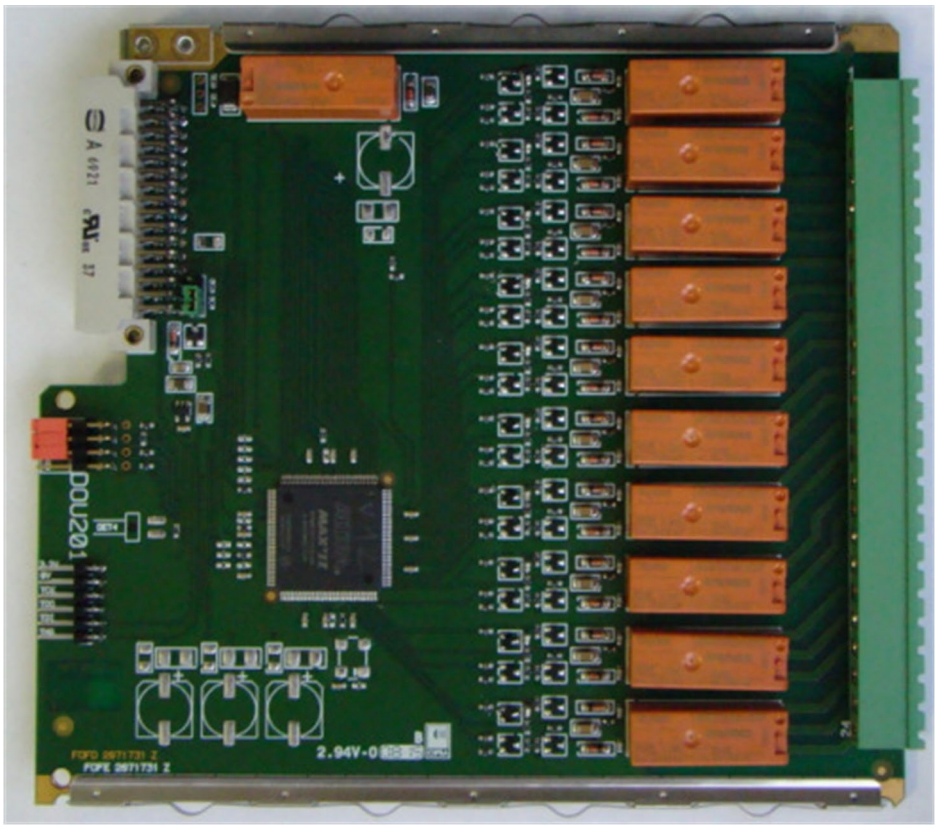


Figure 42: DOU201 board

1.5.14 HIGH BREAK UNIT – HBU200

The High Break Unit (HBU200) board provides 10 normally open single pole output channels. These can be configured to operate in pairs to give dual pole operation or parallel operation for enhanced current carrying capability.

The HBU200 board capabilities are:

- 10 single pole relays with one normally open (NO) contact
- Nominal operating voltage range of 24 V_{DC} to 250 V_{DC} / 250 V_{AC} +20%

The HBU200 has 10 single pole contacts that are normally open.

The address of the board can be defined by the location of the HBU200 in the C26x rack (or by jumper if the board is used as spare of a previous board). This location is defined using the SCE (refer to C26x/EN AP).

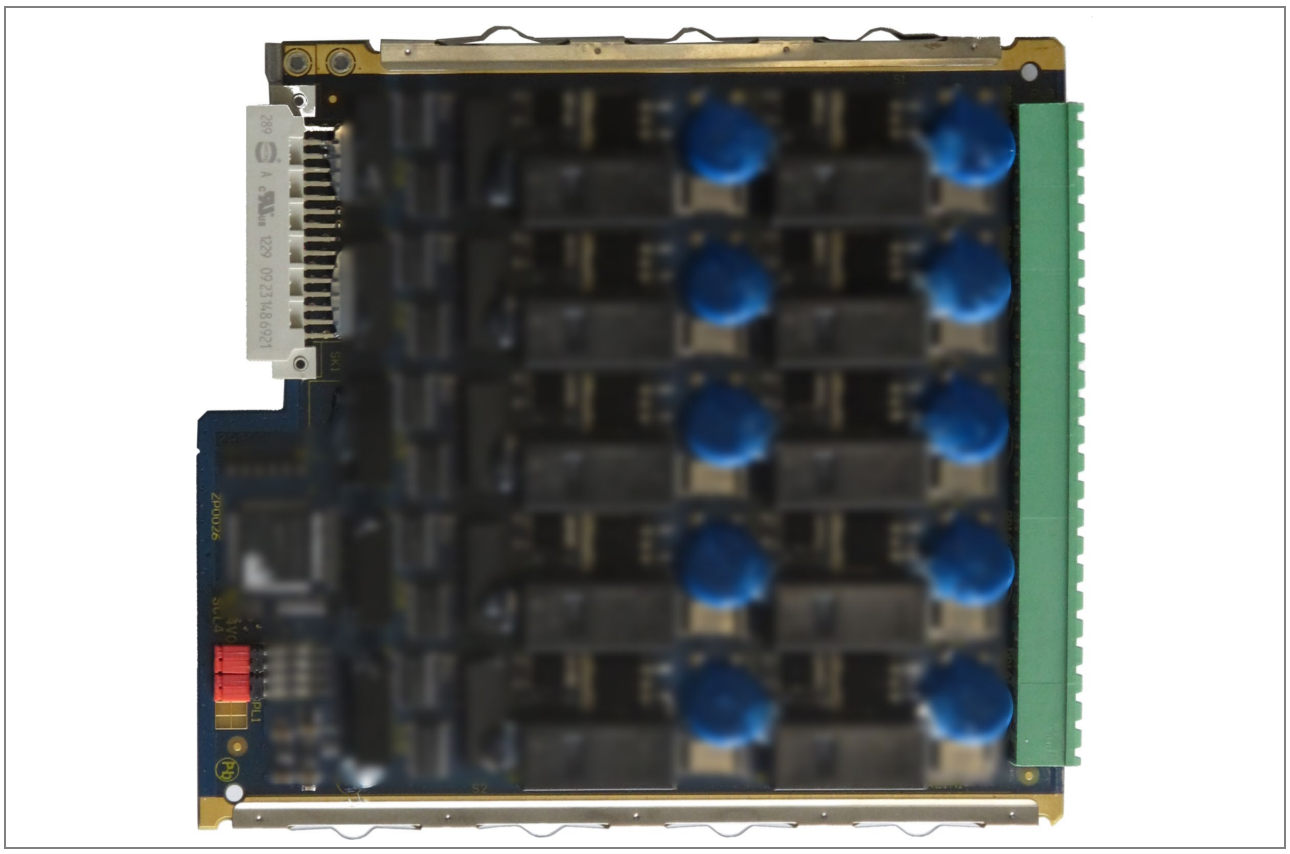


Figure 43: HBU200 board

1.5.15 ANALOGUE INPUT UNIT – AIU201

The Analogue input module (AIU201) has 4 independent Analogue Inputs. Each AI can be software-configured in a voltage or current range.

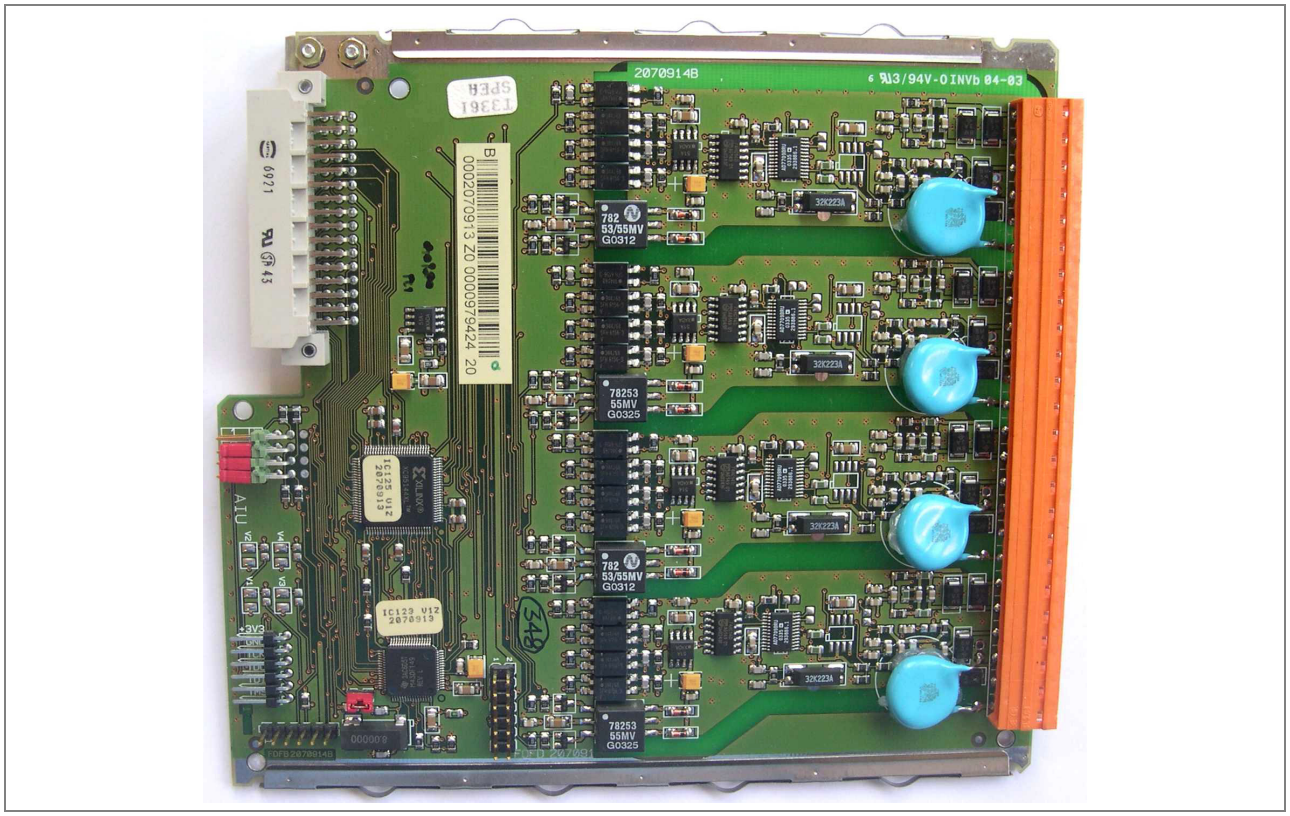


Figure 44: AIU201 board

1.5.16 ANALOGUE INPUT UNIT – AIU211

The Analogue input module (AIU211) has 8 isolated Analogue Inputs.

Analogue inputs (AI) are current DC signals delivered by transducers. Each AI can be software-configured in a current input range (among four ranges).

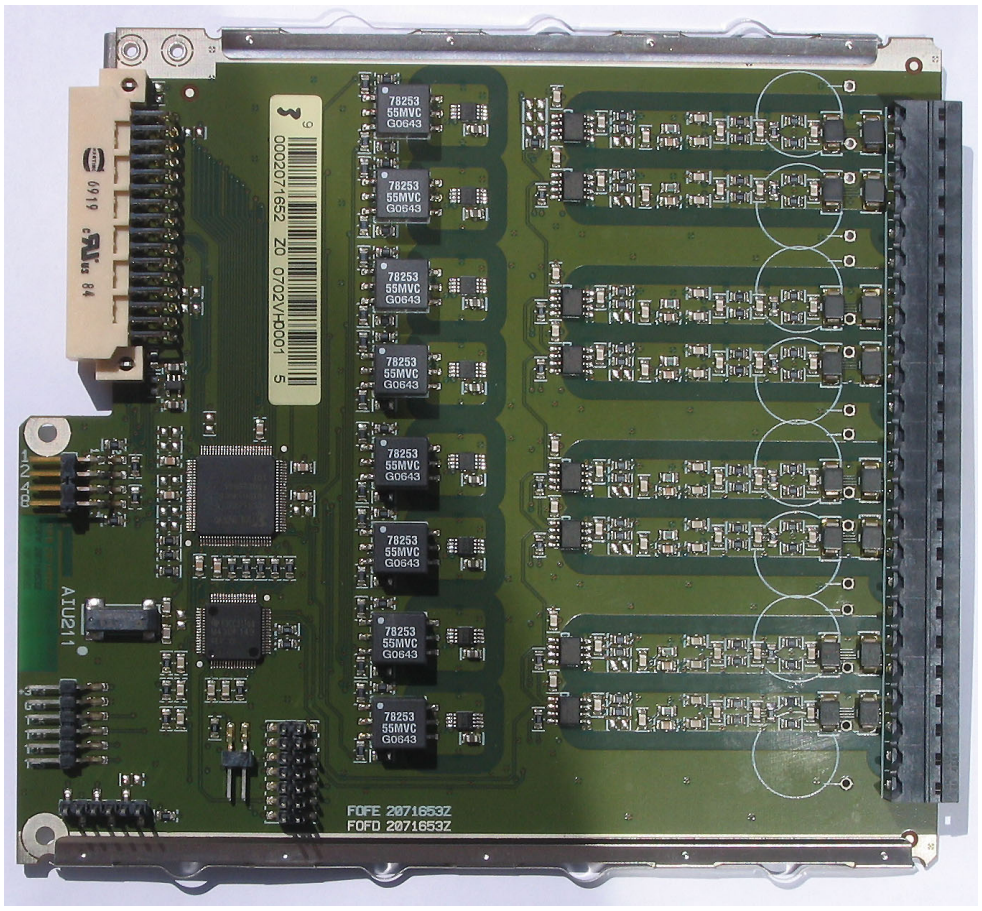


Figure 45: AIU211 board

1.5.17 TRANSDUCERLESS MEASUREMENTS UNIT – TMU200/220

The transducerless measurement capabilities are the following:

- 4 measurement Current Transformers (4 CT) inputs
  - Transformers have two ranges 1 A and 5 A
- for the TMU200 4 measurement Voltage Transformers (4 VT) inputs. For the TMU220 5 measurement Voltage Transformers (5 VT) inputs
  - AC voltage (Vn): 57.73 V_{RMS} to 500 V_{RMS}
- Frequency operating range: 50 or 60 Hz ± 10%

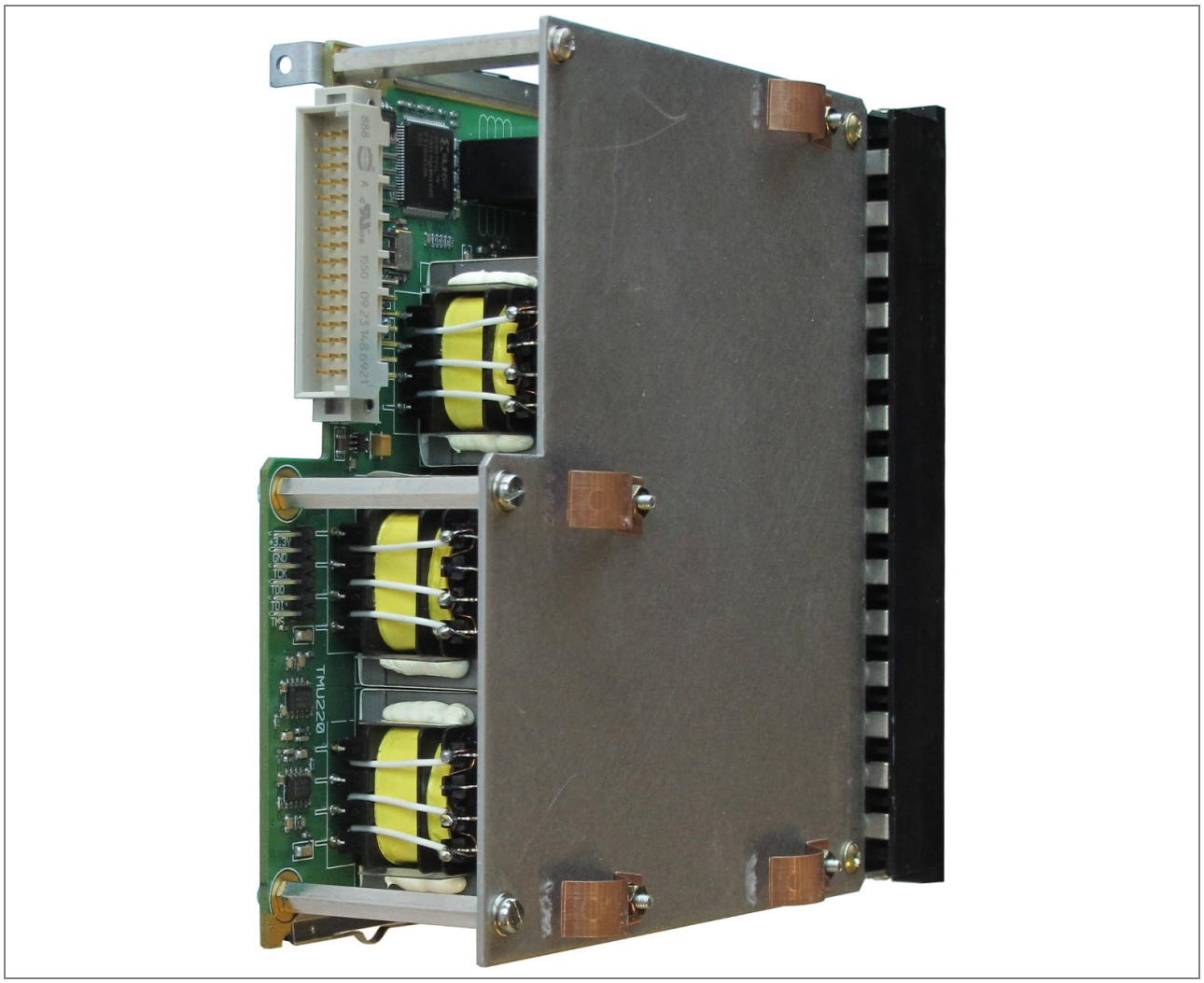


Figure 46: TMU220 board

The measured values are processed by an associated board:

Measurement unit	Processor	Processor board
TMU200	TMS320C6711	DSP260
TMU220	TMS320C6713	DSP220

1.5.18 TRANSDUCERLESS MEASUREMENTS UNIT – TMU210

The TMU210 board is a Protection Current and Voltage acquisition board (CT/VT) module used in the DS Agile C26x device.

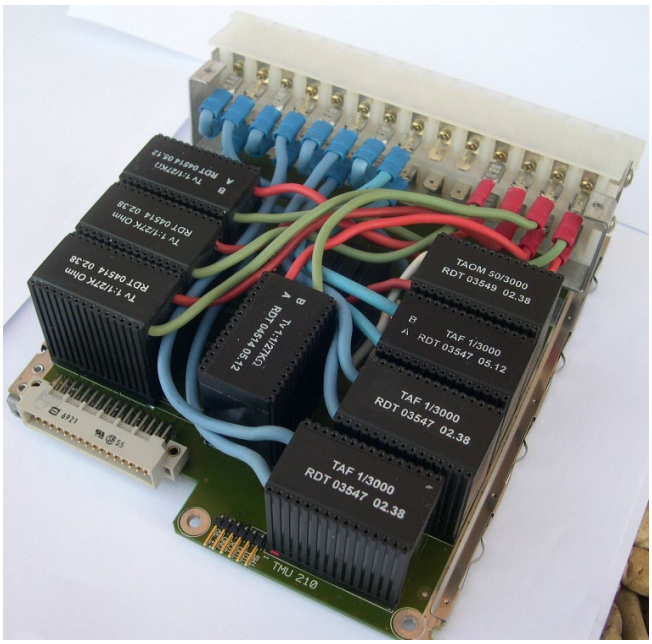


Figure 47: TMU210 board

The transducerless measurement capabilities are the following:

- 4 measurement Current Transformers (4 CT) inputs. Each transformer has two ranges 1 A and 5 A, selectable using a jumper
- 4 measurement Voltage Transformers (4 VT) inputs. Each transformer has two AC voltage ranges (Vn): 57.73 V_{RMS} to 130 V_{RMS} or 220V_{RMS} to 480 V_{RMS}
- Frequency operating range: 50 or 60 Hz ± 10%

3 use cases are available

- A01 (default variant):
  - 4 voltage channels (57.7V to 130V)
  - 4 current channels (1A or 5A)
- A02 (sensitive variant):
  - 4 voltage channels (57.7V to 130V).
  - 3 current channels (1A or 5A)
  - 1 current channel (1A sensible or 5A sensible)
- A03 (ultrasensible variant):
  - 4 voltage channels (57.7V to 130V).
  - 3 current channels (1A or 5A)
  - 1 current channel (1A very sensible or 5A very sensible)

1.5.19 ANALOGUE OUTPUT UNIT – AOU200

The AOU200 board provides 4 current analogue outputs. Each output is associated to a Read Inhibit relay. The outputs are powered using an external power supply. The external power supply has to provide a regulated voltage of +48V (+/- 5%).

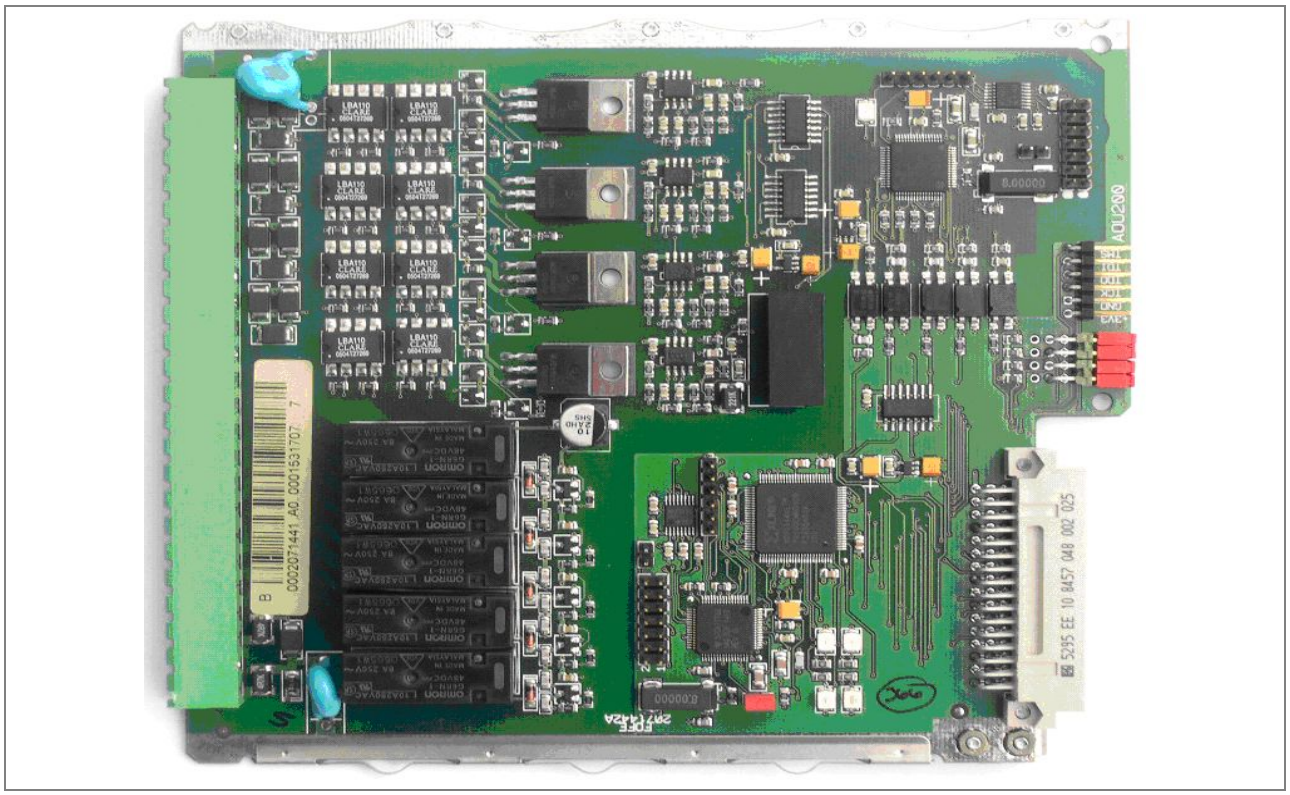


Figure 48: AOU200 board

1.5.20 ETHERNET SWITCH UNIT – SWU200/SWU202/SWU204

The SWU200 board is an Ethernet switch with 4 electrical links.

The SWU202 (resp. 204) board is an Ethernet switch with 4 electrical links 10/100BaseTX and 2 optical multi-mode (resp. single mode) links 100BaseFX.

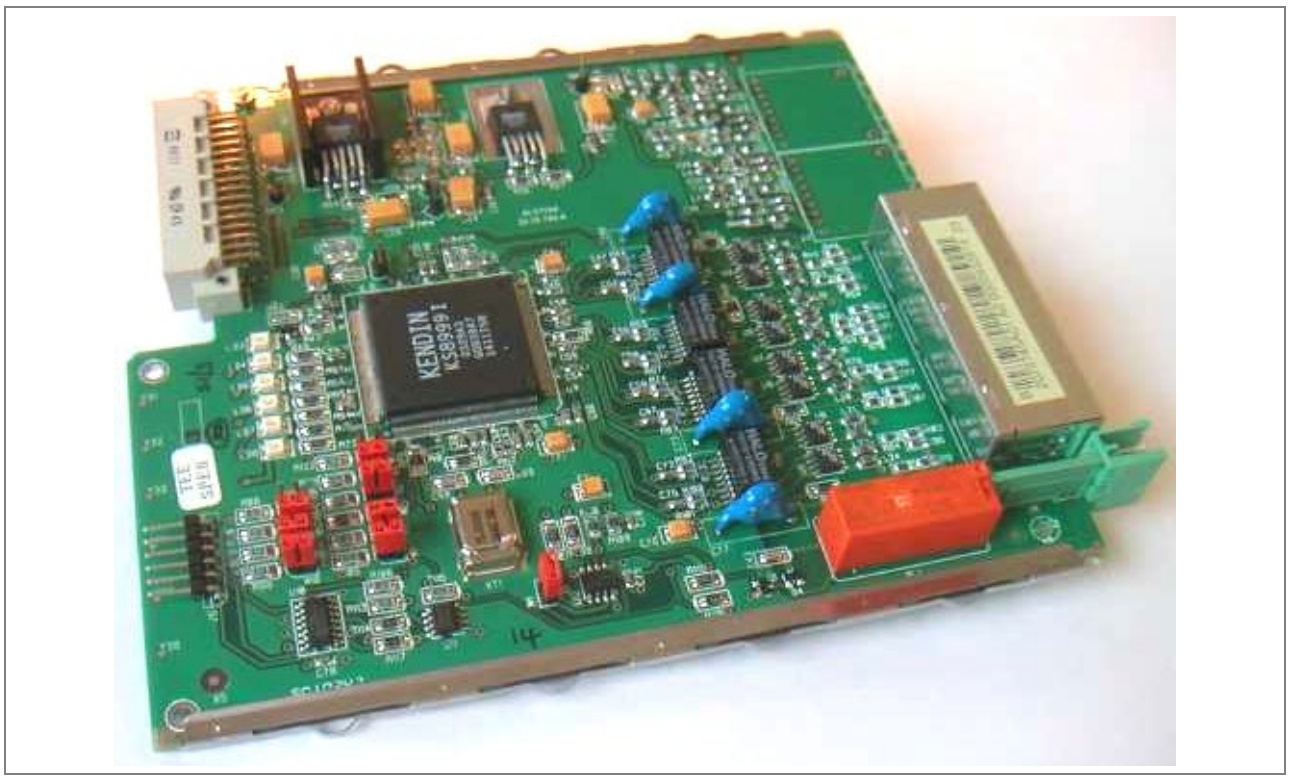
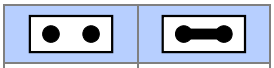


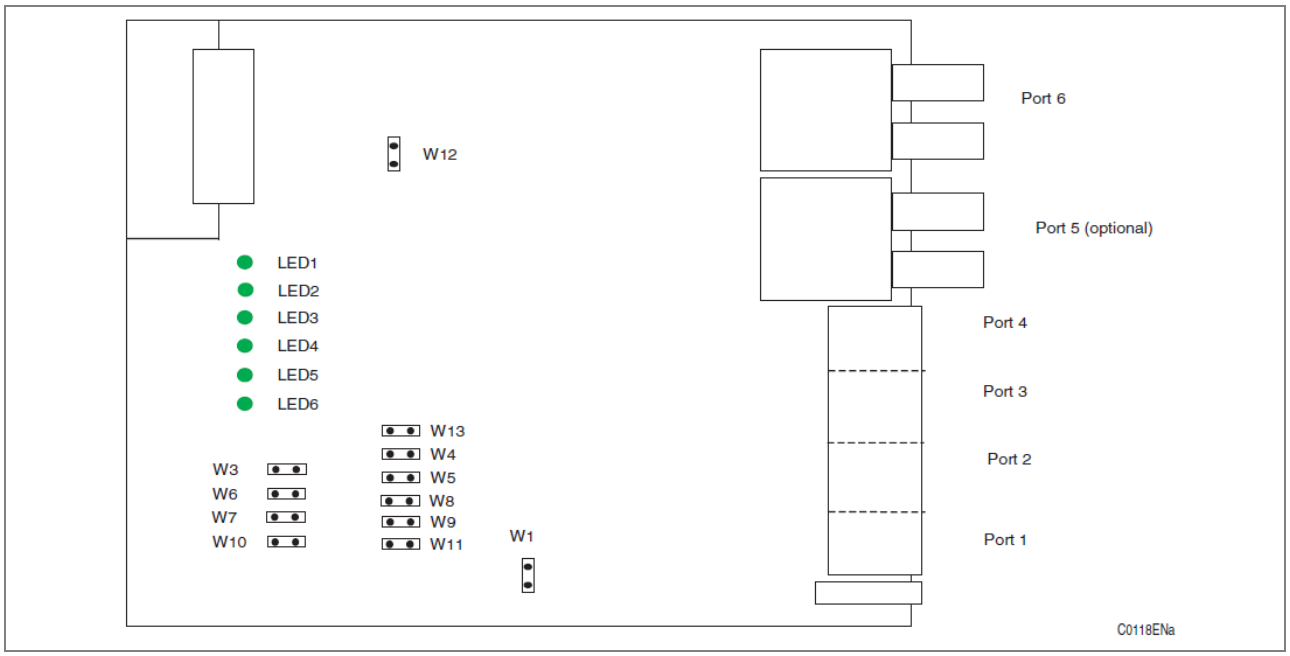
Figure 50: SWU200 board

Jumpers are used to adapt the switch to your network:

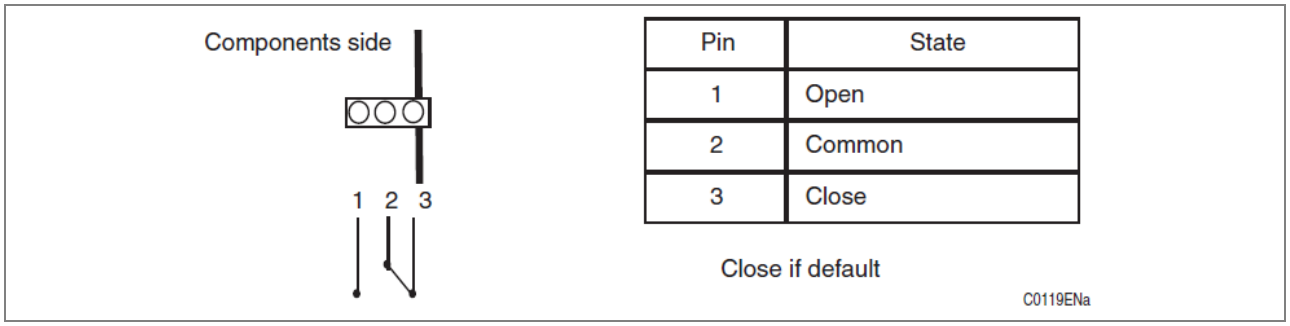


Open	Closed

N°	Open	Closed	Factory setting
W1	No watching port 5	Fault watching Port 5 (Fx)	Open
W3	Enable more aggressive back-off	Enable less aggressive back-off	Open
W4	Max length is 1536 byte	Enable enforce the max frame length for VLAN is 1522	Open
W5	Enable half duplex back pressure	Disable half duplex back pressure	Open
W6	Continue sending frame regard-less of number of collisions	Enable to drop frame after 16 collisions	Open
W7	Enable flow control	Disable flow control	Closed
W8	No priority reserve	Enable 6KB priority buffer reserved	Closed
W9	Half duplex for port 5 (Fx)	Full duplex for port 5 (Fx)	Closed
W10	Unlimited broadcast frames	Enable 5% broadcast frame allowed	Open
W11	Half duplex for port 6 (Fx)	Full duplex for port 6 (Fx)	Closed
W12	Enable 802.1p selected by EEPROM	Enable 802.1p field for all port	Closed
W13	Share buffers up to 512 buffers on a single port	Enable equal amount of buffers per port (113 buffers)	Open



SWU202/204 optical links: these 2 optical links are monitored; if one link fails the fault is announced by the contacts (250V/5A):



Pin	State
1	Open
2	Common
3	Close

The Ethernet star is based on optical connection. Depending on the link length the user may choose between multi-mode optic fibre (up to 2 km) and single mode optic fibre for long distances (up to 20 km).

Variant	Reference	Description	Connectors
SWU200	2070745 A01	Fast Ethernet industrial switch	4 x RJ45
SWU202	2070745 A03	Fast Ethernet industrial switch Multimode 1300 nm	4 x RJ45, 2 x ST
SWU204	2070745 A05	Fast Ethernet industrial switch Single mode 1310 nm	4 x RJ45, 2 x SC

10/100BaseTx Port

Connector type	Shielded RJ45 jack
Twisted pair cable	Cat 5
Max cable length with Cat 5	100m

100BaseFx Multi Mode Port

Fibre port connector	ST
Optimal fibre cable	62,5/125 µm or 50/125 µm
Center wavelength	1300 nm
TX output power	-19 dBm
RX input sensitivity	-31 dBm
Maximum distance	2000 m
Half or full Duplex	Switch selectable

100BaseFx Single Mode Port

Fibre port connector	SC
Optimal fibre cable	9/125 µ or 10/125 µm
Center wavelength	1310 nm
TX output power	-15 dBm
RX input sensitivity	-34 dBm
Maximum distance	20 000 m
Half or full Duplex	Switch selectable

1.5.21 ETHERNET SWITCH – SWX212, SWX214 (X=R FOR DUAL RING, X=D FOR DUAL HOMING, X=T FOR TEAMING)

These boards include 4 electrical links 10/100BaseTX and 2 optical links 100BaseFX for a dual ring/homing.

The 10/100BaseTXports are half/full duplex and auto-sense the transmission speed. They auto-negotiate with the connected device to determine the optimal transmission speed: 10 Mbps or 100 Mbps depending on the connected device's capability.

The SWx212 and SWx214 switches are SNMP-managed.

The SWx212 variants have a multi-mode optical interface.

The SWx214 variants have a single mode optical interface.

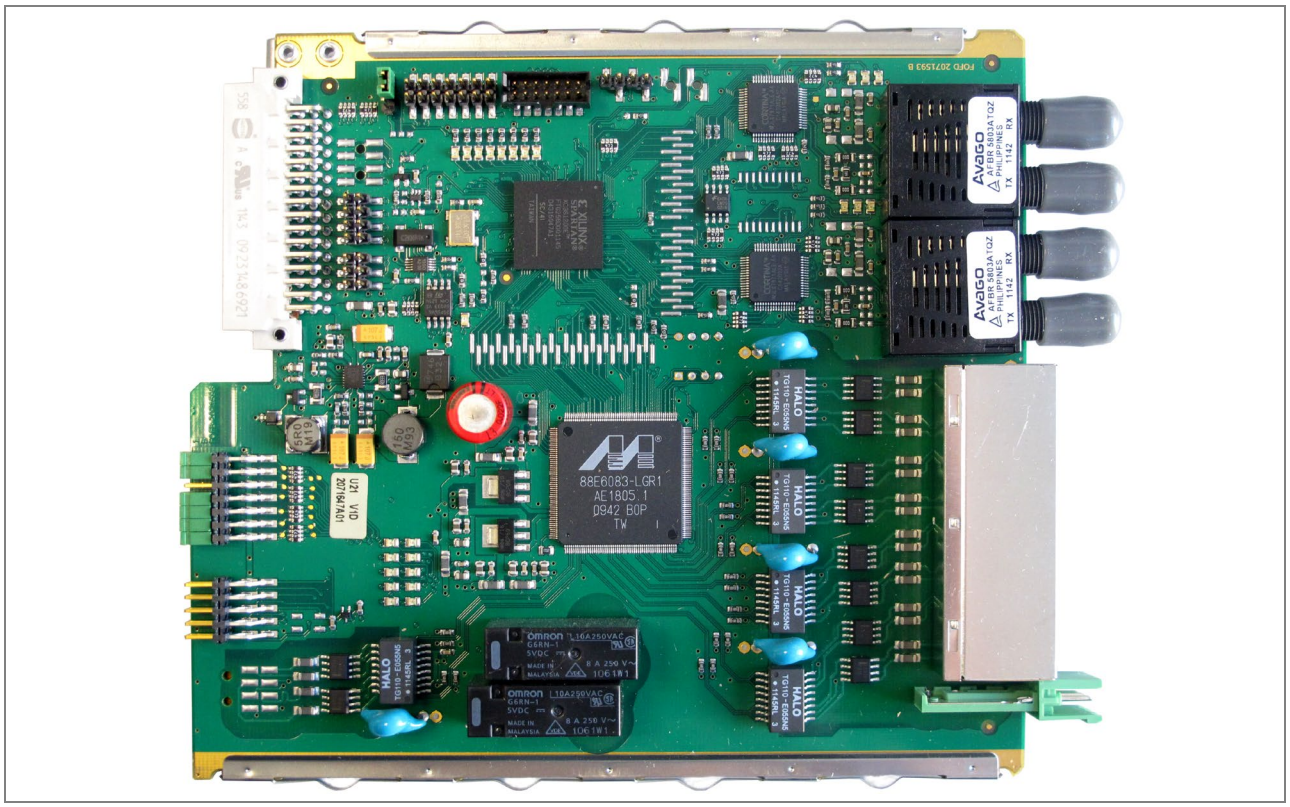


Figure 51: SWR212/SWD212/SWT212 board

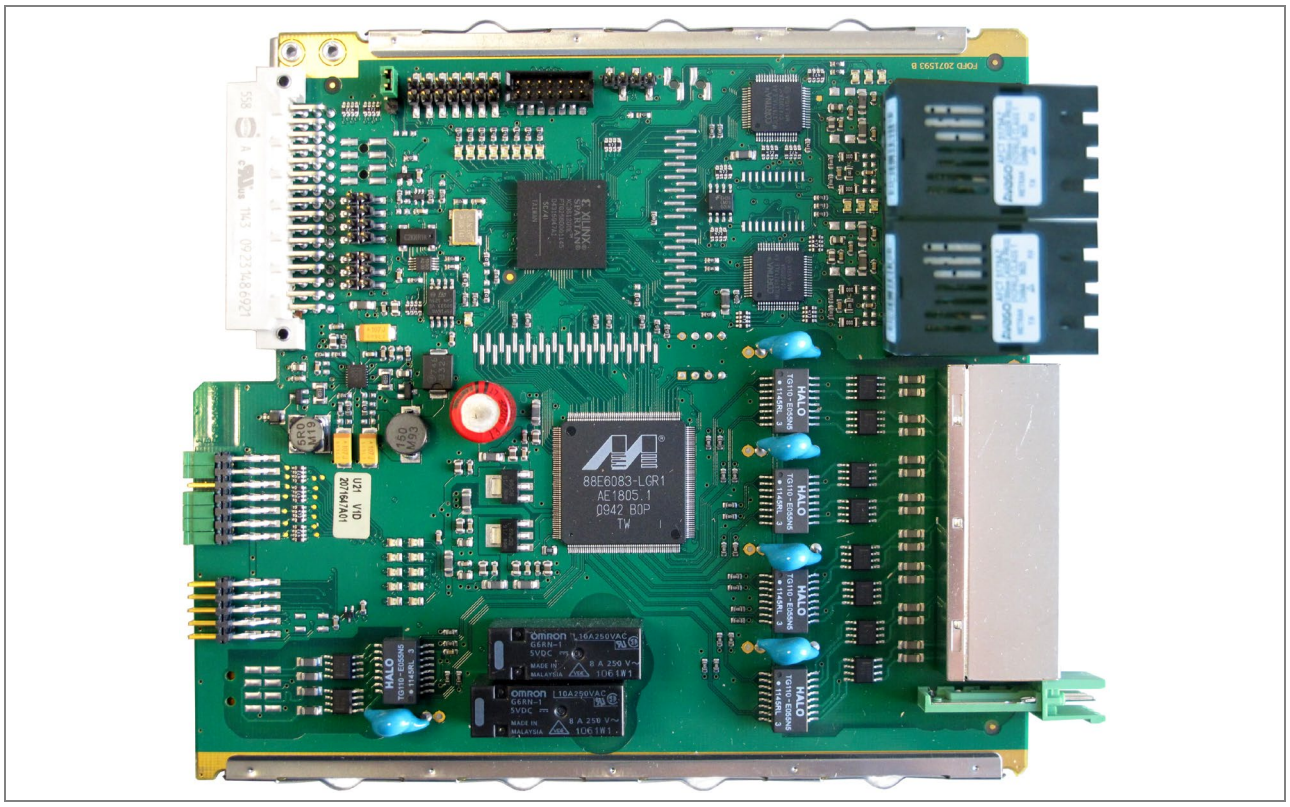


Figure 52: SWR214/SWD214 board

To set the board's address, see chapter C26x/EN NM.

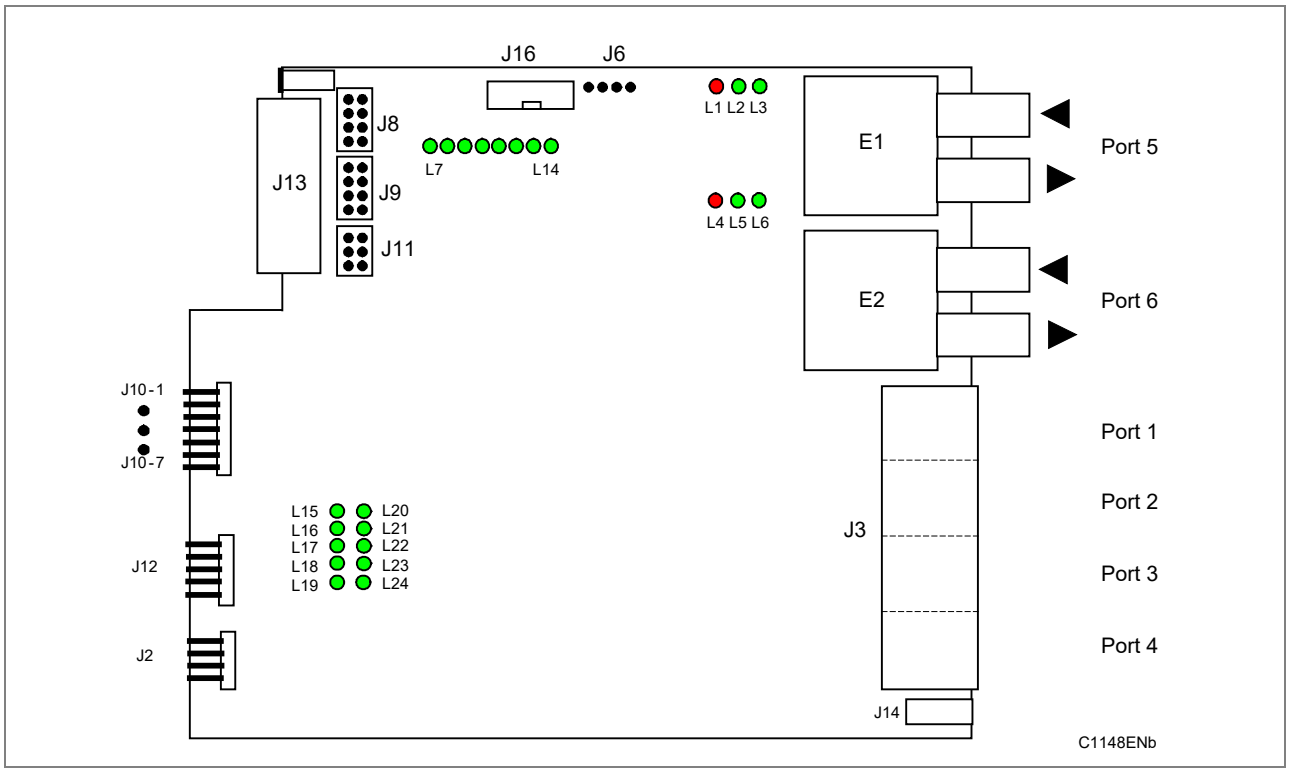


Figure 53: Location of connectors, LEDs and ports

Switch management

It is possible to manage the switch with the serial MDIO bus (J6).

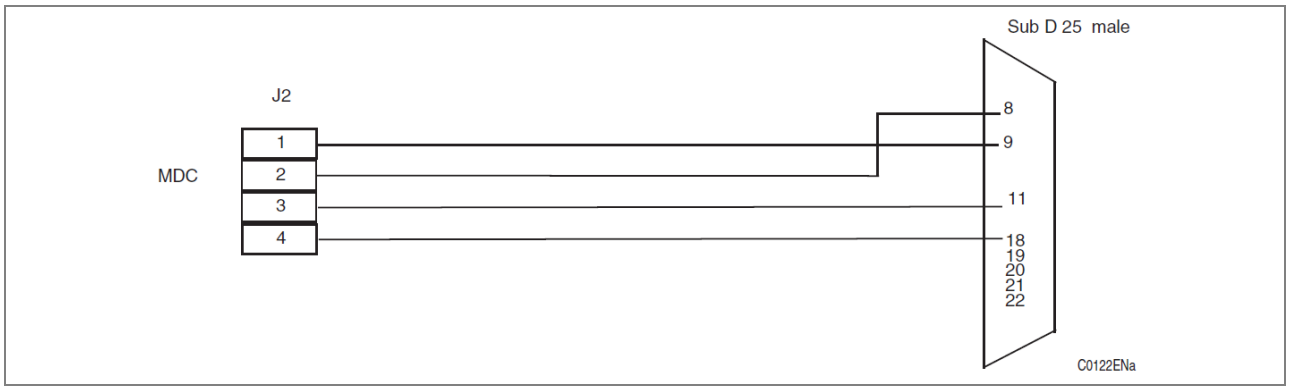


Figure 54: MDIO bus

Ethernet cable type

Use data quality twisted pair shielded cable rated category 5 with standard RJ45 connectors.

The maximum cable length 1.for 10/100BaseTX is 100 meters, straight-through cable.

Ethernet Fibre Optic

The FO cables are connected to the corresponding FO elements.

Fibre optic connectors

Board hardware	Fibre type	Connectors
SWx212	multi-mode	2 x ST
SWx214	single mode	2 x SC

Note:
There is no single mode variant for the SWT board. Only the SWT212 (multi-mode/2 x ST connectors) is available.

Fibre Optic budget calculations

Optical power is expressed in Watts. However, the common unit of power measurement is the dBm, defined by the following equation: Power (dBm) = 10 log Power (mW) / 1 mW.

The fibre optic budget is the difference between the power emitted into the fibre and the sensitivity (minimum amount of power required) of the receiver connected through the fibre optic cable.

Link Power Budget = Transmitter Power (dBm) - Receiver Sensitivity (dBm). The distance over which the signals can be transmitted and successfully received is affected by the optical loss as shown in the figure below.

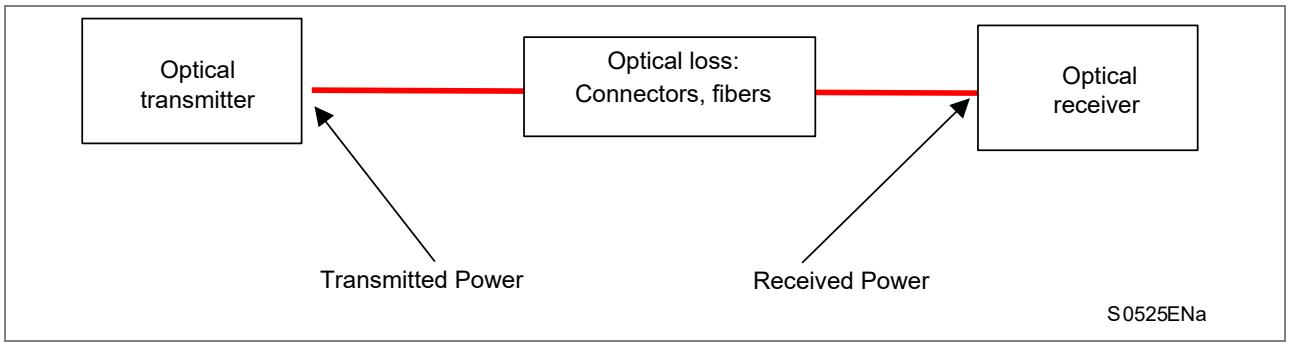


Figure 55: Fibre budget

	Fibre type	
	Multi mode (SWx212)	**Single mode (SWx214)**
	Wavelength: 1300 nm 62.5/125 µm or 50/125 µm	Wavelength: 1310 nm 9/125 µm or 10/125 µm
Power coupled into fibre	- 19 dBm	- 15 dBm
Sensitivity	- 31 dBm	- 34 dBm
Link budget	12 dB	19 dB

Example 1: Between two switches

	Fibre type	
	Multi mode (SWx212)	**Single mode (SWx214)**
Link budget	12 dB	19 dB
Connector loss (1)	0.8 dB	0.8 dB
Safety margin	4 dB	4 dB
Allowed link attenuation	6.4 dB	13.4 dB
Typical cable attenuation	1 dB/km	0.4 dB/km
Maximum range	6.4 km	33 km

Example 2: Between two switches through a patch panel

	Fibre type	
	Multi mode (SWx212)	**Single mode (SWx214)**
Link budget	12 dB	19 dB
Connector loss (1)	0.8 dB	0.8 dB
Patch loss (1)	2 dB	1 dB
Safety margin	4 dB	4 dB
Allowed link attenuation	-0.8 dB	8.2 dB
Typical cable attenuation	1 dB/km	0.4 dB/km
Maximum range	0	20 km

(1) The values given above are approximate. Always use cable and connector losses as specified by their manufacturer.

1.5.22 PRP ETHERNET SWITCH SRP282/284

The SRP28x is a circuit board providing an Ethernet Switch embedded with the Parallel Redundancy Protocol (PRP according to IEC 62439-3) to provide redundancy of communications. The board can also provide support for the Precision Time Protocol (PTP) according to IEEE 1588 v2, to deliver precise local time synchronisation. The board is designed to integrate into DS Agile products such as the H38x.

It is designed to work in an electrical plant environment where standards such as IEC 61000-4 & IEC 60255-5 apply.

You configure the switch using a TELNET connection to a terminal emulation package on a personal computer or similar device.

This board includes 3 electrical links 10/100BaseTX and 2 optical links 100BaseFX for “bumpless” redundancy (PRP). It turns the C26x into a Double Attached Node running PRP.

It features on the rear, from top to bottom:

- Two sockets that receive removable transceivers providing either Single-mode (mono-mode) or Multi-mode optical interface; each transceiver is locked with a clamp and protected with a rubber plug when not used
- Status LEDs on both sides of IRIG-B connector (golden connector)
- Three RJ45 sockets
- A 3-pin connector (Fault signal)

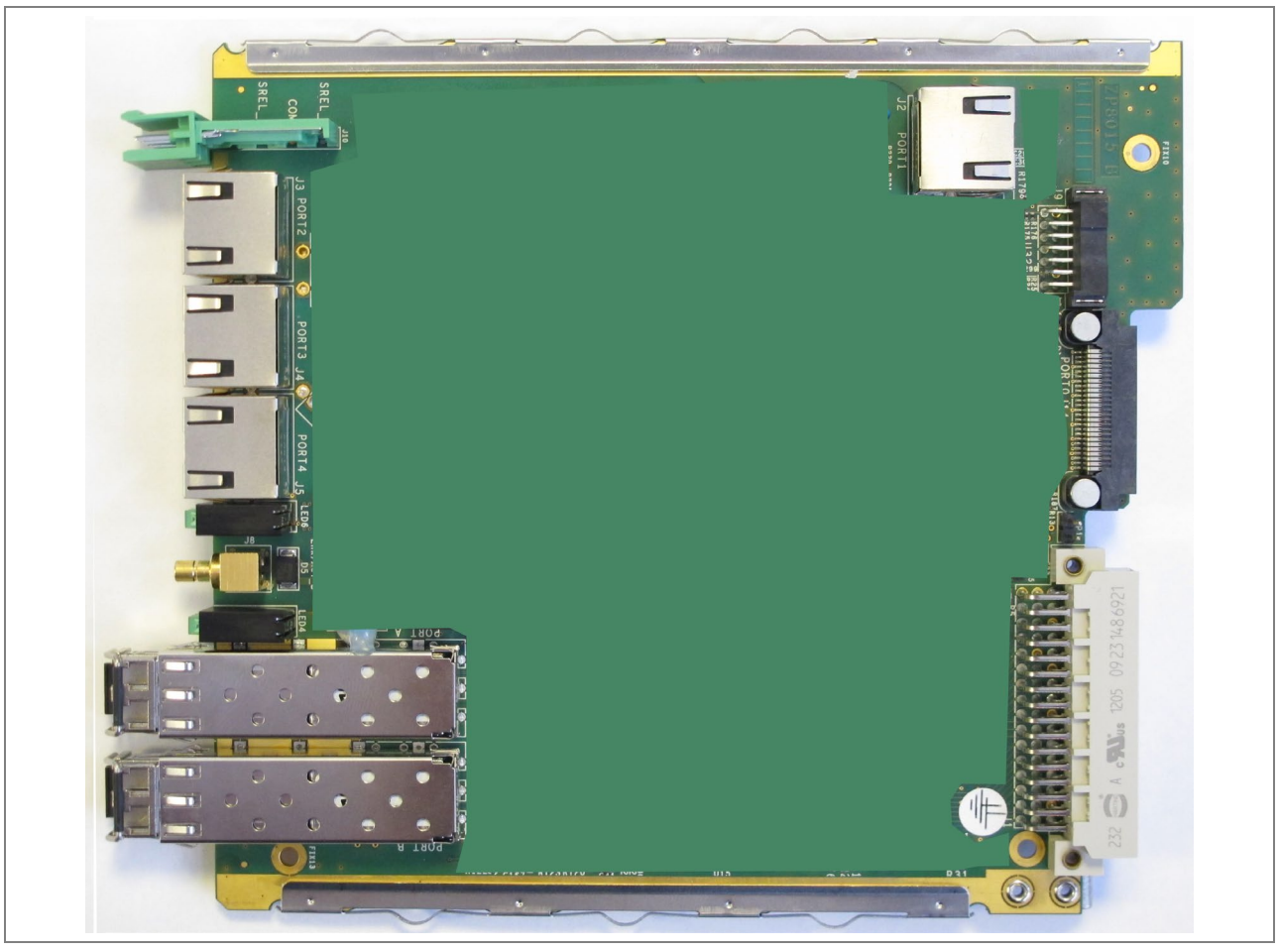


Figure 56: SRP board

LEDs

Eight LEDs are provided as shown in the diagram below, with their meaning indicated in the table that follows it.

They are situated at the rear of the board.

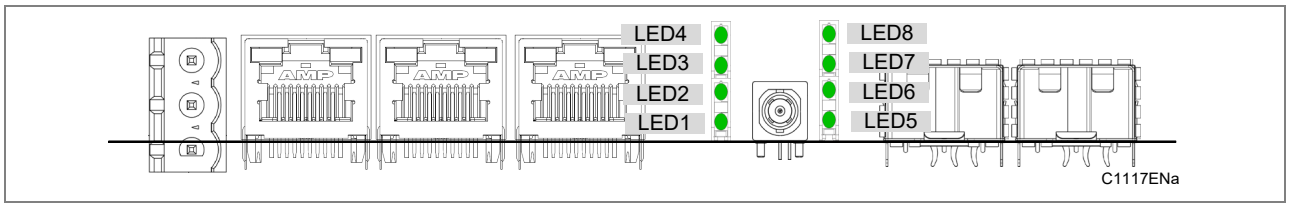


FIGURE 57: SRP28x LED positions

LED number	Assignment	Meaning
1	Port2 status	Off = no link On = link good Blinking = activity on the link
2	Port3 status	
3	Port4 status	
4	PPS	A pulse per second signal generated by the clock core on the board
5	PRP link B status	Off = no link On = link good Blinking = activity on the link
6	PRP link A status	
7	Software status	ON = normal OFF = factory mode, or failsafe/alarm operation
8	Initiation status	ON = configuration in progress OFF = configuration done

Switch management

The switch is SNMP managed (it integrates an SNMP server) and can be remotely accessed using an SNMP “client”. The IP addresses are set via a telnet connection on any port. You can use the CMT; refer to the chapter C26x/EN IN.

Ethernet cable type

Use data quality twisted pair shielded cable rated category 5 with standard RJ45 connectors.

The maximum cable length for 10/100BaseTX is 100 meters. Straight-through cable.

Variants

- SRP282 with two multi-mode optical connectors
- SRP284 with two single-mode optical connectors

Ethernet Optical Fibre

The cables are connected to the corresponding elements.

In both variants, the optical fibre connectors are **LC**-type small form-factor pluggable (SFP) transceivers that can use both single and multi mode fibre.

The table below lists the supports LC-Type SFP and references:

Item	Manufacturer Reference	Manufacturer	Description	Connector Type	Image
SRP282 PRP Switch Multimode	HFBR-57E5APZ	Avago	125Mbps Multimode 1310 nm wavelength	LC Duplex	
SRP284 PRP Switch Single mode	AFCT-5765ATLZ	AVAGO / Fit-foxconn	155Mbps Single-mode SR (up to 2 km) 1310 nm wavelength	LC Duplex	

Fibre Optic budget calculations

Optical power is expressed in Watts. However, the common unit of power measurement is the dBm, defined by the following equation: Power (dBm) = 10 log Power (mW) / 1 mW.

The fibre optic budget is the difference between the power emitted into the fibre and the sensitivity (minimum amount of power required) of the receiver connected through the fibre optic cable.

Link Power Budget = Transmitter Power (dBm) - Receiver Sensitivity (dBm). The distance over which the signals can be transmitted and successfully received is affected by the optical loss as shown in the figure below.

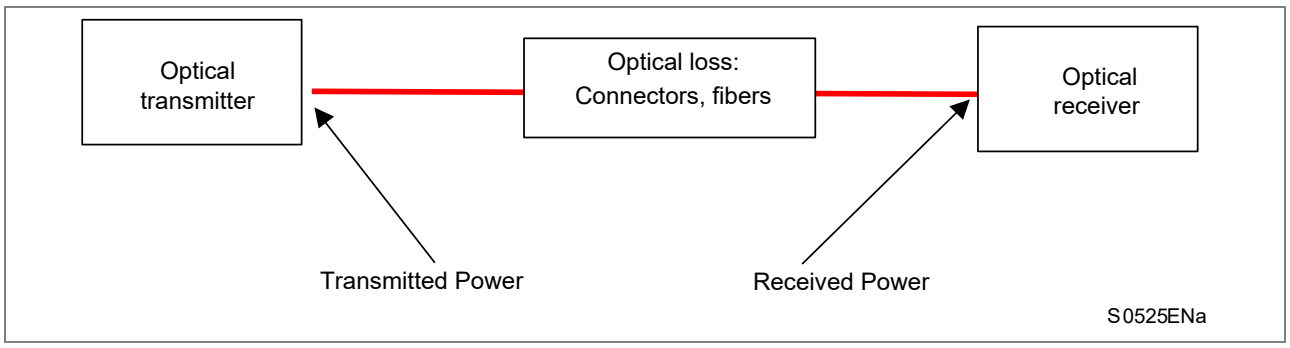


Figure 58: Fibre budget

For this product the optical budget is given in the table below.

Fibre type	Multimode	Single mode
	62.5/125 micron	**9/125 micron**
Power coupled into fibre	-19 dBm	-15 dBm
Sensitivity	-31 dBm	-34 dBm

In calculating the maximum distance, the following figures can be used as a guide, but you should check with your supplier for precise figures.

Fibre type	Multimode	Single mode
Link budget	**12 dB**	**19 dB**
Connector loss (1 per receiver, 1 per transmitter)	0.8 dB	0.8 dB
Safety Margin	4 dB	4 dB
Allowed link attenuation	**6.4 dB**	**13.4 dB**
Typical cable attenuation	1 dB/km	0.4 dB/km
Maximum range	**2 km**	**15 km**
Insertion of a patch panel (per panel)	2 dB	1 db

1.5.23 HSR ETHERNET SWITCH SRP292/294

This board includes 3 electrical links 10/100BaseTX and 2 optical links 100BaseFX for “seamless” redundancy (HSR). It turns the C26x into a Doubly Attached Node running HSR.

It features on the rear, from top to bottom:

- Two sockets that receive removable transceivers providing either Single-mode (mono-mode) or Multi-mode optical interface; each transceiver is locked with a clamp and protected with a rubber plug when not used
- Connection status LEDs
- IRIG-B connector (not used)
- Three RJ45 sockets
- A 3-pin connector (Fault signal)

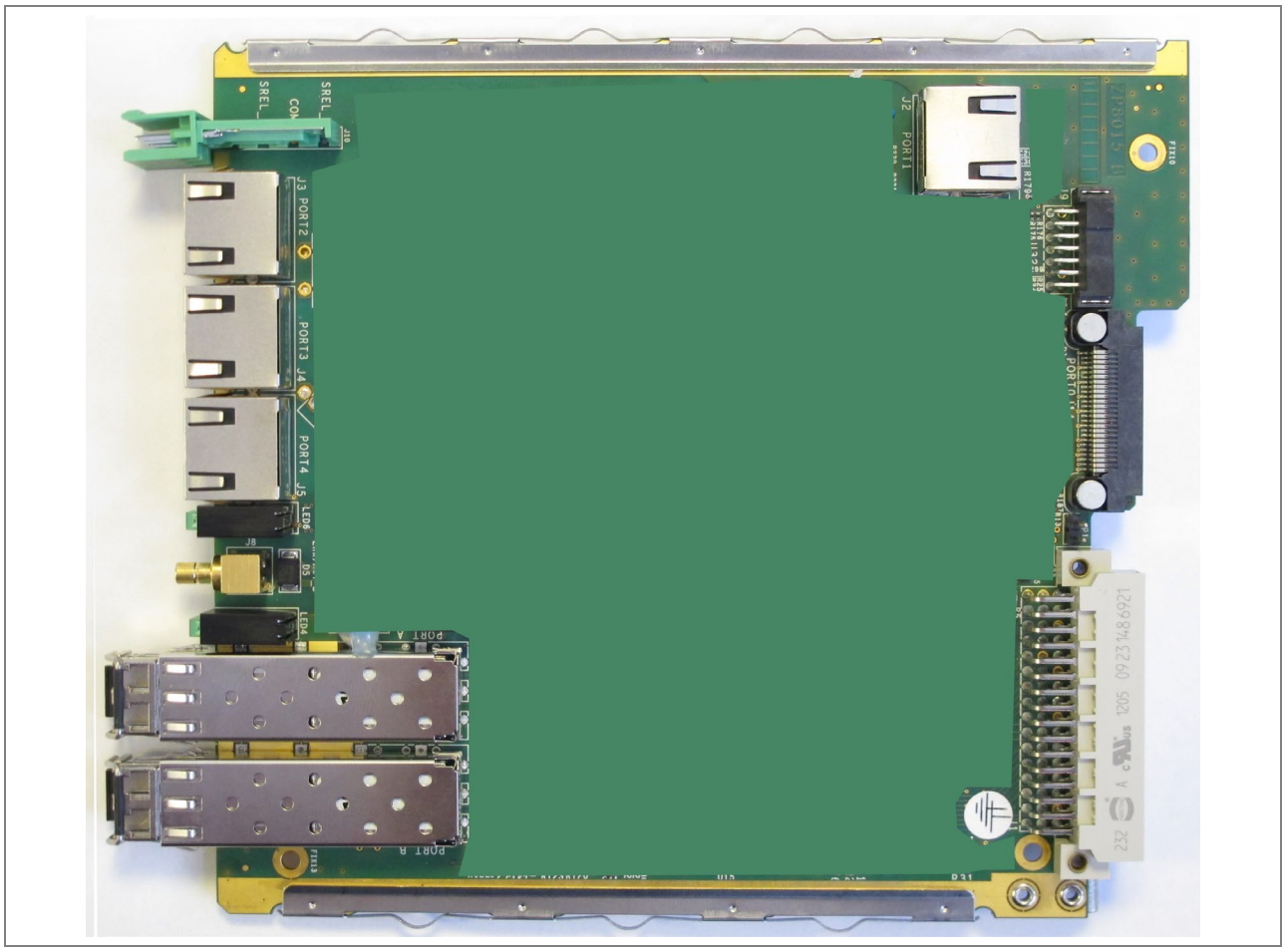


Figure 59: SRP29x board

LEDs

Eight LEDs are provided as shown in the diagram below, with their meaning indicated in the table that follows it.

They are situated at the rear of the board.

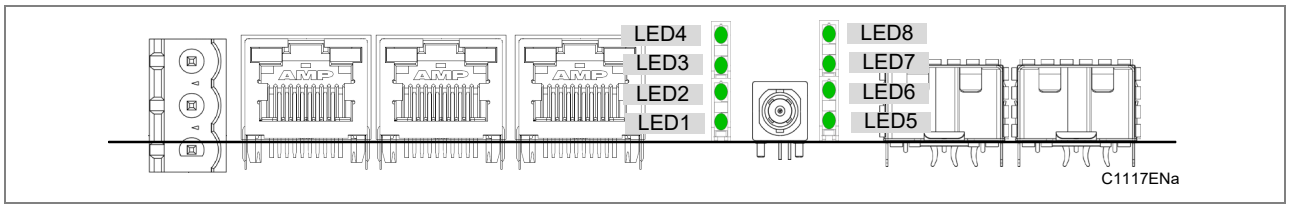


FIGURE 60: SRP29x LED positions

LED number	Assignment	Meaning
1	Port 4 status	Off = No link On = Healthy link Blinking = Activity
2	Port 3 status	
3	Port 2 status	
4	Not used	
5	HSR link B status	Off = No link

LED number	Assignment	Meaning
6	HSR link A status	On = Healthy link Blinking = activity
7	Software status	ON = Normal OFF = Factory mode, or failsafe/alarm operation
8	Initiation status	ON = Configuration in progress OFF = Configuration done

Switch management

The switch is SNMP managed (it integrates an SNMP server) and can be remotely accessed using an SNMP "client". The IP addresses are set via an SSH connection on any port.

Ethernet cable type

Use data quality twisted pair shielded cable rated category 5 with standard RJ45 connectors.

The maximum cable length for 10/100BaseTX is 100 meters. Straight-through cable.

Variants

- SRP292 with two multi-mode optical connectors
- SRP294 with two single-mode optical connectors

Ethernet Optical Fibre

The cables are connected to the corresponding elements.

In both variants, the optical fibre connectors are **LC**-type small form-factor pluggable (SFP) transceivers that can use both single and multi mode fibre.

The table below lists the supports LC-Type SFP and references:

Item	Manufacturer Reference	Manufacturer	Description	Connector Type	Image
SRP292 HSR Switch Multimode	HFBR-57E5APZ	Avago	125Mbps Multimode 1310 nm wavelength	LC Duplex	
SRP294 HSR Switch Single mode	AFCT-5765ATLZ	AVAGO / Fit-foxconn	155Mbps Single-mode SR (up to 2 km) 1310 nm wavelength	LC Duplex	

Fibre Optic budget calculations

Optical power is expressed in Watts. However, the common unit of power measurement is the dBm, defined by the following equation: Power (dBm) = 10 log Power (mW) / 1 mW.

The fibre optic budget is the difference between the power emitted into the fibre and the sensitivity (minimum amount of power required) of the receiver connected through the fibre optic cable.

Link Power Budget = Transmitter Power (dBm) - Receiver Sensitivity (dBm). The distance over which the signals can be transmitted and successfully received is affected by the optical loss as shown in the figure below.

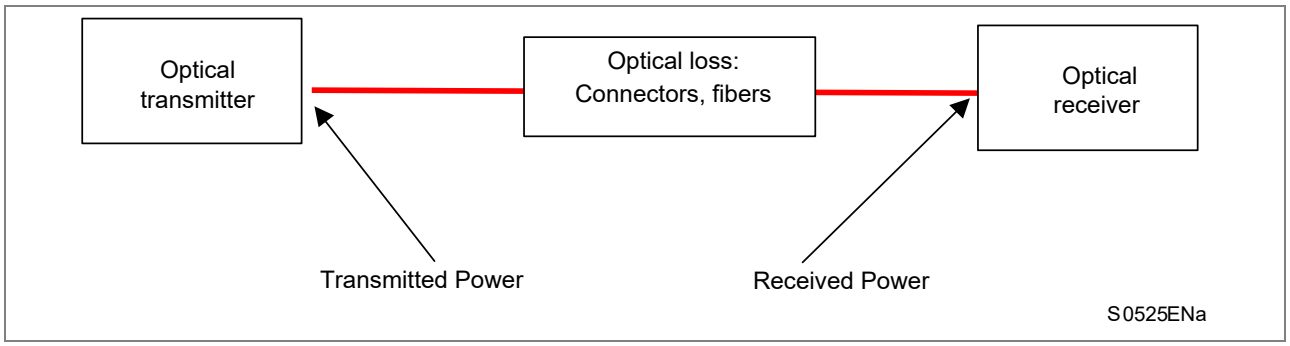


Figure 61: Fibre budget

For this product the optical budget is given in the table below.

Fibre type	Multimode	Single mode
	62.5/125 micron	**9/125 micron**
Power coupled into fibre	-19 dBm	-15 dBm
Sensitivity	-31 dBm	-34 dBm

In calculating the maximum distance, the following figures can be used as a guide, but you should check with your supplier for precise figures.

Fibre type	Multimode	Single mode
Link budget	**12 dB**	**19 dB**
Connector loss (1 per receiver, 1 per transmitter)	0.8 dB	0.8 dB
Safety Margin	4 dB	4 dB
Allowed link attenuation	**6.4 dB**	**13.4 dB**
Typical cable attenuation	1 dB/km	0.4 dB/km
Maximum range	**2 km**	**15 km**
Insertion of a patch panel (per panel)	2 dB	1 db

1.5.24 EXTENDED COMMUNICATION UNIT – ECU200

This is an additional module plugged on DB9 connector of the CPU board. This module converts non-isolated RS232 into optical signal.

A tab can be slid to change the coding:

- For the IEC 60870-5-103 standard, the circle must be visible (light is emitted for the “0” level)
- Otherwise the circle must be hidden (light is sent for the “1” level).

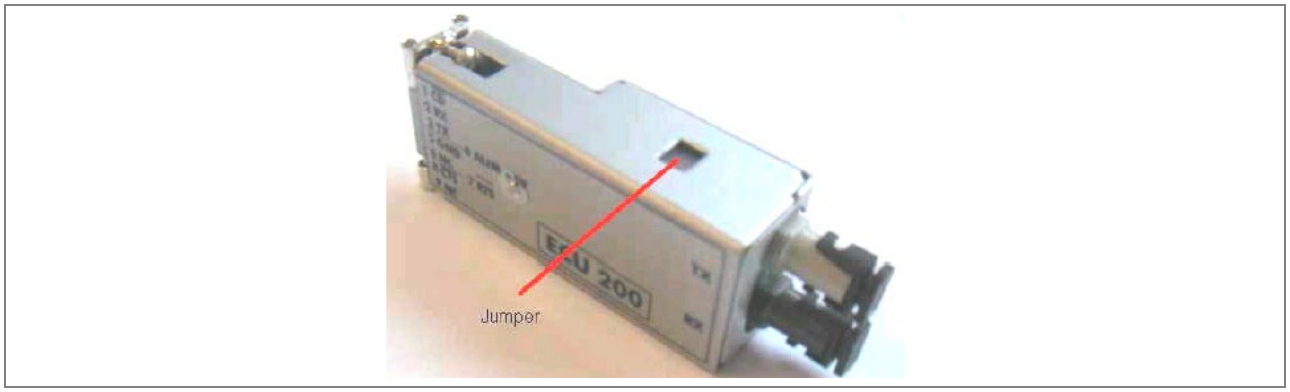


Figure 62: ECU200 module

Optical characteristics:

- Connector type: ST
- Wavelength: 820 nm
- Recommended Fibre cable: 62.5/125 µm

1.5.25 EXTENDED COMMUNICATION UNIT – ECU201

This is an additional module plugged on DB9 connector of the CPU board. This module converts non-isolated RS232 into isolated RS485/RS422.

A tab can be slid to change the connection type:

- RS422 (4 wires): TA (+), TB (–), RA (+) and RA (–) are used. The circle must be hidden
- RS485 (2 wires): only TA (+), TB (–) are used. The circle must be visible

The indication on the module from bottom to top is as follows:

- TA (+)
- TB (–)
- Ground
- RA (+)
- RB (–)

Note:
There is no resistor to polarize the line.

CONNECTION

C26X/EN CO/D40

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1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the connectors of the product I/O connectors and the connection diagrams of each I/O boards.

2 CONNECTOR BLOCKS

2.1 I/O CONNECTORS

Apart from the 2-way connector on the BIU261D's daughter board, all the I/O are connected using a standard type of 24-way connector block with a 5.08 mm pitch.

The 24-way I/O connector block characteristics are as follows:

- Continuous rating 10 A
- Connection method M3 screws
- Cable section 1.0 - 2.5 mm^2
- Connection pitch 5.08 mm
- Insulation between terminals and to the earth 300 V basic insulation
- Standards UL, CSA

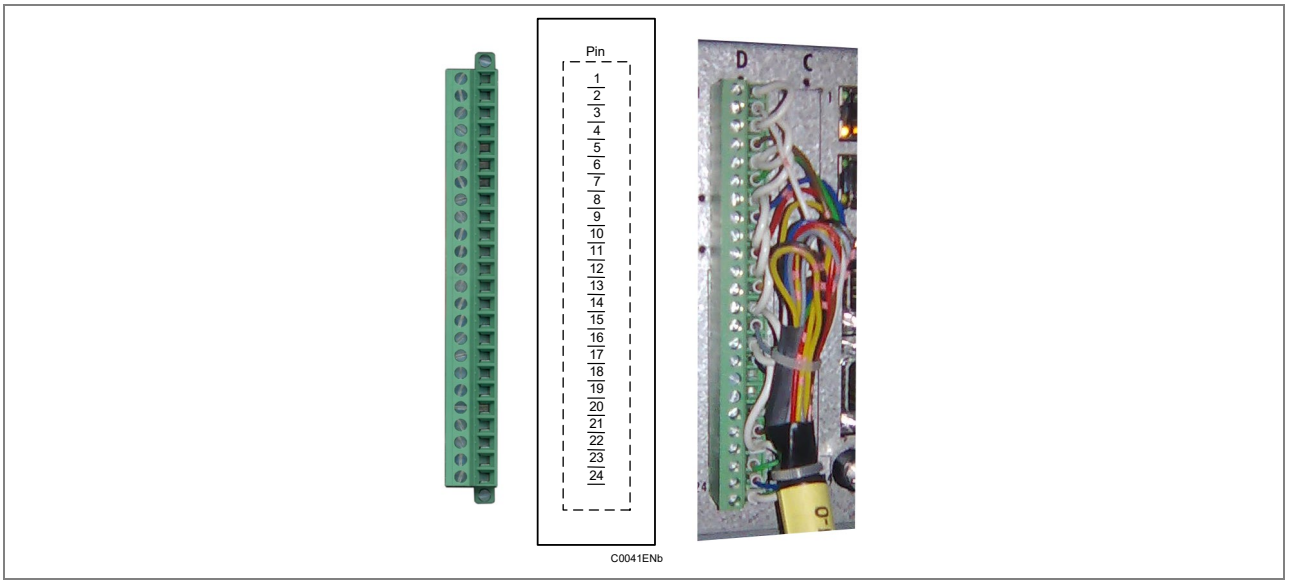


Figure 1: Typical 24-way female connector

Note:
The connector is fixed using 2 M3 screws located at each end of the connector.

The 2-way connector block characteristics are as follows:

- Continuous rating 10 A
- Connection method M2.5 screws
- Cable section 1.0 - 2.5 mm^2
- Connection pitch 5.08 mm
- Insulation between terminals and to the earth 300 V basic insulation
- Standards UL, CSA

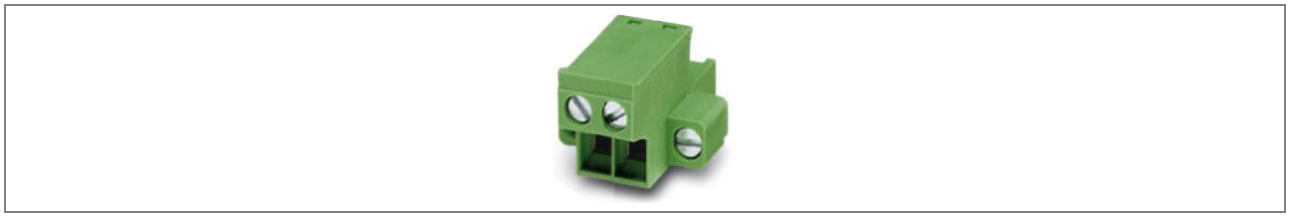


Figure 2: Typical 2-way female connector

2.2 CT/VT CONNECTOR BLOCK

The C26x uses a standard black MiDOS 28-terminal block for transformer connection.

CT connection has 2 dual terminal groups, this allows dual rated transformer (1A/5A). Each group has shorting contact to allow disconnection of CTs without damage.

The CT/VT connector block characteristics are the following:

Parameter	Value
VT connection	
Continuous rating	10 A
3 second rating	30 A
30 ms rating	250 A
Connection method	Screw M4
Cable size	2 off 2.5 mm2
Isolation to other terminal and to earth	500 V basic insulation
CT connection	
Continuous rating	20 A
10 second rating	150 A
1 second rating	500 A
Connection method	Screw M4
Cable size	2 off 2.5 mm2 / 1 off 4 mm2
Isolation to other terminal and to earth	300 V basic insulation

Table 1: CT/VT Connector block

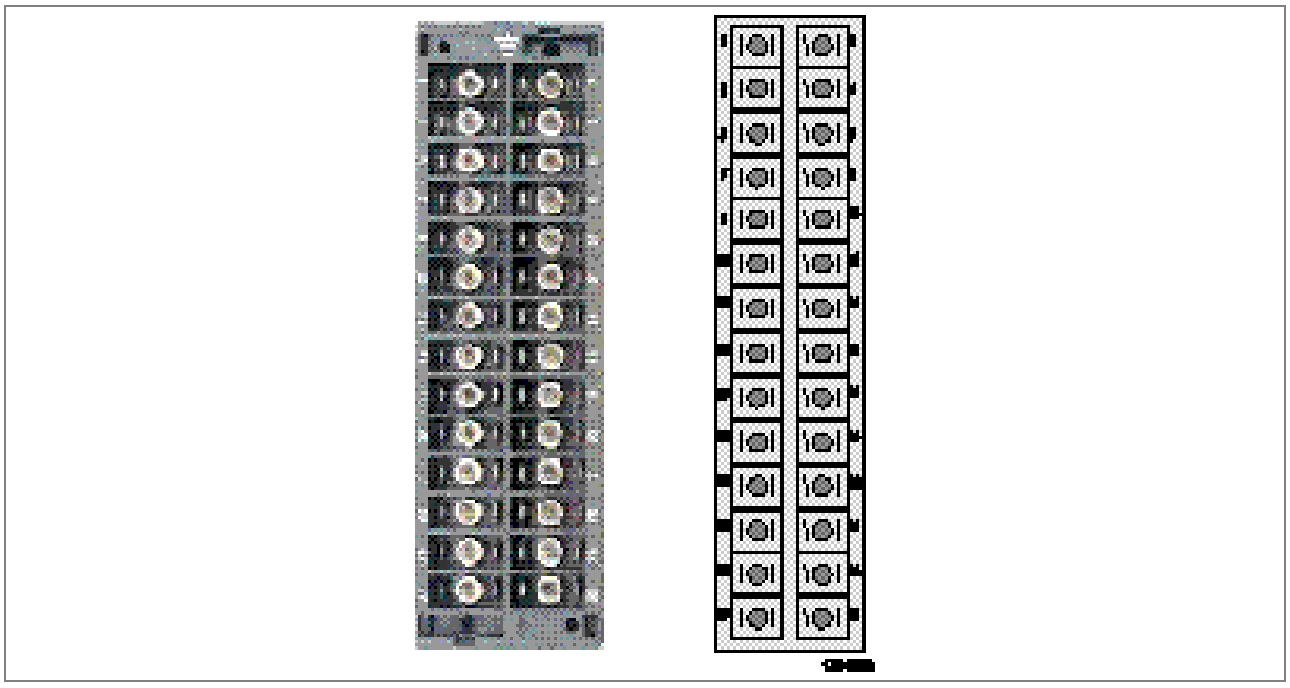


Figure 3: Standard MIDOS 28-way connector

Note:
The connector is fixed to the rack with 4 Phillips screws M4; 2 are located on the top part and 2 on the bottom part.

2.3 SERIAL COMMUNICATIONS CONNECTIONS

For a RS485 or RS422 serial communication interface a termination resistor has to be connected at each extremity of the bus.

If the IEDs or remote equipment (like Control Centre, printer, etc) are located at a long distance (>10 m for RS232, >100 m for RS422 and >1000 m for RS485) from the communication equipment or if the cables run through a noisy area, then optical fibre communication should be used.

For both RS422 and RS485, the cable should be terminated at each end with a 120 ohm resistor or the resistance of the BIU board can be used.

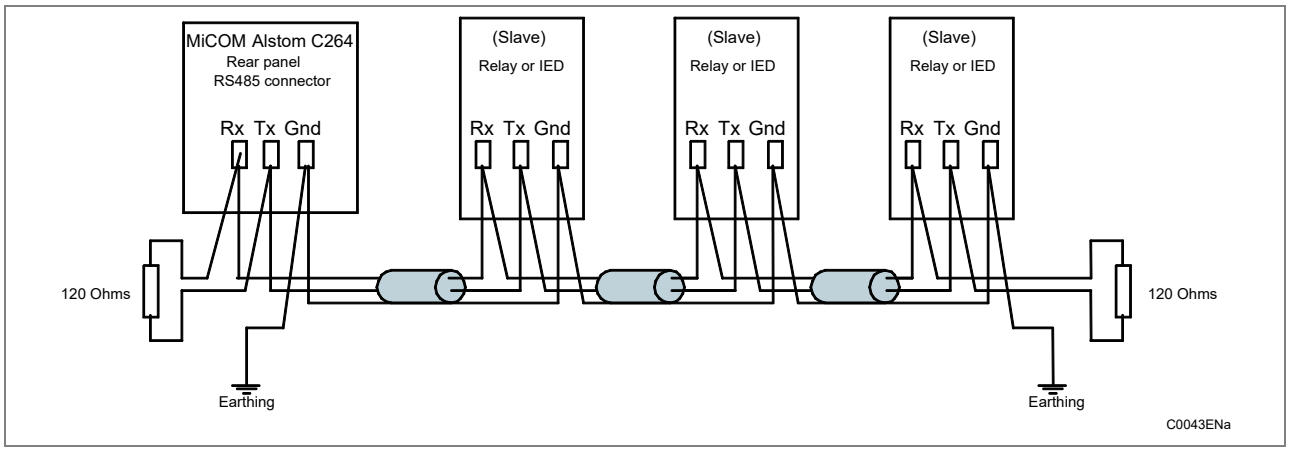


Figure 4: Example of RS485 connections

There must be no more than two wires connected to each terminal, this ensures that a “Daisy Chain or “straight line” configuration is used.

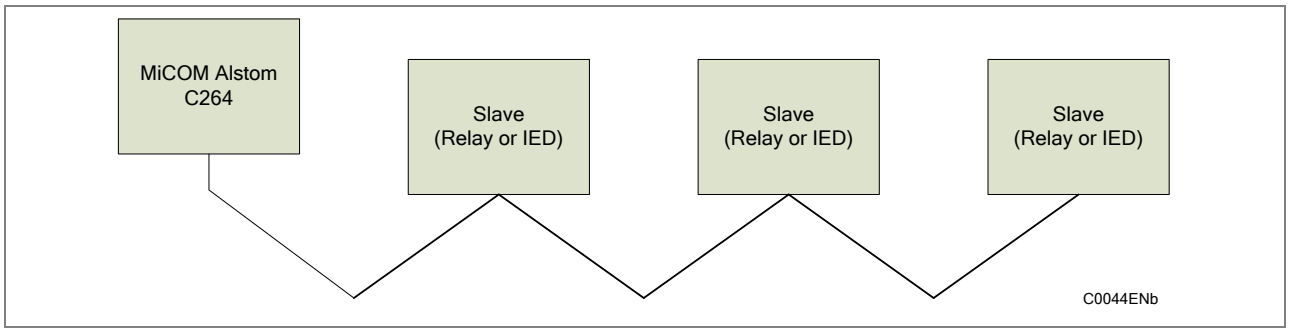


Figure 5: Daisy chain connection

Note:
The “Daisy Chain or “straight line” configuration is recommended and the correct way to construct fieldbus. A “Star” or a network with “Stubs (Tees)” is not recommended as reflections within the cable may result in data corruption.

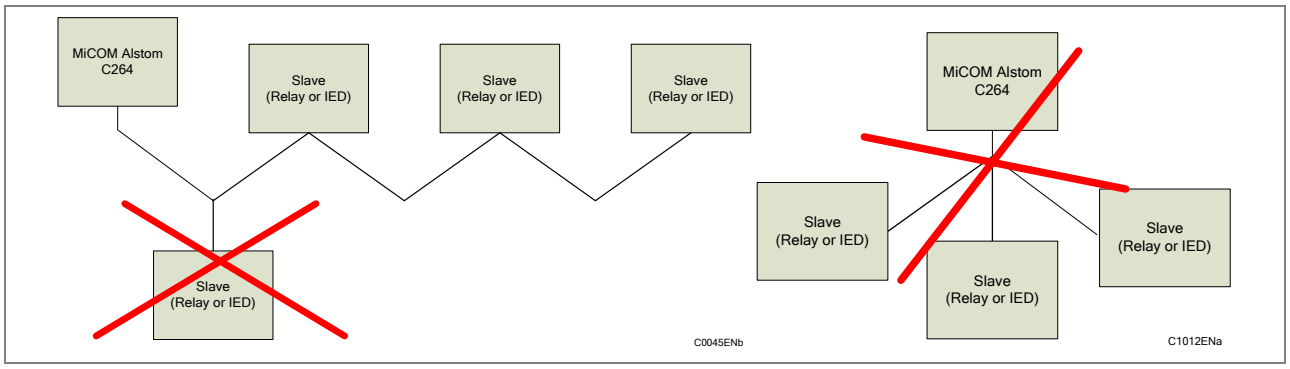


Figure 6: Star network or network with tees – Wrong connections

Note:
A “Star” or a network with “Stubs (Tees)” is not recommended as reflections within the cable may result in data corruption.
Wiring recommendation for RS422:

Master (C26x)	*Slave(IED)*
TA(+)	*R+*
TB(-)	*R-*
RA(+)	*T+*
RB(-)	*T-*

2.4 OPTICAL COMMUNICATIONS CONNECTIONS

WARNING ABOUT LASER RAYS:



Where fibre optic communication devices are fitted, these should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

Non–observance of this rule could possibly result in personal injury.

Signals transmitted via optical fibres are unaffected by interference. The fibres guarantee electrical isolation between the connections.

If electrical to optical converters are used, they must have management of character idle state capability (for when the fibre optic cable interface is "Light off").

2.5 ETHERNET-BASED COMMUNICATIONS CONNECTIONS

The Ethernet-based communication available in the C26x works in full duplex mode, using either fibre optic media or 4 pair twisted cable.

Only the cable isolated category 5 (FTP: Foil Twisted Pair) or isolated (STP - Shielded Twisted Pairs) with RJ45 connectors must be used.

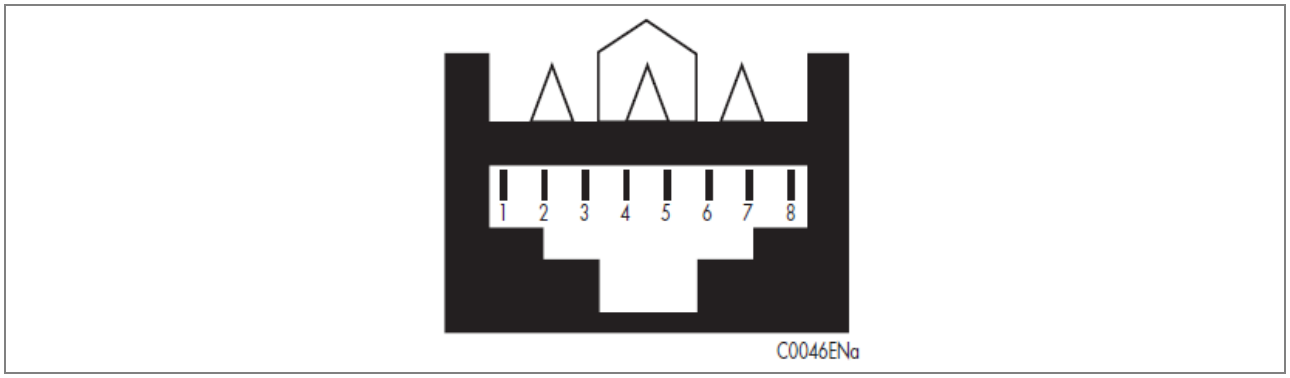


Figure 7: RJ45 connector

Only pins N°1, 2, 3 and 6 is used in RJ45 Ethernet 10/100BaseTX.

The standard is:

- 1 = white / orange
- 2 = orange
- 3 = white / green
- 4 = blue (non used)
- 5 = white / blue (non used)
- 6 = green
- 7 = white / brown (non used)
- 8 = brown (non used)

The RJ45 connector when seen face on, flat side on bottom, side tab on top, then pin 1 is on the left and pin 8 on the right.

3 CONNECTION OF THE PROTECTIVE CONDUCTOR (EARTH)

3.1 EARTHING

The DS Agile C26x must be connected to the earth according to product safety standard EN60255-27:2005 clause 5.1.5 using the protective conductor (earth) terminal located on the rear panel.

Connection of the Protective conductor (earth).

The DS Agile C26x racks must be earthed, for safety reasons, by connection of the protective conductor (earth) to the M4 threaded stud allocated as the protective conductor terminal (PCT), marked with the symbol shown.



Warning:
– To maintain the safety features of the equipment it is essential that the protective conductor (earth) is not disturbed when connecting or disconnecting functional earth conductors such as cable screens, to the PCT stud.
– The protective conductor must be connected first, in such a way that it is unlikely to be loosened or removed during installation, commissioning or maintenance. It is recommended that this is achieved by use of an additional locking nut.

The protective conductor (earth) must be as short as possible with low resistance and inductance. The best electrical conductivity must be maintained at all times, particularly the contact resistance of the plated steel stud surface. The resistance between the DS Agile C26x protective conductor (earth) terminal (PCT) and the protective earth conductor must be less than 10 mΩ at 12 Volt, 100 Hz.

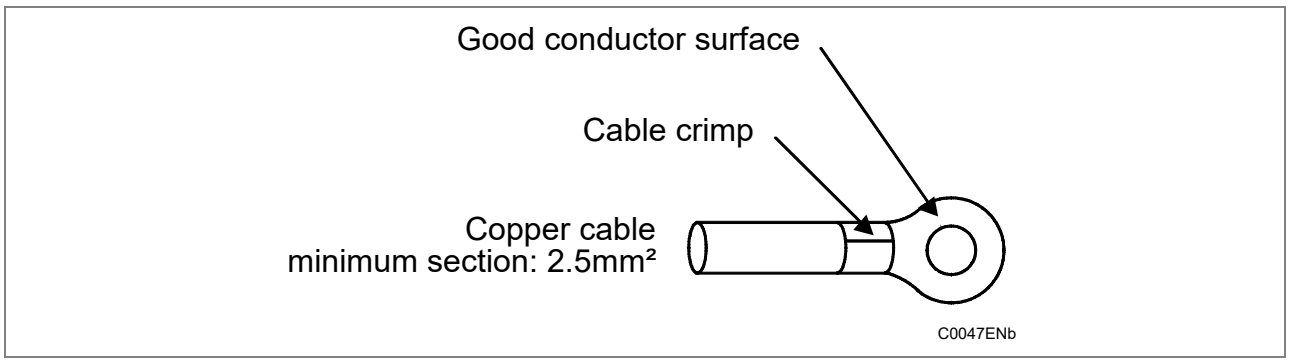


Figure 8: Earthing cable example

3.2 CABLE FITTING

It is recommended to use cables (0.8 mm^2) as following:

- Screened multi-strand cable has to be used for digital input-output signals. For cables within the cubicle the cable screen can be connected to the earth at both ends of the cable. If the cable is taken beyond the system cubicle the cable screen should be earthed at one end only to prevent current flowing in the screen due any differences in ground potential.
- Screened and twisted pair has to be used for analogue input-output signals. The screen is connected to the earth by the end of Bay Module side.
- One or two screened and twisted pairs have to be used for lower communication signals. The screen is connected to the earth by two cable ends.

It is recommended to group cables and fit them as near as possible to an earth plane or to an element of an earth wire-mesh.

First example: DS Agile C26x fitted without metallic cubicle.

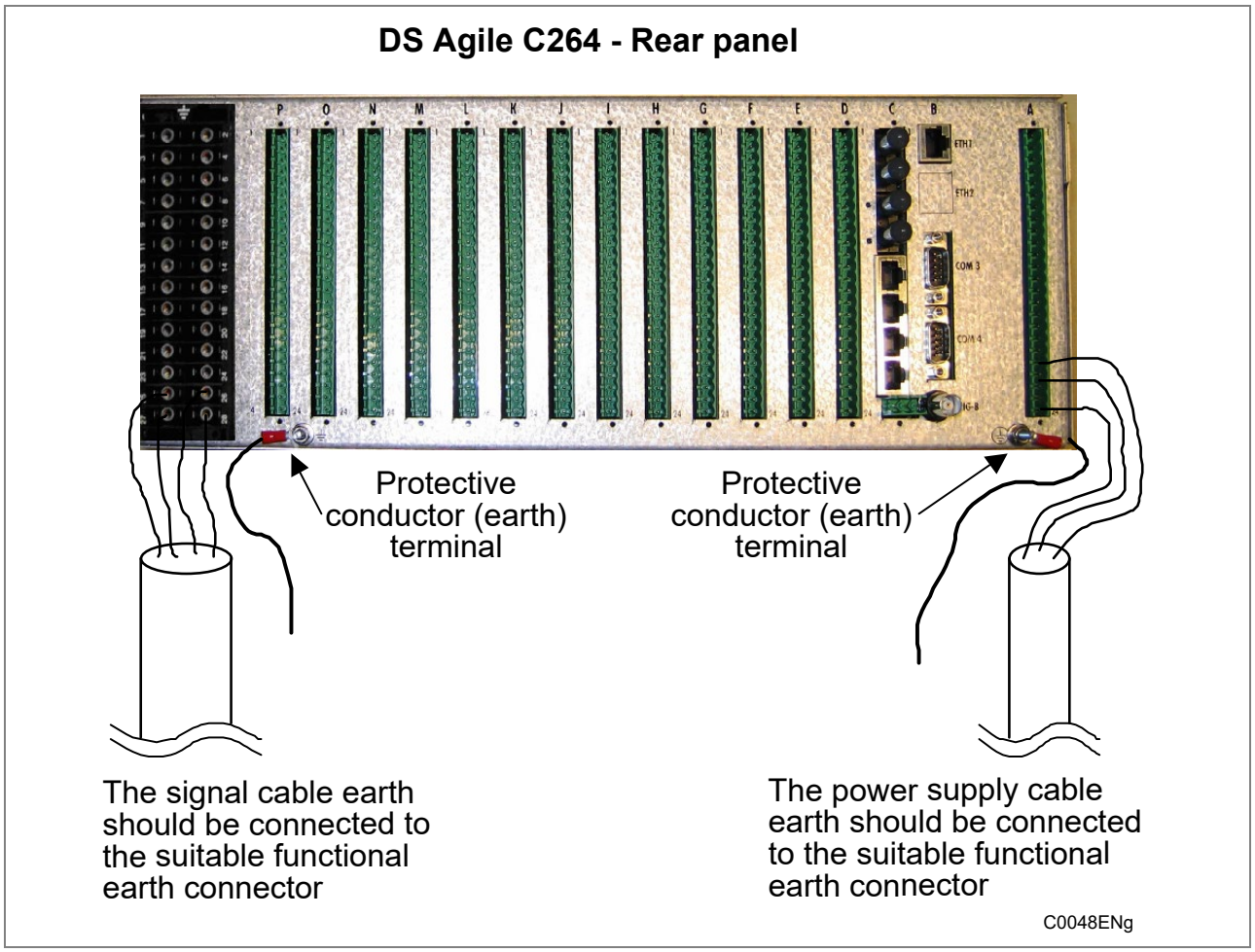


Figure 9: First example of earthing arrangement

Second example: DS Agile C26x fitted in a metallic cubicle with other devices.

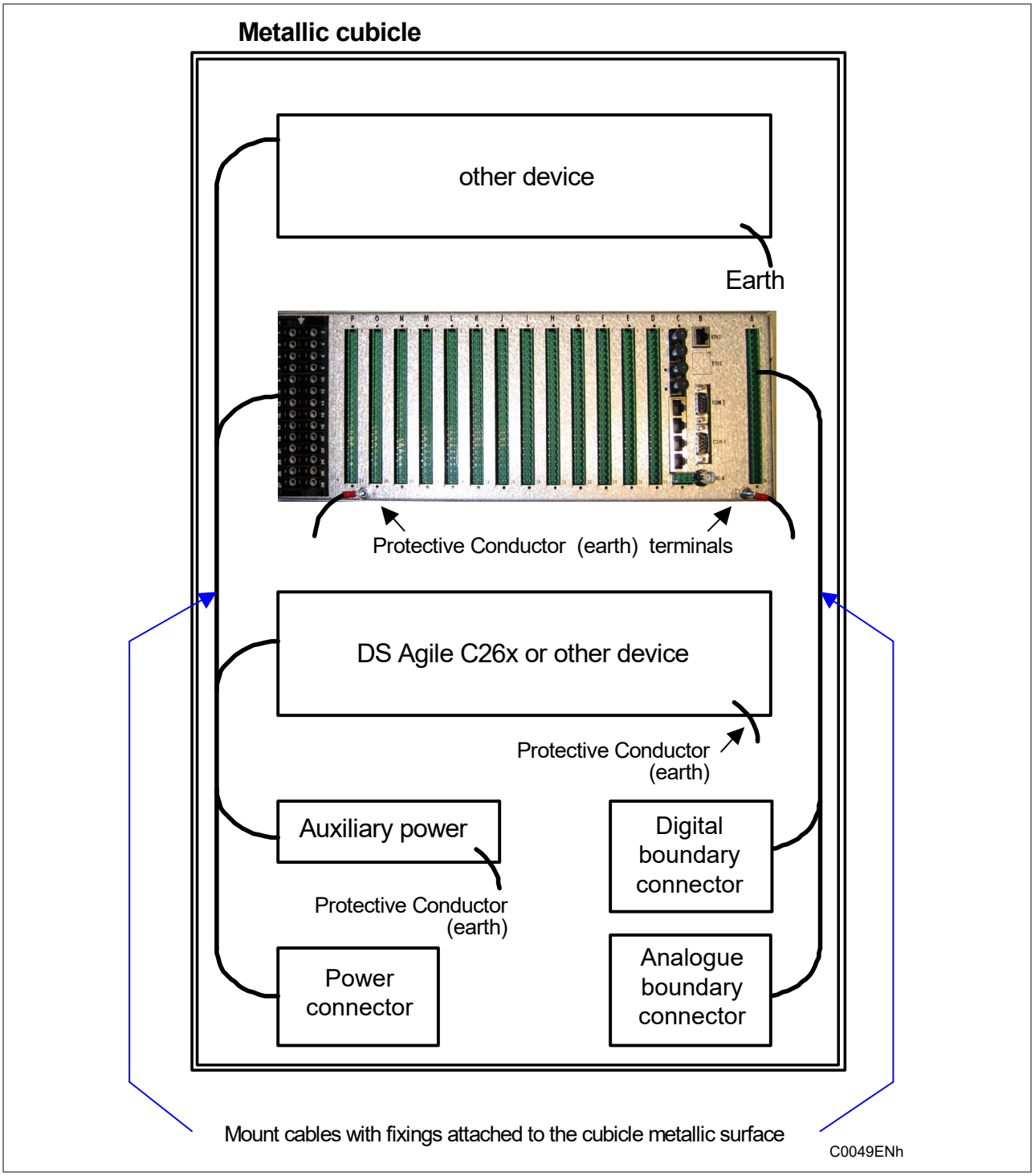


Figure 10: Second example of cable fitting

4 CONNECTION DIAGRAMS FOR EACH I/O BOARD

4.1 SINGLE INPUT POWER SUPPLY AND LEGACY PORTS BOARD – BIU241

This board is fitted with the auxiliary power supply converter, the watchdog relay, 2 inputs / outputs for C26x redundancy and 2 legacy isolated serial ports (Ports N°1 / N°2).

The factory-set combinations for the two legacy isolated serial ports are:

Case	Port N°1	Port N°2
1	RS232	RS232
2	RS232	RS485
3	RS422	RS232
4	RS422	RS485
5	RS485	RS232
6	RS485	RS485

Table 2: Base Legacy ports (ports N°1 / N°2) – capabilities

4.1.1 BLOCK DIAGRAM

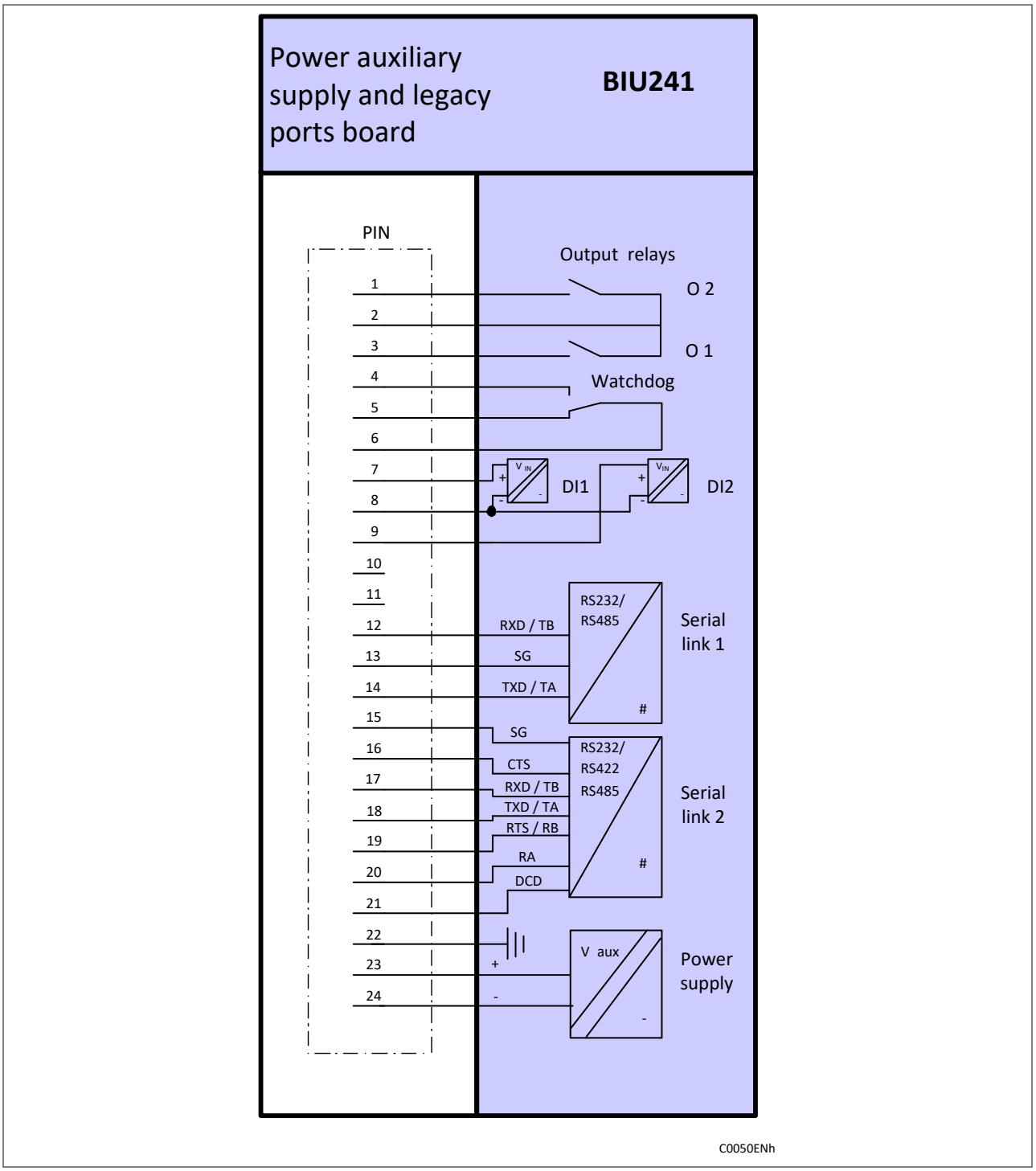


Figure 11: BIU241 board – Block diagram

Caution:
Pins 1 to 9 (redundancy and watchdog functions) are not managed when the board is fitted into an extension rack.



Warning:
For safety reasons, when the communications port of BIU241 boards referenced 2070879 A03-Z and 2070879 A04-Z is connected to devices, it is mandatory to earth some of the "SG pin" of the communications port, as indicated below.

4.1.2 CONNECTOR DESCRIPTION

Pin n°	Signal			
1	Redundancy relay 2			- NO contact
2	Redundancy relay			- common 1-2
3	Redundancy relay 1			- NO contact
4	Watchdog relay			- NO contact
5	Watchdog relay			- NC contact
6	Watchdog relay			- common
7	Redundancy input			- 1+
8	Redundancy input			- common 1 / 2
9	Redundancy input			- 2+
10				
11				
12	RS232: RxD	RS485: B		- Port 1
13	GND			- Port 1
14	RS232: TxD	RS485: A		- Port 1
15	GND			- Port 2
16	RS232: CTS			- Port 2
17	RS232: RxD	RS485 B	RS422: TB	- Port 2
18	RS232: TxD	RS485 A	RS422: TA	- Port 2
19	RS232: RTS	RS422: RB		- Port 2
20		RS422: RA		- Port 2
21	RS232: DCD			- Port 2
22	Voltage input: Gnd			Protective earth
23	Voltage input: AC/DC			(+)
24	Voltage input: AC/DC			(-)

Table 3: BIU241 board – Connector description

RS232:

- If the C26x/BIU241/Port 1 is used -> Pin No 13 (SG) is to be earthed
- If the C26x/BIU241/Port 2 is used - > Pin No 15 (SG) is to be earthed

RS485 / RS422: daisy chain and devices in the same cubicle:

- If the C26x/BIU241/Port 1 is used -> Pin No 13 (SG) is to be earthed
- If the C26x/BIU241/Port 2 is used - > Pin No 15 (SG) is to be earthed
- The GND signal of the daisy chain extremity is to be earthed.

RS485 / RS422: daisy chain and devices in various cubicles:

- If the C26x/BIU241/Port 1 is used -> Pin No 13 (SG) is to be earthed
- If the C26x/BIU241/Port 2 is used - > Pin No 15 (SG) is to be earthed

Note:
In this case, the GND signal of the daisy chain extremity is not to be earthed.

4.1.3 BIU241 WIRING FOR REDUNDANT C26X

In case of C26x redundancy, the following signals are to be wired for the management of main/backup redundancy:

C26x_1 Signal	C26x_1 BIU Pin		C26x_2 BIU Pin	C26x_2 Signal
Redundancy output contact relay 2 (Open on C26x Failure)	1	------>	9	Redundancy input: 2+
Redundancy relay: common 1 & 2 (+)	2	(+)	2	Redundancy relays: common 1 & 2 (+)
Redundancy output contact relay 1 (Closed when “Active”, Open when “Standby”)	3	------>	7	Redundancy input: 1+
Redundancy input: 1+	7	<------	3	Redundancy output contact relay 1 (Closed when “Active”, Open when “Standby”)
Redundancy input - common 1 & 2 (-)	8	(-)	8	Redundancy input - common 1 & 2 (-)
Redundancy input: 2+	9	<------	1	Redundancy output contact relay 2 (Open on C26x Failure)

Note:
Both C26x must be fitted with the same type of BIU board/module. These BIU boards/modules must have the same power supply configuration.

4.2 UNIVERSAL, SINGLE OR DUAL INPUT POWER SUPPLY AND LEGACY PORTS MODULE – BIU261S/BIU261D

This module can be composed of 1 or 2 boards, depending on whether a back-up power supply is present:

- BIU261S – Single source power supply (single board)

  The BIU261S board houses the primary power supply transformer, the watchdog relay, 2 inputs/ outputs for C26x redundancy and 2 legacy isolated serial ports (Ports N°1 / N°2).

- BIU261D – Dual source power supply (mother board + daughter board).

The mother board of the BIU261D module houses the main auxiliary power supply transformer, the watchdog relay, 2 inputs/ outputs for C26x redundancy and 2 legacy isolated serial ports (Ports N°1 / N°2).

The daughter board of the BIU261D module houses the secondary power supply transformer.

In both variants, the factory-set combinations for the two legacy isolated serial ports are:

Case	Port N°1	Port N°2
1	RS232	RS232
2	RS232	RS485
3	RS422	RS232
4	RS422	RS485
5	RS485	RS232
6	RS485	RS485

Table 4: Base legacy ports (ports N°1 / N°2) – capabilities

4.2.1 BLOCK DIAGRAMS

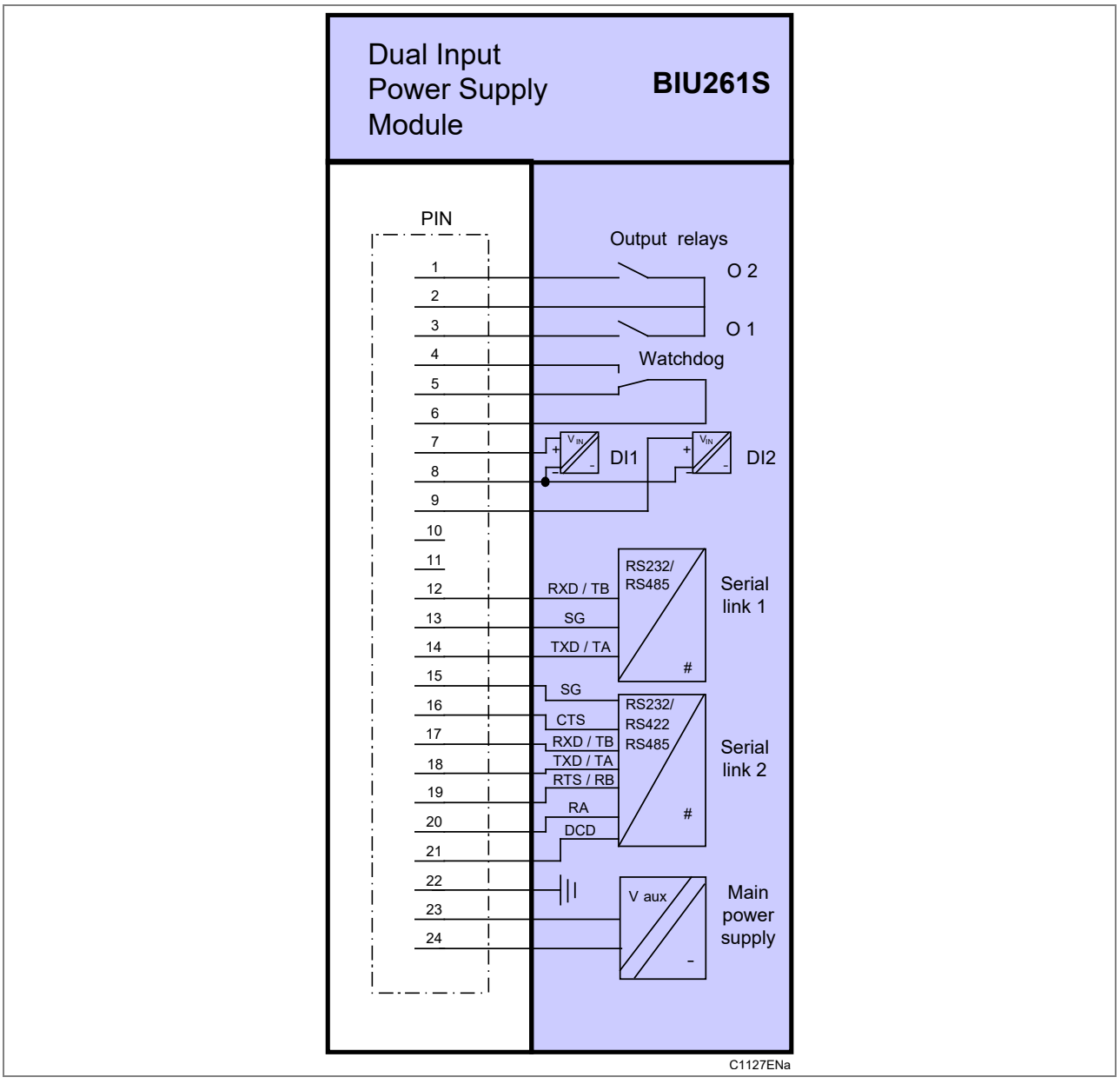


Figure 12: BIU261S board – Block diagram

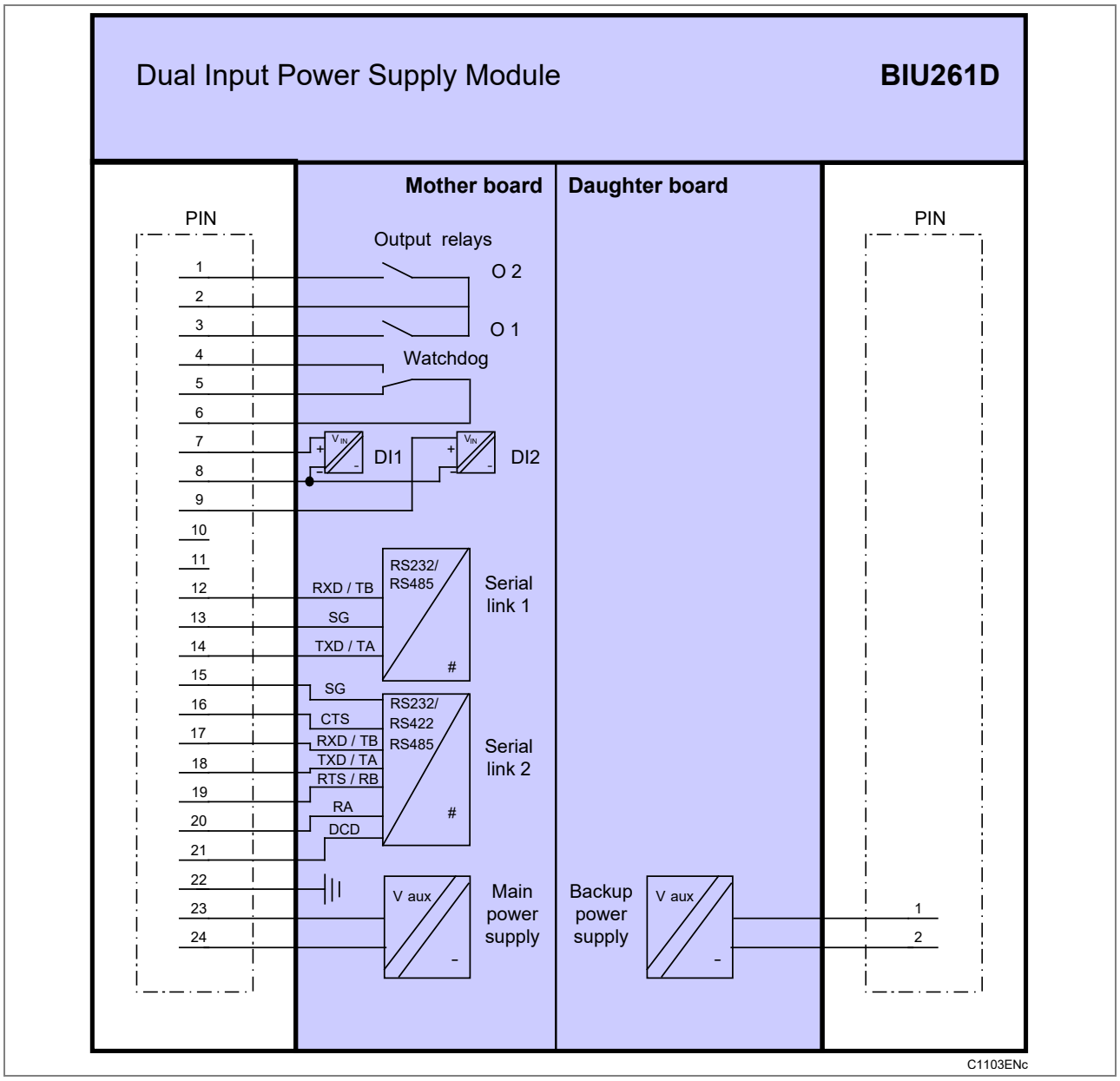


Figure 13: BIU261D module – Block diagram

Note:
Pins 1 to 9 (redundancy and watchdog functions) are not managed when the board is fitted into an extension rack.

4.2.2 BIU261S BOARD/BIU261D MOTHER BOARD CONNECTOR DESCRIPTION

Pin n°	Signal			
1	Redundancy relay 2			- NO contact
2	Redundancy relay			- common 1-2
3	Redundancy relay 1			- NO contact
4	Watchdog relay			- NO contact
5	Watchdog relay			- NC contact
6	Watchdog relay			- common
7	Redundancy input			- 1+
8	Redundancy input			- common 1 / 2
9	Redundancy input			- 2+
10				
11				
12	RS232: RxD	RS485: B		- Port 1
13	GND			- Port 1
14	RS232: TxD	RS485: A		- Port 1
15	GND			- Port 2
16	RS232: CTS			- Port 2
17	RS232: RxD	RS485 B	RS422: TB	- Port 2
18	RS232: TxD	RS485 A	RS422: TA	- Port 2
19	RS232: RTS	RS422: RB		- Port 2
20		RS422: RA		- Port 2
21	RS232: DCD			- Port 2
22	Voltage input: Gnd			Gnd
23	Voltage input: AC/DC			(+)
24	Voltage input: AC/DC			(-)

4.2.3 BIU261D DAUGHTER BOARD CONNECTOR DESCRIPTION

Power supply input

Pin n°	Location	Signal	
1	Left when view from the rear of the device	Voltage input: AC/DC	(+)
2	Right when view from the rear of the device	Voltage input: AC/DC	(-)

4.2.4 BIU261 WIRING FOR REDUNDANT C26X

In case of C26x redundancy, the following signals are to be wired on the BIU261S board or the main board of the BIU261D module for the management of main/backup redundancy:

C26x_1 Signal	C26x_1 BIU Pin		C26x_2 BIU Pin	C26x_2 Signal
Redundancy output contact relay 2 (Open on C26x Failure)	1	------>	9	Redundancy input: 2+
Redundancy relay: common 1 & 2 (+)	2	(+)	2	Redundancy relays: common 1 & 2 (+)
Redundancy output contact relay 1 (Closed when “Active”, Open when “Standby”)	3	------>	7	Redundancy input: 1+
Redundancy input: 1+	7	<------	3	Redundancy output contact relay 1 (Closed when “Active”, Open when “Standby”)
Redundancy input - common 1 & 2 (-)	8	(-)	8	Redundancy input - common 1 & 2 (-)
Redundancy input: 2+	9	<------	1	Redundancy output contact relay 2 (Open on C26x Failure)

Note:
Both C26x must be fitted with the same type of BIU board/module, with the same power supply configuration.

4.3 CENTRAL PROCESSING UNIT – CPU270

In addition to two 10/100BaseT Ethernet interfaces, these boards include:

- The IRIG-B interface: BNC plug

Caution:
The RS232 port on the CPU270 board shall not be connected. In the event, the RS232 port should be used, please contact GE Support service at Stafford beforehand (Tel: +44 (0) 1785 25 00 70, www.gegridsolutions.com/contact/).

4.3.1 BLOCK DIAGRAM

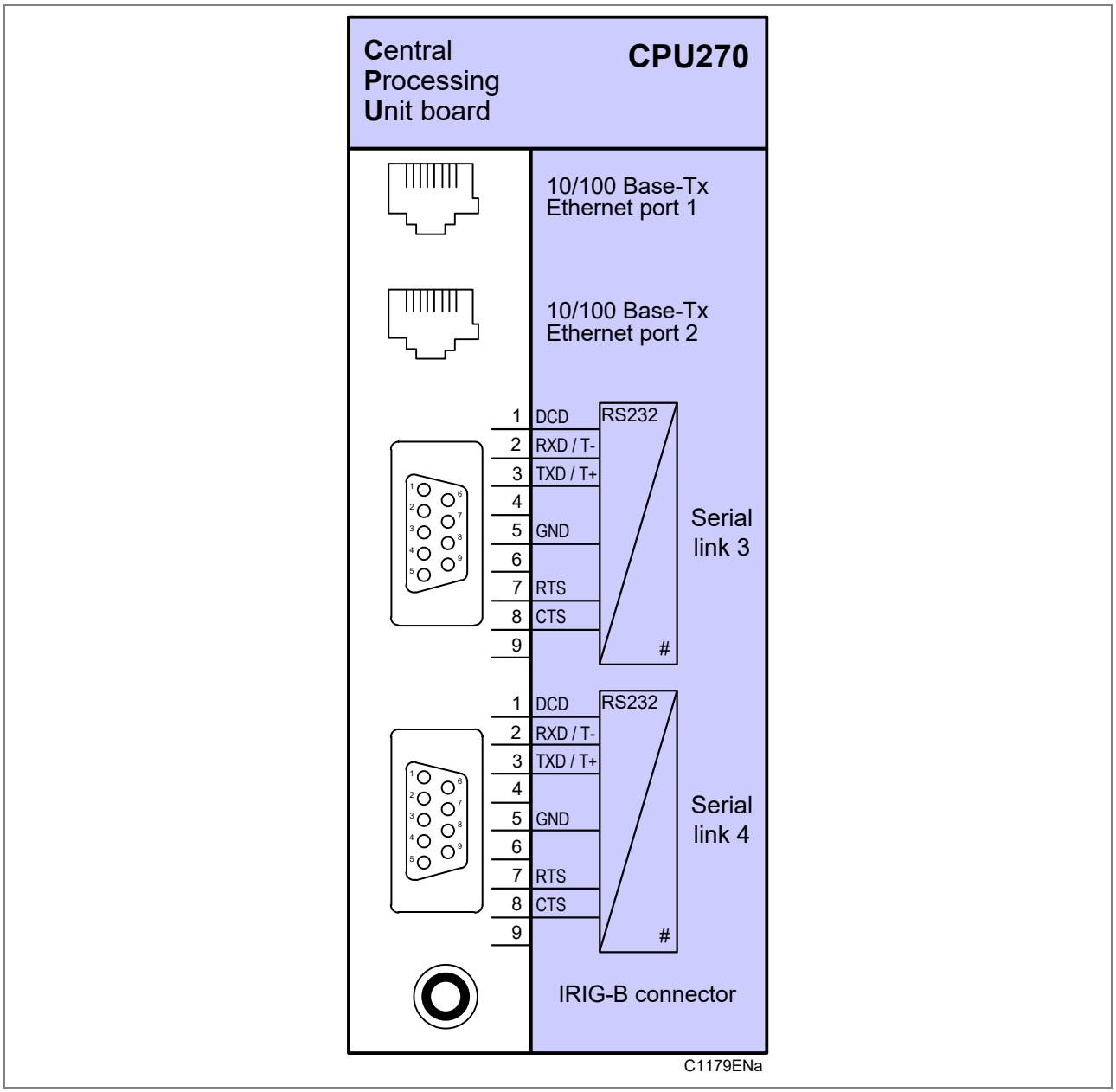


Figure 14: CPU270 board – Block diagram

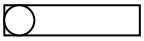
4.3.2 EXTERNAL MODULE

The ECU200/ECU201 external modules convert non-isolated RS232 into optical link/isolated RS485 or RS422.

The ECU201 module has a 5-wire female connector.

1	TA (+)
2	TB (-)
3	Ground
4	RA (+)
5	RB (-)

Table 5: ECU201 – Description

To change the connection type, slide the tab: 

- RS422 (4 wires): TA(+), TB(-), RA(+), RB(-) are used. The circle must be hidden.
- RS485 (2 wires): only TA(+) and TB(-) are used. The circle must be visible.

The ECU200 module has 2 optical fibre connectors (ST type):

- TX: optical emitter
- RX: optical receiver

4.3.3 DSPIO BOARD

The Protection Input & Ouputs module is a daughter board of the CPU board dedicated to the Circuit-breaker Protection feature management. It provides 4 optically isolated digital inputs (with 1 common for 2DI) and 3 outputs (3 DO with 1 common) using relays; these outputs are used by protection functions.

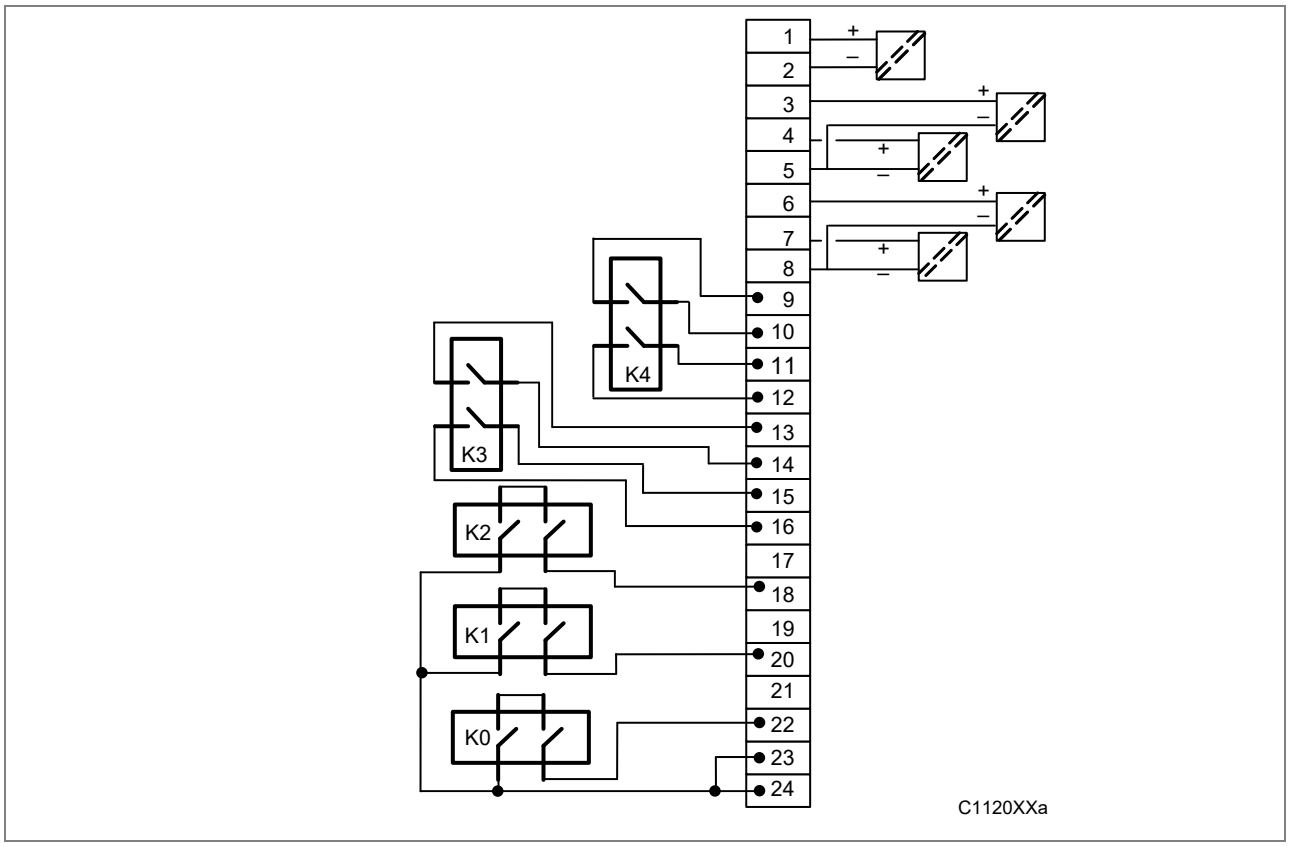


Figure 15: DSPIO board – Block diagram

The DSPIO board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	+ Digital Input Blocking logic
2	- Digital Input Blocking logic
3	+ Logic Selectivity
4	Digital Input (not used)
5	- Logic Selectivity
6	Cold Load Start (CLPU)
7	Disturbance start (Disturbance record trigger)
8	Common to Cold Load Start & Disturbance start
9	K4/1 + Output (not used)
10	K4/1 - Output (not used)
11	K4/2 + Output (not used)
12	K4/2 - Output (not used)
13	K3/1 + Output (50 Breaker Failure)
14	K3/1 - Output
15	K3/2 + Output (50 Breaker Failure)

Pin N°.	Signal
16	K3/2 - Output
17	Not connected
18	Trip phase C
19	Not connected
20	Trip phase B
21	Not connected
22	Trip phase A
23-24	Common Digital outputs A, B & C

Table 6: DSPIO board – Connector description

4.4 CIRCUIT BREAKER CONTROL UNIT – CCU200/CCU211

The Circuit breaker Control boards provide 8 digital inputs (8 DI with one common for 2DI) and 4 double pole outputs (4 DO) using integrated relays.

4.4.1 BLOCK DIAGRAM

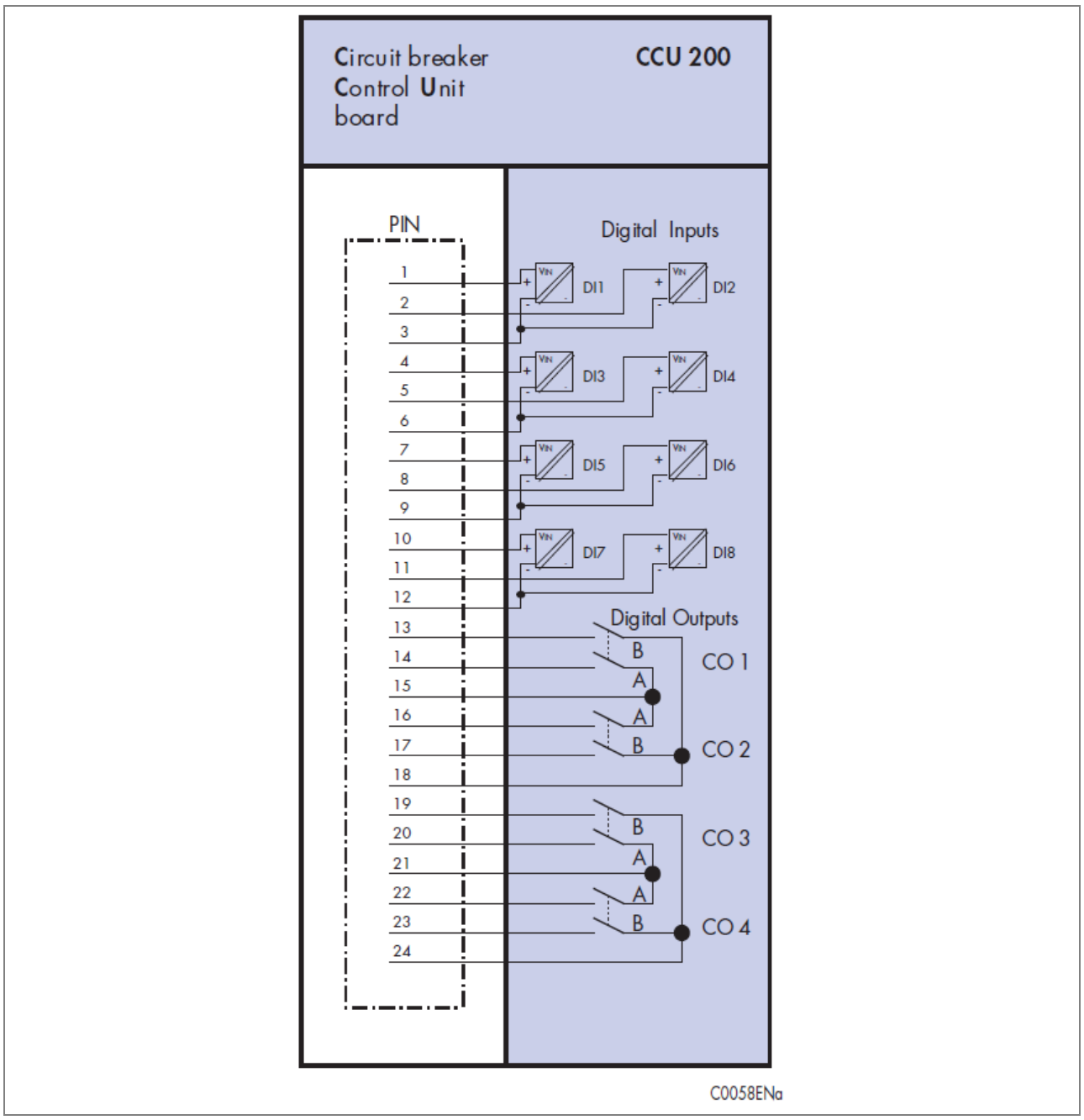


Figure 16: CCU2xx board – Block diagram

Note:
On the CCU211, the + and – of Digital Inputs can be inverted

Note:
Different types of CCU200 boards are available, depending on the input voltage range. Therefore, before connection, special attention should be paid to the version of the board:
- version A01 for 24V_{DC},
- version A02 for 48/60 V_{DC},
- version A03 for 110/125V_{DC}
- version A04 for 220 V_{DC}

4.4.2 CONNECTOR DESCRIPTION

The CCU2xx board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	Digital Input 1+
2	Digital Input 2+
3	Common Digital Input 1 / 2
4	Digital Input 3+
5	Digital Input 4+
6	Common Digital Input 3 / 4
7	Digital Input 5+
8	Digital Input 6+
9	Common Digital Input 5 / 6
10	Digital Input 7+
11	Digital Input 8+
12	Common Digital Input 7 / 8
13	Digital Output 1 B
14	Digital Output 1 A
15	Common Digital Output 1 - 2 A
16	Digital Output 2 A
17	Digital Output 2 B
18	Common Digital Output 1 - 2 B
19	Digital Output 3 B
20	Digital Output 3 A
21	Common Digital Output 3 – 4 A
22	Digital Output 4 A
23	Digital Output 4 B
24	Common Digital Output 3 - 4 B

Table 7: CCU2xx board – Connector description

Note :
On the CCU211, "Common Digital inputs" can be connected with a positive or negative polarity.

4.5 DIGITAL INPUTS MODULE – DIU200

The Digital Input module (DIU200) provides 16 optically isolated Digital Inputs (with one common for two DI).

4.5.1 BLOCK DIAGRAM

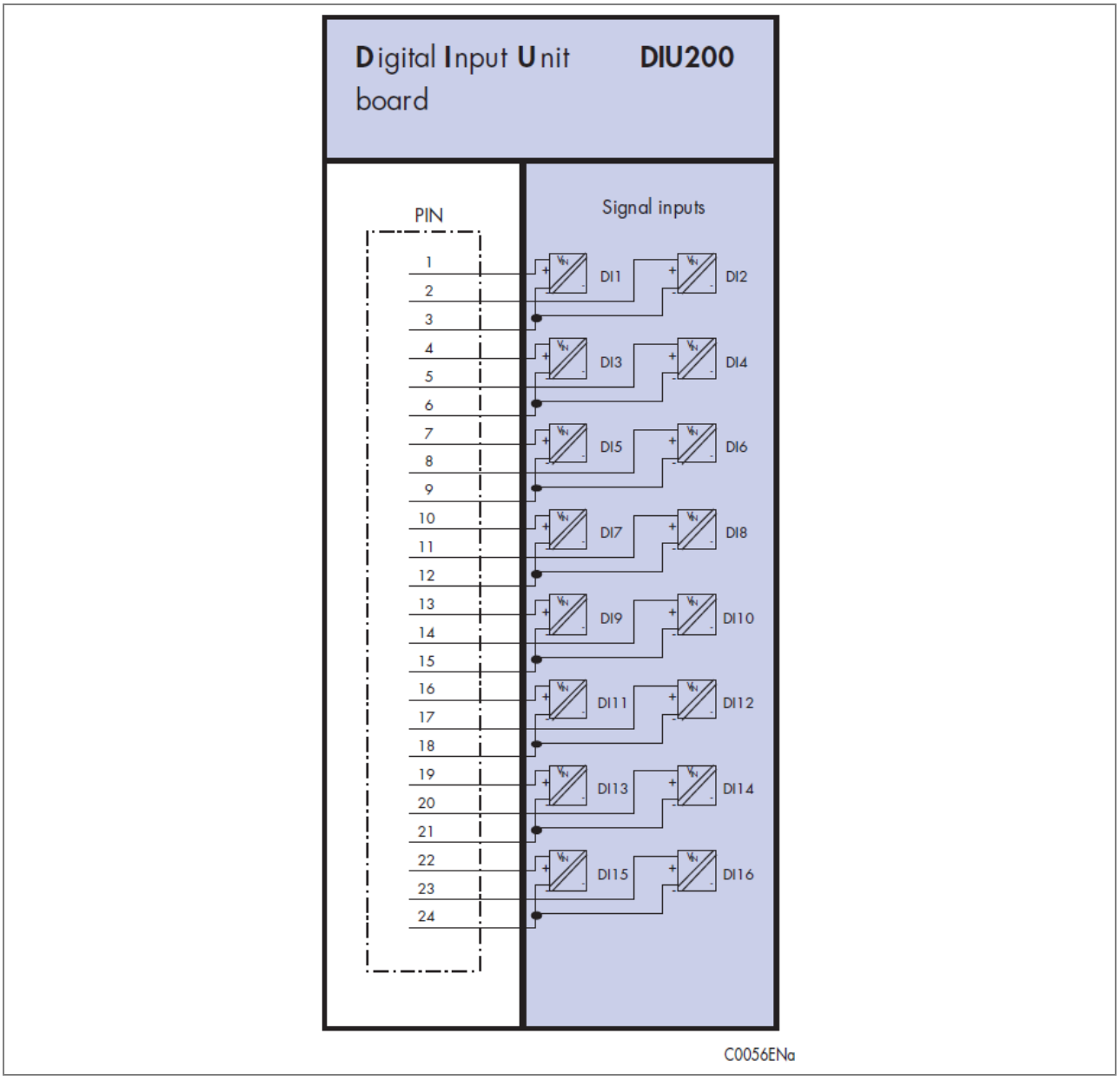


Figure 17: DIU200 board – Block diagram

Note:
Different types of DIU200 boards exist depending on the input voltage range
Before connection, a special attention is to be paid about the version of the board:
- version A01 for 24V_{DC},
- version A02 for 48/60 V_{DC},
- version A03 for 110/125V_{DC}
- version A04 for 220 V_{DC}

4.5.2 CONNECTOR DESCRIPTION

The DIU200 board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	Digital Input 1+
2	Digital Input 2+
3	Negative Common Digital Input 1 / 2
4	Digital Input 3+
5	Digital Input 4+
6	Negative Common Digital Input 3 / 4
7	Digital Input 5+
8	Digital Input 6+
9	Negative Common Digital Input 5 / 6
10	Digital Input 7+
11	Digital Input 8+
12	Negative Common Digital Input 7 / 8
13	Digital Input 9+
14	Digital Input 10+
15	Negative Common Digital Input 9 / 10
16	Digital Input 11+
17	Digital Input 12+
18	Negative Common Digital Input 11 / 12
19	Digital Input 13+
20	Digital Input 14+
21	Negative Common Digital Input 13 / 14
22	Digital Input 15+
23	Digital Input 16+
24	Negative Common Digital Input 15 / 16

Table 8: DIU200 board – Connector description

4.6 DIGITAL INPUTS MODULE – DIU210

The Digital Input module (DIU210) provides 16 optically isolated digital inputs split in eight groups of two inputs. Both inputs of a group have a common pin which can be used either as a negative common pin or a positive common pin.

4.6.1 BLOCK DIAGRAM

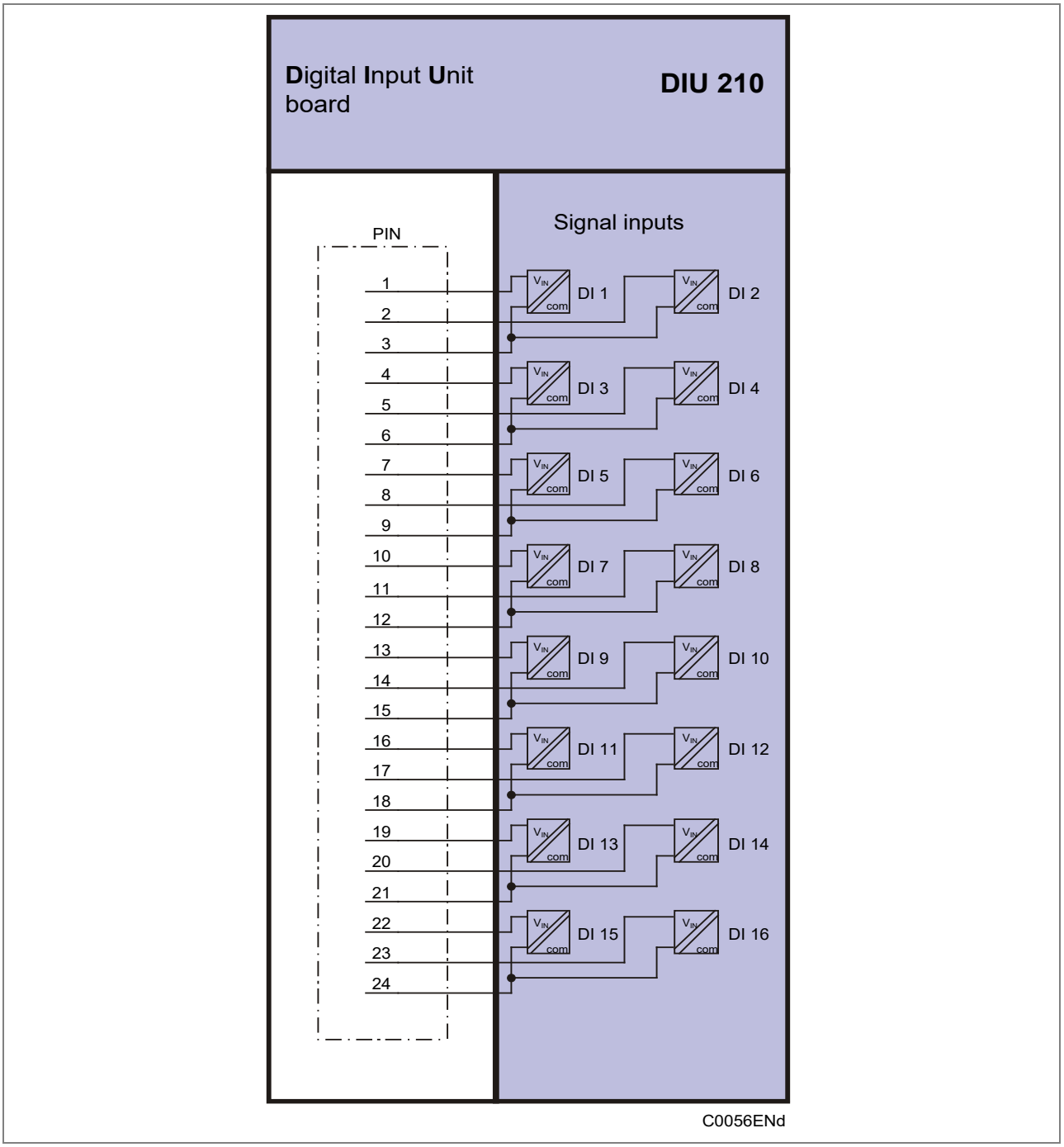


Figure 18: DIU210 board – Block diagram

Note:
There is only one type of DIU210 board, including all wetting voltages between 24 and 220V AC/DC.

4.6.2 CONNECTOR DESCRIPTION

The DIU210 board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	Digital Input 1
2	Digital Input 2
3	Common Digital Input 1 / 2
4	Digital Input 3
5	Digital Input 4
6	Common Digital Input 3 / 4
7	Digital Input 5
8	Digital Input 6
9	Common Digital Input 5 / 6
10	Digital Input 7
11	Digital Input 8
12	Common Digital Input 7 / 8
13	Digital Input 9
14	Digital Input 10
15	Common Digital Input 9 / 10
16	Digital Input 11
17	Digital Input 12
18	Common Digital Input 11 / 12
19	Digital Input 13
20	Digital Input 14
21	Common Digital Input 13 / 14
22	Digital Input 15
23	Digital Input 16
24	Common Digital Input 15 / 16

Table 9: DIU210 board – Connector description

4.7 DIGITAL INPUTS MODULE – DIU211

The Digital Input module (DIU211) provides 16 optically isolated digital inputs with one common for two DIs. This common links the positive inputs of the two opto-couplers.

Note:
The board supports polarity reversal.

4.7.1 BLOCK DIAGRAM

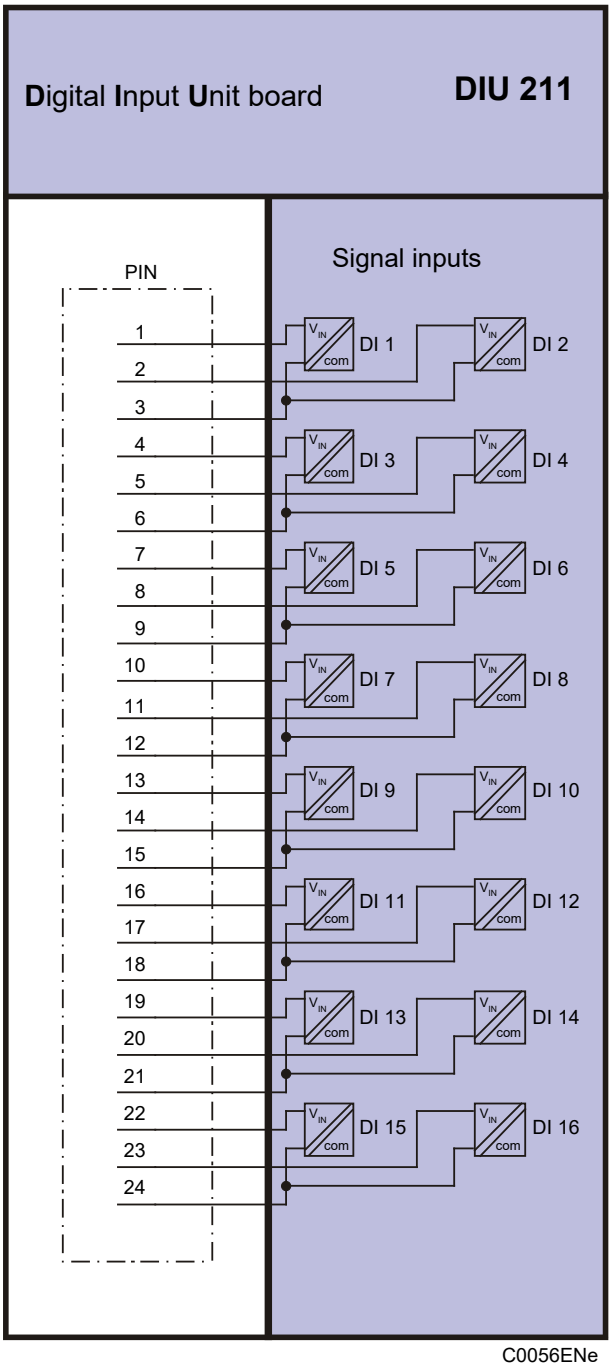


Figure 19: DIU211 board – Block diagram

Note:
Different variants of DIU211 boards are available according to the input voltage range.
Before connection, special attention is to be paid to the board variant:
- variant A01 for 24 V_{DC},
- variant A02 for 48/60 V_{DC},
- variant A03 for 110/125 V_{DC}
- variant A04 for 220 V_{DC}
- variant A07 for 110/125 V_{DC} with 80% threshold
- variant A08 for 220 V_{DC} with 80% threshold

4.7.2 CONNECTOR DESCRIPTION

The DIU211 board is equipped with a standard type of connector with a 24-way and 5.08 mm pitch.

Pin N°.	Signal
1	Digital Input 1-
2	Digital Input 2-
3	Positive Common Digital Input 1 / 2
4	Digital Input 3-
5	Digital Input 4-
6	Positive Common Digital Input 3 / 4
7	Digital Input 5-
8	Digital Input 6-
9	Positive Common Digital Input 5 / 6
10	Digital Input 7-
11	Digital Input 8-
12	Positive Common Digital Input 7 / 8
13	Digital Input 9-
14	Digital Input 10-
15	Positive Common Digital Input 9 / 10
16	Digital Input 11-
17	Digital Input 12-
18	Positive Common Digital Input 11 / 12
19	Digital Input 13-
20	Digital Input 14-
21	Positive Common Digital Input 13 / 14
22	Digital Input 15-
23	Digital Input 16-
24	Positive Common Digital Input 15 / 16

Note:
The triggering threshold depends on jumper positions; see the chapter C26x/EN HW.



Caution:
Protect the opto-inputs and their wiring with a maximum 16 A high rupture capacity (HRC) type NIT or TIA fuse.



Caution:
Protect the opto-inputs and their wiring with a maximum 16 A high rupture capacity (HRC) type NIT or TIA fuse.

4.8 DIGITAL INPUTS MODULE – DIU221

The Digital Input module (DIU221) provides 16 galvanically isolated digital inputs with one common connection for two inputs. This common connection links the positive inputs of the two channels.

Note:
In its A09 (170 V_{DC}) and A10 (250 V_{DC}) voltage variants, the board does not support polarity reversal. It does not operate if the voltage has the wrong polarity.

4.8.1 BLOCK DIAGRAM

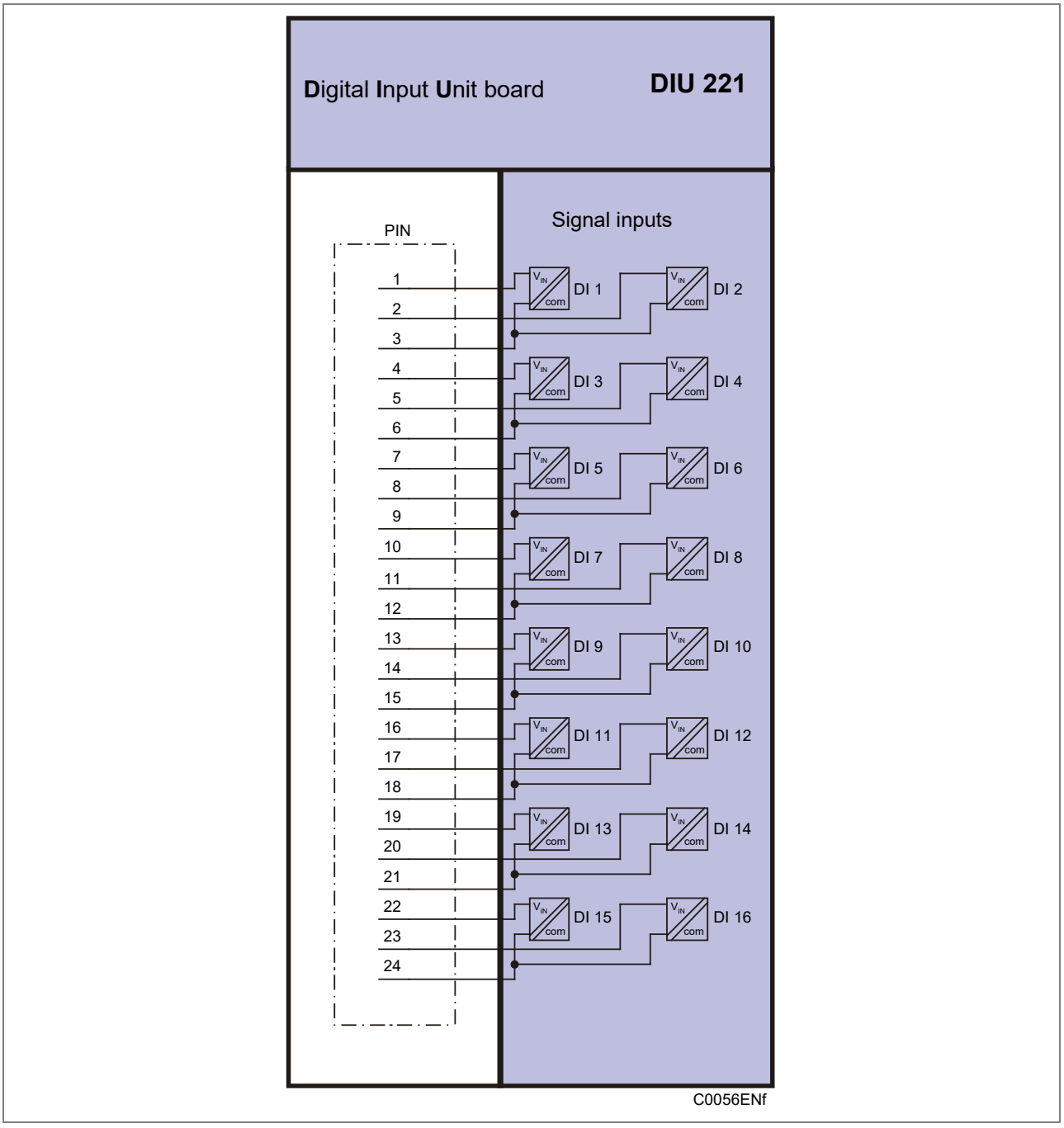


Figure 20: DIU221 board – Block diagram

4.8.2 CONNECTOR DESCRIPTION

The DIU221 board is equipped with a standard type of connector with a 24-pin and 5.08 mm pitch.

Pin N°.	Signal
1	Digital Input 1-
2	Digital Input 2-
3	Positive Common Digital Input 1 / 2
4	Digital Input 3-
5	Digital Input 4-
6	Positive Common Digital Input 3 / 4
7	Digital Input 5-
8	Digital Input 6-
9	Positive Common Digital Input 5 / 6
10	Digital Input 7-
11	Digital Input 8-
12	Positive Common Digital Input 7 / 8
13	Digital Input 9-
14	Digital Input 10-
15	Positive Common Digital Input 9 / 10
16	Digital Input 11-
17	Digital Input 12-
18	Positive Common Digital Input 11 / 12
19	Digital Input 13-
20	Digital Input 14-
21	Positive Common Digital Input 13 / 14
22	Digital Input 15-
23	Digital Input 16-
24	Positive Common Digital Input 15 / 16

4.9 DIGITAL OUTPUTS MODULE – DOU200/DOU201

The Digital Outputs Unit board (DOU200 or DOU201) provides 10 isolated outputs using relays.

4.9.1 BLOCK DIAGRAM

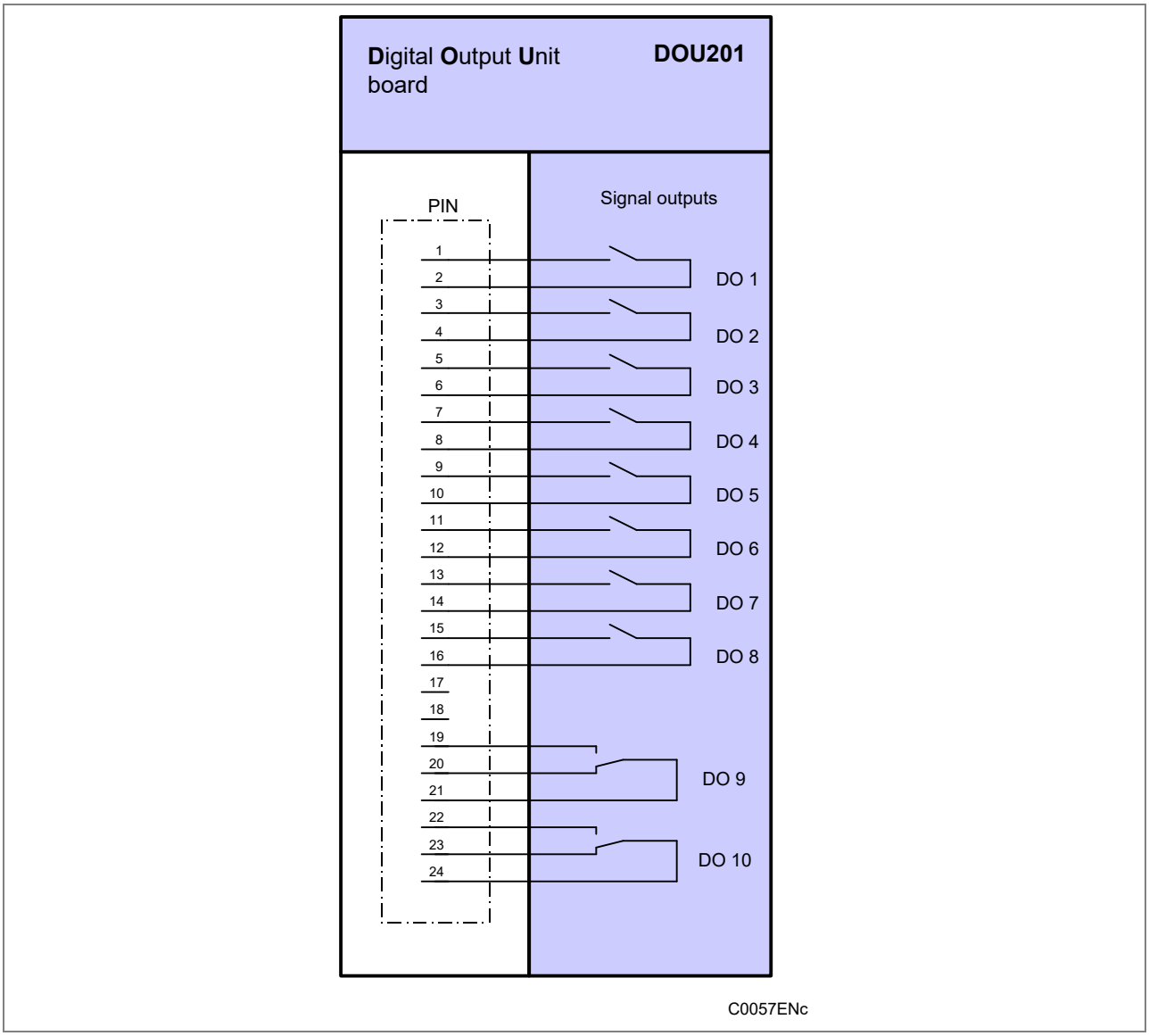


Figure 21: DOU200/DOU201 board – Block diagram

4.9.2 CONNECTOR DESCRIPTION

The DOU200/201 board is equipped with a 24pin 5.08 mm pitch connector.

Pin N°.	Signal
1	Digital output 1 +
2	Digital output 1 -
3	Digital output 2 +
4	Digital output 2 -
5	Digital output 3 +
6	Digital output 3 -
7	Digital output 4 +
8	Digital output 4 -
9	Digital output 5 +
10	Digital output 5 -
11	Digital output 6 +
12	Digital output 6 -
13	Digital output 7 +
14	Digital output 7 -
15	Digital output 8 +
16	Digital output 8 -
17	NC
18	NC
19	Digital output 9 – NO contact
20	Digital output 9 – NC contact
21	Common Digital output 9
22	Digital output 10 – NO contact
23	Digital output 10 – NC contact
24	Common Digital output 10

Table 10: DOU200/201 board – Connector description

4.10 HIGH BREAK-HIGH SPEED OUTPUTS MODULE – HBU200

The High Break Unit board (HBU200) comprises 10 normally open output contacts, which are suitable for high breaking loads.

4.10.1 BLOCK DIAGRAM

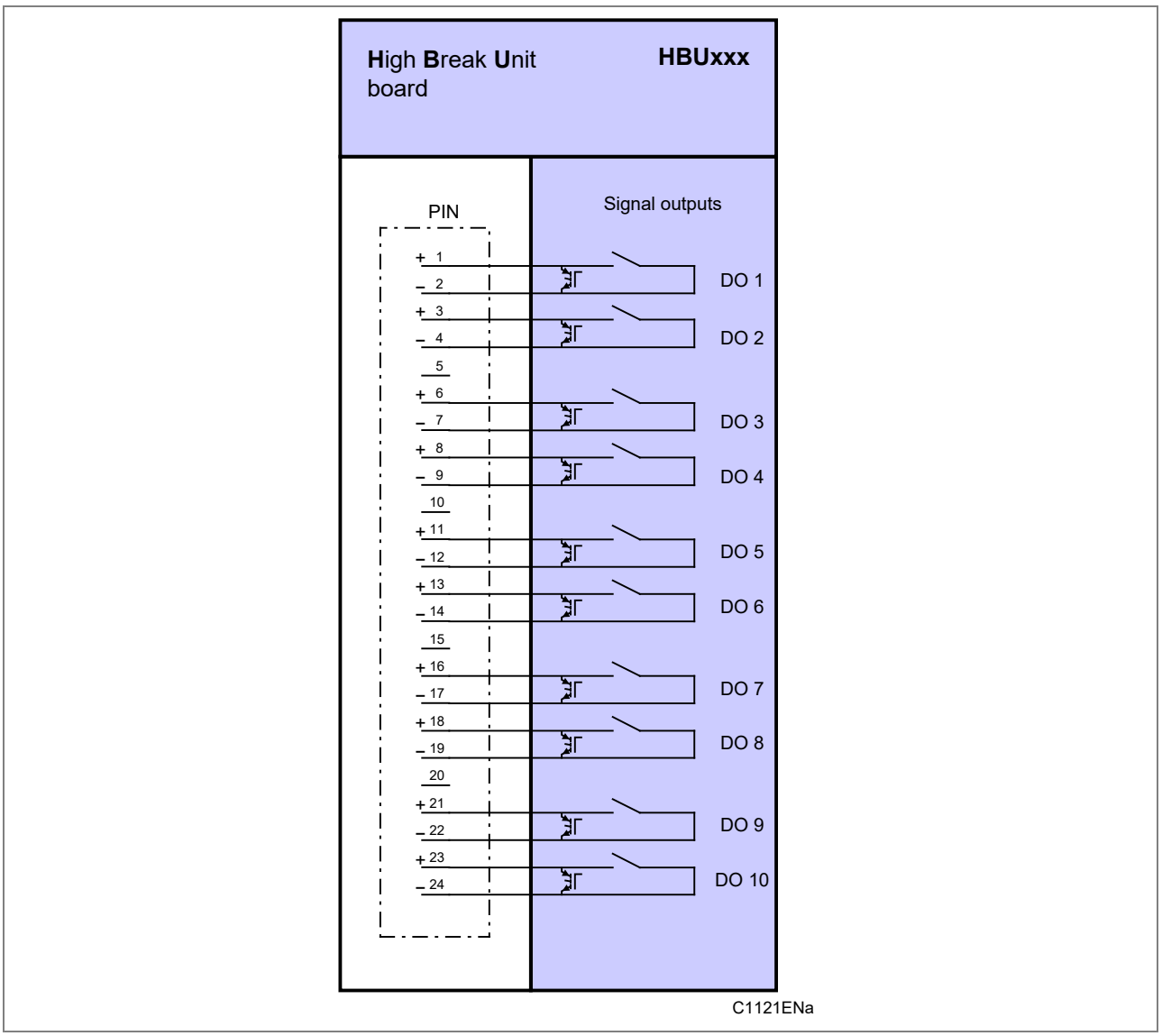


Figure 22: HBU200 board – Block diagram

4.10.2 CONNECTOR DESCRIPTION

The HBU200 board is equipped with a 24pin 5.08 mm pitch connector.

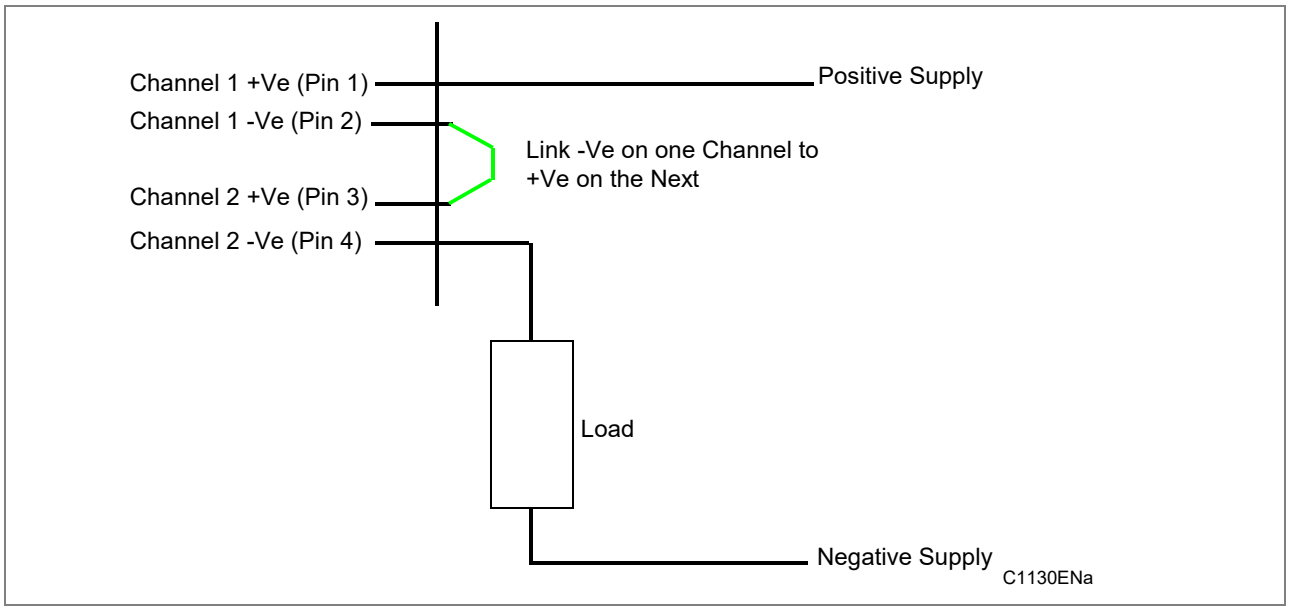
Pin N°.	Signal
1	Digital output 1 +Ve
2	Digital output 1 -Ve
3	Digital output 2 +Ve
4	Digital output 2 -Ve
5	NC
6	Digital output 3 +Ve
7	Digital output 3 -Ve
8	Digital output 4 +Ve
9	Digital output 4 -Ve
10	NC
11	Digital output 5 +Ve
12	Digital output 5 -Ve
13	Digital output 6 +Ve
14	Digital output 6 -Ve
15	NC
16	Digital output 7 +Ve
17	Digital output 7 -Ve
18	Digital output 8 +Ve
19	Digital output 8 -Ve
20	NC
21	Digital output 9 +Ve
22	Digital output 9 -Ve
23	Digital output 10 +Ve
24	Digital output 10 -Ve

Table 11: HBU200 board – Connector description

The pin-out groups the channels into pairs that give a logical grouping for dual cutting operation or for AC operation.

DC Dual-Cutting Operation

Dual Cutting is possible by connecting two channels in series as illustrated below. Note that in this illustration the selected channels are channel 1 & 2, but any pair of channels can be used.

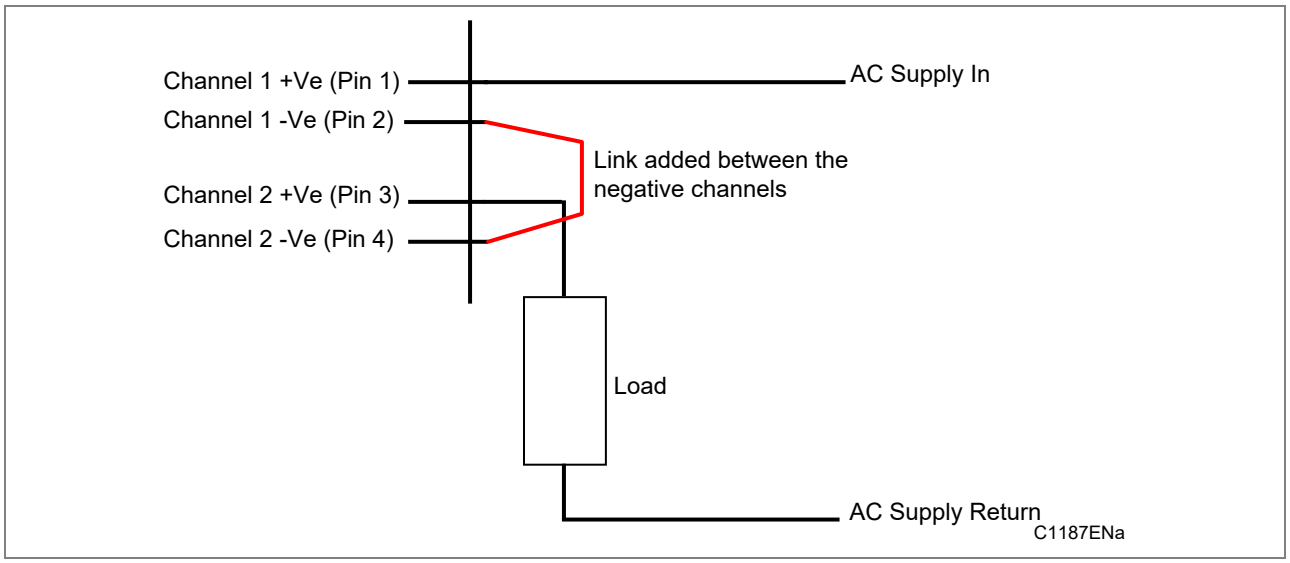


Reversed DC Operation

If the system is operating on DC and a channel is connected incorrectly (+Ve to –Ve -Ve to +Ve) the contact will behave as though it is permanently switched on (activated). It will not be possible to switch the output off.

AC Operation

To use the HBU200 to switch AC loads, two channels are required. These are connected in series with the negative of one channel connected to the negative of the other. The supply is connected to one positive input and the load to the other as illustrated below. This example uses channels 1 and 2 but any two channels can be used.



4.11 ANALOGUE INPUT MODULE – AIU201

The Analogue input module (AIU201) provides 4 independent analogue inputs.

4.11.1 BLOCK DIAGRAM

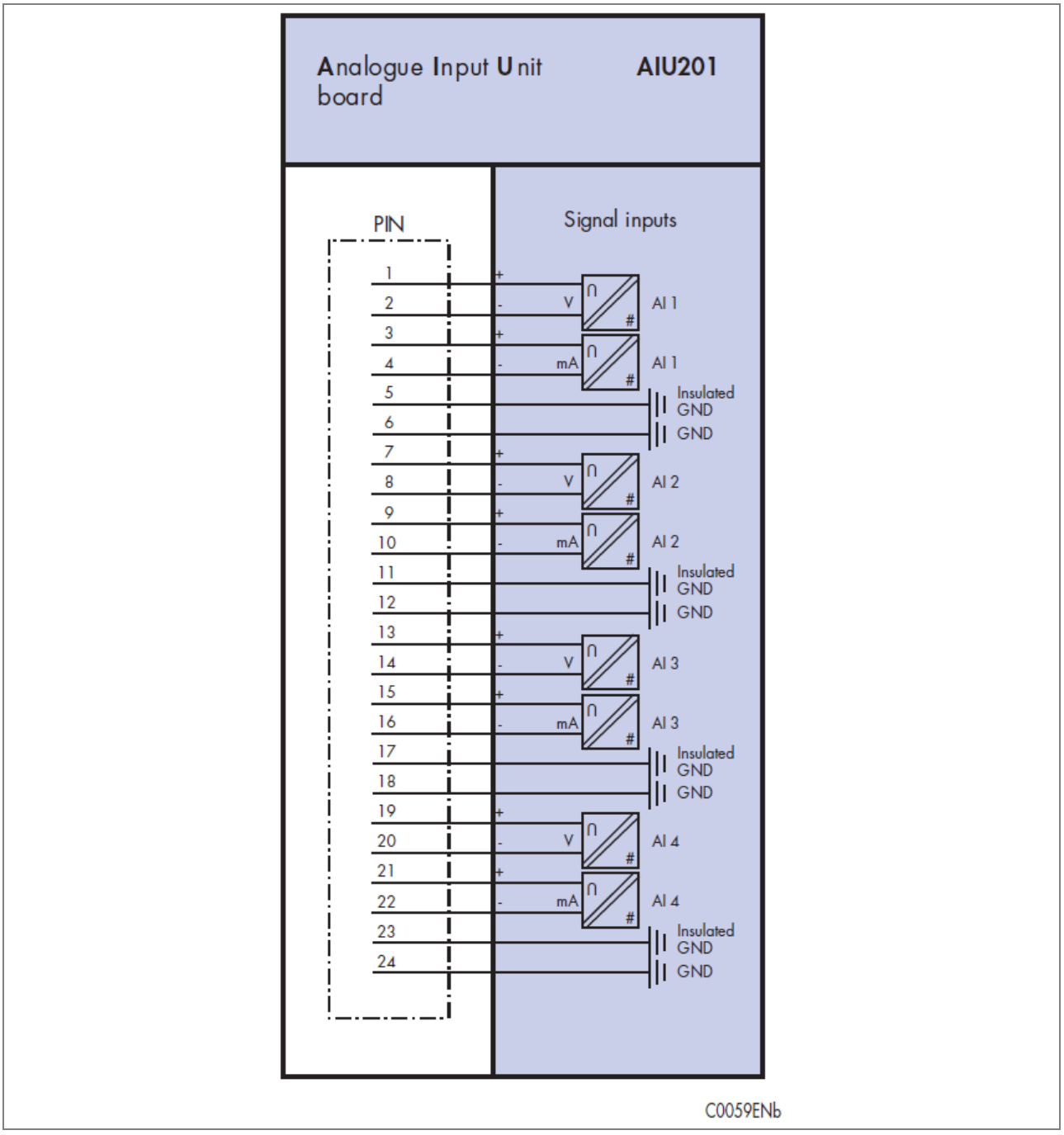


Figure 23: AIU201 board – Block diagram

4.11.2 CONNECTOR DESCRIPTION

The AIU201 board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	Analogue Input 1+ (voltage)
2	Analogue Input 1- (voltage)
3	Analogue Input 1+ (current)
4	Analogue Input 1- (current)
5	Insulated Ground 1
6	Ground for cable shield
7	Analogue Input 2+ (voltage)
8	Analogue Input 2- (voltage)
9	Analogue Input 2+ (current)
10	Analogue Input 2- (current)
11	Insulated Ground 2
12	Ground for cable shield
13	Analogue Input 3+ (voltage)
14	Analogue Input 3- (voltage)
15	Analogue Input 3+ (current)
16	Analogue Input 3- (current)
17	Insulated Ground 3
18	Ground for cable shield
19	Analogue Input 4+ (voltage)
20	Analogue Input 4- (voltage)
21	Analogue Input 4+ (current)
22	Analogue Input 4- (current)
23	Insulated Ground 4
24	Ground for cable shield

Table 12: AIU201 board – Connector description

4.11.3 CONNECTION OF SENSORS TO THE AIU201 ANALOGUE INPUT TERMINALS

Cable shield earthing

Wiring from the sensors may be enclosed in shielded cables and those shields may necessitate earthing. To this effect, the BIU201 board offers 4 dedicated terminals to connect these cables to the case earth of the unit: pins 6, 12, 18 and 24. These terminals are internally linked to the case earth and are independent of the analogue inputs. Therefore, cable shields can be connected to any of those terminals, irrespective of which inputs the sensors are wired to.

If cable shield earthing is used, make sure to earth only one end of each shield, especially for long cables, as the ground loop created by the difference of potential between distant ends could generate noise that may render the measurements from the sensors inaccurate.

Analogue inputs

Wiring of the sensors to the analogue inputs must be done according to instructions given by the sensors' user manuals. In addition, because each analogue input channel has an impedance of 75 ohms, ensure that you only use sensors with outputs rated for 75 ohms.

4.12 ANALOGUE INPUT MODULE – AIU211

The Analogue input board AIU211 provides 8 isolated Analogue inputs.

4.12.1 BLOCK DIAGRAM

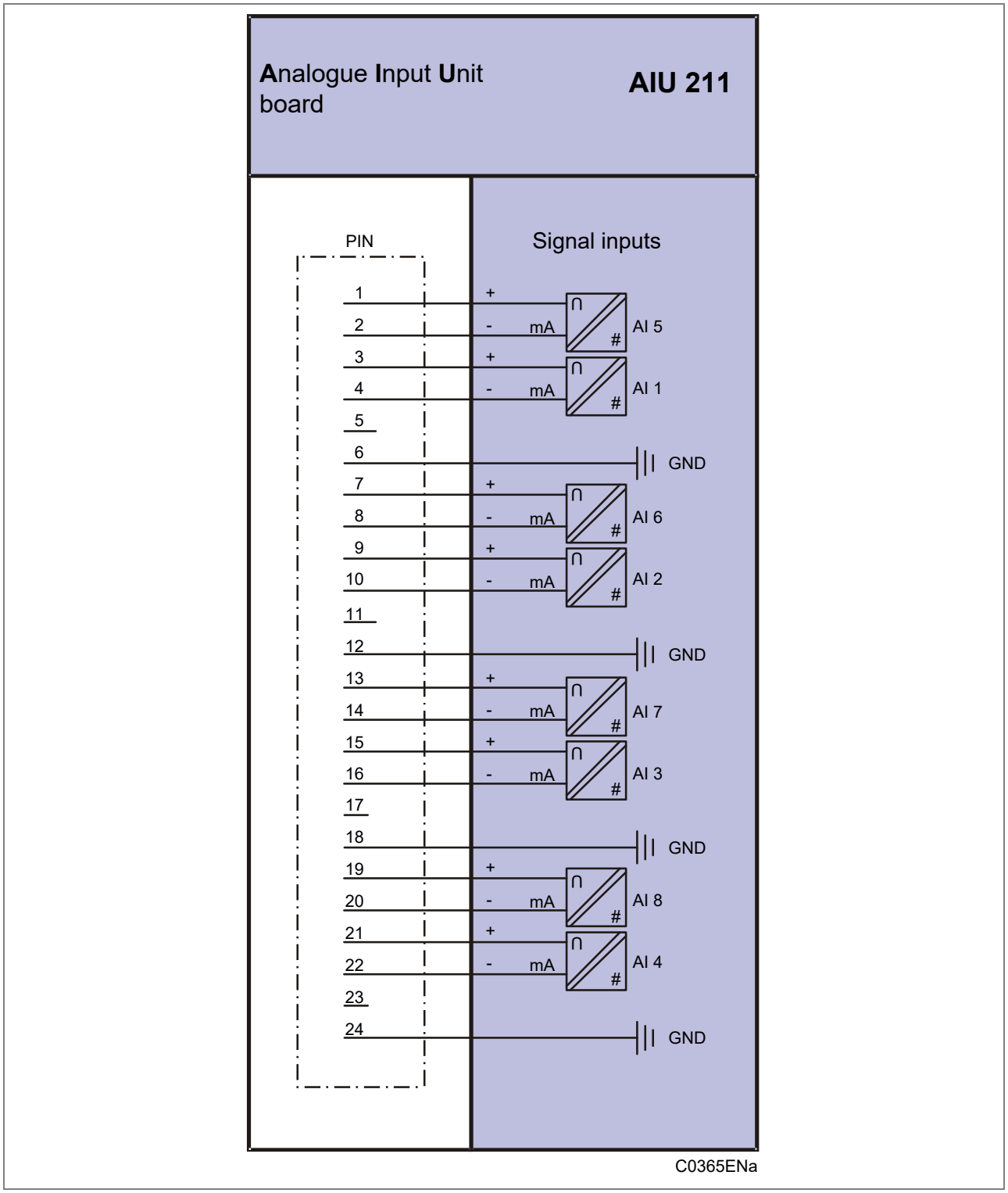


Figure 24: AIU211 board – Block diagram

4.12.2 CONNECTOR DESCRIPTION

The AIU211 board is equipped with a 24-way 5.08 mm pitch connector.

Pin N°.	Signal
1	Analogue Input 5+ (current)
2	Analogue Input 5- (current)
3	Analogue Input 1+ (current)
4	Analogue Input 1- (current)
5	Not Connected
6	Ground for cable shield
7	Analogue Input 6+ (current)
8	Analogue Input 6- (current)
9	Analogue Input 2+ (current)
10	Analogue Input 2- (current)
11	Not Connected
12	Ground for cable shield
13	Analogue Input 7+ (current)
14	Analogue Input 7- (current)
15	Analogue Input 3+ (current)
16	Analogue Input 3- (current)
17	Not Connected
18	Ground for cable shield
19	Analogue Input 8+ (current)
20	Analogue Input 8- (current)
21	Analogue Input 4+ (current)
22	Analogue Input 4- (current)
23	Not Connected
24	Ground for cable shield

Table 13: AIU211 board – Connector description

4.12.3 CONNECTION OF SENSORS TO THE AIU211 ANALOGUE INPUT TERMINALS

Cable shield earthing

Wiring from the sensors may be enclosed in shielded cables and those shields may necessitate earthing. To this effect, the BIU211 board offers 4 dedicated terminals to connect these cables to the case earth of the unit: pins 6, 12, 18 and 24. These terminals are internally linked to the case earth and are independent of the analogue inputs. Therefore, cable shields can be connected to any of those terminals, irrespective of which inputs the sensors are wired to.

If cable shield earthing is used, make sure to earth only one end of each shield, especially for long cables, as the ground loop created by the difference of potential between distant ends could generate noise that may render the measurements from the sensors inaccurate.

Analogue inputs

Wiring of the sensors to the analogue inputs must be done according to instructions given by the sensors' user manuals. In addition, because each analogue input channel has an impedance of 75 ohms, ensure that you only use sensors with outputs rated for 75 ohms.

4.13 TRANSDUCERLESS MEASUREMENTS UNIT MODULE – TMU220

The Transducerless Measurements Unit module (TMU220) provides 5 transducerless voltage inputs (VT) and 4 transducerless current inputs (CT).

4.13.1 BLOCK DIAGRAM

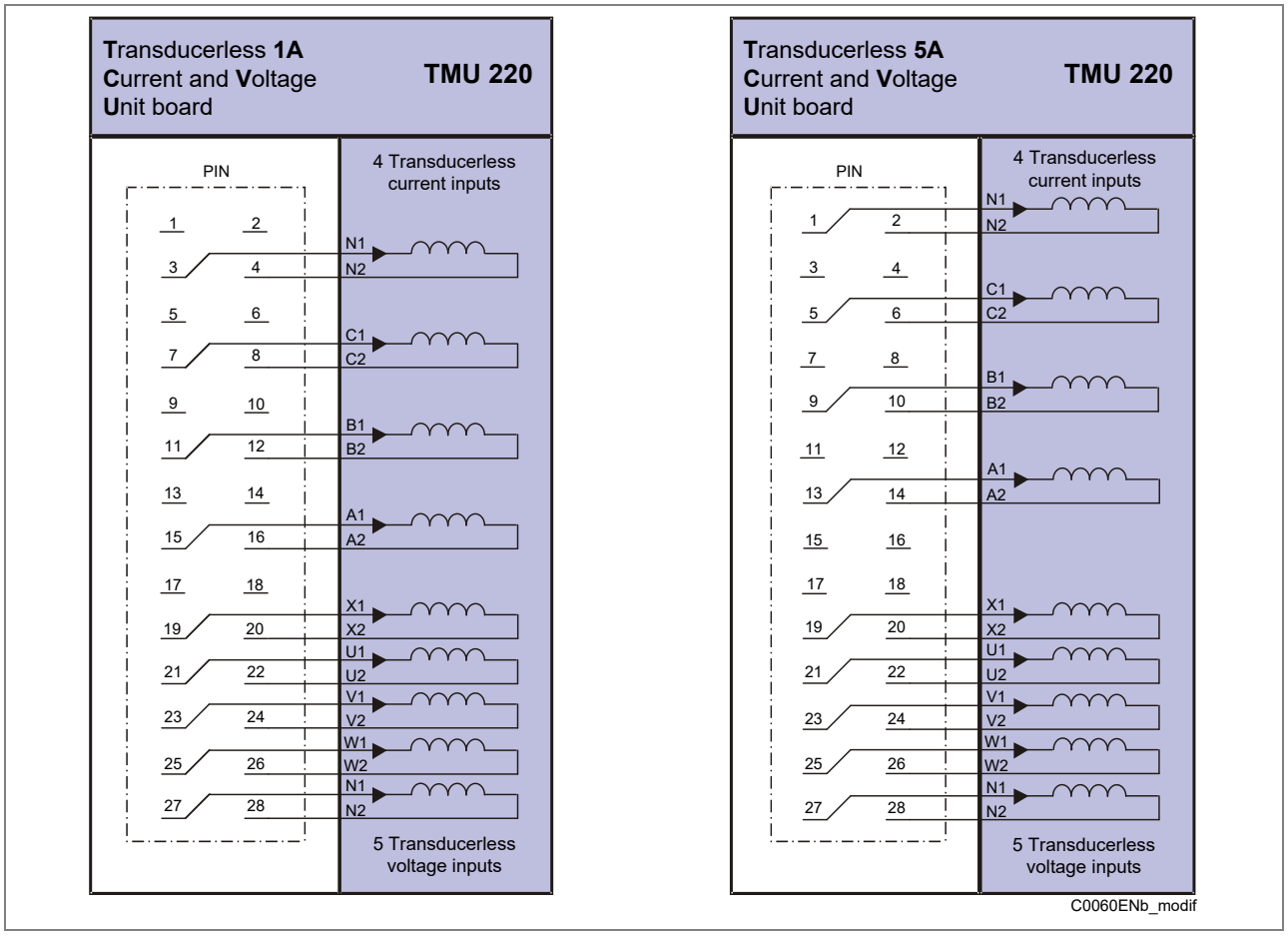


Figure 25: TMU220 board – Block diagram

4.13.2 CONNECTOR DESCRIPTION

The TMU220 board is fitted with a standard MIDOS 28 connector (see *Figure 2: Standard MIDOS 28 connector*).

Pin N°.	Signal	Electrical Signal	STAR topology "Measure type" label in DS Agile SCE Wiring panel	DELTA topology "Measure type" label in DS Agile SCE Wiring panel	Waveform channel
1	Current Input 5A - N1	IN 5A -	Ibusbar RMS 1 value of the current phase	Ibusbar RMS 1 value of the current phase	CI#4
2	Current Input 5A – N2	IN 5A +			
3	Current Input 1A – N1	IN 1A -			
4	Current Input 1A – N2	IN 1A +			
5	Current Input 5A – C1	IC 5A -	IC, RMS value of the current phase C	IC, RMS value of the current phase C	CI#3
6	Current Input 5A – C2	IC 5A +			
7	Current Input 1A – C1	IC 1A -			

Pin N°.	Signal	Electrical Signal	STAR topology "Measure type" label in DS Agile SCE Wiring panel	DELTA topology "Measure type" label in DS Agile SCE Wiring panel	Waveform channel
8	Current Input 1A – C2	IC 1A +			
9	Current Input 5A – B1	IB 5A -	IB, RMS value of the current phase B	IB, RMS value of the current phase B	CI#2
10	Current Input 5A – B2	IB 5A +			
11	Current Input 1A – B1	IB 1A -			
12	Current Input 1A – B2	IB 1A +			
13	Current Input 5A – A1	IA 5A -	IA, RMS value of the current phase A	IA, RMS value of the current phase A	CI#1
14	Current Input 5A – A2	IA 5A +			
15	Current Input 1A – A1	IA 1A -			
16	Current Input 1A – A2	IA 1A +			
17	NC	NC	NA	NA	NA
18	NC	NC	NA	NA	NA
19	Voltage Input – X1	V busbar2 -	Vbusbar, RMS 2 value of the busbar voltage	Vbusbar, RMS 2 value of the busbar voltage	VI#5
20	Voltage Input – X2	V busbar2 +			
21	Voltage Input – U1	VAN - / VAB -	VAN, RMS value of the voltage phase A	VAB, RMS value of the voltage phase AB	VI#1
22	Voltage Input – U2	VAN + / VAB +			
23	Voltage Input – V1	VBN - / VBC -	VBN, RMS value of the voltage phase A	VBC, RMS value of the voltage phase BC	VI#2
24	Voltage Input – V2	VBN + / VBC +			
25	Voltage Input – W1	VCN - / VCA -	VCN, RMS value of the voltage phase C	VCA, RMS value of the voltage phase CA	VI#3
26	Voltage Input – W2	VCN+ / VCA+			
27	Voltage Input – N1	V busbar1 - / VN -	Vbusbar, RMS 1 value of the busbar voltage	Vbusbar, RMS 1 value of the busbar voltage	VI#4
28	Voltage Input – N2	V busbar1 + / VN +			

Table 14: TMU220 board – Connector description

Note:
Odd-numbered terminals should be connected to the neutral current or voltage. However, because the board acquires AC signals, inverting that connection (even-numbered terminals to neutral) is permitted, provided that the connections of ALL the terminals are inverted.

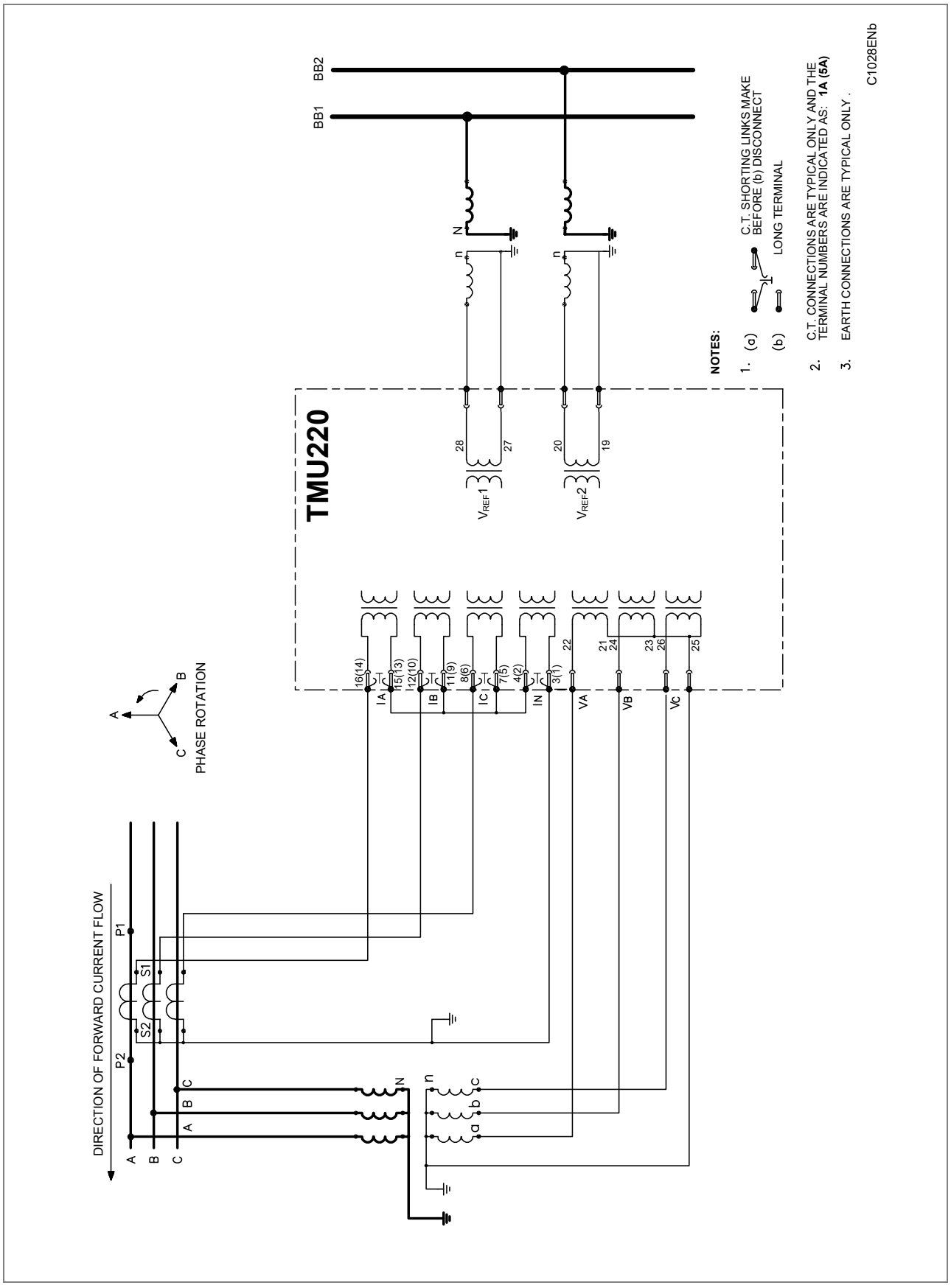


Figure 26: TMU220 board – External connection diagram with 2 x V_{REF}

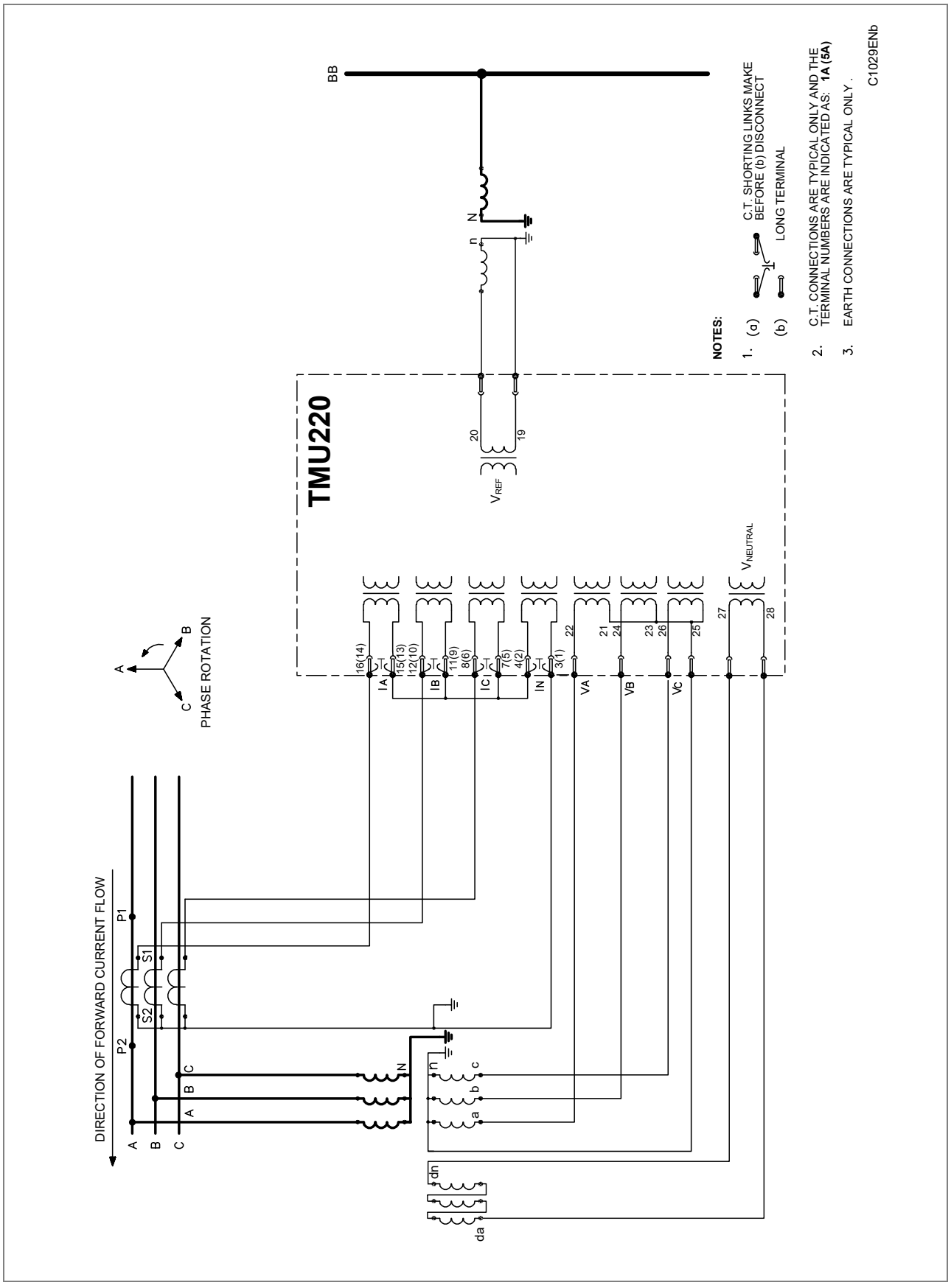


Figure 27: TMU220 board – External connection diagram with V_{REF} +V_N

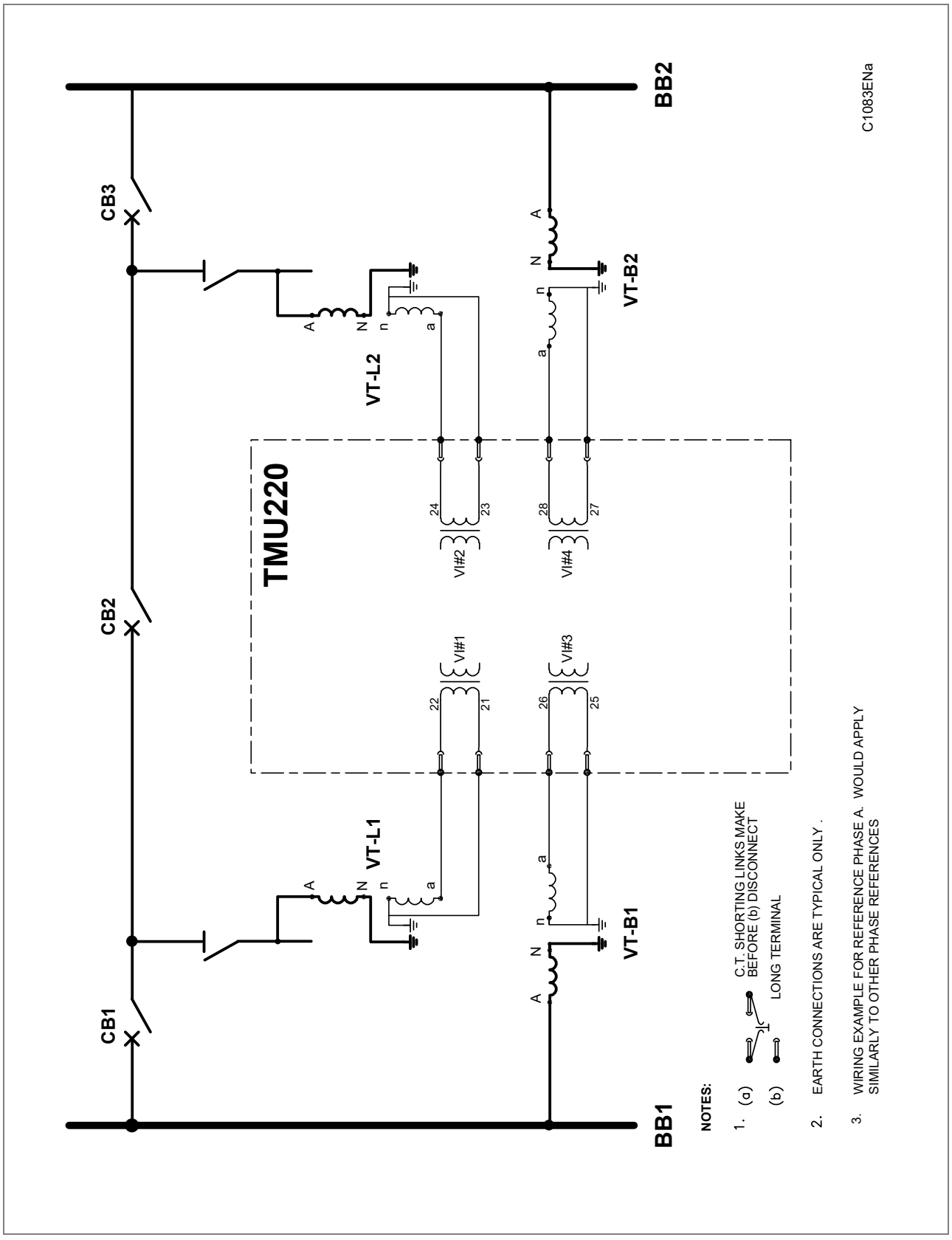


Figure 28: TMU220 board – External connection diagram for breaker-and-a-half topology

4.14 TRANSDUCERLESS MEASUREMENTS UNIT MODULE – TMU210

The Transducerless Measurements Unit module TMU210 provides 4 transducerless voltage inputs (VT) and 4 transducerless current inputs (CT).

4.14.1 BLOCK DIAGRAM

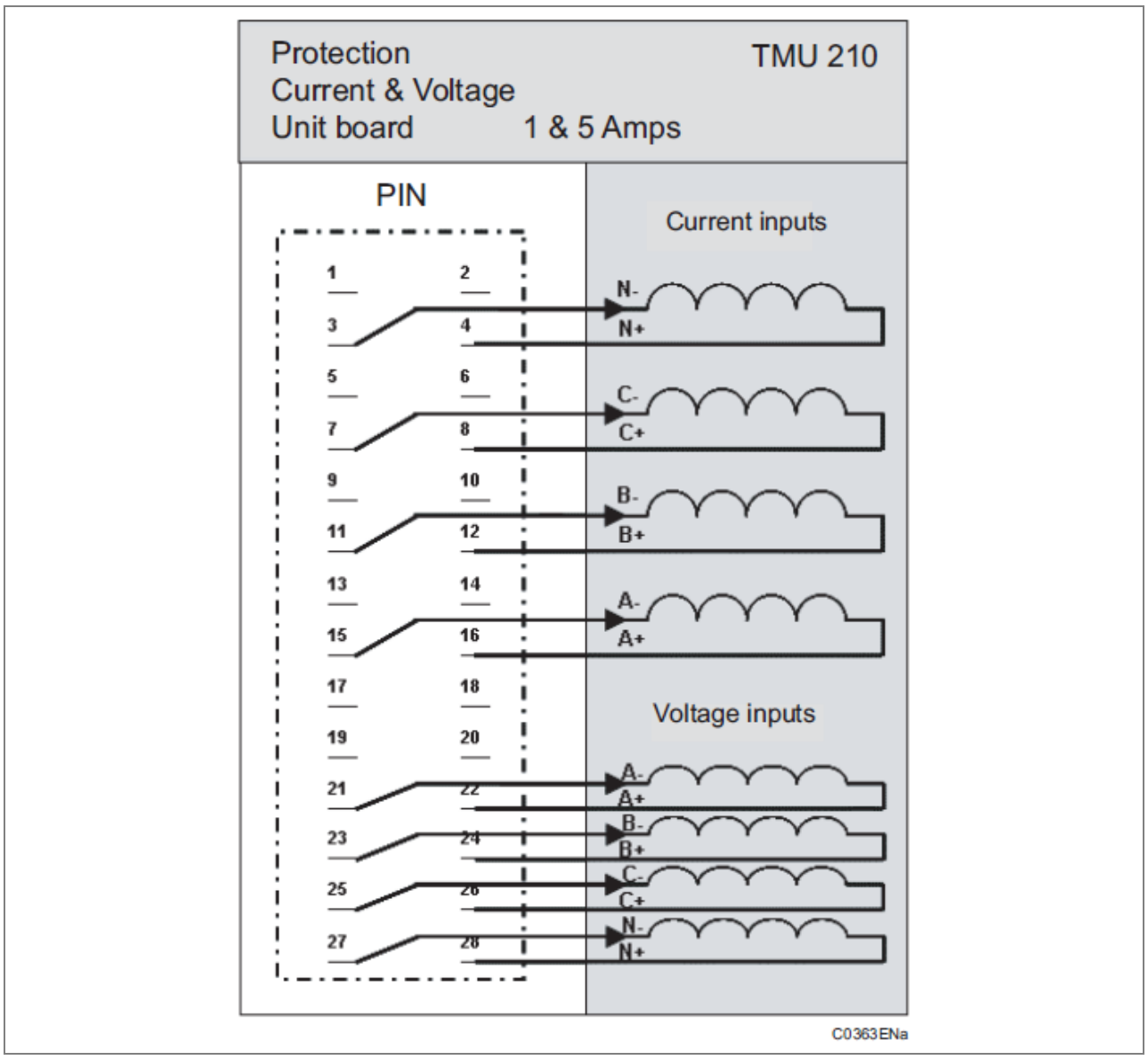


Figure 29: TMU210 board – Block diagram

4.14.2 CONNECTOR DESCRIPTION

The TMU210 board is equipped with a standard MiDOS 28 connector (see Figure 2: Standard MiDOS 28 connectors).

Pin N°.	Signal
1	Current Input 5A - N1
2	Current Input 5A – N2
3	Current Input 1 Amps or 5 Amps – N-
4	Current Input 1 Amps or 5 Amps – N+
5	Not connected
6	Not connected
7	Current Input 1 Amps or 5 Amps – C-
8	Current Input 1 Amps or 5 Amps – C+
9	Not connected
10	Not connected
11	Current Input 1 Amps or 5 Amps – B-
12	Current Input 1 Amps or 5 Amps – B+
13	Not connected
14	Not connected
15	Current Input 1 Amps or 5 Amps – A-
16	Current Input 1 Amps or 5 Amps – A+
17	Not connected
18	Not connected
19	Not connected
20	Not connected
21	Voltage Input – U1
22	Voltage Input – U2
23	Voltage Input – V1
24	Voltage Input – V2
25	Voltage Input – W1
26	Voltage Input – W2
27	Voltage Input – N1
28	Voltage Input – N2

Table 15: TMU210 board - Connector description

Note:
Odd-numbered terminals should be connected to the neutral current or voltage. However, because the board acquires AC signals, inverting that connection (even-numbered terminals to neutral) is permitted, provided that the connections of ALL the terminals are inverted.

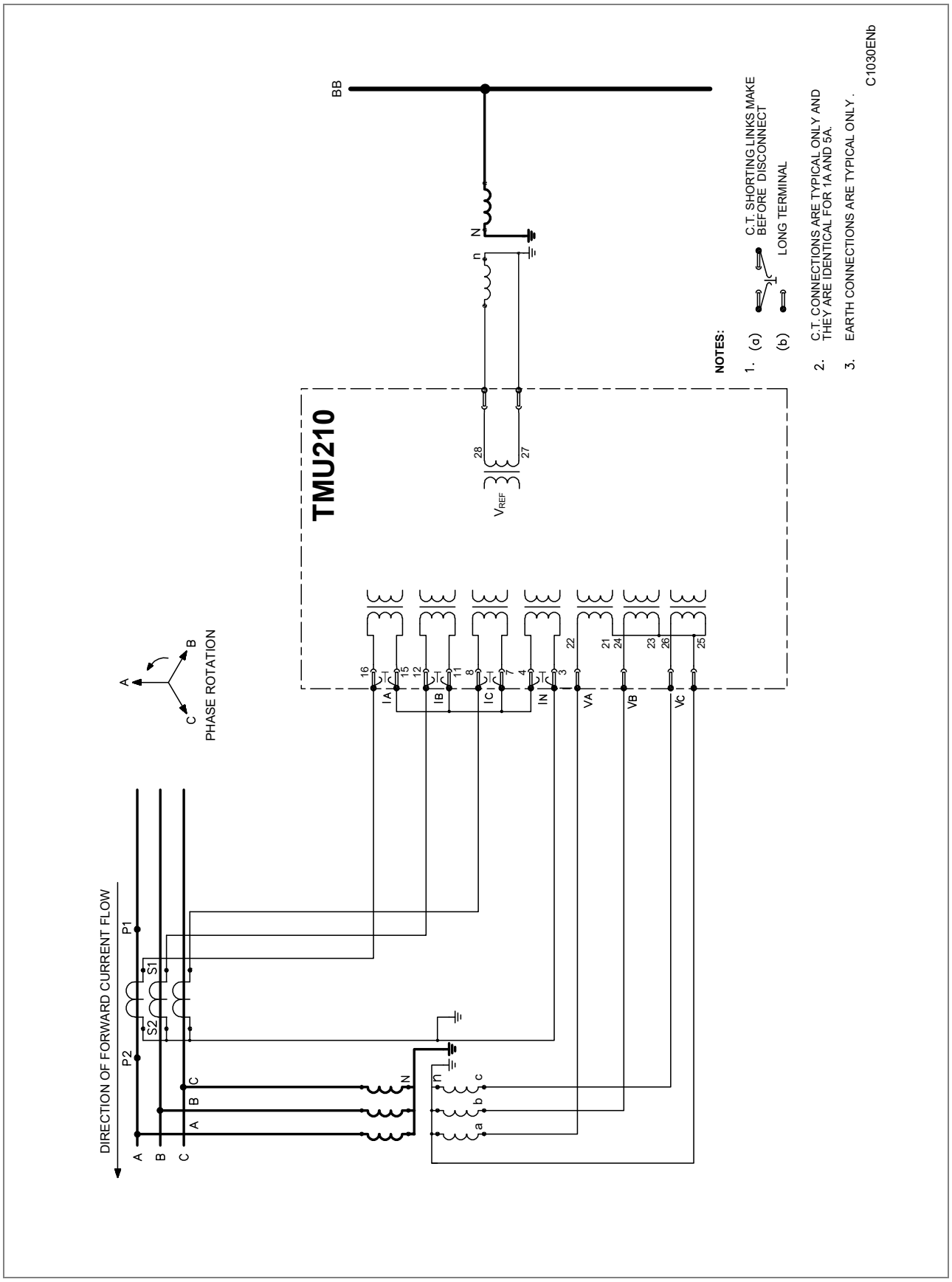


Figure 30: TMU210 board – External connection diagram with V_{REF}

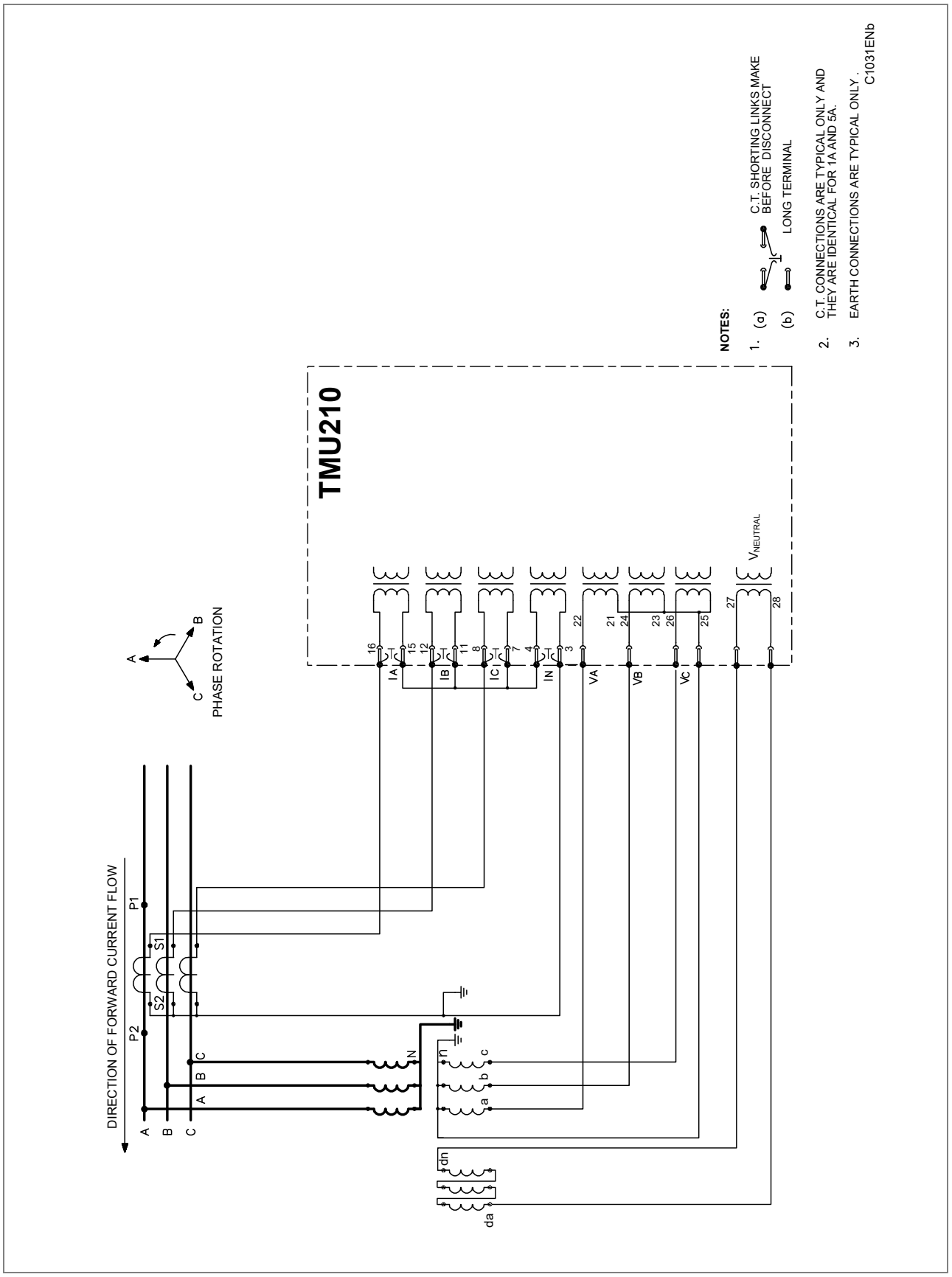


Figure 31: TMU210 board – External connection diagram with V_N

4.15 ANALOGUE OUTPUT MODULE – AOU200

The AOU200 board provides 4 current analogue outputs. Each output is associated to a Read Inhibit relay. The outputs are powered using an external power supply. The external power supply has to provide a regulated voltage of +48V (+/- 5%).

This power supply will supply a minimum of 7W per AOU200 board.

Ex: if four AOU200 boards are installed in the C26x, it must supply at least 28 W.

4.15.1 BLOCK DIAGRAM

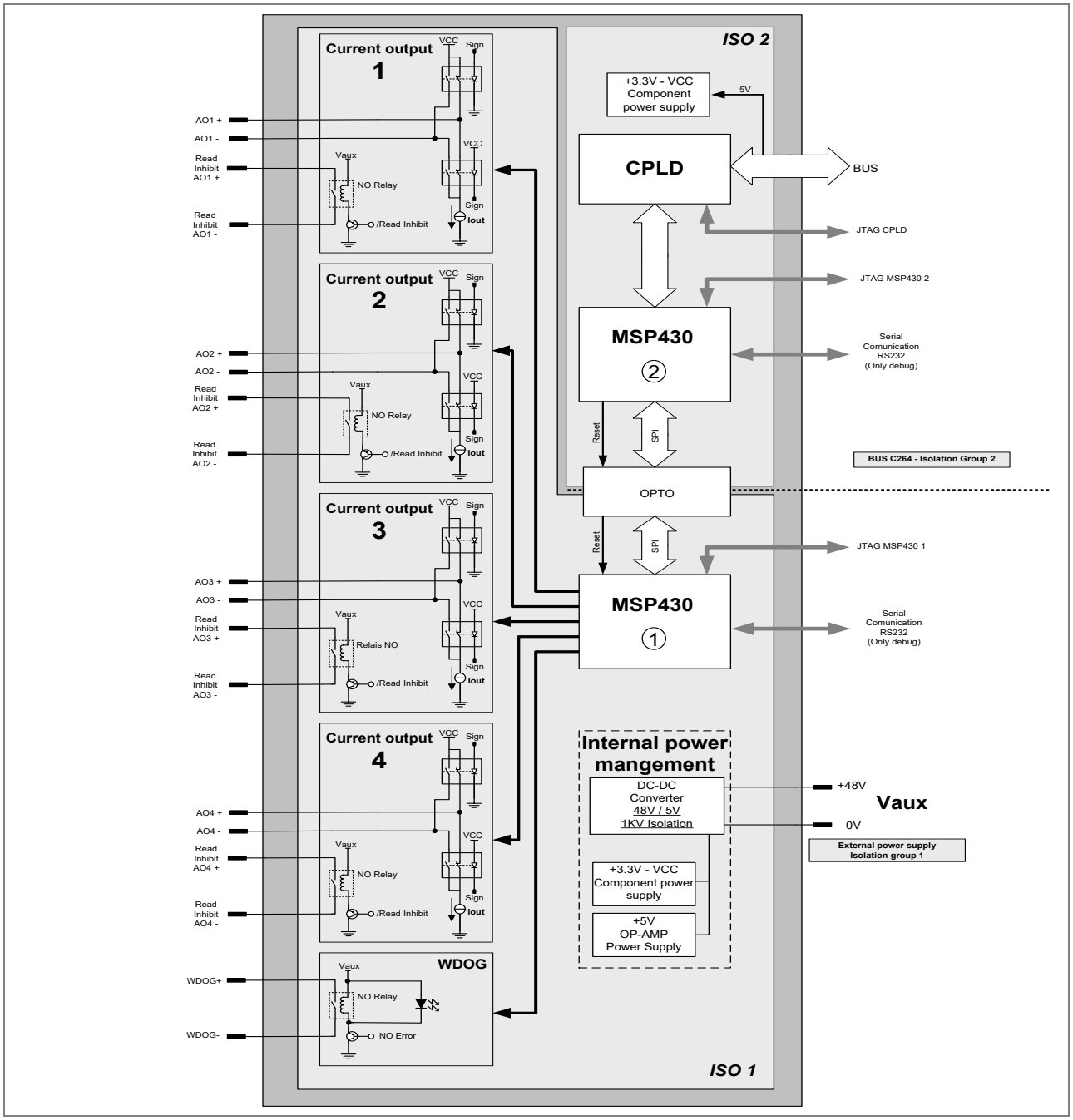


Figure 32: AOU200 board – Block diagram

4.15.2 CONNECTOR DESCRIPTION

N°	Description
1	External power supply +48V
2	NIL
3	External power supply (0V)
4	NIL
5	WDOG+
6	WDOG-
7	NIL
8	READ INHIBIT AO n° 1+
9	READ INHIBIT AO n° 1-
10	READ INHIBIT AO n° 2+
11	READ INHIBIT AO n° 2-
12	READ INHIBIT AO n° 3+
13	READ INHIBIT AO n° 3-
14	READ INHIBIT AO n° 4+
15	READ INHIBIT AO n° 4-
16	NIL
17	AO n° 1+
18	AO n° 1-
19	AO n° 2+
20	AO n° 2-
21	AO n° 3+
22	AO n° 3-
23	AO n° 4+
24	AO n° 4-

Table 16: AOU200 board – Connector description

4.16 ETHERNET SWITCH UNIT - SWU200/SWU202/SWU204

The SWU200 board provides four electrical links.

The SWU202 board provides four electrical links and two multi-mode optical links (ST connectors).

The SWU204 board provides four electrical links and two single mode optical links (ST connectors).

Use a (straight-through or not) patch cord between the port ETH1 (CPU) and one of the electrical ports (SWU).

4.16.1 ETHERNET CONNECTORS DESCRIPTION

These boards are equipped with four RJ45 connectors.

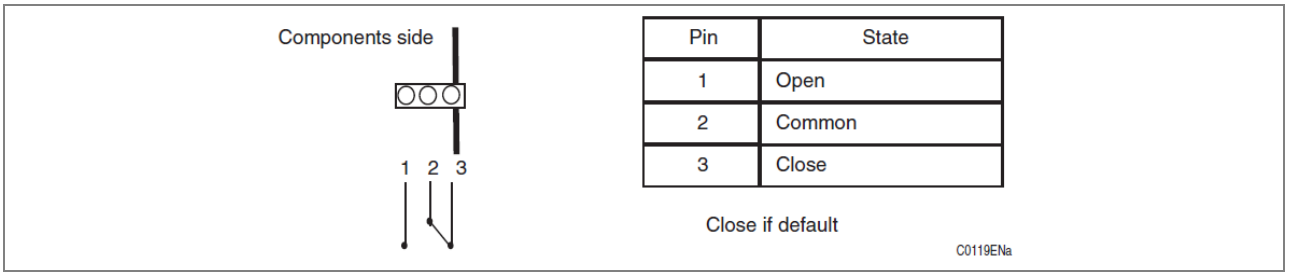
The top connector is for port 1. The bottom connector is for port 4.

Pin N°.	Signal
1	Rx+
2	Rx-
3	Tx+
4	not used
5	not used
6	Tx-
7	not used

Table 17: SWU200/202 board – RJ45 Connector description

4.16.2 FAULT SIGNAL CONNECTOR DESCRIPTION

These boards are equipped with a 3-way connector block to deliver a communication fault signal.



Wiring recommendation:

Due to the proximity of the port 4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

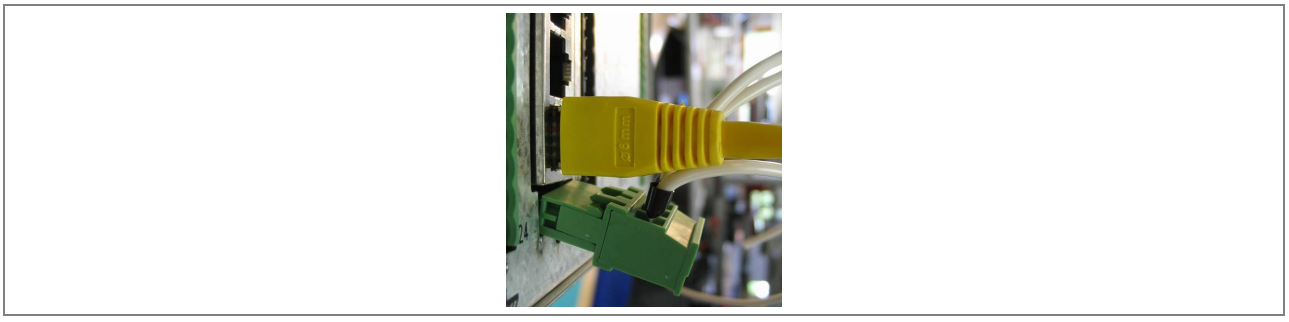


Figure 39: Switches – Port 4 Ethernet and Fault signal connectors

4.17 REDUNDANT ETHERNET SWITCH UNIT – SWR212, SWR214

These boards are Ethernet switches with 4 electrical links and 2 optical links for a redundancy ring. Use a (straight-through or not) patch cord between the port ETH1 (CPU) and one of the electrical ports (SWR).

The SWR21x switches are SNMP managed (they integrate an SNMP server) and can be remotely accessed from SNMP “client”.

The SWR212 model has a multi-mode optical interface.

The SWR214 model has a single mode optical interface.

4.17.1 ETHERNET CONNECTORS DESCRIPTION

These boards are equipped with four RJ45 connectors.

The top connector is for port 1. The bottom connector is for port 4.

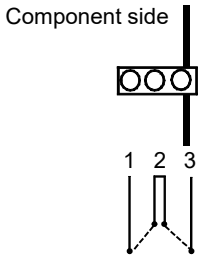
Pin N°.	Signal
1	Rx+
2	Rx-
3	Tx+
4	not used
5	not used
6	Tx-
7	not used

Table 18: SWR212/SWR214 board – RJ45 Connector description

4.17.2 FAULT SIGNAL CONNECTOR DESCRIPTION

These boards are equipped with a 3-way connector block to deliver a communication fault signal.

If one link of the optical ring fails, the fault is indicated by the output contacts (max. 250 V/5 A):



Closed pin	Faulty link	Self-healing link
1	Rs-Tp	Rp-Ts
2	Common	
3	Rp-Ts	Rs-Tp

C0121ENe

Wiring recommendation:

Due to the proximity of the port 4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

4.18 DUAL HOMING ETHERNET SWITCH UNIT – SWD212, SWD214

These boards are Ethernet switches with 4 electrical links and 2 optical links for a dual homing solution. Use a (straight-through or not) patch cord between the port ETH1 (CPU) and one of the electrical ports (SWD).

The SWD21x switches are SNMP managed (they integrate an SNMP server) and can be remotely accessed from SNMP “client”.

The SWD212 model has a multi-mode optical interface.

The SWD214 model has a single mode optical interface.

4.18.1 ETHERNET CONNECTORS DESCRIPTION

These boards are equipped with four RJ45 connectors.

The top connector is for port 1. The bottom connector is for port 4.

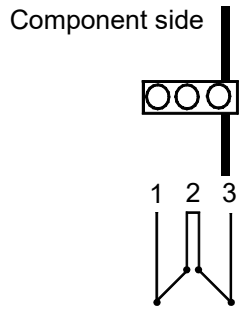
Pin N°.	Signal
1	Rx+
2	Rx-
3	Tx+
4	not used
5	not used
6	Tx-
7	not used

Table 19: SWD212/SWD214 BOARD – RJ45 Connector description

4.18.2 FAULT SIGNAL CONNECTOR DESCRIPTION

These boards are equipped with a 3-way connector block to deliver a communication fault signal.

If one link of the optical ring fails, the fault is indicated by the output contacts (max. 250 V/5 A):



Pin	State
1	Faulty link A
2	Common
3	Faulty link B

Closed if link faulty

C0297ENb

Wiring recommendation:

Due to the proximity of the port 4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

4.19 TEAMING ETHERNET SWITCH UNIT – SWT212

SWT212 boards are Ethernet switches for a hot standby redundancy solution. Use a (straight-through or not) patch cord between the port ETH1 (CPU) and one of the electrical ports (SWT).

4.19.1 ETHERNET CONNECTION

The Ethernet-based communication available in the SWT212 uses either optical fibre media (ST/connector) or 4 twisted pair cable.

If the equipment is located at a long distance (>100 m for RJ45) from the communication equipment or multiplexer, or if the cables run through a noisy area, then optical communication should be used to interconnect the IEDs and the communication equipment.

4.19.2 ETHERNET CONNECTORS DESCRIPTION

SWT212 boards are equipped with four RJ45 connectors.

The top connector is for port 1. The bottom connector is for port 4.

Pin N°.	Signal
1	Rx+
2	Rx-
3	Tx+
4	not used
5	not used
6	Tx-
7	not used
8	not used

Table 20: SWT212 BOARD – RJ45 Connector description

4.19.3 ETHERNET CABLE TYPE

Only the cable insulated category 5 (FTP: Foil Twisted Pair) or insulated (STP – Shielded Twisted Pair) with RJ45 connectors must be used.

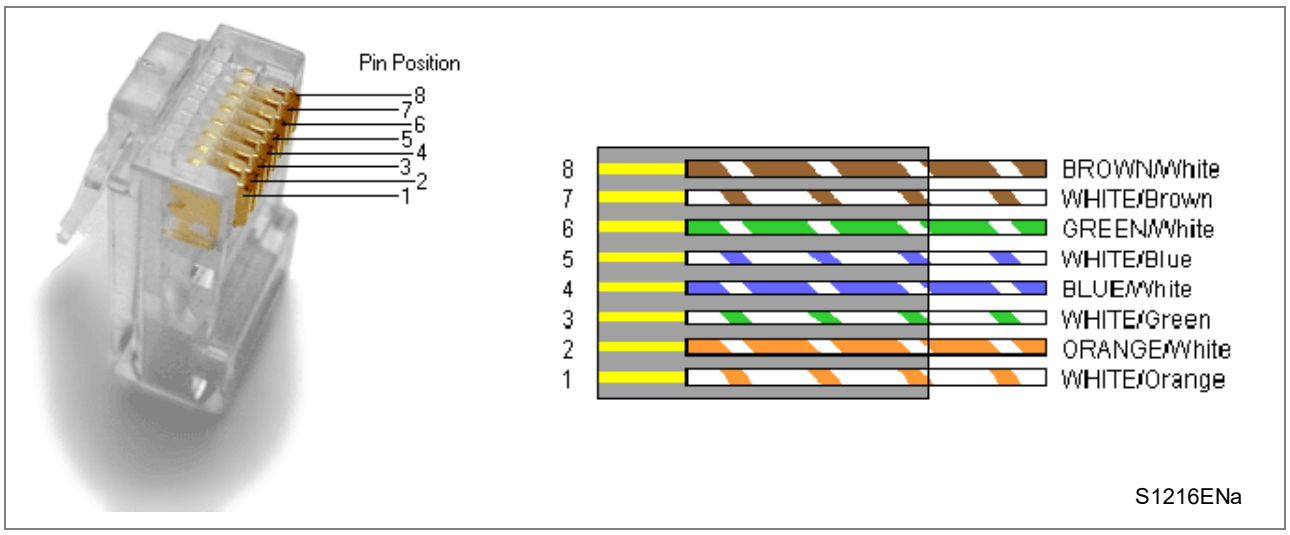


Figure 7: RJ45 connector

The standard is:

- 1 = white / orange
- 2 = orange
- 3 = white / green
- 4 = blue (not used
- 5 = white / blue (not used)
- 6 = green
- 7 = white / brown (not used)
- 8 = brown (not used)

The maximum authorized cable length for 10/100BaseTx without using a repeater is 100 meters.

4.19.4 ETHERNET OPTICAL FIBRE

The optical fibre cables are connected to the corresponding optical fibre elements.

The SWT212 (multimode fibre) has a type ST connector.

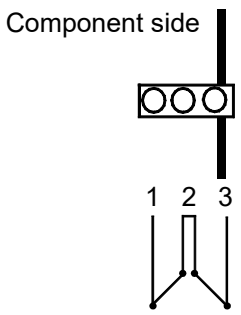


Figure 8: Ethernet optical fiber – ST cable

4.19.5 FAULT SIGNAL CONNECTOR DESCRIPTION

SWT212 boards are equipped with a 3-way connector block to deliver a communication fault signal.

If one link of the optical ring fails, the fault is indicated by the output contacts (max. 250 V/5 A):



Pin	State
1	Faulty link A
2	Common
3	Faulty link B

Closed if link faulty

C0297ENb

Wiring recommendation:

Due to the proximity of the port 4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

4.20 PRP ETHERNET SWITCH UNIT – SRP282/SRP284

These boards are Ethernet switches with 3 electrical links and 2 optical links for a redundancy star. Use a (straight-through or not) patch cord between the port ETH1 (CPU) and the one of the electrical ports (SRP).

The picture below shows connections to an SRP28x board fitted in a DS Agile C26x unit.

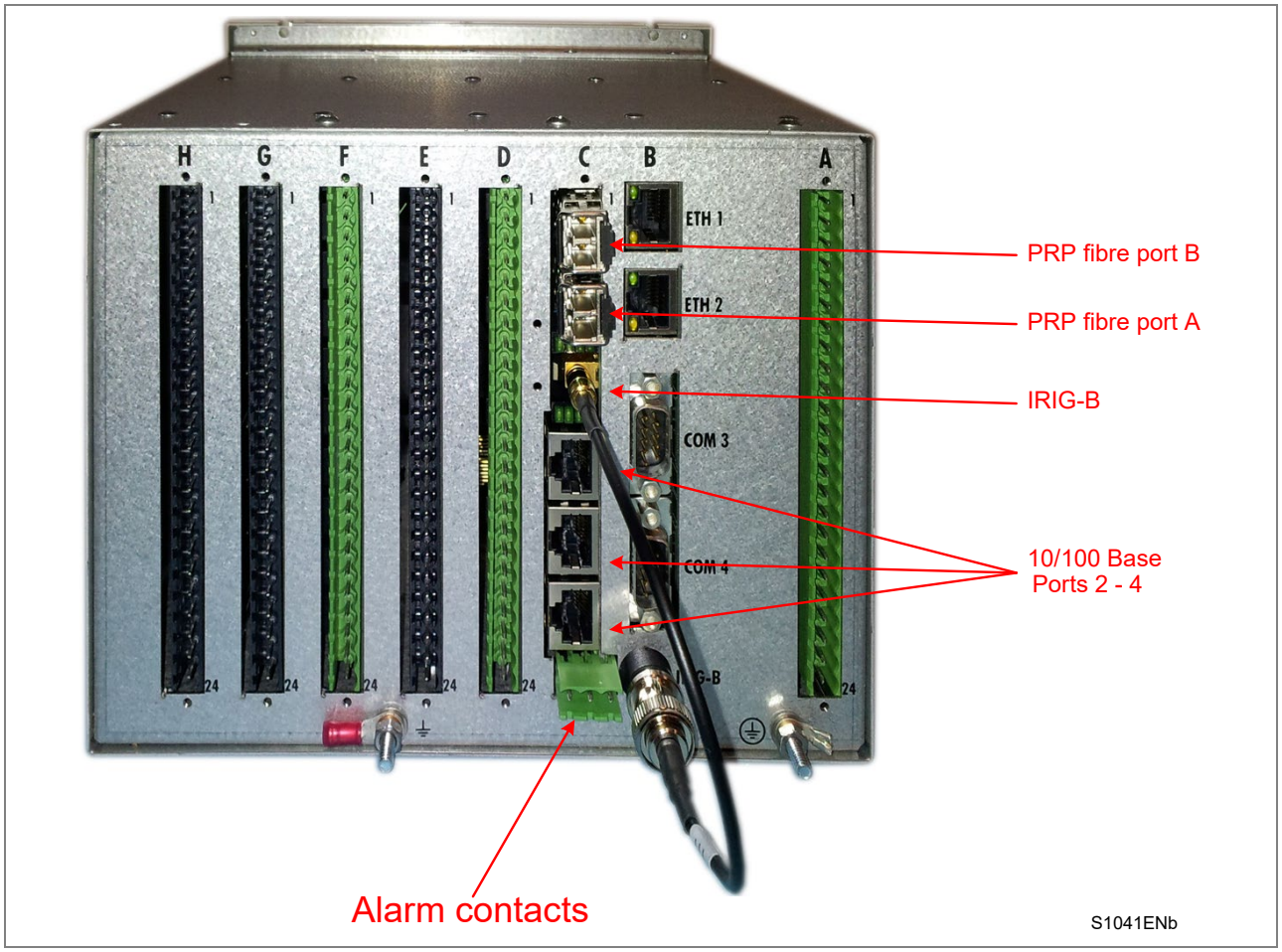


Figure 42: Example SRP28x User connections

4.20.1 BLOCK DIAGRAM

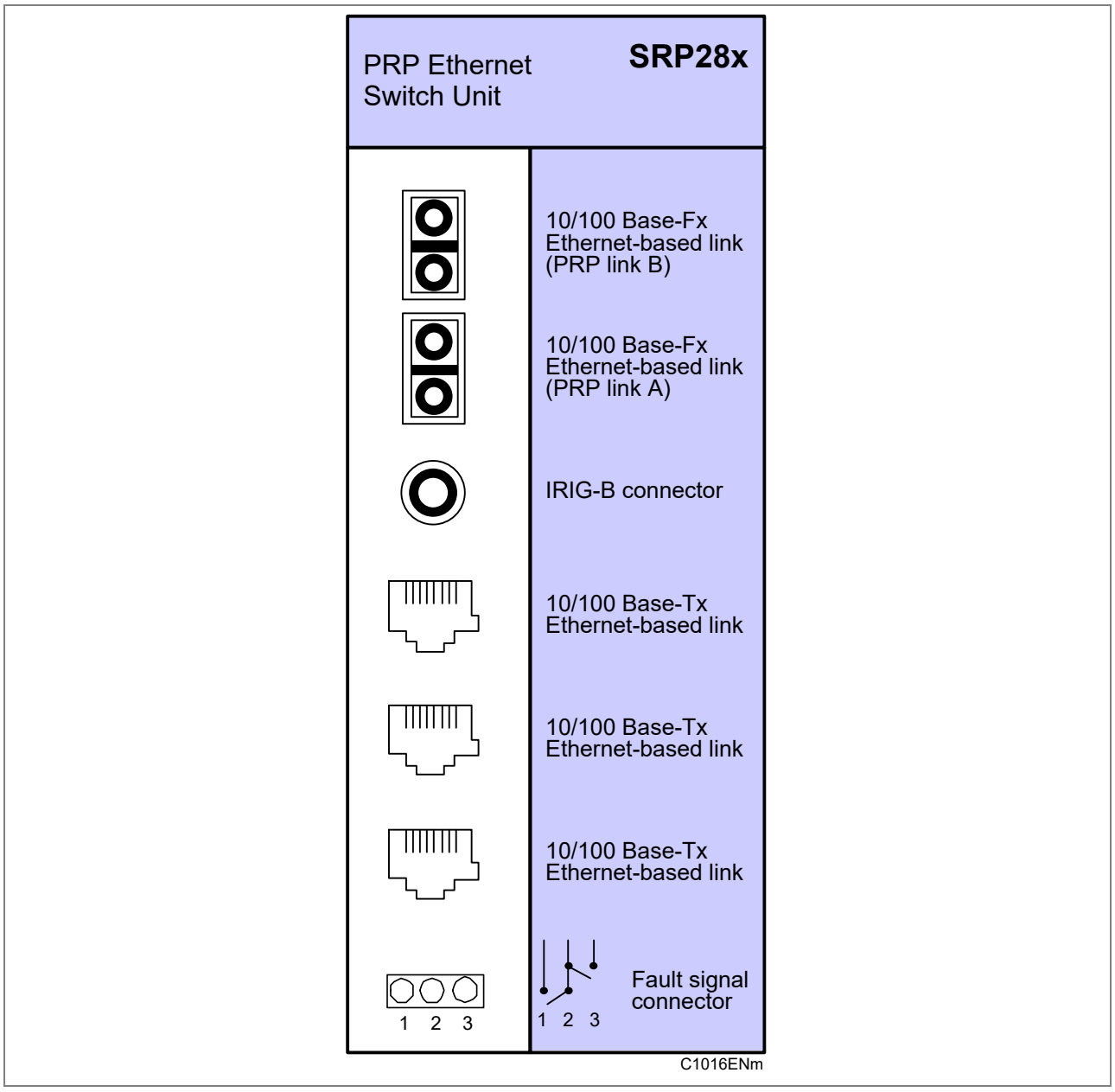


Figure 43: SRP28x Board – Block diagram

4.20.2 PARALLEL REDUNDANCY PROTOCOL (PRP) CONNECTION

The SRP2xx PRP ports use type **LC** connectors as shown in the figure below.



Figure 44: Ethernet optical FIBRE – LC Connections

4.20.3 COPPER ETHERNET CONNECTIONS

The user-accessible copper Ethernet communication ports use 4 twisted pair cable.

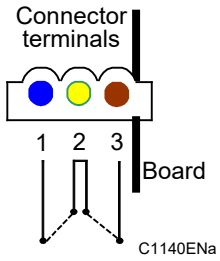
If connected devices are located a long distance away from the switch (>100 m), or if the cables run through a harsh electrical environment, then copper to fibre converters should be used in conjunction with optical fibres.

Ethernet cable type

Category 5 (FTP: Foil Twisted Pair) or insulated (STP – Shielded Twisted Pair) with RJ45 connectors should be used.

4.20.4 FAULT SIGNAL CONNECTOR DESCRIPTION

The status of the two PRP links is indicated on contacts at the rear of the board according to the diagram and table below: The alarm contacts share a common terminal.



Terminal number	Assignment	Meaning
1	PRP link A status	Open = Link healthy Close = Link failure
2	Common	
3	PRP link B status	Open = Link healthy Close = Link failure

A closed contact indicates an alarm or a fault.

The characteristics of the alarm contacts are presented below.

- Connections — 2 normally closed (NC) contacts - potential free
- Continuous current — 5 A
- Switching current — 100 A / 30 ms
- Power breaking with time constant — 10 W below 48 V with τ = 20 ms

Wiring recommendations:

For safety reasons and for compliance with the European Commission Low Voltage Directive (2014/35/EC), the authorised voltage rating to be applied on the "Fault signal connector" is limited to 70 V_{DC} or 33 V_{AC} and does not exceed 5 A.

Due to the proximity of the port N°4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

The figure below shows the allocation of the SRP28x alarm contacts.

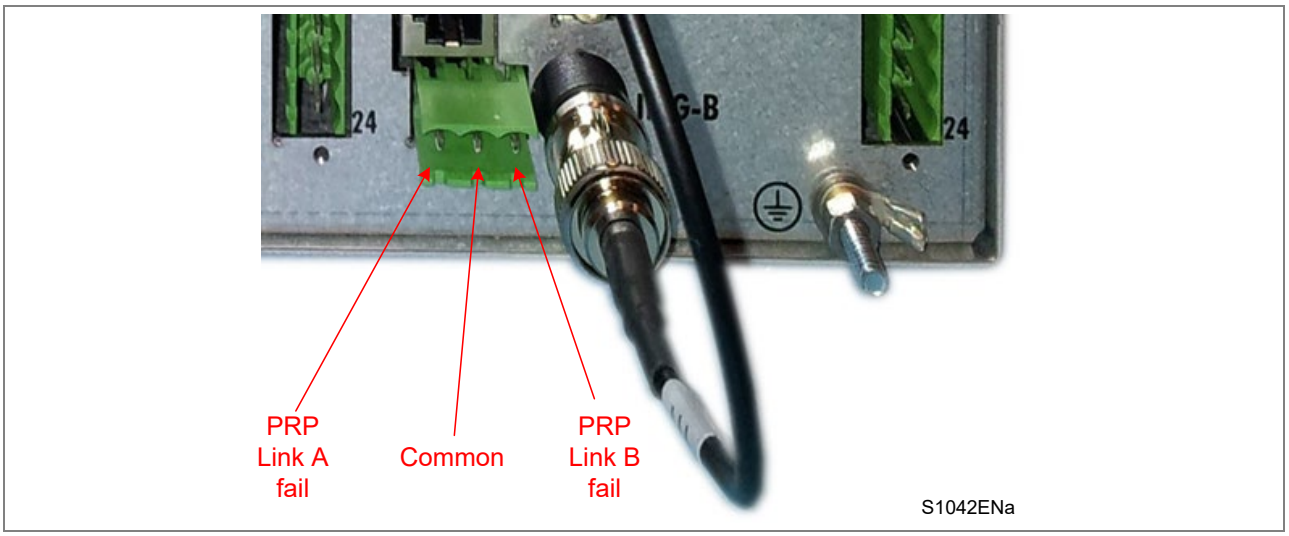


Figure 45: SRP28x PRP Alarm Contact connections

4.20.5 IRIG-B CONNECTOR DESCRIPTION

The SRP board receives the 1588 (PTP) time-synchronisation signal via the PRP Ethernet network. The IRIG-B connector on the SRP board is an SMB output connector used to distribute time synchronization to the CPU board.

IRIG-B cable characteristics

- Length: 20 cm
- SRP end: Male SMB connector
- CPU end: Male BNC connector

4.21 HSR ETHERNET SWITCH UNIT – SRP292/SRP294

These boards are Ethernet switches with 3 electrical links and 2 optical links for a redundant ring. Use a (straight-through or not) patch cord between the port ETH1 (CPU) and the one of the electrical ports (SRP29x).

The picture below shows connections to an SRP29x board fitted in a DS Agile C26x unit.

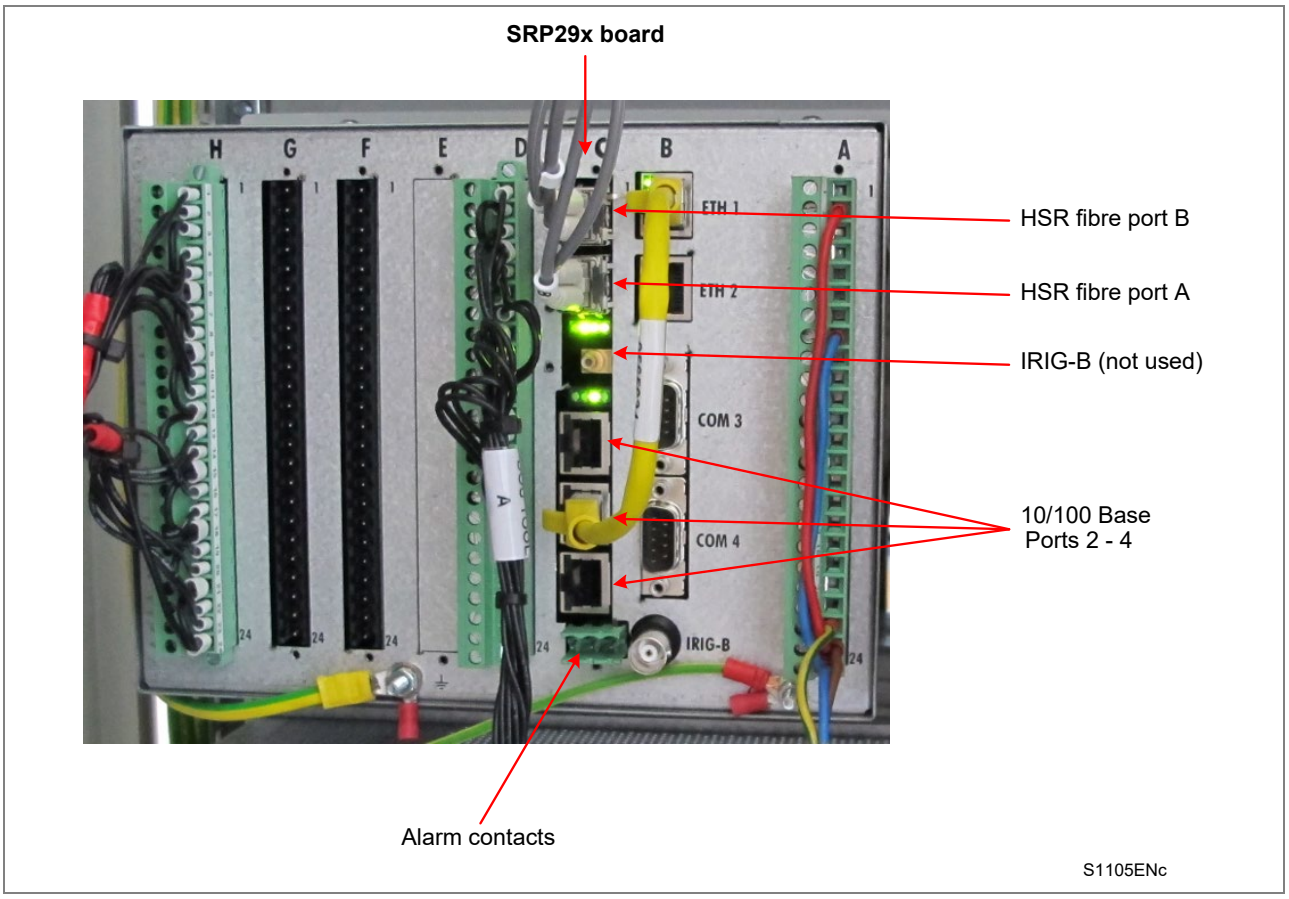


Figure 46: Example SRP29x User connections

4.21.1 BLOCK DIAGRAM

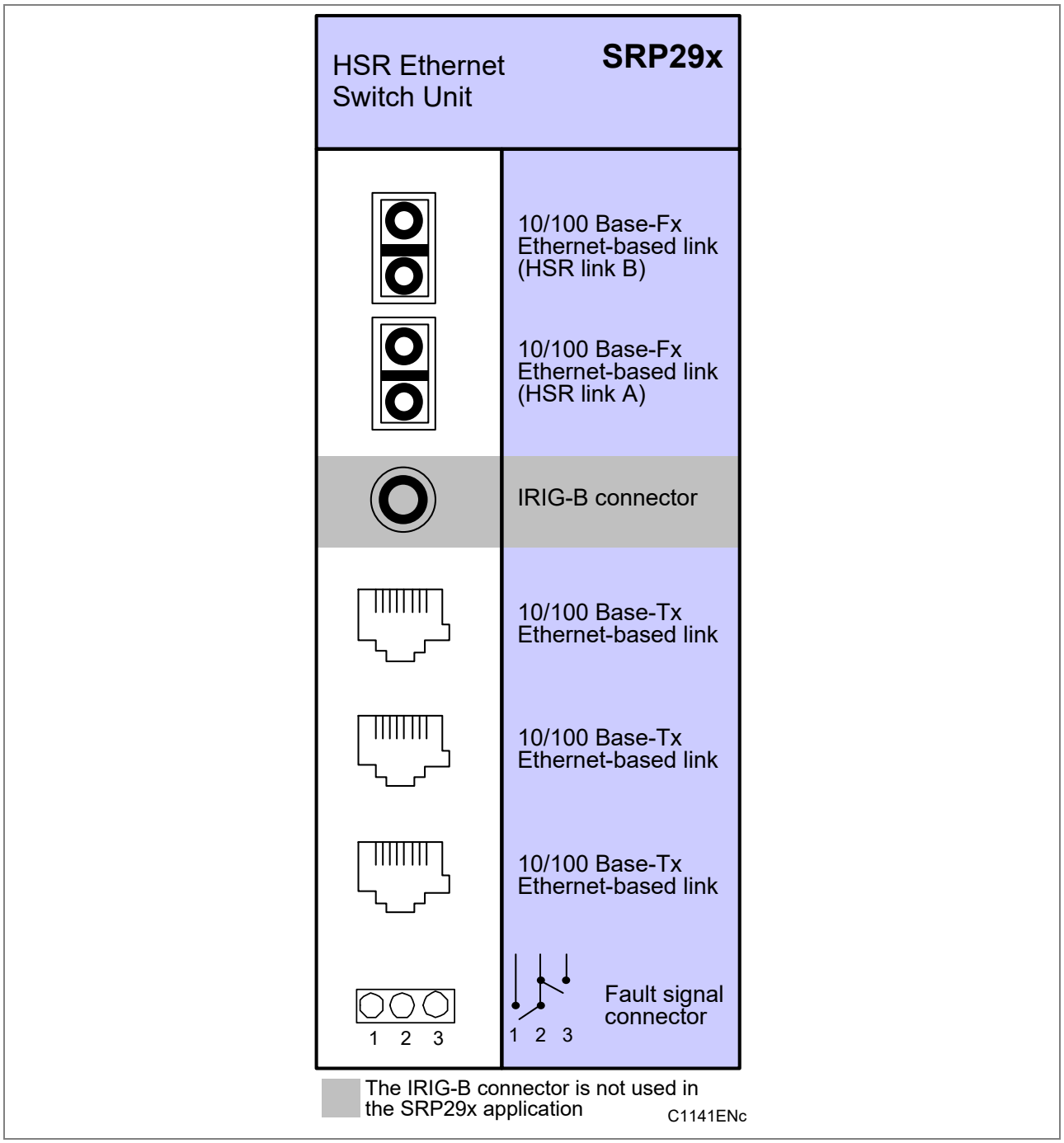


Figure 47: SRP29x Board – Block diagram

4.21.2 HIGH-AVAILABILITY SEAMLESS REDUNDANCY PROTOCOL (HSR) FIBRE-OPTIC CONNECTION

The SRP29x HSR ports use type **LC** connectors as shown in the figure below.



Figure 48: Ethernet optical fibre – LC connections

Warning about Laser Rays



Caution:
NEVER look into optical fibres. Always use optical power meters to determine operation or signal level.

Non–observance of this rule could possibly result in personal injury.

Signals transmitted via optical fibres are unaffected by interference. The fibres guarantee electrical isolation between the connections.

If electrical to optical converters are used, they must have management of character idle state capability (for when the fibre optic cable interface is "Light off").

The SRP29**2** variant provides two 100BASE-FX **multi-mode** optical links.

The SRP29**4** variant provides two 100BASE-FX **single-mode** optical links.

In both variants, the optical fibre connectors are LC-type small form-factor pluggable (SFP) transceivers that can use both single and multi mode fibre.

Centre wavelength: 1310 nm.

Compatibility

LC/ST or LC/SC optical patch cords may be used to connect the board to devices fitted with ST or SC connectors.

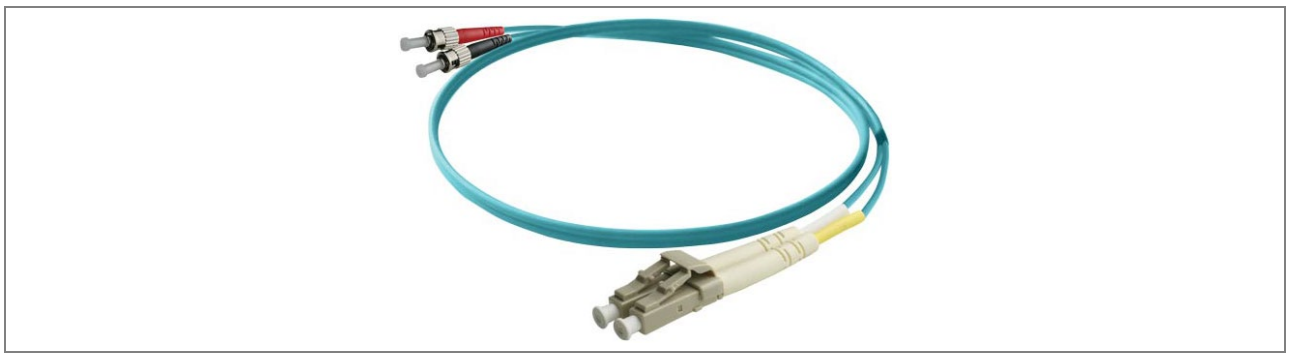


Figure 49: Optical patch cord example (multimode duplex LC/ST)

4.21.3 RJ45 ETHERNET CONNECTIONS

The user-accessible copper Ethernet communication ports use 4 twisted pair cable.

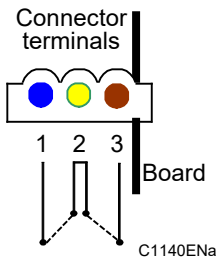
If connected devices are located a long distance away from the switch (>100 m), or if the cables run through a harsh electrical environment, then copper to fibre converters should be used in conjunction with optical fibres.

Ethernet cable type

Category 5 (FTP: Foil Twisted Pair) or insulated (STP – Shielded Twisted Pair) with RJ45 connectors should be used.

4.21.4 FAULT SIGNAL CONNECTOR DESCRIPTION

The status of the two HSR links is indicated on contacts at the rear of the board according to the diagram and table below: The alarm contacts share a common terminal.



Terminal number	Assignment	Meaning
1	HSR link A status	Open = Link healthy Close = Link failure
2	Common	
3	HSR link B status	Open = Link healthy Close = Link failure

A closed contact indicates an alarm or a fault.

The characteristics of the alarm contacts are presented below.

- Connections — 2 normally closed (NC) contacts - potential free
- Continuous current — 5 A
- Switching current — 100 A / 30 ms
- Power breaking with time constant — 10 W below 48 V with τ = 20 ms

Wiring recommendations

For safety reasons and for compliance with the European Commission Low Voltage Directive (2014/35/EC), the authorised voltage rating to be applied on the "Fault signal connector" is limited to 70 V_{DC} or 33 V_{AC} and does not exceed 5 A.

Due to the proximity of the port N°4 Ethernet connector, it is strongly recommended that the “Fault signal connector” connections are visually checked before any handling of the Ethernet connectors.

Particular attention is to be paid not to damage the cable’s isolation during the wiring phase.

The figure below shows the allocation of the SRP29x alarm contacts.

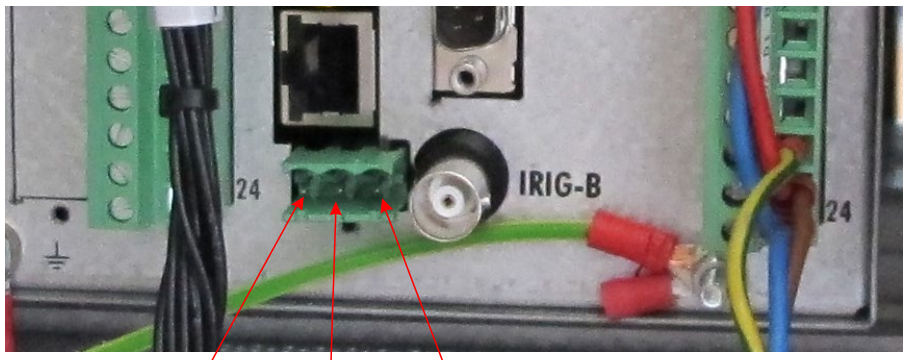


Figure 50: SRP29x HSR Alarm Contact connections

4.21.5 IRIG-B CONNECTOR DESCRIPTION

The IRIG-B connector is not used in the SRP29x application.

4.22 FRONT PANEL

The front panel includes a serial RS232 interface that is not galvanically isolated and is intended for maintenance purposes only.



Warning:
The front serial port is not intended for user connection and ESD precautions should be taken when accessing it.

The properties of the serial link (DB9 female connector) for the maintenance dialogue are:

- Baud rate: 19200
- Data bits: 8
- Parity: No
- Stop bit: 1
- Control Xon/Xoff

Connector description:

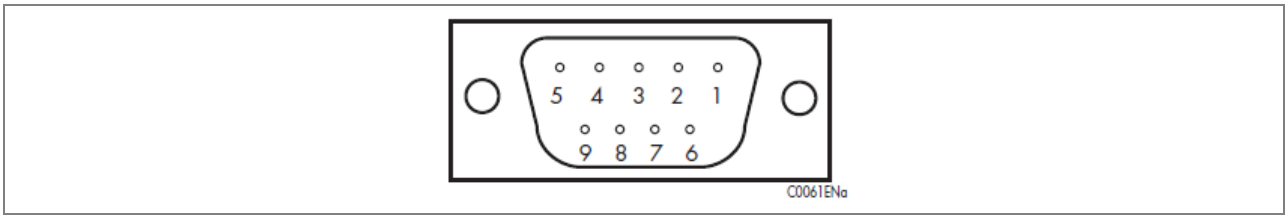


Figure 51: Front panel connector view

Pin N°.	Signal
1	Data Carrier Detect (DCD) – input
2	Receive Data (RxD) – input
3	Transmit data (TxD) – output
4	Data Terminal Ready (DTR) – output
5	Signal Ground (SG) - 0V
6	Data Set Ready (DSR) – input
7	Ready To Send (RTS) – input
8	Clear To Send (CTS) – input
9	NC

COMMUNICATIONS

C26X/EN CT/D40

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1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the various standard communication protocols implemented in the C26x.

The DS Agile C26x supports different types of communications:

- Station Bus Communications: communications with IEDs and system devices using the IEC 61850-8-1 protocol over an Ethernet network
- Inter-rack Communications: inside a multirack configuration
- Communications with the SCADA: communications with an upper level SCADA system using various protocols (IEC 60870-5-101, IEC 60870-5-104, DNP3.0, MODBUS, DNP3 on TCP)
- Communications between a C26x–Standalone unit and a DS Agile Gateway using the IEC 60870-5-101 protocol
- Communications with legacy IEDs: The C26x acts as a master (IEC 60870-5-103, DNP3.0, MODBUS, IEC 60870-5-101).

2 STATION BUS COMMUNICATIONS

The DS Agile C26x BCU communicates over the Station Bus with other DS Agile sub-systems such as the Substation Control Point (system HMI: DS Agile OI or aView), the Gateway, etc., as well as IEC 61850-8-1-compliant IEDs such as protection units by means of GOOSE and Report messages.

This section describes IEC61850-8-1 implementation in the C26x for communications over the Station Bus.

2.1 INPUTS

2.1.1 INFORMATION: C26X APPLICATION ➔ SCP

The types of information that can be transmitted are:

- Changes of binary input states
- Measurements (Analogue or CT/VT)
- Counters
- Controls
- Control acknowledgements
- Time synchronisation message
- Records (event, fault, disturbance)
- C26x information (Init. report, Operating mode, control mode, Date)

2.1.2 INFORMATION SCP ➔ C26X APPLICATION

The type of information that can be transmitted are:

- Changes of of binary input states
- Measurements (Analogue or CT/VT)
- Counters
- Controls
- Control acknowledgements
- Time synchronisation message
- Request for records
- Database downloading

2.2 SUPPORTED SERVICES

Services supported by the IEC 61850-8-1 SBUS Agency integrated in the C26x are listed in the ACSI service conformance statement defined in Table A.3 of the document DS Agile C26x PICS.

Supported Common Data Classes: refer to C26x/EN FT.

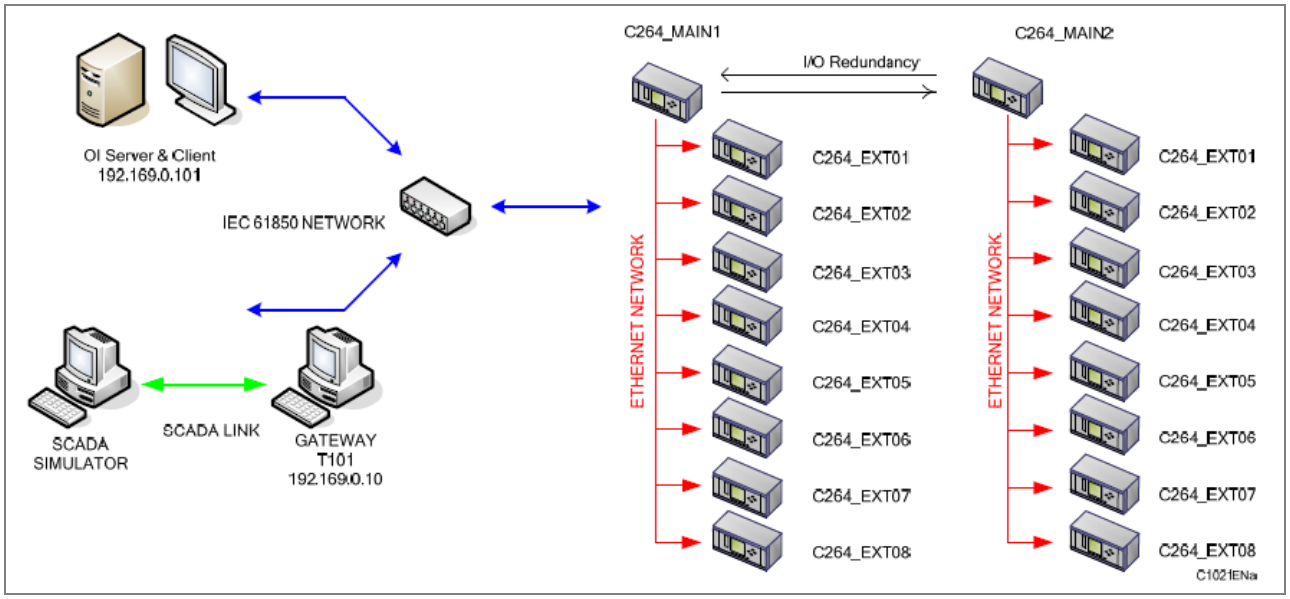
3 INTER-RACK COMMUNICATIONS

3.1 OVERVIEW

A C26x is used as a main rack connected to a cluster of C26x extensions over an Ethernet network using a proprietary protocol.

No CT/VTs are connected to the extensions.

A similar branch can be installed for redundancy purposes. In this case, no AOU board is allowed.



3.2 MAIN1-MAIN2 COMMUNICATIONS

Refer to the chapter C26x/EN FT.

3.3 MAIN-EXTENSION COMMUNICATIONS

An Ethernet proprietary network supports the same objects and services as the SCP communication.

4 COMMUNICATIONS WITH THE SCADA

4.1 OVERVIEW

A C26x can be directly connected to a SCADA through networks using various protocols:

Protocol	C26x BCU	C26x–Standalone RTU
DNP3	Serial & over IP	–
Modbus	Serial	–
IEC 60870-5-101 (T101)	Serial	Serial
IEC 60870-5-104 (T104)	Over IP	Over IP
HNZ	–	Elenas (Indonesia) & Yemen

It is possible to have:

- Two different protocols running in parallel on different serial links
- Four different protocols running in parallel on Ethernet communications
- The same protocol on two links (redundant mode). Not supported by Modbus.
- For protocols running on TCP/IP link, there is only one Ethernet port. So redundancy is not available for those protocols, and they all are running on the same physical network (including IEC 61850-8-1 protocol).
- In T104 protocol the C26x (server) can manage four client channels (SCADA front end ports) simultaneously. These four channels are configured separately but may have same data. On the SCADA side, up to 4 ports can be defined, corresponding to 1 active port and 3 standby ports. So, up to 4 IP addresses will be defined during the configuration of each T104 protocol connection.

Common features to all SCADA communication and all protocols are specified below.

Specific features of each protocol are specified in subsequent paragraphs.

4.2 SCADA COMMON FUNCTIONALITY

4.2.1 INTERFACE TO SCADA

This paragraph describes the exchange of data between the “SCADA communication” function and the Master SCADA. It includes two sub-paragraphs:

- Inputs: data received from SCADA.
- Outputs: data sent from the “SCADA communication” function to SCADA.

For each kind of protocol, it is indicated if the data is treated or not.

4.2.2 C26X BCU

4.2.2.1 INPUT

Data	DNP3	T101	T104	MODBUS
Remote link initialisation	Treated	Treated	Treated	Treated
General interrogation	Treated	Treated	Treated	Not Treated
Control	Treated	Treated	Treated	Treated
Setpoint	Treated	Treated	Treated	Treated
Time synchronisation	Treated	Treated	Treated	Not Treated
Database (download)	Not Treated	Not Treated	Not Treated	Not Treated

4.2.2.2 OUTPUT

Data	DNP3	T101	T104	MODBUS
Digital input	Treated	Treated	Treated	Treated
Dated Digital input	Treated	Treated	Treated	Not Treated
Measurement (Events)	Treated	Treated	Treated	Not Treated
Measurement (Cyclical)	Treated	Treated	Treated	Treated
Counter	Treated	Treated	Treated	Treated
Tap position	Treated	Treated	Treated	Treated
Control acknowledgement	Treated	Treated	Treated	Treated
Setpoint acknowledgement	Treated	Treated	Treated	Treated
C26x Disturbance	Not Treated	Slow waveform only	Slow waveform only	Not Treated
Sequence Of Event file	Not Treated	Treated	Treated	Not Treated

4.2.3 C26X-STANDALONE RTU

4.2.3.1 INPUT

Data	T101	T104	HNZ (Elenas)	HNZ (Yemen)
Remote link initialisation	Treated	Treated		Treated
General interrogation	Treated	Treated		Treated
Control	Treated	Treated		Treated
Setpoint	Treated	Treated		Treated
Time synchronisation	Treated	Treated		Treated
Database (download)	Treated	Treated		Not treated
Switch database	Treated	Treated		
Reboot computer	Treated	Treated		

Note:
The “Reboot Computer” function is restricted and only accessible after the “database download”.

4.2.3.2 OUTPUT

Data	T101	T104	HNZ (Elenas)	HNZ (Yemen)
Digital input	Treated	Treated		Treated
Dated Digital input	Treated	Treated		Treated
Measurement (Events)	Treated	Treated		Treated
Measurement (Cyclical)	Treated	Treated		Treated
Counter	Treated	Treated		Not treated
Tap position	Treated	Treated		Treated
Control acknowledgement	Treated	Treated		Treated
Setpoint acknowledgement	Treated	Treated		Treated
C26x Disturbance	Slow waveform only			
Sequence Of Event file	Treated	Treated		Not treated

4.2.4 BEHAVIOUR AND SPECIFIC TREATMENTS

Note:
In subsequent sections, the master station (e.g.: SCADA) is referred to as the controlling station.

4.2.4.1 INITIALISATION

There is a running database for each SCADA link. Upon initialisation, a GI is performed on the application in order to initialise these databases.

The GI sequence consists of different requests to the C26x application in order to get the value and state of all data (binary input, measurement, counter, step position indication).

4.2.4.2 GENERAL INTERROGATION

The Outstation interrogation function is used for updating the controlling station after the internal station initialisation procedure, or when the controlling station detects a loss of information, or when the link layer connection has been re-established. The general interrogation function of the controlling station requests the C26x to transmit the actual values of all addressed datapoints.

The C26x marks the end of the general interrogation procedure by sending an indication to the controlling station when the protocols allow it.

In a multirack application and in redundant configuration, the main rack becomes the master rack on General Interrogation reception.

4.2.4.3 CLOCK SYNCHRONISATION

The clock in the C26x may be synchronised by the controlling station.

Note:
The clock can be synchronised by other means: external clock, Master Clock, operator. Only one source will be selected at a given time. This selection is performed by the clock synchronisation function based on configuration and priority level. However the controlling station is not informed of this fact and must continue to send clock synchronisation commands.

The controlling station must perform the correction made on the time sent in synchronisation commands.

4.2.4.4 DATABASE UPLOADING AND SWITCHING

This function is only implemented with the T101 and T104 protocols. The SCADA can upload one database only. Then the file type is 1 (Transparent file) and the IOA (information object address) must be 1. The uploaded database will become the standby database.

To switch that database to current, the SCADA must send a reset process command (C_RP_NA_1 (105)) with the cause of transmission equal to *6* (activation) and the QRP field set to *1* (general reset of process).

4.2.4.5 LOCAL/REMOTE MODE

There are 2 types of L/R modes:

- "Substation" L/R mode, at station bus level, applicable either globally to the substation, or independently per bay
- "Bay" L/R mode, at each controller level, applicable independently to each bay that the controller manages.

For information on Local/Remote operating modes, see the Functional Description chapter (C26x/EN FT).

Each L/R mode can be switched to Local or Remote by wiring the datapoint on a binary input.

4.2.4.6 TAKING CONTROL

A Substation can be configured in taking control mode. This means:

- At a given time, only one SCADA can send controls to the substation (the one which has the control).
- To be allowed to send controls, a SCADA must take control of the substation by sending a specific command to the C26x.

On each SCADA link, there is a binary input indicating if the corresponding SCADA has the control of the substation.

On reception of a Taking Control command, the C26x:

- Puts the substation in Remote mode (if it was in Local Mode)
- Gives the control to the (last) SCADA which asks for it
  - Reset the “Taking Control Binary input” of the SCADA which had previously the control
  - Set the “Taking Control Binary input” of the SCADA which asks the control

If the take control command is set for a SCADA, C26x should refuse all commands from other SCADAs.

4.2.4.7 SBMC MODE

This mode is used to test a substation while it is in Remote mode. As this mode is a test mode, the C26x will not send all the state changes to SCADA.

When a bay switches to SBMC mode, the C26x will send to SCADA all concerned data (configured Bay Based in the SCE) at specific states defined in the SCE for the management of SBMC.

For those data, state changes will not be transmitted, but will be saved in the C26x memory while the Bay is in SBMC mode.

When the Bay switches back to Non-SBMC mode, the C26x sends the current state of any data that changed while the Bay was in SBMC mode.

4.2.4.8 REDUNDANCY

Serial links can be configured as redundant. In this case, SCADA can send requests on both serial links: “main link “or “redundant link”.

The C26x always responds on the link used by SCADA for requesting the slave.

4.2.4.9 AUTOMATIC SYNCHROCHECK

SCADA can send control to synchronised circuit breakers with a facility to bypass the synchrocheck.

4.2.5 DATA SENT TO THE SCADA

After the initialisation sequence, the C26x Slave sends the state of all of its data to the SCADA. The current state of data is sent as state or as state change messages, depending on the protocol.

The data, which can be sent to SCADA, is detailed in the paragraphs below.

4.2.5.1 BINARY INPUTS

Binary inputs can be sent as states or as state changes depending on the protocol.

A binary input can be associated with a single point or a double point.

Note:
Multipoint status is not treated.

4.2.5.2 MEASUREMENTS

Measurements can be sent in various formats: float, integer, normalised, scaled…

Measurements can be sent as periodical messages or as state changes: variation, threshold, and invalidity.

The choices of format and mode of transmission are done by configuration according to the protocol.

4.2.5.3 COUNTERS

Counters can be sent as spontaneous messages (state changes) or on demand (counter General Interrogation).

The choice whether to use spontaneous messages for a counter is done by configuration, according to the protocol.

4.2.5.4 TAP POSITION

Tap position indication (TPI) can be sent to SCADA as states or as state changes. The choice between state and state change depends on the protocol. If the protocol allows both, the choice is made by configuration.

A digital input can be associated with a single point or a double point.

4.2.5.5 C26X DISTURBANCE FILE

Only Slow WaveForm recordings may be transmitted to the SCADA using the T101 or T104 protocols. A maximum of 5 slow waveform files can be simultaneously available. The IOA (Information Object Address) of the first file is configured and the others are consecutive; the file type is 1 (Transparent file). When a slow waveform file is available, an ASDU Directory (F_DR_TA_1 (126)) is sent by the C26x with cause of transmission spontaneous (3). The file remains available until a new file is created and replaces it. The SCADA can identify the file only by its date. The file size must be lower or equal to the size of one section.

Note:
Slow waveform files are stored in volatile memory (in the "/RAMDEV/" folder) and are deleted whenever the C26x is powered off or rebooted.

4.2.5.6 SEQUENCE OF EVENTS FILE (SOE)

The SOE record is a circular file in which C26x Events are stored. There is one SOE recorder per SCADA link.

The Events, which can be stored in the SOE file, are Binary Input states and measurements. The choice is made by configuration.

The following information in the C26x configuration is used to manage the SOE file:

- For each SCADA protocol
  - A flag indicating whether the SOE file must be managed
  - The identifiers of the SOE file on the link (Name, Address, …)
  - The maximum size of the file
  - The fill rate triggering the transmission of the SOE file
- For each BI / measurement
  - A flag indicating whether it must be stored in the SOE file

The rules for SOE management are as follows:

- When the C26x starts up, the SOE file is Empty
- When the SOE file is full, the oldest Event is deleted and the new one is added
- As soon as the fill rate set in configuration (**'full' SOE file nb of events**) is reached, the C26x tries to transmit the SOE file
- Once a SOE file has been successfully transmitted, all the Events included in the transmission are deleted from the SOE file.

Note:
SOE files are stored in volatile memory (in the "/RAMDEV/SOE/" folder) and are deleted whenever the C26x is powered off or rebooted.

4.2.5.7 SYNCHRONISATION STATUS

The C26x can inform the controlling station about its synchronisation status.

Depending on the protocol, this may be done by a specific message or by a binary input.

4.2.5.8 EVENTS BUFFER FOR T101 AND T104

During a SCADA disconnection, some events might be generated at Substation level. The C26x buffer records these events in order to transfer them spontaneously (COT=3) to the related SCADA at reconnection time. Refer to C26x/EN AP for buffer management.

A buffer overflow information is an optional extra with a SCADA address. The type of datapoint is ASDU30, SPS with Time stamp at date of the detection of overflow and is set to "OFF" in General and Group Interrogation.

Events are recorded in the Master and Backup C26x. Only events issued and dated from extension racks are synchronized.

Recorded events:

- DI (SPS and DPS)
- AI (MV normalized, adjusted, short float, normalized unipolar)
- Counter reported as spontaneous change,
- Step position information
- Unrecorded events:
  - Information transmitted cyclically or as background scan,
  - Acknowledgement of command,
  - Information transmitted in GI.

4.2.5.9 COMMUNICATIONS LINK STATUS

In the case of a redundant T101 link, when one of the channels is lost, the C26x can send a failure signal to the SCADA over the remaining healthy channel through 2 configurable datapoints.

4.2.6 DATA SENT TO THE C26X

SCADA can send data to the C26x. The type of data is described in subsequent paragraphs.

4.2.6.1 DIGITAL CONTROLS OR SETPOINTS

A control is transmitted to the handling of control sequences function.

At the end of the control sequence an acknowledgement is sent to SCADA if protocol allows it.

4.2.6.2 COUNTER COMMANDS

The commands allowed on counters are:

- Reset of a group of Counters
- Reset of all Counters
- Freeze of a group of counters
- Freeze of all counters
- Read (frozen value) of a group of Counters
- Read (frozen value) of all Counters

4.2.6.3 SYNCHRONISATION

Depending on the configuration, the C26x can be synchronised by a SCADA.

4.2.6.4 C26X REBOOT

The C26x-Standalone RTU can be rebooted from SCADA. If a new database had been downloaded and not switched yet, the C26x performs a database switch before rebooting.

4.3 SLAVE DNP3 PROFILE (SERIAL OR OVER IP)

<table>
<tr><th colspan="5">DNP V3.00 Device Profile</th></tr>
<tr><td colspan="3">Highest DNP Level Supported:
For Requests Level 3
For Responses Level 3</td><td colspan="2">Device Function:
☐ Master ■ Slave</td></tr>
<tr><td colspan="5">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels supported:</td></tr>
<tr><td colspan="3">Maximum Data Link Frame Size (octets):
Transmitted: 292
Received: (must be 292)</td><td colspan="2">Maximum Application Fragment Size (octets):
Transmitted 2048
Received 2048</td></tr>
<tr><td colspan="3">Maximum Data Link Re-tries:
☐ None
■ Fixed at 2
☐ Configurable, range to</td><td colspan="2">Maximum Application Layer Re-tries:
■ None
☐ Configurable, range to
(Fixed is not permitted)</td></tr>
<tr><td colspan="5">Requires Data Link Layer Confirmation:
■ Never
☐ Always
☐ Sometimes - If 'Sometimes', when?
☐ Configurable If 'Configurable', how?
User option to set Data Link Confirmation to:
• Always – device will always request Data Link Confirmations.
• Multi-packet only – the device will request Data Link Confirmations when sending multi-packet responses.
• Never – the device will never request Data Link Confirmations.</td></tr>
<tr><td colspan="5">Requires Application Layer Confirmation:
☐ Never
☐ Always (not recommended)
■ When reporting Event Data (Slave devices only)
■ When sending multi-fragment responses (Slave devices only)
☐ Sometimes - If 'Sometimes', when?
☐ Configurable If 'Configurable', how?</td></tr>
<tr><td colspan="5">Timeouts while waiting for:
Data Link Confirm ■ None ☐ Fixed at ☐ Variable ☐ Configurable
Complete Appl. Fragment ■ None ☐ Fixed at ☐ Variable ☐ Configurable
Application Confirm ☐ None ☐ Fixed at 10s ■ Variable * ☐ Configurable
Complete Appl. Response ■ None ☐ Fixed at ☐ Variable ☐ Configurable
Others
* When reporting Event Data (Slave devices only) & When sending multi-fragment responses (Slave devices only)</td></tr>
</table>

DNP V3.00 Device Profile				
Sends/Executes Control Operations:				
WRITE Binary Outputs	■ Never	☐ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☐ Never	☐ Always	☐ Sometimes	■ Configurable
DIRECT OPERATE	☐ Never	☐ Always	☐ Sometimes	■ Configurable
DIRECT OPERATE - NO ACK	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Count > 1	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Pulse Off	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Latch Off	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable
• **Select timeout: configurable (same value for all controls)**				
A pulse duration can be specified from Scada, for trip and close control with a transient DO.				
When no value is specified, the default configured value is used.				
FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY:				

Reports Binary Input Change Events when no Specific variation requested: ☐ Never ☐ Only time-tagged ☐ Only non-time-tagged ■ Configurable to send both, one or the other (explanation below) User option to have all Binary Input Change Events returned as either: • time-tagged OR • non-time-tagged	Reports time-tagged Binary Input Change Events When no specific variation requested: ☐ Never ■ Binary Input Change With Time ☐ Binary Input Change With Relative Time ☐ Configurable (attach explanation)
Send Unsolicited Responses: ☐ Never ■ Configurable (attach explanation) ☐ Only certain objects ☐ Sometimes (attach explanation) ■ ENABLE/DISABLE UNSOLICITED Function codes supported	Send Static Data in Unsolicited Responses: ■ Never ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.

DNP V3.00 Device Profile	
Default Counter Object/Variation: ☐ No Counters Reported ■ Configurable (explanation below) ☐ Default Object 20 ☐ Default Variation 02 ☐ Point-by-point list attached User option to return all static counters in one of the following variations: • 32-Bit Binary Counter • 32-Bit Binary Counter Without Flag • 16-Bit Binary Counter • 16-Bit Binary Counter Without Flag	Counters Roll Over at: ■ No Counters Reported ☐ Configurable (explanation below) ☐ 16 Bits ☐ 32 Bits ☐ Other Value ☐ Point-by-point list attached User option to select roll over: • 32 bit counters roll over at 2^32. • 16 bit counters roll over at 2^16
Send Multi-Fragment Responses: ■ Yes ☐ No	
Binary Input (BI) double management: For a BI double, two binary inputs are configured, with a point address for the open contact and the address + 1 for the close contact. All the BIs double are transmitted this way.	

DNP3 level 3: IMPLEMENTATION TABLE

Information on blue background is not implemented.

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	Var	Description	Func Codes (dec)	Qual Codes (2) (hex)	Func Codes (dec)	Qual Codes (hex)
1	0	Binary Input – All Variations	1	00,01,06,17,28	129	00,17,28
1	1	Binary Input	1	00,01,06,17,28	129	00,17,28
1	2	Binary Input with Status	1	00,01,06,17,28	129	00,17,28
2	0	Binary Input Event - All Variations				
2	1	Binary Input Event without Time				
2	2	Binary Input Event with Time				
2	3	Binary Input Event with Relative Time				
10	0	Binary Output - All Variations				
10	1	Binary Output				
10	2	Binary Output Status	1		129	00,17,28
12	0	Control Block - All Variations (1)	1		129	00,17,28
12	1	Control Relay Output Block (1)	1, 3,4,5,6	17,28	129	Request echo
12	2	Pattern Control Block	1		129	00,17,28
12	3	Pattern Mask	1		129	00,17,28
20	0	Binary Counter - All Variations	1, 7,8,9,10	06,17,28	1	
20	1	32-Bit Binary Counter	1, 7,8,9,10	00,01,06,17,28	1129	00,17,28
20	2	16-Bit Binary Counter	1, 7,8,9,10	00,01,06,17,28	1129	00,17,28
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter without Flag	1, 7,8,9,10	00,01,06,17,28	1 129	00,17,28

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
20	6	16-Bit Binary Counter without Flag	1, 7,8,9,10	00,01,06,17,28	1 129	00,17,28
20	7	32-Bit Delta Counter without Flag				
20	8	16-Bit Delta Counter without Flag				
Qualifier Codes (in hexa) (example of Binary Input)						
			Request Qualifier		Response Qualifier	
Range of Points (8 bits)			0		0	
Range of Points (16 bits)			1		0	
All Points			6		0	
Count of Points (8 bits)			7		0	
Count of Points (16 bits)			8		0	
List of Points (8 bits)			17		17	
List of Points (16 bits)			28		28	
Qualifier Codes 17 and 28 are only available on one point, except for controls (controls can be selected/executed on one or more points)						
“Binary Counter - All Variations” (Object 20, Var 0): Functions 7,8 ,9 & 10 are only available with qualifiers 06, 17 and 28						
21	0	Frozen Counter - All Variations	Static&event:1	00,01,06,17,28	129, 130	
21	1	32-Bit Frozen Counter	Static: 1	00,01,06,17,28	129	00,17,28
21	2	16-Bit Frozen Counter	Static: 1	00,01,06,17,28	129	00,17,28
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter with Time of Freeze	Event: 1			
21	6	16-Bit Frozen Counter with Time of Freeze	Event: 1			
21	7	32-Bit Frozen Delta Counter with Time of Freeze				
21	8	16-Bit Frozen Delta Counter with Time of Freeze				
21	9	32-Bit Frozen Counter without Flag	Static: 1	00,01,06,17,28	129	00,17,28
21	10	16-Bit Frozen Counter without Flag	Static: 1	00,01,06,17,28	129	00,17,28
21	11	32-Bit Frozen Delta Counter without Flag				
21	12	16-Bit Frozen Delta Counter without Flag				
22	0	Counter Event - All Variations				
22	1	32-Bit Counter Event without Time				
22	2	16-Bit Counter Event without Time				
22	3	32-Bit Delta Counter Event without Time				
22	4	16-Bit Delta Counter Event without Time				
22	5	32-Bit Counter Event with Time				
22	6	16-Bit Counter Event with Time				
22	7	32-Bit Delta Counter Event with Time				
22	8	16-Bit Delta Counter Event with Time				
23	0	Frozen Counter Event - All Variations	1	06,07,08	129, 130	
23	1	32-Bit Frozen Counter Event without Time				
23	2	16-Bit Frozen Counter Event without Time				
23	3	32-Bit Frozen Delta Counter Event without Time				

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
23	4	16-Bit Frozen Delta Counter Event without Time				
23	5	32-Bit Frozen Counter Event with Time	1	06,07,08	129,130	17
23	6	16-Bit Frozen Counter Event with Time	1	06,07,08	129,130	17
23	7	32-Bit Frozen Delta Counter Event with Time				
23	8	16-Bit Frozen Delta Counter Event with Time				
30	0	Analog Input - All Variations	1	00,01,06,17,28	129	
30	1	32-Bit Analog Input	1	00,01,06,17,28	129	00, 17,28
30	2	16-Bit Analog Input	1	00,01,06,17,28	129	00,17,28
30	3	32-Bit Analog Input without Flag	1	00,01,06,17,28	129	00,17,28
30	4	16-Bit Analog Input without Flag	1	00,01,06,17,28	129	00,17,28
31	0	Frozen Analog Input - All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input with Time of Freeze				
31	4	16-Bit Frozen Analog Input with Time of Freeze				
31	5	32-Bit Frozen Analog Input without Flag				
31	6	16-Bit Frozen Analog Input without Flag				
32	0	Analog Change Event - All Variations	1	06,07,08	129, 130	
32	1	32-Bit Analog Change Event without Time				
32	2	16-Bit Analog Change Event without Time				
32	3	32-Bit Analog Change Event with Time	1	06,07,08	129,130	17
32	4	16-Bit Analog Change Event with Time	1	06,07,08	129,130	17
33	0	0 Frozen Analog Event - All Variations				
33	1	32-Bit Frozen Analog Event without Time				
33	2	16-Bit Frozen Analog Event without Time				
33	3	32-Bit Frozen Analog Event with Time				
33	4	16-Bit Frozen Analog Event with Time				
40	0	Analog Output Status - All Variations				
40	1	32-Bit Analog Output Status				
40	2	16-Bit Analog Output Status				
41	0	Analog Output Block - All Variations				
41	1	32-Bit Analog Output Block	3,4,5,6	17,28	129	Request echo
41	2	16-Bit Analog Output Block	3,4,5,6	17,28	129	Request echo
50	0	Time and Date - All Variations				
50	1	Time and Date				
50	2	Time and Date with Interval				
51	0	Time and Date CTO - All Variations				
51	1	Time and Date CTO	1, 2		129	
51	2	Unsynchronized Time and Date CTO				
52	0	Time Delay - All Variations				

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
52	1	Time Delay Coarse				
52	2	Time Delay Fine				
60	0					
60	1	Class 0 Data	1	06,07,08	129	
			20,21	06		
60	2	Class 1 Data	1	06,07,08	129	
			20,21	06		
60	3	Class 2 Data	1	06,07,08	129	
			20,21	06		
60	4	Class 3 Data	1	06,07,08	129	
70	0	File management – All variations				
80	1	Internal Indications	2			
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				
No Object (Cold Restart)						
No Object (Warm Restart)						
No Object (Delay Measurement)						

“On-line” Quality bit management:

The table below described the management of the DNP3 binary input status object for each DS Agile xPS status, MV and counter value.

This management is the same for data with or without the time tag. You can choose between two modes. Only the mode 1 is backwards compatible.

MODE 1 / SBMC set to OFF

SPS:

DS Agile SPS Status SBMC is set to Off	DNP3 binary input status object							
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Chatter filter BS1[5]	Reserved BS1[6]	State BS1[7]
RESET	1	-	-	-	-	-	-	0
SET	1	-	-	-	-	-	-	1
TOGGLING	1	-	-	-	-	1	-	0
SELFCHECKFAULT	0	-	-	-	-	-	-	0
UNKNOWN	1	-	1	-	-	-	-	(1)
SUPPRESSED	1	-	-	1	-	-	-	X
FORCED	1	-	-	1	-	-	-	(2)
SUBSTITUTED	1	-	-	1	-	-	-	(2)

DPS:

DS Agile DPS Status SCE Inversion = No SBMC is set to Off	DNP3 binary input status object DNP3 Address (CO)								DNP3 binary input status object DNP3 Address + 1 (CC)							
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Chatter filter BS1[5]	Reserved BS1[6]	State BS1[7]	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Chatter filter BS1[5]	Reserved BS1[6]	State BS1[7]
OPEN	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-	0
CLOSED	1	-						0	1	-	-	-	-	-	-	1
JAMMED	0	-						0	0	-						1
UNDEFINED	0	-	-	-				0	0	-						1
TOGGLING	1	-	-	-	-	1	-	0	1	-	-	-	-	1	-	1
SELFCHECKFAULT	0	-	-	-	-	-	-	0	0	-	-	-	-	-	-	1
UNKNOWN	1	-	1	-	-	-	-	(1)	1	-	1	-	-	-	-	(1)
SUPPRESSED	1	-	-	1	-	-	-	X	1	-	-	1	-	-	-	X
FORCED	1	-	-	1	-	-	-	(2)	1	-	-	1	-	-	-	(2)
SUBSTITUTED	1	-	-	1	-	-	-	(2)	1	-	-	1	-	-	-	(2)

(1) For the the status UNKNOWN, the C26x action for each data source shows in the table below:

Data source	Condition	C26x action
IEC61850 server	Server connection	Data shows as transmitted on IEC61850
	Server disconnection	Resets the data from the server
A T101 IED or a DNP3 IED	IED disconnection	Resets the bit
A VDEW IED or a Modbus IED	IED disconnection	Does not change the previous status

(2) Value is given by the client that forces, suppresses or substitutes the data, also assigns and gives the value to the data.

"-" stands for 0 except when 0 is significant, in this case the 0 appears in the cell.

"X stands for No change. It means no change from the previous status.

The table below shows the management of the DNP3 Object coding status Flag and current value for each DS Agile MV and SPI status. This management is the same for data with or without the time tag. The SBMC is set to off.

DS Agile MV & SPI Status SBMC is set to Off	DNP3 object coding status flag								DNP3 object coding status Current value
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Over-range BS1[5]	Reference check BS1[6]	Reserved BS1[7]	
VALID	1	-	-	-	-	-	-	-	VALUE*
SELFCHECK FAULT	0	-	-	-	-	-	-	-	X*
UNKNOWN	1	-	1	-	-	-	-	-	X*
FORCED	1	-	-	1	-	-	-	-	VALUE*
SUPPRESSED	1	-	-	1	-	-	-	-	VALUE*
SUBSTITUTED	1	-	-	1	-	-	-	-	VALUE*
OVERRANGE (0x6000)	0	-	-	-	-	-	-	-	Min or Max or (1)*
UNDEFINED	0	-	-	-	-	-	-	-	X*
OPENCIRCUIT	0	-	-	-	-	-	-	-	X*

*the value can be scaled and depends to the format: Natural or Scaled. If the result of the scaling is not between minimum and maximum as defined in the configuration, then the MV shows as OVERRANGE

(1) If the scaling value is between minimum and maximum then this value is transmitted

For each DS Agile COUNTER status, the table below shows the management of the DNP3 Object coding status Flag and Delta value. This management is the same same for data with or without the time tag. The SBMC is set to off.

DS Agile Counter Status	DNP3 object coding status flag								DNP3 object coding status Value
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Over-range BS1[5]	Reference check BS1[6]	Reserved BS1[7]	
VALID	1	-	-	-	-	-	-	-	VALUE
SELFCHECK FAULT	0	-	-	-	-	-	-	-	X
UNKNOWN	1	-	1	-	-	-	-	-	X
OVERRANGE	0	-	-	-	-	-	-	-	X
UNDEFINED	0	-	-	-	-	-	-	-	X

MODE 2 / SBMC set to OFF:

DS Agile SPS Status SBMC is set to Off	DNP3 binary input status object							
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Chatter filter BS1[5]	Reserved BS1[6]	State BS1[7]
RESET	1	-	-	-	-	-	-	0
SET	1	-	-	-	-	-	-	1
TOGGLING	1	-	-	-	-	1	-	0
SELFCHECKFAULT	0	-	-	-	-	-	-	0
UNKNOWN	0	-	1	-	-	-	-	(1)
SUPPRESSED	1	-	-	1	-	-	-	X
FORCED	1	-	-	1	-	-	-	(2)
SUBSTITUTED	1	-	-	1	-	-	-	(2)

DS Agile DPS Status SCE Inversion = No SBMC is set to Off	DNP3 binary input status object DNP3 Address (CO)								DNP3 binary input status object DNP3 Address + 1 (CC)							
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Chatter filter BS1[5]	Reserved BS1[6]	State BS1[7]	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Chatter filter BS1[5]	Reserved BS1[6]	State BS1[7]
OPEN	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-	0
CLOSED	1	-						0	1	-	-	-	-	-	-	1
JAMMED	0	-						1	0	-						0
UNDEFINED	0	-	-	-				1	0	-						0
TOGGLING	1	-	-	-	-	1	-	1	1	-	-	-	-	1	-	0
SELFCHECKFAULT	0	-	-	-	-	-	-	1	0	-	-	-	-	-	-	0
UNKNOWN	0	-	1	-	-	-	-	(1)	0	-	1	-	-	-	-	(1)
SUPPRESSED	1	-	-	1	-	-	-	X	1	-	-	1	-	-	-	X
FORCED	1	-	-	1	-	-	-	(2)	1	-	-	1	-	-	-	(2)
SUBSTITUTED	1	-	-	1	-	-	-	(2)	1	-	-	1	-	-	-	(2)

DS Agile MV & SPI Status SBMC is set to Off	DNP3 object coding status flag								DNP3 object coding status Current value
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Over-range BS1[5]	Reference check BS1[6]	Reserved BS1[7]	
VALID	1	-	-	-	-	-	-	-	VALUE*
SELFCHECK FAULT	0	-	1	-	-	-	-	-	X*
UNKNOWN	0	-	1	-	-	-	-	-	X*
FORCED	1	-	-	1	-	-	-	-	VALUE*
SUPPRESSED	1	-	-	1	-	-	-	-	VALUE*
SUBSTITUTED	1	-	-	1	-	-	-	-	VALUE*
OVERRANGE (0x6000)	0	-	-	-	-	-	-	-	Min or Max or (1)*
UNDEFINED	0	-	-	-	-	-	-	-	X*
OPENCIRCUIT	0	-	1	-	-	-	-	-	X*

DS Agile Counter Status: same as mode 1
MODE 1 = MODE 2 if SBMC is set to ON:

SBMC is set to On SCE SPS profile attribute "Value" equal to	DNP3 binary input status object							
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Chatter filter BS1[5]	Reserved BS1[6]	State BS1[7]
RESET	1	-	-	-	-	-	-	0
SET	1	-	-	-	-	-	-	1
SUPPRESSED	1	-	-	1	-	-	-	0

SBMC is set to On SCE DPS profile attribute "Value" equal to	DNP3 binary input status object DNP3 Address (CO)								DNP3 binary input status object DNP3 Address + 1 (CC)							
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Chatter filter BS1[5]	Reserved BS1[6]	State BS1[7]	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Chatter filter BS1[5]	Reserved BS1[6]	State BS1[7]
SUPPRESSED	1	-	-	-	1	-	-	0	1	-	-	-	1	-	-	0
OPEN	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-	0
CLOSED	1	-	-	-	-	-	-	0	1	-	-	-	-	-	-	1
JAMMED	0	-	-	-	-	-	-	0	0	-	-	1	-	-	-	1

SBMC is set to On SCE MV profile attribute "Value" equal to	DNP3 object coding status flag								DNP3 object coding status Current value
	On-line BS1[0]	RestartBS1[1]	Comm.lost BS1[2]	Remote Forced BS1[3]	Local Forced BS1[4]	Over-range BS1[5]	Reference check BS1[6]	Reserved BS1[7]	
Yes to SUPPRESSED	1	-	-	-	1	-	-	-	0

4.4 SLAVE IEC 60870-5-101 PROFILE

The companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameters values, such as the number of bytes in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system.

Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ Function or ASDU is used as standardized (default)

The possible selection (blank, X) is specified for each specific clause or parameter.

Note:
In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

4.4.1 SYSTEM OR DEVICE

(system specific parameter, indicates the definition of a system or a device by marking one of the following with '**X**')

☐ System definition

☐ Controlling station definition (Master)

☒ Controlled station definition (Slave)

4.4.2 NETWORK CONFIGURATION

(network specific parameter, all configurations that are used are to be marked 'X')

☒ Point-to-point ☒ Multipoint-party line

☒ Multiple point-to-point ☒ Multipoint-star

4.4.3 PHYSICAL LAYER

(network specific parameter, all interfaces and data rates that are used are to be marked '**X**')

Transmission speed (control direction)

Unbalanced interchange Circuit V24/V28				**Balanced interchange Circuit X24/X27**			
Standard		**Recommended if > 1200 bits/s**					
☐	100 bits/s	☒	2400 bits/s	☒	2400 bits/s	☐	56000 bits/s
☐	200 bits/s	☒	4800 bits/s	☒	4800 bits/s	☐	64000 bits/s
☒	300 bits/s	☒	9600 bits/s	☒	9600 bits/s		
☒	600 bits/s	☒	19200 bits/s	☒	19200 bits/s		
☒	1200 bits/s			☒	38400 bits/s		

Transmission speed (monitor direction)

Unbalanced interchange Circuit V24/V28				Balanced interchange Circuit X24/X27			
Standard		Recommended if > 1200 bits/s					
☐	100 bits/s	☒	2400 bits/s	☒	2400 bits/s	☐	56000 bits/s
☐	200 bits/s	☒	4800 bits/s	☒	4800 bits/s	☐	64000 bits/s
☒	300 bits/s	☒	9600 bits/s	☒	9600 bits/s		
☒	600 bits/s	☒	19200 bits/s	☒	19200 bits/s		
☒	1200 bits/s			☒	38400 bits/s		

4.4.4 LINK LAYER

(network specific parameter, all options that are used are to be marked '**X**'. Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure

☒ Balanced transmission

☒ Unbalanced transmission

Address field of the link

☐ Not present (balanced transmission only)

☒ One octet

☒ Two octets

☐ Structured

☒ Unstructured

Frame length (number of bytes)

255 Maximum length L in control direction

up to 255 Maximum length L in monitor direction – configurable

4.4.5 APPLICATION LAYER

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Structured

☒ Two octets ☒ Unstructured

☒ Three octets

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Two octets (with originator address)

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<1>	:=	Single-point information	M_SP_NA_1
☒	<2>	:=	Single-point information with time tag	M_SP_TA_1
☒	<3>	:=	Double-point information	M_DP_NA_1
☒	<4>	:=	Double-point information with time tag	M_DP_TA_1
☒	<5>	:=	Step-position information	M_ST_NA_1
☒	<6>	:=	Step-position information with time tag	M_ST_TA_1
☐	<7>	:=	BitString of 32 bit	M_BO_NA_1
☐	<8>	:=	BitString of 32 bit with time tag	M_BO_TA_1
☒	<9>	:=	Measured value, normalized value	M_ME_NA_1
☒	<10>	:=	Measured value, normalized value with time tag	M_ME_TA_1
☒	<11>	:=	Measured value, scaled value	M_ME_NB_1
☒	<12>	:=	Measured value, scaled value with time tag	M_ME_TB_1
☒	<13>	:=	Measured value, short floating point value	M_ME_NC_1
☒	<14>	:=	Measured value, short floating point value with time tag	M_ME_TC_1
☒	<15>	:=	Integrated totals	M_IT_NA_1
☒	<16>	:=	Integrated totals with time tag	M_IT_TA_1
☐	<17>	:=	Event of protection equipment with time tag	M_EP_TA_1
☒	<18>	:=	Packed start events of protection equipment with time tag	M_EP_TB_1
☒	<19>	:=	Packed output circuit transmission of protection equipment with time tag	M_EP_TC_1
☐	<20>	:=	Packed single-point information with status change detection	M_PS_NA_1
☐	<21>	:=	Measured value, normalized value without quality descriptor	M_ME_ND_1
☒	<30>	:=	Single-point information with time tag CP56Time2a	M_SP_TB_1
☒	<31>	:=	Double-point information with time tag CP56Time2a	M_DP_TB_1
☒	<32>	:=	Step-position information with time tag CP56Time2a	M_ST_TB_1
☐	<33>	:=	Bistring of 32 bits with with time tag CP56Time2a	M_BO_TB_1
☒	<34>	:=	Measured value, normalized with time tag CP56Time2a	M_ME_TD_1
☒	<35>	:=	Measured value, scaled with time tag CP56Time2a	M_ME_TE_1
☒	<36>	:=	Measured value, short floating point number with time tag CP56Time2a	M_ME_TF_1
☒	<37>	:=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38>	:=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☒	<39>	:=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☒	<40>	:=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Process information in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<45>	:=	Single command	C_SC_NA_1
☒	<46>	:=	Double command	C_DC_NA_1
☒	<47>	:=	Regulating step command	C_RC_NA_1

☒	<48>	:=	Set point command, normalized value	C_SE_NA_1
☒	<49>	:=	Set point command, scaled value	C_SE_NB_1
☒	<50>	:=	Set point command, short floating point value	C_SE_NC_1
☐	<51>	:=	BitString of 32 bits	C_BO_NA_1

System information in monitor direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<70>	:=	End of initialisation	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<100>	:=	Interrogation command	C_IC_NA_1
☒	<101>	:=	Counter Interrogation Command	C_CI_NA_1
☐	<102>	:=	Read command	C_RD_NA_1
☒	<103>	:=	Clock synchronisation command	C_CS_NA_1
☒	<104>	:=	Test command	C_TS_NB_1
☐	<105>	:=	Reset process command	C_RP_NC_1
☒	<106>	:=	Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐	<110>	:=	Parameter of measured value, normalized value	P_ME_NA_1
☐	<111>	:=	Parameter of measured value, scaled value	P_ME_NB_1
☐	<112>	:=	Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113>	:=	Parameter activation	P_AC_NA_1

File transfer

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<120>	:=	File ready	F_FR_NA_1
☒	<121>	:=	Section ready	F_SR_NA_1
☒	<122>	:=	Call directory, select file, call file, call section	F_SC_NA_1
☒	<123>	:=	Last section, last segment	F_LS_NA_1
☒	<124>	:=	Ack file, ack section	F_AF_NA_1
☒	<125>	:=	Segment	F_SG_NA_1
☒	<126>	:=	Directory	F_DR_TA_1

Special use (private range)

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<136>	:=	Database version	M_DB_NA_1
☒	<137>	:=	Regulating delay command	C_RC_NB_1

Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used

Mark type identification/cause of transmission combinations:

'X' if used only in the standard direction

'R' if used only in the reverse direction

'B' if used in both directions

Type ID		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1		X	X								X			X					
<2>	M_SP_TA_1			X								X								
<3>	M_DP_NA_1		X	X								X			X					
<4>	M_DP_TA_1			X								X								
<5>	M_ST_NA_1		X	X								X			X					
<6>	M_ST_TA_1			X								X								
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1	X	X	X											X					
<10>	M_ME_TA_1			X																
<11>	M_ME_NB_1	X	X	X											X					
<12>	M_ME_TB_1			X																
<13>	M_ME_NC_1	X	X	X											X					
<14>	M_ME_TC_1			X																
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1			X												X				
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1			X																
<19>	M_EP_TC_1			X																
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X								X	X							
<31>	M_DP_TB_1			X								X	X							
<32>	M_ST_TB_1			X								X	X							
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1			X																
<35>	M_ME_TE_1			X																
<36>	M_ME_TF_1			X																
<37>	M_IT_TB_1			X												X				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1			X																

Type ID		Cause of transmission																	
<40>	M_EP_TF_1			X															
<45>	C_SC_NA_1						X	X	X	X	X							X	X	X
<46>	C_DC_NA_1						X	X	X	X	X							X	X	X
<47>	C_RC_NA_1						X	X	X	X	X							X	X	X
<48>	C_SE_NA_1						X	X	X	X	X							X	X	X
<49>	C_SE_NB_1						X	X	X	X	X							X	X	X
<50>	C_SE_NC_1						X	X	X	X	X							X	X	X
<51>	C_BO_NA_1																X			
<70>	M_EI_NA_1				X															
<100>	C_IC_NA_1						X	X	X	X	X							X	X	X
<101>	C_CI_NA_1						X	X			X							X	X	X
<102>	C_RD_NA_1																X			
<103>	C_CS_NA_1						X	X										X	X	X
<104>	C_TS_NA_1						X	X										X	X	X
<105>	C_RP_NA_1																X			
<106>	C_CD_NA_1						X	X									X			
<110>	P_ME_NA_1																X			
<111>	P_ME_NB_1																X			
<112>	P_ME_NC_1																X			
<113>	P_AC_NA_1																X			
<120>	F_FR_NA_1													X				X	X	X
<121>	F_SR_NA_1													X				X	X	X
<122>	F_SC_NA_1													X				X	X	X
<123>	F_LS_NA_1													X				X	X	X
<124>	F_AF_NA_1													X				X	X	X
<125>	F_SG_NA_1													X				X	X	X
<126>	F_DR_TA_1			X		X														
<136>	M_DB_NA_1																X			
<137>	C_RC_NB_1						X	X	X	X	X							X	X	X

4.4.6 BASIC APPLICATION FUNCTIONS

Station initialisation

(station-specific parameter, mark 'X' if function is used)

☐ Remote initialisation

between Reset User ASDU's

Cyclic data transmission

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Cyclic data transmission

Read procedure

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Read procedure

Spontaneous transmission

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Spontaneous transmission

Link state between Controlling and Controlled Station

☒ Management of the COM lost (Problem detecting on the link)

☒ Management of the COM recovering (Problem not detecting on the link)

General interrogation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ global

☒	group 1	☒	group 7	☒	group 13
☒	group 2	☒	group 8	☒	group 14
☒	group 3	☒	group 9	☒	group 15
☒	group 4	☒	group 10	☒	group 16
☒	group 5	☒	group 11	Addresses per group have to be defined	
☒	group 6	☒	group 12		

Counter General interrogation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ global

☒	group 1	☒	group 2	☒	group 3
☒	group 4				

Clock synchronisation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Clock synchronisation

Notes:
– The controlled station does not report the change of hour by sending a clock synchronisation message (ASDU 103) to the controlling station.
– When the controlling station send to controlled station a clock synchronisation and if the system (includes controlled station), is not synchronized by an other source: the clock synchronisation response is positive.
– When the controlling station send to controlled station a clock synchronisation and if the system (includes controlled station), is synchronized by an other source: the clock synchronisation response is negative.

Command transmission

(object -specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Direct command transmission

☒ Direct set-point command transmission

☒ Select and execute command

☒ Select and execute set-point command

☒ C_SE ACTTERM used

☒ No additional definition

☐ Short pulse duration (duration determined by a system parameter in the outstation)

☐ Long pulse duration (duration determined by a system parameter in the outstation)

☐ Persistent output

Transmission of integrated totals

(object -specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Mode A: local freeze with spontaneous transmission

☐ Mode B: local freeze with counter interrogation

☒ Mode C: freeze and transmit by counter interrogation commands

☐ Mode D: freeze by counter interrogation command, frozen values reported spontaneously

Counter General interrogation

(object -specific parameter)

☒ Counter read

☒ Counter freeze without reset

☒ Counter freeze with reset

☒ Counter reset

☒ General request counter

☒ Request counter group 1

☒ Request counter group 2

☒ Request counter group 3

☒ Request counter group 4

Parameter loading

(object-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

Parameter activation

(object-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Act-/deact-ivation of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☒ Test procedure

File transfer

(station-specific parameter), mark ‘X’ if function is used)

File transfert in monitor direction

☒ Transparent file

☐ Transmission of disturbance data of protection equipment

☒ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☒ Background scan

Acquisition of transmission delay

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Acquisition of transmission delay

Management events priorities

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

Digitals Inputs and Analogs Inputs, management events priorities.
See T101 standard Amendment 2, section 7.2.2.2

4.4.7 PROTOCOL REQUIREMENTS

Class 1 data

The following types of information must be configured at the controlled station to be Class 1:

- Single point information with or without time tag (on change)
- Double point information with or without time tag (on change)
- Step position information with or without time tag (on change)
- Measured value, normalised with or without time tag (on change)
- Measured value, scaled with or without time tag (on change)
- Measured value, floated with or without time tag (on change)
- Integrated totals with or without time tag (on change)
- Time messages
- All command responses (ACT_CONF, and ACT_TERM)

Class 2 data

The following types of information must be configured at the controlled station to be Class 2:

- Single point information (GI scan, or BackGroundScan cycle)
- Double point information (GI scan, or BackGroundScan cycle)
- Step position information (GI scan, or BackGroundScan cycle)
- Measured values, normalised (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Measured values, scaled (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Measured values, floated (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Integrated totals (Counter GI scan)

4.4.8 APPLICATION FUNCTIONS

The following IEC-60870-5-5 standard application processes are supported.

Station Initialisation

Station initialisation consists of a reset of the communications link (a Reset CU frame and Time Synchronisation message are sent to the station), followed by a general interrogation of the controlled station. Once this initialisation sequence is performed the controlling station can start the polling for data report.

Communications failure

Communications to the controlled station must be re-initialised by the controlling station when the frame repeat process has completed without successfully transmitting the frame (ie the frame time-out period times the number of repeats).

If the controlled station fails to communicate with the controlling station then the controlling station should perform a communications system initialisation for that controlled station.

Controlled station failure

The controlled station shall indicate to the controlling station that it has initialised by sending a frame indicating End of Initialisation with a Cause Of Initialisation (COI) field, which will identify the reason for the initialisation in unbalanced mode only).

Data Acquisition by Polling

The default for all analogue values shall be reporting as Class 2 data (COT=1, periodic/cyclic, or COT = 2, BackgroundScan cyclic).

Values returned as Class 2 data do not have a time tag (since they are constantly repeated).

The controlled station may return Class 1 data in response to a Class 2 request if no Class 2 data is available and Class 1 data is awaiting transmission.

At the controlled station, if a request for Class 2 data is received and no data is available, a negative response, data not available, is returned to the controlling Station. The negative response might be a fixed length frame (FC=9), which in this event is treated as a NACK.

Normal Acquisition of Events

The default for all status changes are reported as Class 1 data (COT=3, spontaneous).

Values returned as Class 1 data have a time tag (either CP24Time2a, or CP56Time2a).

Status changes at the controlled station causes the ACD bit to be set in the next Class 1 or Class 2 data response. The controlling station responds to ACD set by inserting a scan for Class 1 (spontaneous) data as the next scan.

The response to a Class 1 data request has also the ACD bit set if more Class 1 data is awaiting transmission. In this case a further scan for Class 1 data is scheduled by the controlling station.

Abnormal Acquisition of Events

At the controlled station, if a request for Class 1 data is received and no data is available an error must be raised and a negative response, data not available, returned to the controlling Station. The negative response is a fixed length frame (FC=9), which in this case is treated as a NACK.

At the controlling station, if a response to a scan for Class 1 data indicates no data is available an error is raised and scanning returned to Class 2 data requests.

General Interrogation

The GI returns the current status information directly from the C26x database.

Time tags are not used for data items returned as part of the GI response.

The GI groups are supported so, these are set up in the C26x configuration and each of the (up to 16) groups is requested/reported individually.

Clock synchronisation

The System (including the controlled station) may have different synchronisation sources (IRIG-B, SCADA).

When the controlling station sends to controlled station a clock synchronisation:

- if the system is not synchronized by another source: clock synchronisation response is positive
- if the system is synchronized by another source: clock synchronisation response is negative

All Class 1 data are time-tagged with:

- either the 3 bytes time-stamp (CP24Time2a), giving minutes & millisec within the hour,
- or the 7 bytes time-stamp (CP56Time2a), giving minutes, milliseconds, hours, day, month and year according to the C26x configuration.

The invalid bit in the time-stamp is set when the C26x is not synchronised.

Command transmission

All control commands are Select before Execute, or Direct Execute.

For only the control commands: Activation termination is returned to the controlling station to signal the end of a control sequence.

The QU field of the Qualifier of Command is set to zero (0), no additional definition.

Test procedure

A test command may be issued by the controlling station to ensure the availability of the communications link and the commands subsystem.

Test commands are received at the controlled station on the active link. The controlled station mirrors the test command, on the link from which it was received, with a cause of transmission indicating activation confirmation.

An error response must be sent if the command is incorrect, with a cause of transmission indicating negative activation confirmation.

4.4.9 FRAME EXAMPLE

ASDU1: Single-point information without time tag

TYPE IDENT 1: M_SP_NA_1

Sequence of information objects (SQ = 0)

8	7	6	5	4	3	2	1	Bit		
0	0	0	0	0	0	0	1		TYPE IDENTIFICATION	
SQ	Number i of objects								VARIABLE STRUCTURE QUALIFIER	DATA UNIT
T	P/N	2^5	Cause				2^0		CAUSE OF TRANSMISSION	
1 byte (can be two) 1..254, 255 = global address									COMMON ADDRESS OF ASDU	IDENTIFIER
B^7							B^0		INFORMATION OBJECT ADDRESS	
B^{15}							B^8			INFORMATION
IV	NT	SB	BL	0	0	0	SPI		SIQ = Single-point information with quality descriptor, see below.	OBJECT 1

B^7							B^0		INFORMATION OBJECT ADDRESS	
B^{15}							B^8			INFORMATION
IV	NT	SB	BL	0	0	0	SPI		SIQ = Single-point information with quality descriptor, see below.	OBJECT i

M_SP_NA_1 := CP{Data unit identifier, i(Information object address, SIQ)}

i := number of objects defined in the variable structure qualifier

Quality descriptor

BL = BLOCKED/NOT BLOCKED

The value of the INFORMATION OBJECT is blocked for transmission; the value remains in the state that was acquired before it was blocked. Blocking and deblocking may be initiated e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by input of an operator (dispatcher) or by an automatic source.

NT = NOT TOPICAL/TOPICAL

A value is topical if the most recent update was successful. It is not topical if it was not updated successfully during a specified time interval or it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises abnormal conditions of the information source (missing or non operating updating devices), the value is then marked invalid. The value of the INFORMATION OBJECT is not defined under this condition. The mark INVALID is used to indicate to the destination that the value may be incorrect and cannot be used.

4.5 SLAVE IEC 60870-5-104 SERVER PROFILE

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the choice of "structured" or "unstructured" fields of the INFORMATION OBJECT ADDRESS of ASDU represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarises the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

Paragraph in grey are those which are not applicable for the IEC 60870-5-104 profile.

The selected parameters should be filled up (❍ --> ●).

Note:
In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.
To simplify the PID , we use the following conventions:
❍ *Not supported*
● *Supported*

4.5.1 SYSTEM OR DEVICE

❍ System definition

❍ Controlling station definition (Master)

● Controlled station definition (Slave)

4.5.2 NETWORK CONFIGURATION (NETWORK-SPECIFIC PARAMETER)

❍ Point-to-point ❍ Multipoint-party line

❍ Multiple point-to-point ❍ Multipoint-star

4.5.3 PHYSICAL LAYER (NETWORK-SPECIFIC PARAMETER)

Transmission speed (control direction):

Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange circuit X.24/X.27, V35
❍ 100 bit/s	❍ 2 400 bit/s	❍ 2 400 bit/s
❍ 200 bit/s	❍ 4 800 bit/s	❍ 4 800 bit/s
❍ 300 bit/s	❍ 9 600 bit/s	❍ 9 600 bit/s
❍ 600 bit/s	❍ 19 200 bit/s	❍ 19 200 bit/s
❍ 1 200 bit/s		❍ 38 400 bit/s
		❍ 56 000 bit/s
		❍ 64 000 bit/s

Transmission speed (monitor direction):

Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange circuit X.24/X.27, V35
❍ 100 bit/s	❍ 2 400 bit/s	❍ 2 400 bit/s
❍ 200 bit/s	❍ 4 800 bit/s	❍ 4 800 bit/s
❍ 300 bit/s	❍ 9 600 bit/s	❍ 9 600 bit/s
❍ 600 bit/s	❍ 19 200 bit/s	❍ 19 200 bit/s
❍ 1 200 bit/s		❍ 38 400 bit/s
		❍ 56 000 bit/s
		❍ 64 000 bit/s

4.5.4 LINK LAYER (NETWORK SPECIFIC PARAMETER)

(Network-specific parameter, all options that are used should be filled up (❍ --> ●). Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure	Address field of the link
❍ Balanced transmission	❍ Not present (balanced transmission only)
❍ Unbalanced transmission	❍ One octet
	❍ Two octets
	❍ Structured
	❍ Unstructured

Frame length

_255_ Maximum length L (number of bytes)

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

❍ The standard assignment of ASDUs to class 2 messages is used as follows:

Type Identification	Cause of transmission
9,11,13,21	<1>

❍ A special assignment of ASDUs to class 2 messages is used as follows:

Type Identification	Cause of transmission
1,3,5	<20> to <41>

Note:
In response to a class 2 poll, a controlled station prevent the controlling station with ACD parameter, when there is no class 2 data available.

4.5.5 PROTOCOL REQUIREMENTS

4.5.5.1 EVENT

The following types of information are to be configured at the controlled station to be Event:

- Single point information with or without time tag (on change)
- Double point information with or without time tag (on change)
- Step position information with or without time tag (on change)
- Measured value, normalised with or without time tag (on change)
- Measured value, scaled with or without time tag (on change)
- Measured value, floated with or without time tag (on change)
- Integrated totals with or without time tag (on change)

4.5.5.2 STATIC

The following types of information are to be configured at the controlled station to be Static:

- Single point information (GI scan, or BackGroundScan cycle)
- Double point information (GI scan, or BackGroundScan cycle)
- Measured values, normalised (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Measured values, scaled (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Measured values, floated (GI scan, or Periodic cycle, or BackGroundScan cycle)
- Step position values (GI scan, or BackGroundScan cycle)
- Integrated totals (Counter GI scan)

4.5.6 APPLICATION LAYER

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(System specific parameter)

The address field of the link and the common address of ASDU could have a different number of bytes

❍ One octet	● Two octets

Information object address

(System specific parameter)

❍ One octet	● Structured
❍ Two octets	● Unstructured
● Three octets	

Cause of transmission

(System-specific parameter)

❍ One octet	● Two octets (with originator address)

Length of APDU

(System-specific parameter)

The maximum length of APDU is 253 (default). The maximum length may be reduced by the system.

Configurable	Maximum length of APDU per system

Selection of standard ASDUs

Process information in monitor direction

(Station-specific parameter)

●	<1>: =	Single-point information	M-SP-NA-1
❍	<2>: =	Single-point information with time tag	M-SP-TA-1
●	<3>: =	Double-point information	M-DP-NA-1
❍	<4>: =	Double-point information with time tag	M-DP-TA-1
●	<5>: =	Step position information	M-ST-NA-1
❍	<6>: =	Step position information with time tag	M-ST-TA-1
❍	<7>: =	Bit-string of 32 bit	M-BO-NA-1
❍	<8>: =	Bit-string of 32 bit with time tag	M-BO-TA-1
●	<9>: =	Measured value, normalised value	M-ME-NA-1
❍	<10>: =	Measured value, normalised value with time tag	M-ME-TA-1
●	<11>: =	Measured value, scaled value	M-ME-NB-1
❍	<12>: =	Measured value, scaled value with time tag	M-ME-TB-1
●	<13>: =	Measured value, short floating point value	M-ME-NC-1
❍	<14>: =	Measured value, short floating point value with time tag	M-ME-TC-1
●	<15>: =	Integrated totals	M-IT-NA-1
❍	<16>: =	Integrated totals with time tag	M-IT-TA-1
❍	<17>: =	Event of protection equipment with time tag	M-EP-TA-1
❍	<18>: =	Packed starts events of protection equipment with time tag	M-EP-TB-1
❍	<19>: =	Packed output circuit information of protection equipment with time tag	M-EP-TC-1
❍	<20>: =	Packed single-point information with status change detection	M-PS-NA-1
❍	<21>: =	Measured value, normalised value without quality descriptor	M-ME-ND-1

Process information in monitor direction with the Extension of time tag

(Station-specific parameter)

●	<30>: =	Single-point information with time tag CP56Time2a	M-SP-TB-1
●	<31>: =	Double-point information with time tag CP56Time2a	M-DP-TB-1
●	<32>: =	Step position information with time tag CP56Time2a	M-ST-TB-1
❍	<33>: =	Bit-string of 32 bit with time tag CP56Time2a	M-BO-TB-1
●	<34>: =	Measured value, normalised value with time tag CP56Time2a	M-ME-TD-1
●	<35>: =	Measured value, scaled value with time tag CP56Time2a	M-ME-TE-1
●	<36>: =	Measured value, short floating point value, time tag CP56Time2a	M-ME-TF-1
●	<37>: =	Integrated totals with time tag CP56Time2a	M-IT-TB-1
❍	<38>: =	Event of protection equipment with time tag CP56Time2a	M-EP-TD-1
●	<39>: =	Packed start event of protection equipment, time tag CP56Time2a	M-EP-TE-1
●	<40>: =	Packed output circuit information of protection equipment with time tag CP56Time2a	M-EP-TF-1

Process information in control direction

(station specific parameter)

●	<45>: =	Single command	C-SC-NA-1
●	<46>: =	Double command	C-DC-NA-1
●	<47>: =	Regulating step command	C-RC-NA-1
●	<48>: =	Set point command normalised value	C-SE-NA-1
●	<49>: =	Set point command scaled value	C-SE-NB-1
●	<50>: =	Set point command, short floating point value	C-SE-NC-1
❍	<51>: =	Bit-string of 32 bit	C-BO-NA-1
●	<58>: =	Single command with time tag CP56Time2a	C_SC_TA_1
●	<59>: =	Double command with time tag CP56Time2a	C_DC_TA_1
●	<60>: =	Regulating step command with time tag CP56Time2a	C_RC_TA_1
●	<61>: =	Set point command normalized value with time tag CP56Time2a	C_SE_TA_1
●	<62>: =	Set point command scaled value with time tag CP56Time2a	C_SE_TB_1
●	<63>: =	Set point command short floating point value with time tag CP56Time2a	C_SE_TC_1
❍	<64>: =	Bitstring of 32 bits with time tag CP56Time2a	C_BO_TA_1

Note:
Time tag command (ASDU 58 to 63) are managed as standard command (ASDU 45 to 50), i.e. the time tag is not used.

System information in monitor direction

(station specific parameter)

●	<70>: =	End of initialisation	M-EI-NA-1

System information in control direction

(station-specific parameter)

●	<100>: =	Interrogation commands	C-IC-NA-1
●	<101>: =	Counter interrogation command	C-CI-NA-1
❍	<102>: =	Read command	C-RD-NA-1
●	<103>: =	Clock synchronisation command	C-CS-NA-1
❍	<104>: =	Test command	C-TS-NA-1
●	<105>: =	Reset process command	C-RP-NA-1
❍	<106>: =	Delay acquisition command	C-CD-NA-1
●	<107>: =	Test command with time tag CP56time2a	C-TS-TA-1

Parameter in control direction

(station specific parameter)

❍	<110>: =	Parameter of measured value, normalised value	P-ME-NA-1
❍	<111>: =	Parameter of measured value, scaled value	P-ME-NB-1
❍	<112>: =	Parameter of measured value, short floating point value	P-ME-NC-1
❍	<113>: =	Parameter activation	P-AC-NA-1

File transfer

(station specific parameter)

- <120>: = File ready F-FR-NA-1
- <121>: = Section ready F-SR-NA-1
- <122>: = Call directory, select file, call file, call section F-SC-NA-1
- <123>: = Last section, last segment F-LS-NA-1
- <124>: = Ack file, ack section F-AF-NA-1
- <125>: = Segment F-SG-NA-1
- <126>: = Directory F-DR-TA-1

File transfer is only implemented in PC-hosted gateway.

Special use

(private range)

- <136>: = Data base version M-DB-NA-1
- <137>: = Regulating delay command C-RC-NB-1
- <138>: = Regulating delay command with time tag CP56Time2a C-RC-TB-1

Type identifier and cause of transmission assignments

(station specific parameters)

X	Mark type identification/cause of transmission combinations: 'X' if used
	Shaded boxes are not required
	Blank = function or ASDU is not used
~~X~~	Required in 1995 standard, suppressed in 2000.

Type ID		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1		X	X								X	X		X					
<2>	M_SP_TA_1																			
<3>	M_DP_NA_1		X	X								X	X		X					
<4>	M_DP_TA_1														~~X~~					
<5>	M_ST_NA_1		X	X								X	X		X					
<6>	M_ST_TA_1														~~X~~					
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1	X	X	X											X					
<10>	M_ME_TA_1																			
<11>	M_ME_NB_1	X	X	X											X					
<12>	M_ME_TB_1																			
<13>	M_ME_NC_1	X	X	X											X					
<14>	M_ME_TC_1																			
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1																			
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1																			

Type ID		Cause of transmission																		
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X								X	X							
<31>	M_DP_TB_1			X								X	X							
<32>	M_ST_TB_1			X								X	X							
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1			X																
<35>	M_ME_TE_1			X																
<36>	M_ME_TF_1			X																
<37>	M_IT_TB_1			X												X				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1			X																
<40>	M_EP_TF_1			X																
<45>	C_SC_NA_1						X	X	X	X	X							X	X	X
<46>	C_DC_NA_1						X	X	X	X	X							X	X	X
<47>	C_RC_NA_1						X	X	X	X	X							X	X	X
<48>	C_SE_NA_1						X	X	X	X	X							X	X	X
<49>	C_SE_NB_1						X	X	X	X	X							X	X	X
<50>	C_SE_NC_1						X	X	X	X	X							X	X	X
<51>	C_BO_NA_1																			
<58>	C_SC_TA_1						X	X	X	X	X							X	X	X
<59>	C_DC_TA_1						X	X	X	X	X							X	X	X
<60>	C_RC_TA_1						X	X	X	X	X							X	X	X
<61>	C_SE_TA_1						X	X	X	X	X							X	X	X
<62>	C_SE_TB_1						X	X	X	X	X							X	X	X
<63>	C_SE_TC_1						X	X	X	X	X							X	X	X
<64>	C_BO_TA_1																			
<70>	M_EI_NA_1				X															
<100>	C_IC_NA_1						X	X	X	X	X							X	X	X
<101>	C_CI_NA_1						X	X			X							X	X	X
<102>	C_RD_NA_1																			
<103>	C_CS_NA_1						X	X										X	X	X
<104>	C_TS_NA_1																			
<105>	C_RP_NA_1																			
<106>	C_CD_NA_1																			
<107>	C_TS_TA_1						X	X										X		
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1																			
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1													X				X		
<121>	F_SR_NA_1													X				X		
<122>	F_SC_NA_1					X								X				X		

Type ID		Cause of transmission																		
<123>	F_LS_NA_1												X				X			
<124>	F_AF_NA_1												X				X			
<125>	F_SG_NA_1												X				X			
<126>	F_DR_TA_1			X		X														
<136>	M_DB_NA_1																			
<137>	C_RC_NB_1						X	X	X	X	X							X	X	X
<138>	C_RC_TB_1						X	X	X	X	X							X	X	X

- COT <45>:= Unknown Cause of Transmission

4.5.7 BASIC APPLICATION FUNCTIONS

Station initialisation

(Station specific parameter)

- Remote initialisation

(Between Reset User ASDU's).

Cyclic data transmission

(Station specific parameter)

- Cyclic data transmission

(It's the same cyclic for all data).

Read procedure

(Station specific parameter)

- Read procedure

Spontaneous transmission

(Station-specific parameter)

- Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station specific parameter), each information is marked where both a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

Single point information	M_SP_NA_1, M_SP_TA_1, M_SP_TB_1, M_PS_NA_1
Double point information	M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1
Step position information	M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1
Bitstring of 32 bit	M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project)
Measured value, normalized value	M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1
Measured value, scaled value	M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1
Measured value, short floating point number	M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

General interrogation

(System or station-specific parameter)

- Global
- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8
- Group 9
- Group 10
- Group 11
- Group 12
- Group 13
- Group 14
- Group 15
- Group 16

Information Object Addresses assigned to each group must be shown in a separate table

Counter General interrogation

(System or station specific parameter)

- Global
- Group 1
- Group 2
- Group 3
- Group 4

Clock synchronisation

(Station specific parameter)

- Clock synchronisation

Command transmission

(Object specific parameter)

- Direct command transmission
- Direct set point command transmission
- Select and execute command
- Select and execute set point command
- C-SE ACTTERM used

- No additional definition
- ❍ Short pulse duration (duration determined by a system parameter in the outstation)
- ❍ Long pulse duration (duration determined by a system parameter in the outstation)
- ❍ Persistent output

Transmission of integrated totals

(Station or object-specific parameter)

- Mode A: local freeze with spontaneous.
- ❍ Mode B: local freeze with counter.
- Mode C: freeze and transmit by counter interrogation.
- ❍ Mode D: freeze by counter interrogation command, frozen values reported.
- Counter read
- Counter freeze without reset
- Counter freeze with reset
- Counter reset
- General request counter
- Request counter group 1
- Request counter group 2
- Request counter group 3
- Request counter group 4

Parameter loading

(Object-specific parameter)

- ❍ Threshold value
- ❍ Smoothing factor
- ❍ Low limit for transmission of measured value
- ❍ High limit for transmission of measured value

Parameter activation

(Object-specific parameter)

- ❍ Act/Desactivation of persistent cyclic or periodic transmission of the addressed object

Test procedure

(Station-specific parameter)

- ● Test procedure

File transfer

(Station-specific parameter)

File transfer in monitor direction

- ● Transparent file
- ❍ Transmission of disturbance data of protection equipment
- ● Transmission of sequences of events
- ❍ Transmission of sequences of recorded analogue values

Only in PC-hosted gateway

File transfer in control direction

- ● Transparent file

Background scan

(Station-specific parameter)

- ● Background scan

Acquisition of transmission delay

(Station-specific parameter)

- ❍ Acquisition of transmission delay

Management events priorities

(Station-specific parameter)

- ❍ Digital Inputs, Step-position, Analogues Inputs and Integrated Totals, management events priorities.

Definition of time outs

Parameter	Default value	Remarks	Selected value
t0	30s	Time out of connection establishment	configurable
t1	15s	Time out of send or test APDUs	configurable
t2	10s	Time out for acknowledges in case of no data messages t2 < t1	configurable
t3	20s	Time out for sending test frames in case of a long idle state	configurable

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

Maximum number of outstanding I format APDUs k and latest acknowledge

Parameter	Default value	Remarks	Selected value
K	12 APDUs	Maximum difference receive sequence number to send state variable	configurable
W	8 APDUs	Latest acknowledge after receiving w I-format APDUs	configurable

Maximum range of values k: 1 to 255 APDUs, accuracy 1 APDU

Maximum range of values w: 1 to 255 APDUs, accuracy 1 APDU (Recommendation: w should not exceed 2/3 of k).

Portnumber

Parameter	Value	Remarks
Portnumber	2404	In all cases, but configurable in Registry (only for Gateway PC)

RFC 2200 suite

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

- ● Ethernet 802.3
- ❍ Serial X.21 interface
- ❍ Other selection from RFC 2200

4.5.8 FRAME EXAMPLE

Binary counter reading
BCR:= CP40{Counter reading, Sequence notation}
Counter reading:= I32[1..32]<–231..+231–1> (Type 2.1)
Sequence notation:= CP8{SQ,CY,CA,IV}

bit		description	type	value
0…4	SQ	SeQuence number	UI5[33..37]<0..31> (Type 1.1)	
5	CY	CarrY (counter overflow occurs when the value increments from +231–1 to zero or from –231 to zero)	BS1[38]<0..1> (Type 6)	<0>:= no counter overflow occurred in the corresponding integration period
				<1>:= counter overflow occurred in the corresponding integration period
6	CA	Counter Adjustment (the counter is considered to have been adjusted if it is initialized to some value, e.g. set to zero or another value at startup).	BS1[39]<0..1> (Type 6)	<0>:= counter was not adjusted since last reading
				<1>:= counter was adjusted since last reading
7	IV	invalid	BS1[40]<0..1> (Type 6)	<0>:= counter reading is valid
				<1>:= counter reading is invalid

Example: Adjusted, valid => 0x40

Note: CA, CY and IV are only modified when the value is determined. This may be in response to a counter interrogation command or in response to an automatic internal function that performs the counter freeze or freeze and reset command.

4.6 SLAVE MODBUS (MODICON) PROFILE

The purpose of this chapter is to describe the support of the MODBUS RTU protocol in the DS Agile system.

The MODBUS RTU protocol defines a message structure that controllers will recognise and use. It describes the process a controller uses to request access to another device, how it will respond to requests from other devices, and how errors will be detected.

4.6.1 INTRODUCING MODBUS

Controllers communicate using a master-slave scheme, in which only the master (called SCADA) can initiate requests. The MODBUS gateway is a slave device that responds by supplying the requested data to the master.

Transmission mode used is the MODBUS RTU. Queries and replies have the same format on a master-slave query-response cycle:

Query message from Server		Response message from Slave
Function code		Function code
Eight-bit Data bytes		Eight-bit data bytes
Error check		Error check

4.6.1.1 DEVICE ADDRESS FIELD

The device address field of a message frame contains eight bits. Valid slave device addresses in queries are in the range 0 – 247, but individual slave devices are assigned addresses in the range 1- 247 and address 0 is reserved for broadcast operations.

The device address field of a message frame always identifies a slave (slave destination in master to slave queries and slave source in slave to master responses).

If the gateway receives a frame with a broadcast device address, no reply is returned.

If the gateway receives a frame with a not expected device address, no reply is returned.

4.6.1.2 FUNCTION CODE FIELD

The function code field of a message frame contains eight bits. Valid codes are in the range 1-255.

In master to slave queries, the function code identifies the operation that is to be executed by the slave.

In slave to master responses, the function code is used to indicate either a normal (error-free) response or a failure of the operation execution (called an exception response). For a normal response, the slave simply echoes the original function code. For an exception response, the slave returns a code that is equivalent to the original function code with its MSB set to 1. In addition to the modification of the function code the slave places a unique code into the data field of the response message, which identifies the reason for the exception.

4.6.1.3 DATA FIELD

The data field of a message frame is constructed using sets of two hexadecimal digits, in the range 00h to FFh.

In master to slave queries, the data field contains additional information to be used by the slave to execute the operation defined by the function code.

In slave to master responses, the data field contains the data requested by the master.

The data field can be non-existent in some kind of messages.

4.6.1.4 ERROR CHECK FIELD

The error-checking field contains a 16-bit value implemented as two 8-bit bytes [low significant byte first]. The error check value is the result of a Cyclical Redundancy Check [CRC] calculation performed on the message contents.

The gateway does not reply to corrupted data messages, i.e when the CRC is not correct or when parity is not correct.

4.6.2 SLAVE RESPONSES

4.6.2.1 WHEN THE SLAVE ANSWERS

Except for broadcast messages (no response in this case), when a master device sends a query to a slave device it expects a normal response.

One of four possible events can occur from the master's query:

- If the slave device receives the query without communication error, and can handle the query normally, it returns a normal response.
- If the slave does not receive the query due to a communication error, no response is returned. The master program will process a timeout condition for query.
- If the slave receives the query, but detect a communication error [bad CRC or framing error for example], no response is returned. The master program will process a timeout condition for query.
- If the slave device receives the query without communication error, but cannot handle it, the salve will return an exception response informing the master of the nature of the error.

4.6.2.2 EXCEPTION RESPONSES CODES

The exception code is sent as an 8-bit data, the range of valid codes is 1-8 in the protocol.

Supported exception responses codes are:

Code	Name	Meaning
01	ILLEGAL FUNCTION	The function code received in the query is not an allowable action for the slave. An illegal function will be send in the main following cases: An unsupported request [see after, the table with the functions supported] An unsupported sub-function code for Diagnostic request
02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the slave. An illegal data address will be send in the main following cases: A read coil / input status starting to a none existent point in configuration A read holding registers / input registers starting to a none existent point in configuration A force coil / multiple coils request starting on an non-configured address. A preset single / multiple register(s) on an non-configured point
03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for the slave. An illegal data value exception will be send in the main following cases: An illegal value received in force coils request (so value different from FF00h and 0000h) Illegal count value for multiple preset registers
04	SLAVE DEVICE FAILURE	Not used in the gateway
05	ACKNOWLEDGE	Not used in the gateway
06	SLAVE DEVICE BUSY	Not used in the gateway
07	NEGATIVE ACKNOWLEDGE	The slave cannot perform the program function received in the query. A negative acknowledge will be send in the main following cases: Some errors in the frame A read coil / input status on more than 2000 points Force coil refused if command is incorrect or cannot be executed (equipment absent, invalid, in local, …)
08	MEMORY PARITY ERROR	Not used in the gateway

4.6.3 SERIAL TRANSMISSION MODE

When messages are transmitted on standard MODBUS serial networks, each byte is sent LSB first.

The format for each byte in MODBUS RTU mode is:

- **Coding system:** 8-bit binary, hexadecimal 0-9, A-F
  Two hexadecimal characters contained in each 8-bit field of the message
- **Bits per Byte:** 1 start bit8 data bits,
  LSB sent first2 stop bits if no parity, or 1 parity bit and 1 stop bit)
- **Error Check Field:** Cyclical Redundancy Check (CRC-16)

4.6.4 MODBUS FUNCTIONS

MODBUS defines 24 functions, valid codes are in the range of 1-24.

4.6.4.1 SUPPORTED FUNCTIONS

Code	Function name	Supported
01	READ COIL STATUS [identical to function code 02]	YES
02	READ INPUT STATUS [identical to function code 01]	YES
03	READ HOLDING REGISTERS [identical to function code 04]	YES
04	READ INPUT REGISTERS [identical to function code 03]	YES
05	FORCE SINGLE COIL	YES
06	PRESET SINGLE REGISTER	YES
07	READ EXCEPTION STATUS	YES
08	DIAGNOSTICS [only sub function 0 is supported]	YES
09	PROGRAM 484	NO
10	POLL 484	NO
11	FETCH COMM. EVENT CTR.	NO
12	FETCH COMM. EVENT LOG	NO
13	PROGRAM CONTROLLER	NO
14	POLL CONTROLLER	NO
15	FORCE MULTIPLE COILS [identical to function code 05, one point only]	YES
16	PRESET MULTIPLE REGISTERS [identical to function code 06, one point only]	YES
17	REPORT SLAVE ID	NO
18	PROGRAM 884/M84	NO
19	RESET COMM. LINK	NO
20	READ GENERAL REFERENCE	NO
21	WRITE GENERAL REFERENCE	NO
22	MASK WRITE 4X REGISTER	NO
23	READ/WRITE 4X REGISTERS	NO
24	READ FIFO QUEUE	NO

4.6.4.2 GENERAL FORMAT OF MODBUS FUNCTIONS

A query message typically contains some of the following 8-bit fields:

- Starting Address Hi
- Starting Address Lo
- No. of Registers / Points Hi
- No. of Registers / Points Lo
- Force / Preset Data Hi
- Force / Preset Data Lo

A response message typically contains some of the following fields:

- Byte Count *
- Data
- Data Hi
- Data Lo
- No. of Registers / Points Hi
- No. of Registers / Points Lo
- Force / Preset Data Hi
- Force / Preset Data Lo

(*) Byte Count Field:A Byte Count Field is used in slave responses to indicate the number of 8-bit bytes in the Data field; the value is exclusive of all other field contents, including the Byte Count field.

4.6.4.3 MODBUS DATA ADDRESSES

Point addresses in the data field are 16-bit values in the range 0 – 65535 for each item type.

That's means that you can have a coil item configured at address 100 for example, and a holding register item configured at address 100 too.

Starting addresses in queries from SCADA may begin from address 0.

Example: request to read the 16 first coils on device 17.

Slave address	11
Function	01
Starting Address HI	00
Starting address LO	00
Number of points HI	00
Number of points LO	10
CRC	XX

4.6.5 FUNCTION 01 / 02: READ COIL STATUS – READ INPUT STATUS

The request function 01 or 02 reads the ON / OFF status of digital inputs in the slave. These status may be any digital points (physical, automations, system information, grouping, …).

These two functions are the only way to read digital points with the MODBUS protocol. Sequence of events, digital flags (validity, topical, ..) are not supported.

This is equal using the Read Coil Status request or the Read Input Status request.

Broadcast is not supported.

Addresses in frames may start from 0…65535.

Query:

Slave Address	Function Code = 01	Starting Address (H)	Starting Address (L)	No. of Points (H)	No. of Points (L)	CRC (L)	CRC (H)

The query message specifies the starting coil address and the quantity of coils to be read.

Response:

Slave Address	Function Code = 01	Byte Count = <nbytes>	Data Byte #1	Data Byte #i	Data Byte #nbytes	CRC (L)	CRC (H)

The coil or status in the response message is packed as one coil per bit of the data field.

Digital inputs can be single (coded on one bit) or double (in this case 1 or 2 bits defined in configuration).

For Single DI or Double DI coded on one bit, status is indicated as: 1 = ON, 0 = OFF.

For double DI coded on two bits, status indicates: [open contact, closed contact] = [0,1] for open, [1,0] for closed, [0,0] for jammed], [1,1] for the other states

The less significant bit of the first data byte contains the coil addressed in the query. The other coils follow toward the high order end of this byte, and from 'low order to high order' in subsequent bytes, as described in the frame example.

Important notes:

- If the returned coil quantity is not a multiple of eight, the remaining bits in the final byte will be padded with zeros (toward the high order end of the byte). The Byte Count Field specifies the quantity of complete bytes of data.
  For easiest understanding between the gateway and the SCADA, it is recommended to read a number of points which is a multiple of 8.
- If the starting address is not a point in configuration, the message will be not be accepted, and an error exception 2 will be returned.
- If the starting address is in configuration and if there is some “holes” (addresses not in configuration) theses holes will be padded with 0 (i.e value OFF).

4.6.6 FUNCTION 03 / 04: READ HOLDING REGISTERS / INPUT REGISTERS

The request function 03 or 04 reads the values of analogue inputs, tap position and counters values in the slave.

In case of tap position and counters values, only natural coding is supported.

These two functions are the only way to read registers points with the MODBUS protocol. Flags (validity, topical, ..) are not supported in the MODBUS protocol base.

This is equal using the Read Holding Registers request or the Read Input Registers request.

Broadcast is not supported.

Addresses in frames may start from 0…65535.

Query:

Slave Address	Function Code = 03	Starting Address (H)	Starting Address (L)	No. of Points (H)	No. of Points (L)	CRC (L)	CRC (H)

The query message specifies the starting register and the quantity of registers to be read.

Response:

Slave address	Function code = 03	Byte Count = <nbytes>	Data (H) #1	Data (L) #1	Data (H) #i	Data (L) #i	Data (H) #nbytes/ 2	Data (L) #nbytes/2	CRC (L)	CRC (H)

The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

Important notes:

- If the starting address is not a point in configuration, the message will be not be accepted, and an error exception 2 will be returned.
- If the starting address is in configuration and if there is some “holes” (addresses not in configuration) theses holes will be padded with the value 0

4.6.6.1 SIGNED NORMALISED CODING

The signed normalised coding is used to encode the 16 bits-registers. Analogue maximal value will be coded 7FFFh (decimal value + 32767), and minimal value will be coded 8000h (decimal value –32768).

For this mode, the gateway may now code the value on 8 to 16 bits [low part of the register will be used]. But, 16 bits is normally the standard to use the full scale conversion.

Example:

in configuration the maximal value for an analogue point is +3000 and minimum value for this analogue is 0.

That means that when the analogue is received with value 0 from the system, the gateway will send to the SCADA the register with 8000h value. If this analogue is equal to the maximal value +3000, the value sent to the SCADA is 7FFFh. Calculation is linear for the coding between the min and max values.

4.6.6.2 UNSIGNED NORMALISED CODING

The unsigned normalised coding is used to encode the 16 bits-registers. Analogue maximal value will be coded FFFFh (decimal value + 65535), and minimal value will be coded 0000h (decimal value 0).

For this mode, the gateway may now code the value on 8 to 16 bits [low part of the register will be used]. But, 16 bits is normally the standard to use the full scale conversion.

Example:

in configuration the maximal value for an analogue point is +3000 and minimum value for this analogue is 0.

That means that when the analogue is received with value 0 from the system, the gateway will send to the SCADA the register with 0h value. If this analogue is equal to the maximal value +3000, the value sent to the SCADA is FFFFh. Calculation is linear for the coding between the min and max values.

4.6.6.3 NATURAL CODING

The natural coding is used to encode data without any calculation. That's means that integer value will be send.

Example:

if the gateway receives the value 10.xxxx, the value 0Ah will be set in the appropriate register. The gateway receives the value –10,xxxx the value FFF6h will be coded. Sent values are considered as signed values which are included between –32768 and +32767.

When minimum and maximum values are reached values FFF6h and FFFFh are respectively sent.

4.6.7 FUNCTION 05: FORCE SINGLE COIL

This request function 05 is used to realise a control on an address point.

When broadcast, the function forces the same coil reference in all attached slaves.

Query:

Slave Address	Function Code = 05	Point Address (H)	Point Address (L)	Force Data (H)	Force Data (L)	CRC (L)	CRC (H)

The query message specifies the coil reference to be forced. Points addresses are between 0…65535. The requested ON / OFF state is specified by a constant in the query data field.

A value of FF00h requests the coil to be ON.

A value of 0000h requests it to be OFF.

Response:

Slave Address	Function Code = 05	Point Address (H)	Point Address (L)	Force Data (H)	Force Data (L)	CRC (L)	CRC (H)

The normal response is an echo of the query, returned after the command has been sent to the system.

Note:
If value is incorrect, or if the control is refused for any reason (equipment absent, equipment present and in local mode, equipment invalid, …) an exception error 7 is returned.

4.6.8 FUNCTION 06: PRESET SINGLE REGISTER

This request function 06 is used to preset a value in a register.

Query:

Slave Address	Function Code = 06	Point Address (H)	Point Address (L)	Force Data (H)	Force Data (L)	CRC (L)	CRC (H)

The query message specifies the register address to be preset. Points addresses are between 0…65535. The requested value is specified by in the query data field.

Response:

Slave Address	Function Code = 06	Point Address (H)	Point Address (L)	Force Data (H)	Force Data (L)	CRC (L)	CRC (H)

The normal response is an echo of the query, returned after the register has been preset.

Note:
Only natural setpoints are managed by this function (no scaling is done)

4.6.9 FUNCTION 08: DIAGNOSTIC [SUB-FUNCTION 0 ONLY]

This request function 08 sub-function 0 is used to test the transmission.

Query:

Slave Address	Function Code = 08	Sub Function code (H)	Sub Function code (L)	Data (H)	Data (L)	CRC (L)	CRC (H)

The query message specifies the data that will be echoed.

Response:

Slave Address	Function Code = 08	Sub Function code (H)	Sub Function code (L)	Echoed Data (H)	Echoed Data (L)	CRC (L)	CRC (H)

The normal response is an echo of the query with the same data send in the request.

Note:
If the sub-function is different from 0, an exception error "illegal function" is returned.

4.6.10 FUNCTION 15: FORCE MULTIPLE COILS

Normally, this request function 15 is used to realise a control on several contiguous addresses.

This function can be used, but only one control can be send at the same time.

Note:
Only a count number equal to 1 is allowed, otherwise an exception error 3 will be replied.

4.6.11 FUNCTION 16: PRESET MULTIPLE REGISTERS

Normally, this request function 16 is used to preset on several contiguous addresses.

This function can be used, but only one preset can be send at the same time.

Note:
Only a count number equal to 1 is allowed, otherwise an exception error 3 will be replied.

5 COMMUNICATIONS BETWEEN A C26X–STANDALONE UNIT AND A DS AGILE GATEWAY

The Slave profile of the C26x–Standalone unit is the same as for SCADA communications using IEC 60870-5-101 protocol (T101).

6 COMMUNICATIONS WITH LEGACY IEDS

6.1 OVERVIEW

Different types of IEDs are connected to a C26x through networks using various legacy protocols:

- IEC 60870-5-103 (T103)
- Modbus
- DNP3
- IEC 60870-5-101 (T101)

All these networks use a serial link to communicate with IEDs. As there are several serial links on a C26x, it is possible to have:

- Different protocols running in parallel on different links
- The same protocol on several links

All these networks use a Master / Slave protocol where the C26x is the Master. So, there are two kinds of exchange:

- Request / reply
  Master emits a request to a slave of its choice and wait for the response. Between master and slave, only one transaction can be initiated. Then, in order to transmit the same request to two different slaves, two transactions are required.
- Broadcast
  Master transmits a command to all of slaves connected to the network. They perform it without send any response.

Common features to all IEDs and all protocols are specified below.

Specific features to each protocol are specified in subsequent paragraphs.

6.2 IED COMMON FUNCTIONALITY

6.2.1 INTERFACE TO IEDS

6.2.1.1 INPUT

Data	Note
Digital input	Treated
Measurement	Treated
Default position	Depending on the protocol
Counter	Treated
Tap position	Treated
Control acknowledgement	Treated
Setpoint acknowledgement	Treated
Alarm	Not Treated
Disturbance record	Depending on the protocol

6.2.1.2 OUTPUT

Data	Note
Control	Treated
Setpoint	Depending on the protocol
Alarm acknowledgement	Not Treated
Time synchronisation	Treated

6.2.2 BEHAVIOUR

6.2.2.1 NETWORK SUPERVISION

The number of networks and IEDs is known by configuration.

Each network is managed independently of the other networks.

The management of a network consists of:

- Initialising the serial line
  At start-up of the network monitoring, the serial line has to be initialised according to the configuration.
- Synchronising the IEDs connected to the network.
- Polling the IEDs
  This polling allows to connect IEDs, to exchange data with IEDs and to monitor the connection of IEDs.
- Performing the monitoring of the each IED connected to this network.
  Each IED is managed independently of the other IEDs. The state of each IED, i.e. connected, disconnected, is monitored and every state change is signalled to the C26x management function.

6.2.2.2 TIME SYNCHRONISATION

If the network has to be synchronised, the synchronisation is performed in one of two ways:

1 At connection of an IED, a synchronisation frame is sent to this IED.

2 Regularly, a synchronisation frame is broadcasted on the network.

When this is supported by the IEDs, the calculation of the transmission delay is performed.

Note:
The synchronisation is a network attribute [not an IED attribute]. That means, that the synchronisation is either sent to all the IEDs, or is not sent.

6.2.2.3 POLLING OF IEDS

Once the line is initialised, the C26x has to try to connect IEDs and to manage exchanges of data with each IEDs.

That's done by polling: cyclically the C26x questions each IED one after the other.

The polling manages the following items:

- Sequencing the interrogation of the IEDs
- Connection of an IED [when a disconnected IED responds, it becomes Connected]
- Repetitions [if an IED does not reply to a request, this request will be repeated the next cycle]
- Disconnection of an IED [after N questions without answer, an IED becomes Disconnected]
- Maximum time to wait for a response
- Minimum time between two frames on the network
- Sending functional requests to IEDs

Optimisation of polling may be done according to the followings ideas:

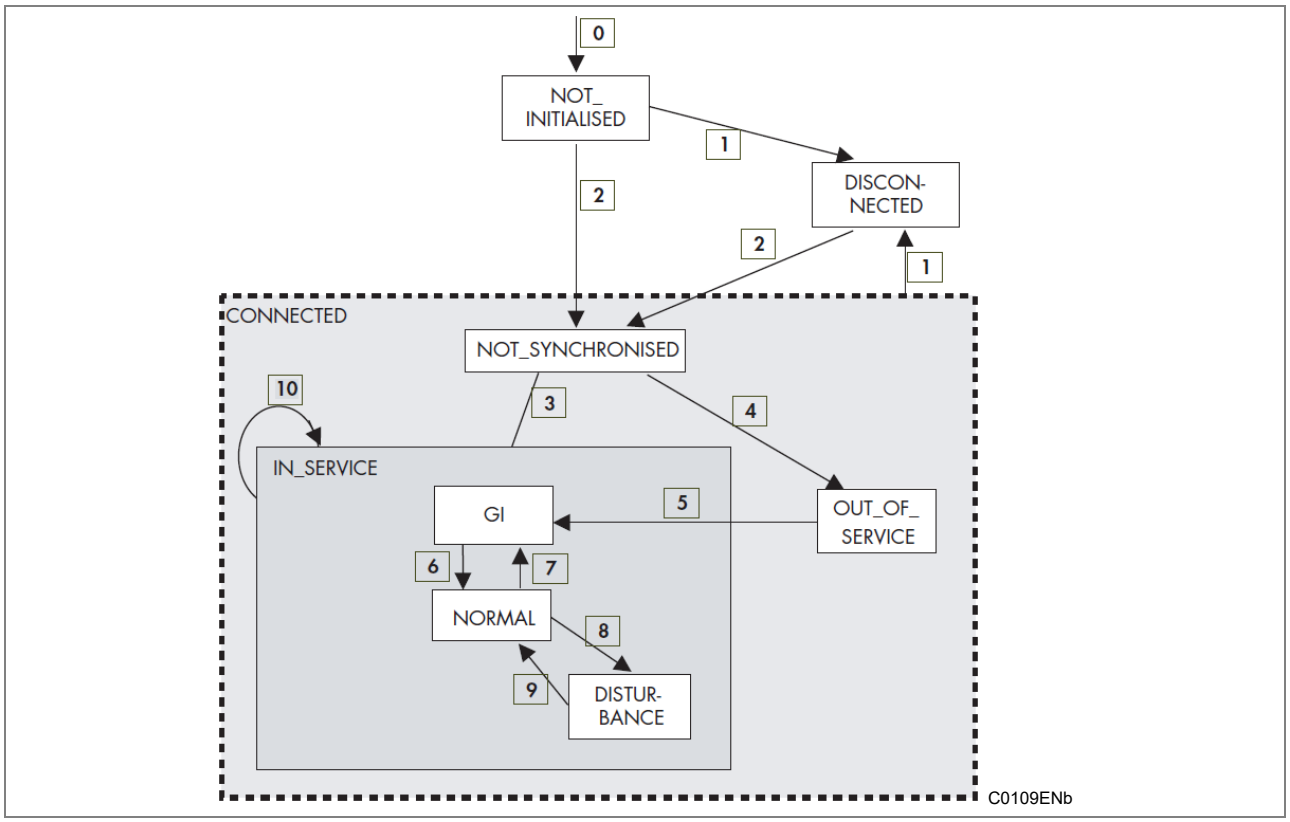
- When an IED is disconnected, it may be questioned only time to time [not all cycles]
- When an IED has important data to transmit [DI], it may be questioned successively several times
- The maximum time to wait an answer may be configurable

The polling sequencing may be only stopped in the two following cases:

- Time synchronisation
  Synchronisation is done periodically by sending a broadcast frame. After the synchronisation frame has been sent, the polling starts again.
- Remote control to transmit to a slave
  Control is a priority request. So, when a control must be sent to an IED, the polling is stopped, the control is sent and the polling starts again.

6.2.2.4 MONITORING OF AN IED

Each IED is managed according to the following graph:



Description of the possible states of an IED:

- NOT_INITIALISED: That's the initial state of an IED. The C26x polls the IED every cycle in order to connect it.
  If the IED responds, it becomes CONNECTED [2].
  If after some attempts the IED does not respond, it becomes DISCONNECTED [1].
- DISCONNECTED: The IED is disconnected. The C26x polls the IED time to time in order to connect it.

  If the IED responds, it becomes CONNECTED [2].
- CONNECTED: The IED is connected. This state includes several states. When an IED becomes Connected, it goes to the NOT_SYNCHRONISED state.
- NOT_SYNCHRONISED: The IED has just became Connected. It must be synchronised. Once it is synchronised, according to the information given by the IED, it becomes IN_SERVICE [3] or OUT_OF_SERVICE [4]. (This information is not available for some protocols. In this case, the IED becomes IN_SERVICE by default).
- OUT_OF_SERVICE: The IED is connected and says it is Out of service. The C26x polls the IED time to time waiting for the IED to become IN_SERVICE [5].
- IN_SERVICE: The IED is connected and it says it is In Service. This state includes several states. When an IED becomes In Service, it goes to the GI state.
- GI: The IED is In Service and a General Interrogation is in process.
  For each information received during the GI, the information becomes available and its state is

transmitted to the application [see below for more information on GI treatment].
At the end of the GI, the IED goes in the NORMAL state 6.

- NORMAL: The IED is In Service and the monitoring of DI, AO and DO are performed.
  If a disturbance record becomes present and the C26x have enough places to store the file, the IED goes in the DISTURBANCE state 8.
  Time to Time, a GI may be done. In this case the IED goes in the GI state 7.
- DISTURBANCE: The IED is In Service and a disturbance record is being uploaded.
  When the uploading of the disturbance file is finished, the IED goes back in the NORMAL state 9.

That shows that GI and Disturbance uploading are mutually exclusive. That is done to limit the overload of the network

Description of the transitions between states:

- 0: Initialisation of the transmission.
- 1: The IED becomes DISCONNECTED.
  The disconnection is signalled to the application.
  Every data normally received from the IED is marked as unknown and a state change is signalled for each one.
- 2: The IED becomes CONNECTED.
  A synchronisation frame is sent to it and after, the status of the IED is red.
- 3: The status of the IED indicates that the IED is In Service.
  A General Interrogation is activated.
- 4: The status of the IED indicates the IED is Out Of Service.
- 5: see 3
- 6: The general Interrogation is finished.
- 7: A general Interrogation is activated [cyclical GI].
- 8: A disturbance file is available in the IED and there is enough available space to store it in the C26x.
  A disturbance upload is initiated.
- 9: End of disturbance file upload.
- 10: Request to send a control command to the IED.
  Polling is interrupted and the command is sent as soon as possible.

Initialisation procedure

Initially, all data normally received from an IED is marked as unknown. When an IED is first connected, a general interrogation request is sent. A table is updated with data received in response to the general interrogation. When the general interrogation is finished, the content of the table is sent to the processing functions: binary inputs processing and measurement treatment. Messages received subsequently are checked against the content of the table and a state change message is sent when there is a difference.

General interrogation

A general interrogation is performed:

- at initialisation time,
- upon reconnection,
- cyclically [optional].

Messages received during the initial general interrogation are not sent to the processing function. Instead the content of the table is sent at the end of the sequence.

Messages received during a general interrogation performed after the initialisation sequence are immediately sent to the processing function.

Some IEDs send a message indicating the end of the response to a general interrogation. When this message is received, the sequence is considered as complete. If the IED does not send this message, the C26x must check that all of the data is received.

If not all of the data is received within a given time another request is sent. This process can be repeated N times. If the response is still not received after N times a fault message is sent, however the IED is still polled.

Disturbance File Management

The following rules apply for the management of the Disturbance Files of the IED:

- For each IED, there is a parameter in the configuration indicating whether disturbance files should be automatically downloaded. This parameter may be overruled by a command from the application.
- When the C26x detects that an IED has a Disturbance File ready for download and that automatic download is enabled, it downloads and stores it. When the download is complete, an indication is sent to the Upper level transmission management task to inform it that a Disturbance file is ready for upload.
- When there is not enough available space to store a Disturbance File, the oldest file is overwritten.
- Only Disturbance files stored in the C26x can be transmitted to the upper level. Once a file has been uploaded, it is deleted.

Note:
IED disturbance files are stored in volatile memory (in the "/RAMDEV/PERT_IED/" folder) and are deleted whenever the C26x is powered off or rebooted.

6.2.3 DATA RECEIVED FROM IEDS

After the initialisation sequence, IEDs are polled regularly. Depending on the type of IED the current state of data can be received as state messages, or as state change messages.

When a state message is received, the content is checked against the table and if there is a difference a message is sent to processing functions and the table is updated. In this case, the C26x time stamps the change.

When a state change message is received, the table is updated and the message is transmitted to processing functions. In this case, the time stamping is made by the IED.

The data, which can be received from IEDs, are detailed in the paragraphs below.

6.2.3.1 DIGITAL INPUTS

Digital inputs can be received as states or as state changes. The choice between state and state change depends on the IED and on the protocol. This is known by configuration.

Even if digital inputs are received as state change, it is still possible to request data as states for general interrogations.

The conversion from digital input to binary input is performed by the binary input processing function. A digital input can be associated with a single point or a double point.

6.2.3.2 MEASUREMENTS

Measurements can be received in various formats: float, binary, BCD, etc. The received value is converted into an internal format, which is common to all measurements in the C26x.

Measurements can be received as periodical messages or as state changes: variation, threshold, and invalidity.

A message is sent to the processing function whenever a measurement is received from an IED.

6.2.3.3 COUNTERS

Counters are treated for DNP3.0

6.2.3.4 TAP POSITION

Tap position are treated like measurements

6.2.3.5 DISTURBANCE FILE

The C26x stores disturbance files as they are sent by IEDs without control of the format of the Disturbance Files (Comtrade, …).

6.2.4 DATA SENT TO IEDS

After the initialisation sequence, data can be sent to IEDs. The type of data, which can be sent to IEDs, is described in subsequent paragraphs.

6.2.4.1 CONTROLS

Controls are priority message. The polling sequence must be interrupted in order to send the control as soon as possible.

Not all IEDs send control acknowledgement. If they do not, an acknowledgement is simulated and sent to the handling of control sequences function.

When an IED is disconnected [or out of service] a negative acknowledgement is sent.

If the command is a “select before operate” command, the application must send two commands to the transmission software: the first one for the selection and the second for the execution.

If the command is a double command, the application sends one order, and depending on the protocol, two cases have to be distinguished:

- The Double command is referenced only once in the IED Mapping. In this case, if an OPEN (respectively CLOSE) command is received from the application, the master send an OFF (respectively ON) order to the IED at the corresponding address.
- The double command is referenced by two addresses in the IED Mapping: one refers to the Open Contact and the other to the Close Contact. In this case, if an OPEN (respectively CLOSE) command is received from the application, the master sends an ON order to the IED, at the address corresponding to the Open Contact (respectively Close Contact).

6.2.4.2 SETPOINTS

SP controls are priority message. The polling sequence must be interrupted in order to send the SP control as soon as possible.

Not all IEDs send SP control acknowledgement. If they do not, an acknowledgement is simulated and sent to the handling of SP control sequences function.

When an IED is disconnected [or out of service] a negative acknowledgement is sent.

If the SP commands are always "direct execute" command (no “select before operate”).

For an IED, only one SP command is possible at a time.

6.2.5 LIMITS AND SPECIFICATIONS

- The number of serial links available limits the number of legacy network that can be managed simultaneously by a C26x.
- The maximum number of IED that can be managed for a network is 16.
- Specifications depend on the used protocol and on the number of IEDs connected to each network.

6.3 MODBUS COMMUNICATIONS

6.3.1 SCOPE OF THIS SECTION

MODBUS is a legacy bus master/slave protocol that is used by many devices such as relays, controllers or monitoring devices. The aim of this section is not to describe the protocol itself and its mechanisms, but to describe the functions implemented in the C26x:

- available function numbers
- the way in which each type of data is internally or externally updated
- general mechanisms used for the synchronisation

The protocol is implemented in various ways:

- Generic: this implementation allows connecting most types of IED to a MODBUS network
- Legacy: this implementation is based on the legacy rules (M300, Px2x series, Px4x series)
- Particular IEDs: M230, Rish Pro M10, ABB-Flexgate, Sepam 40 and 80, WAGO

6.3.2 POLLING CYCLES

IEDs' measured values:

The time interval between general interrogations is of at least 1 second. It could be longer if the number of polled IEDs is such that polling takes more than 1 s.

Datapoint values:

The time interval between general interrogations is of at least 200 ms. It could be longer if the number of polled datapoints is such that polling takes more than 200 ms.

6.3.3 GENERIC MODBUS COMMUNICATIONS

The generic communications function is the common base to most IEDs. The following MODBUS functions are implemented in the C26x:

Function No.	Sub-code	Used to	Details
1 – 2	/	Read DIs	Read N bits
3 – 4	/	Read AIs /DIs	Read N words
5	/	Write DO	Write 1 bit
15	/	Write DOs	Write N bits Restriction: write DOs after one another
7	/	Poll status	Read status byte Used to detect a DI state change
8	0	Poll presence	Echo Alternative to detect if a device is connected or not

The disturbance files are not treated. Function 7 cannot be used fully or at all with a number of IEDs (e.g.Rish Pro M10, Flexgate); they require a specific treatment.

6.3.3.1 POLLING AND CONNECTION TEST

All the slaves are polled after one another. This means that the C26x waits for the answer to each polling request sent to a device before sending a new request to the same or another device.

There are 2 types of polling:

- the polling for the measurements and the digital inputs (functions 1 to 4) or the byte status (function 7)
- the polling for IEDs presence (low level polling)

If an IED does not correctly answer after a user-configurable timeout, the C26x repeats the request.

If the IED does not correctly answer after a defined number of retries, it is considered as disconnected. This status is updated by low-frequency polling.

Depending on configuration, the C26x tests the connections with:

- function 7
- functions 1 to 4 (DIs)
- functions 3 to 4 (AIs)
- function 8 (mirror frame)

or uses a user-defined frame.

6.3.3.2 DATA RECEIVED FROM IEDS

6.3.3.2.1 AIs

The C26x polls the AIs at a defined frequency.

A block of measurements is a set of measurements mapped at consecutive addresses. As a result, all of them are read in one exchange.

The C26x supports 18 formats of Analogue Inputs:

Format	Description	Comment
INT8_LB	Signed integer on 8 bits	Modbus does not provide a 'Read byte' function. So, a 'Read word' function is used. LB and HB indicate which byte in the word is used (resp., Low/High)
INT8_HB		
UINT8_LB	Unsigned integer on 8 bits	
UINT8_HB		
INT16	Signed integer on 16 bits	
UINT16	Unsigned integer on 16 bits	
INT32_LW_LB	Signed integer on 32 bits	The first pair of letters indicates which word is sent first: the lower word (LW) or the higher word (HW). The second pair of letters indicates which byte is sent first in a word: the lower byte (LB) or the higher byte.
INT32_LW_HB		
INT32_HW_LB		
INT32_HW_HB		
UINT32_LW_LB	Unsigned integer on 32 bits	
UINT32_LW_HB		
UINT32_HW_LB		
UINT32_HW_HB		
REAL32_LW_LB	Float IEEE754 on 32 bits	
REAL32_LW_HB		
REAL32_HW_LB		
REAL32_HW_HB		

6.3.3.2.2 DIs

A block of DIs is a set of DIs mapped to consecutive addresses. As a result, all of them are read in one exchange.

By default, the function 1-2 polls for DI blocks. the C26x compares each DI state with the latest state and time stamps the potential state change.

6.3.3.3 DATA SENT TO IEDS

6.3.3.3.1 Connection check

Generic IEDs

Each device on the network is regularly polled with a specific frame to know if it is connected or not. This frame could be the status byte polling frame if it exists, the measurement polling frame if it exists, the BI polling frame if it exists, the mirror frame if it has been implemented in the device or a user defined frame. This choice is performed through the configuration options.

MiCOM IEDs

The “Read status byte” frame is used for checking the connection of the device.

6.3.3.3.2 Clock synchronisation

All the devices connected to a given network must use the same synchronisation method (and the same address and time-date format) because the C26x synchronises them through a broadcast frame.

Synchronisation is not specified generically and no calculation of the transmission delay is performed.

6.3.3.3.3 DOs

Commands are sent to the IED and have the highest priority level.

They have to be transmitted to the destination device as fast as possible.

The C26x waits for an acknowledgement (answer of the IED).

If the acknowledgement is not received after a defined timeout, the C26x considers that the command has not been taken into account.

6.3.3.4 ERROR MANAGEMENT

The MODBUS protocol handles a mechanism of exception answer. This means that an IED answers with an exception frame if it does not understand the request. There are different exception codes:

Exception code	Description	C26x processing
01	Illegal function	Reports a "Configuration error” and continue
02	Illegal data address	Reports a “Configuration error” message and continues
03	Illegal data value	Reports a “Configuration error” message and continues
04	Slave device failure	Reports an “IED error” message
05	IED busy due to a long processing duration	Retries after a defined time-out
06	IED busy	Retries after a defined time-out
07	Processing not possible	Reports an “IED error”
08	IED memory parity error	Reports an “IED error”

6.3.3.5 LIMITS AND SPECIFICATIONS

The specifications depend a lot on the number of devices connected on the network. It is advised to connect devices that have similar specifications on a given network, i.e. the same reply time for instance.

Each device on a MODBUS network must have the same synchronisation mode.

6.3.4 LEGACY MODBUS COMMUNICATIONS

Three ranges comply with the legacy rules:

- M300: Energy analyzer and measurement central unit
- Px2x: MiCOM S20
- Px4x: MiCOM ALSTOM S40

Function No.	Sub-code	Used to	Details
1 – 2	/	Read DIs	Read N bits
3 – 4	/	Read AIs /DIs	Read N words
5	/	Write DO	Write 1 bit
15	/	Write DOs	Write N bits Restriction: write DOs after one another
7	/	Poll status	Read status byte. Used to detect a DI state change and the presence of disturbance files
8	0	Poll presence	Echo Alternative to detect if a device is connected or not

6.3.4.1 STATUS BYTE

The connection is tested using the function 7.

Bit No	Description	Detail	Event generated
b0	General state of the device	1 = active, 0 = not active	Yes
b1	Presence of a minor failure (*)	1 = present / 0 = absent	Yes
b2	Presence of a not acknowledged time-stamped event	1 = present / 0 = absent	No
b3	State of synchronisation (**)	1= synchronised, 0= out of synchronisation Compatible with relays OPN7000, MODN	Yes
b4	Presence of a not extracted Disturbance record	1= present, 0 = absent Compatible with relays OPN7000, MODN	Yes on Set
b5	Presence of a not extracted Fault record	1 = present / 0 = absent	Yes on Set
b6	Trip Alarm Set	1= a trip has occurred, not acknowledged	No
b7	Alarm Set	1= at least one alarm bit in the front panel alarm cell not acknowledged	No

If a bit of this status has no significance for the equipment, this bit is fixed to 0.

Any state change generates an event. Except for b2 set/reset, b4 and b5 reset, b6 and b7 set/reset.

* indicates a device failure ("SRAM Failure"…) and generates an event.

** 0 indicates that synchronisation was not received or not understood since 1 min, according to protection criteria (by MODBUS or IRIG-B synchronism). This rule covers potential drift of 10 ms of non synchronised device. “Loss of synchronisation” has a major impact in all events treatment. All the events coming from a device that has lost its synchronisation need special treatment in substation chronological list of events. This particular event helps determine also any network disconnection in the device history.

6.3.4.1.1 Events buffer management

The IEDs store the events, Fault Records, Disturbance files in a circular buffer of various sizes.

When the C26x acknowledges an event, a FREC or Disturbance file, the IED clears the memory for future events, FREC …

When all events, FREC, DR have been cleared from buffer, the corresponding bit is reset in the status byte without generating any event.

If a device is disconnected, the buffering function saves all of history. If one of its buffers gets filled up then the IED:

- generates an event to inform that this buffer is full,
- erases the oldest event if the queue is full
- sends a saturation reset event when the buffer is not full any more.
- replaces the oldest data in the full buffer by the newest ones (event, FREC, Disturbance file).

6.3.4.1.2 M300

The bits have other meanings:

- Bit 0: Availability of a Disturbance record [0 = not available; 1= available]
- Bit 4: 0 = active; 1 = inactive
- Bit 5: 1 = Presence of Event
- Bit 6: 1 = Presence of Alarm.

6.3.4.1.3 MiCOM Alstom S40 (Px4x series)

The status can be read with function 3 or 4 in register 3x00001 (@ 0). The table below shows this 16-bit status:

Bit No	Value/bit mask	Meaning	Conform
0	0x0001	Presence Status (1 = present / 0 = mute)	OK
1	0x0002	Minor Self Test Failure (1 = Failure / 0 = No failure)	OK
2	0x0004	New event available (1 = Available / 0 = Not Available)	OK
3	0x0008	Clock synchronization (=1 after Modbus sync. Resets to 0 after 5 minutes unless it is synced again. Other time sources do not affect this bit)	OK
4	0x0010	New auto extraction disturbance record available (1 = Available / 0 = Not available)	OK
5	0x0020	Fault (Not used - always 0).	NOK
6	0x0040	Trip LED status (1 = LED on, 0 = LED off)	-
7	0x0080	Alarm status summary (logical OR of all alarm status bits)	-
8	0x0100	Unused	-
9	0x0200	Unused	-
10	0x0400	Unused	-
11	0x0800	Unused	-
12	0x1000	Unused	-
13	0x2000	Unused	-
14	0x4000	Unused	-
15	0x8000	Unused	-

Even if the access function (3 or 4 instead of 7) does not comply with the internal MODBUS rules, the events can still be managed, as far as the bits 2 and 3 are compliant with them.

6.3.4.2 DATA RECEIVED FROM IEDS

6.3.4.2.1 AIs

The formats supported by the C26x include:

- IEEE STD 754 (recommended)
- integer signed or not on 1 Byte
- integer signed or not on 2 Bytes
- integer signed or not on 4 Bytes (for energy metering precision)

It is desirable that all the AIs have the same format (type and byte number); otherwise, divide them in several groups, each with a given format.

The values must be directly usable. Single scaling (e.g. x1000) is accepted. As complex computation use boundary, scaling is forbidden for measurements.

AIs are mapped at consecutive MODBUS addresses to increase the acquisition efficiency. Or, they can be in a fundamental data area.

The transmission of the measurements in double word must start with the most significant byte, which is not a common practice:

	Bytes order			
Intel products	1	2	3	4
Motorola products	4	3	2	1
Most common (2 consecutive addresses)	2	1	4	3
Recommended transmission with MODBUS	4	3	2	1

The units of the readings must be identical throughout a range of products. If possible stick to the list of the recommended units. The format for encoding IEEE makes unit coding easy, as it makes possible to treat at system level the large or small values without using derived units (example: tenths of Amperes, tens of Volts, MW).

Description	Units
Volts	V
Amperes	A
Kilowatt	kW
Kilo Volt Ampere	kVA
Kilo VAR	kVAR
Kilo Watt . Hour	kWh
Kilo Volt Ampere Hour	kVAh
Kilo VAR Hour	kVARh
Hertz	Hz
Celsius or centigrade Degree	°C
Mho	1/Ω
Ohms	Ω
Seconds of closing time	s
Degree of angle	Angular degree
Without unit	–

For all the quality descriptors used for the measurements or counters, split quality descriptor indication (like CP8(i+1) Info + Quality from IEC 870-5-4) from the value in separate address groups.

Some IEDs encode Valid/Invalid quality statuses with binary values. For such IED, map the AI Statuses in consecutive words.

6.3.4.2.2 M300

The measurements are periodically polled for. The available formats include:

	Format to configure	Comments
T1	UINT16 (5)	16 bit unsigned value: "12345" (0x3039) represents 12345
T3	UINT16 (5)	16 bit unsigned value with 2 decimals: "12345" (0x3039) represents 123,45
T8	INT16 (4)	16 bit signed value with 3 decimals: "-12345" (0xCFC6) represents -12,345
T9	UINT32_HW_HB (13)	32 bit signed value: “big Endian” *
T10	UINT32_HW_HB (13)	32 bit signed value with 2 decimals: “big Endian”*
T11	UINT32_HW_HB (13)	32 bit signed value with 3 decimals: “big Endian”*
T13	UINT32_HW_HB (13)	32 bit signed value with 5 decimals: “big Endian”*
T20	Energy: T09 for the primary values (base unit kWh),T11 for the secondary (base unit Wh)	
T21	Power: T10 for the primary values (base unit kW),T12 for the secondary values (base unit W)	
T39	Voltage: T10 for the primary values (base unit V),T11 for the secondary values (base unit V)	
T40	Current: T10 for the primary values (base unit A), T13 for the secondary values (base unit A)	
T53	Idem T1	

* the higher word is transmitted first, the higher byte in the word is transmitted first

These formats do not take into account the multiplying factor. Moreover, the next table gives a non exhaustive list of measurements (in secondary mode):

Meas.	C26x type	Scaling factor	Address	Formats
Va	UINT32_HW_HB	0.001	0x01C6	T39 (=T11 for the secondary mode)
Vb	UINT32_HW_HB	0.001	0x01C8	T39 (=T11 for the secondary mode)
Vc	UINT32_HW_HB	0.001	0x01CA	T39 (=T11 for the secondary mode)
Uab	UINT32_HW_HB	0.001	0x01CC	T39 (=T11 for the secondary mode)
Ubc	UINT32_HW_HB	0.001	0x01CE	T39 (=T11 for the secondary mode)
Uca	UINT32_HW_HB	0.001	0x01D0	T39 (=T11 for the secondary mode)
Ia	UINT32_HW_HB	0.0001	0x01D2	T40 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
Ib	UINT32_HW_HB	0.0001	0x01D4	T40 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
Ic	UINT32_HW_HB	0.0001	0x01D6	T40 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
In	UINT32_HW_HB	0.0001	0x01D8	T40 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
Freq.	UINT32_HW_HB	0.001	0x01DA	T11
Power	UINT32_HW_HB	0.0001		T21 (=T12 for the secondary mode, mistaken as T11 in the manual R8605C2)
Energies	UINT32_HW_HB	0.001		T20 (=T11 for the secondary mode)

The addresses 0x01DB, 0x01DC, 0x01DE and 0x01DF generate an exception frame with code number 2.

6.3.4.2.3 MiCOM Px2 series and MiCOM Alstom Px4 series

Measurements are read through the Modbus functions 3 or 4 (read word functions). Select the correct format for the measurement: 16 or 32 bits.

Notice that the lower word of 32 bit values is generally transmitted first and, in each word, the higher byte is transmitted first (use formats such as YYYY32_LW_HB for 32 bit values).

- Basic Address (Mapping address) 0xyyyyy
- Extra Address 1: not used
- Extra Address 2: Modbus function (3 or 4)
- Extra Address 3: not used
- Format: See table

6.3.4.2.4 DIs

6.3.4.2.4.1 IED synchronised

Same as generic Modbus (block mode)

6.3.4.2.4.2 IED NOT synchronised

The status byte is regularly polled at low level and compared with the latest one. The status byte in a legacy IED contains the indication that at least one DI change has occurred.

If a change is detected, the C26x reads the event queue inside the IED, checks out which data have changed, checks if the data have been configured and reads the information itself.

In this case, the DI changes are time-stamped in the IED and the C26x downloads their date and time.

Any DI change generates an event. For any event, there is a DI address that can be retrieved.

All the DIs have two states (0/1, on/off, open/closed, synchronised/out of synchronisation). Each DI generates 2 events (Reset to 0 at this time, Set to 1 at that time).

The DIs are stored at consecutive addresses. In consequence, all the DIs can be read in only one request (except if the number of DIs exceeds the capacity of a MODBUS message, and except may be for fast status word).

DIs at connection

At connection or periodically, the C26x can fetch the global states of one device in a single message. Automation can start at once as it is based on states. Event reading can be delayed due to the need to get the disconnection history and time stamp the current state.

A transient DI is in fact an event not associated to a real state but to a transition (e.g. Trip order). It is only SET never RESET. The practice shows that state approach is more commonly used than the transition approach and help know the global status at connection. For this purpose, a transient DI like the trip order is held for a configurable time (300ms), and results in 2 events (set and reset). The IED translates an inner transient DI to a pulsed indication over the network (with a configurable time e.g. 100 to 300ms).

M300 read request

The time-stamped events of the M300 are NOT treated (there is no indication on the state of synchronisation of the M300). In consequence, the C26x acquires the DIs of the M300 by polling and time stamps them.

The DIs are read through the Modbus function 4 (read words) with the values that follow:

- mapping address in the basic address field
- 4 in the extra address 2 field
- bit number in the extra address 1 field

Example for reading the 2 DIs of an M300 device:

- BI0:
  - Base address: 28d
  - Extra address 1: 0
  - Extra address 2: 4
  - Extra address 3: /
- BI1:
  - Basic address: 28d
  - Extra address 1: 1
  - Extra address 2: 4
  - Extra address 3: /

Example for reading alarm status of an M300 device (@30030):

- BI16:
  - Base address: 30d
  - Extra address 1: 0 “Error EEPROM: alarm group 4”
  - Extra address 2: 4
  - Extra address 3: /
- BI17:
  - Base address: 30d
  - Extra address 1: 1
  - Extra address 2: 4
  - Extra address 3: /
- BI23:
  - Base address: 30d
  - Extra address 1: 7 “serial port default Analogue output”
  - Extra address 2: 4
  - Extra address 3: /
- BI0:
  - Base address: 31d
  - Extra address 1: 0 “Test timeout for watchdog”
  - Extra address 2: 4
  - Extra address 3: /
- BI1:
  - Base address: 31d
  - Extra address 1: 1
  - Extra address 2: 4
  - Extra address 3: /

- BI15:
  - Base address: 31d
  - Extra address 1: 15 “Error EEPROM: alarm group 3”
  - Extra address 2: 4
  - Extra address 3: /

To read bit fields in 32-bit values, configure at least one BI in each part of the long value (lower word and higher word) as described in the previous example.

MiCOM Px2 series and MiCOM Alstom Px4 series read request

The C26x acquires the DIs through the function Nr 3 or 4 (read word functions).

- Base Address (Mapping Address) 0x0010
- Extra Address 1 (bit Number) 0
- Extra Address 2 (Modbus function) 4
- Extra Address 3 (Not Used) X

To improve the process, the events are handled in the C26x. This means that each action on the relay activates an event that is uploaded and decoded in the relay. If the DI corresponding to the event has been configured, the C26x reports the new DI value.

6.3.4.2.5 Disturbance files

The disturbance record includes any transfer of file of measurements sampled at high frequency:

- conventional disturbance
- monitoring data (pressure in GIS, harmonics, brush distance in CB closing ..)

Such a file is breakdown into limited size blocks (defined by MODBUS) to be uploaded.

Any file data format can be used as far as it can be converted to a standard file format, COMTRAD or at least CSV format (Excel, Matlab…).

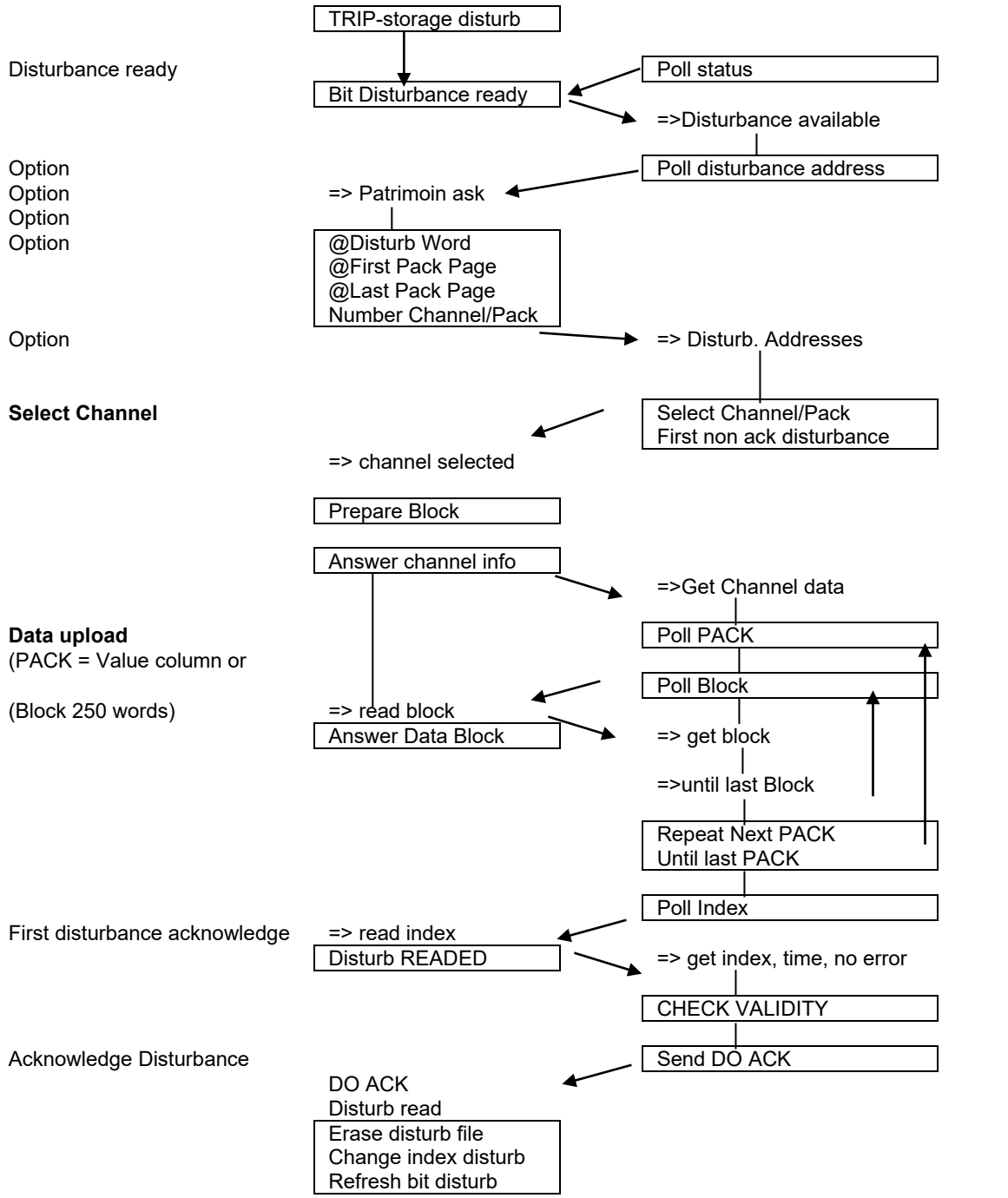
Regardless of the kind of transmission, a header must define the kind of data transfer (file or column values) and the required file reader. The name of the exploitation files (usually COMTRAD) is based on the configured device, master reference, IED MODBUS reference, and cyclic disturbance number.

C26x is informed that a disturbance is stored by reading the bit b4 in the Status byte. Each block is transmitted on the C26x request. At the global end of transfer, after a check-up of the file, the C26x sends the “Ack.DO” and the device can erase its disturbance file. If another “disturbance file” is still present, the bit b4 remains set (e.g. EPAC multi disturbance upload).

The date in disturbance file must be the same as in events (for trip indication…). The device is compliant with:

- the file upload mechanism (Stream of data)
- the disturbance upload mechanism (Column of values); example: series P20

Comment	LED	Net	Master	



6.3.4.2.5.1 M300

There are 2 types of Disturbance record:

- Waveform Analysis Record (max = 1 file)
- Disturbance Record (max = 4 files)

The detection of the availability of a disturbance record in the M300 is done by regularly polling the status of the M300 (bit “Presence of a Disturbance record”).

The disturbance record of an IED is uploaded only if the maximum number of simultaneous disturbance uploading is not reached for the Modbus line and the opening of a disturbance file on the C26x is possible.

Uploading

The C26x opens a file to store disturbance data. If it is not possible, the treatment ends.

The type of disturbance record to upload is selected by writing to register @40567 (0x0237):

- ‘0’ for a Waveform Analysis
- ‘1’ for a Disturbance Record

The record number is selected by writing to register@40568 (0x0238) the value ‘0’ in order to select the last one.

The C26x reads the general information and writes the information that follows to the file:

- Serial number of the IED 8 words at @30001 (0x0001)]
- Frequency [@40572 (0x023C)]
- Trigger date [@30055 (0x0037) ➔@30060 (0x003C)]
- Available channels [@30061 (0x003D)]
- Type of channels @30062 (0x003E)]
- Number of samples by channel [@30063 (0x003F)]
- Number of pages [of sample] by channel @30064 (0x0040)]
- Number of samples by cycle [@40560 (0x0230)]
- Trigger position [@30066 (0x0042)]
- Time base [@30067 (0x0043)]
- Scaling factors of analogue channels [@30068 (0x0044) ➔@30081 (0x0044)]
- Names of analogue channels
- Names of TOR channels

The disturbance data are uploaded channel by channel, starting with channel ‘0’ which is the time channel, and for each channel, page by page.

Lastly, the C26x closes the disturbance file.

The bit 7 of register @40047 allows to erase ALL the disturbance records.

For mapping information, refer to the Service manual volume 2, ref. R8605C2.

6.3.4.2.5.2 MiCOM Alstom Px4 series

No disturbance files.

6.3.4.2.5.3 MiCOM Px2 series

The Px2x can store up to five Disturbance records. The number of channels depends on the kind of Px2x (6 to 9).

The C26x detects the presence of a disturbance record in the Px2x by regularly polling for the status of the Px2x (bit “Presence of a Disturbance record”).

Uploading

C26x:

1 opens a file to store disturbance data; if this is not possible, the treatment ends

2 reads the number of Disturbance records and the associated information (Read of 36 words at @0x3D00); this information enables to know the number (between 0 and 4) of the latest unacknowledged disturbance records. If there is no unacknowledged disturbance record, the treatment ends

3 reads all the IED identification model based on the pattern “Px2x” in order to determine the number of channels and the selection size (Read of 5 words at @0x0000) and after, it writes this information to the disturbance file

4 uploads the disturbance data channel by channel, and for each channel page by page.

5 reads the index frame of the disturbance (Read 7 words at @ 0x2200) and writes this information to the disturbance file

6 closes the disturbances file

7 acknowledges the disturbance records in the Px2x by setting the bit @0x4032 to 1; another disturbance record can be uploaded from the IED.

Differences between Px2x Models:

Products	Number of analogue channels	Number of TOR channels	Overall channels number	selection information size Pages 0x38-0x3C
P120	No disturbance management			
P121	No disturbance management			
P122	5 (IA, IB, IC, I0, Frequency)	1 (3 Inputs, 7 Outputs)	6	11 Words
P123	5 (IA, IB, IC, I0, Frequency)	1 (5 Inputs, 9 Outputs)	6	11 Words
P124D	5 (IA, IB, IC, I0, Frequency)	1 (5 Inputs, 9 Outputs)	6	11 Words
P124S	No disturbance management			
P125	No disturbance management			
P126	6 (IA, IB, IC, I0, V, Frequency)	1 (7 Inputs, 9 Outputs)	7	19 Words
P127	8 (IA, IB, IC, I0, VA, VB, VC, Frequency)	1 (7 Inputs, 9 Outputs)	9	19 Words
P220	5 (IA, IB, IC, I0, Frequency)	1 (5 Inputs, 6 Outputs)	6	11 Words
P225	6 (IA, IB, IC, I0, UAC, Frequency)	1 (6 Inputs, 6 Outputs)	7	19 Words
P226C	6 (IA, IB, IC, I0, UAC, Frequency)	1 (6 Inputs, 6 Outputs)	7	19 Words
P521	7 (IA, IB, IC, I0, timing)	2 (5 Inputs, 9 Outputs, 9 internal data)	9	11 Words
P920	No disturbance management			
P921	No disturbance management			
P922	5 (Voltage, Frequency)	1 (5 Inputs, 9 Outputs)	6	19 Words
P923	5 (Voltage, Frequency)	1 (5 Inputs, 9 Outputs)	6	19 Words
P925	No disturbance management			

@ Mapping	Modbus Function	Words	Format	Description
Pages 0x09 to 0x21: Disturbance Data. Each page contains the samples [250 data word] of the selected channel				
0x0900 ➔ 0x09FA	3	250	INT16	Up to 250 samples
0x0A00 ➔ 0x0AFA	3	250		Up to 250 samples
…				
0x2100 ➔ 0x21FA	3	250		Up to 250 samples
Page 0x22: Index of the Disturbance				
0x2200	3	1	UINT16	Disturbance record Number
0x2201 ➔ 0x2204	3	4	Time Stamp	Disturbance record finish date
0x2205	3	1	UINT16	Disturbance record starting condition
0x2206	3	1	UINT16	Frequency at post-time beginning

@ Mapping	Modbus Function	Words	Format	Description
Page 0x3D: Number of disturbance records available				
0x3D00	3	1	UINT16	Number of disturbance records [1 .. 5]
0x3D01	3	1		Oldest disturbance record (n)
0x3D02 ➔ 0x3D05	3	4	Time Stamp	disturbance record Date
0x3D06	3	1		disturbance record starting origin
0x3D07	3	1		0 ⇔ Not Acknowledged 1 ⇔ 1 Acknowledged
0x3D08	3	1		Preceding disturbance record (n+1)
0x3D09 ➔ 0x3D0C	3	4	Time Stamp	disturbance record Date
0x3D0D	3	1		disturbance record starting origin
0x3D0E	3	1		0 ⇔ Not Acknowledged 1 ⇔ 1 Acknowledged
….				
0x3D1D	3	1		Preceding disturbance record (n+4)
0x3D1E ➔ 0x3D21	3	4	Time Stamp	disturbance record Date
0x3D22	3	1		disturbance record starting origin
0x3D23	3	1		0 ⇔ Not Acknowledged 1 ⇔ 1 Acknowledged

Pages 0x38 to 0x3C: Selection of the Disturbance and channel [Each page correspond to one out of the 5 Disturbance records]. The second header line is the number of words uploaded for each access reading:

@map-ping	Modbus function	Words number	P122/P123/ P124D/P220	P126	P127	P225/P226C	P521	P922/P923
			11 words	19 words			11 words	19 words
Pages 0x38 to 0x3C: selection of the Disturbance and channel [Each page correspond to 1 of the 5 Disturbance record]								
0x..00	3	1	Ia	Ia	Ia	Ia	Ia	Ua
0x..01	3	1	Ib	Ib	Ib	Ib	Ib	Ub
0x..02	3	1	Ic	Ic	Ic	Ic	Ic	Uc
0x..03	3	1	Io	Io	Io	Io	Io	Vo
0x..04	3	1	Frequency	reserved	Ua	Frequency	Timing	Frequency

@map-ping	Modbus function	Words number	P122/P123/ P124D/P220	P126	P127	P225/P226C	P521	P922/P923
			11 words	19 words			11 words	19 words
0x..05	3	1	TOR	reserved	Ub	TOR	TOR1	TOR
0x..06	3	1	unavailable	Uo	Uc/Uo	Uac	TOR2	unavailable
0x..07	3	1		frequency	frequency	unavailable	unavailable	
0x..08	3	1		TOR	TOR			

For each register read request, the following information is uploaded. This information describes the selected channel:

Word	P122/P123/ P124D/P220	P126	P127	P225 / P226C	P521	P922/P923
0	Total samples number					
1	Sample number in pre-time					
2	Sample number in post-time					
3	Primary phase CT ratio					
4	Secondary phase CT ratio					
5	Earth primary CT ratio					
6	Earth secondary CT Ratio					
7	Phase internal CT ratio					
8	Earth internal CT Ratio					
9	Last page Number	Reserved	Primary phase VT Ratio [LB]		Last page nb	Primary phase VT Ratio [LB]
10	Last page word number	Reserved	Primary phaseVT Ratio [HB]		Last pg word nb	Primary phaseVT Ratio [HB]
11	Unavailable	Reserved	Secondary phase VT ratio		Unavailable	Secondary phase VT ratio
12		Earth primary VT ratio [LB]		Reserved		Earth primary VT ratio [LB]
13		Earth primary VT ratio [HB]		Reserved		Earth primary VT ratio [HB]
14		Earth secondary VT ratio		Reserved		Earth secondary VT ratio
15		Internal VT ratio – numerator 100				Internal VT ratio–num. 100
16		Internal VT Ratio – denominator				Internal VT Ratio – denom.
17		Last page Number				Last page Number
18		Last page words number				Last page words number

Specific treatments

P126: the channels are not consecutive; the 5th & 6th channels must be skipped.

P127: the mapping address 0x0127 must be read. It gives the voltage wiring of the IED. This value must be written in the file (but it does not change the uploading process).

P922 &P923: the mapping address 0x0126 must be read. It gives the voltage wiring of the IED. This value must be written in the file. This value changes the uploading process: in some cases, the channels must be skipped.

Wiring value	Voltage wiring of the IED	Used channels	
0	3Vpn (3 phase-to-neutral voltages)	0	Ua
		1	Ub
		2	Uc
		3	Not used
		4	Frequency
		5	TOR
1	3Vpn + Vr (3 phase-to-neutral voltages + residual voltage)	0	Ua
		1	Ub
		2	Uc
		3	Vo
		4	Frequency
		5	TOR
2	2Vpp + Vr (2 phase-to-phase voltages + residual voltage)	0	Uab
		1	Ubc
		2	Not used
		3	Vo
		4	Frequency
		5	TOR
3	3Vpp + Vr (3 phase-to-phase voltages + residual voltage)	0	Uab
		1	Ubc
		2	Uca
		3	Vo
		4	Frequency
		5	TOR

6.3.4.2.6 Events

An event is a time-stamped state change of a logical data.

When the IED gets connected, the C26x reads the current status of logical information, then manages the status changes from the file of the time-stamped events.

The time-stamped events are gathered in one file. The bit b2 of the status indicates the presence of at least one event not extracted. Events are stored by IED, and are read one by one by the master, starting from the oldest event.

The C26x's reading of one event does not withdraw it from the file. An IED withdraws an event from its list:

- when the C26x acknowledges it
- when the file of the events gets saturated (the queue sheds the oldest event)
- directly after the C26x reads whether an automatic event retrieval is set on IED. The event can be read again at address @event +1 (3601h if the latest event address is 3600h). Event reply is 0 if the events list is empty.
- the C26x reads one event, and then sends “DO ok“ if it correctly receives the event. When receiving this acknowledgement, the IED deletes its latest event, and updates its events list (and resets the event bit in status word if applicable: refer to IED documentation). This makes sure that no event is lost. DO acknowledgement is bit 13 (0400h).
- IEDs and C26xs are configured for automatic event retrieval (at start-up the C26x checks the bit b12 at 0400h). The C26x reads the latest event.

The IED shifts this event to the next address in the event list. If the C26x detects a transmission error, it reads again the event at address +1.

Any event includes the information that follows:

- Date - Time, using inverse order as per IEC 870-5-4 CP56T2a format (no short format, no CP16, same format as clock synchronisation).
- MODBUS mapping address of logical information that has changed.
- New state value of the transmitted data (new value of the word, stored at the MODBUS mapping address).

The C26x extracts the events meant for upper functions and sends them to the corresponding service: automation, alarms, textual message converter, event & logging printing….).

Note: all textual information associated to events are not needed by a system master as customers have their own labels, wording, or writing (Cyrillic, Cantonese …). A separate device is in charge of textual logging. The text only reduces communication bandwidth.

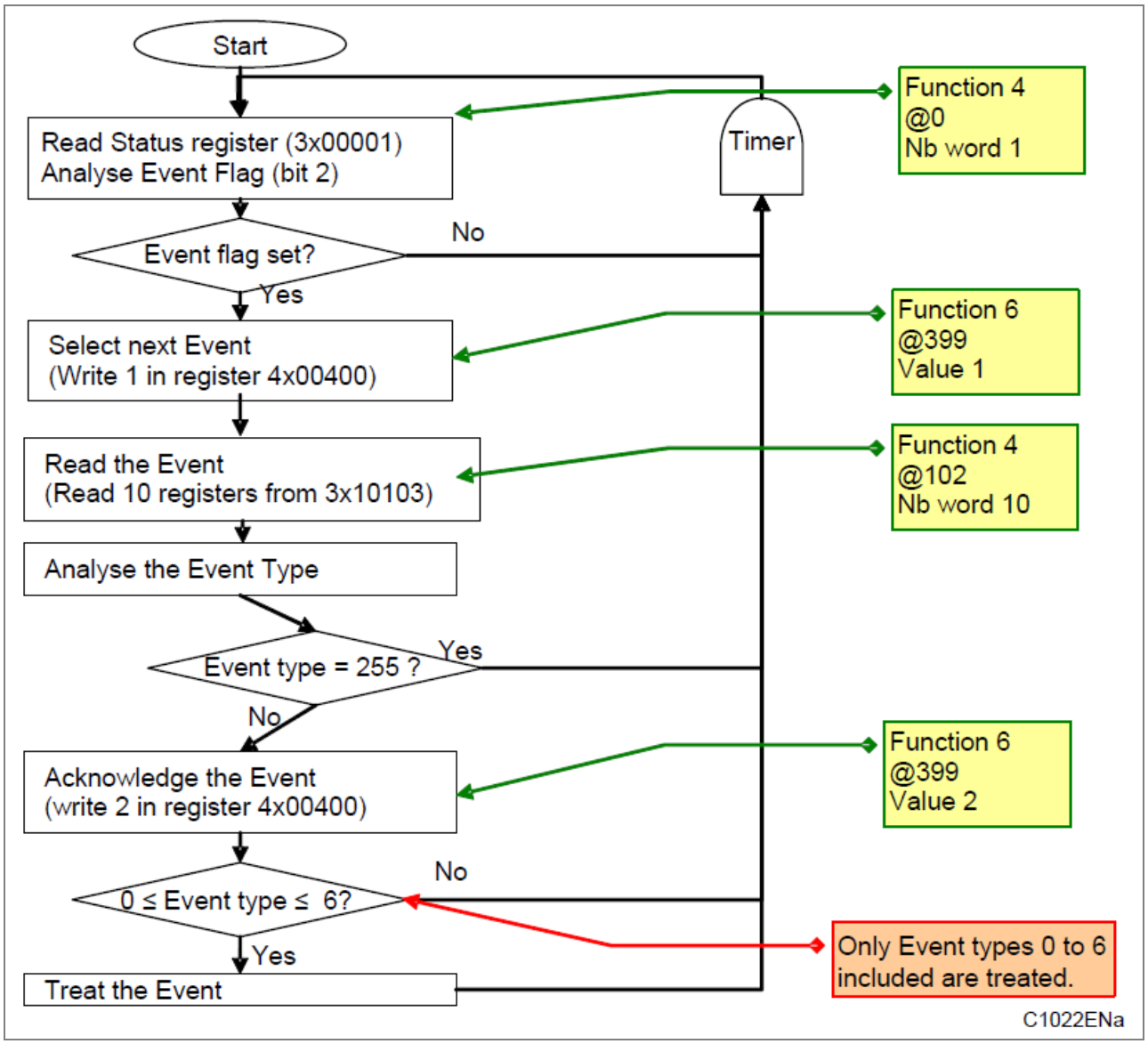
The C26x can manage several state changes in one event (for changes in same time accuracy period, to increase transfer…), even if each event has only one state change. Then, one state change is linked to one event and one event is linked to several possible state changes (if they are at the same MODBUS address).

MiCOM Alstom Px4 series

The command register can be written with Modbus function 6 in register 4x00400 [@ 399]. Each action is activated when a ‘1’ is written to the corresponding bit.

Bit No.	Value / bit mask	Used to
0	0x0001	Select the next event
1	0x0002	Accept event
2	0x0004	Select the next disturbance record
3	0x0008	Accept disturbance record
4	0x0010	Select the next disturbance record page
x	x	Other bits are unused

Automatic event-record extraction allows records to be extracted as they occur. Event records are extracted in sequential order:



The C26x determines whether the Px4x has any events stored that have not yet been extracted by reading the Px4x's status register 3x00001 (G26 data type). If the event bit is set, the Px4x contains event records that have not yet been extracted.

To select the next event for sequential extraction, the C26x writes 1 to the command register 4x00400 (G18 data type). The event data together with any fault/maintenance data can be read from the registers as specified in the flow chart and table.

Once the data has been read, the event record can be marked as read by writing 2 to register 4x00400.

Alternatively, since the G18 data type consists of bit fields, it is possible to both marks the current record as having been read and to automatically select the next unread record by writing 3 to the register.

When the latest (most recent) record has been accepted, the event flag in the status register (3x00001) is reset.

If the latest record was accepted by writing 3 to the command register (4x00400), a dummy record appears in the event record registers, with an "Event Type" value of 255.

Attempting to select another record, when none are available, results in a Modbus exception code 3 – "Invalid value".

Event formats:

<table>
<tr><th>Modbus Register /Address</th><th>Contents</th><th>Description</th><th>Nb Register</th></tr>
<tr><td>3x00103…3x00106
102 … 105</td><td>(G12) Time stamp of the event</td><td>IEC870 Time & Date</td><td>4</td></tr>
<tr><td>3x00107
106</td><td>(G13)
Event type</td><td><table><tr><td>0,1,2, 3</td><td>alarm</td></tr><tr><td>4</td><td>output contact</td></tr><tr><td>5</td><td>opto input</td></tr><tr><td>6</td><td>protection</td></tr><tr><td>255</td><td>dummy event</td></tr></table></td><td>1</td></tr>
<tr><td>3x00108…3x00109
107 ... 108</td><td>(G27)
Event value</td><td>New values of the 32 bits register containing the BI(s) which have changed.</td><td>2</td></tr>
<tr><td>3x00110
109</td><td>(G1)
32-bit Register reference</td><td>Modbus address of the 32-bit register containing the BI(s) that have changed.
CAUTION: real Modbus address must be recomputed by subtracting 30001 !!!<table><tr><td>Event type</td><td>Event index</td></tr><tr><td>0,1,2,3</td><td>11</td></tr><tr><td>4</td><td>723</td></tr><tr><td>5</td><td>725</td></tr><tr><td>6</td><td>727 to 785 (associated DDB status register)</td></tr></table></td><td>1</td></tr>
<tr><td>3x00111
110</td><td>Event Index</td><td><table><tr><td>Event type</td><td>Event index</td></tr><tr><td>0,1,2,3</td><td>Alarm ID</td></tr><tr><td>4, 5</td><td>Not used – set to 0</td></tr><tr><td>6</td><td>bit 16 = state, bits 1-15 DDB ID</td></tr></table></td><td>1</td></tr>
<tr><td>3x00112</td><td>Not used by C26x</td><td>–</td><td>1</td></tr>
</table>

According to the Event Type, the Event Index can be used – or not – to analyses the Event. Two cases have to be considered:

- Event of type 0,1,2,3 and 6. In this case, the Event Index can be used.
  - Bit16 of the Event Index indicates the new Digital Input state (0 or 1)
  - Bit1-15 of the Event Index [modulo 32] indicate the Bit Number of the Digital Input in the 32bits register
  - The 32bits register reference and the Digital Input Bit Number allows finding the Digital Input in the C26x DB (if configured).
- Event of type 4 and 5. In this case, the Event Index is not significant and cannot be used. The C26x DB has to be parsed against the Event Value, looking for a state change of all Digital Input of the 32-bit register reference.

6.3.4.2.7 File upload

A file is defined by a header, a parameter set and a stream of data. Each time the C26x reads a block of data, the IED shifts data to the next page (Repeat page) and replaces it by a new block of data. In event of transmission error, the C26x requests the block wrongly received to the repeat page.

Addresses	Function	Contents
FA00 to FAFA	Read 24 words	Read header
FB00 to FBFA	Read N words	Read N words of file parameters and shift parameter stream
FC00 to FCFA	Read N words	Read N words again of file (repeat)
FD00 to FDFA	Read N words	Read N words of file data and shift data stream
FE00 to FEFA	Read N words	Read N words again of file (repeat)

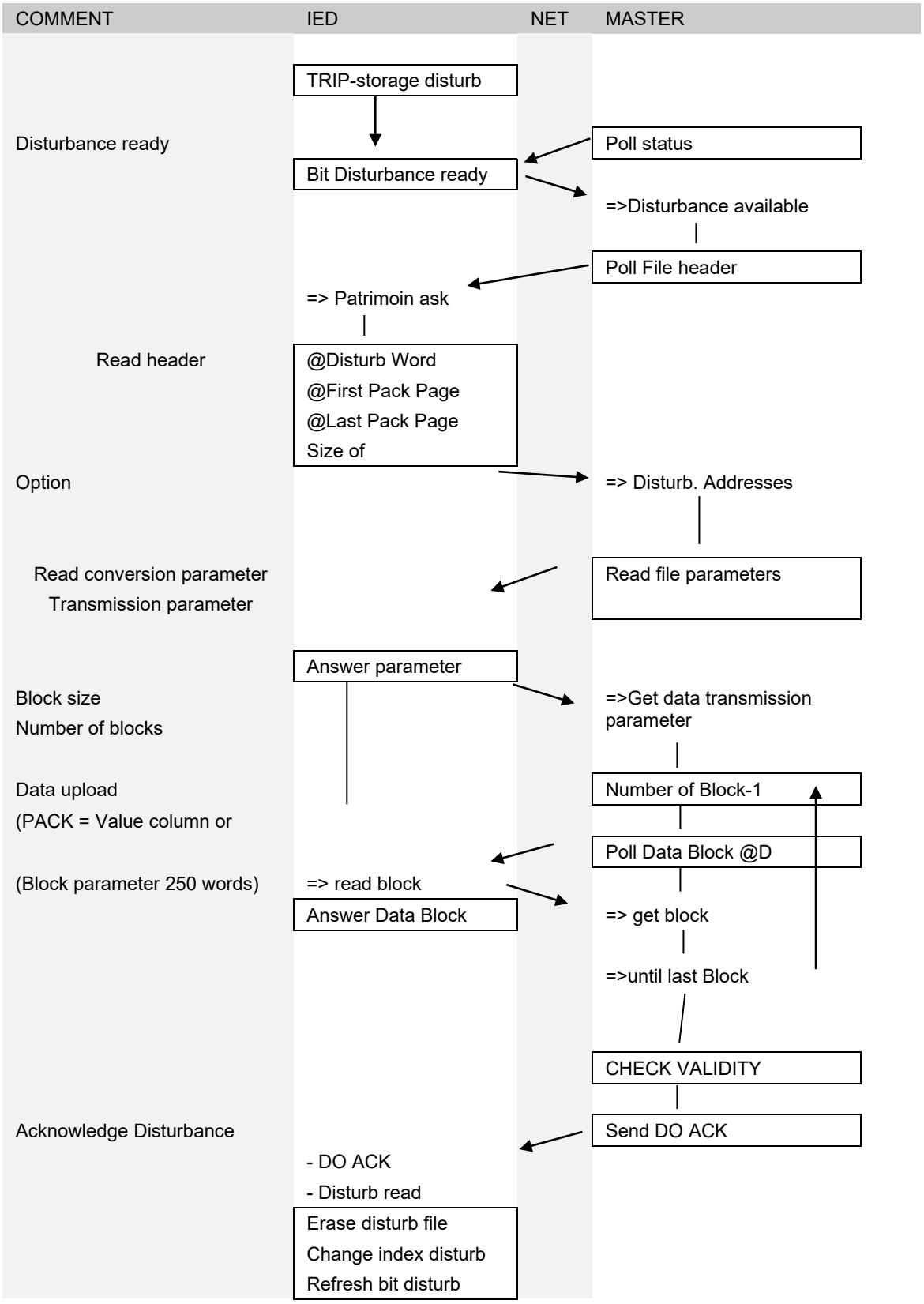
The header defines data to transmit and file treatment to trigger by the C26x on data reception:

Word	Description	Format
1	Kind of file transfer	0 for the following mechanism, 1 for a future one
2-3	Number of words in parameter field	Nb_Byte_Para
4-5	Number of words in data field	Nb_Byte_Data
6	Manufacturer	1 « ALSTOM PCB Lattes » (for M7xx)
7-8	Product reference	4 ASCII {« M710 », « M711 » , « M720 », « M721 »… }
9	Transmission product version	1 First version or A
10-13	Product serial number	8 ASCII characters: SS Week AA Year NNNN Number in week (shift left + blank).
14	Kind of File transfer used below by the product	0 very short time 1 short time 2 quality events 3 disturbance 4 compressed disturbance
15-18	First element time tag	IEC 840-5-4 (64 bits = 4 x 16-bit words)
19	Reserved e.g. sampling, trigger timer	0x0000
…	…	…
24	Reserved	0x0000

All the data samplings are transmitted after one another without compression.

Word	Description for decoding software
0-1	First value of first sampling
2-3	Second value of first sampling
Nb_Byte_Data	Last word

Algorithm:



Downloading is done using function 15 or 16 at specific address. Acceptance is signalled.

To speed up the global downloading, writing can be done to several consecutive addresses.

6.3.4.3 DATA SENT TO IEDS

6.3.4.3.1 Clock synchronization

Type of synchronization: GE Grid Solutions (proprietary)

All the devices connected to a given network must have the same synchronization procedure (address and time and date format) because the synchronization order is broadcast.

Date and time comply with the inverted IEC 870-5-4 CP56Time2a format:

Word	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
1	0	0	0	0	0	0	0	0	0	Year: 00…99						
2	0	0	0	0	Month: 1...12				DayOfWeek:1..7			DayOfMonth:1..31				
3	su	0	0	Hour: 0…23					iv	0	Minutes: 0…59					
4	Milliseconds (High)								Milliseconds (Low)							

Su (=0 for Standard, =1 for Summer Time)

iv (=0 for valid, =1 for non valid or out of synchronisation for a system)

First day of the week: Monday

Date and time is set at address 0800h with function 16. No calculation of transmission delay.

If an IED does not have (this) synchronisation, it must be unaware of these synchronisation messages (no error indication, no failure).

If an IED that does not stick to the rule, the C26x supplies out-of-synchronisation devices with its own time stamp. The time accuracy is deeply degraded.

An IED does not generate any event when receiving the synchronisation, or when missing one broadcast message.

Synchronisation comes from a specialised clock device like GPS. The first bit is the reference. The C26x transmits time corrected by its treatment delay. It sends a synchronic message periodically (e.g. 3 times per minutes). The absence of reception within 1 minute results in a “Loss of synchronisation” event.

A “Loss of synchronisation” event requires a set/reset. Synchronisation information is also signalled by the IV bit in the event time stamp: 0 means that when the event occurred, the IED was out of synchronisation.

Any IED with 2 clocks systems (MODBUS synchronization mechanism AND an IRIG B or other) must have an inner setting to deactivate each clock.

If the C26x has lost its own synchronisation, it still time stamps events (but with IV bit set) to still synchronise the IEDs with a same reference (relative time tagging).

M300

The M300 supports 2 time formats:

- The GE Grid Solutions (proprietary) synchronization format, which is used only to set the Date & Time
- The M300 format which is used to set the Date & Time in the M300 or for time stamping in the M300 (e.g. Disturbance time stamping)

The synchronisation according to the Modbus legacy rules is accepted by the M300 only if the bit “summer” is NOT set.

MiCOM Px2 series

The Px2x support 2 time formats:

- the GE Grid Solutions (proprietary) synchronization format, which is used only to set the Date & Time in the Px2x
- the Px2x format which is used for time stamping in the Px2x (e.g. Event & Disturbance time stamping)

Time stamping format:

Word	Description
0	Lower word of Seconds
1	Higher word of Seconds
2	Lower word of MilliSeconds
3	Higher word of MilliSeconds

The number of seconds given in the previous table (32-bit value in word 0 and 1) is the number of seconds elapsed since 1994 January 1st.

Since the V4C version of the PX2X relays, a private format and the IEC format are both available. Select the IEC format to obtain a correct event decoding.

Moreover, a PX2X relay goes out of synchronization after a 1 min delay. As a result, select a synchronization period lesser than 60 seconds.

MiCOM Alstom Px4 series

The Px4x support the GE Grid Solutions (proprietary) format. To keep the Px4x synchronized, the C26x sends a synchronization frame at least once every 5 minutes.

It is possible to use both Px2x and Px4x relays on the same communication channel and to activate the synchronization.

The register 4x00306 is used to configure the time format managed by the relay:

- Writing value '0' in this register selects the 'standard IEC' time format (default value).
- Writing value '1' in this register selects the 'reverse IEC' time format (Modbus GE Grid Solutions (proprietary) time format used by the C26x).

So, at Px4x connection, value "1" must be written in register @305 [4x00306] to signal the Px4x to use the GE Grid Solutions (proprietary) time format.

If the 'Modbus GE Grid Solutions (proprietary) format' is selected (see above), the time tag format in events is as show below:

Word No.	Byte No.	Data (MSB first)	Mask
0	0	Dummy byte (set to 0)	0x00
	1	Years	0x7F
1	2	Month	0x0F
	3	Day of week / Day of Month	0xE0, 0x1F
2	4	Summertime / Hours	0x80, 0x1F
	5	Validity / Minutes	0x80, 0x3F
3	6	Milliseconds MSB	0xFF
	7	Milliseconds LSB	0xFF

6.3.4.3.2 Commands

Any control sent from the C26x to an IED is called a Digital Output:

- Logical control: DO to acknowledge a Disturbance record, a time stamped event, DO to activate or inhibit a specific protective function.
- Physical control: DO to open or close a feeder circuit breaker, or specific output.

To simplify Master MODBUS configuration and run time, it is desirable to gather controls at consecutive addresses.

Communication DOs or controls are transmitted by Modbus writing functions:

- function 5 (write 1 bit)
- function 6 (write 1 word)
- function 15 (write N bits)

If the function 6 or 15 are used, the word of control must be formatted in fields of bits.

The DO used to acknowledge reception of dated events must always be accepted by the IED, even if it is in local mode (no protection mode filtering on this particular DO).

For a single control on a bits field, there is no special need or common description of “Control accepted”. The DI changes subsequent to a control action are sufficient to control execution.

For other controls, reserve a special word on IED for all the device acknowledgements.

If there are several devices on IED, a more elaborate control message sequence between the C26x & IED are required. For a control message, keep the Modbus acknowledgement rules.

On reception of a control request, an IED sends 0 (OK) if function/address/data are correct.

If its inner algorithm forbids it to initiate ordered sequence with physical Digital Output (because of interlock, locking, running control, invalid position…), the IED transmits an “application” error code via an event DI configured in the C26x. the C26x determines if the sequence is acceptable, and runs correctly (for higher control algorithm or protocol conversion).

When operating control is implemented on IED (OBS, Cx2x, P4xx) a lot of failure cases are defined, and over several plants.

At least use for each controlled plant only one word (4 control bits set by the C26x and reset by IED, and 12 main informative bits). Extra words can be defined for further automation indication.

Case 1: Switching device may need to be split into synchronised CB and disconnections:

CONTROL *				MONITORING												
				Control Plant State					Plant secondary DI							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
													0	0	0	Plant position MOTION
													0	0	1	Plant position OPEN
													0	1	0	Plant position CLOSE
													0	1	1	Error!
													1	0	0	Plant positionINVALID(DBI00)
													1	1	1	PlantpositionINVALID(DBI11)
													1	0	1	Other INVALID (polarity…)
													1	1	0	Reserve other INVALID
												0/1				(opt) Plant inLOCAL/REMOTE
											0/1					(opt) Plant LOCKED (WITHDRAW)
										0/1						(opt) DI select in SBO
									0/1							(opt) Synchro-check OK
								1								Control Fail Abnormal termination
							1									Control Fail mismatch plant position
						1										Control Fail Lock (pressure…)
					1											Control Fail Interlock
				1												Control accepted Latch (any control)
	0	0	1													OPEN control
	0	1	0													CLOSE control
	1	0	0													(opt) CLOSE2 control (Forced)
1																(opt) SELECT control

* All DOs latched by the C26x, the front panel cell is reset at the sequence end by IED.

Case 2: Transformer with TPI position on other word

CONTROL				MONITORING												
				ControlPlant St				Plant secondary DI								
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
															0/1	Plant position MOTION / FIXE
														0/1		Mini CB OPEN/CLOSE
													1			Plant position INVALID
												0/1				(opt) AVRegulation ON/OFF
											0/1					(opt) Plant LOCKED
										x						Reserve
									1							Low Tap Reach
								1								High Tap Reach
							1									Control Fail Abnormal termination
						1										Control Fail Lock (oil,..)
					1											Control Fail Interlock (unusual)
				1												Control accepted Latch (any control)
	0	0	1													Tap RAISE control
	0	1	0													Tap CLOSE control
	1	0	0													(opt)Regulation ON Control
1																(opt) Regulation OFF Control

* All DOs latched by the C26x, the front panel cell is reset at the sequence end by IED

Several kinds of control are defined to manage any measurement that can be frozen (Maintenance counter, metering, or classical measurement). The following “control structure” byte can be used for each measurement:

CONTROL				MONITORING				
7	6	5	4	3	2	1	0	
							0/1	AI Valid/Invalid
						0/1		AI not Frozen/Frozen
					x			Reserve Topical, saturated…
				x				Reserve
			1					Unitary reset
		1						Unitary reset & start
	1							Unitary restart
1								Unitary freeze

Any IED has kind of alarm management that deeply differs from the one used at system or SCADA level. An alarm is any indication given to an operator to warn against a non standard condition, usually by LED indications on IED (2 states ON/OFF), alarm list at upper level (with 4 states defined by STANDING/RESET, NOT_ACK/ACKNOWLEDGE).

It is asked that IED alarms indication be accessed in one address. A DO can globally acknowledge/reset alarms (but one alarm is maintained if condition is still present). In the cell words, a first byte is dedicated to indicating alarm, a byte+8 to resetting each alarm.

M300

There is one command register in the M300 [@40047 (0x002F)]. This register is set using the function 6. Each bit of the register corresponds to a different command:

Basic Address (Mapping Address) 0x002F

Extra Address 1 (bit Number) Bit number to write

Extra Address 2 (Modbus function) 6

Extra Address 3 (Not Used) x

MiCOM Px2 series

There are 3 command registers in the Px2x [@0x0400, @0x0402, 0x0403]. This register is set using the function 5, 6 or 15. Each bit of the register corresponds to a different command:

@ Mot	@Bit	Usable Function	Comment
0x0400	0x4000 ➔ 0x400F	5, 6, 15	Remote control Word N° 1
0x0402	0x4020 ➔ 0x402F	5, 6, 15	Remote control Word N° 2
0x0403	0x4030 ➔ 0x403F	5, 6, 15	Remote control Word N° 3

Configuration using function 5 of the bit4 [Remote closing] of register 0x0400:

- Basic Address (Mapping Address) 0x4003
- Extra Address 1 (bit Number) X
- Extra Address 2 (Modbus function) 5
- Extra Address 3 (Not Used) X

Configuration using function 6 of the bit4 of register 0x0402:

- Basic Address (Mapping Address) 0x0402
- Extra Address 1 (bit Number) 4
- Extra Address 2 (Modbus function) 6
- Extra Address 3 (Not Used) X

Special commands used by the C26x:

@Bit	Comment
0x400C	Set in order to switch to manual acknowledgement mode for Event and Disturbance uploading
0x400D	Set in order to acknowledge the latest Event
0x4032	Set in order to acknowledge the latest uploaded Disturbance

MiCOM Alstom Px4 series

No specific treatment.

6.3.4.3.3 AOs

The analogue control or AO or Set point, or control reference is a value transmitted by the C26x to device using the function 6 or 16. They can be used to define a reference (for physical output in regulation scheme, generator…) or to define a protection parameter (threshold…).

The values to write must comply with formats and units described for Analogues Inputs (IEEE signed 754, Integer / not signed on 1/2/4 bytes).

When several values at consecutive addresses can be written, IED must support writing to this block of addresses.

6.3.4.3.4 Settings of the current relays

In order to parameterize the remote relays, a setting software is necessary.

The tool is Modbus connected on the rear (as commonly used by system in run time).

A front connection with the same software and same framing protocol at both customer validation and after sale phase is recommended.

Setting software requirements:

- Interface with at least a DLL for Emission / Acceptance of messages developed by the supervisor system, in order to use the tool with other link than serial port. Modbus messages are encapsulated by system sub-station protocol to be used in system architecture.
- Possibility of inhibiting some options of the menu (pooling, disturbance upload …).
- Complete management of the function by the application (Timer on failure to reply, causes of failure…).
- Off-line setting before download
- In run-time the Modbus master is the only master. The tool should not disturb the standard polling of events and data.

6.3.4.3.5 Error management

6.3.4.3.5.1 Faults records

The processing of recommended Fault records is as follows:

- Creation of a zone dedicated to describing Fault, apart from the Fault proper
- Sorting of information according to the type of data.

The Fault Record has the same Modbus address for a whole range of products – that means, for all the IEDs in the series the same address for the latest not acknowledged fault. A good practice is to have the same address for all MiCOM products (e.g. 0x003E for not acknowledged FREC).

To access to the Fault Record, use the functions 3 or 4.

6.3.4.3.5.2 Alarms

Most IED LEDs can be configured for alarms. In most cases they are managed in a two-state way that differs a lot from an IED to another or to the system (5 states).

An alarm is a standard event (time-stamped state change managed by event rules), stored in the IED till acknowledgement, and that aims at warning the operator via a LED.

There are 2 kinds of alarm:

- TRIP (signalling that a control is sent to a breaker when a particular protective function is triggered)
- ALARM (other information intended for the operator)

Each alarm/trip indication is controlled by a bit in a set of consecutive cells (like Digital Inputs). Each bit retains that alarm condition has been set (even if the condition is no more fulfilled). A global Digital Output acknowledgement ‘Alarm/trip’ is used to reset all alarm indications. If one alarm condition is still fulfilled, the corresponding bit is not changed by the IED, else it is reset (with an event generation).

When at least one alarm is set in alarm cells (single alarm appearance), the bit 7 of fast status byte is set.

When at least one Trip function is set in trip cells, the bit 6 of fast status byte is set.

Each bit is reset when all the alarm/trip appearance conditions have disappeared and a global ACK alarm Digital Output is received.

A global ALARM/TRIP_ACK_DO is mapped (reset bit). IED mapping must explicitly give the list of cells/bits indicating alarm/trip and effect on bits b6 and b7.

The answer to global ALARM_ACK_DO or global TRIP_ACK_DO (if applicable) to the C26x can never be BUSY (no applicative mechanism, only transport error code).

The bits b6 and b7 are directly linked to LEDs on the front face. The rule manages only 2 states for LED ON or OFF, and no third state is managed. The state ON can be fixed or blinking. The current mechanism is a global acknowledgement AND clearance of alarm list if the alarm appearance condition has been reset.

6.3.4.3.6 Limits and specifications

It is mandatory that within the same range, each piece of equipment has the same operation as others:

- Management of events file (event format/file address/address of acknowledgement DO).
- Management of Fault records (fault format, base fault addresses, address descriptive zone, address of acknowledgement DO…).
- DIs, DOs, AIs are grouped at identical base addresses.
- Format of AI.
- Format of Status.
- Address range of the fundamental data.

In order to use information coming from IED in fast automation, or to answer to the SCADA inquiries, or in alarm tagging, the following specifications are recommended:

- Operating time, answering time to the various requests < 20 ms.
- Low-level address filtering of the irrelevant requests.
- Respect of MODBUS protocol control (correct CRC, parity check, separate message silence of 3.5-char time, continuous flow in one message i.e. a silence limited to 1.5-char transmission time).
- Speed of communication: at least 19200 bauds (38400 is usual, 128000 is a future standard).
- If it is overbooked, a device must answer BUSY (exception code 06) or at least not answer (it is reputed disconnected to be reconnected).
- An IED must answer with a delay lesser than 20ms.
- An IED can ask to implement a FAR BUSY (code 05) to solve an SRAM access problem. The C26x repeats the request at N times its polling period. After 10 BUSY answers, the IED is disconnected.

The official number of devices on Modbus is 32, 16 on PSCN3020 and future system. Typically the application engineers must not include more 8 IEDs to comply with common customer needs (triggered analogues < 500ms, triggered DI < 100ms, physical ping as control/Digital Output/bi-stable/Digital Input/alarm < 300ms, network avalanche profiles, …).

6.3.5 PARTICULAR MODBUS IEDS

Summary:

IED	Read status	Extra functions	Synchroniz.	DI	AI	Commands	Setting software
M230		4, address 1, length 3	–	–	6 new formats	–	ISDP
RishM10	–	–	not specified	Generic	Generic	Generic	
Flexgate	x		Flexgate	Generic	Generic	Generic	
SEPAM	x		Sepam	Generic	Generic	Generic	SFT
WAGO	x	–		Generic	Generic	SP: 15 bits	

No disturbance files.

6.3.5.1 M230

In addition to the generic Modbus, to test IED communication, the function code 4, address 1, length 3 can be used.

6.3.5.1.1 Data received from M230

No DIs.

Analogue Inputs are regularly polled.

The C26x supports six 32-bit extra formats of Analogue Inputs:

Format	Value	Bit 31 to 24	Bit 23 to 16	Bit 15 to 00
M230_T5_TYPE	Unsigned.meas	decimal exponent (signed)	Binary value unsigned	
M230_T6_TYPE	Signed meas.	decimal exponent (signed)	Binary value unsigned	
M230_T7_TYPE	Power factor	signed: Import/ Export (00/FF)	Signed: Inductive/ capacitive (00/FF)	Unsigned value (16 bytes)
ION_MODULUS_10000_UNSIGNED	10000RH+RL	Reg. High: unsigned value/10000		Reg. Low: unsigned value modulus 10000
ION_MODULUS_10000_SIGNED	10000RH+RL	Reg. High: signed value/10000		Reg. Low: signed value modulus 10000
KITZ202_K8	Refer to KITZ202 documentation			

- The byte transmission order is: 4-3-2-1.

6.3.5.1.2 Data sent to M230

The M230 is NOT synchronized using Modbus.

Setting software: IDSP application can NOT be used to set Date and Time, only the front panel can.

The M230 does NOT process the commands.

6.3.5.2 RISH PRO M01

6.3.5.2.1 Initialization sequence

To establish a communication with the relay (upon start-up of the C26x), the C26x reads registers 202, 221, 222 (table of measurements) and registers 300 to 392 (scaling factors table).This initialization sequence is done after each disconnection (i.e. loss of communication or communication error with the IED).

Without interruption:

Step	C26x			Rish Pro M01	
	State	Request		Frame	State
1			←	connection	
2		read "table of measurements"	→		
3			←	measurements	
4		read "scaling factors table"	→		
5	Wait TimeOut				
5bis			←	error	
5ter	Stand by				
go to 2					
6			←	end Time Out	
7		Writes general status	→		RUNNING
8	Stand by				
Timeout					Ready

Disconnection:

	State	Request		Frame	State
5	Wait TimeOut				
6				disconnection	
7	Stand by				
8		Writes general status	→		DCNX

6.3.5.2.2 Polling

The beginning of Digital Inputs and Analogue Inputs polling is delayed by a time-out starting at the end of the Rish Pro M01 initialization. The C26x can send a synchronous frame during the initialization phase. Depending on the function and the read use in this frame, the M01 answers with a correct frame or an exception frame but does not invalidate the initialization.

6.3.5.2.3 Error management

The Rish Pro M01 has no register to read status value and the function 7 is not supported. So, to detect a problem, the C264 uses the exception codes sent by the Rish Pro M01. Rish Pro M01 generates the error codes that follow:

Code	Description
01h	Unsupported function code
02h	Invalid memory register address: use of invalid register number or attempt to write to a memory protected register
03h	Invalid data, i.e. an invalid number of registers
06h	Device is busy. This code signals that the relay is occupied with functions performed via the local RS232 interface (changing configuration, simulation or calibration of analogue outputs..)
0Ah	Possible change of rated values. The device configuration has been modified since the latest request for measurements or this is the first request for measurements since the relay was switched on. Read the table of measurements and the scaling factors table.

Error code 06h and 0Ah must be treated as a disconnection of the IED and a new initialization phase must be completed before reading the Rish Pro M01 data. Other codes can be treated as usually.

Only errors from initialization sequence or polling DIs and AIs report an error code. Errors from synchronous frame only generate an error message, but do not cause a new initialization sequence.

At reception of the message error code 0x6h or 0xAh, if the mode polling is active, reauthorize future polling. The IED general status goes to INIT and the C26x goes to state "STAND BY" and extracts the event "RISHM01 CNX".

In event of trouble, the IED sends the Modbus exception 'Busy'. The C26x considers the IED as disconnected (that will force the initialization sequence to be redone) but DOES NOT PUT the IED information to unknown.

6.3.5.3 FLEXGATE

6.3.5.3.1 Polling

Upon start-up of the C26x, a polling request is sent to determine the status (function 7). A response means that the Flexgate IED is connected.

No Digital Inputs polling: a DI change is signaled by an event.

The C26x polls for fields ‘Internal status bits’ at address 18993 to 19000 with function 2:

Fields	Address	Description
Events pending bit	18993	Is there a new event ?
Time is not sent from Modbus master within last 16 minutes	18994	Is Flexgate IED synchronized with C26x ?
Time is not synchronized by minute pulse within last 1.5 min	18995	Not used

6.3.5.3.2 Other data received from Flexgate

If an event is received (flag at Modbus address 18993), the C26x reads the events queue.

To read the events, the C26x realize an alternative reading between addresses 39001 and 39011, which allows reading next event.

If the C26x reads the same address – without any other request in between – it gives the same event.

The Flexgate sends a response on six words. Refer to the converter documentation.

The C26x continues to read the event file until there is no new event. Then, it polls for the ‘Internal status bits’.

Sequence numbers

In the event response, the sequence number is between 1 and 65535.

Reserved numbers:

- 0 indicates that there is no event anymore
- 1 indicates that the converter (Flexgate) has been reinitialized
- 50 indicates the re-initialization of the converter (Flexgate)
- 51 indicates an overflow events buffer. The event buffer size is 200. The Flexgate does not allow to add new events until the event 51 is read. At this time, the C26x considers that one or more events have been lost. Then it repeats the General Interrogation, and the cycle continues starting with the internal status bits polling.

If a gap appears in the sequence number, the C26x considers that an event has been lost. Then it repeats the General Interrogation; the cycle continues polling the internal status bits.

6.3.5.3.3 Data sent to Flexgate

The C26x sends Date and Time in one request with function 16 at Modbus addresses 49001…49007 (2328h to 232Eh).

The following format is used to write the date: [year/month/day/hour/minutes/milliseconds since midnight] to two words by data except for milliseconds which takes four words.

The C26x periodically sends the date to synchronize the Flexgate. The time must be sent with a period smaller than 16 minutes.

As they are sent to a specific address, there can be only one Flexgate on the legacy bus.

6.3.5.3.4 Error management

Flexgate generates the following error code:

Code	Description
03h	Illegal data value, i.e. invalid number of register (send a “Configuration error” message to the application and continue). Also used to indicate a hardware malfunction like an interlock condition not ok on a protective relay

6.3.5.4 SEPAM

As for standard Modbus, three modes are available:

- ‘General Interrogation’: The C26x waits for the end of initialization, the disappearance of data loss signal. Then, it polls for all the DIs.
- 'Desynchronized': events are NOT managed. The DIs are updated by polling. DIs are read and decoded group by group. The status is read and decoded when all the groups have been read.
- 'Synchronized': events are managed. The C26x reads the status word, then the events. The DIs are updated when the events are decoded.

6.3.5.4.1 Data received from Sepam

DIs

- Modes GI and ‘not synchronized’:
  - The C26x reads DI group with function 3 at address that follow:

Mode	Address Sepam 40	Address Sepam 80
GI	0x100 to 0x10A	0xC10 to 0xC16
‘not synchronized’	0x100 to 0x10A	0xC90 to 0xC9F

  - When it receives a data, it decodes the status frame and the DI group frame.

- Mode ‘synchronized’:
  - The C26x reads the status frame (function 7) till it detects a data
  - it checks event and reads the event table using function 3 at address 0x40 with size 33.
  - it decodes the event frame and acknowledges using function 6 at address 0x40 with value ‘ExchangeNumber’ at 0.

6.3.5.4.2 Data sent to Sepam

Date and time format: [Day/month/Year Hour.Min:Ms] [14/5/38 6.43:16785] for the 38th year since 1970 (ie. 2008), the 14th May at 6 hours 43 minutes and 16785 milliseconds.

Address for synchronization: 0x0002.

6.3.5.5 WAGO

The Wago relay behaves generically except for the setpoints that are integers not signed on 15 bits.

6.4 DNP 3.0 COMMUNICATIONS

6.4.1 SCOPE OF THIS SECTION

The purpose of this chapter is not to describe the DNP3 protocol but to specify the use of the DNP3 protocol on a legacy bus of the C26x.

As the C26x is the master on the legacy bus - regards to protections and IEDs - this protocol is referenced as “Master DNP3” in the C26x.

Here are described:

- Specific behaviours attached to the protocol DNP3
- Restriction and enhancement
- Part of the DNP3 protocol used and not used

6.4.2 INTERFACE TO IEDS

6.4.2.1 INPUT

Object	Variation	Data	GI	Polling	Function
01	0	Static BI (SPS)	●		[1] READ
02	0	BI Event (SPS)		●	[1] READ
20	0	Static Counter	●		[1] READ
22	0	Counter Event		●	[1] READ
30	0	Static Measurement	●		[1] READ
32	0	Measurement Event		●	[1] READ
60	01	Class 0	●		[1] READ
60	02, 03, 04	Class 1,2,3		●	[1] READ

Note:
BI, Measurement and Counter are polled with the variation 0. That means that all variations are required.
All other DNP3 objects are not treated.

6.4.2.2 OUTPUT

Object	Variation	Data	Function	Note
12	01	Command: Control Relay Output Block	[3] SELECT	Treated
			[4] OPERATE	Treated
			[5] DIRECT OPERATE	Treated
41	01	SetPoint : 32 bit Analog Output Block	[3] SELECT	Supported
			[4] OPERATE	Supported
			[5] DIRECT OPERATE	Supported
50	01	Time and Date	[2] WRITE	Treated

The DNP3 Master manages both direct control Command and Select before Operate for digital control only.

When operate command is received from application, the Master checks in database to know if the command is:

- An execute command, which belongs to a SBO Control: OPERATE function is used in this case.
- A direct control: DIRECT OPERATE function is used is this case

6.4.3 BEHAVIOUR

- Synchronisation:
  - The “Master DNP3” is always synchronised by the C26x. No calculation of the transmission delay is performed.
  - The DNP3 object used to synchronise IEDs is “Write Date and Time Request (Object 50, Variation 01).
  - Synchronisation is performed first at connection of an IED.
  - Then, synchronisation is sent cyclically to all the IEDs.
- Initialisation:
  - To connect an IED, a “Reset CU” (function 0) frame is sent to the IED.
  - When the response is OK, the Master DNP3 send a message to the application to tell that connection step is passed.
  - Next step is General Interrogation
- General Interrogation:

When the IED is connected, the C26x ask for static data state and value with a sequence of:

- Read BI,
- Read Measurement,
- Read TPI,
- Read Counter

This Sequence is the General Interrogation. Next step is Polling

- Polling:

The polling cycle depends on the configuration:

- class 0 only: the CURRENT value of a BI, measurement, or counter, …. is polled for. The GI polling period is configurable using the “class 0 polling period” configuration parameter; when this parameter is set to 0 second, there is no cyclic GI.
- Poll Class 0 or Class 1 or Class 2 or Class 3: this is a poll for all EVENT data followed in return by all (static) current data.

The polling cycle must be interrupted at minimum in the two following case:

- Clock Synchronisation
- Remote control

- Event acquisition:

Event occurs spontaneously. The slave device waits for being polled by the master. With unsolicited reporting, Slave devices can send updates as values change, without having to wait for a poll from the Master.

- IED monitoring:

A General Interrogation may be done after connection of an IED

6.4.4 DATA RECEIVED FROM IEDS

- Digital inputs:
  - A DI is identified by an Index, associated with a pair “Object + Variation” which identify the type of data.
  - Digital inputs which are received as state changes are identified by the DNP3 object number 02
  - Digital inputs which are received as static data are identified by the DNP3 object number 01
- Measurements:
  - A Measurement is identified by an Index, associated with a pair “Object + Variation” which identify the type of data.
  - Both analogue and numeric measurements are treated
  - Measurements which are received as state changes are identified by the DNP3 object number 32
  - Measurements which are received as static data are identified by the DNP3 object number 30
- Counters:
  - A Counter is identified by an Index, associated with a pair “Object + Variation” which identify the type of data.
  - Counters which are received as state changes are identified by the DNP3 object number 22
  - Counters which are received as static data are identified by the DNP3 object number 20

6.4.5 DATA SENT TO IEDS

- Controls:
  - A Control is identified by an Index, associated with a pair “Object + Variation” which identify the type of data.
  - In case of basic control (Set, Reset, Trip, Close), DNP3 object 12 is used with the Variation 01

6.4.6 MASTER DNP3.0 PROFILE

<table>
<tr><th colspan="2">DNP V3.00 Device Profile</th></tr>
<tr><td colspan="2">Vendor Name: GE Grid Solutions</td></tr>
<tr><td colspan="2">Device Name: DS Agile C26x</td></tr>
<tr><td>Highest DNP Level Supported:
For Requests Level 3
For Responses Level 3</td><td>Device Function:
■ Master ☐ Slave</td></tr>
<tr><td colspan="2">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels supported:
_____
_____</td></tr>
<tr><td>Maximum Data Link Frame Size (octets):
Transmitted 292
Received: (must be 292)</td><td>Maximum Application Fragment Size (octets):
Transmitted 2048
(configurable: 15 to 2048 octets)
Received 2048</td></tr>
<tr><td>Maximum Data Link Re-tries:
☐ None
☐ Fixed at _____
■ Configurable, range 1 to 10</td><td>Maximum Application Layer Re-tries:
■ None
☐ Configurable, range ___ to _____
(Fixed is not permitted)</td></tr>
</table>

DNP V3.00 Device Profile

Requires Data Link Layer Confirmation:

☐ Never
■ Always
☐ Sometimes If 'Sometimes', when?

☐ Configurable If 'Configurable', how?

User option to set Data Link Confirmation to:

- Always – device will always request Data Link Confirmations.
- Multi-packet only – the device will request Data Link Confirmations when sending multi-packet responses.
- Never – the device will never request Data Link Confirmations.

Requires Application Layer Confirmation:

■ Never
☐ Always (not recommended)
☐ When reporting Event Data (Slave devices only)
☐ When sending multi-fragment responses (Slave devices only)
☐ Sometimes If 'Sometimes', when?

☐ Configurable If 'Configurable', how?

Timeouts while waiting for:

Data Link Confirm	☐ None	■ Fixed at 3s	☐ Variable	☐ Configurable
Complete Appl. Fragment	☐ None	☐ Fixed at	■ Variable	☐ Configurable
Application Confirm	■ None	☐ Fixed at	☐ Variable	☐ Configurable
Complete Appl. Response	☐ None	☐ Fixed at	■ Variable	☐ Configurable

Others

Attach explanation if 'Variable' or 'Configurable' was checked for any timeout

Sends/Executes Control Operations:

WRITE Binary Outputs	■ Never	☐ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☐ Never	☐ Always	☐ Sometimes	■ Configurable
DIRECT OPERATE	☐ Never	☐ Always	☐ Sometimes	■ Configurable
DIRECT OPERATE - NO ACK	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Count > 1	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Pulse Off	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Latch Off	☐ Never	☐ Always	☐ Sometimes	■ Configurable
Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable

- Select timeout: configurable

6.4.7 DNP 3 LEVEL 3 IMPLEMENTATION TABLE

Information on blue background is not implemented

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	FuncCode (dec)	Qual Codes (hex)
1	0	Binary Input – All Variations	1, 22	00,01,06		
1	1	Binary Input	1	00,01,06	129	00,01 (start-stop)
1	2	Binary Input with Status	1	00,01,06	129	00,01 (start-stop)
2	0	Binary Input Change - All Variations	1	06,07,08		
2	1	Binary Input Change without Time	1	06,07,08	129	17,28 (index)
2	2	Binary Input Change with Time	1	06,07,08	129	17,28 (index)
2	3	Binary Input Change with Relative Time	1	06,07,08	129,130	17,28
10	0	Binary Output - All Variations	1	00,01,06		
10	1	Binary Output				
10	2	Binary Output Status	1	00,01,06	129	00,01
12	1	Control Relay Output Block (1)	3,4,5,6	17,28 (index)	129	Request echo
20	0	Binary Counter - All Variations	1,7,8,9,10,22	00,01,06		
20	1	32-Bit Binary Counter	1	00,01,06	129	00,01 (start-stop)
20	2	16-Bit Binary Counter	1	00,01,06	129	00,01 (start-stop)
20	5	32-Bit Binary Counter without Flag	1	00,01,06	129	00,01 (start-stop)
20	6	16-Bit Binary Counter without Flag	1	00,01,06	129	00,01 (start-stop)
(1) Commands must be selected/executed on one point						
21	0	Frozen Counter - All Variations	1	00,01,06		
21	1	32-Bit Frozen Counter	1	00,01,06	129	00,01
21	2	16-Bit Frozen Counter	1	00,01,06	129	00,01
21	9	32-Bit Frozen Counter without Flag	1	00,01,06	129	00,01
21	10	16-Bit Frozen Counter without Flag	1	00,01,06	129	00,01
22	0	Counter Change Event - All Variations	1	06,07,08		
22	1	32-Bit Counter Change Event without Time	1	06,07,08	129	17,18 (index)
22	2	16-Bit Counter Change Event without Time	1	06,07,08	129	17,18 (index)
22	5	32-Bit Counter Change Event with Time	1	06,07,08	129	17,18 (index)
22	6	16-Bit Counter Change Event with Time	1	06,07,08	129	17,18 (index)
Notes: *Frozen counters (type21) are uploaded during general interrogation, but never polled after this.*						
23	0	Frozen Counter Event - All Variations	1	06,07,08		

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
23	1	32-Bit Frozen Counter Event without Time	1	06,07,08	129,130	17,18 (index)
23	2	16-Bit Frozen Counter Event without Time	1	06,07,08	129,130	17,18 (index)
23	3	32-Bit Frozen Delta Counter Event without Time	1	06,07,08	129,130	17,18
23	4	16-Bit Frozen Delta Counter Event without Time	1	06,07,08	129,130	17,18
30	0	Analogue Input - All Variations	1	00,01,06		
30	1	32-Bit Analogue Input	1	00,01,06	129	00,01 (start-stop)
30	2	16-Bit Analogue Input	1	00,01,06	129	00,01 (start-stop)
30	3	32-Bit Analogue Input without Flag	1	00,01,06	129	00,01 (start-stop)
30	4	16-Bit Analogue Input without Flag	1	00,01,06	129	00,01 (start-stop)
32	0	Analogue Change Event - All Variations	1	06,07,08		
32	1	32-Bit Analogue Change Event without Time	1	06,07,08	129	17,18 (index)
32	2	16-Bit Analogue Change Event without Time	1	06,07,08	129,	17,18 (index)
32	3	32-Bit Analogue Change Event with Time	1	06,07,08	129,130	17,18
32	4	16-Bit Analogue Change Event with Time	1	06,07,08	129,130	17,18
40	0	Analogue Output Status - All Variations	1	00,01,06		
40	1	32-Bit Analogue Output Status	1	00,01,06	129	00,01 (start-stop)
40	2	16-Bit Analogue Output Status	1	00,01,06	129	00,01 (start-stop)
41	1	32-Bit Analogue Output Block	5,6	17,28 (index)	129	Request echo
41	2	16-Bit Analogue Output Block	5,6	17,28 (index)	129	Request echo
50	0	Time and Date - All Variations				
50	1	Time and Date	1	07 (quantity=1)	129	07 (quantity=1)
50	2	Time and Date with Interval	2	07 (quantity=1)		
51	1	Time and Date CTO			129,130	07 (quantity=1)
51	2	Unsynchronized Time & Date CTO			129,130	07 (quantity=1)
52	1	Time Delay Coarse			129,	07 (quantity=1)
52	2	Time Delay Fine			129,	07 (quantity=1)
60	1	Class 0 Data	1	06		
60	2	Class 1 Data	1	06,07,08		
			20,21,22	06		

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
60	3	Class 2 Data	1	06,07,08		
			20,21,22	06		
60	4	Class 3 Data	1	06,07,08		
			20,21,22	06		
80	1	Internal Indications	2	00 (start-stop) (index=7)		
			1	00,01 (start-stop)	129	00,01 (start-stop)
No Object (Cold Restart)			13			
No Object (Delay Measurement)			23			

"On-line" Quality bit management:

The table below described the management of the DNP3 binary input status object for each SPS status. This management is the same whether the information is with or without time tag. SBMC is off.

IEC 61850 SPS quality	[0x00	VALID			UNKNO	
IEC 61850 Associated SPS State			V			V
DNP3 binary input status object						
State BS1[7]			V			X
Reserved BS1[6]			X			X
Chatter filter BS1[5]			X			X
Local Forced BS1[4]			X			X
Remote Forced BS1[3]			X			X
Comm.lost BS1[2]			X			X
RestartBS1[1]			X			X
On-line BS1[0]			1			0

V stands for received value or start-up value

"-" stands for 0. When 0 is significant for the understanding, 0 appears in the cell.

"X" stands for "indifferent status bit".

Note:
IEC 61850 TOGGLING, SELFCHECK FAULTY, SUPPRESSED, FORCED and SUBSTITUED status are not used with DNP3 MASTER Protocol. When the IED is disconnected, the SPS status is set to "UNKNOWN".

DNP3 Meas. status obj.	[0x 0000]	Valid		[0x 4100]	Unknown		[0x6000]	Overrange	
IEC MV VALUE		V			V			V	
Reserved [7]		X			X			X	
Reference error BS1[6]		X			X			X	
Over-range BS1[5]		0			0			1	
LocalForced BS1[4]		X			X			X	
Remote Forced BS1[3]		X			X			X	
Comm.lost BS1[2]		0			1			X	
RestartBS1[1]		X			X			X	
On-line BS1[0]		1			X			X	

For analogue inputs, the third column header becomes [0x4080] Undefined.

DNP3 counterstatus obj. object	[0x 0000]	Valid		[0x4200]	Self-check faulty		[0x 4100]	Un-known		[0x6000]	Over-range	
Counter VALUE		V				V			V			V
Reserved [7]		X				X			X			X
Reserved BS1[6]		X				X			X			X
Roll-Over BS1[5]		0				0			0			1
Local Forced BS1[4]		X				X			X			X
Remote Forced BS1[3]		X				X			X			X
Comm.lost BS1[2]		0				0			1			X
RestartBS1[1]		X				X			X			X
On-line BS1[0]		1				0			X			X

6.5 IEC 60870-5-103 COMMUNICATIONS

6.5.1 SCOPE OF THIS SECTION

The purpose of this chapter is not to describe the T103 but to specify the use of the T103 protocol on a legacy bus of the C26x.

As the C26x is the master on the legacy bus - regards to protections and IEDs - this protocol is referenced as “Master T103” in the C26x.

Here are described:

- Specific behaviours attached to the protocol T103
- Restrictions and enhancements
- Part of the T103 protocol used and not used
- Specific behaviours attached to implementation of Private Range of T103

6.5.2 INTERFACE TO IEDS

6.5.2.1 INPUT

ASDU	Data	Note
1	Dated Digital input (absolute dating) Control acknowledgement	Treated
2	Dated Digital input (relative dating)	Treated
3	Measurement	Treated
4	Measurement: Default position	Treated
5	Identification	Not treated
6	Time synchronisation acknowledgement	Treated
8	End of GI	Treated
9	Measurement	Treated
10	General Data	Not treated (some measurements only)
11	General Identification	Not treated
17	Measurement	Reg D only
23 … 31	Disturbance file management	Treated
45	Ack of Single Command	MiCOM Px3x only
46	Ack of Double Command	MiCOM Px3x only
49	Analog protection signal Only adress 0 which is DVICE: Device type	MiCOM Px3x only
65	Single Point	MiCOM Px3x only
66	Single Point with Time Tag	MiCOM Px3x only
67	Double Point	MiCOM Px3x only
68	Double Point with Time Tag	MiCOM Px3x only
71	BitString 32 Bit without time tag pair FUN /TYP computed: F8h / 70h: State of the IED F8h / 74h: Request Station Interlock	MiCOM Px3x only
72	BitString 32 Bit with time tag – see ASDU 71	MiCOM Px3x only
73	Measurement, Normalised value	MiCOM Px3x only
77	Measurement	MiCOM Px2x only
79	Energy Counter	MiCOM Px3x only

6.5.2.2 OUTPUT

ASDU	Data	Note
6	Time synchronisation	Treated
7	Request a GI	Treated
20	Command	Treated
23 … 31	Disturbance file management	Treated
45	Single Command	MiCOM Px3x only
46	Double Command	MiCOM Px3x only
140	Read protection parameter Only address 0 which is DVICE: Device type	MiCOM Px3x only
144	Setpoint	Reg D only

6.5.3 BEHAVIOUR

6.5.3.1 SYNCHRONISATION

The “Master T103” link is always synchronised by the C26x. No calculation of the transmission delay is performed.

6.5.3.2 POLLING

To connect an IED, a “Reset CU” frame is sent to the IED.

By default an IED is polled by a “Polling C2” frame, allowing to get “non priority information”.

If an IED signals it has “priority information”, it is polled with a “Polling C1” frame.

6.5.3.3 IED MONITORING

The “OUT_OF_SERVICE” state is managed. It corresponds to the “Lock of communication” [DI 20].

The C26x may regularly look for Disturbance file presence

6.5.3.4 STATION INTERLOCKING

This functionality is only available on MiCOM P139 in private T103 range (Alstom D protocol variant)

After GI, and only if IED is MiCOM Px3x, we send a read on MiCOM Px3x parameter adress 0 which corresponds to Device Type. If MiCOM Px3x responds with analog parameter set to 139, we activate Station Interlocking Management.

Case of **local control** (front panel of the MiCOM P139) with Station interlock:

As soon as a user will try to control a switchgear by the front panel, the MiCOM P139 will send an ASDU 72 with FUN/TYP = F8h/74h in order to request to DS Agile system the station interlock conditions. The DS Agile system should check whether the command is allowed (specific treatment done by CONDUITE of the C26x) and respond to the MiCOM P139.

Case of **remote control** (from DS Agile system) with Station interlock:

As soon as a user tries to control a device managed by MiCOM P139 by DS Agile system through T103 communication, the MiCOM P139 sends an ASDU 72 with FUN/TYP = F8h/74h in order to request to DS Agile system the station interlock conditions. The DS Agile system should respond to the MiCOM P139 with a positive acknowledgement (checks have already been done before)

If station Interlock is de-activated on MiCOM P139, the control of a switchgear on MiCOM P139 by DS Agile system through T103 communication is done by an EXECUTE ORDER (selection will be refused by MiCOM P139)

6.5.3.5 REG D

The Reg D equipment manages 2 ASDU (144 and 17), for control of setpoints (144) and setpoint value feedback (17), which is treated as a measurement in the C26x. Setpoints managed by the Reg D are "Direct Execute" only, there is no SBO management. The Reg D setpoint command sequence is like the command sequence (ASDU20). The C26x sends the setpoint (ASDU 144), with the setpoint value, the Reg D sends its acknowledge (ASDU1), if the acknowledge is OK, the Reg D sends the setpoint value feedback (ASDU17).

6.5.3.6 TAPCON260

The Tapcon260 equipment supports ASDU 204 / FUN TYP=110/ INF=54 for TPI acquisition. Nevertheless, the object type in SCE must be MV, not TPI.

6.5.4 DATA RECEIVED FROM IEDS

6.5.4.1 DIGITAL INPUTS

An ASDU number [(1,2) in public Range],[(66,67,68,69) in private Range]

A DI is identified by a pair (Function Type, Information Number).

Digital inputs are received as state changes.

Special DI may be managed:

- DI 20: Lock of the communication. A GI must be done when the communication is unlocked
- DI 23 to 26: Change of configuration number
- DI which are not transmitted during a GI. For these DI, the IED signals only state change from OFF to ON. The C26x must generate by itself the change from ON to OFF.

6.5.4.2 MEASUREMENTS

A Measurement is identified by:

- An ASDU Number [(3,4,9) in public range, (10, 21, 73,77) in private range]
- a pair (Function Type, Information Number)
- the rank of the Measurements in the ASDU
- the kind of Measurements [Current, Voltage, Power, Frequency, Other]
- the common address of ASDU

ASDU 21 and 10 provide the acquisition of the following measurements coming from P44x relay:

- Current tripping values
- Residual voltages and currents
- Sum of trips
- Sum of cut amperes

The C26x polls regularly the cells containing the measurement values.

It reads by ASDU 21 a single entry:

Description	TI	VSQ	COT	ADR	FUN	INF	RII	NOG	GIN	KOD
Measurement	15H	81H	2AH	CAD	FEH	F4H	x	1	Courier cell number	1

TI = Type identification
VSQ = variable structure qualifier
COT = cause of transmission
ADR = CAD = common address
FUN = function number
INF = information number
RII = Return information identifier
NOG = Number Of Generic identification
GIN = Generic Identification Number

ASDU 10 provides the response.

6.5.4.3 BITSTRING 32-BITS:

The state of the IED is identify by the ASDU 71 or 72 with pair FUN / TYP = F8h / 70h. This ASDU describes the status of the IED (Station Interlocking active or not …)

A request to check station interlocking is identify by the ASDU 71 or 72 with pair FUN / TYP = F8h / 74h. In this request, the pair FUN/TYP of the command to spend is defined.

6.5.4.4 ANALOG PROTECTION SIGNAL (ASDU 49):

Only for MiCOM Px3x, an analogue protection signal is received after GI

Only address 0 is managed. It is used to recognise MiCOM P139 in order to activate station interlocking management.

6.5.4.5 ENERGY COUNTER (ASDU 79):

Only for MiCOM Px3x, four energy counters are available.

Energy counters are identified by:

- An ASDU number (79) in private range
- a pair Function Type, Information number
- the rank of the counter in the ASDU
- the common address of the ASDU

Description	TI	VSQ	COT	ADR	FUN	INF	DB0-DB4	DB5-DB9	DB10-DB14	DB15-DB19
Energy counter	4FH	04H	01H	CAD	F8H	6CH	Active +	Active -	Reactive +	Reactive -

TI = Type identification
VSQ = variable structure qualifier
COT = cause of transmission
ADR = CAD = common address
FUN = function number
INF= information number
DB0-DB4 = active energy output
DB5-DB9 = active energy input
DB10-DB14 = reactive energy output
DB15-DB19 = reactive energy input

Format of the energy counter value

Value			
Value			
Value			
S	Value		
IV	CA	CY	Sequence number

S: 0 Value positive, 1 = value negative

CY: 0 = no carry, 1= carry

CA: 0 = not adjusted, 1 = adjusted

6.5.5 DATA SENT TO IEDS

6.5.5.1 CONTROLS

An ASDU Number and a pair (Function Type, Information Number) identify a control.

The acknowledgement of a control is to be waited as:

- A DI with the same (Function Type, Information Number) as the control and with a 'Cause Of Transmission' equals to 'positive return' or 'negative return' in public range
- A ASDU 45 or 46 with a 'Cause Of Transmission' equals to 'end of activation OK' or 'en of activation KO', or 'deactivation OK', or 'deactivation KO' in private range

6.5.5.2 SETPOINTS CONTROLS:

A setpoint control is identified by an ASDU Number plus a pair (Function Type, Information Number). In the case of the Reg D equipment the ASDU is 144.

The acknowledgement of a setpoint control is to be waited as:

- A DI (ASDU 1) with the same (Function Type, Information Number) as the control and with a 'Cause Of Transmission' equals to 'positive return' or 'negative return' in public range.
- An ASDU 17 with a 'Cause Of Transmission' equals to 'Local Operation' in public range. The ASDU is a measurement which contains the setpoint feedback value.

6.5.5.3 READ PROTECTION PARAMETER:

Only for MiCOM Px3x, a read of protection parameter (ASDU 140) address 0 (Device Type) is sent to IED

The IED responds with ASDU 49 in which Device Type is set (139 if IED is a MiCOM P139 for example).

6.5.5.4 ASDU 232 / 105 MANAGEMENT

It allows to send control to IEC60870-5-103 legacy IED. It requires to manage also the ASDU 105 as response to ASDU 232.

Comparing ASDU232 & ASDU20

ASDU232			ASDU20	
Field	**Value**		**Field**	**Value**
ASDU No	E8H		ASDU No	14H
VSQ	81H		VSQ	81H
COT	14H		COT	14H
Device address	@ied		Common Address of ASDU	@ied
DN2	*Cfg*		*Function type*	*Cfg*
DN3	*Cfg*		*Information Number*	*Cfg*
DC0	1=OFF; 2=ON		DC0	1=OFF; 2=ON
X	0		RII	Set by master

Comparing ASDU105 & ASDU01

ASDU105			ASDU01	
Field	**Value**		**Field**	**Value**
ASDU No	69H		ASDU No	01H
VSQ	81H		VSQ	81H
COT	45H, 46H, 47H, 7FH		COT	14H, 15H, 0BH
Device address	@ied		Common Address of ASDU	@ied

ASDU105			ASDU01	
Field	**Value**		**Field**	**Value**
DN2	*Idem ASDU232*		*Function type*	*Idem ASDU20*
DN3	*Idem ASDU232*		*Information Number*	*Idem ASDU20*
DPI	1=OFF; 2=ON		DPI	1=OFF; 2=ON
X	0		msLow	Four octet binary time CP32Time2a
msLow	Four octet binary time CP32Time2a		msHigh	
msHigh			IV 0 mmmmmm	
IV 0 mmmmmm			SU 00 hhhhhh	
SU 00 hhhhhh			SIN	*Idem RII ASDU20*

Configuration

Management of commands through ASDU 232.

- The ASDU number [232]
- DN2 & DN3 (respectively ‘y’ & ‘x’ component of PID)

Management of state through ASDU 105.

- The ASDU number [232]
- DN2 & DN3 (respectively ‘y’ & ‘x’ component of PID)

DN2 & DN3 will be given – respectively – as ‘Function type’ & ‘Information Number’.

6.6 IEC 60870-5-101 COMMUNICATIONS

6.6.1 PURPOSE

The purpose of this chapter is not to describe the T101 protocol but to specify the implementation of T101 protocol on a legacy bus inside the C26x.

6.6.2 MASTER IEC 60870-5-101 PROFILE

The companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameters values, such as the number of bytes in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system.

Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarises the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ Function or ASDU is used as standardised (default)

The possible selection (blank, X) is specified for each specific clause or parameter.

Note: In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

6.6.2.1 SYSTEM OR DEVICE

(system specific parameter, indicates the definition of a system or a device by marking one of the following with '**X**')

☐ System definition

☐ Controlling station definition (Master)

☒ Controlled station definition (Slave)

6.6.2.2 NETWORK CONFIGURATION

(network specific parameter, all configurations that are used are marked 'X')

☒ Point-to-point ☒ Multipoint-party line

☒ Multiple point-to-point ☒ Multipoint-star

6.6.2.3 PHYSICAL LAYER

(network specific parameter, all interfaces and data rates that are used are marked '**X**')

Transmission speed (control direction)

Unbalanced interchange Circuit V24/V28				Balanced interchange Circuit X24/X27			
Standard		Recommended if > 1200 bits/s					
☒	100 bits/s	☒	2400 bits/s	☒	2400 bits/s	☐	56000 bits/s
☒	200 bits/s	☒	4800 bits/s	☒	4800 bits/s	☐	64000 bits/s
☒	300 bits/s	☒	9600 bits/s	☒	9600 bits/s		
☒	600 bits/s	☒	19200 bits/s	☒	19200 bits/s		
☒	1200 bits/s			☒	38400 bits/s		

Transmission speed (monitor direction)

Unbalanced interchange Circuit V24/V28				Balanced interchange Circuit X24/X27			
Standard		Recommended if > 1200 bits/s					
☒	100 bits/s	☒	2400 bits/s	☒	2400 bits/s	☐	56000 bits/s
☒	200 bits/s	☒	4800 bits/s	☒	4800 bits/s	☐	64000 bits/s
☒	300 bits/s	☒	9600 bits/s	☒	9600 bits/s		
☒	600 bits/s	☒	19200 bits/s	☒	19200 bits/s		
☒	1200 bits/s			☒	38400 bits/s		

6.6.2.4 LINK LAYER

(network specific parameter, all options that are used are marked '**X**'. Specify the maximum frame length).

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure

☒ Balanced transmission

☒ Unbalanced transmission

Address field of the link

☐ Not present (balanced transmission only)

☒ One octet

☒ Two octets

☒ Structured

☒ Unstructured

Frame length (number of bytes)

255 Maximum length L in control direction

up to 255 Maximum length L in monitor direction – configurable

6.6.2.5 APPLICATION LAYER

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Structured

☒ Two octets ☒ Unstructured

☒ Three octets

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked 'X')

☒ One octet ☒ Two octets (with originator address)
Set to zero in case of no originator address.

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<1>	:=	Single-point information	M_SP_NA_1
☒	<2>	:=	Single-point information with time tag	M_SP_TA_1
☒	<3>	:=	Double-point information	M_DP_NA_1
☒	<4>	:=	Double-point information with time tag	M_DP_TA_1
☒	<5>	:=	Step-position information	M_ST_NA_1
☒	<6>	:=	Step-position information with time tag	M_ST_TA_1
☐	<7>	:=	BitString of 32 bit	M_BO_NA_1
☐	<8>	:=	BitString of 32 bit with time tag	M_BO_TA_1
☒	<9>	:=	Measured value, normalized value	M_ME_NA_1
☒	<10>	:=	Measured value, normalized value with time tag	M_ME_TA_1
☒	<11>	:=	Measured value, scaled value	M_ME_NB_1
☒	<12>	:=	Measured value, scaled value with time tag	M_ME_TB_1
☒	<13>	:=	Measured value, short floating point value	M_ME_NC_1
☒	<14>	:=	Measured value, short floating point value with time tag	M_ME_TC_1
☒	<15>	:=	Integrated totals	M_IT_NA_1
☒	<16>	:=	Integrated totals with time tag	M_IT_TA_1
☐	<17>	:=	Event of protection equipment with time tag	M_EP_TA_1
☐	<18>	:=	Packed start events of protection equipment with time tag	M_EP_TB_1
☐	<19>	:=	Packed output circuit transmission of protection equipment with time tag	M_EP_TC_1
☐	<20>	:=	Packed single-point information with status change detection	M_PS_NA_1
☒	<21>	:=	Measured value, normalized value without quality descriptor	M_ME_ND_1
☒	<30>	:=	Single-point information with time tag CP56Time2a	M_SP_TB_1

☒	<31>	:=	Double-point information with time tag CP56Time2a	M_DP_TB_1
☒	<32>	:=	Step-position information with time tag CP56Time2a	M_ST_TB_1
☐	<33>	:=	Bistring of 32 bits with with time tag CP56Time2a	M_BO_TB_1
☒	<34>	:=	Measured value, normalized with time tag CP56Time2a	M_ME_TD_1
☒	<35>	:=	Measured value, scaled with time tag CP56Time2a	M_ME_TE_1
☒	<36>	:=	Measured value, short floating point number with time tag CP56Time2a	M_ME_TF_1
☒	<37>	:=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38>	:=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39>	:=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40>	:=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Process information in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<45>	:=	Single command	C_SC_NA_1
☒	<46>	:=	Double command	C_DC_NA_1
☒	<47>	:=	Regulating step command	C_RC_NA_1
☒	<48>	:=	Set point command, normalized value	C_SE_NA_1
☒	<49>	:=	Set point command, scaled value	C_SE_NB_1
☒	<50>	:=	Set point command, short floating point value	C_SE_NC_1
☐	<51>	:=	BitString of 32 bits	C_BO_NA_1

System information in monitor direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<70>	:=	End of initialisation	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<100>	:=	Interrogation command	C_IC_NA_1
☒	<101>	:=	Counter Interrogation Command	C_CI_NA_1
☐	<102>	:=	Read command	C_RD_NA_1
☒	<103>	:=	Clock synchronisation command	C_CS_NA_1
☒	<104>	:=	Test command	C_TS_NB_1
☐	<105>	:=	Reset process command	C_RP_NC_1
☐	<106>	:=	Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐	<110>	:=	Parameter of measured value, normalized value	P_ME_NA_1
☐	<111>	:=	Parameter of measured value, scaled value	P_ME_NB_1
☐	<112>	:=	Parameter of measured value, short floating point value	P_ME_NC_1

☐	<110>	:=	Parameter of measured value, normalized value	P_ME_NA_1
☐	<113>	:=	Parameter activation	P_AC_NA_1

File transfer

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒	<120>	:=	File ready	F_FR_NA_1
☒	<121>	:=	Section ready	F_SR_NA_1
☒	<122>	:=	Call directory, select file, call file, call section	F_SC_NA_1
☒	<123>	:=	Last section, last segment	F_LS_NA_1
☒	<124>	:=	Ack file, ack section	F_AF_NA_1
☒	<125>	:=	Segment	F_SG_NA_1
☒	<126>	:=	Directory	F_DR_TA_1

Special use

- (station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)
- None

Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used

Mark type identification/cause of transmission combinations:

'X' if used only in the standard direction

'R' if used only in the reverse direction

'B' if used in both directions

Type ID		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1		X	X								X	X		X					
<2>	M_SP_TA_1			X								X	X							
<3>	M_DP_NA_1		X	X								X	X		X					
<4>	M_DP_TA_1			X								X	X							
<5>	M_ST_NA_1		X	X								X	X		X					
<6>	M_ST_TA_1			X								X	X							
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1	X	X	X											X					
<10>	M_ME_TA_1			X																
<11>	M_ME_NB_1	X	X	X											X					
<12>	M_ME_TB_1			X																

Type ID		Cause of transmission																		
<13>	M_ME_NC_1	X	X	X											X					
<14>	M_ME_TC_1			X																
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1			X																
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1																			
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1	X	X	X																
<30>	M_SP_TB_1			X								X								
<31>	M_DP_TB_1			X								X								
<32>	M_ST_TB_1			X								X								
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1			X																
<35>	M_ME_TE_1			X																
<36>	M_ME_TF_1			X																
<37>	M_IT_TB_1			X																
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						X	X	X	X	X						X	X	X	X
<46>	C_DC_NA_1						X	X	X	X	X						X	X	X	X
<47>	C_RC_NA_1						X	X	X	X	X						X	X	X	X
<48>	C_SE_NA_1						X	X	X	X	X						X	X	X	X
<49>	C_SE_NB_1						X	X	X	X	X						X	X	X	X
<50>	C_SE_NC_1						X	X	X	X	X						X	X	X	X
<51>	C_BO_NA_1																			
<70>	M_EI_NA_1				X															
<100>	C_IC_NA_1						X	X			X									
<101>	C_CI_NA_1						X	X			X									
<102>	C_RD_NA_1																			
<103>	C_CS_NA_1						X	X												
<104>	C_TS_NA_1						X	X												
<105>	C_RP_NA_1																			
<106>	C_CD_NA_1																			
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1																			
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1													X						
<121>	F_SR_NA_1													X						
<122>	F_SC_NA_1													X						
<123>	F_LS_NA_1													X						
<124>	F_AF_NA_1													X						

Type ID		Cause of transmission																		
<125>	F_SG_NA_1												X							
<126>	F_DR_TA_1			X		X														

6.6.2.6 BASIC APPLICATION FUNCTIONS

Station initialisation

(station-specific parameter, mark 'X' if function is used)

☐ Remote initialisation

Cyclic data transmission

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Cyclic data transmission

Read procedure

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Read procedure

Spontaneous transmission

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Spontaneous transmission

Link state between Controlling and Controlled Station

☒ Management of the COM lost (Problem detecting on the link)

☒ Management of the COM recovering (Problem not detecting on the link)

General interrogation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Global

☐ Group 1	☐ Group 7	☐ Group 13
☐ Group 2	☐ Group 8	☐ Group 14
☐ Group 3	☐ Group 9	☐ Group 15
☐ Group 4	☐ Group 10	☐ Group 16
☐ Group 5	☐ Group 11	Addresses per group have to be defined
☐ Group 6	☐ Group 12	

Counter General interrogation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Global

☐ Group 1 ☐ Group 2 ☐ Group 3 ☐ Group 4

Clock synchronisation

(station-specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Clock synchronisation

Notes: The controlled station reports the change of hour by sending a clock synchronisation message (ASDU 103) to the controlling station.

Command transmission

(object -specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☒ Direct command transmission

☒ Direct set-point command transmission

☒ Select and execute command

☒ Select and execute set-point command

☒ C_SE_ACTTERM used (returned to the controlling station to signal the end of a control sequence)

☒ No additional definition

☐ Short pulse duration (duration determined by a system parameter in the outstation)

☐ Long pulse duration (duration determined by a system parameter in the outstation)

☐ Persistent output

Transmission of integrated totals

(object -specific parameter, mark each type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' is used in both directions)

☐ Mode A: local freeze with spontaneous transmission

☐ Mode B: local freeze with counter interrogation

☐ Mode C: freeze and transmit by counter interrogation commands

☐ Mode D: freeze by counter interrogation command, frozen values reported spontaneously

☒ Counter read	☒ General request counter
☐ Counter freeze without reset	☐ Request counter group 1
☐ Counter freeze with reset	☐ Request counter group 2
☐ Counter reset	☐ Request counter group 3
	☐ Request counter group 4

Parameter loading

(object-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

Parameter activation

(object-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☒ Test procedure

File transfer

(station-specific parameter), mark ‘X’ if function is used)

File transfer in monitor direction

☒ Transparent file

☒ Transmission of disturbance data of protection equipment

☒ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☒ Background scan

Acquisition of transmission delay

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Acquisition of transmission delay

Management events priorities

(station-specific parameter, mark each type ID ‘X’ if it is only used in the standard direction, ‘R’ if only used in the reverse direction, and ‘B’ is used in both directions)

☐ Digital Inputs and Analog Inputs, management events priorities.
See: T101 standard Amendment 2 §7.2.2.2

6.6.2.7 APPLICATION FUNCTIONS

The following IEC-60870-5-5 standard application processes are required to be supported.

Station Initialisation

Station initialisation consists of a reset of the communications link (a “Reset CU” frame and a Time Synchronisation message are sent to the IED), followed by a general interrogation of the controlled station. Once this initialisation sequence is performed, the controlling station can start the polling for data report.

Communications failure

Communications to the controlled station must be re-initialised by the controlling station when the frame repeat process has completed without successfully transmitting the frame (ie the frame time-out period times the number of repeats).

If the controlled station fails to communicate with the controlling station then the controlling station should perform a communications system initialisation for that controlled station.

Controlled station failure

The controlled station shall indicate to the controlling station that it has initialised by sending a frame indicating End of Initialisation with a Cause of Initialisation (COI) field, which will identify the reason for the initialisation.

Data Acquisition by Polling

The default for all analogue values shall be reporting as Class 2 data (COT=1, periodic/cyclic, or COT = 2, BackgroundScan cyclic).

Values returned as Class 2 data do not have a time tag (since they are constantly repeated).

The controlled station may return Class 1 data in response to a Class 2 request if no Class 2 data is available and Class 1 data is awaiting transmission.

At the controlled station, if a request for Class 2 data is received and no data is available a negative response, data not available, shall be returned to the controlling Station. The negative response is a fixed length frame (FC=9) or the Single Control Character (E5), which in this case is treated as a NACK.

By default an IED is polled by a “Polling C2” frame, allowing to get “non priority information”. If an IED signals it has “priority information” (ACD bit set), it is polled with a “Polling C1” frame.

Normal Acquisition of Events

The default for all status changes are reported as Class 1 data (COT=3, spontaneous).

Values returned as Class 1 data shall have a time tag (either CP24Time2a, or CP56Time2a).

Status changes at the controlled station shall cause the ACD bit to be set in the next Class 1 or Class 2 data response. The controlling station shall respond to ACD set by inserting a scan for Class 1 (spontaneous) data as the next scan.

The response to a Class 1 data request shall also have the ACD bit set if more Class 1 data is awaiting transmission. In this case a further scan for Class 1 data shall be scheduled by the controlling station.

Abnormal Acquisition of Events

At the controlled station, if a request for Class 1 data is received and no data is available an error should be raised and a negative response, data not available, returned to the controlling Station. The negative response shall be a fixed length frame (FC=9) or the single Control Character (E5), which in this case is treated as a NACK (configurable).

At the controlling station, if a response to a scan for Class 1 data indicates no data is available, an error shall be raised and scanning returned to Class 2 data requests.

General Interrogation

The GI returns the current status information directly from the C26x database.

Time tags are not used for data items returned as part of the GI response.

The GI groups are not supported, only the global general interrogation is supported.

Clock synchronisation

The System (including the controlled station) may have different synchronisation sources (IRIG-B, SCADA).

When the controlling station sends to controlled station a clock synchronisation and if the system is not synchronised by another source: the clock synchronisation response is positive.

When the controlling station send to controlled station a clock synchronisation and if the system (including the controlled station) is synchronised by another source: the clock synchronisation response is negative.

Time stamping

All Class 1 data are time-tagged with:

- either the 3 bytes time-stamp (CP24Time2a), giving minutes & millisec within the hour
- or the 7 bytes time-stamp (CP56Time2a), giving minutes, milliseconds, hours, day, month and year according to the C26x configuration.

In case of using relative time-Tag (CP24Time2a), the controlled station reports:

- the change of hour
- any time correction
- by sending a clock synchronisation message (ASDU 103) to the controlling station, as Class 1 data, with a cause of transmission spontaneous (3); the first frame is broadcast, the subsequent ones are sent point to point.

At initialisation or disconnection IEDs are not synchronised.

If the difference between IED time and C26x time is higher than 1s, the IED is considered to be not synchronised.

The invalid bit in the time-stamp is set when the time source is not available.

If the datapoint validity changes to “unknown” then it can be time-stamped as the latest received event or at the date of the change.

Command transmission

All control commands are Select Before Operate, or Direct Execute.

For only the control commands: Activation termination is returned to the controlling station to signal the end of a control sequence.

The QU field of the Qualifier of Command shall be set to zero (0), no additional definition.

Test procedure

A test command may be issued by the controlling station to ensure the availability of the communications link and the commands subsystem.

Test commands are received at the controlled station on the active link. The controlled station mirrors the test command, on the link from which it was received, with a cause of transmission indicating activation confirmation.

An error response is sent if the command is incorrect, with a cause of transmission indicating negative activation confirmation.

In the case of balanced mode, the controlled station may also send a test command to the controlling station, to ensure the availability of the communications link as there is no polling made by the controlling station.

6.7 COMMUNICATIONS WITH IEDS: LEGACY T104 MASTER NETWORK

A C26x can communicate as an IEC 60870-5-104 master (“T104M”) with networked IEDs.

A C26x may be connected to one IEC 60870-5-104 master network only.

That network may contain up to 16 IEC 60870-5-104 IEDs.

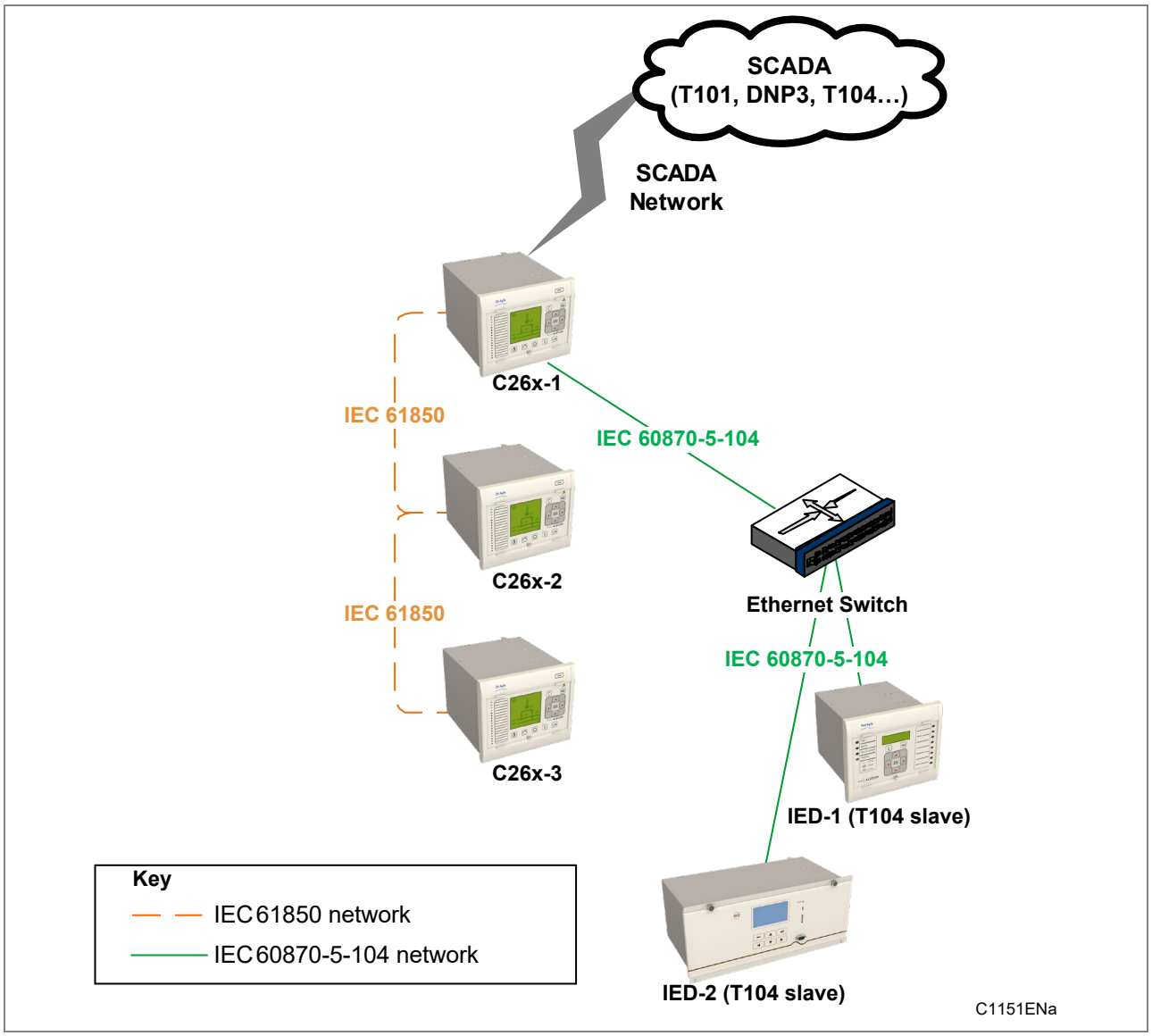


Figure 4: Architecture example for a C26x managing a T104 master network

6.7.1 MASTER IEC 60870-5-104 PROFILE

The user interface presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameters values, such as the choice of “structured” or “unstructured” fields of the INFORMATION OBJECT ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system.

Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarises the parameters of the previous clauses to facilitate a suitable selection for a specific application.

If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

The selected parameters are marked in the white boxes as follows:

☐ Function or ASDU is NOT used

☒ Function or ASDU is used as standardised (default)

Note 1:
In addition, the full specification of a system may require individual selection of some parameters for some parts of the system, such as the individual selection of scaling factors for individually addressable measured values.
Note 2:
Reverse mode is NOT implemented.

6.7.1.1 APPLICATION LAYER

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 60870-5-4, is used exclusively in this user interface.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked 'X')

☐ One octet ☒ Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked 'X')

☐ One octet ☒ Structured

☐ Two octets ☒ Unstructured

☒ Three octets

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked 'X')

☐ One octet ☒ Two octets (with originator address)

☒ Structured ☒ Unstructured

Length of APDU

The maximum length of APDU for both directions is 253. It is a fixed system parameter.

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☒	<1>	:=	Single-point information	M_SP_NA_1
☐	<2>	:=	Single-point information with time stamp	M_SP_TA_1
☒	<3>	:=	Double-point information	M_DP_NA_1
☐	<4>	:=	Double-point information with time stamp	M_DP_TA_1
☒	<5>	:=	Step-position information	M_ST_NA_1
☐	<6>	:=	Step-position information with time stamp	M_ST_TA_1
☐	<7>	:=	BitString of 32 bit	M_BO_NA_1

☐	<8>	:=	BitString of 32 bit with time stamp	M_BO_TA_1
☒	<9>	:=	Measured value, normalised value	M_ME_NA_1
☐	<10>	:=	Measured value, normalised value with time stamp	M_ME_TA_1
☒	<11>	:=	Measured value, scaled value	M_ME_NB_1
☐	<12>	:=	Measured value, scaled value with time stamp	M_ME_TB_1
☒	<13>	:=	Measured value, short floating point value	M_ME_NC_1
☐	<14>	:=	Measured value, short floating point value with time stamp	M_ME_TC_1
☒	<15>	:=	Integrated totals	M_IT_NA_1
☐	<16>	:=	Integrated totals with time stamp	M_IT_TA_1
☐	<17>	:=	Event of protection equipment with time stamp	M_EP_TA_1
☐	<18>	:=	Packed start events of protection equipment with time stamp	M_EP_TB_1
☐	<19>	:=	Packed output circuit transmission of protection equipment with time stamp	M_EP_TC_1
☐	<20>	:=	Packed single-point information with status change detection	M_PS_NA_1
☐	<21>	:=	Measured value, normalised value without quality descriptor	M_ME_ND_1
☒	<30>	:=	Single-point information with time stamp CP56Time2a	M_SP_TB_1
☒	<31>	:=	Double-point information with time stamp CP56Time2a	M_DP_TB_1
☒	<32>	:=	Step-position information with time stamp CP56Time2a	M_ST_TB_1
☐	<33>	:=	Bistring of 32 bits with with time stamp CP56Time2a	M_BO_TB_1
☒	<34>	:=	Measured value, normalised with time stamp CP56Time2a	M_ME_TD_1
☒	<35>	:=	Measured value, scaled with time stamp CP56Time2a	M_ME_TE_1
☒	<36>	:=	Measured value, short floating point number with time stamp CP56Time2a	M_ME_TF_1
☒	<37>	:=	Integrated totals with time stamp CP56Time2a	M_IT_TB_1
☐	<38>	:=	Event of protection equipment with time stamp CP56Time2a	M_EP_TD_1
☐	<39>	:=	Packed start events of protection equipment with time stamp CP56Time2a	M_EP_TE_1
☐	<40>	:=	Packed output circuit information of protection equipment with time stamp CP56Time2a	M_EP_TF_1

Process information in control direction

(station-specific parameter, mark each type ID ‘X’ if it is used in the standard direction)

☒	<45>	:=	Single command	C_SC_NA_1
☒	<46>	:=	Double command	C_DC_NA_1
☒	<47>	:=	Regulating step command	C_RC_NA_1
☒	<48>	:=	Set point command, normalised value	C_SE_NA_1
☒	<49>	:=	Set point command, scaled value	C_SE_NB_1
☒	<50>	:=	Set point command, short floating point value	C_SE_NC_1
☐	<51>	:=	BitString of 32 bits	C_BO_NA_1
☐	<58>	:=	Single command with time tag CP56Time2a	C_SC_TA_1
☐	<59>	:=	Double command with time tag CP56Time2a	C_DC_TA_1
☐	<60>	:=	Regulating step command with time tag CP56Time2a	C_RC_TA_1
☐	<61>	:=	Set point command, normalized value with time tag CP56Time2a	C_SE_TA_1
☐	<62>	:=	Set point command, scaled value with time tag CP56Time2a	C_SE_TB_1
☐	<63>	:=	Set point command, short floating point value with time tag CP56Time2a	C_SE_TC_1
☐	<64>	:=	Bitstring of 32 bit with time tag CP56Time2a	C_BO_TA_1

System information in monitor direction

(station-specific parameter, mark each type ID ‘X’ if it is used in the standard direction)

☒	<70>	:=	End of initialisation	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☒	<100>	:=	Interrogation command	C_IC_NA_1
☒	<101>	:=	Counter Interrogation Command	C_CI_NA_1
☐	<102>	:=	Read command	C_RD_NA_1
☐	<103>	:=	Clock synchronisation command	C_CS_NA_1
☒	<104>	:=	Test command	C_TS_NB_1
☐	<105>	:=	Reset process command	C_RP_NC_1
☐	<106>	:=	Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☐	<110>	:=	Parameter of measured value, normalised value	P_ME_NA_1
☐	<111>	:=	Parameter of measured value, scaled value	P_ME_NB_1
☐	<112>	:=	Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113>	:=	Parameter activation	P_AC_NA_1

Special use (private range)

(station-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☐	<136>	:=	Database version	M_DB_NA_1
☐	<137>	:=	Regulating delay command	C_RC_NB_1

Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used

Mark type identification/cause of transmission combinations:

'X' if used only in the standard direction

'R' if used only in the reverse direction

'B' if used in both directions

Type ID		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1		X	X								X			X					
<2>	M_SP_TA_1																			
<3>	M_DP_NA_1		X	X								X			X					
<4>	M_DP_TA_1			X								X								
<5>	M_ST_NA_1		X	X								X			X					
<6>	M_ST_TA_1																			
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1	X	X	X											X					
<10>	M_ME_TA_1			X																

Type ID		Cause of transmission																	
<11>	M_ME_NB_1	X	X	X										X					
<12>	M_ME_TB_1																		
<13>	M_ME_NC_1	X	X	X										X					
<14>	M_ME_TC_1			X															
<15>	M_IT_NA_1			X											X				
<16>	M_IT_TA_1																		
<17>	M_EP_TA_1																		
<18>	M_EP_TB_1																		
<19>	M_EP_TC_1																		
<20>	M_PS_NA_1																		
<21>	M_ME_ND_1																		
<30>	M_SP_TB_1			X								X	X						
<31>	M_DP_TB_1			X								X	X						
<32>	M_ST_TB_1			X								X	X						
<33>	M_BO_TB_1																		
<34>	M_ME_TD_1			X															
<35>	M_ME_TE_1			X															
<36>	M_ME_TF_1			X															
<37>	M_IT_TB_1			X											X				
<38>	M_EP_TD_1																		
<39>	M_EP_TE_1																		
<40>	M_EP_TF_1																		
<45>	C_SC_NA_1						X	X	X	X	X						X	X	X
<46>	C_DC_NA_1						X	X	X	X	X						X	X	X
<47>	C_RC_NA_1						X	X	X	X	X						X	X	X
<48>	C_SE_NA_1						X	X	X	X	X						X	X	X
<49>	C_SE_NB_1						X	X	X	X	X						X	X	X
<50>	C_SE_NC_1						X	X	X	X	X						X	X	X
<51>	C_BO_NA_1																		
<58>	C_SC_TA_1																		
<59>	C_DC_TA_1																		
<60>	C_RC_TA_1																		
<61>	C_SE_TA_1																		
<62>	C_SE_TB_1																		
<63>	C_SE_TC_1																		
<64>	C_BO_TA_1																		
<70>	M_EI_NA_1				X														
<100>	C_IC_NA_1						X	X	X	X	X						X	X	X
<101>	C_CI_NA_1						X	X			X						X	X	X
<102>	C_RD_NA_1															X			
<103>	C_CS_NA_1						X	X									X	X	X
<104>	C_TS_NA_1						X	X									X	X	X
<105>	C_RP_NA_1															X			
<106>	C_CD_NA_1						X	X								X			

Type ID		Cause of transmission																		
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1																			
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1																			
<127>	C_RC_NB_1																			

6.7.1.2 BASIC APPLICATION FUNCTIONS

Station initialisation

(station-specific parameter, mark ‘X’ if function is used)

☒ Remote initialisation

between Reset User ASDU’s

Cyclic data transmission

(station-specific parameter, mark each type ID ‘X’ if it is used in the standard direction)

☐ Cyclic data transmission

Read procedure

(station-specific parameter, mark each type ID ‘X’ if it is used in the standard direction)

☐ Read procedure

Spontaneous transmission

(station-specific parameter, mark each type ID ‘X’ if it is used in the standard direction)

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter, mark each information type "X" where both a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1

☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1

☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1

☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project)

☐ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1

☐ Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1

☐ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

General interrogation

(system or station-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☒ Global

☐ Group 1	☐ Group 7	☐ Group 13
☐ Group 2	☐ Group 8	☐ Group 14
☐ Group 3	☐ Group 9	☐ Group 15
☐ Group 4	☐ Group 10	☐ Group 16
☐ Group 5	☐ Group 11	
☐ Group 6	☐ Group 12	

Information object addresses assigned to each group must be shown in a separate table.

Clock synchronisation

(station-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☒ Clock synchronisation

Notes:
– The controlled station does not report the change of hour by sending a clock synchronisation message (ASDU 103) to the controlling station.
– When the controlling station sends the controlled station a clock synchronisation and if the system (includes controlled station), is not synchronised by an other source: the clock synchronisation response is positive.
– When the controlling station sends the controlled station a clock synchronisation and if the system (includes controlled station), is synchronised by an other source : the clock synchronisation response is negative.

Command transmission

(object -specific parameter, mark each type ID 'X' if it is used)

☒ Direct command transmission

☒ Direct set point command transmission

☒ Select and execute command

☒ Select and execute set-point command

☒ C_SE ACTTERM used

☒ No additional definition

☐ Short pulse duration (duration determined by a system parameter in the outstation)

☐ Long pulse duration (duration determined by a system parameter in the outstation)

Persistent output

Note:
Pulse duration can be defined in configuration. Short and long pulse bit on ASDU command is supported by link level but not transmitted to application level.

Transmission of integrated totals

(station-specific or object-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☐ Mode A: local freeze with spontaneous transmission

☐ Mode B: local freeze with counter interrogation

☐ Mode C: freeze and transmit by counter interrogation commands

☐ Mode D: freeze by counter interrogation command, frozen values spontaneously reported

Counter General interrogation

(object -specific parameter)

☐ Counter read

☐ Counter freeze without reset

☐ Counter freeze with reset

☐ Counter reset

☒ General request counter

☐ Request counter group 1

☐ Request counter group 2

☐ Request counter group 3

☐ Request counter group 4

Parameter loading

(object-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☐ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

Parameter activation

(object-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☐ Act/deactivation of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☒ Test procedure

File transfer

(not implemented)

Background scan

(station-specific parameter, mark each type ID 'X' if it is used in the standard direction)

☒ Background scan

Definition of timeouts

Parameter	Default value	Remarks	Selected value
t0	30 s	Time-out of connection establishment	
t1	15 s	Time-out of send or test APDUs	
t2	10 s	Time-out for acknowledges in case of no data messages t2 < t1	
t3	20 s	Time-out for sending test frames in case of a long idle state	

- Maximum range for timeouts t_0 to t_2: 1 s to 255 s, accuracy 1 s.
- Recommended range for timeout t_3: 1 s to 48 h, resolution 1 s.
- Long timeouts for t_3 may be needed in special cases where satellite links or dialup connections are used (for instance to establish connection and collect values only once per day or week).

Maximum number of outstanding I format APDUs *k* and latest acknowledge APDUs (*w*)

Parameter	Default value	Remarks	Selected value
k	12 APDUs	Maximum difference receive sequence number to send state variable	
w	8 APDUs	Latest acknowledge after receiving w I format APDUs	

- Maximum range of values *k*: 1 to 32767 (2^{15}–1) APDUs, accuracy 1 APDU
- Maximum range of values *w*: 1 to 32767 APDUs, accuracy 1 APDU
  (Recommendation: *w* should not exceed two-thirds of *k*).

Port number

Parameter	Value	Notes
Portnumber	2404	In all cases

6.7.1.3 LIMITS

- The C26x only supports one T104M IED network, which cannot be redundant.
- The T104M network can manage up to 16 IEDs.
- This feature is not compatible with C26x redundancy.
- T104 IED redundancy is not supported.
- Reverse mode is not implemented.
- The following ASDU are **not implemented**:
  - ASDU 7: Bitstring of 32 bits
  - ASDU 20: Packed single-point information with status change detection
  - ASDU 33: Bit-string of 32 bit with time tag CP56Time2a
  - ASDU 38: Event of protection equipment with time tag CP56Time2a
  - ASDU 39: Packed start event of protection equipment, time tag CP56Time2a
  - ASDU 40: Packed output circuit information of protection equipment with time tag CP56Time2a
  - ASDU 51: Bit-string of 32 bit
  - ASDU 58 to 64: commands with time tag CP56Time2a (only commands without time-tag are implemented)
  - ASDU 102: Read command
  - ASDU 103: Time synchronization message (CCSNA1)
  - ASDU 105: reset process command
  - ASDU 106: delay acquisition command
  - ASDU 110 to 113 concerning Parameters in control direction
  - ASDU 120 to 127 concerning File transfer

6.7.2 SYSTEM FUNCTIONS

Station Initialisation

In order to establish a connection with an IED, the T104 Master sends a "STARTDT.act" frame. The IED answers with a “STARTDT.con”. After it receives an "End of Initialisation" message, the T104 Master sends a "General Interrogation" message and also a "Counter Interrogation" message if at least one counter is configured.

There is no IED polling.

In the absence of I-frame transmission (“long idle state”), the T104 Master or the slave IED periodically sends a "TESTFR" message to check whether the link is still active.

A General Interrogation message is sent upon each IED connection.

Once this initialisation sequence is complete, the T104 master can wait for the data ASDU messages from the slave IEDs.

Communications failure

A communication failure occurs when:

- The IED does not acknowledge a data transmission within a specific time-delay: ADPU timeout T1.
- No Test Link frame (TESTFR) is received within a specific time-delay: see ADPU timeout T1.

The communications link with the controlled IED is re-initialised by the controlling T104 master when the frame repeat process was completed without successfully transmitting the frame (i.e.: the frame timeout period * the number of repeats).

If the controlled IED fails to communicate with the controlling T104 master then the latter performs a communications system initialisation for that controlled IED.

Controlled IED failure

Depending on the configuration, the controlled IED can let the controlling T104 master know that it has initialised by sending a frame indicating End of Initialisation (ASDU 70) with a Cause of Initialisation (COI) field, which will identify the reason for the initialisation.

Data Acquisition

The defaults for all analogue values are reported as data with COT=1 (periodic/cyclic) or COT=3 (spontaneous).

The transmitted values do not have a time stamp (since they are constantly repeated).

The Slave sends spontaneously ASDU message, on BI change of state/quality or on MEAS and SPI change of value/quality.

Normal Acquisition of Events

The default for all status changes are reported with COT=3 (spontaneous).

Transmitted Values shall have a time stamp (CP56Time2a).

Depending on configuration, time stamp reference can be Local or UTC.

General Interrogation

The General Interrogation returns the current status information directly from the IED's database.

General Interrogation groups are not supported, only the global general interrogation is supported

Time stamps are not used for data items returned as part of a response to the General Interrogation.

Synchronisation

The T104 master gateway C26x does not synchronise the IEDs.

Time Stamping

In case of time-stamped ASDUs received by the C26x, the data (binary inputs, measurements, step position indication and counters) are tagged with a 7-byte time stamp (CP56Time2a), giving minutes, milliseconds, hours, day, month and year according to the Computer configuration.

If the datapoint validity changes to “unknown” then it can be time-stamped as the latest received event or at the date of the change.

Test procedure

A test command (TESTFR) can be issued by the controlling T104 master to ensure the availability of the communications link and the commands subsystem.

Test commands are received by the controlled IED via the active link. The controlled IED answers the test command over the same link with the cause of transmission "acknowledgement of activation".

If the command is incorrect, an error response is sent with the cause of transmission "negative acknowledgement of activation".

The controlled IED can also send a test command to the controlling T104 master to ensure the availability of the communications link as there is no polling from the T104 master.

Command transmission

All the control/set point commands are set to either *Select before Execute (SE)* or *Direct Execute (DE)*.

For command requests, Activation termination (C_SE_ACTTERM) can be returned to the controlling T104 master to signal the end of a control sequence.

The QU field of the Command Qualifier is not taken into account.

6.7.3 APPLICATION FUNCTIONS

6.7.3.1 DATA RECEIVED FROM IEDS

Binary inputs

A BI is identified by an ASDU number: 1 and 30 for Single Point Status (SPS), 3 and 31 for Double Point Status (DPS).

A BI is also identified by its configurable point information address.

Any change of state or quality is transmitted by the T104 master to the C26x kernel.

If there is no change to the input or the validity, no received ASDU is forwarded to the C26x's kernel.

BIs without time stamp are time-stamped to the C26x's time.

If the IED has accepted the time synchronisation, the time stamp is considered synchronous, if it has not, it is considered asynchronous.

Measured values

An MV is identified by an ASDU number: 9, 11, 13, 21, 34, 35, or 36.

An MV is also identified by its configurable information object address.

Any change in value or quality is transmitted by the T104 master to the C26x kernel.

3 MV formats can be transmitted using the T104 protocol: normalized (ASDU 9, 34 and 21), scaled (ASDU 11 and 35) and floating (ASDU 13 and 36).

If the IED has accepted the time synchronization, the time stamp is considered as synchronous, not synchronous otherwise.

Step Position Indication

A SPI is identified by an ASDU number: 5 and 32.

A SPI is also identified by its configurable information object address.

Any change in value or quality is transmitted by the T104 master to the C26x kernel.

If the IED has accepted the time synchronization, the time stamp is considered as synchronous, not synchronous otherwise.

Counters

A CT is identified by an ASDU number: 15 and 37.

A CT is also identified by its configurable information object address.

Any change in value or quality is transmitted by the T104 master to the C26x kernel.

If the IED has accepted the time synchronization, the time stamp is considered as synchronous, not synchronous otherwise.

BitString 32-bits : not supported.

Automation

Any information acquired by the T104 master can be processed by an FBD and/or ISAGRAF automation configured on the C26x.

Gateway

Any information acquired by the T104 master can be transmitted through available SCADA protocols that have been configured on the C26x.

6.7.3.2 DATA SENT TO IEDS

Controls

A CO is identified by an ASDU number 45 for Single Point Command (SPC), 46 for Double Point Command (DPC) and 47 for regulating step command.

A CO is also identified by its configurable information object address.

The acknowledgement of a control is expected to be an ASDU 45, 46 or 47 with an appropriate "Cause Of Transmission" (activation confirmation, deactivation confirmation, activation termination).

Set point Commands (SP)

A SP is identified by an ASDU number 48 (normalized), 49 (scaled) and 50 (floating).

A SP is also identified by its configurable information object address.

The acknowledgement of a control is expected to be an ASDU 48, 49 or 50 with an appropriate "Cause Of Transmission" (activation confirmation, deactivation confirmation, activation termination).

NETWORK MONITORING

C26x/EN NM/D40

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1 INTRODUCTION

DS Agile Ethernet switches are designed to address the needs of a wide range of electric plant. Emphasis has been placed on strong compliance to standards, scalability, modularity and open architecture.

These facilitate use in a range of applications from the most basic to the most demanding. They also ensure interoperability with existing components.

GE Grid Solutions' philosophy is to provide a range of Ethernet products such as switches that match all the general requirements needed in an electric substation: power supply, immunity to environmental constraints.

It provides also solutions to specific requirement like for example network redundancy management and high availability performances.

Each of these boards can be used in the "C26x-Standalone" RTU application or can be integrated to a Digital Control System (DCS) (such as DS Agile) or to various types of system and SCADA architectures.

1.1 ETHERNET SWITCH BOARDS IN THE DS AGILE C26X

Driven by the requirements around the world for advanced applications in SCADA, Digital Control Systems, Automation, control and monitoring, GE Grid Solutions has designed and continues to expand a comprehensive range of products that communicate via Ethernet links.

Electric plant requirements lead to constraints that are rarely met by standard Ethernet products: environmental, power supply, redundancy, etc.

GE Grid Solutions' ranges of Ethernet switches, the DS Agile Hxxx, as well as SWx2xx/SRPxxx, are especially tailored for the DS Agile system. The DS Agile Hxxx and SWx2xx/SRPxxx ranges are designed to address the needs of a wide range of installations, from small to large and customer applications.

1.2 ETHERNET SWITCH NAMES

Basically the naming of Ethernet switch boards depends on its facilities and its interface: copper, optical single-mode, optical multi-mode.

The existing devices are:

- SWR21x Ethernet Switch board for Ethernet Dual Ring Architecture
- SWD21x Ethernet Switch board for Ethernet Dual Star Architecture
- SWT21x Ethernet Switch board for Hot standby redundancy between an Ethernet LAN and end nodes
- SWU20x Ethernet Switch board for Ethernet Star Architecture
- SRP28x Ethernet Switch board for Ethernet Dual Star PRP Architecture
- SRP29x Ethernet Switch board for Ethernet HSR Architecture

1.3 C26X ETHERNET SWITCH BOARDS

The SWxxx/SRPxxx Ethernet switch board ranges is composed of managed switches, easy to install and operate, designed to be implemented in an electric plant environment (IEC 61000-4 & 60255-5).

On the media side, the range supports 10BaseT, 100BaseTX and 100BaseFX as specified by the IEEE 802.3 committee. Management of the full duplex is available for 100BaseTx or 100BaseFx.

To adapt the switch to your application you have to configure the necessary parameters with "jumpers" located on the board.

2 SWR21X RANGE - DUAL RING ARCHITECTURE

The SWR21x range is dedicated for fast redundant Ethernet ring. All SWR21boards have 4 Copper connections through RJ45, with speed automatically adjusted from external emitters to 10 or 100 Mbps.

Copper Ethernet link is limited in distance and subject to perturbation. The Ethernet redundant ring is based on optical inter-switch connection, depending on the link length. The user may choose between Multi-mode Fibre optic, or Single mode Fibre Optic for long distance.

Model	Description	Connectors
SWR212 (Ref: ZP0021001)	Fast Ethernet industrial switch Multimode 1300 nm	4 x RJ45 2 x ST
SWR214 (Ref: ZP0021002)	Fast Ethernet industrial switch Single mode 1310 nm	4 x RJ45 2 x SC

2.1 FAST REDUNDANT RING CAPABILITY

2.1.1 SELF HEALING RING

Ethernet switches learn MAC addresses in order to switch packets to their destination port, and save the addresses in their memory as long as they are active. If a MAC address ceases to be active, it is aged out of the switch memory after a few minutes.

This switch-address-ageing delay presents a problem when a LAN needs to be reconfigured quickly.

There is no benefit to having a fast ring recovery technique if the switch members of the ring prevent Ethernet traffic from moving to the recovery traffic path.

With the GE Grid Solutions redundant ring, whether or not there is a fault on the ring, the switches on the ring see no difference in the advance of the frame: there is no need to reset a switch or to relearn the MAC address.

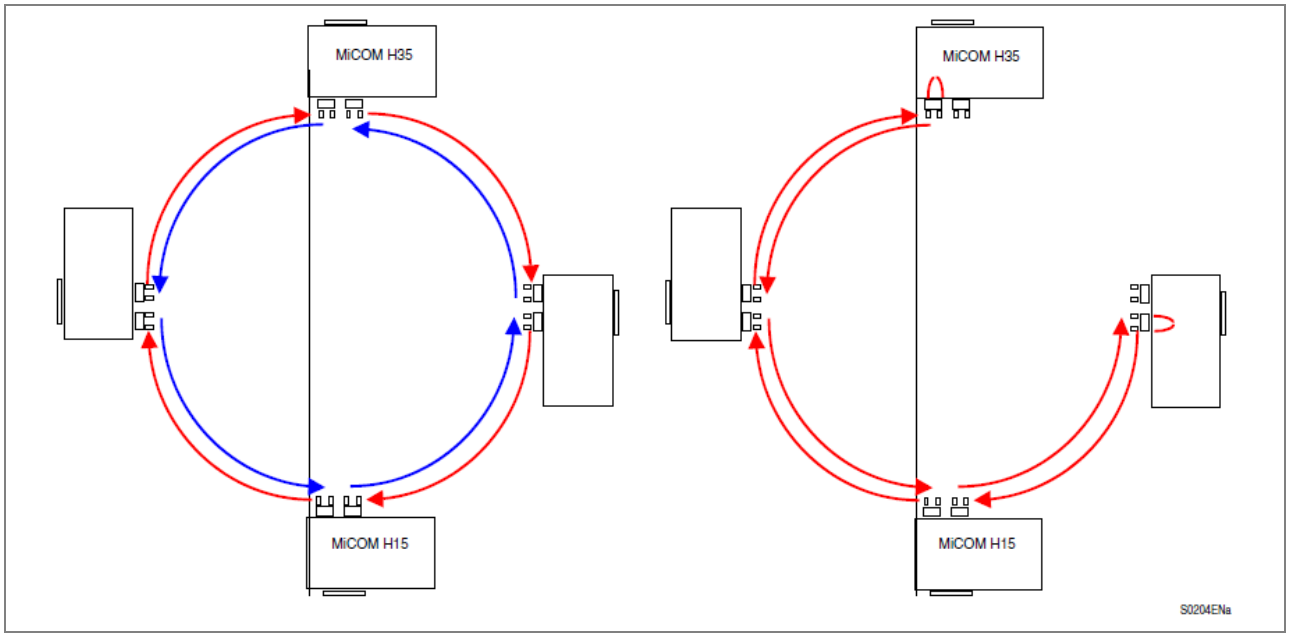


Figure 1: Self-Healing ring mechanism

2.1.2 ETHERNET SWITCH WITH SELF-HEALING RING FACILITIES

The SWR21x is a “repeater” with a standard 802.3 Ethernet switch plus the self healing manager (SHM). The following drawing describes the internal architecture of such device.

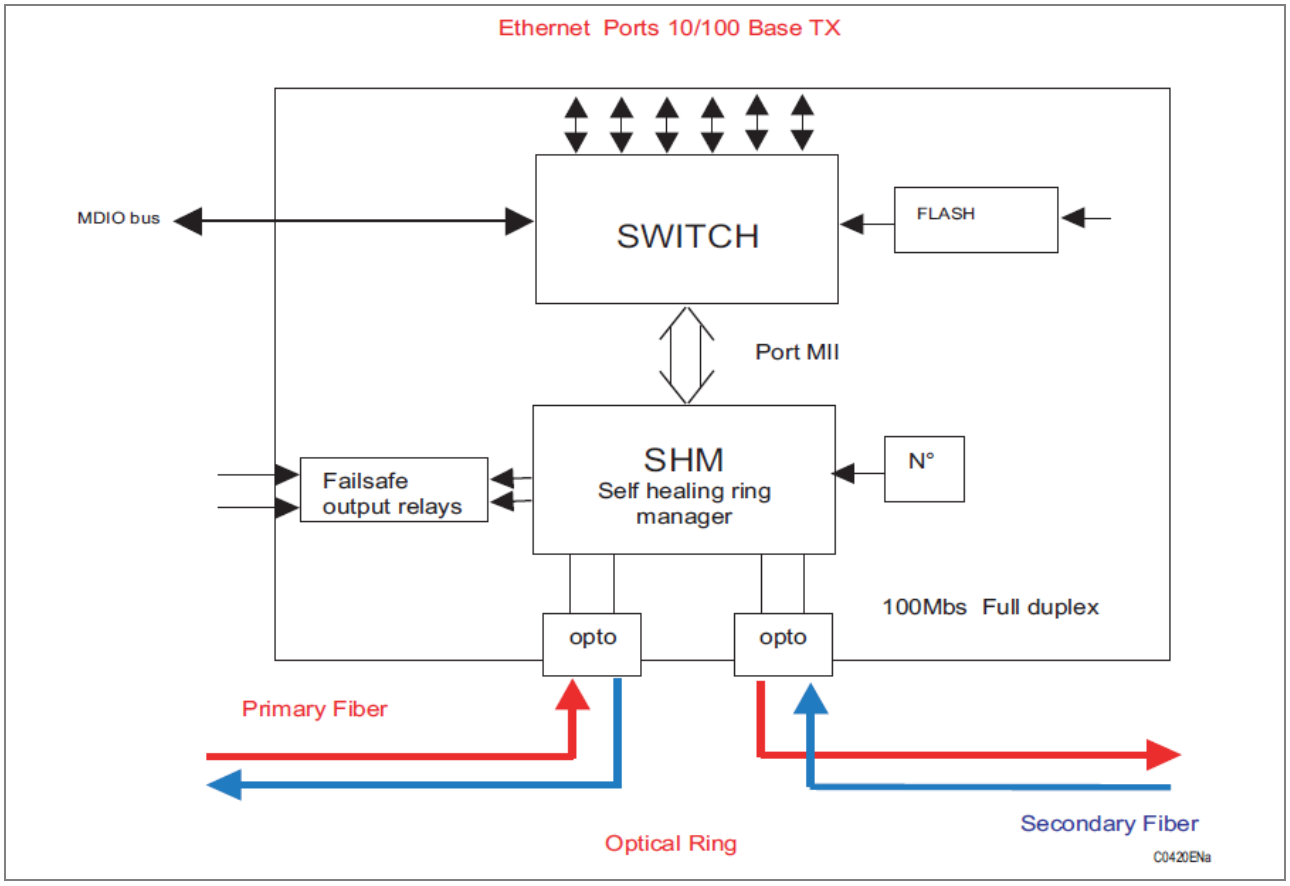


Figure 2: Internal architecture of SWR21x board

2.1.3 GE GRID SOLUTIONS ETHERNET RING REDUNDANCY

The SHM functions manage the ring. If the optic Fibre connection between two devices is broken, the network continues to run correctly.

During nominal situation, Ethernet packet goes in primary Fibre always in the same direction, and only a checking frames (4 bytes) is sent every 5µs in secondary Fibre in the opposite direction.

If link is cut, both SHM start immediately the network self-healing. At one side messages receive are no more emitted to the primary fibre but to the secondary fibre. On the other side of the cut off, messages received to secondary are emitted to primary and the new topological loop is closed.

Thanks to this property it is possible to extend the number of equipments or the size of a sub-station without stopping exploitation. When the loop is open, new equipments are connected on one side and the redunded loop is closed.

To increase the reliability some specific mechanisms are used:

- Watching the quality of transmission. Each frame (Ethernet packet or checking frame) is controlled by the SHM. A detection of large error rate will eliminate the faulty link and start automatically the self healing,
- Supervising the link same in the absence of traffic on the primary link (every 5 µs checking frames are sending to test the link). The link is supervised permanently with the real frame.

2.1.4 ETHERNET SYSTEM PERFORMANCE

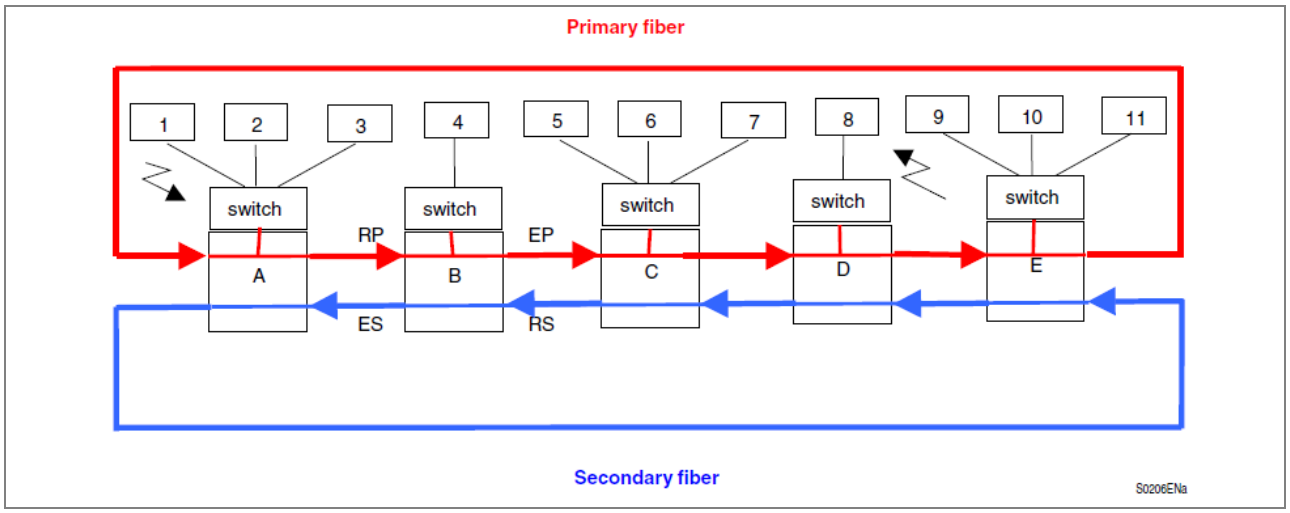


Figure 3: Nominal redundant Ethernet ring architecture with DS Agile SWR21x and Hx5x switches

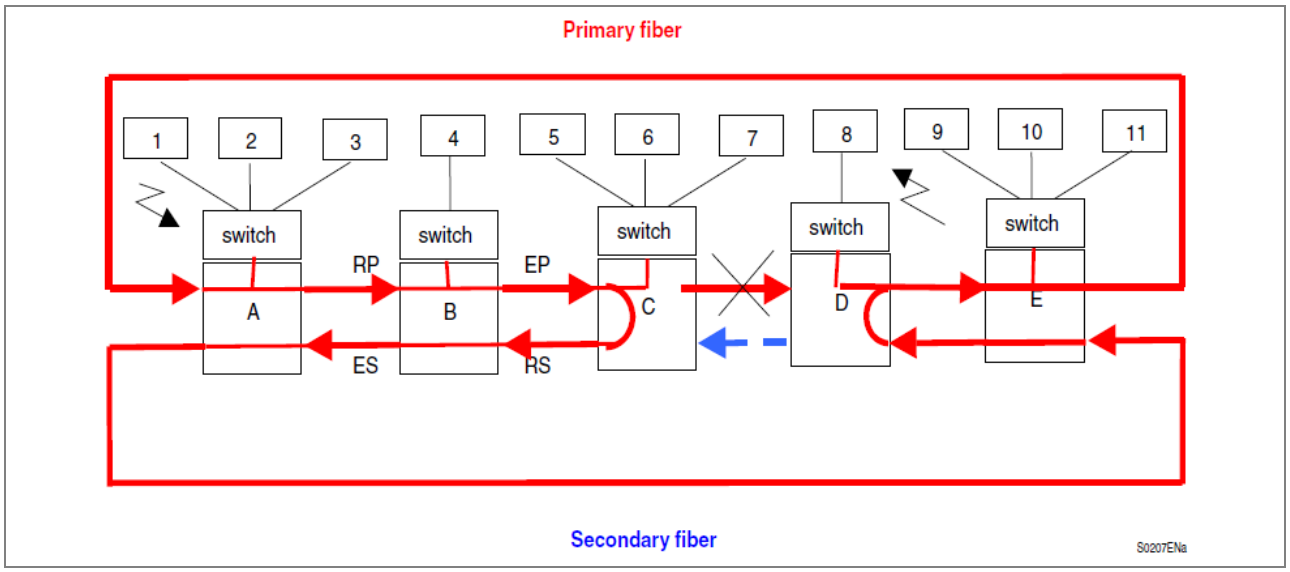


Figure 4: Ethernet ring architecture with DS Agile SWR21x and Hx5x switches, after failure

2.1.5 MAX TIME OF END-TO-END DELAY

To calculate the time from end to end, use the following table based on the nominal situation:

Send a Goose frame from... to…	Time at 100Mbps	Abr.	Comments
IED 1 to Switch A	22 µs		262 bytes + inter-frame
Switch A to IED 2	22 µs		Store and forward mechanism
Switch A to the network	2 µs	tl	Repeater latency time
Propagation time on the fibre	µs		4.8 µs /km
Network to network	2 µs	tl	Repeater latency time

When the frame circulates on the ring, it does not cross the switch; the transit time is only tl.

2.1.6 BENEFITS

- Ultra fast ring redundant capability (< 1ms for network reconfiguration)
- Fast propagation on the ring (no transfer time (Store-forward mechanism) with the switch)
- No central redundancy manager
- Specific mechanism of frames checking
- Ring management

2.2 SNMP V1 MANAGEMENT

Simple Network Management Protocol is the network protocol developed to manage devices on an IP network. With SNMP the available information is defined by Management Information Bases (MIB). The format of SNMP data takes the form of a tree structure, with each node in the tree being identified by a numerical Object IDentifier (OID). Each OID identifies a variable that can be read or set via SNMP with an appropriate software. The information in the MIBs is standardised.

2.2.1 SWR21X - MIB STRUCTURE

The SNMP MIB consists in distinct OIDs; each of them refers to a defined collection of specific information used to manage devices on the GE Grid Solutions ring. The GE Grid Solutions MIB uses two types of OID.

System

Address												Name	
0												ccitt	
	1											iso	
		3										org	
			6									dod	
				1								internet	
					2							mgmt	
						1						mib-2	
							1					sys	
								1				sysDescr	Alstom switch
								2				sysObjectID	Optical Link Status : 1 – No Fault 2 – Faulty Rs 3 – Faulty Rp 4 – No Link
								3				sysUpTime	Time (in hundredths of a second) since the switch was last reinitialized
								5				sysName	SWR21
								7				sysServices	Firmware Version

RMON

Address												Name	Description
0												ccitt	
	1											iso	
		3										org	
			6									dod	
				1								internet	

Address												Name	Description
					2							mgmt	
						1						mib-2	
							16					rmon	
								1				statistics	
									1			etherStatsTable	
										1		etherStatsEntry	Port number (*)
											1	etherStatsIndex	Unique index ID
											4	etherStatsOctets	Total number of octets of data (including those in bad packets) received on the network (excluding framing bits but including FCS octets)
											6	etherStatsBroadcastPkts	Total number of good packets received that were directed to the broadcast address
											7	etherStatsMulticastPkts	Total number of good packets received that were directed to a multicast address
											8	etherStatsCRCAlignErrors	Total number of packets received that had a length (excluding framing bits, but including FCS octets) of between 64 and 1518 octets, inclusive, but were not an integral number of octets in length or had a bad Frame Check Sequence (FCS)
											9	etherStatsUndersizePkts	Total number of packets received that were less than 64 octets long (excluding framing bits, but including FCS octets) and were otherwise well formed
											10	etherStatsOversizePkts	Total number of packets received that were longer than 1518 octets (excluding framing bits, but including FCS octets) and were otherwise well formed
											11	etherStatsFragments	Total number of packets received that were not an integral number of octets in length or that had a bad Frame Check Sequence (FCS), and were less than 64 octets in length (excluding framing bits but including FCS octets)

Address												Name	Description
											12	etherStatsJabbers	Total number of packets received that were longer than 1518 octets (excluding framing bits, but including FCS octets), and were not an integral number of octets in length or had a bad Frame Check Sequence (FCS)
											13	etherStatsCollisions	Best estimate of the total number of collisions on this Ethernet segment
											14	etherStatsPkts64Octets	Total number of packets (including error packets) received that were 64 octets in length (excluding framing bits but including FCS octets)
											15	etherStatsPkts65to127Octets	Total number of packets (including error packets) received that were between 65 and 127 octets in length inclusive (excluding framing bits but including FCS octets)
											16	etherStatsPkts128to255Octets	Total number of packets (including error packets) received that were between 128 and 255 octets in length inclusive (excluding framing bits but including FCS octets)
											17	etherStatsPkts256to511Octets	Total number of packets (including error packets) received that were between 256 and 511 octets in length inclusive (excluding framing bits but including FCS octets)
											18	etherStatsPkts512to1023Octets	Total number of packets (including error packets) received that were between 512 and 1023 octets in length inclusive (excluding framing bits but including FCS octets)
											19	etherStatsPkts1024to1518Octets	Total number of packets (including error packets) received that were between 1024 and 1518 octets in length inclusive (excluding framing bits but including FCS octets)

*Port number: 1 to 4: standard ports
5 and 6: ports for redundant ring

2.2.2 SNMP CLIENT SOFTWARE

MIB Browser software enables to perform all the basic SNMP operations, such as GET, GETNEXT, and RESPONSE. Very simple SNMP Client software is sufficient for using the MIB in our range of switches.

- The SNMP agent runs on the SWR21x Switches.
- The SWR21x Switches are accessed remotely from a SNMP client.

2.3 LEDS

LEDs are used to indicate the state of SWR21x and of the links. They are meant for experts.

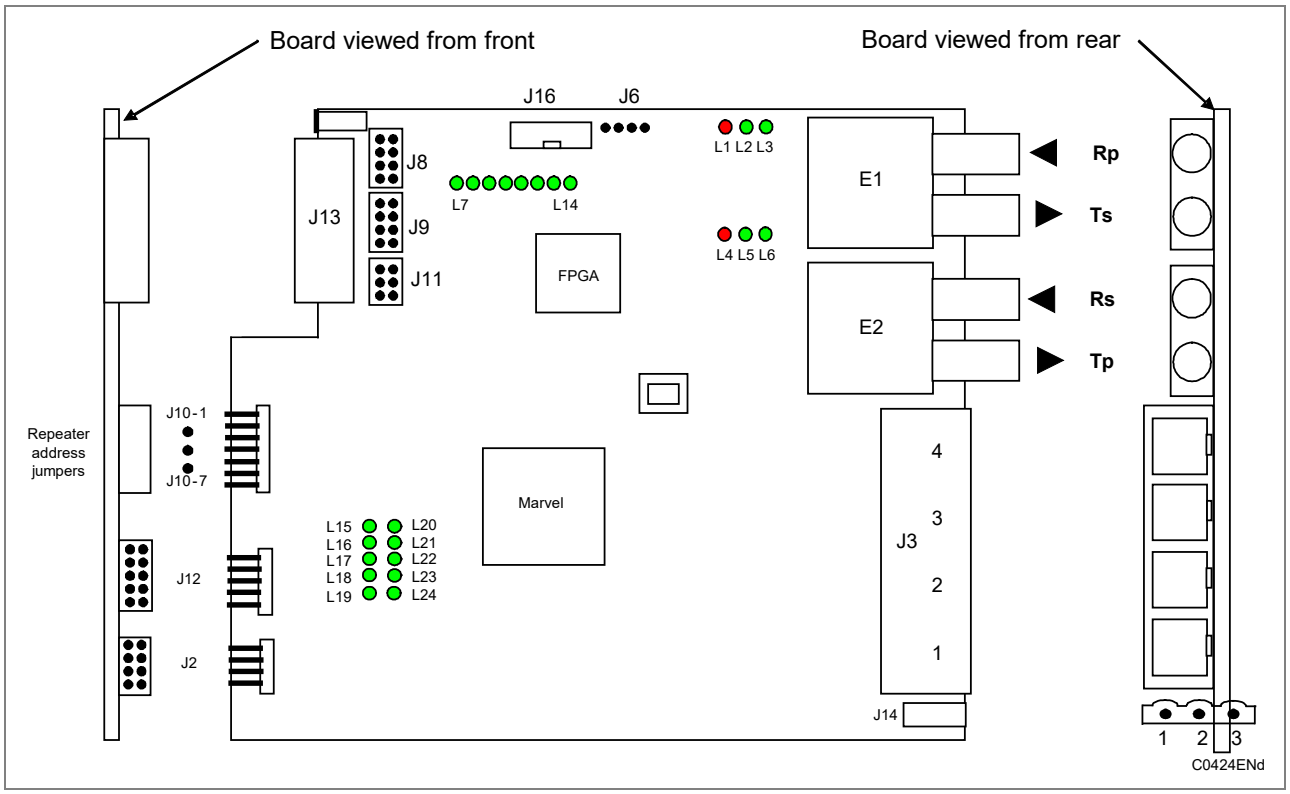


Figure 5: LED location on SWR21x board

The table below indicates the function of each LED:

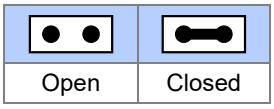
LED	N°	Colour	Description
E1 default	L1	Red	E1 Default
Link Rp	L2	Green	Rp (Reception Primary) Link OK
Receive Rp	L3	Green	Traffic detected
E2 default	L4	Red	E2 Default
Link Rs	L5	Green	Link OK
Receive Rs	L6	Green	Traffic detected
Number of switch detected on the ring bit 0	L7	Green	
Number of switch detected on the ring bit 1	L8	Green	
Number of switch detected on the ring bit 2	L9	Green	
Number of switch detected on the ring bit 3	L10	Green	
Number of switch detected on the ring bit 4	L11	Green	
Number of switch detected on the ring bit 5	L12	Green	
Number of switch detected on the ring bit 6	L13	Green	
Number of switch detected on the ring bit 7	L14	Green	
Link and activity port 1	L15	Green	Off : no connection Green : link Green + blink : link + activity
Link and activity port 2	L16	Green	“
Link and activity port 3	L17	Green	“

LED	N°	Colour	Description
Link and activity port 4	L18	Green	“
Link and activity port 5	L19	Green	“
Speed port 1	L20	Green	Off: 10Mbps Green : 100Mbps
Speed port 2	L21	Green	“
Speed port 3	L22	Green	“
Speed port 4	L23	Green	“
Speed port 5	L24	Green	Port not used

On power-up the SWR21xx goes through a self-testing sequence. The 5 “link" LEDs flash for a few seconds.

2.4 SETTINGS

2.4.1 INTERNAL JUMPERS



Open	Closed

The status is “closed” when the jumper is set.

N°	Open	Closed	Factory setting
J10-1	Board address bit 1 = 1	Board address bit 1 = 0	Closed
J10-2	Board address bit 2 = 1	Board address bit 2 = 0	Closed
J10-3	Board address bit 4 = 1	Board address bit 4 = 0	Closed
J10-4	Board address bit 8 = 1	Board address bit 8 = 0	Closed
J10-5	Board address bit 16 = 1	Board address bit 16 = 0	Closed
J10-6	Board address bit 32 = 1	Board address bit 32 = 0	Closed
J10-7	Board address bit 64 = 1	Board address bit 64 = 0	Closed

2.4.2 ADDRESS OF THE BOARD

Each board on the ring has a specific address. Each address must be unique and comprised between 1 and 127.

The address is equal to the sum of the “open" bits.

At the beginning address = 0
If J10-1 = open address = address + 1 if not address = address + 0
If J10-2 = open address = address + 2 if not address = address + 0
If J10-3 = open address = address + 4 if not address = address + 0
If J10-4 = open address = address + 8 if not address = address + 0
If J10-5 = open address = address + 16 if not address = address + 0
If J10-6 = open address = address + 32 if not address = address + 0
If J10-7 = open address = address + 64 if not address = address + 0

Example :

J10-1 = open address = address + 1
J10-2 = open address = address + 2
J10-3 = closed address = address + 0
J10-4 = open address = address + 8

J10-5 = closed address = address + 0
J10-6 = closed address = address + 0
J10-7 = closed address = address + 0

Address = 11

2.4.3 IP ADDRESS OF THE REPEATER

The repeater IP address breaks down as follows:

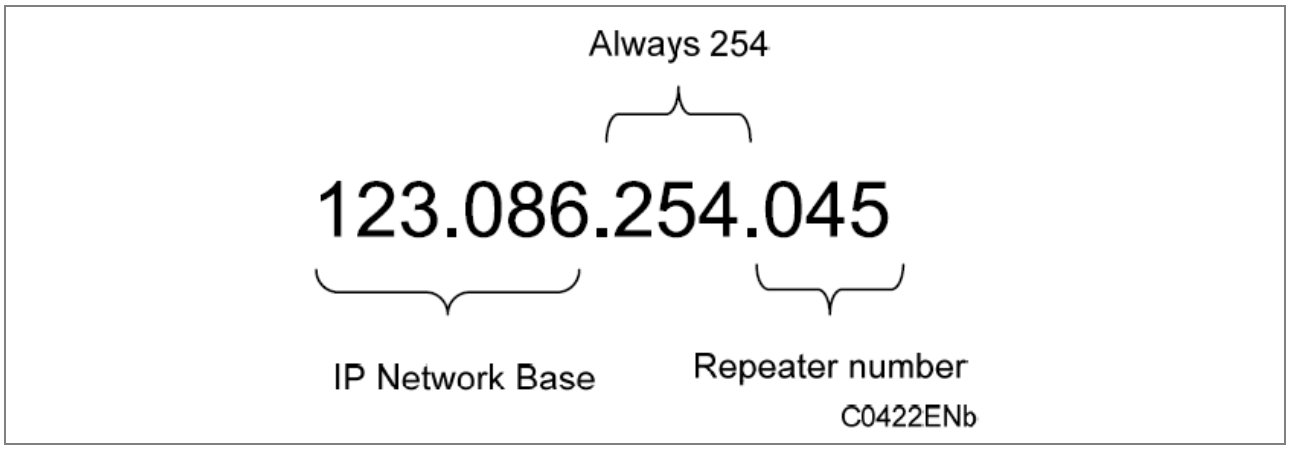


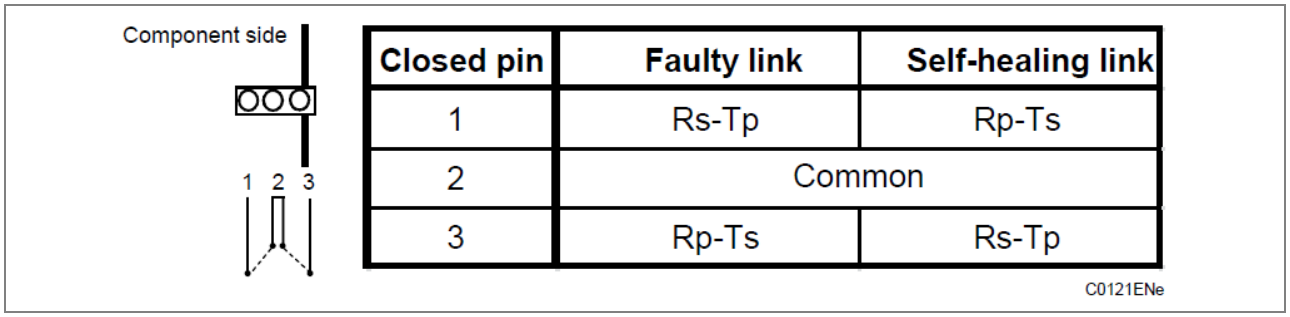
Figure 6: IP Address

Note:
It is important to note that the Alstom_Switch_manager Software forces the third IP field to the "254" value.

2.5 CONNECTIONS

J14 Fault signal output:

The optical ring is monitored. If one link come down the default is indicated by the contacts:



Closed pin	Faulty link	Self-healing link
1	Rs-Tp	Rp-Ts
2	Common	
3	Rp-Ts	Rs-Tp

Figure 7: J14 Pin out

3 SWD21X RANGE – DUAL HOMING ARCHITECTURE

The SWD21x range of Ethernet boards is dedicated to Dual Ethernet Star architecture and defined by the type of Ethernet optical fibre it is connected (Single Mode or Multi Mode) to. All the boards in the SWD21x range have 4 RJ45 copper connections, with speed automatically adjusted to match external transmitters at 10 or 100 Mbps, and 2 Ethernet optical ports with dual homing mechanism.

The Ethernet dual homing star is based on optical connection. Depending on the link length, the user may choose between Multi-mode optic fibre (up to 2 km) and Single mode optic fibre (up to 20 km) for long distance.

Model	Description	Connectors
SWD212 (Ref: ZP0022001)	Fast Ethernet industrial switch Multimode 1300 nm	4 x RJ45 2 x ST
SWD214 (Ref: ZP0022002)	Fast Ethernet industrial switch Single mode 1310 nm	4 x RJ45 2 x SC

3.1 DUAL HOMING SWITCH DESCRIPTION

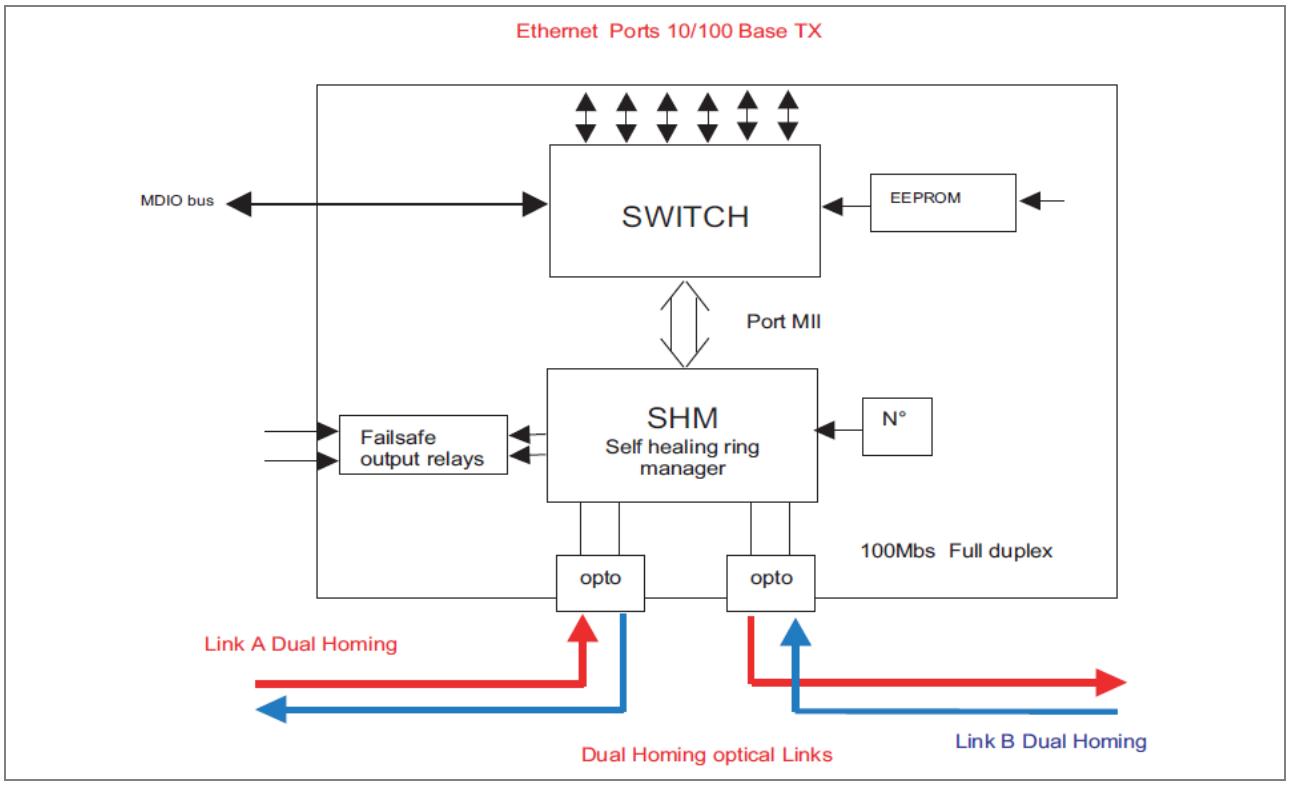


Figure 8: Internal architecture of an SWD21x board

3.2 ETHERNET MANAGEMENT

3.2.1 10BASE T AND 100BASE TX

The copper ports are full/half duplex and auto-sense the transmission speed. They will auto-negotiate with the connected device to determinate the optimal speed. When the connected device is only capable of transmitting at 10Mbps, the switch follows the 10Mbps.

3.2.2 POWER MANAGEMENT

If there is no cable on a port, most of the circuitry for that port is disabled to save power.

3.2.3 ADDRESS LOOK UP

Each Ethernet device inserts its unique “MAC address” into each message it send out. The port on the switch used for given MAC address is automatically learned when a frame is received from that address. Once an address is learned, the switch will route messages to only the appropriate port. A time stamp is also placed in memory when a new address is learned. This time stamp is used with the aging feature, which will remove unused MAC Addresses from table after 300 s. The broadcasting messages are transmit in the all ports.

Up to 2048 MAC addresses can be stored and monitored at any time.

3.2.4 BACK PRESSURE FOR HALF DUPLEX

The DS Agile SWD21x will apply "back pressure" when necessary with half-duplex operation. This "back pressure" will reduce congestion on busy networks.

3.2.5 AUTO NEGOTIATION AND SPEED-SENSING

All six RJ45 ports independently support auto negotiation for speeds in the 10BaseT and 100BaseTx modes. Operation is according to the IEEE 802.3u standard.

3.2.6 FORWARDING

The DS Agile SWD21x supports store and forward mode. It will forward messages with know addresses out only the appropriate port. Messages with unknown addresses, broadcast messages and multicast messages will get forwarded out all ports except the source port. The switch will not forward error packets, 802.3x pause frames or local packets.

3.2.7 PRIORITY TAGGING

802.1p priority is enabled on all ports.

3.2.8 FLOW CONTROL

The DS Agile SWD21x Ethernet switch board automatically supports standard flow control frames on both the emission and reception sides.

On the reception side, if the switch receives a pause control frame it will not transmit the next normal frame until the timer, specified in the pause control frame, expires. If another pause frame is received before the current timer expires, the timer will be updated with the new value in the second pause frame. During this period (being flow controlled), only flow control packets from the switch will be transmitted.

On the transmission side, the switch has intelligence and determines when to invoke the flow control. The flow control is based on availability of the system resources, including available buffers, available transmission queues and available reception queues. The switch will flow control a port, which just received a packet, if the destination port resource is being used up. The switch will issue a flow control frame (XOFF), containing the maximum pause time defined in IEEE standard 802.3x. A hysteresis feature is provided to prevent flow control mechanism from being activated and deactivated too many times.

The switch will flow control all ports if the reception queue becomes full.

3.3 SNMP V1 MANAGEMENT

Simple Network Management Protocol is the network protocol developed to manage devices on an IP network. With SNMP the available information is defined by Management Information Bases (MIB).
The format of SNMP data takes the form of a tree structure, with each node in the tree being identified by a numerical Object IDentifier (OID). Each OID identifies a variable that can be read or set via SNMP with an appropriate software. The information in the MIBs is standardised.

The SWD21x Ethernet switch is only compatible with the SNMP V1 management information bases.

3.3.1 SWD21X - MIB STRUCTURE

The SNMP MIB consists in distinct OIDs; each of them refers to a defined collection of specific information used to manage devices on the ring. The MIB uses two types of OID.

System

Address												Name	
0												ccitt	
	1											iso	
		3										org	
			6									dod	
				1								internet	
					2							mgmt	
						1						mib-2	
							1					system	
								1				sysDescr	Alstom Switch
								2				sysObjectID	Optical Link Status: 1 – No Fault 2 – Faulty link A 3 – Faulty link B 4 – No Link
								3				sysUpTime	Time (in hundredths of a second) since the switch was last reinitialized: "*a* days *b*h: *c*m: *d*s. *e*ms"
								5				sysName	SWD21
								7				sysServices	Firmware Version

RMON

Address												Name	Description
0												ccitt	
	1											iso	
		3										org	
			6									dod	
				1								internet	
					2							mgmt	
						1						mib-2	
							16					rmon	
								1				statistics	
									1			etherStatsTable	
										1		etherStatsEntry	Port number (*)
											1	etherStatsIndex	Unique index ID

Address											Name	Description
										4	etherStatsOctets	Total number of octets of data (including those in bad packets) received on the network (excluding framing bits but including FCS octets)
										6	etherStatsBroadcastPkts	Total number of good packets received that were directed to the broadcast address
										7	etherStatsMulticastPkts	Total number of good packets received that were directed to a multicast address
										8	etherStatsCRCAlignErrors	Total number of packets received that had a length (excluding framing bits, but including FCS octets) of between 64 and 1518 octets, inclusive, but were not an integral number of octets in length or had a bad Frame Check Sequence (FCS)
										9	etherStatsUndersizePkts	Total number of packets received that were less than 64 octets long (excluding framing bits, but including FCS octets) and were otherwise well formed
										10	etherStatsOversizePkts	Total number of packets received that were longer than 1518 octets (excluding framing bits, but including FCS octets) and were otherwise well formed
										11	etherStatsFragments	Total number of packets received that were not an integral number of octets in length or that had a bad Frame Check Sequence (FCS), and were less than 64 octets in length (excluding framing bits but including FCS octets)
										12	etherStatsJabbers	Total number of packets received that were longer than 1518 octets (excluding framing bits, but including FCS octets), and were not an integral number of octets in length or had a bad Frame Check Sequence (FCS)
										13	etherStatsCollisions	Best estimate of the total number of collisions on this Ethernet segment
										14	etherStatsPkts64Octets	Total number of packets (including error packets) received that were 64 octets in length (excluding framing bits but including FCS octets)

Address												Name	Description
											15	etherStatsPkts65to127Octets	Total number of packets (including error packets) received that were between 65 and 127 octets in length inclusive (excluding framing bits but including FCS octets)
											16	etherStatsPkts128to255Octets	Total number of packets (including error packets) received that were between 128 and 255 octets in length inclusive (excluding framing bits but including FCS octets)
											17	etherStatsPkts256to511Octets	Total number of packets (including error packets) received that were between 256 and 511 octets in length inclusive (excluding framing bits but including FCS octets)
											18	etherStatsPkts512to1023Octets	Total number of packets (including error packets) received that were between 512 and 1023 octets in length inclusive (excluding framing bits but including FCS octets)
											19	etherStatsPkts1024to1518Octets	Total number of packets (including error packets) received that were between 1024 and 1518 octets in length inclusive (excluding framing bits but including FCS octets)

*Port number: 1 to 4: standard ports
5 and 6: ports for redundant ring

3.3.2 SNMP CLIENT SOFTWARE

MIB Browser software enables to perform all the basic SNMP operations, such as GET, GETNEXT, and RESPONSE. Very simple SNMP Client software is sufficient for using the MIB in our range of switches.

- The SNMP agent runs on the SWD21x Switches.
- The SWD21x Switches are accessed remotely from a SNMP client.

3.4 LEDS

LEDs are used to indicate the state of SWD21x and of the links. They are meant for experts.

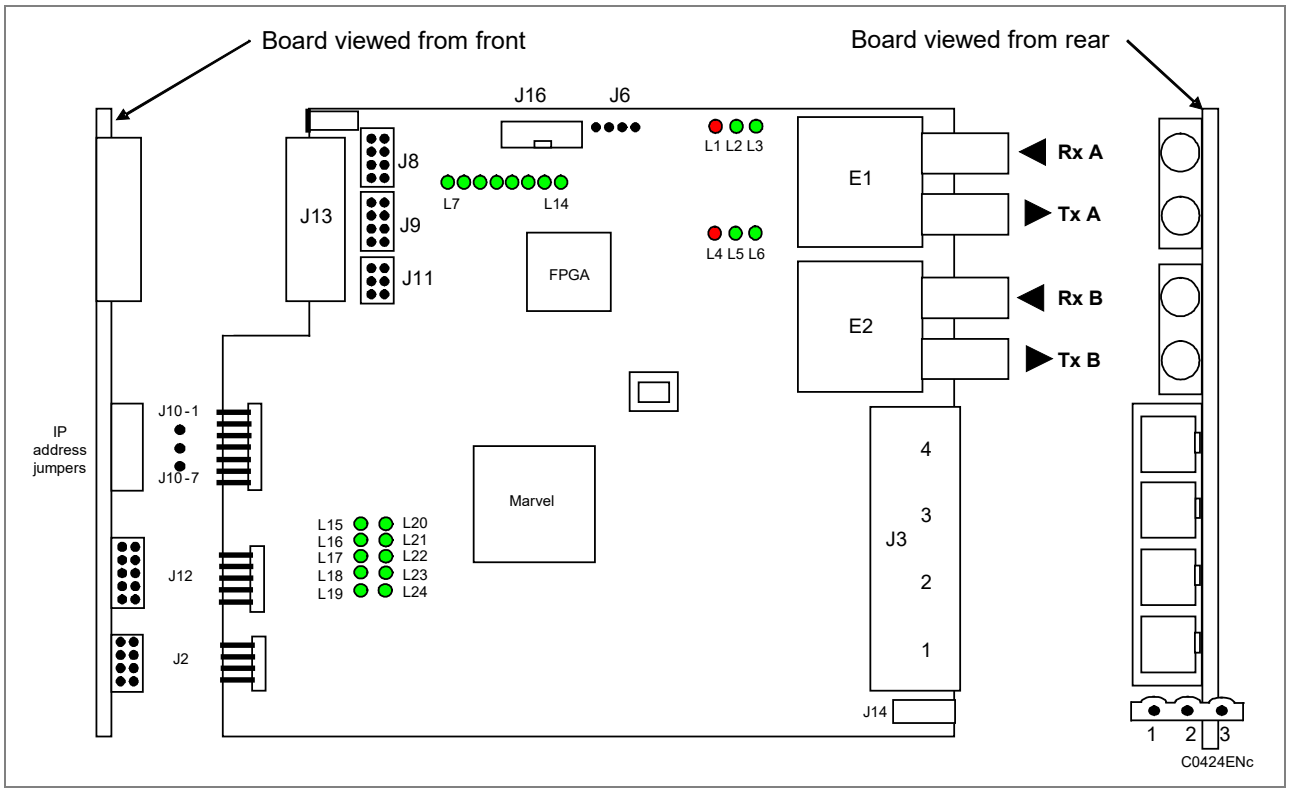


Figure 9: LED location on an SWD21x board

The table below indicates the function of each LED:

LED	N°	Colour	Description
Link A fault	L1	Red	Fault on link A
Link A reception	L2	Green	Reception Link A
Link A traffic	L3	Green	Traffic on Link A
Link B fault	L4	Red	Fault on Link B
Link B reception	L5	Green	Reception Link B
Link B traffic	L6	Green	Traffic Link B
Switch Number bit 0	L7	Green	
Switch Number bit 1	L8	Green	
Switch Number bit 2	L9	Green	
Switch Number bit 3	L10	Green	
Switch Number bit 4	L11	Green	
Switch Number bit 5	L12	Green	
Switch Number bit 6	L13	Green	
Switch Number bit 7	L14	Green	
Link and activity port 1	L15	Green	Off: no connection Green: link Green + blink: link + activity
Link and activity port 2	L16	Green	"

LED	N°	Colour	Description
Link and activity port 3	L17	Green	"
Link and activity port 4	L18	Green	"
Link and activity port 5	L19	Green	"
Speed port 1	L20	Green	Off: 10Mbps Green: 100Mbps
Speed port 2	L21	Green	"
Speed port 3	L22	Green	"
Speed port 4	L23	Green	"
Speed port 5	L24	Green	Port not used

On power-up the SWD21 goes through its self-check sequence. The 5 “link" LEDs flash for a few seconds.

3.5 SETTINGS

Refer to section *2.4*.

3.6 CONNECTIONS

J14 Fault signal output:

The optical health is monitored. If one link come down the default is announced by the contacts:

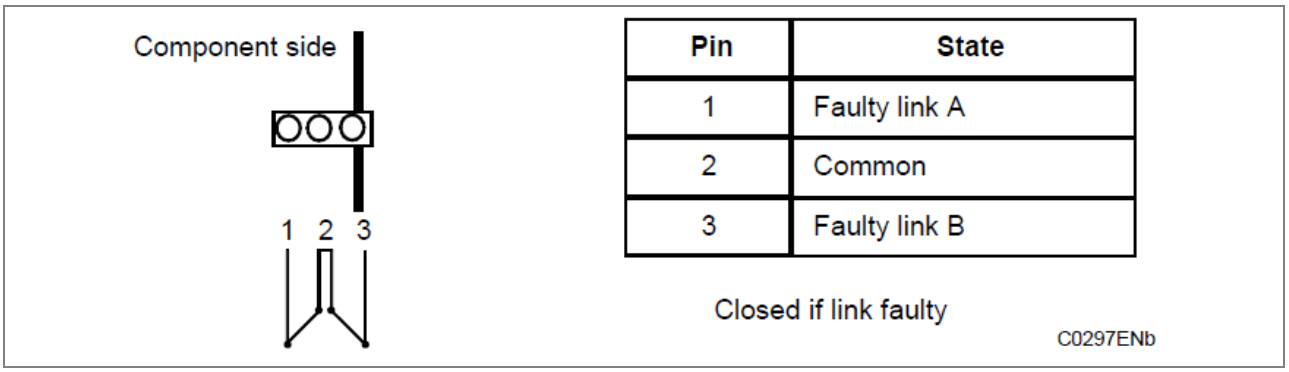


Figure 10: J14 Pin out

4 SWT21X RANGE – ETHERNET TEAMING

The SWT212 Ethernet board is dedicated to Teaming, i.e. hot standby redundancy of Ethernet links, and is defined by the type of Ethernet connector. The SWD212 board has 4 RJ45 copper connections, with speed automatically adjusted to match external transmitters at 10 or 100 Mbps, and 2 Ethernet optical ports with teaming mechanism.

Ethernet copper links are limited in distance and subject to interference.

Model	Description	Connectors
SWT212 (Ref: ZP0032001)	Fast Ethernet industrial switch Multimode 1300 nm	4 x RJ45 2 x ST

4.1 TEAMING (HOT STANDBY REDUNDANCY)

A teaming switch provides hot standby redundancy links between one or several nodes and a local area network (LAN). This protocol implements redundancy of the devices through Doubly Attached Nodes (DAN) that use a Teaming mechanism.

A DAN is attached to a LAN by two links. A source DAN with Teaming sends the frame over one of the two links. Should the main link fail, the second link, also called hot standby link, becomes active and takes over the transmission of data.

A Teaming switch can be connected to any standard network, such as star or ring networks.

Teaming switches offer hot standby link redundancy to any standard communicating devices, such as IEDs, computers or printers (end-nodes).

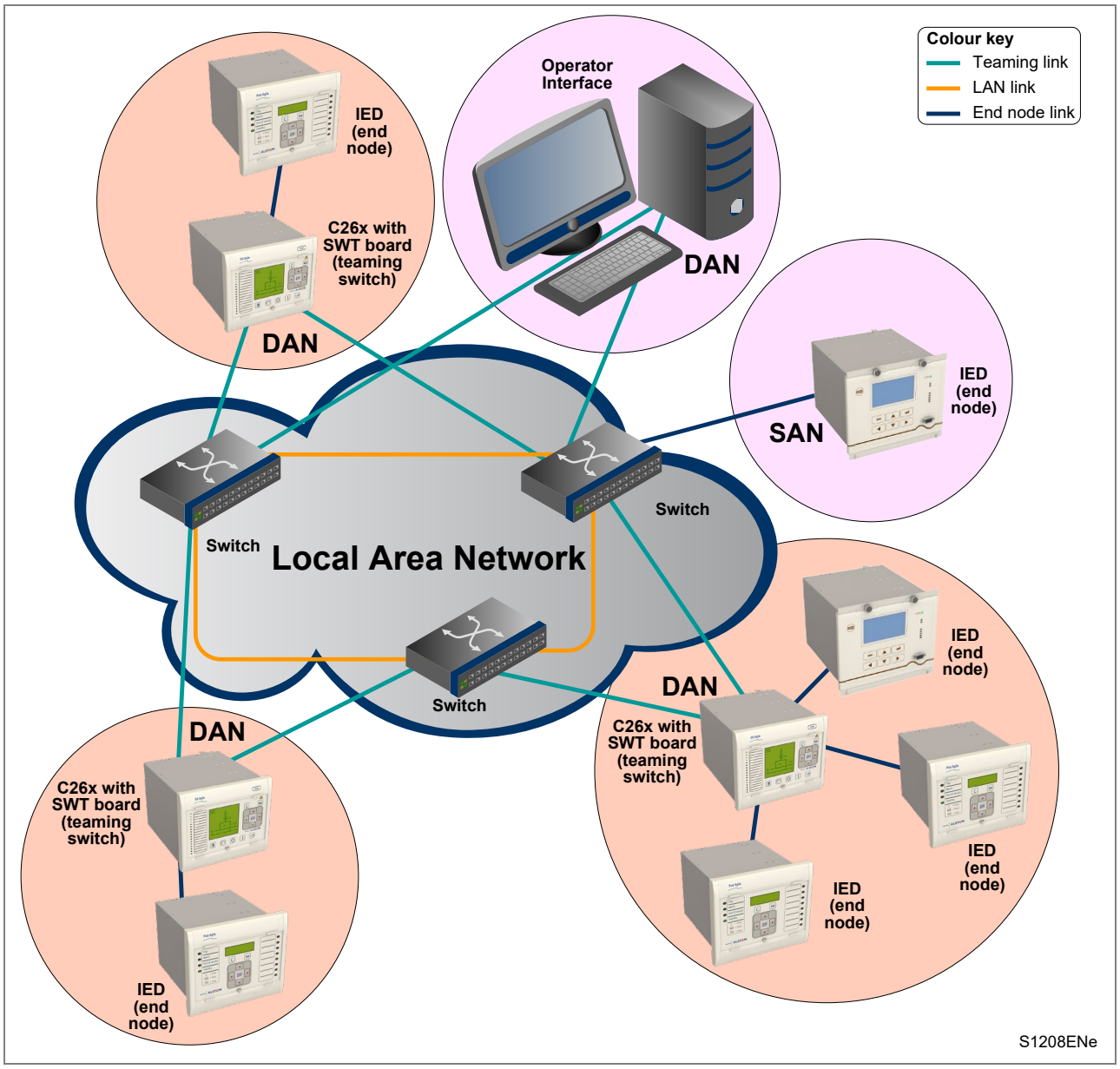


Figure 11: Teaming switches in a typical architecture

4.1.1 REDUNDANCY PORTS

Teaming switch boards are fitted with two types of Ethernet port:

- 4 RJ45 ports used to connect the end nodes to the switch,
- 2 optical ports used to connect the switch to the main network. These ports manage two redundant links that operate in hot standby operating mode: only one link is active at a time; the second link becomes active only if the first one is lost. Link A has priority over Link B; therefore if Link A fails, Link B automatically returns to standby mode when Link A recovers.

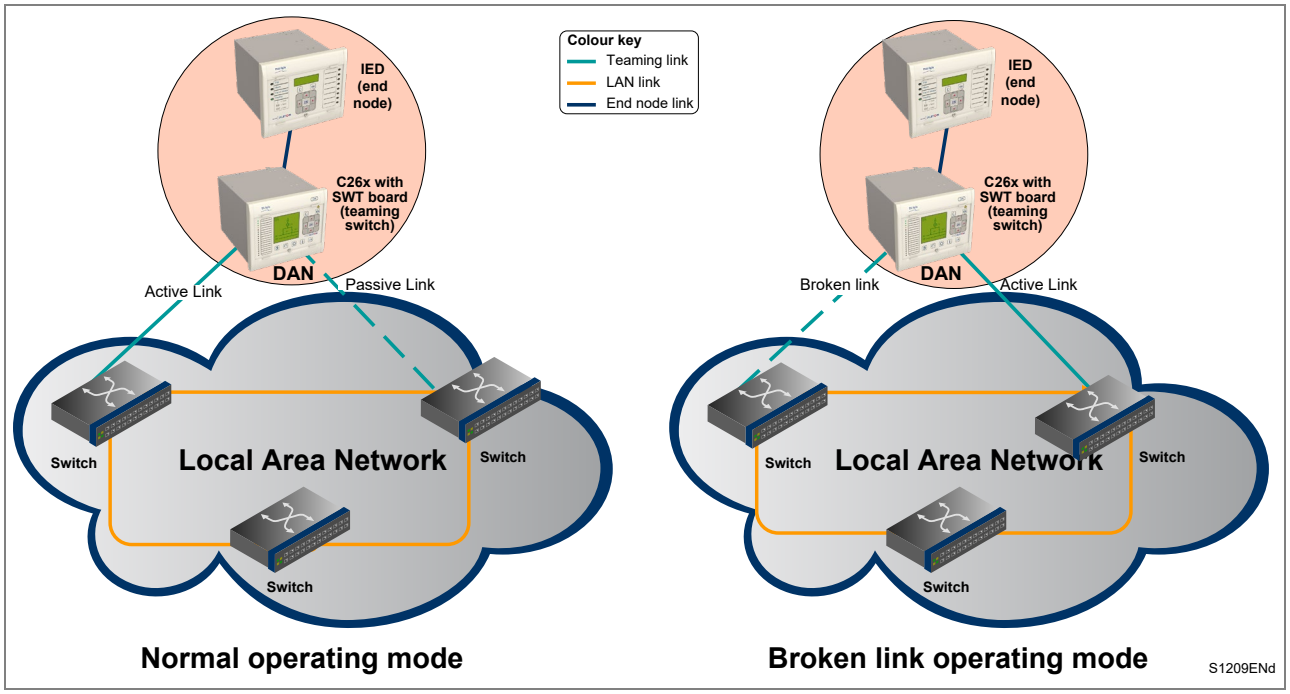


Figure 12: Normal vs. broken link operating modes

Notes:

- The switch does not aggregate its redundant links; therefore the bandwidth is not doubled when both links are operational. As the links operate in hot standby mode, only one link is active at any time.
- When the active link fails it takes less than 1ms for the passive link to become active. The amount of seconds to restore the communications varies on the topology of the network.

4.1.2 NETWORK TOPOLOGY

The Teaming switch can be connected to any standard network, such as star or ring networks.

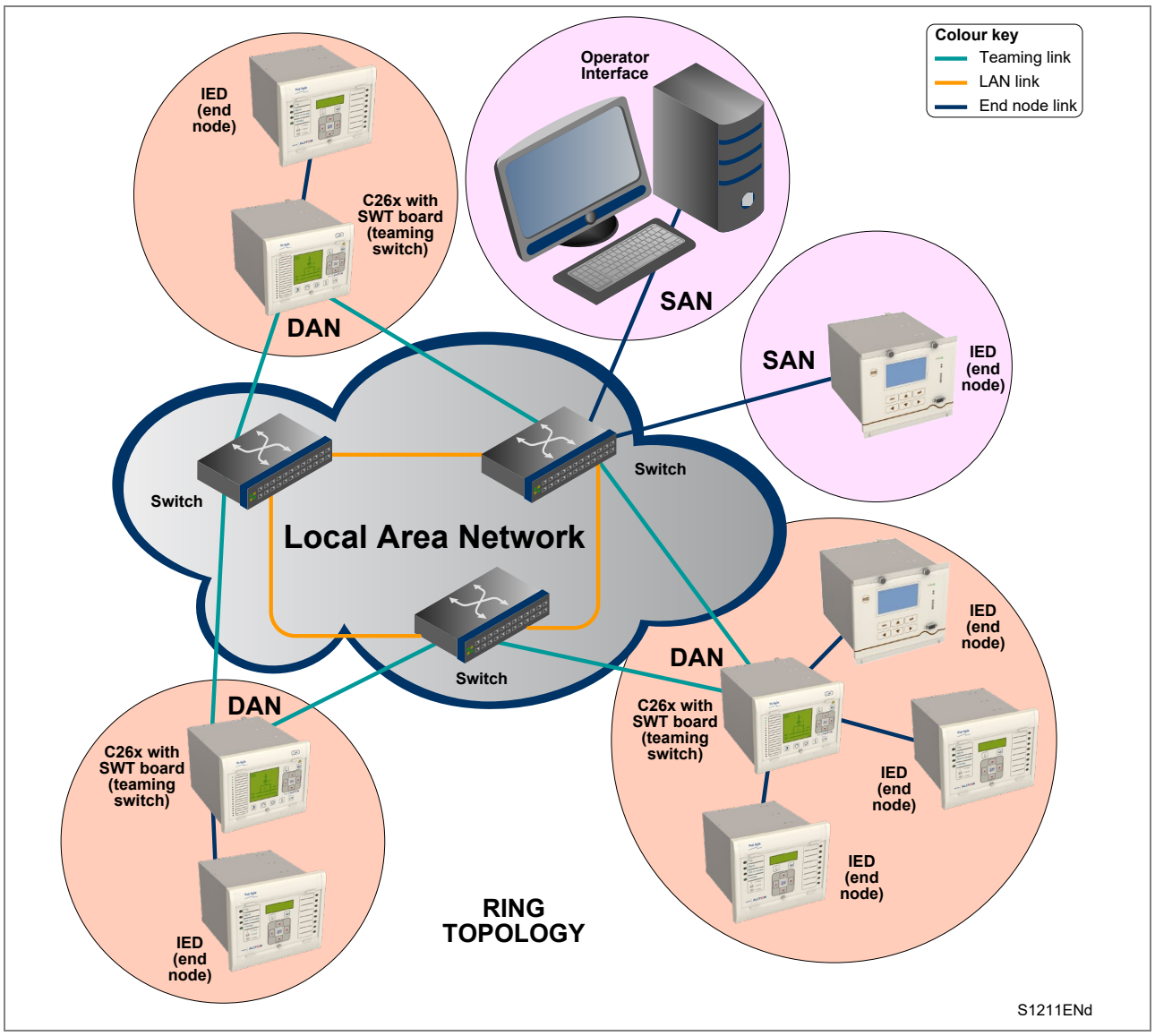


Figure 13: Ring network topology

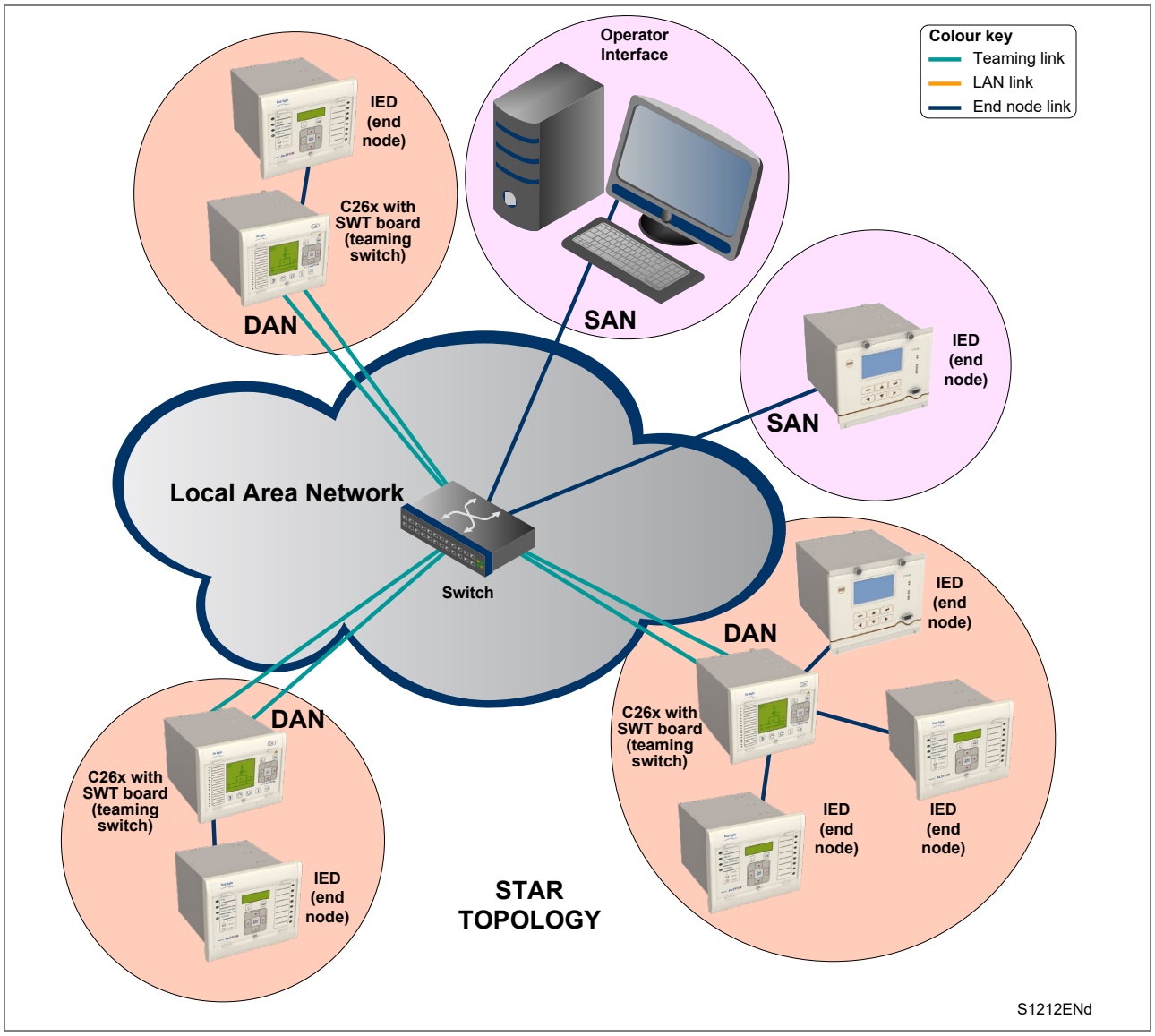


Figure 14: Star network topology

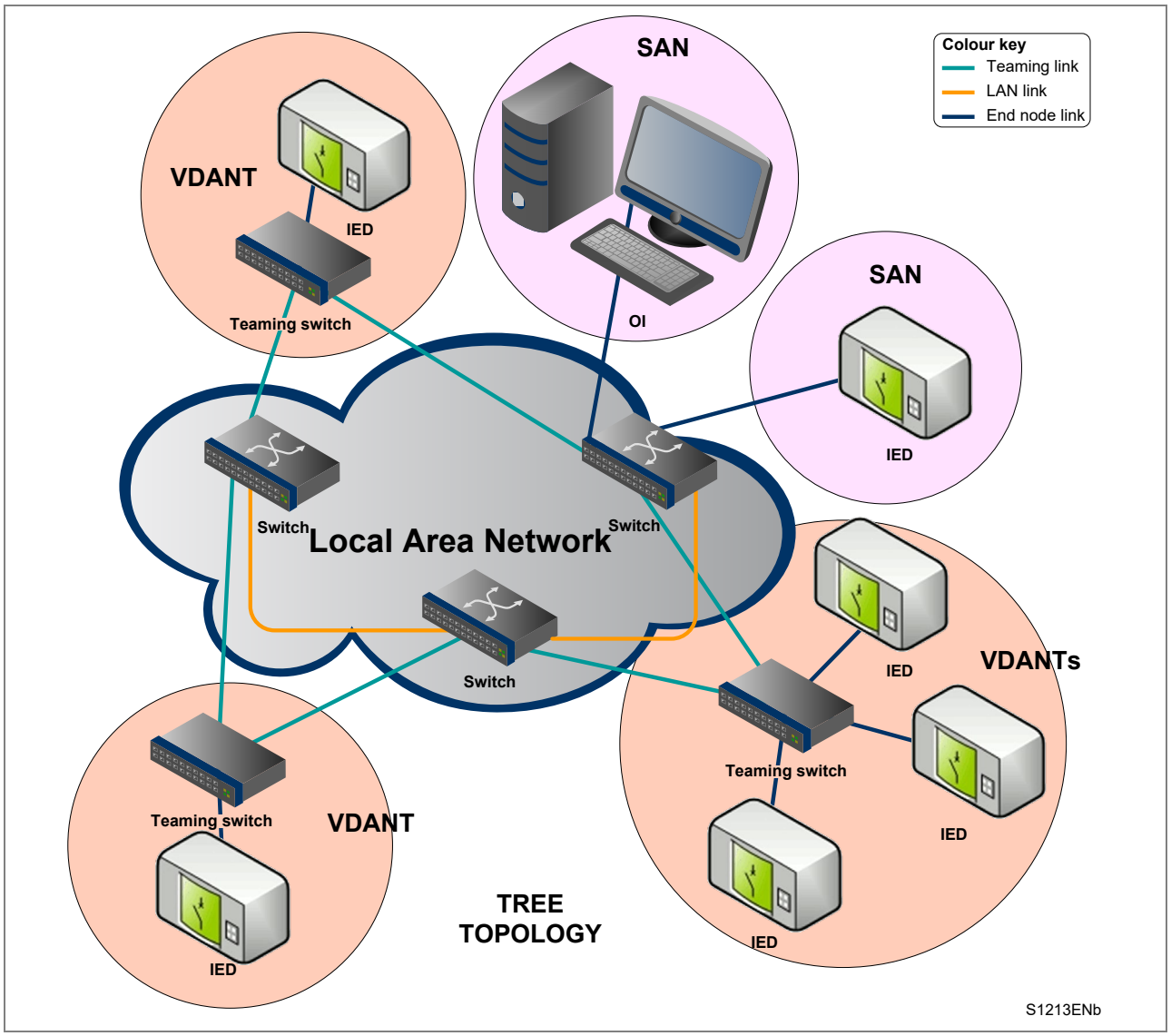


Figure 15: Tree network topology

4.2 ETHERNET MANAGEMENT

4.2.1 POWER MANAGEMENT

When a port is not in use, that port is disabled to save power.

4.2.2 ADDRESS LOOK UP

Each Ethernet device inserts its unique “MAC address” into each message it sends out. The port on the switch used for a given MAC address is automatically learned when a frame is received from that address.

Up to 2048 MAC addresses can be stored and monitored at any time.

4.2.3 MAC ADDRESS AGING

Unused MAC addresses are removed after 300 seconds.

4.2.4 BACK PRESSURE FOR HALF DUPLEX

The SWT212 will apply "back pressure" when necessary with half-duplex operation. This "back pressure" will reduce bottleneck on busy networks.

4.2.5 AUTO NEGOTIATION AND SPEED

All four RJ45 ports independently support the auto negotiation for the speeds of the 10BaseT and of the 100BaseTX modes. Performance is according to the IEEE 802.3u standard.

4.2.6 FORWARDING

The SWT212 board supports the store-and-forward modes. It forwards messages with known addresses out only to the appropriate port. Messages with unknown addresses, broadcast messages and multicast messages will get forwarded out to all ports except the source port. The switch does not forward error packets, 802.3x pause frames or local packets.

4.2.7 PRIORITY TAGGING

802.1p priority is enabled on all ports.

4.2.8 FLOW CONTROL

The SWT212 Ethernet switch board automatically supports standard flow control frames on both the emission and reception sides.

On the reception side, if the switch receives a pause control frame it will not transmit the next normal frame until the timer, specified in the pause control frame, expires. If another pause frame is received before the current timer expires, the timer will be updated with the new value in the second pause frame. During this period (being flow controlled), only flow control packets from the switch will be transmitted.

On the transmission side, the switch has intelligence and determines when to invoke the flow control. The flow control is based on availability of the system resources, including available buffers, available transmission queues and available reception queues. The switch will flow control a port, which just received a packet, if the destination port resource is being used up. The switch will issue a flow control frame (XOFF), containing the maximum pause time defined in IEEE standard 802.3x. A hysteresis feature is provided to prevent flow control mechanism from being activated and deactivated too many times.

The switch will flow control all ports if the reception queue becomes full.

4.3 SNMP V1 MANAGEMENT

Simple Network Management Protocol is the network protocol developed to manage devices on an IP network. With SNMP the available information is defined by Management Information Bases (MIB). The format of SNMP data takes the form of a tree structure, with each node in the tree being identified by a numerical Object IDentifier (OID). Each OID identifies a variable that can be read or set via SNMP with an appropriate software. The information in the MIBs is standardised.

The SWT212 Ethernet switch is only compatible with the SNMP V1 management information bases.

4.3.1 SWT212 - MIB STRUCTURE

The SNMP MIB consists in distinct OIDs; each of them refers to a defined collection of specific information used to manage devices on the ring. The MIB uses two types of OID.

System

Address												Name	
0												ccitt	
	1											iso	
		3										org	
			6									dod	
				1								internet	
					2							mgmt	
						1						mib-2	
							1					sys	
								1				sysDescr	Alstom switch
								2				sysObjectID	Optical Link Status: 1 – No Fault 2 – Faulty link A 3 – Faulty link B 4 – No Link
								3				sysUpTime	Time (in hundredths of a second) since the switch was last reinitialized
								5				sysName	SWT21
								7				sysServices	Firmware Version

RMON

Address											Name	Description
0											ccitt	
	1										iso	
		3									org	
			6								dod	
				1							internet	
					2						mgmt	
						1					mib-2	
							16				rmon	
								1			statistics	
									1		etherStatsTable	
										1	etherStatsEntry	Port number (*)
											1 etherStatsIndex	Unique index ID
											4 etherStatsOctets	Total number of octets of data (including those in bad packets) received on the network (excluding framing bits but including FCS octets)
											6 etherStatsBroadcastPkts	Total number of good packets received that were directed to the broadcast address

Address												Name	Description
											7	etherStatsMulticastPkts	Total number of good packets received that were directed to a multicast address
											8	etherStatsCRCAlignErrors	Total number of packets received that had a length (excluding framing bits, but including FCS octets) of between 64 and 1518 octets, inclusive, but were not an integral number of octets in length or had a bad Frame Check Sequence (FCS)
											9	etherStatsUndersizePkts	Total number of packets received that were less than 64 octets long (excluding framing bits, but including FCS octets) and were otherwise well formed
											10	etherStatsOversizePkts	Total number of packets received that were longer than 1518 octets (excluding framing bits, but including FCS octets) and were otherwise well formed
											11	etherStatsFragments	Total number of packets received that were not an integral number of octets in length or that had a bad Frame Check Sequence (FCS), and were less than 64 octets in length (excluding framing bits but including FCS octets)
											12	etherStatsJabbers	Total number of packets received that were longer than 1518 octets (excluding framing bits, but including FCS octets), and were not an integral number of octets in length or had a bad Frame Check Sequence (FCS)
											13	etherStatsCollisions	Best estimate of the total number of collisions on this Ethernet segment
											14	etherStatsPkts64Octets	Total number of packets (including error packets) received that were 64 octets in length (excluding framing bits but including FCS octets)
											15	etherStatsPkts65to127Octets	Total number of packets (including error packets) received that were between 65 and 127 octets in length inclusive (excluding framing bits but including FCS octets)

Address												Name	Description
											16	etherStatsPkts128to255Octets	Total number of packets (including error packets) received that were between 128 and 255 octets in length inclusive (excluding framing bits but including FCS octets)
											17	etherStatsPkts256to511Octets	Total number of packets (including error packets) received that were between 256 and 511 octets in length inclusive (excluding framing bits but including FCS octets)
											18	etherStatsPkts512to1023Octets	Total number of packets (including error packets) received that were between 512 and 1023 octets in length inclusive (excluding framing bits but including FCS octets)
											19	etherStatsPkts1024to1518Octets	Total number of packets (including error packets) received that were between 1024 and 1518 octets in length inclusive (excluding framing bits but including FCS octets)

*Port number: 1 to 4: standard ports
5 and 6: ports for redundant ring

4.3.2 SNMP CLIENT SOFTWARE

MIB Browser software enables to perform all the basic SNMP operations, such as GET, GETNEXT, and RESPONSE. Very simple SNMP Client software is sufficient for using the MIB in our range of switches.

- The SNMP agent runs on the SWT212 Switches.
- The SWT212 Switches are accessed remotely from a SNMP client.

4.4 LEDS

LEDs are used to indicate the state of SWT212 and of the links. They are meant for experts.

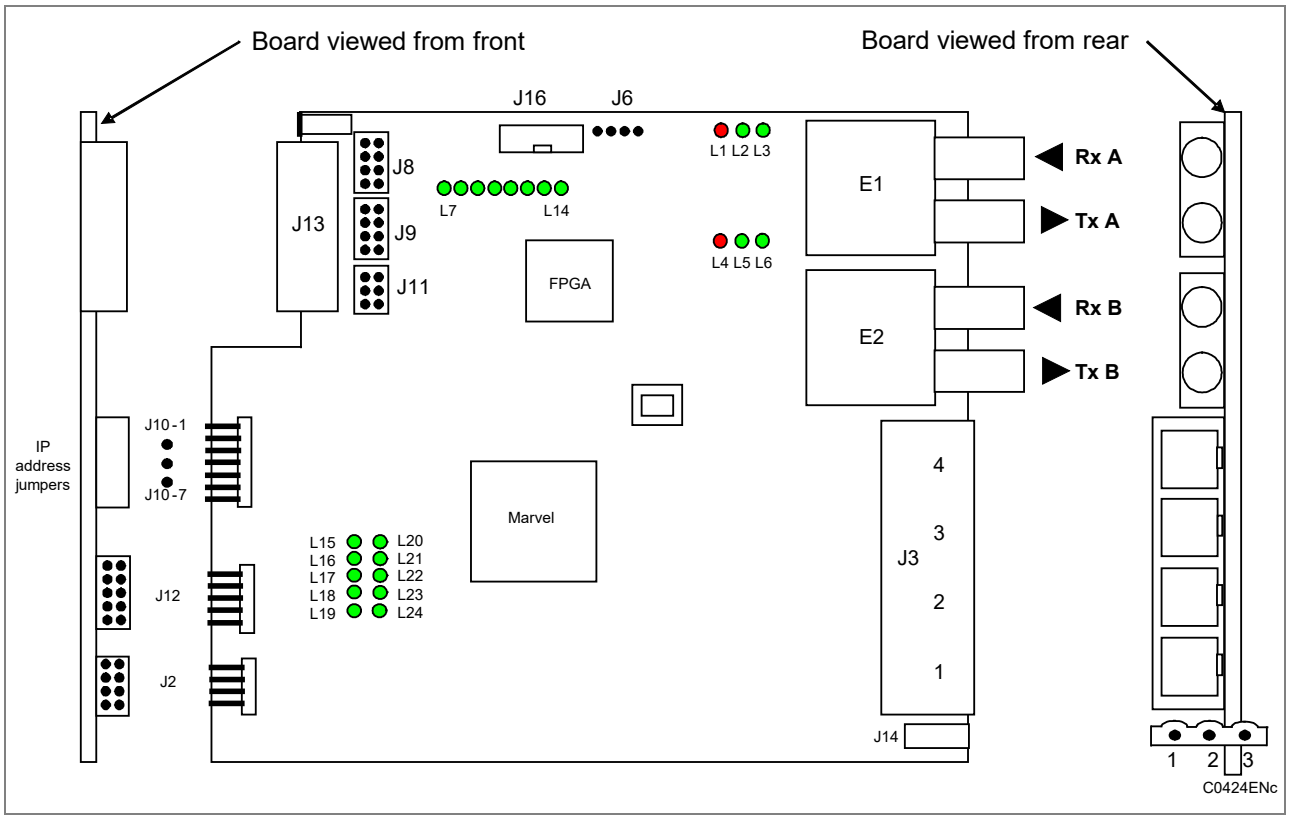


Figure 16: LED location on an SWT212 board

The table below indicates the function of each LED:

LED	N°	Colour	Description
Link A fault	L1	Red	Fault on link A
Link A reception	L2	Green	Reception Link A
Link A traffic	L3	Green	Traffic on Link A
Link B fault	L4	Red	Fault on Link B
Link B reception	L5	Green	Reception Link B
Link B traffic	L6	Green	Traffic Link B
Switch Number bit 0	L7	Green	
Switch Number bit 1	L8	Green	
Switch Number bit 2	L9	Green	
Switch Number bit 3	L10	Green	
Switch Number bit 4	L11	Green	
Switch Number bit 5	L12	Green	
Switch Number bit 6	L13	Green	
Switch Number bit 7	L14	Green	
Link and activity port 1	L15	Green	Off: no connection Green: link Green + blink: link + activity
Link and activity port 2	L16	Green	"

LED	N°	Colour	Description
Link and activity port 3	L17	Green	"
Link and activity port 4	L18	Green	"
Link and activity port 5	L19	Green	"
Speed port 1	L20	Green	Off: 10Mbps Green: 100Mbps
Speed port 2	L21	Green	"
Speed port 3	L22	Green	"
Speed port 4	L23	Green	"
Speed port 5	L24	Green	Port not used

On power-up the SWT212 goes through its self-check sequence.

4.5 SETTINGS

The board's unique IP address (repeater number) is defined by setting jumpers as shown below.

4.5.1 JUMPERS

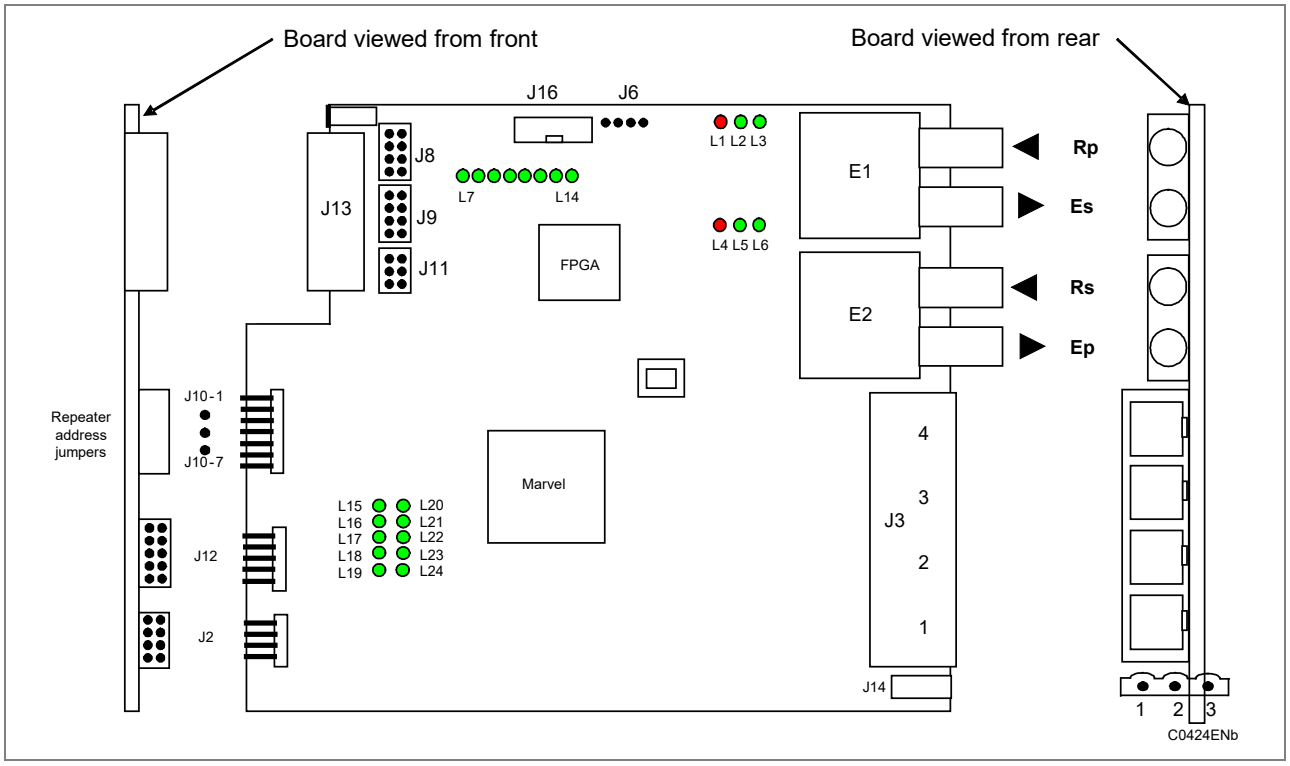
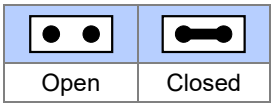


Figure 15: Jumper location on an SWT212 board



The state is “closed” when the jumper is set.

N°	Open	Closed	Factory setting
J10-1	Board address bit 1 = 1	Board address bit 1 = 0	Closed
J10-2	Board address bit 2 = 1	Board address bit 2 = 0	Closed
J10-3	Board address bit 4 = 1	Board address bit 4 = 0	Closed
J10-4	Board address bit 8 = 1	Board address bit 8 = 0	Closed
J10-5	Board address bit 16 = 1	Board address bit 16 = 0	Closed
J10-6	Board address bit 32 = 1	Board address bit 32 = 0	Closed
J10-7	Board address bit 64 = 1	Board address bit 64 = 0	Closed

4.5.2 IP ADDRESS OF THE BOARD (REPEATER NUMBER)

Each board on the ring has a specific address (repeater number). Each address must be unique and comprised between 1 and 127.

The repeater number is equal to the sum of the "open bits", i.e. pins not linked by jumpers on the board.

With all jumpers set, the number is 0. Remove jumpers to increase the number ("address"):

Starting address (with all jumpers set) = 0

If J10-1 = open (no jumper):	address = address + 1	if jumper set:	address = address + 0
If J10-2 = open (no jumper):	address = address + 2	if jumper set:	address = address + 0
If J10-3 = open (no jumper):	address = address + 4	if jumper set:	address = address + 0
If J10-4 = open (no jumper):	address = address + 8	if jumper set:	address = address + 0
If J10-5 = open (no jumper):	address = address + 16	if jumper set:	address = address + 0
If J10-6 = open (no jumper):	address = address + 32	if jumper set:	address = address + 0
If J10-7 = open (no jumper):	address = address + 64	if jumper set:	address = address + 0

Example

J10-1 = open: address = address + 1
J10-2 = open: address = address + 2
J10-3 = closed: address = address + 0
J10-4 = open: address = address + 8
J10-5 = closed: address = address + 0
J10-6 = closed: address = address + 0
J10-7 = closed: address = address + 0
=> **Address (repeater number) = 1 + 2 + 8 = 011**

4.5.3 IP ADDRESS OF THE REPEATER

The repeater IP address breaks down as follows:

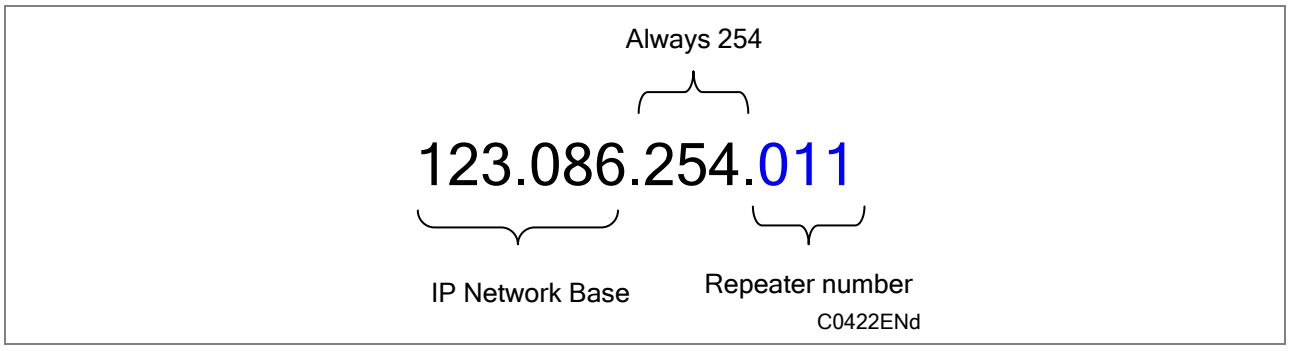


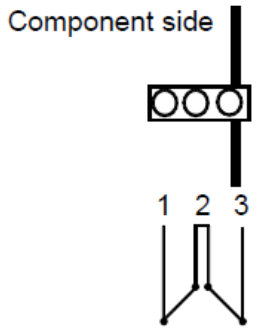
Figure 16: IP Address

Note:
It is important to note that the Switch Manager software forces the third IP field to the value "254".

4.6 CONNECTIONS

J14 Fault signal output:

The optical health is monitored. If one link come down the default is announced by the contacts:



Pin	State
1	Faulty link A
2	Common
3	Faulty link B

Closed if link faulty

C0297ENb

Figure 19: J14 Pin out

5 SWU20X RANGE – STAR ARCHITECTURE

The SWU20x range of Ethernet boards is dedicated to Ethernet Star architecture and defined by the optional type of Ethernet optical fibre it is connected (single Mode or Multi Mode). All the boards in the SWU20x range have 4 Copper connections through RJ45, with speed automatically adjusted from external emitters to 10 or 100 Mbps, and optionally 2 Ethernet optical ports.

5.1 ETHERNET PORT SWITCHING FEATURES

The SWUxxx determines automatically at message reception the speed of its transmission layer 10 or 100 Mbps and it automatically adapts to this transmission speed and other transmission parameters such as half or full duplex.

The copper ports are full/half duplex and auto-sense the transmission speed. They will auto-negotiate with the connected device to determinate the optimal speed. When the connected device is only capable of transmitting at 10Mbps, the SWU20x follows the 10Mbps.

The fibre optic ports are full/half duplex at 100Mbps.

5.2 ETHERNET MANAGEMENT

Refer to section *3.2.* Ethernet Management

6 SRP28X RANGE – DUAL STAR ARCHITECTURE (PRP)

6.1 FUNCTIONAL DESCRIPTION

The SRP28x is an Ethernet Switch housed on a printed circuit board which can be incorporated into a number of DS Agile devices including the H38x and the C26x.

The SRP28x facilitates connecting Ethernet equipped devices via a Parallel Redundancy Protocol (PRP in accordance with IEC 62439-3). Devices connect to the switch by copper connections using RJ45 connectors. These connections comply with 10/100Base-Tx. Three ports (ports 2, 3, & 4) are available for connecting external devices. Each port, independently, detects the speed of the connected device (10Mbps or 100Mbps) and whether the link is half-duplex or full-duplex. It then automatically adjusts to suit.

Ethernet copper links are limited in distance and subject to interference. You should keep them as short as possible.

The Parallel Redundancy Protocol connection uses fibre-optic inter-switch connections. A multi-mode fibre-optic version is available for short distance connections (typically up to around 2km), and a single-mode version is available for longer distances (potentially in excess of 15km). The PRP ports support 100Base-Fx using LC connectors.

The SRP28x also supports the Precision Time Protocol (PTP in accordance with IEEE1588), taking time synchronisation from a master clock and distributing it locally.

Time synchronisation is distributed using IRIG-B on a dedicated SMB connector.

An internal Ethernet connection is also provided (port 1). It provides a 10/100Base-Tx port on an RJ45 connector.

6.1.1 PARALLEL REDUNDANCY PROTOCOL (PRP)

The Parallel Redundancy Protocol (PRP) is implemented according to the definition in the standard IEC 62439-3.

PRP allows seamless communication in the face of a single network disruption (for instance cable, driver, switch or controller failure).

A PRP compatible device has two ports operating in parallel, each port being connected to a separate local area network (LAN) segment. IEC62439-3 assigns the term DANP (Doubly Attached Node running PRP) to such devices. Critical devices should be doubly attached using two ports.

The figure below shows an example of a PRP network. The doubly attached nodes DANP 1 and DANP 2 have full node redundancy, while the singly attached nodes SAN 1 and SAN 4 do not have any redundancy. Singly attached nodes can, however, be connected to both LANs, via a device that converts a singly attached node into a doubly attached node. This is what the SRP28x does. Devices performing this function are often referred to as redundancy boxes or RedBoxes. Devices with single network cards such as personal computers, printers, etc., are singly attached nodes that may be connected into the PRP network via a RedBox as shown in the figure. This is the case for SAN2 and SAN3. Because these SANs connect to both LANs, they can be considered as Virtual Doubly Attached Nodes and described as VDANs.

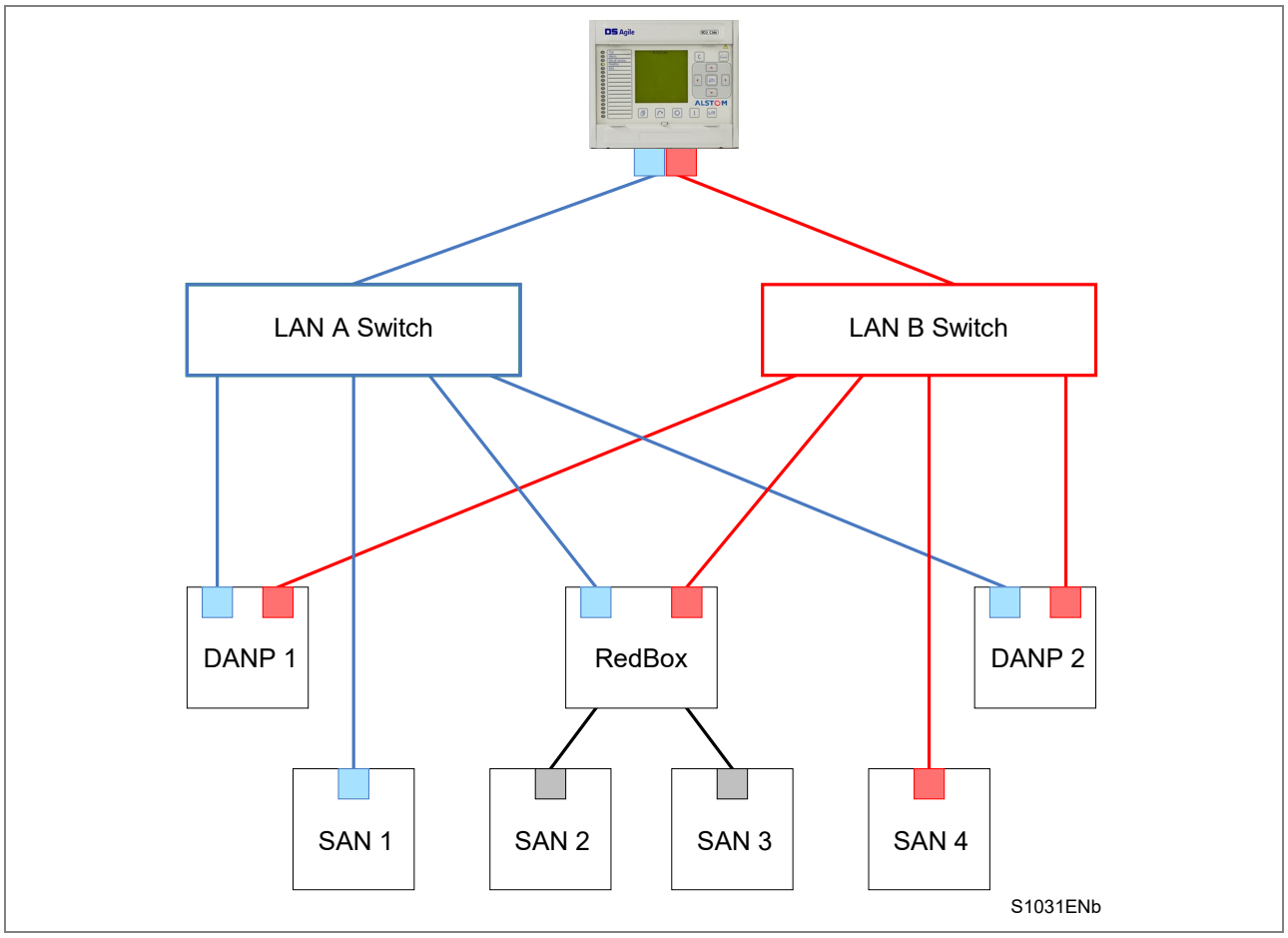


Figure 20: Example PRP Redundant Network

To achieve high-availability configuration the first interface is connected to LAN A and the second to LAN B. The topologies of LAN A and LAN B are open and the networks could be utilising other redundancy approaches. A DANP transmits its packets on both interfaces and hence over both networks. In an error-free environment a second DANP receives the same packets on both interfaces, possibly with a time delay between them. The receiving DANP will use the first of these packets, ignoring the second. PRP networks do not need reconfiguration or path switching.

The two LANs are identical in protocol at the Media Access Control (MAC) level, but they can differ in performance and topology. Transmission delays may also be different. The LANs have no direct connection between them and they are assumed to be fail-independent.

The SRP28x acts a RedBox with optical connections to the redundant networks and electrical connexion to SAN devices that then become VDANs connecting a device to both redundant networks. The figure below shows this diagrammatically.

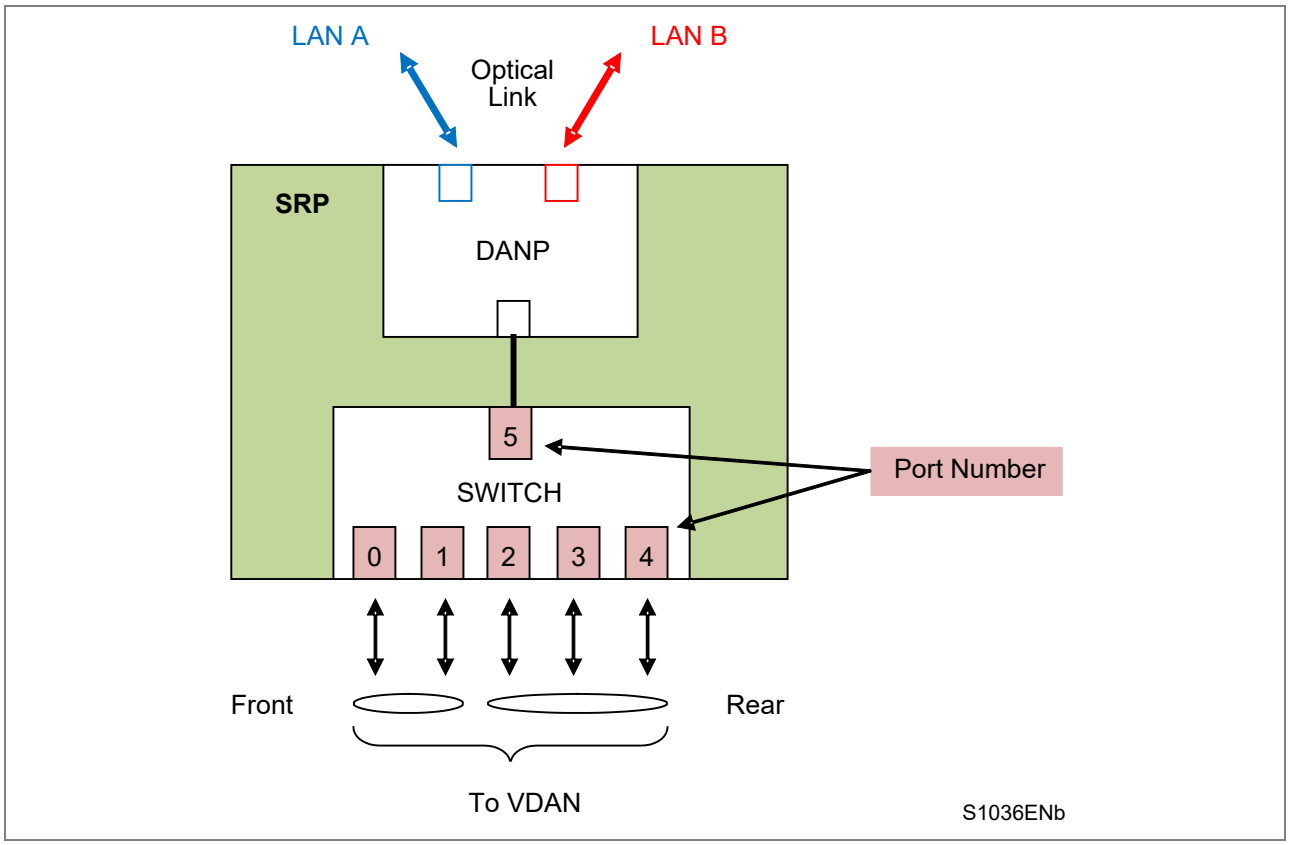


Figure 21: SRP28x connecting singly attached nodes to doubly attached networks

For products that connect directly to the PRP LANs, the two ports of the DANP operate in parallel. They are attached to the same upper layers of the communication stack through a link redundancy entity (LRE) as shown in the figure below.

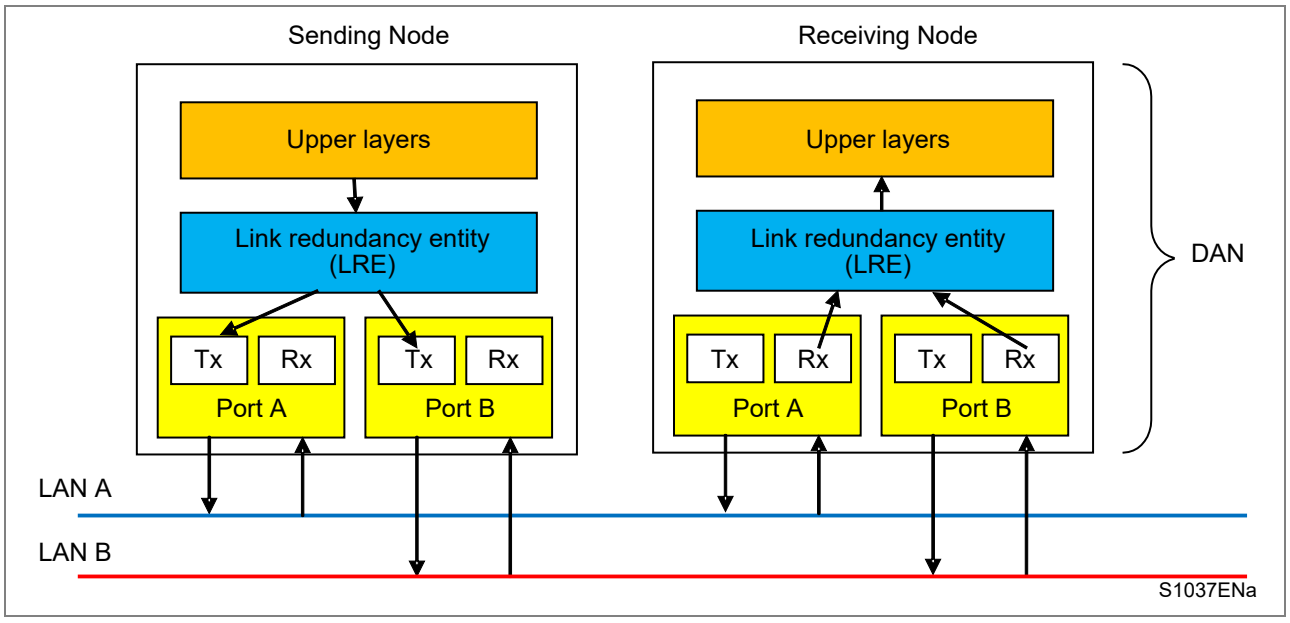


Figure 22: DANP structure

6.1.2 TIME SYNCHRONISATION

The SRP28x supports real-time clock synchronisation using either Precision Time Protocol (PTP in accordance with IEEE 1588 v2), or Network Time Protocol (NTP).

The SRP28x takes timing information presented over the network and distributes it locally.

A one pulse-per-second (PPS) signal is generated and is displayed on an LED.

6.1.2.1 PRECISION TIME PROTOCOL (PTP)

Time synchronisation from a master clock synchronised to the Global Positioning Satellite (GPS) system is accepted over the network and distributed locally according to IEEE 1588 v2 as demonstrated in the figure below:

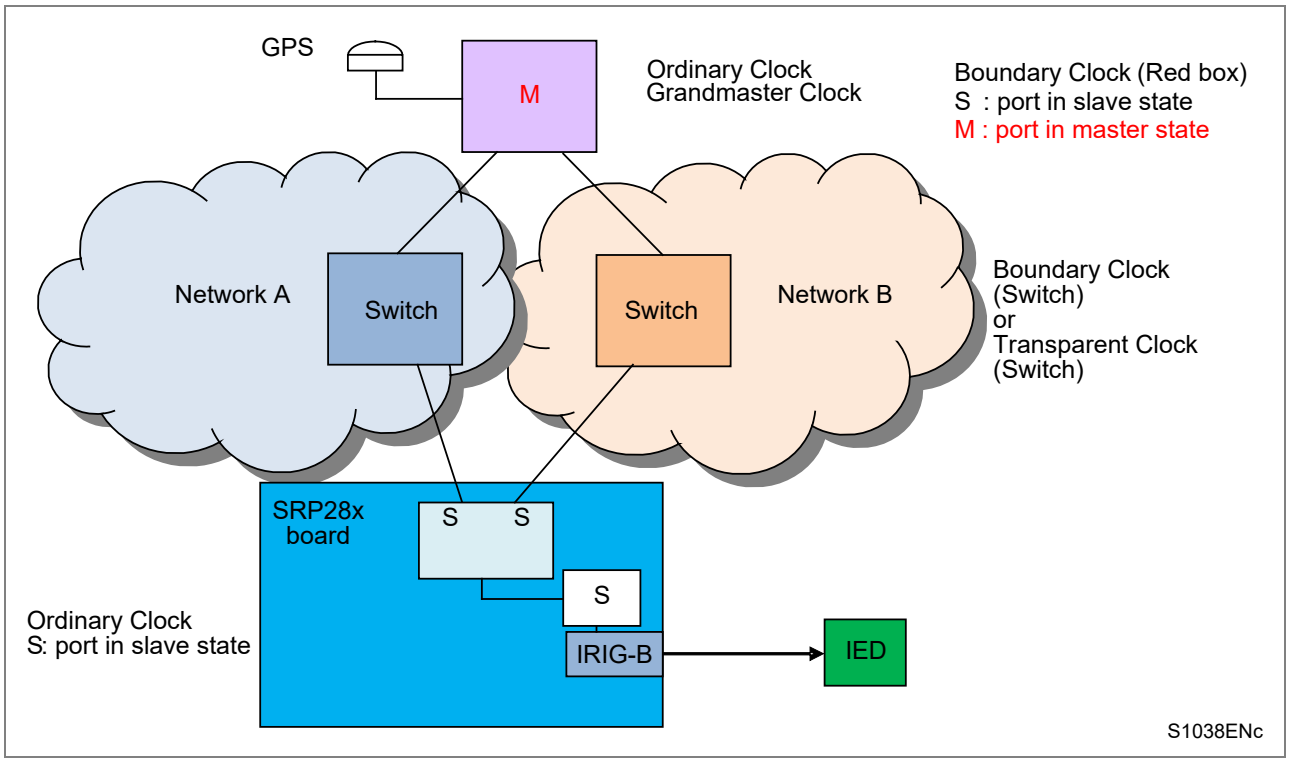


Figure 23: PTP architecture

PTP synchronises all clocks within a network by adjusting distributed clocks to a grandmaster clock. PTP enables distributed clocks to be synchronised and maintained to sub-microsecond accuracy.

The grandmaster clock is the primary time source. Boundary clocks create segmented synchronisation sub-domains. So-called 'ordinary' clocks can either act as time servers or as time clients.

The SRP28x board uses IEEE1588 to provide the IRIG-B output.

Note:
The SRP28x board does NOT forward the PTP data to the access ports.

6.1.2.2 NETWORK TIME PROTOCOL

Network Time Protocol (NTP) is a networking protocol for clock synchronisation between computer systems over packet-switched, variable-latency data networks.

NTP is supported by the SRP28x as shown diagrammatically in the figure below.

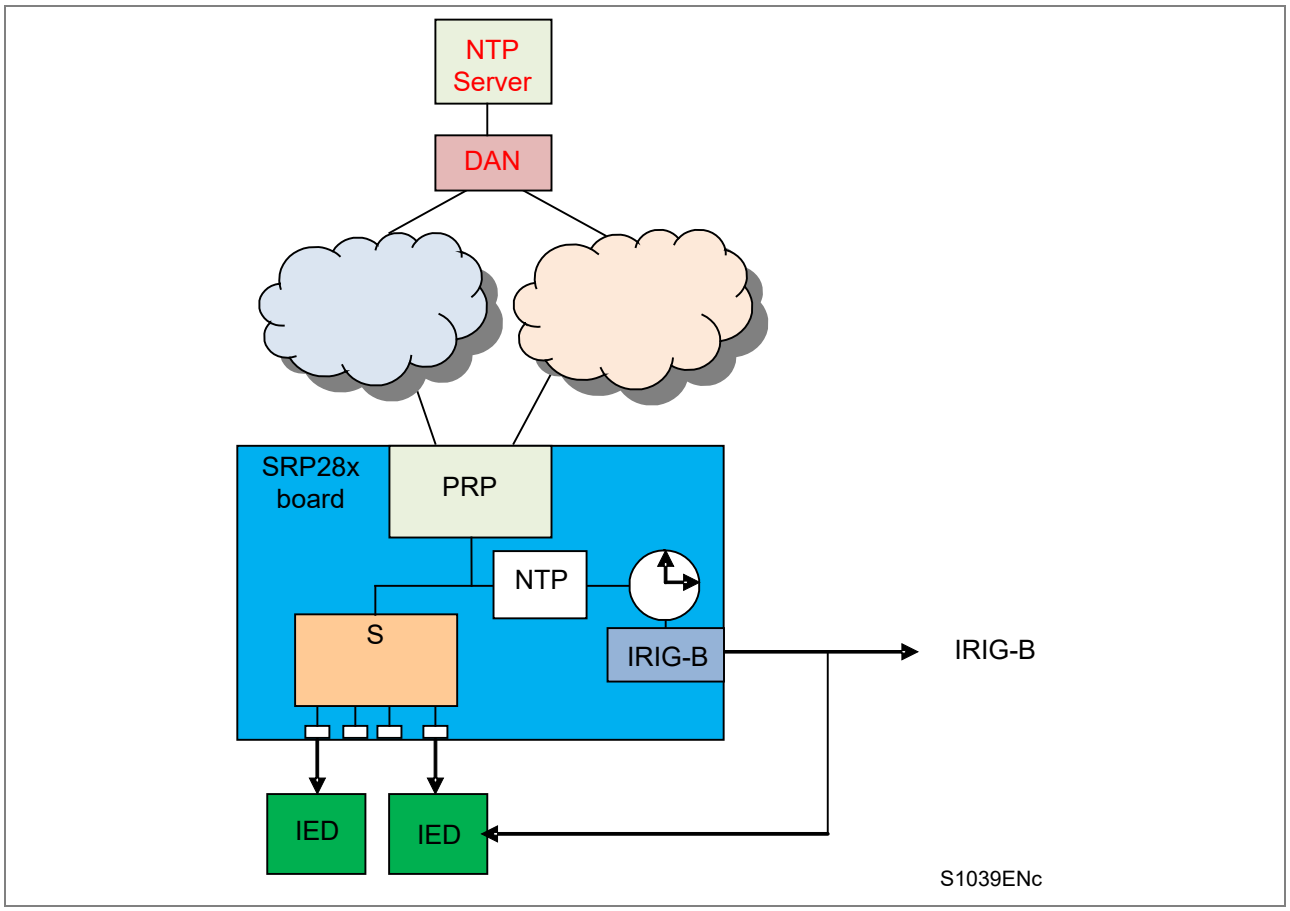


Figure 24: NTP architecture

6.1.2.3 TIME SYNCHRONISATION DISTRIBUTION

Time synchronisation is distributed via a dedicated IRIG-B connection or via Ethernet services.

6.1.2.4 IRIG-B

The clock reference for the SRP28x comes from either the PTP or the NTP services. It is used to generate a timing signal that is output to a connector at the rear of the unit.

The output is compliant with the Inter-Range Instrumentation Group time code B standard (IRIG-B).

The signal is in accordance with the standard IRIG-B 126: Sine wave carrier (amplitude modulated) at 1 kHz (1 ms resolution), Binary Coded Decimal (BCD). The IRIG-B time reference provided is the UTC time.

6.1.3 FUNCTIONAL DESIGN

The figure below shows the main functional blocks of the SRP28x:

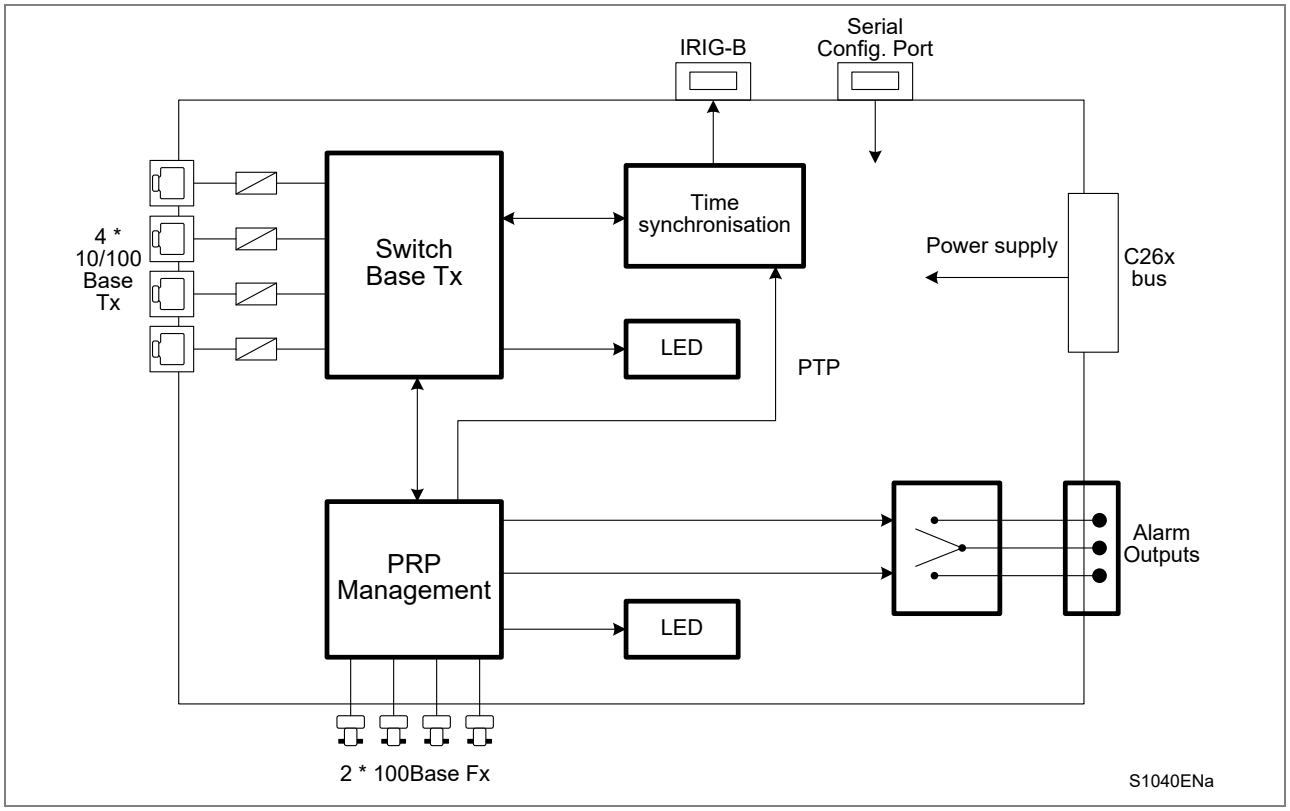


Figure 25: SRP28x functional diagram

The principal functional component parts are:

- The Base-Tx Ethernet Switch
- The Parallel Redundancy Protocol (PRP) management
- Time synchronisation management
- SNMP (Simple Network Management Protocol) management
- Light Emitting Diodes (LED) and alarm outputs.
- SSH/Telnet configuration port

6.1.4 BASE-TX ETHERNET SWITCH FUNCTION

The Base-Tx Ethernet Switch function manages three Ethernet ports presented for user connection (ports 2, 3, & 4), and two internal ports for service connection. The user ports are 10/100 Base-Tx using RJ45 connectors. Ports 2, 3, & 4 are located at the rear of the unit and are qualified by LED indications of link activity. Port 1 is a 10/100 Base-Tx internal service port using an RJ45 connector located at the front of the board. The other internal service connection port is Port 0, and is also located at the front of the board. It supports 10/100/1000 Base-Tx and uses a Samtec ERF8-RA connector. The port shares a connector with signals described under the time synchronisation section of this document.

If a cable is not connected to a port, most of the circuitry for that port is disabled to save power.

Using auto-negotiation, the SRP28x automatically determines the speed of transmission on the 10/100 Base-Tx ports according to the IEEE 802.3u standard. It also determines whether communication is half-duplex or full-duplex, and adapts accordingly.

Each Ethernet device inserts its unique “MAC address” into each message it sends. The receiving port on the SRP28x automatically recognises the MAC address in a received frame and stores it. Once an address is recognised and stored, the SRP28x will forward frames to the appropriate port. Up to 1024 MAC addresses can be stored and monitored at any time.

The SRP28x supports the store and forward mechanism of the IEEE 802.3 standard. It forwards messages with known addresses to the appropriate port. Messages with unknown addresses, broadcast messages, and multicast messages are forwarded out to all ports except the source port. It does not forward error packets or 802.3x pause frames.

Priority tagging according to IEEE 802.1p is enabled on all ports.

6.1.5 PARALLEL REDUNDANCY PROTOCOL (PRP) MANAGEMENT FUNCTION

The Parallel Redundancy Protocol (PRP) management function manages traffic over the dual redundant 100 Base-Fx fibre-optic Ethernet connections according to IEC 62439-3.

6.1.6 TIME SYNCHRONISATION FUNCTION

This product supports real-time clock synchronisation using either Precision Time Protocol (PTP in accordance with IEEE 1588 v2), or Network Time Protocol (NTP).

A one pulse-per-second (PPS) signal is generated and is displayed on an LED labelled as “Heartbeat” on the display.

Time synchronisation is available as an NTP service or via IRIG-B.

6.1.6.1 PRECISION TIME PROTOCOL (PTP)

Time synchronisation from a master clock synchronised to the global positioning satellite (GPS) system is accepted over the network according to IEEE 1588.

PTP synchronises all clocks within a network by adjusting distributed clocks to a grandmaster clock. PTP enables distributed clocks to be synchronised and maintained to sub-microsecond accuracy.

6.1.6.2 NETWORK TIME PROTOCOL (NTP)

Network Time Protocol (NTP) is a networking protocol for clock synchronisation between computer systems over packet-switched, variable-latency data networks.

NTP is supported by this product.

6.1.6.3 IRIG-B

A time synchronisation signal compliant with the Inter-Range Instrumentation Group time code B (IRIG-B) is generated within the product.

The signal is in accordance with the standard IRIG-B 126: Sine wave carrier amplitude modulated at 1 kHz (1 ms resolution), Binary Coded Decimal (BCD). The IRIG-B time reference provided is the UTC time.

The signal is presented on a connector located between the LEDs. An SMB connector is used which provides 2 kVrms isolation and >100 MOhms insulation resistance. Up to 10 devices can be connected for synchronisation.

6.1.7 ETHERNET MANAGEMENT

Standards	IEEE802.3, 802.3u, 802.3x, 802.1p
Forwarding mode	Store and forward
Memory bandwidth	2 Gbps
MAC Address	1K
Address learning	Automatic
Broadcast storm protection	Limited to 5%
Illegal frame	Dropped per 802.3
Late collision	Dropped after 512 bit times

6.1.8 SNMP MANAGEMENT

Simple Network Management Protocol (SNMP) is the network protocol developed to manage devices on an IP network. SNMP is based on a model consisting of a manager, an agent, a database of management information, managed objects and the network protocol. The manager provides the interface between the human network manager and the management system. The agent provides the interface between the manager and the physical device(s) being managed according to the figure below.

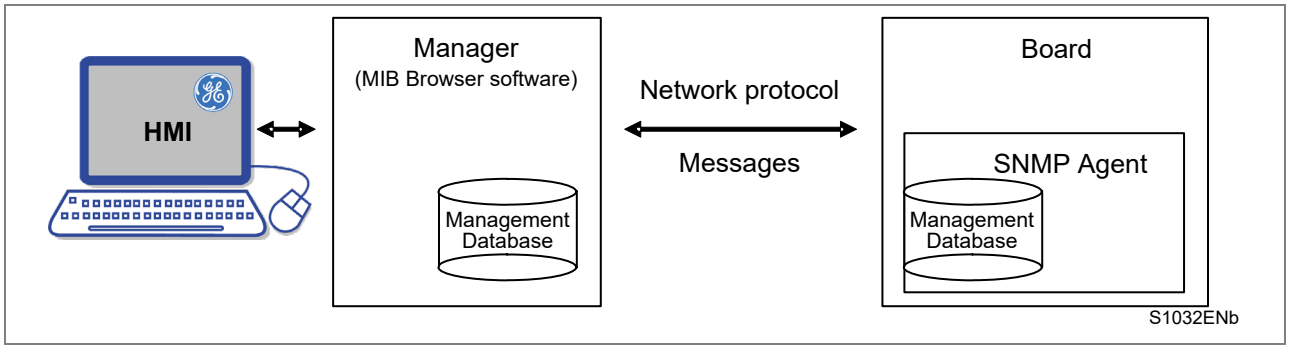


Figure 26: SNMP management

The manager and agent use a Management Information Base (MIB) and a relatively small set of commands to exchange information. The MIB is organised in a tree structure with individual variables, such as point status or description, being represented as leaves on the branches. A long numeric tag known as an Object IDentifier (OID) is used to distinguish each variable uniquely in the MIB and in the SNMP messages. The Manager is an MIB Browser Software. SNMP versions 1, 2, and 3 are supported.

Each SNMP element manages specific objects with each object having specific characteristics. Each object/characteristic has a unique object identifier (OID) consisting of numbers separated by decimal points (for example: 1.3.6.1.4.1.2682.1). The MIB associates each OID with a readable label (for example: dpsRTUAState) and various other parameters related to the object. The MIB then serves as a data dictionary or codebook that is used to assemble and interpret SNMP messages.

For this board, the GE Grid Solutions management information bases (MIB) use the following types of object identifiers (OID):

- System
- Interface
- Remote network monitoring (RMON)
- Parallel redundancy protocol (PRP)

These are defined in the tables below.

6.1.8.1 SYSTEM MIB STRUCTURE

Address												Name	
0												Ccitt	
	1											ISO	
		3										Org	
			6									DOD	
				1								Internet	
					2							mgmt	
						1						Mib-2	
							1					sys	
								1				sysDescr	Redundant switch PRP
								2				sysObjectID	TBD
								3				sysUpTime	Time (in hundredths of a second) since the switch was last reinitialised
								4				sysContact	user-configurable
								5				sysName	SRP28x (user-configurable)
								6				sysLocation	user-configurable
								7				sysServices	2

6.1.8.2 INTERFACE MIB STRUCTURE

Address												Name	
0												Ccitt	
	1											ISO	
		3										Org	
			6									DOD	
				1								Internet	
					2							mgmt	
						1						Mib-2	
							2					interfaces	Interface number
								1				ifNumber	Redundant switch PRP
								2				ifTable	TBD
									1			ifEntry	Time (in hundredths of a second) since the switch was last reinitialised
										7		ifAdminStatus	1: up, 2: down
										8		ifOperStatus	1: up, 2: down
										9		ifLastChange	time (in hundredths of a second) since the latest change

6.1.8.3 RMON MIB STRUCTURE

Address												Name
0												Ccitt
	1											ISO
		3										Org
			6									DOD
				1								Internet

Address												Name
					2							mgmt
						1						Mib-2
							16					RMON
								1				stat
									1			etherstatsTable
										1		etherStatsIndex
										6		etherStatsBroadcastPkts
										7		etherStatsMulticastPkts
										8		etherStatsCRCAlignErrors
										9		etherStatsUndersizePkts
										10		etherStatsOversizePkts
										11		etherStatsFragments
										12		etherStatsJabbers
										13		etherStatsCollision
										14		etherStatsPkts64Octets
										15		etherStatsPkts65to127Octets
										16		etherStatsPkts128to255Octets
										17		etherStatsPkts256to511Octets
										18		etherStatsPkts512to1023Octets
										19		etherStatsPkts1024to1518Octets

6.1.8.4 PRP MIB STRUCTURE

The PRP MIB is accessible only through SNMPv3.

Address												Name
0												ccitt
1												iso
	0											std
		64239										iec62439
			1									mrp
			2									prp
				20								linkRedundancyEntityNotifications
				21								linkRedundancyEntityObjects
					0							lreConfiguration
						0						lreConfigurationGeneralGroup
							1					lreManufacturerName
							2					lreInterfaceCount
						1						lreConfigurationInterfaceGroup
							0					lreConfigurationInterfaces
								1				lreInterfaceConfigTable
									1			lreInterfaceConfigEntry
										1		lreInterfaceConfigIndex
										2		lreRowStatus
										3		lreNodeType

Address												Name
										4		lreNodeName
										5		lreVersionName
										6		lreMacAddress
										7		lrePortAdminStateA
										8		lrePortAdminStateB
										9		lrelinkStatusA
										10		lrelinkStatusB
										11		lreDuplicateDiscard
										12		lreTransparentReception
										13		lreHsrLREMode
										14		lreSwitchingEndNode
										15		lreRedBoxIdentity
										16		lreEvaluateSupervision
										17		lreNodesTableClear
										18		lreProxyNodeTableClear
					1							lreStatistics
						1						lreStatisticsInterfaceGroup
							0					lreStatisticsInterfaces
								1				lreInterfaceStatsTable
									1			lreInterfaceStatsEntry
										1		lreInterfaceStatsIndex
										2		lreCntTxA
										3		lreCntTxB
										4		lreCntTxC
										5		lreCntErrWrongLanA
										6		lreCntErrWrongLanB
										7		lreCntErrWrongLanC
										8		lreCntRA
										9		lreCntRxB
										10		lreCntRxC
										11		lreCntErrorsA
										12		lreCntErrorsB
										13		lreCntErrorsC
										14		lreCntNodes
										15		lreCntProxyNodes
										16		lreCntUniqueA
										17		lreCntUniqueB
										18		lreCntUniqueC
										19		lreCntDuplicateA
										20		lreCntDuplicateB
										21		lreCntDuplicateC
										22		lreCntMultiA
										23		lreCntMultiB
										24		lreCntMultiC

Address												Name
										25		lreCntOwnRxA
										26		lreCntOwnRxB
									2			lreNodesTable
										1		lreNodesEntry
											1	lreNodesIndex
											2	lreNodesMacAddress
											3	lreTimelastSeenA
											4	lreTimelastSeenB
											5	lreRemNodeType
									3			lreProxyNodeTable
										1		lreProxyNodeEntry
											1	lreProxyNodeIndex
											2	lreProxyNodeMacAddress
				22								linkRedundancyEntityConformance

6.1.8.5 SNMP CLIENT SOFTWARE

Readily available Management Information Bases (MIB) browser software enables you to perform all the basic Simple Network Management Protocol (SNMP) operations, such as GET, GETNEXT, and RESPONSE, by connecting to the switch.

6.1.8.6 SNMP TRAPS

A Simple Network Management Protocol (SNMP) trap is a change-of-state message. The SRP28x generates SNMP traps on coldstart, warmstart, linkup, linkdown or authentication failure. The version used is SNMP v1 and the traps are shown in the table below:

Trap Type	Name	Description
0	coldstart	The switch is booting
1	warmstart	The switch is rebooting
2	linkdown	An interface has gone down
3	linkup	An interface has come up
4	authentication failure	An invalid password was received in a message

6.1.8.7 SNMP ACCESSIBILITY

The Simple Network Management Protocol (SNMP) supports the versions 1 – 3 according to the rules below:

SNMP v1 and v2:

- Read community: Public
- Write community: Private

SNMP v3:

Level	System MIB	Other MIB
Observer	Read, plain	-
Operator	Read, encrypted	Read, encrypted
Administrator	Read/Write, encrypted	Read/Write, encrypted

An Administrator can change any user password. Other users can only change their own password.

6.2 CONFIGURATION AND SETTINGS

The SRP28x is configured using a series of dialogues between the board and a terminal emulator on a personal computer (PC) or similar device. Connection is made via an SSH connection over the Ethernet.

The connection is used to configure, manage, and monitor the board. LED indications provide complementary status information.

The connection can also be used to upgrade the firmware of the board should that be necessary.

There are 2 possible external access points:

- over an Ethernet network connected to any of the three RJ45 ports accessible on the back panel of the C26x,
- via SSH, over the HSR network connected to its redundant optical connectors.

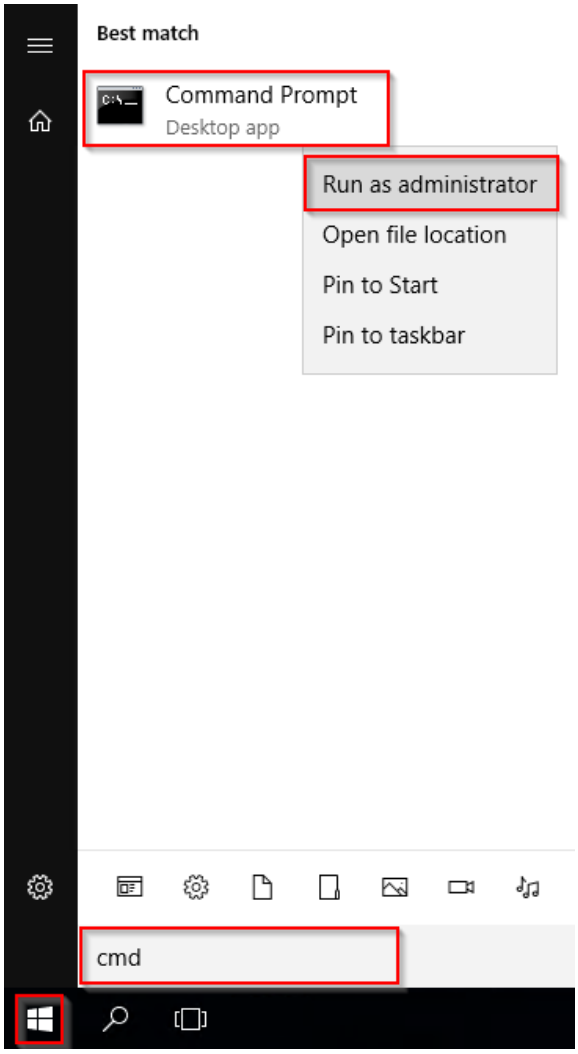
6.2.1 MTU CONFIGURATION

Note:
This section only applies to Windows 10 LTSB 2016 for Enterprise 64-bits edition. It does not apply to older versions of Windows.

In order to connect an SSH terminal emulator running under Windows 10 to the board, it is necessary to adjust the size of the frames ("Maximum Transmission Unit") sent over the network. The default size is *1500*. It must be changed to *1494*.

To do this:

- First open a Command Prompt (**cmd.exe**) window, running it as administrator (right-click and select *Run as administrator*):



- Type the command line `netsh interface ipv4 show interface` and press **Enter**.
  This displays the networks and the setting for their MTU (*1500* by default).

```
C:\Windows\system32>netsh interface ipv4 show interface

Idx     Met         MTU          State                Name
---  ----------  ----------  ------------  ---------------------------
  1          50  4294967295  connected     Loopback Pseudo-Interface 1
 11          20        1500  connected     LowerNetwork
 13          20        1500  connected     UpperNetwork
```

- For each network, in this example: *LowerNetwork* and *UpperNetwork*, type the command line `netsh interface ipv4 set subinterface "x" mtu=1494 store=persistant` and press **Enter**.
  (with x = name of the network, see example below)
  This permanently changes the setting for the corresponding network's MTU to *1494*.

```
C:\Windows\system32>netsh interface ipv4 show interface

Idx     Met         MTU          State                Name
---  ----------  ----------  ------------  ---------------------------
  1          50  4294967295  connected     Loopback Pseudo-Interface 1
 11          20        1500  connected     LowerNetwork
 13          20        1500  connected     UpperNetwork

C:\Windows\system32>netsh interface ipv4 set subinterface "LowerNetwork" mtu=1494 store=persistent
Ok.
```

- Again, type the command line `netsh interface ipv4 show interface` and press **Enter**.
  This displays the networks to check that the setting for their MTU is effectively changed to *1494*.

```
C:\Windows\system32>netsh interface ipv4 show interface

Idx     Met         MTU          State                Name
---  ----------  ----------  ------------  ---------------------------
  1          50  4294967295  connected     Loopback Pseudo-Interface 1
 11          20        1494  connected     LowerNetwork
 13          20        1500  connected     UpperNetwork
```

6.2.2 SSH COMMUNICATIONS

An SSH access is provided to configure and manage the board.

SSH is a virtual terminal protocol of TCP/IP. It provides encrypted interconnectivity between elements of a network. The terminal is connected to the network like any other device as shown in the figure below.

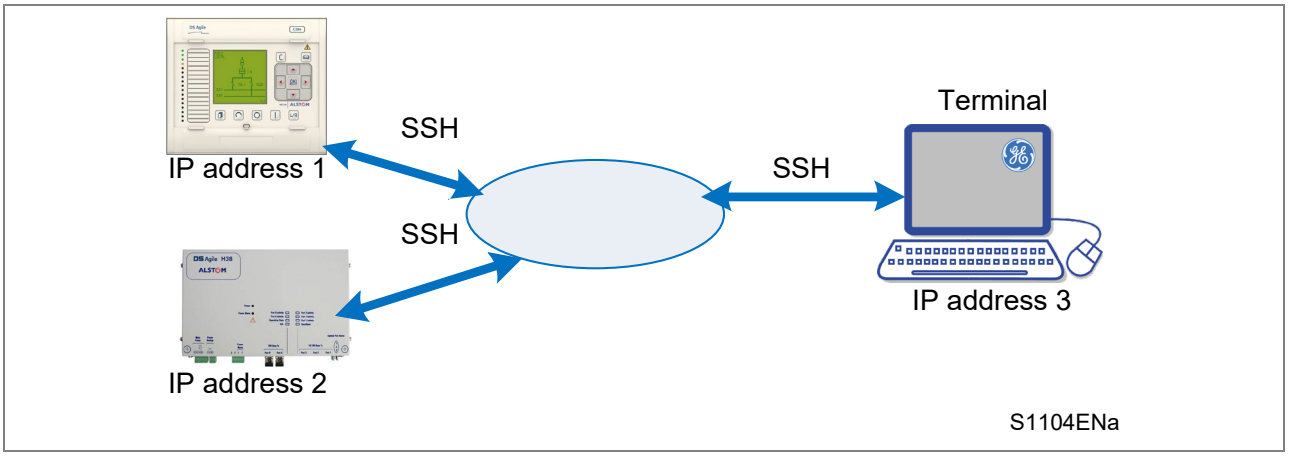


Figure 27: SSH connection example over the HSR network

Note:
The IP addresses must be part of the same network as the terminal and the subnet mask must not exclude them.

With the SSH connection, the terminal can be used to communicate with all functions of the SRP28x.

There are two default accounts:

- root
- user

Both have the same default password:

- changeit

The default IP address is:

- 192.168.254.100

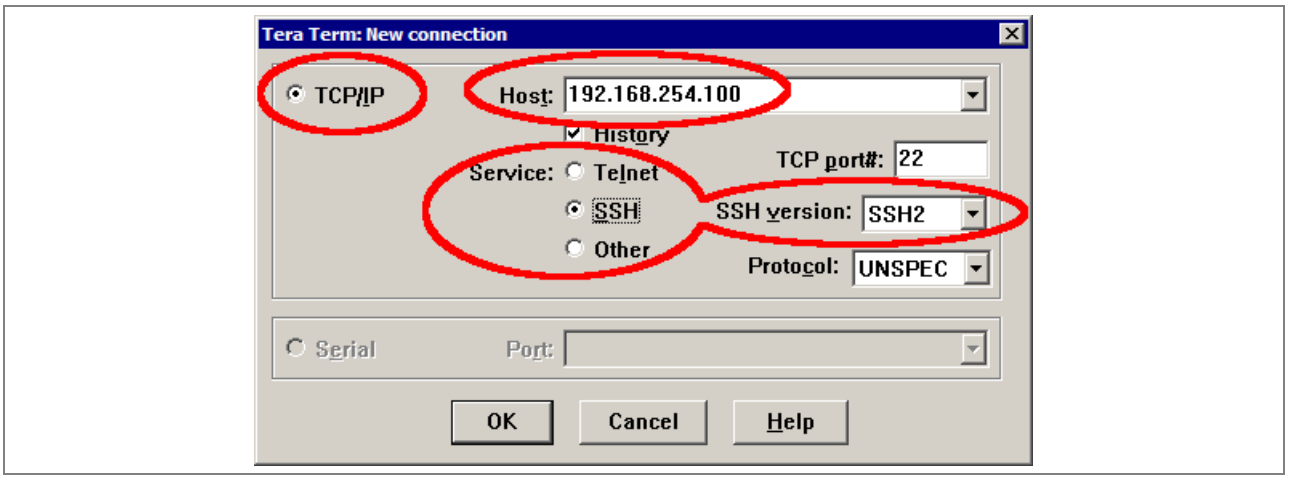
6.3 CONFIGURATION VIA SSH

Most of the available SSH commands are advanced configuration settings that will rarely be used, if ever, since the default settings should fit most applications.
HOWEVER, THE PASSWORDS AND IP ADDRESSES MUST BE CHANGED.

6.3.1.1 SSH SESSION

To open an SSH session with thse board, use a standard SSH2-compatible client:

1 Launch the SSH client application.



2 Select the options *TCP/IP* and *SSH service*, *SSH version 2*.

3 Type the *IP address* of the board in the appropriate field.

4 Click **OK** or **Connect** (or equivalent, depending on the chosen SSH client).

A login window is displayed.

The board is supplied with a unique Media Access Control (MAC) address which should not be changed. It is supplied with a default Internet Protocol (IP) address of **192.168.254.100**.

6.3.1.2 LOGIN

Before the session is opened, you will have a login dialogue as shown in the figure below. You login according to the role(s) associated with your user account.

Default accounts

The board is delivered with two pre-defined accounts:

- "root"
- "user"

The default password for both accounts is "changeit".

Note:
Upgrading a board's firmware does not reset accounts and passwords.

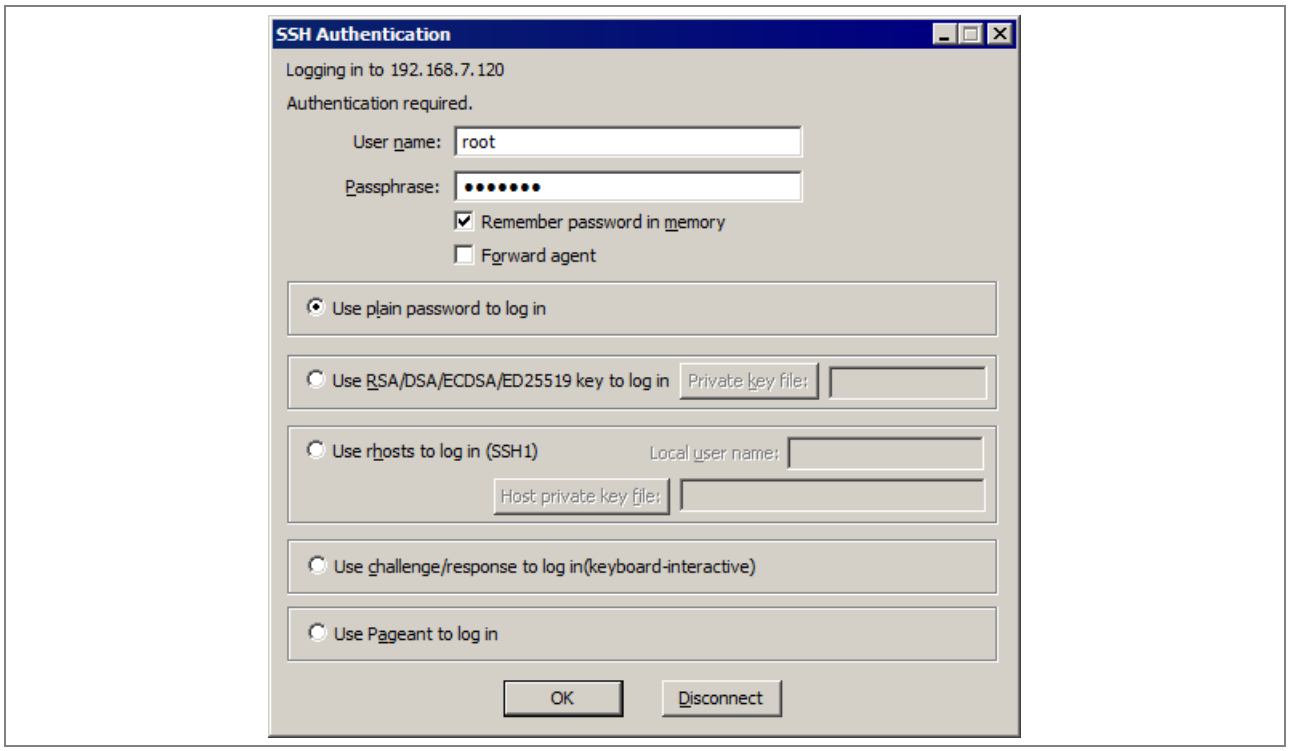


Figure 28: Example of Login window (may vary depending on the selected terminal emulator)

Note 1:

See Cyber-Security section for more information on user accounts.

Note 2.

The connection process on SSH may take up to 1 minute

The connection is established and an SSH console is displayed. Once the session is in progress, your access level is indicated by either a # for Security administrator level, or a $ for non-administrator level (Observer/System engineer roles).



Caution:
Change the default passwords immediately.
To do so, log in as "root" and type the commands:
- `setPassword user` for the account "user"
- `setPassword` for the account "root" (currently logged in),
press Enter, and then follow the onscreen prompts.

6.3.1.3 PASSWORDS AND AUTHENTICATION LEVELS FOR SNMP ACCESS TO MIB DATA

There are three possible authentication levels for SNMP:

- Observer: Does not require login and password, can only read unencrypted data.
- Operator: Requires login and password, can read all data.
- Administrator: Requires login and password, can read and write all data.

SNMP V3 passwords must be a minimum of 8 characters long in accordance with the standard.

Examples of the dialogue to set the passwords are given in the below.

Setting the SNMP V3 Administrator/Operator Passwords

1 Type the command **# setSnmpPassword Administrator** or **setSnmpPassword Operator** and press **Enter**.

2 When prompted, type the name of the account for which you want to change the password: **Administrator** or **Operator**. Press **Enter**.

3 When prompted, type the new password (note that it is not displayed) and then press **Enter**.

4 Retype the new password (note that it is not displayed) and press **Enter**.

5 Repeat this procedure to change the password for the other account.

```
# setSnmpPassword Administrator
New password:
Retype the new password:
```

6.3.1.4 HELP COMMAND

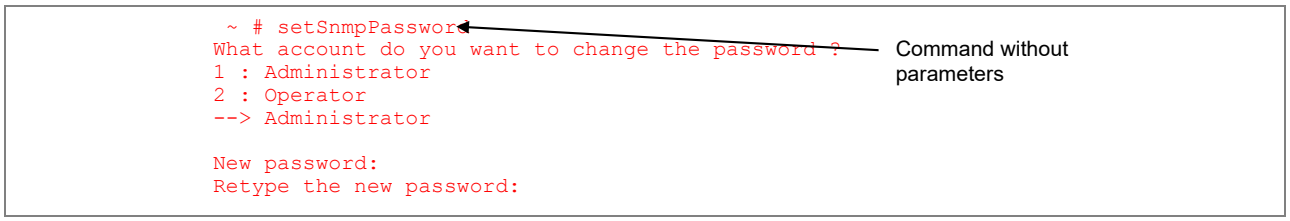
To access the Help screen with the list of available commands, type the letter **h** and press enter.

The Command help screen shows all the options that can be used to configure and manage the SRP28x board. There are five types of commands:

- Configuration commands
- Management commands
- Informative commands
- PRP registers
- Information on the PRP and Ethernet switch ports

Command Line Syntax

To display a command line syntax, type in the command alone (without parameters) and press **Return**. The syntax and available parameters are then displayed, along with a setting example:



6.3.1.5 CONFIGURATION COMMANDS

Configuration command	Syntax	Example
Enable/disable password policy	`passwdPolicy <options>`	`passwdPolicy 0 = disable` `passwdPolicy 1 = enable`
Set authentication timeout (in seconds) Time allowed to log in before the connection is terminated.	`setAuthenticationTimeout <time>`	`setAuthenticationTimeout 60`
Set session timeout (in seconds) If no command is sent for that duration, the session is automatically closed.	`setSessionTimeout <time>`	`setSessionTimeout 300`
Set Account locking parameters Number of failed attempts that trigger a lockout and duration of the lockout (in seconds).	`setLockAccount <login retries> <lock_time>`	`setLockAccount 3 60`
Set MAC address seen from the network (Do not change!)	`setMac <mac_addr>`	`setMac AA:BB:CC:DD:EE:FF`
Set board internal MAC address (Do not change!)	`setMacFunction <mac_addr>`	`setMacFunction AA:BB:CC:DD:EE:FF`
Set network addresses: Board IP address and sub-network mask, Gateway IP address if applicable	`setNetworkSettings`	`setNetworkSettings` then follow onscreen prompts
Set NTP parameters: NTP server activation, IP address of NTP client.	`setNtpSettings`	`setNtpSettings` then follow onscreen prompts
Set current user's own password	`setPassword`	`setPassword` then follow onscreen prompts
Set another user's password	`setPassword <user_name>`	`setPassword user` then follow onscreen prompts

Configuration command	Syntax	Example
Set SNMP Operator or Admin password	`setSnmpPassword <account_name>`	`setSnmpPassword admin` then follow onscreen prompts
Set IP address of the SNMP server that receives traps (events)	`setSnmpTrapIp <ip_addr>`	`setSnmpTrapIp 192.168.254.12`

IP Interfaces

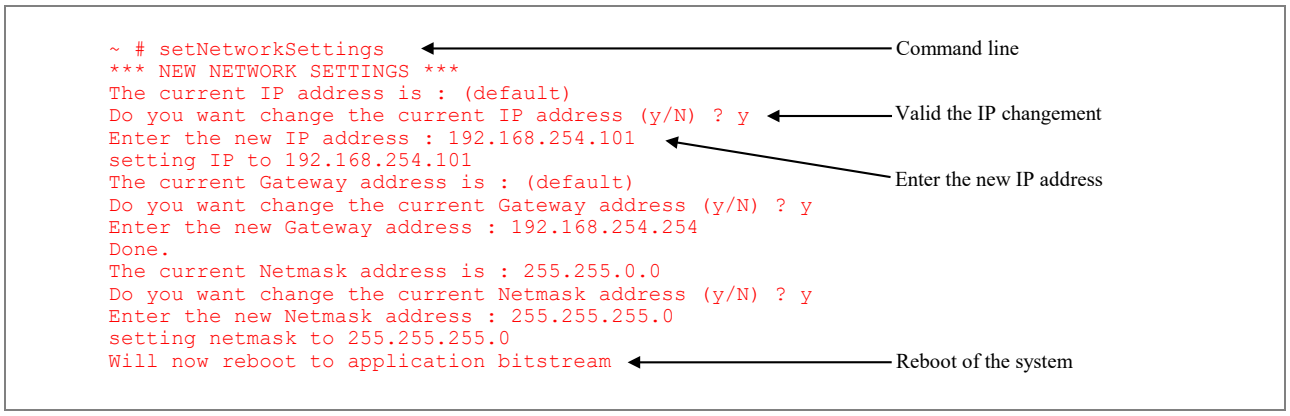
Assigning the IP address and Subnet mask is the responsibility of the Network Manager.



Caution:
A unique IP address should be applied.

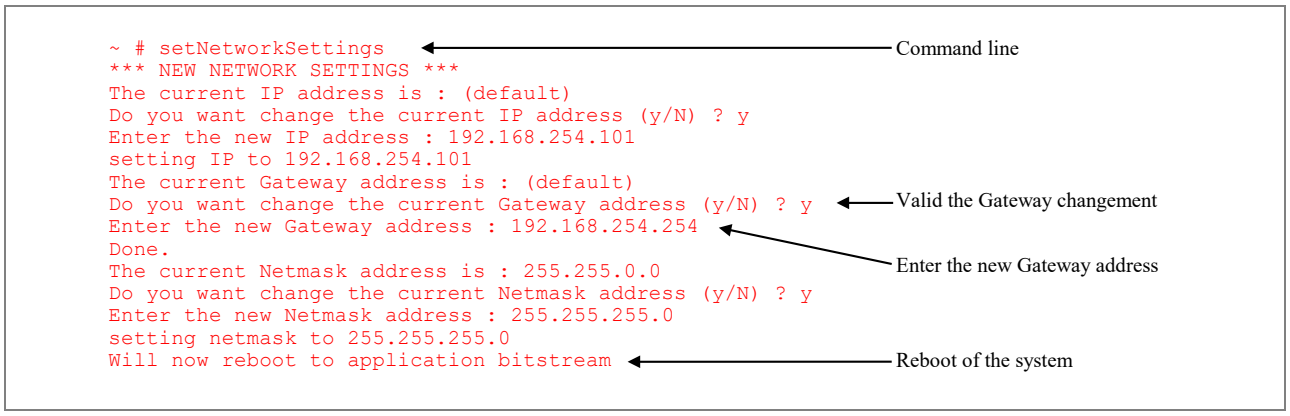
IP Address

The default IP address is 192.168.254.100. Use the “setNetworkSettings” command as shown in the figure below to change it.



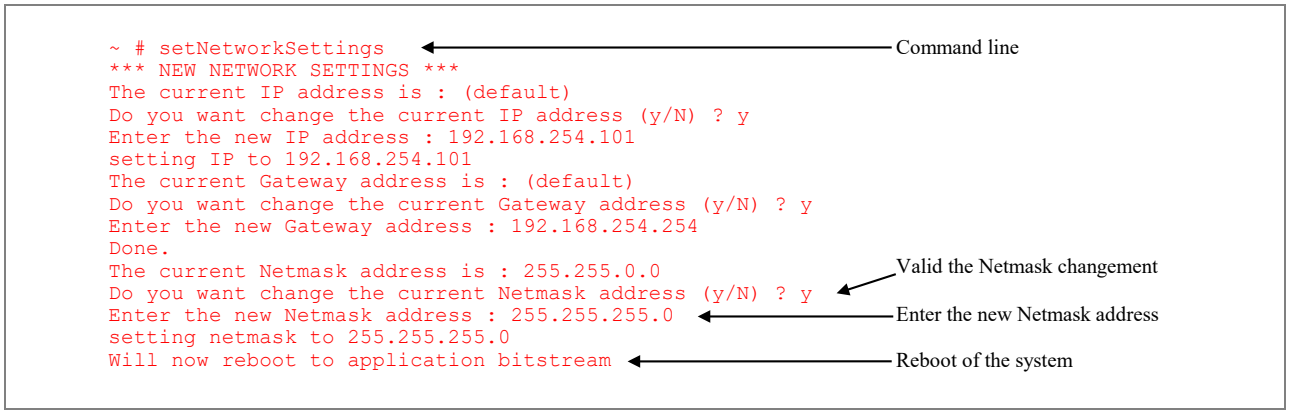
Subnet mask

Set the subnet mask numbers using the “setNetworkSettings” command. Typically subnetwork mask number fields are either 0 or 255 as in the figure below (255.255.255.0).



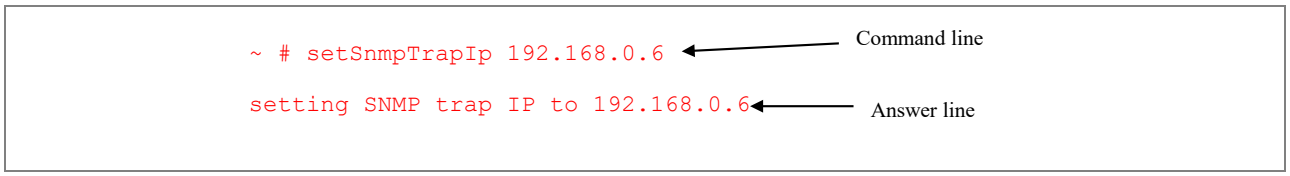
Gateway

The “setNetworkSettings” command defines the gateway IP address. The gateway address must be on the same IP subnet as the hosting device. An example is given below:



SNMP trap

The “setSnmpTrapIp” command sets the IP address for the SNMP trap. An example is given below:



6.3.1.6 MANAGEMENT COMMANDS

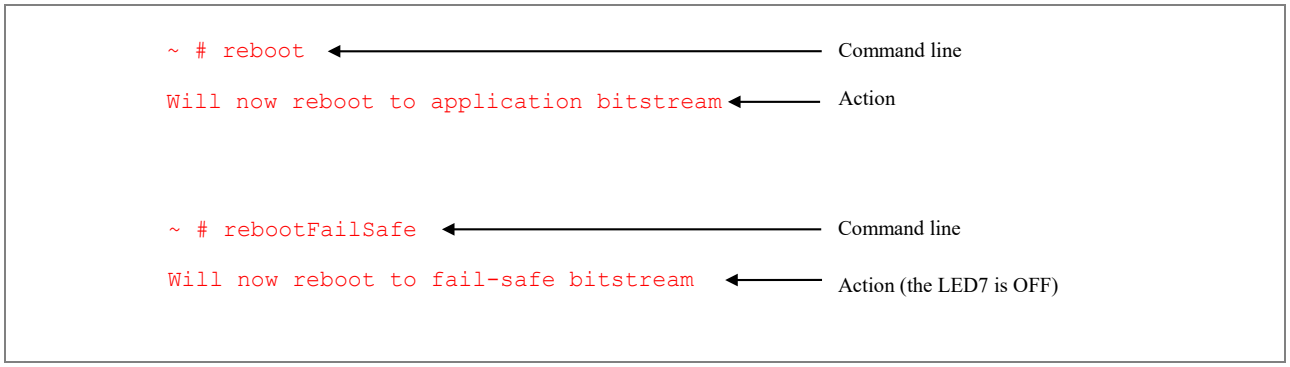
Management command	Syntax	Example
Management of user accounts Options: -c = Create new user, -d = Delete user -u = Unlock account -n = Change login name -r = Change role	`AccountManagement <options>`	`AccountManagement -c` then follow onscreen prompts
Force a value (0 or 1) on the relay1	`forceRelay1 <0/1>`	`forceRelay1 0`
Force a value (0 or 1) on the relay2	`forceRelay2 <0/1>`	`forceRelay2 0`
Turn a PRP core port On or Off	`prpPortOnOff <port> <ON/OFF>`	`prpPortOnOff A OFF`
Enable/Disable Optical Transceiver A 0 = Enable 1 = Disable	`prpTransceiverADisable <0/1>`	prpTransceiverADisable 0
Enable/Disable Optical Transceiver B 0 = Enable 1 = Disable	`prpTransceiverBDisable <0/1>`	prpTransceiverBDisable 0
Hard Reboot	`reboot`	`reboot`
Reboot in factory mode	`rebootFailSafe`	`rebootFailSafe`
Remote shell access Options: 0 = Disable 1 = Telnet 2 = SSH (default value) 3 = Telnet and SSH	`remoteShell <0/1/2/3>`	`remoteShell 0`
Enable/disable remote Syslog server	`remoteSyslog 4 <1/0>`	`remoteSyslog 4 1`
Configure remote Syslog server 0 = UDP (Port 514) 1 = TCP (Port 601)	`remoteSyslog <ip_addr> <1/0>`	`remoteSyslog 192.168.254.12 0`
Turn a switch port On or Off	`switchPortOnOff <port> <ON/OFF>`	`switchPortOnOff 2 OFF`
Reset all statistics of the switch	`switchResetStats`	`switchResetStats`
Remove forced value for the relay1	`unforceRelay1`	`unforceRelay1`
Remove forced value for the relay2	`unforceRelay2`	`unforceRelay2`
Update the firmware, available only in factory mode	`update <FTP server ip_addr.>`	`update 192.168.254.12`
Update the disclaimer banner text	`updateBannerText <FTP server ip_addr> <your_text_file>`	`updateBannerText 192.168.254.12 disclaimer.txt`

Note.

The SRP board is not reachable when Remote Shell Access is disabled (option 0). We recommend not to disable the Remote Shell Access.

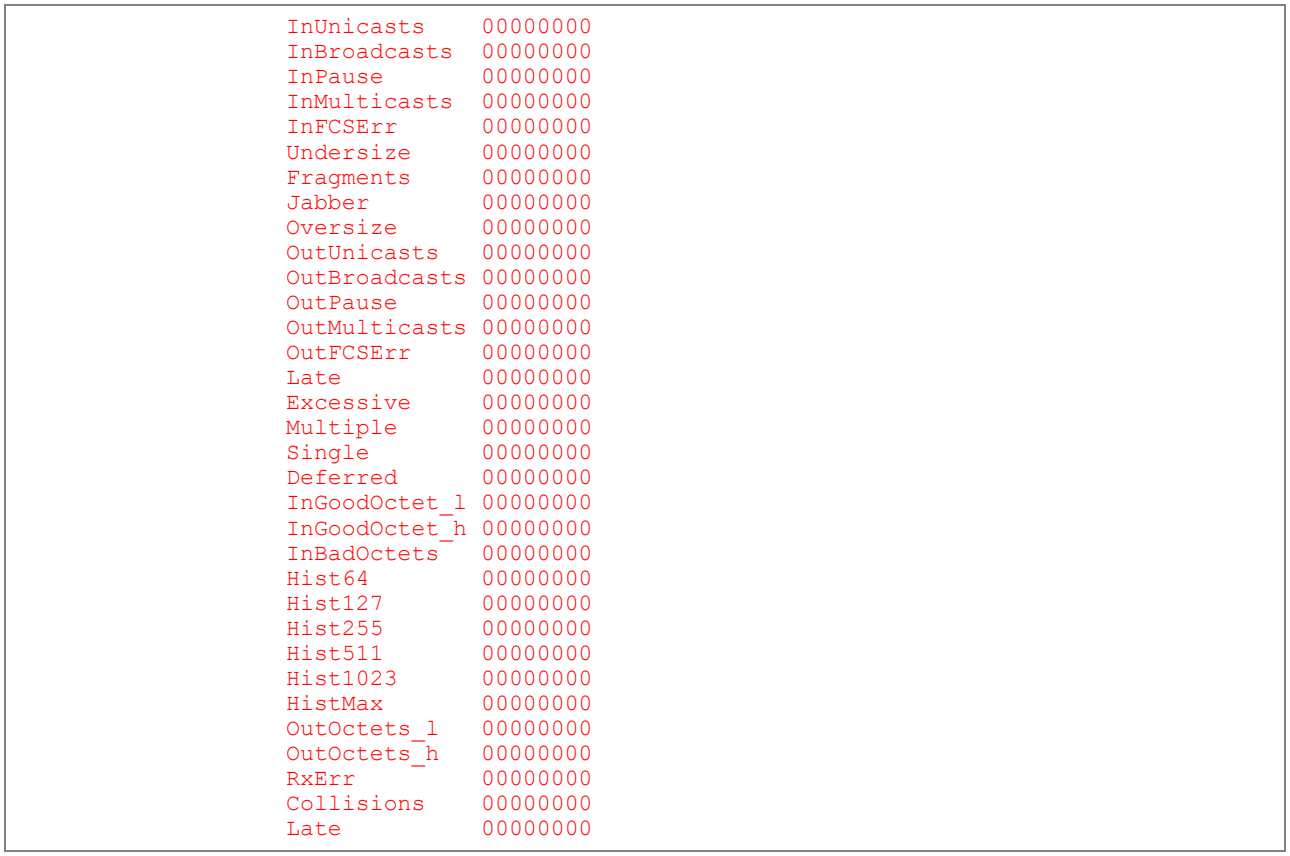
Reboot commands

Two reboot commands are available. The command “reboot” forces a hard reboot equivalent to a power-up. The command “rebootFailSafe” forces a reboot to the factory mode and extinguishes LED7 as shown in the figures below:



Switch statistics

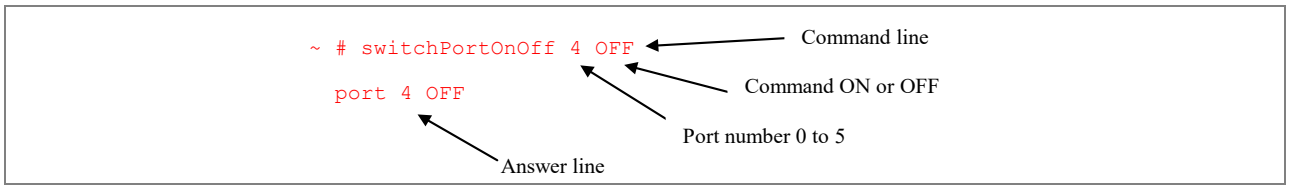
You can view switch statistics using the “getSwitchStats” command. The figure below shows the statistics available for each port.



You can reset the switch statistics using the “switchResetStats” command.

Ethernet ports

You turn Ethernet switch ports on or off using the “switchPortOnOff” command. An example of turning port 4 off is given in the figure below.



There are three commands associated with controlling the PRP ports. They are outlined in the diagram below:

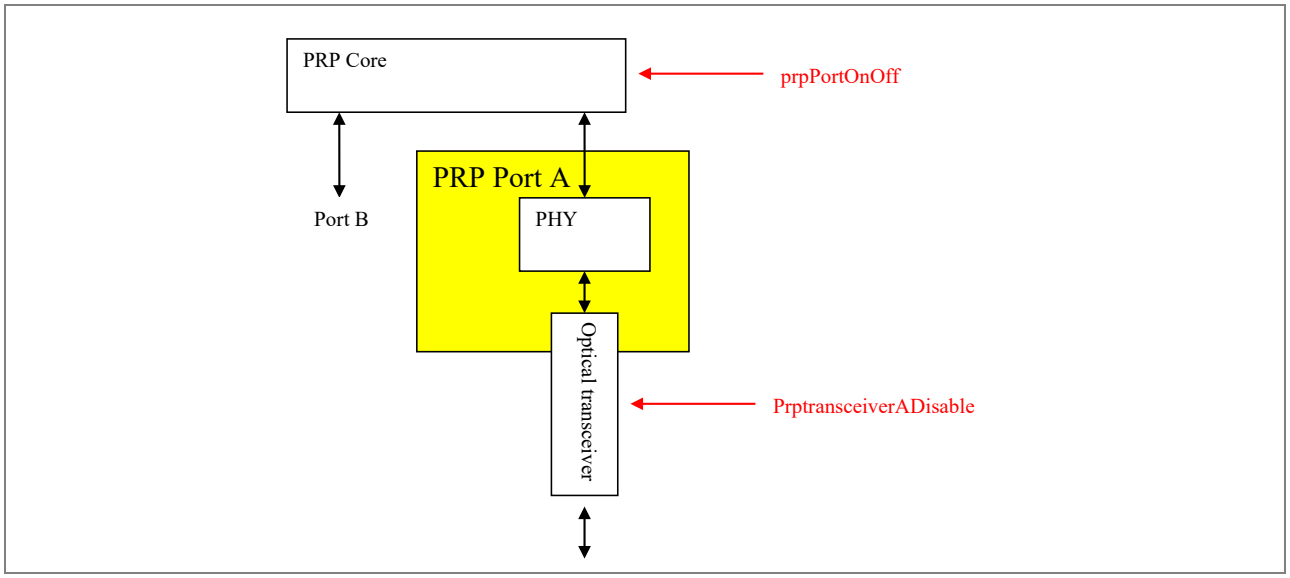
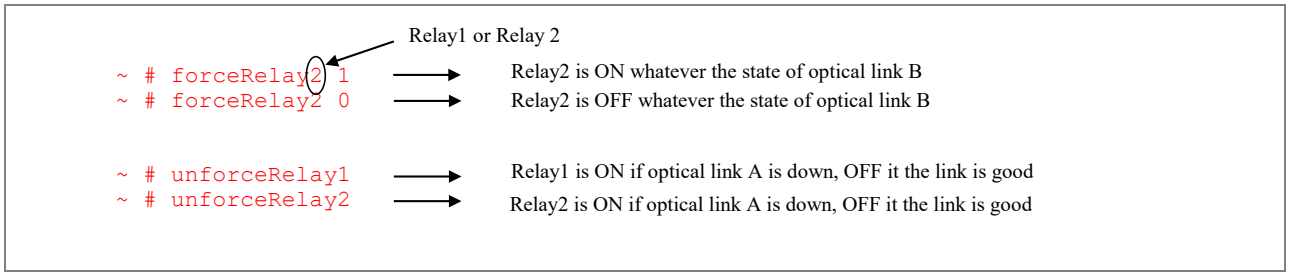


Figure 29: PRP Control

The command “prpPortOnOff” turns the core port on or off. The command “prpTransceiverADisable <0/1>” enables or disables optical transceiver A. The command “prpTransceiverBDisable <0/1>” enables or disables optical transceiver B. If set to ‘1’the port continues to receive data but does not transmit data. If set to ‘0’, the port is enable to transmit as well as receive.

Alarm contacts

Typing in the “forceRelay” and “unforceRelay” commands will drive the alarm contacts associated with the status of the PRP network optical links according to the figure below:



6.3.1.7 INFORMATION RETRIEVAL COMMANDS

The informative commands are given in the table below.

Informative command	Syntax	Example
Configuration summary	`getConfig`	`getConfig`
Status indication of various elements of the board	`getStatus`	`getStatus`
Print the proxy node table	`pn`	`pn`
Dumps the switch ATU table	`getSwitchATU`	`getSwitchATU`
Get all statistics of the switch	`getSwitchStats`	`getSwitchStats`

Configuration

Typing in the “getConfig” command will return the switch configuration, an example of which is shown in the figure below:

```
/ # getConfig          <-- Command line
SRP version :
--------------------
 - Board type          : SRP
 - Board version       : srp282-2.1.1.0-build03
- PRP core version    : 4.4
 - HDL version         : 1.9
 - Linux version       : 2 PREEMPT Wed Oct 14 10:17:18 CEST 2015 nios2 GNU/Linux

Current configuration
---------------------
  - IP Add               : 192.168.254.113
  - Gateway IP Add       : No Gateway defined (default)
  - Netmask              : 255.255.0.0 (default)
  - MAC Add              : 80:B3:2A:FF:01:50
  - MAC function Add     : 80:B3:2A:FF:00:01
  - PTPPriority1         : 128 (default)
  - PTPPriority2         : 128 (default)
  - Synchronization mode : 0 (default)
  - PTP steps            : 2 (default)

Available users
---------------
root
user

Duplicate Detection
-------------------
memory for 1024 frames, 400 ms aging time          Answer lines
```

Status

Typing in the “getStatus” command will return the switch status, an example of which is shown in the figure below:

```
~ # getStatus

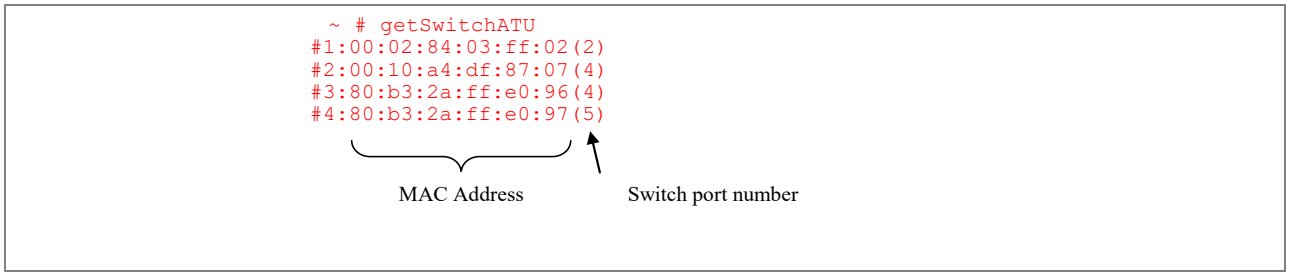
FPGA configuration used (Factory or Application mode) :
------------------------------------------------------ :
Mode: application with watchdog (or Fail-Safe (Factory))

Port status
-----------
sw0: down
sw1: down
sw2: up
sw3: down
sw4: up
lreA: up
lreB: up
lreI: always connected
sw5: always connected
```

Mac Address

Typing in the “getSwitchATU” command will return the switch Address Translation (ATU) table:

The Address Translation Unit (ATU) performs MAC address searching, learning, and ageing functions for all ports of the switch. By default, the ATU table allows a total of 1024 entries and an ageing time is 300 seconds for each entry. An example of using the “getSwitchATU” command is given in the figure below.



Current user

Typing the “whoami” command will return the login name of the current user, an example of which is shown in the figure below, for the user “root”:

```
# whoami
root
```

Proxy Node table

Typing “pn” returns the proxy node table. The proxy node table keeps track of peer PRP nodes. The key attribute of the node table is the MAC address of the source node as received in the PRP supervision frame sent by a PRP node. By default the proxy node entry is cleared after 60s although this time can be changed by changing the value in the PNT_AGT register.

An example of extracting a proxy node table is given in the figure below:

```
~ # pn
00:16:d3:b7:51:46
00:50:da:e4:e6:e0
2 entries in proxy node table
```

6.4 OPERATING MODES

The board has two operating modes: Failsafe mode and User mode.

The normal operating mode is User. The board switches to Failsafe mode:

- if the software watchdog is OFF (if there is a problem with the user mode),
- after a rebootFailSafe command,
- during a firmware upgrade operation.

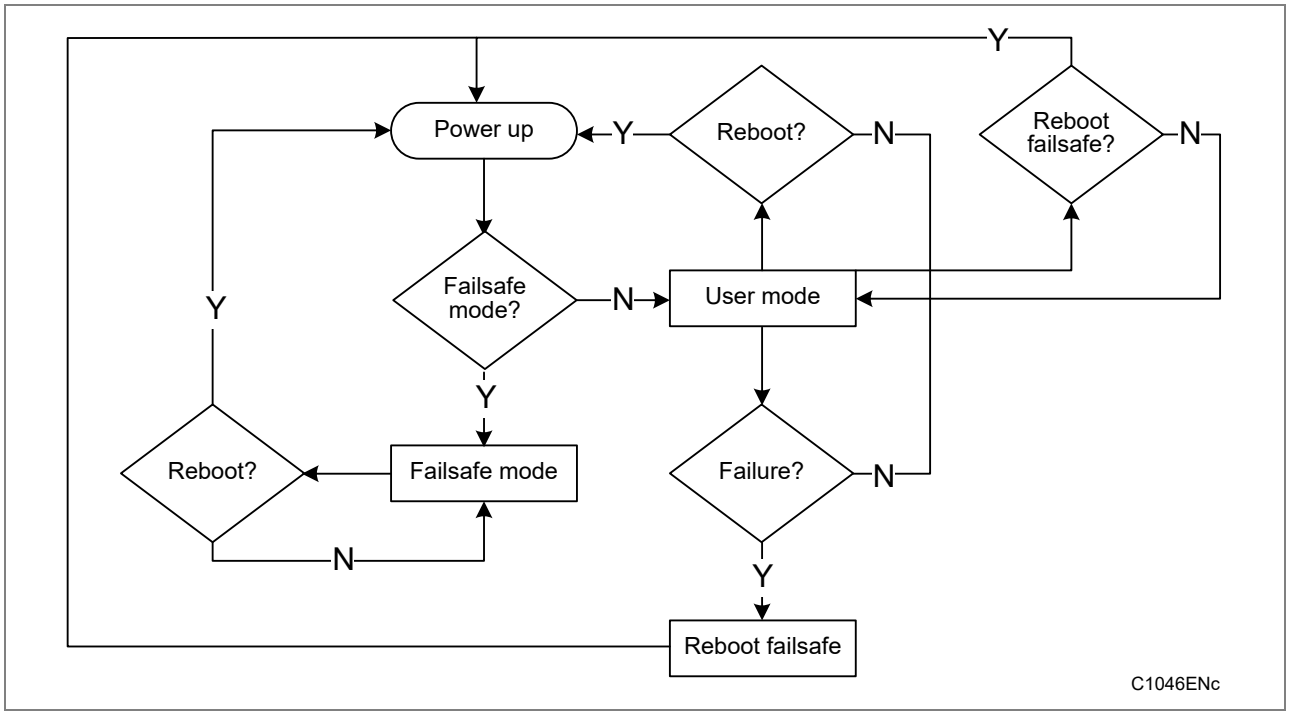


Figure 30: Power up and reboot functions of the SRP28x board

6.5 FIRMWARE UPGRADE

Upgrading the SRP28x to the latest firmware version may sometimes be necessary in order to take advantage of new features or bug fixes.

The link to be used to upgrade the SRP28x firmware differs depending on which version you are using and wish to migrate:

- From **srp_v2.0.0.0** (unsecured protocols), a telnet link is required
- From **srp_2.1.x** (secured protocols), an SSH link is required

Caution:
The failsafe firmware cannot be upgraded (only the application part).
Upgrading an SRPv2 firmware to a former version is not recommended.

The upgrade operation requires that the files of the application firmware, along with a correctly configured FTP server, be available on a computer with a network connection to the device to be upgraded.

Note:
To upgrade the firmware, the SRP28x board has to be in Failsafe mode (`rebootFailsafe` command)

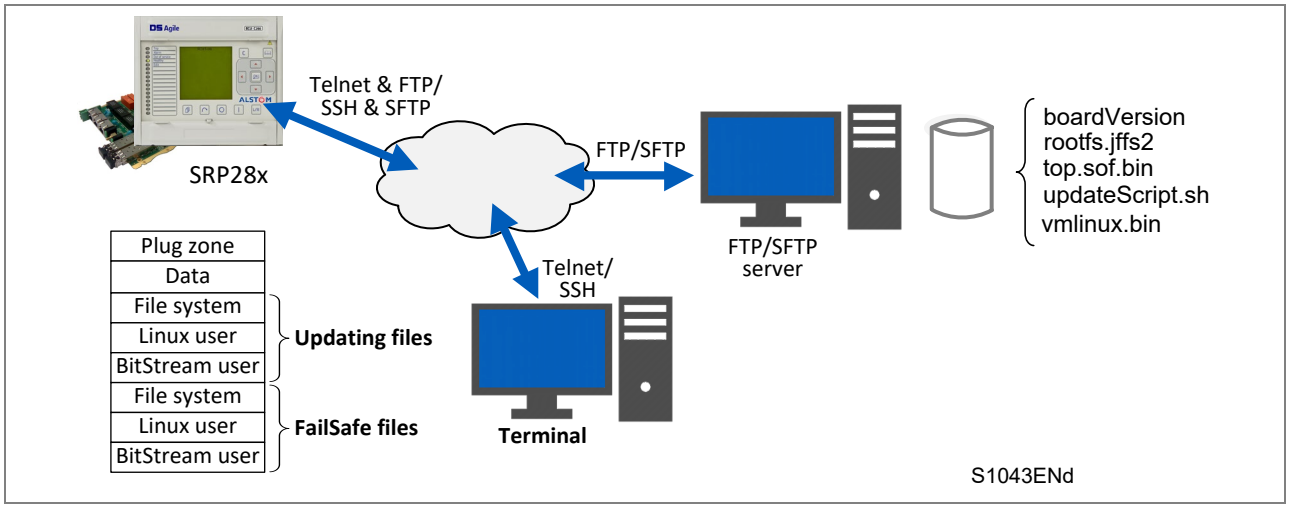


Figure 31: Standard SRP28x upgrade process

1 On the FTP server, copy the firmware files in the `<FTP Parent_Folder>` directory.

2 Use an FTP solution (FileZilla for instance) to select the root path of the folder `<FTP Parent_Folder>/` containing the firmware files:

- **rootfs.jffs2** (file system)
- **vmlinux.bin** (Linux kernel)
- **top.sof.bin** (VHDL bitstream)
- **updatescript.sh** (script to update the switch)
- **boardVersion** (firmware version)

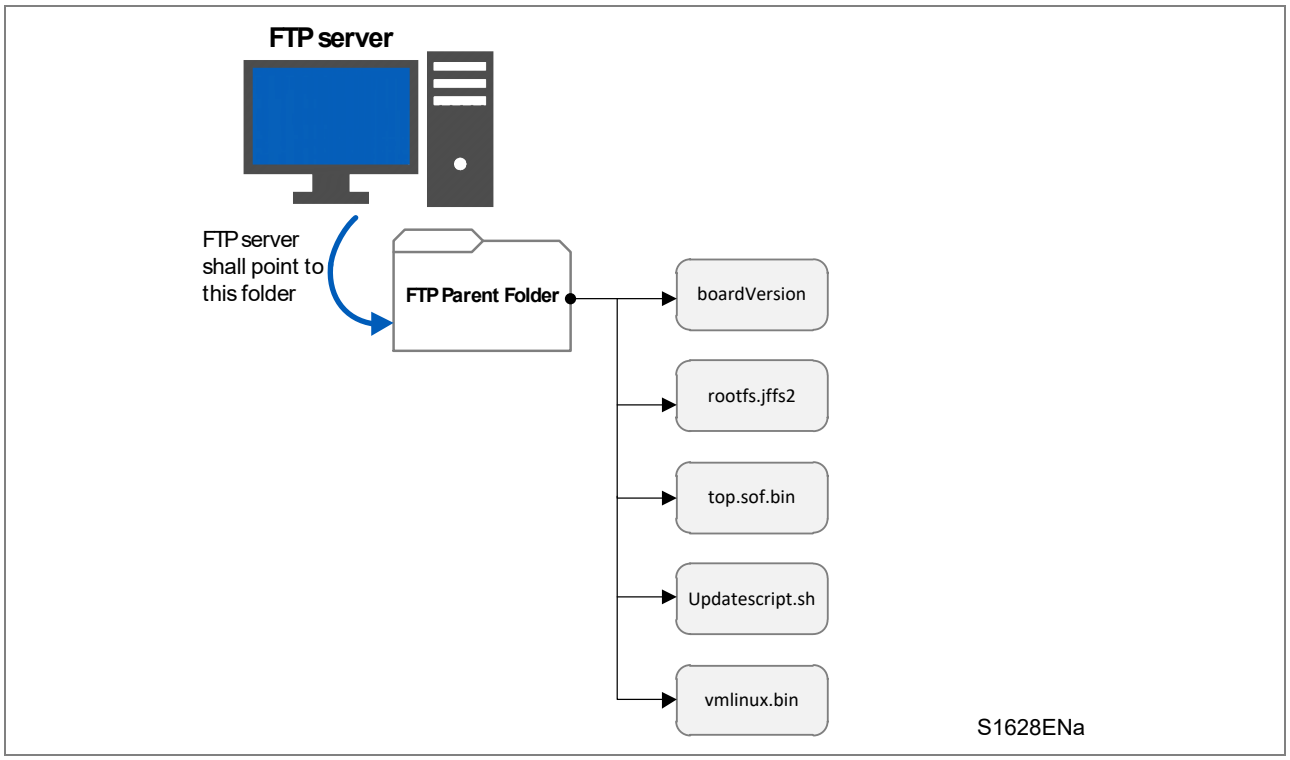


Figure 32: FTP parent folder containing the firmware files

3 Write down the IP address of the FTP server containing the new firmware.

4 Establish a console connection to the SRP28x board to be upgraded, using the Telnet or SSH protocol with a terminal emulator. The terminal and the FTP server can be installed on the same PC.

- The factory-set IP address is 192.168.254.100
- If you use an unsecured FTP server, it must be configured to be accessed without password ("anonymous" logon).

5 Run the **`rebootFailsafe`** command via the command-line console. This command causes the SRP28x board to reboot. Your Telnet/SSH connection might be lost.

6 Wait one minute before making the Telnet/SSH connection to the SRP28x board.

7 Then, run the command line

- `update <FTP server IP address>`

This will download the files to the SRP28x board. The board automatically reboots to normal user mode after the files have been successfully downloaded. In case of a download failure, it reboots to failsafe mode. The firmware files transferred to the server are stored in non-volatile memory.

8 Reboot the DS Agile C26x once the upgrade process is complete.

6.6 CYBER-SECURITY

Note:
In remote authentication all parameters, user profiles and roles are same as local authentication. See C264/EN FT for remote authentication parameters or configuration.

In addition to supporting secure communications for settings and commands, the SRP board meets modern cyber-security requirements:

- User accounts can have differentiated roles depending on their functions.
- Password complexity can be enforced to prevent users to define easily “crackable” passwords.
- A timeout can be set so that sessions are automatically terminated after an inactivity period.
- A security data log keeps track of all security-related operations.
- The security log can be automatically sent to a remote log repository (“syslog” server).

6.6.1 ACCOUNT AND PROFILE MANAGEMENT

Each account is composed of a login name and a password. The login name is unique.

If an attempt is made to create a user account with an already existing login name, the creation is denied and the message “Login name already exists” is displayed.

Each user can change his/her own login name and password. The login name and password of all the accounts, including the predefined accounts, can be changed.

One of three roles, i.e. predefined sets of privileges can be assigned to new user accounts:

Roles	Privileges
Observer	This role only allows reading information. It does not allow changing any password except the user's own password. It does not give access to any security log.
System engineer	This role only gives access to data useful to run the system. In addition to Observer privileges, it also allows setting parameters on the SRP board. It does not allow changing any password except the user's own password. It does not give access to any security log.
Security administrator	This role gives the user complete control over the board: In addition to System engineer privileges, it allows the user to upgrade the SRP software version, display data and change the board's operating mode. It is the only role that allows the user to create user accounts, configure its own role as well as the System engineer and Observer roles, change other users' passwords and display security logs.

Only users with the *Root* or *Security administrator* role can create new accounts on the SRP board and define their role. The same applies to user account deletion. It is not possible to assign the *Root* role to a new account.

The maximum number of user accounts is **10**.

Default commands per authentication level

Commands	Root	Security Administrator	System Engineer	Observer
Configuration commands				
passwdPolicy <options>	X	X		
setAuthenticationTimeout <time>	X	X		
setSessionTimeout <time>	X	X		
setLockAccount <login retries> <lock_time>	X	X		
setMac <mac_addr>	X		X	
setMacFunction <mac_addr>	X		X	
setNetworkSettings	X		X	
setNtpSettings	X		X	
setPassword (*)	X	X	X	X
setPassword <user>	X	X		
setSnmpPassword (**)	X	X		
setSnmpTrapIp <ip_addr>	X		X	
setSynchroMode <mode>	X		X	
setPTPPriority1 <priority>	X		X	
setPTPPriority2 <priority>	X		X	
setPTPSteps <steps number>	X		X	
Management commands				
AccountManagement <options>	X	X		
remoteShell <0/1/2/3>	X	X		
remoteSyslog	X	X		
reboot	X	X	X	
rebootFailSafe	X	X		
update <FTP server IP Addr>	X	X		
updateBannerText <FTP server IP Addr> <your_text_file>	X	X		
switchResetStats	X		X	
switchPortOnOff	X		X	
prpPortOnOff	X		X	
prpTransceiverADisable	X		X	
prpTransceiverBDisable	X		X	
forceRelay1	X		X	
forceRelay2	X		X	
unforceRelay1	X		X	
unforceRelay2	X		X	
Informative commands				
getConfig	X	X	X	X
getStatus	X	X	X	X
getSwitchATU	X		X	X
getSwitchStats	X		X	X
whoami	X	X	X	X
pn	X	X	X	X

(*) Set own password only. (**) Unique password to access the MIB data.

Default accounts

The board is delivered with two pre-defined accounts:

- **root**
- **user**

Both accounts are assigned the *Root* role, i.e. all access rights, by default.

The default password for both accounts is *changeit*. It is recommended to change both passwords immediately.

Note:
*The **root** account cannot be deleted nor have its role changed.*

6.6.2 PASSWORD POLICY

The Security administrator can force users to select passwords that comply with a minimum complexity using the setting **passwdPolicy**. If password policy is enabled, the passwords must comply with the following rules:

1 Contain at least 9 characters

2 All of these 4 types of characters must be used in the password:

  a Uppercase letter

  b Lowercase letter

  c Digit

  d ASCII non-alphanumeric character (such as @,!,#,{, etc.)

Passwords that do not comply with this rule are refused, an error message is displayed.

Note:
Password policy is enabled by default.

A forgotten or lost password cannot be recovered. A new password must be defined by a user with Security administrator privileges.

6.6.3 AUTHENTICATION

Concurrent logins

Concurrent logins are not allowed. Only one user can be logged in at any time. A current session cannot be overridden by another user, even one with administrator privileges.

Failed login

When authentication fails, the message "Login failed" is displayed.

Account lockout further to failed login attempts

A password locking policy is implemented:

1 After a settable number of consecutive failed login attempts (incorrect password), the account is locked for a settable period of time. The number of failed login attempts triggering a lockout is settable from 3 (default) to 10. The lockout period is settable from 1 hour to 24 hours (default setting: 1 hour) for accounts with the Observer and System engineer roles. For the accounts with the Security administrator role, the lockout duration is fixed to 5 minutes.

2 The account is unlocked when the first connection is successful after the lockout period has expired.

3 Only a user with the **Security administrator** privilege can unlock a locked user account before the end of the lockout period.

Authentication timeout

Open sessions are automatically terminated after a settable inactivity (no command sent) timeout. Default setting: 600 seconds (10 minutes) for all user accounts. Settable in steps of 60 seconds.

Only a user with the Security administrator privilege can change the setting for the authentication timeout.

This settable inactivity timeout is the same for all accounts.

Disclaimer banner text

Using the command **updateBannerText** a Security administrator can define a text that will be displayed when any user logs in. Due to storage capacity limits, we recommend using a text that does not exceed 1000 characters, including blank spaces.

Default banner text:
"`Access to this system is limited to specifically users having received all training required by applicables laws, regulations, and by policies and procedures implemented by the legal hosting this system.`
`Unauthorized users may face criminal or civil liabilities and/or penalties. The use of this system may be recorded and monitored for system operations, security policy and intellectual property compliance related purposes and any information related to the use of this system may further be disclosed to third parties or law enforcement officials as necessary.`
`Disconnect now if you are not an authorized user or do not agree with the above terms.`"

Prompt: `Do you agree with these terms? [Y/n].`

To access the board's commands, the user only needs to press the **Enter** key. If the user does not wish to accept the terms, he must type N and enter. Not typing anything is equivalent to typing *Y* (yes).

6.6.4 SECURITY DATA LOG

All-important activity and system operations are logged in the `/mnt/config/log/SRPV2.log` file that only users with the role **Security administrator** can read. That file is not encrypted. It contains:

- Startup log (start, stop and reboot)
- Successful and failed login attempts with cause of failure
- Logouts
- User account (local) changes (creation, deletion, password reset, lockout/unlock, change of role)
- Firmware updates
- Setting changes
- Syslog server unavailability

The `/mnt/config/log` folder and its contents are not affected by software updates and will not be deleted when they occur.

The maximum size of the log files is 512 kB. When that size is reached, the oldest entries are deleted.

Note:
Passwords are not logged.

The security logs can be automatically forwarded to a central repository (“Syslog” server) if one is available and configured on the SRP28x board (`remoteSyslog` management command). Whether logs occurring during a communications loss are received depends on the communications protocol:

- UDP: The SRP28x is not informed of the communications loss, therefore it continues to send the logs during the downtime. These logs are stored locally but are not received by the Syslog server.
- TCP: The SRP28x is informed of the communications loss. It stores its date and time and sends the intervening logs when the communications are restored.

6.7 LEDS AND CONNECTIONS

- LEDs: refer to the **Hardware** chapter of the C264 user manual;
- Connections: refer to the **Connections** chapter of the C264 user manual.

7 SRP29X RANGE – SEAMLESS REDUNDANCY (PRP)

The DS Agile C26x is an Ethernet communications board that is installed in DS Agile C26x BCU in order to add HSR capability.

The DS Agile C26x board is connected to the HSR ring using fibre optic communications. A multi-mode fibre-optic version is available for short distance connections (typically up to around 2 km), and a single-mode version is available for longer distances (potentially in excess of 15 km).

The HSR fibre-optic Ethernet ports have LC connectors.

The board is also fitted with three 100Base-TX RJ45 connector that can be used to attach up to 2 non-HSR-compliant devices, effectively making the DS Agile C26x a RedBox.

7.1 FUNCTIONAL DESCRIPTION

7.1.1 HIGH-AVAILABILITY SEAMLESS REDUNDANCY (HSR) PROTOCOL

The HSR protocol is implemented according to the definition in the standard IEC 62439-3-5.

HSR allows seamless communication in the face of a single network disruption (for instance cable, driver, switch or controller failure).

An HSR-compatible device has two ports operating simultaneously, both ports being connected to the same local area network (LAN) segment (usually a ring). Such devices are called DANH (Doubly Attached Node running HSR).

The figure below shows an example of an HSR network. The doubly attached nodes SRP29x, DANH 1 and DANH 2 send and receive HSR frames in both directions, while the singly attached nodes SAN 1 and SAN 2 can only send and receive frames without HSR header. Singly attached nodes can, however, be connected to HSR network, via a device that converts a singly attached node into a doubly attached node. Devices performing this function are often referred to as redundancy boxes or RedBoxes. Devices with single network cards such as personal computers, printers, etc., are singly attached nodes that may be connected to the HSR network via a RedBox as shown in the figure. This is the case for SAN 1 and SAN 2. Because these SANs connect to the HSR network, they can be considered as Virtual Doubly Attached Nodes and described as VDANs.

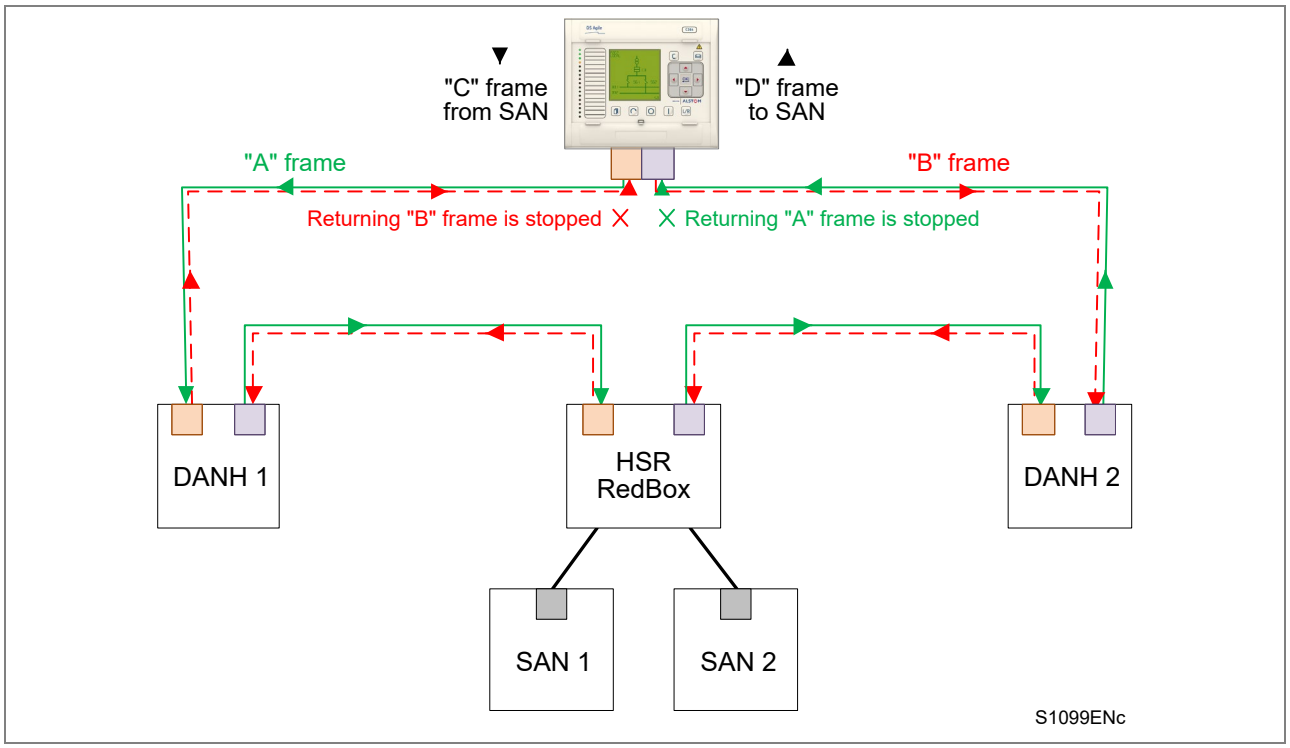


Figure 33: Example HSR Redundant Network

The SRP29x communications board is a DANH with optical connections to the network. The DANH can be connected to the C26x unit housing it and/or to any other compatible SANs.

To achieve high-availability configuration the first optical interface sends the frames in the “A” direction and the second sends the same frames in the “B” direction. Frames are forwarded in both directions by the connected DANH devices.

The frames are identified as “A” and “B” and also by their sender: When the SRP29x or any other DANH receives a frame that it originally sent or that is specifically destined to it, it does not forward it.

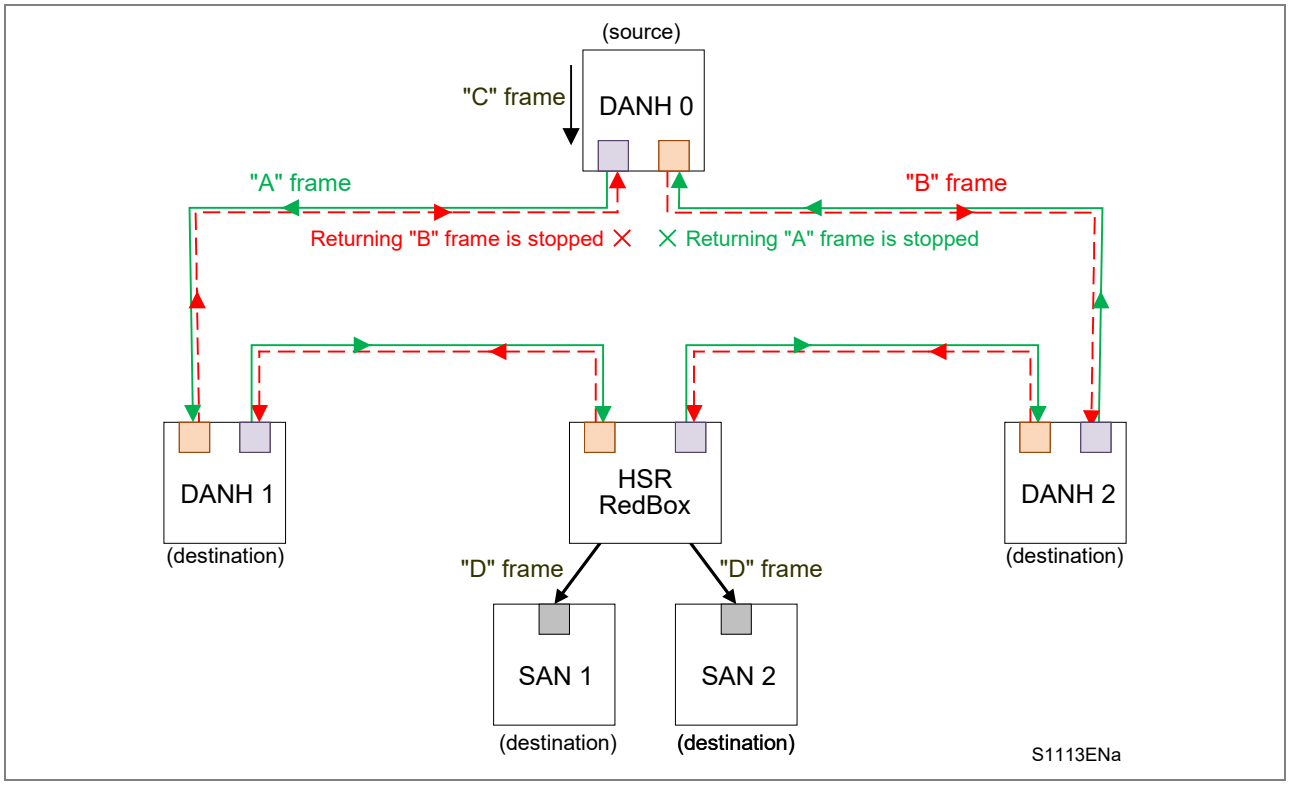
When an already received frame is received again from the other direction the DANH or RedBox does not process it. It only moves the frame forward in the ring, unless it is itself the frame’s unicast recipient.

Frames sent by the PC (“C” frames) are converted into 2 “A” and “B” frames and sent over the HSR network.

Received frames that are addressed to a SAN managed by the board (such as MMS messages) are not forwarded on to the HSR network.

There are two basic operation principles, depending on whether the broadcasted frames are multicast (e.g. GOOSE) or unicast (e.g. MMS reports).

Multicast frames (e.g. GOOSE)



Key:
dotted arrows: “A” frames
cross-hatched arrows: “B” frames
black arrows: non-HSR frames exchanged between ring and host
cross: frame is removed from the ring by the next node

Figure 34: HSR example of ring configuration for multicast traffic (e.g. GOOSE)

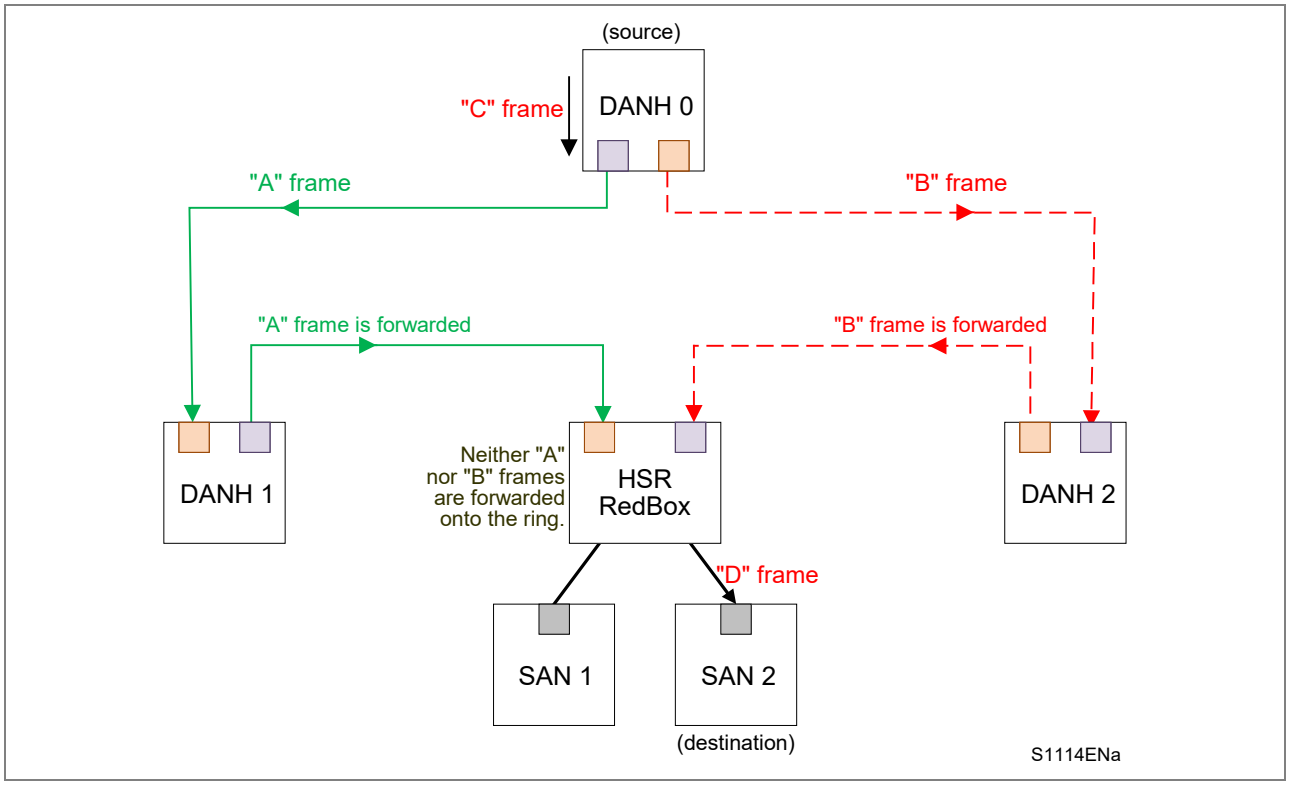
A source DANH, e.g. a DS Agile C26x, sends a frame passed from its upper layers (“C” frame), prefixes it by an HSR tag to identify frame duplicates and sends the frame over each port (“A”-frame and “B”-frame).

A destination DANH receives, in the fault-free state, two identical frames from each port within a certain interval, removes the HSR tag of the first frame before passing it on to its upper layers and, if it is a RedBox, to its SANs (“D”-frame). It discards any duplicate.

The nodes support the IEEE 802.1D bridge functionality and forward frames from one port to the other, except if they already sent the same frame in that same direction.

In particular, the node will not forward a frame that it injected into the ring.

Unicast (e.g. MMS reports)



Key:
dotted arrows: “A” frames
cross-hatched arrows: “B” frames
black arrows: non-HSR frames exchanged between ring and host
cross: frame is removed from the ring by the next node

Figure 35: HSR example of ring configuration for unicast traffic (e.g. MMS reports)

A destination node of a unicast frame does not forward a frame for which it is the only destination:
For example, if the SRP29x board (HSR RedBox) receives a report destined to the C264 or another of its VDANs (for instance SAN 2 in the above diagram), it will not forward it onto the HSR ring.

Frames circulating in the ring carry the HSR tag inserted by the source, which contains a sequence number. The doublet {source MAC address, sequence number} uniquely identifies copies of the same frame.

SRP29x RedBox principle

The SRP29x acts a RedBox with optical connections to the dual HSR network and electrical connexion to SAN devices that then become VDANs connecting a device to the HSR network, as illustrated below.

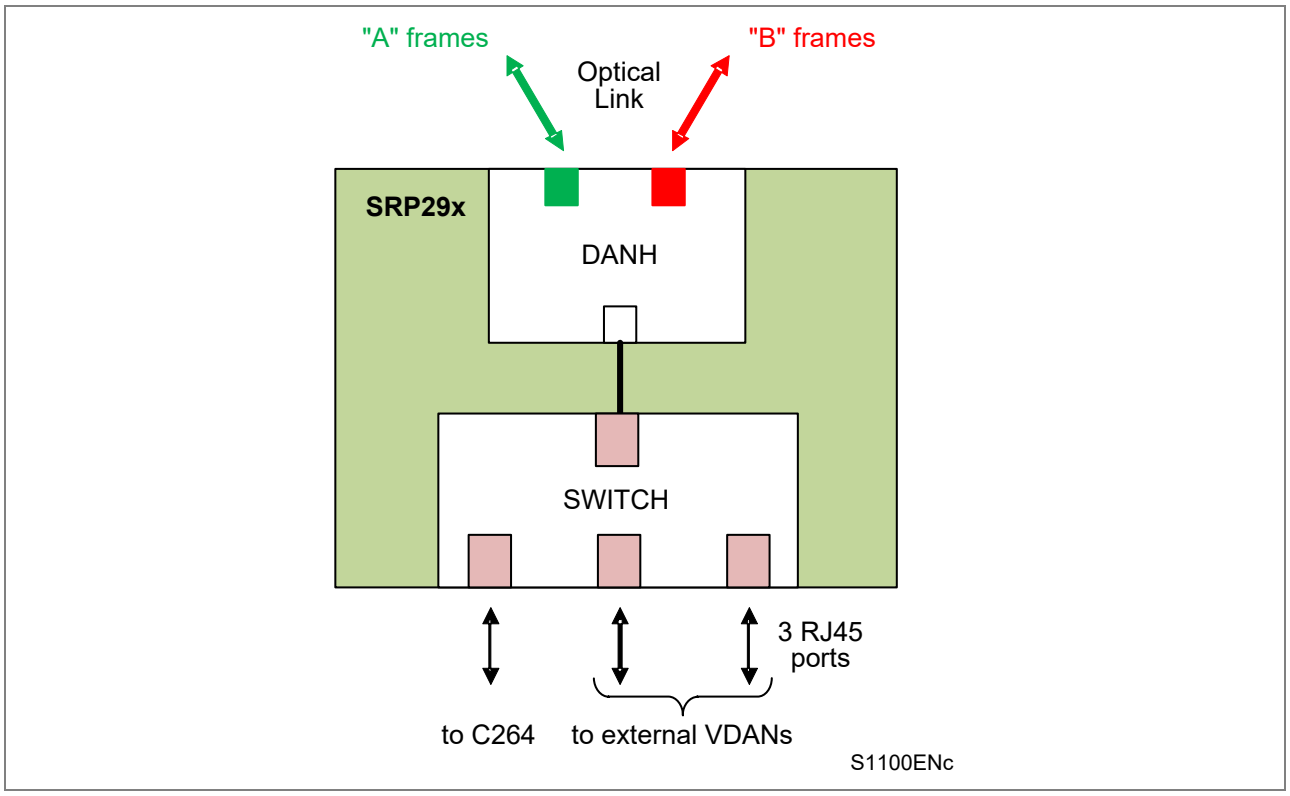


Figure 36: SRP29x connecting singly attached nodes to a dual HSR network

For products that connect directly to the HSR LAN, the two ports of the DANH operate simultaneously. They are attached to the same upper layers of the communication stack through a link redundancy entity (LRE) as shown in the figure below.

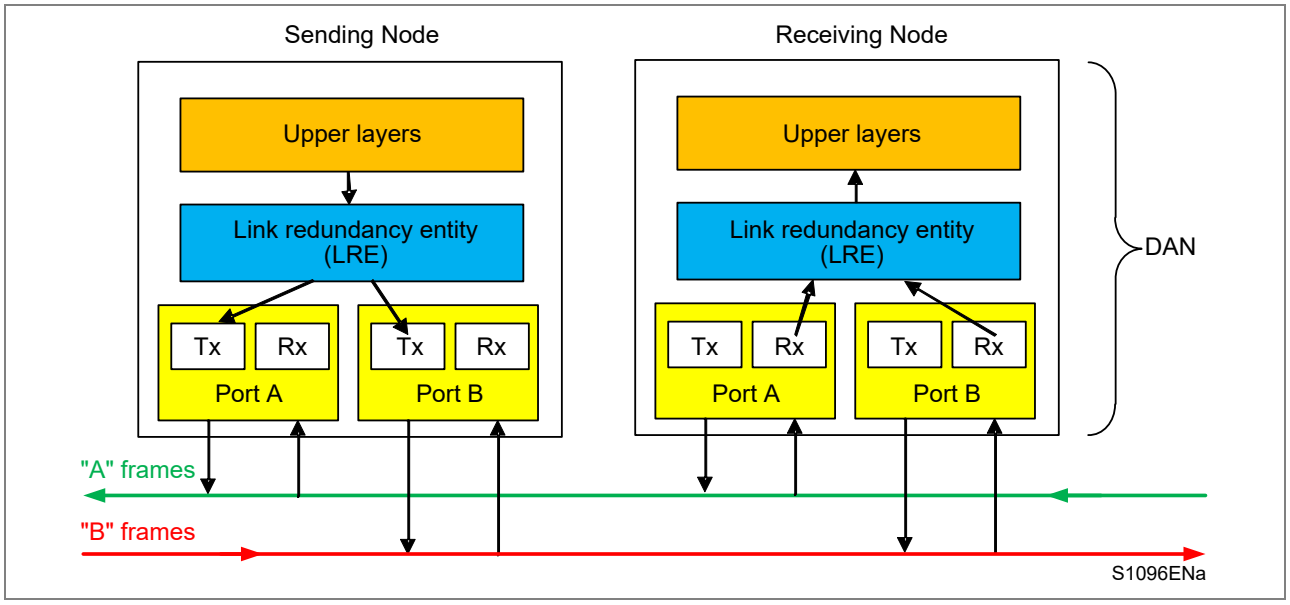


Figure 37: DANH structure

HSR ring characteristics

The transmission latency introduced to the HSR network depends on the transmitted frame size and on the number of “hops” (IEDs) the frames go through.

Note:
The board can support the same maximum number of IEDs as the DS Agile system: 250.

The latency can be calculated using these equations:

- 64-byte frame: f(x) = 11.11x + 12.0
- 128-byte frame: f(x) = 15.92x + 22.9
- 256-byte frame: f(x) = 25.96x + 44.2
- 512-byte frame: f(x) = 46.10x + 85.4
- 1024-byte frame: f(x) = 87.05x + 167.4

  where:

  - "f(x)" is the total latency in micro seconds
  - "x" the number of hops/number of IEDs.

For example, the latency results for 250 IEDs are:

- Latency = f(x) = 2790 µs for a 64-byte frame
- Latency = f(x) = 4003 µs for a 128-byte frame
- Latency = f(x) = 6534 µs for a 256-byte frame
- Latency = f(x) = 11610 µs for a 512-byte frame
- Latency = f(x) = 21930 µs for a 1024-byte frame

7.1.2 FUNCTIONAL DESIGN

The figure below shows the main functional blocks of the SRP29x:

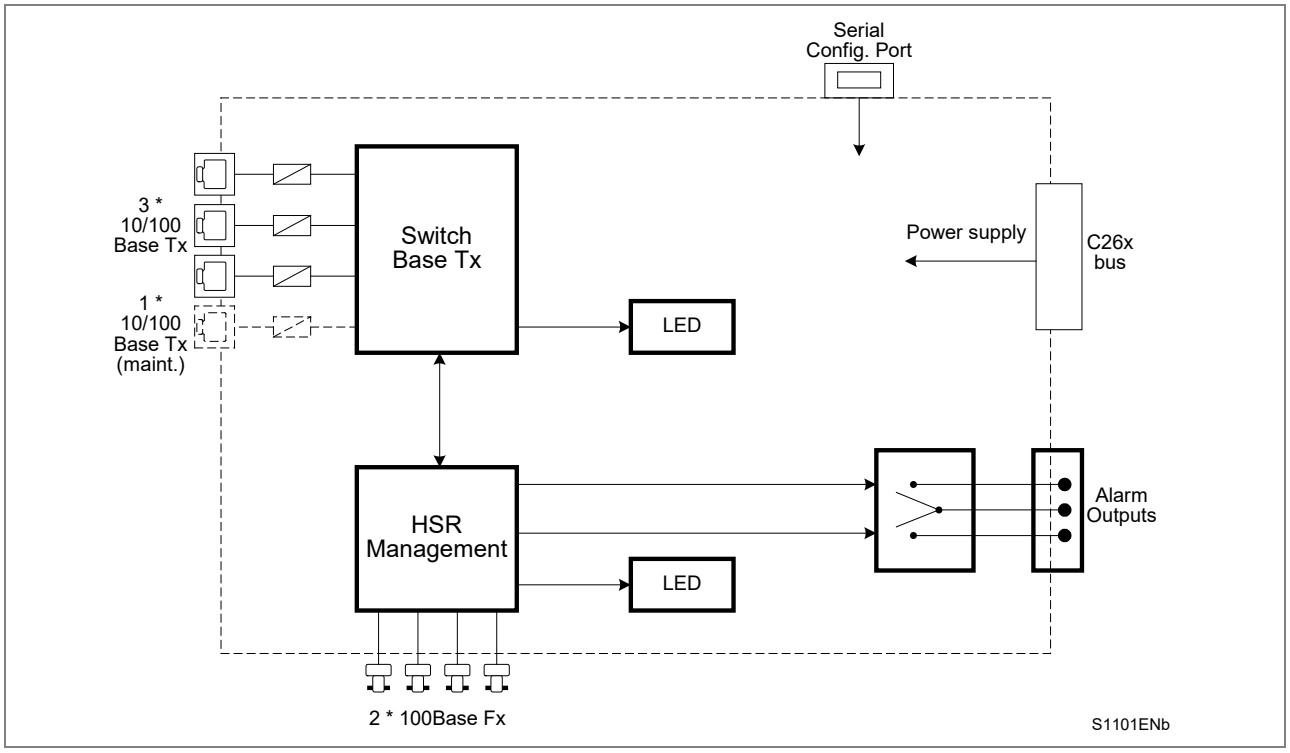


Figure 38: SRP29x functional diagram

The principal functional component parts are:

- The Base-Tx Ethernet Switch
- The High-availability Seamless Redundancy protocol (HSR) management
- SNMP (Simple Network Management Protocol) management
- Light Emitting Diodes (LED) and alarm outputs.
- SSH configuration port

7.1.3 BASE-TX ETHERNET SWITCH FUNCTION

The Base-Tx Ethernet Switch function manages three Ethernet ports presented for user connection (ports 2, 3, & 4), and two internal ports for service connection. The user ports are 10/100 Base-Tx using RJ45 connectors. Ports 2, 3, & 4 are located at the rear of the unit and are qualified by LED indications of link activity. Port 1 is a 10/100 Base-Tx internal service port using an RJ45 connector located at the front of the board. The other internal service connection port is Port 0, and is also located at the front of the board. It supports 10/100/1000 Base-Tx and uses a Samtec ERF8-RA connector.

If a cable is not connected to a port, most of the circuitry for that port is disabled to save power.

Using auto-negotiation, the SRP29x automatically determines the speed of transmission on the 10/100 Base-Tx ports according to the IEEE 802.3u standard. It also determines whether communication is half-duplex or full-duplex, and adapts accordingly.

Each Ethernet device inserts its unique “MAC address” into each message it sends. The receiving port on the SRP29x automatically recognises the MAC address in a received frame and stores it. Once an address is recognised and stored, the SRP29x will forward frames to the appropriate port. Up to 1024 MAC addresses can be stored and monitored at any time.

The SRP29x supports the store and forward mechanism of the IEEE 802.3 standard. It forwards messages with known addresses to the appropriate port. Messages with unknown addresses, broadcast messages, and multicast messages are forwarded out to all ports except the source port. It does not forward error packets or 802.3x pause frames.

Priority tagging according to IEEE 802.1p is enabled on all ports.

7.1.4 ETHERNET MANAGEMENT

Standards	IEEE802.3, 802.3u, 802.3x, 802.1p
Forwarding mode	Store and forward
Memory bandwidth	2 Gbps
MAC Address	1K
Address learning	Automatic
Broadcast storm protection	Limited to 5%
Illegal frame	Dropped per 802.3
Late collision	Dropped after 512 bit times

7.1.5 SNMP MANAGEMENT

Simple Network Management Protocol (SNMP) is the network protocol developed to manage devices on an IP network. SNMP is based on a model consisting of a manager, an agent, a database of management information, managed objects and the network protocol. The manager provides the interface between the human network manager and the management system. The agent provides the interface between the manager and the physical device(s) being managed according to the figure below.

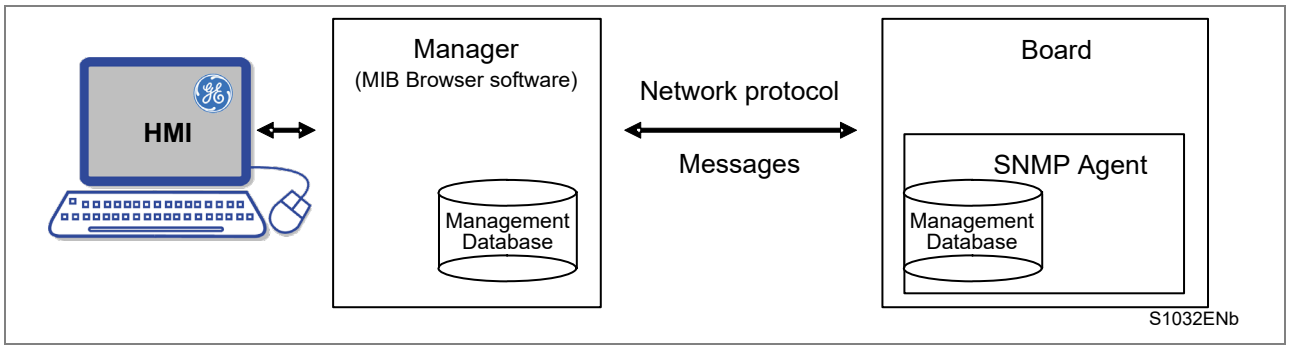


Figure 39: SNMP management

The manager and agent use a Management Information Base (MIB) and a relatively small set of commands to exchange information. The MIB is organised in a tree structure with individual variables, such as point status or description, being represented as leaves on the branches. A long numeric tag known as an Object IDentifier (OID) is used to distinguish each variable uniquely in the MIB and in the SNMP messages. The Manager is an MIB Browser Software. SNMP versions 1, 2, and 3 are supported.

Each SNMP element manages specific objects with each object having specific characteristics. Each object/characteristic has a unique object identifier (OID) consisting of numbers separated by decimal points (for example: 1.3.6.1.4.1.2682.1). The MIB associates each OID with a readable label (for example: dpsRTUAState) and various other parameters related to the object. The MIB then serves as a data dictionary or codebook that is used to assemble and interpret SNMP messages.

For this board, the GE Grid Solutions management information bases (MIB) use the following types of object identifiers (OID):

- System
- Interface
- Remote network monitoring (RMON)
- High-availability Seamless Redundancy protocol (HSR)

These are defined in the tables below.

7.1.5.1 SYSTEM MIB STRUCTURE

Address												Name	
0												Ccitt	
	1											ISO	
		3										Org	
			6									DOD	
				1								Internet	
					2							mgmt	
						1						Mib-2	
							1					sys	
								1				sysDescr	Redundant switch HSR
								2				sysObjectID	TBD
								3				sysUpTime	Time (in hundredths of a second) since the switch was last reinitialised
								4				sysContact	user-configurable
								5				sysName	SRP29x (user-configurable)
								6				sysLocation	user-configurable
								7				sysServices	2

7.1.5.2 INTERFACE MIB STRUCTURE

Address												Name	
0												Ccitt	
	1											ISO	
		3										Org	
			6									DOD	
				1								Internet	
					2							mgmt	
						1						Mib-2	
							2					interfaces	Interface number
								1				ifNumber	Redundant switch HSR
								2				ifTable	TBD
									1			ifEntry	Time (in hundredths of a second) since the switch was last reinitialised

Address												Name	
										7		ifAdminStatus	1: up, 2: down
										8		ifOperStatus	1: up, 2: down
										9		ifLastChange	time (in hundredths of a second) since the latest change

7.1.5.3 RMON MIB STRUCTURE

Address												Name
0												Ccitt
	1											ISO
		3										Org
			6									DOD
				1								Internet
					2							mgmt
						1						Mib-2
							16					RMON
								1				stat
									1			etherstatsTable
										1		etherStatsIndex
										6		etherStatsBroadcastPkts
										7		etherStatsMulticastPkts
										8		etherStatsCRCAlignErrors
										9		etherStatsUndersizePkts
										10		etherStatsOversizePkts
										11		etherStatsFragments
										12		etherStatsJabbers
										13		etherStatsCollision
										14		etherStatsPkts64Octets
										15		etherStatsPkts65to127Octets
										16		etherStatsPkts128to255Octets
										17		etherStatsPkts256to511Octets
										18		etherStatsPkts512to1023Octets
										19		etherStatsPkts1024to1518Octets

7.1.5.4 HSR MIB STRUCTURE

Address												Name
0												Ccitt
	1											ISO
		0										Standard
			64239									IEEE
				1								Redundancy Protocols HSR
				2								Redundancy Protocols MRP
				3								Redundancy Protocols PRP
					1							manufacturerName

Address												Name
					2							interfaceCount
					3							redundantInterfaces
						1						
						2						
							1					redundantInterfaceIndex
							2					nodeType
							3					nodeName
							4					versionName
							5					macAddressA
							6					macAddressB
							7					linkStatusA
							8					linkStatusB

7.1.5.5 SNMP CLIENT SOFTWARE

Readily available Management Information Bases (MIB) browser software enables you to perform all the basic Simple Network Management Protocol (SNMP) operations, such as GET, GETNEXT, and RESPONSE, by connecting to the switch.

7.1.5.6

7.1.5.6 SNMP ACCESSIBILITY

The Simple Network Management Protocol (SNMP) supports the versions 1 – 3 according to the rules below:

SNMP v1 and v2:

- Read community: Public
- Write community: Private

SNMP v3:

Level	System MIB	Other MIB
Observer	Read, plain	-
Operator	Read, encrypted	Read, encrypted
Administrator	Read/Write, encrypted	Read/Write, encrypted

An Administrator can change any user password. Other users can only change their own password.

7.2 SETTINGS

There are 2 possible external access points:

- over an Ethernet network connected to any of the three RJ45 ports accessible on the back panel of the C26x,
- via SSH, over the HSR network connected to its redundant optical connectors.

7.2.1 SSH COMMUNICATIONS

An SSH access is provided to configure and manage the board.

SSH is a virtual terminal protocol of TCP/IP. It provides encrypted interconnectivity between elements of a network. The terminal is connected to the network like any other device as shown in the figure below.

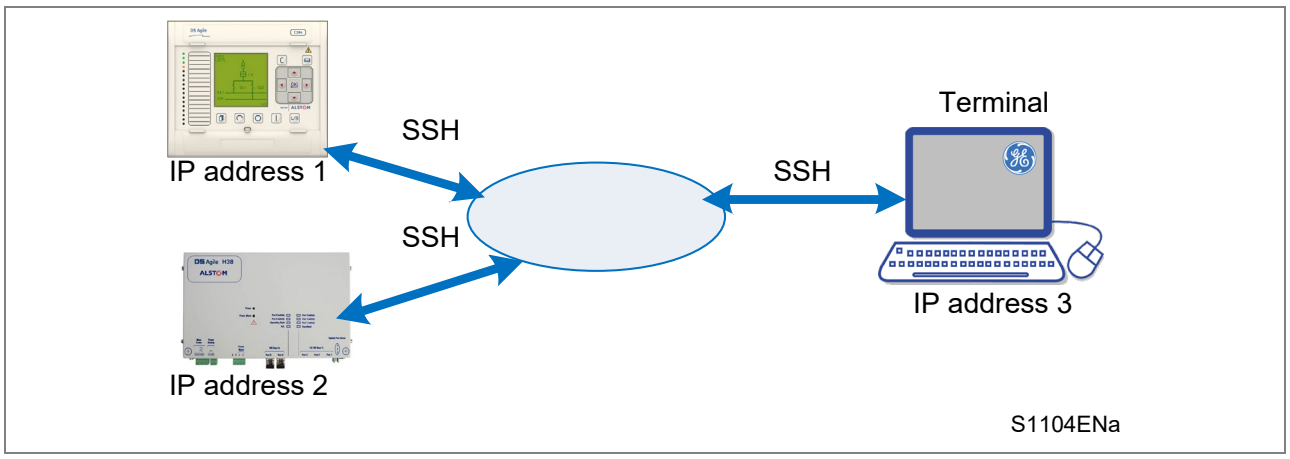


Figure 40: SSH connection example over the HSR network

Note:
The IP addresses must be part of the same network as the terminal and the subnet mask must not exclude them.

With the SSH connection, the terminal can be used to communicate with all functions of the SRP29x.

There are two default accounts:

- user
- root

Both have the same default password:

- changeit

The default IP address is:

- 192.168.7.1

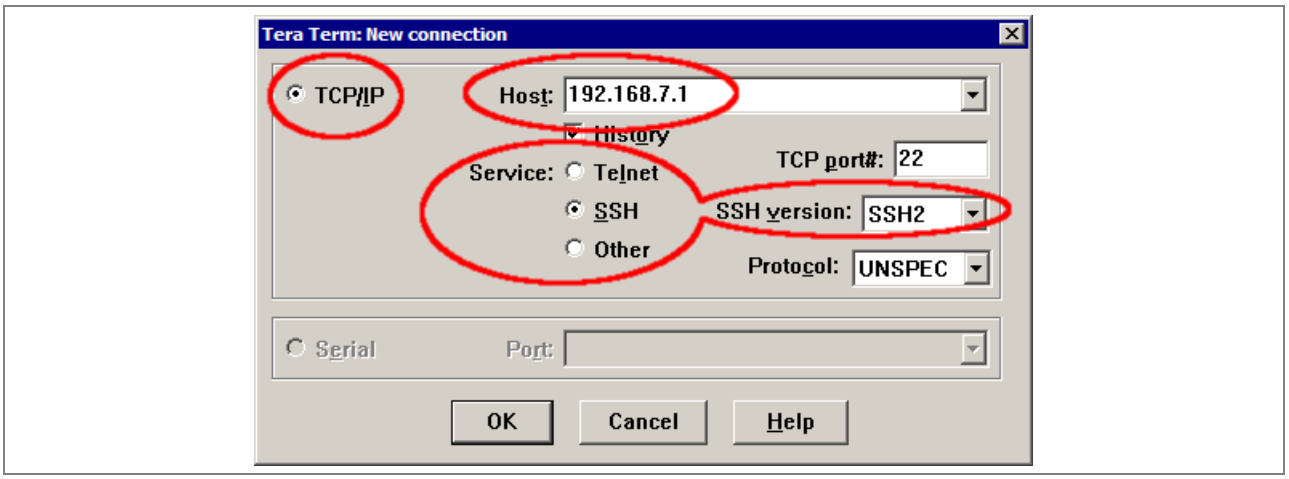
7.2.2 CONFIGURATION VIA SSH

Most of the available SSH commands are advanced configuration settings that will rarely be used, if ever, since the default settings should fit most applications.
HOWEVER, THE PASSWORDS AND IP ADDRESSES MUST BE CHANGED.

7.2.2.1 SSH SESSION

To open an SSH session with the board, use a standard SSH2-compatible client:

1 Launch the SSH client application.



2 Select the options *TCP/IP* and *SSH service*, *SSH version 2*.

3 Type the *IP address* of the board in the appropriate field.

4 Click **OK** or **Connect** (or equivalent, depending on the chosen SSH client).

A login window is displayed.

The board is supplied with a unique Media Access Control (MAC) address which should not be changed. It is supplied with a default Internet Protocol (IP) address of **192.168.7.1**.

7.2.2.2 LOGIN

Before the session is opened, you will have a login dialogue as shown in the figure below. You login according to the role(s) associated with your user account.

Default accounts

The board is delivered with two pre-defined accounts:

- "Root"
- "User"

The default password for both accounts is "changeit".

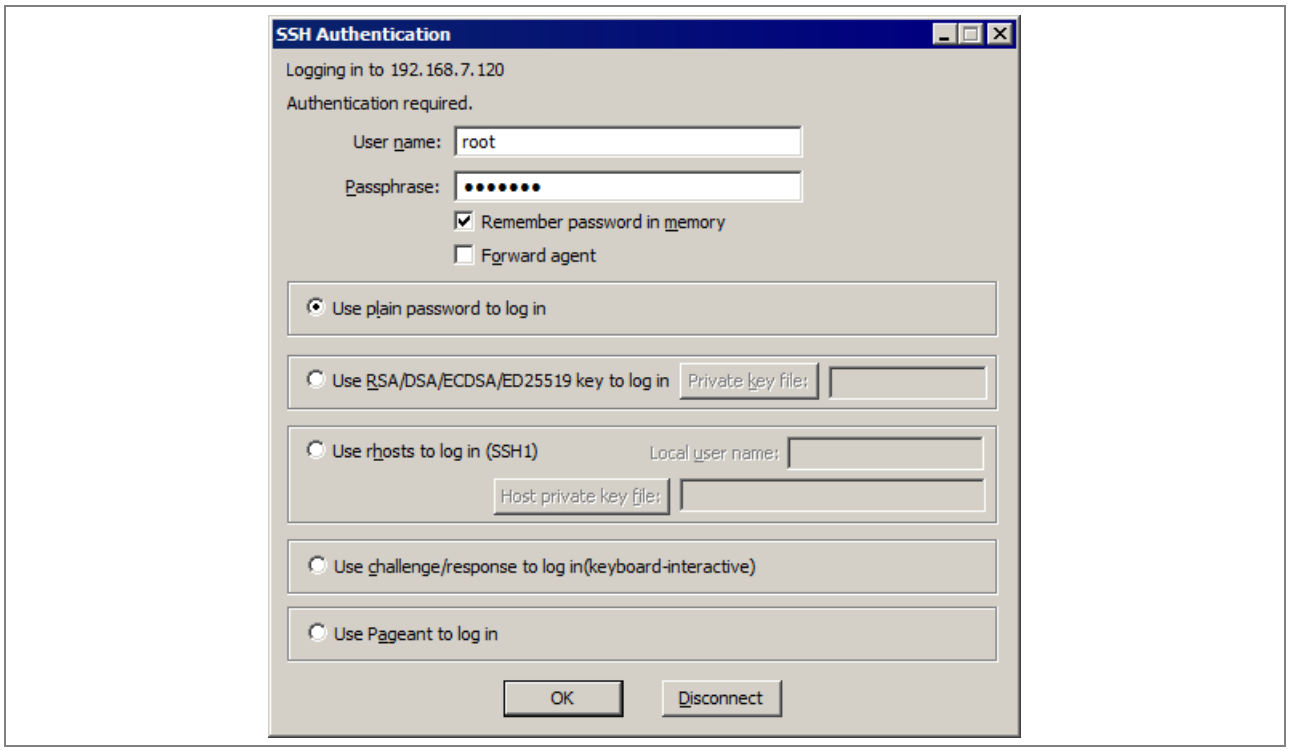


Figure 41: Example of Login window (may vary depending on the selected terminal emulator)

Note:
See Cyber-Security section for more information on user accounts.

The connection is established and an SSH console is displayed. Once the session is in progress, your access level is indicated by either a # for Security administrator level, or a $ for non-administrator level (Observer/System engineer roles).



Caution:
Change the default passwords immediately.
To do so, log in as "root" and type the commands:
- `setPassword <user>` for the account "user"
- `setPassword` for the account "root" (currently logged in).

7.2.2.3 PASSWORDS AND AUTHENTICATION LEVELS FOR SNMP ACCESS TO MIB DATA

There are three possible authentication levels for SNMP:

- Observer: Does not require login and password, can only read unencrypted data.
- Operator: Requires login and password, can read all data.
- Administrator: Requires login and password, can read and write all data.

SNMP V3 passwords must be a minimum of 8 characters long in accordance with the standard.

They must both be changed immediately when the board is delivered to the customer.

Setting the SNMP V3 Administrator/Operator Passwords

1 Type the command **# setSnmpPassword Administrator** or **setSnmpPassword Operator** and press **Enter**.

2 When prompted, type the name of the account for which you want to change the password: **Administrator** or **Operator**. Press **Enter**.

3 When prompted, type the new password (note that it is not displayed) and then press **Enter**.

4 Retype the new password (note that it is not displayed) and press **Enter**.

5 Repeat this procedure to change the password for the other account.

```
# setSnmpPassword Administrator
New password:
Retype the new password:
```

7.2.2.4 CONFIGURATION COMMANDS

Configuration command	Syntax	Example
Set session timeout (in seconds) If no command is sent for that duration, the session is automatically closed.	setSessionTimeout <time>	setSessionTimeout 300
Enable/disable password policy	passwdPolicy <options>	passwdPolicy 0 = disable passwdPolicy 1 = enable
Set Account locking parameters Number of failed attempts that trigger a lockout and duration of the lockout (in seconds).	setLockAccount <login retries> <lock_time>	setLockAccount 3 60
Set Mac address seen from the network	setMac <mac_addr>	setMac AA:BB:CC:DD:EE:FF
Set network addresses: Board IP address and sub-network mask, Gateway IP address if applicable	setNetworkSettings	setNetworkSettings then follow onscreen prompts
Set current user's own password	setPassword	setPassword then follow onscreen prompts
Set another user's password	setPassword <user>	setPassword bnufdp12
Set SNMP Operator or Admin password	setSnmpPassword	setSnmpPassword then follow onscreen prompts

IP Interfaces

Assigning the IP address and subnet mask is done by network managers, i.e. users with the System Engineer role. A unique IP address should be applied.

All addresses are set using the **setNetworkSettings** command, as shown in the example below:

```
# setNetworkSettings
The current IP address is : 192.168.7.120
Do you want change the current IP address (y/N) ? y
Enter the new IP address : 192.168.7.120
INFO : /usr/bin/verificationIPaddress done, The IP address is valid
(192.168.7.120)
setting IP to 192.168.7.120
The current Gateway address is : (default)
Do you want change the current Gateway address (y/N) ? n
Gateway address hasn't changed
The current Netmask address is : 255.255.255.0
Do you want change the current Netmask address (y/N) ?
Netmask address hasn't changed
Unloading drivers: OK
Loading drivers: OK
Setup interfaces: OK
INFO : /usr/bin/setNetworkSettings Done
```

IP Address

The default IP address is 192.168.7.1.

Subnet mask

Typically subnet mask number fields are either 0 or 255 as in the figure below (255.255.255.0).

Gateway

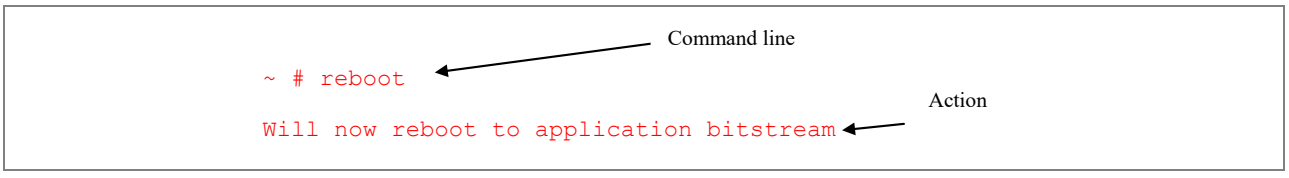
The gateway address must be on the same IP subnet as the hosting device.

7.2.2.5 MANAGEMENT COMMANDS

Management command	Syntax	Example
Management of user accounts Options: -c = Create a user account, -d = Delete a user account -u = Unlock a user account -n = Change a user name -r = Change a user role	AccountManagement <options>	AccountManagement –c then follow onscreen prompts
Hard Reboot	reboot	reboot

Reboot command

The command “reboot” forces a hard reboot equivalent to a power-up as shown in the figure below:



Note:
Only a user logged in with the root account or an account with Security Administrator privileges is allowed to send this command. If the account's rights are insufficient, an error message "Access Denied" is displayed and the command is not executed.

7.2.2.6 INFORMATION RETRIEVAL COMMANDS

The informative commands are given in the table below.

Informative command	Syntax	Example
Configuration summary	getConfig	getConfig
Current user information	whoami	whoami

Configuration

Typing in the "getConfig" command will return the switch configuration, an example of which is shown in the figure below:

```
# getConfig                                   Command line

Alstom Board version
--------------------
 - Board type          : SRH

Current configuration
---------------------
  - IP Add (default)      : 192.168.7.1

  - Gateway IP Add        : No Gateway defined (default)

  - Netmask               : 255.255.255.0 (default)

  - MAC Add               : 7E:63:AB:9C:55:4F (default)

  - MAC function Add      : (default)

  - NTP Server            : Not set (default)

  - NTP Client            : disabled

  - NTP Server            : disabled

  - Trap IP               :  (default)

Available users
---------------
root
user
ftp

INFO : /usr/bin/getConfig Done
#
```

Current user

Typing the “whoami” command will return the login name of the current user, an example of which is shown in the figure below, for the user “root”:

```
# whoami
root
```

7.3 CYBER-SECURITY

The DS Agile C26x board provides security measures for system protection. They are described below.

7.3.1 ACCOUNT AND PROFILE MANAGEMENT

Each account is composed of a login name and a password. The login name is unique and cannot be changed.

If an attempt is made to create a user account with an already existing login name, the creation is denied and the message “Login name already exists” is displayed.

Each user can change his/her own login name and password. The password of all the accounts, including the default accounts, can be changed.

All the accounts can be deleted, except the “Root” account.

One of three roles, i.e. predefined sets of privileges can be assigned to each user account:

Roles	Privileges
Observer	This role only allows reading information. It does not allow changing any password except the user's own password. It does not give access to any security log.
System engineer	This role only gives access to data useful to run the system. In addition to Observer privileges, it also allows setting parameters on the board. It does not allow changing any password except the user's own password. It does not give access to any security log.
Security administrator	This role gives the user complete control over the board: In addition to System engineer privileges, it allows the user to upgrade the software version, display data and change the board's operating mode. It is the only role that allows the user to create user accounts, configure its own role as well as the System engineer and Observer roles, change other users' passwords and display security logs.

Only users with the Security administrator role can create new accounts on the board and define their role. The same applies to user account deletion.

The maximum number of user accounts is **10**.

Default commands per authentication level

Commands	Security Administrator	System Engineer	Observer
Configuration commands			
setSessionTimeout <time>	X		
passwdPolicy <options>	X		
setLockAccount <login retries> <lock_time>	X		
setMac <mac_addr>		X	
setNetworkSettings		X	
setPassword (*)	X	X	X
setPassword <user>	X		

Commands	Security Administrator	System Engineer	Observer
setSnmpPassword (**)	X		
Management commands			
AccountManagement <options>	X		
reboot	X		
Informative commands			
getConfig	X	X	X
whoami	X	X	X

(*) Set the password for any account.
(**) Unique password to access the MIB data.

Default accounts

The board is delivered with two pre-defined accounts:

- "Root"
- "User"

Both these accounts are assigned the Security administrator role by default.

The default password for both accounts is "changeit". It is recommended to change it immediately.

Note:
The "root" account cannot be deleted.

7.3.2 PASSWORD POLICY

The Security administrator can force users to select passwords that comply with a minimum complexity using the setting **passwdPolicy**. If password policy is enabled, the passwords must comply with the following rules:

1 Contain at least 9 characters

2 All of these 4 types of characters must be used in the password:

a Uppercase letter

b Lowercase letter

c Digit

d ASCII non-alphanumeric character (such as @,!,#,{, etc.)

Passwords that do not comply with this rule are refused, an error message is displayed.

Note:
Password policy is enabled by default.

A forgotten or lost password cannot be recovered. A new password must be defined by a user with Security administrator privileges.

7.3.3 AUTHENTICATION

Concurrent logins

Concurrent logins are not allowed. Only one user can be logged in at any time. A current session cannot be overridden by another user, even one with administrator privileges.

Failed login

When authentication fails, the message "Login failed" is displayed.

Account locking following too many failed login attempts

A password locking policy is implemented:

1 After a settable number of consecutive failed login attempts (incorrect password), the account is locked for a settable period of time. The number of failed login attempts triggering a lockout is settable from 3 (default) to 10. The lockout period is settable from 1 hour to 24 hours (default setting: 1 hour) for accounts with the Observer and System engineer roles. For the accounts with the Security administrator role, the lockout duration is fixed to 5 minutes in order to minimise a potential denial of service effect if the account is attacked.

2 The account is unlocked when the first connection is successful after the lockout period has expired.

3 Only a user with the **Security administrator** privilege can unlock a locked user account before the end of the lockout period.

Authentication timeout

The login prompt is automatically terminated after a settable inactivity (no command sent) timeout. Default setting: 600 seconds (10 minutes) for all user accounts. Settable in steps of 60 seconds.

Only a user with the Security administrator privilege can change the setting for the authentication timeout.

This settable inactivity timeout is the same for all accounts.

7.3.4 SESSION TIMEOUT

A timeout disconnects the current user when no commands are sent to the board for a duration settable in steps of 60 seconds. The default timeout setting is 10 minutes (600 seconds).

7.3.5 SECURITY DATA LOG

All-important activity and system operations are logged in the **`/var/log/syslog.log`** file that only users with the **Security administrator** role can read.

This file contains:

- Startup log (boot and reboot)
- Successful and failed login attempts
- User account (local) changes (password reset, change of role)

The **`/var/log/`** folder and its contents are not affected by software updates or system reboots and will not be deleted when they occur.

The maximum size of the log files is 512 kB. Two log file archives are kept in addition to the current one.

Note:
Passwords are not logged.

7.4 LEDS AND CONNECTIONS

- LEDs: refer to the **Hardware** chapter of the C264 user manual;
- Connections: refer to the **Connections** chapter of the C264 user manual.

INSTALLATION

C26x/EN IN/D40

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1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the product installation and start-up settings. Before any handling of the device, read the Safety information chapter carefully.

This document is divided into the following parts:

- Delivery
- Mechanical mounting
- Wiring:
  - I/O board wiring
  - Network wiring
  - Power supply wiring
- Power-up without I/O
- Network setting
- Data Base Download

Use this document in conjunction with the Commissioning chapter.

For details on HyperTerminal/Tera Term, refer to the Maintenance chapter.

.

2 REQUIREMENTS

DS Agile C26x boot setting and software installation is carried out using a Windows PC with common utilities and serial/Ethernet link to the controller.

The DS Agile CD-ROM System installation is needed to run the C26x's install software on the Host PC.

2.1 DS AGILE C26X

The DS Agile C26x requires at least

- CPU board CPU270
- Power board BIU241 or BIU261
- Internal bus FBP24x (for 40TE case) or FBP28x (for 80TE case)

The BIU2x1 needs to be correctly wired to its voltage level as described in the Connection Chapter.

Before any operational voltage is applied the shield wiring should be checked following rules of the Safety Guide: SFTY/4L M/C11 (or later issue) and rules in the Safety & Handling chapter).

The CPU270 natively integrates factory parameters.

Before starting installation, the following information is required:

- C26x IP address
- C26x alias name (with the CMT, the network name must be less than 15 characters).

Both parameters are also defined in the DS Agile C26x database. If parameters inside database differ from the CPU settings, the IEC 61850-8-1 communication with other DS Agile pieces of equipment is not possible.

2.2 PERSONAL COMPUTER

A Personal Computer is used for setting and download. The required Windows operating system is Windows 10 LTSC 2019 for Enterprise 64-bits edition.

The PC hardware requirement is:

- Ethernet port 10 Mb/s or 100 Mb/s
- 100 Mb of free space on hard disk

The PC software's needed is:

- Computer package named **Computer_cx66--*.*.*.*-build**.exe**

3 DELIVERY

The delivery is composed of:

- the hardware delivery: DS Agile C26x unit with a CPU board
- the software delivery: **Computer_cx66--*.*.*.*-build**.exe**

3.1 PACKING INSPECTION AND OPENING

On receipt of the unit, inform the delivery agent if there is any sign of damage.

Check the box for documentation, or hardware options added to the delivery form, such as ribbon, screws, port extension etc.

3.2 DELIVERY FORM CHECKING

The delivery form is based on the order form issued from CORTEC. It lists the type of C26x, the boards (with supply, serial numbers and position in the rack) and the options.

Verify that the composition of the device is as ordered.

The C26x is delivered with the required connectors.

4 MECHANICAL MOUNTING

The Hardware chapter gives the size of DS Agile C26x rack, the mounting holes diameters and their position.

If an electrical screwdriver is used the torque limitation should be set to the small diameters of the screws.

The DS Agile C26x can be mounted in a rack or a panel.

4.1 RACK MOUNTING

The DS Agile C26x can be rack mounted using single tier rack frames (our part number FX0021 001):



These frames are designed with dimensions in accordance with IEC60297 and are supplied pre-assembled ready to use.

The two horizontal rails of the rack frame have holes drilled at approximately 26 mm intervals. The C26x cases are attached by their mounting flanges using M4 Taptite self-tapping screws with captive 3 mm thick washers to ensure a good earth contact (our part number ZB5865250).

It is possible to install two 40TE C26x side by side or one 80TE C26x in the rack.

Ensure that the devices are earthed, using the screw terminal on the rear of the unit.

4.2 PANEL MOUNTING

The DS Agile C26x can be flush mounted into panels using M4 Taptite self-tapping screws with captive 3 mm thick washers to ensure a good earth contact (our part number ZB5865250).

Alternatively, tapped holes can be used if the panel has a minimum thickness of 2.5 mm.

Where several products are to be mounted in a single cut-out in the panel, mechanically group them together horizontally or vertically into rigid assemblies before mounting in the panel.

Note:
Fastening DS Agile C26x devices with pop rivets is not advised because it does not allow easy removal if repair is necessary.

5 WIRING

Wiring has to be prepared before installation. The DS Agile C26x is delivered with required connectors for I/O boards and Ethernet switches. The wire diameters stated in the Connection chapter are mandatory.

Tighten the screws in a cross pattern (e.g. top left, then bottom right etc), take care not to exceed the torque rated for the screws.

5.1 GENERAL WIRING

Only two wires can be screwed together onto any one connector. The AC and DC analogue, digital signal, and communication wires should use separate shielded cable.

From a practical point of view the power supply of each device should have a switch (MCB, link, or fuse) to turn off the power during installation and commissioning tests.

The DS Agile C26x description sheet describes the type of board Installed on each slot (C, D etc.) It is very important to use it to correctly plug the connectors.

Connection diagrams of the C26x are given in the Connection chapter of the C264 user manual. Wires should be connected with the connector unplugged. Each wired signal has to be tested before plugging and fixing the connectors. The connectors have to be fixed on the C26x case with the screws available at each extremity of the connector.

For connection of the protective (earth) conductor see chapter *Earthing*, in the Connection chapter of the C264 user manual.

5.2 POWER SUPPLY WIRING

The BIU connector wiring is vital as it provides the power supply. Power voltage should be tested and checked to BIU reference defined in the Hardware chapter to ensure that supply is compliant to BIU voltage. Switch off the power before plugging in the connector.

5.3 I/O BOARD WIRING

Several DIU, CCU, BIU board voltages are available for Digital Inputs. Check that the DIU voltage as stated on the delivery form matches with the nominal signal input before plugging connector to the C26x.

DOU and CCU, the boards generate Digital Output with a defined inductive characteristic. On the other side of the wire the inductance should be compliant. To avoid damage to the DO board connected to inductive circuits it may be necessary to use an anti-surge diode.

5.4 NETWORK WIRING

Network wiring can be through fibre optic or copper cables.

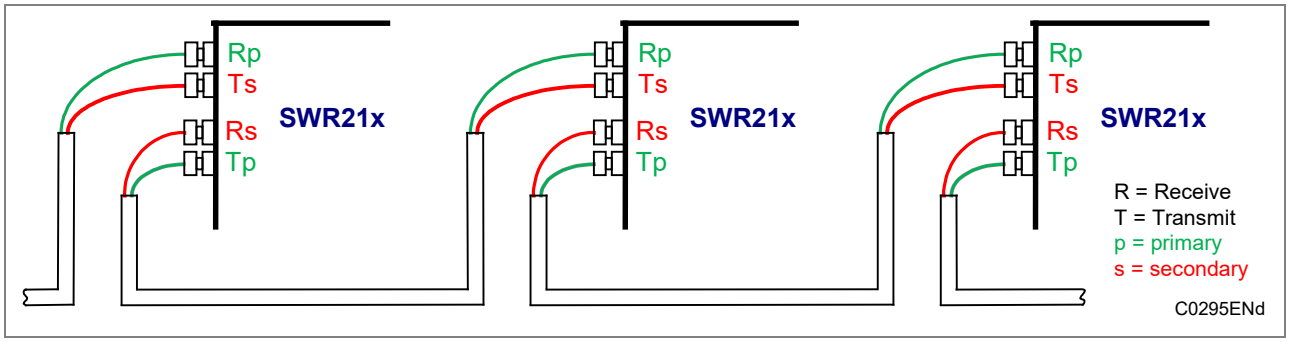
Fibre optic communications is an option and should be ordered as such along with the required mechanical modules. There are specific rules governing the installation of fibre optics (refer to the Connection chapter). Specific care should be taken with the bend radius of the fibres, and the use of optical shunts is not recommended as these can damage the transmission path over time.

Never look into the end of a fibre optic as there is a risk of causing serious damage to the eyes.

Copper networks should follow class recommendation and shielding. When using a Legacy bus (with IEDs mounted in daisy chain), the correct resistor, at both ends only, should be fitted (120 ohms for RS422 and RS485). Copper Ethernet networks stay within a cubicle. Optic fibre has to be used between cubicles.

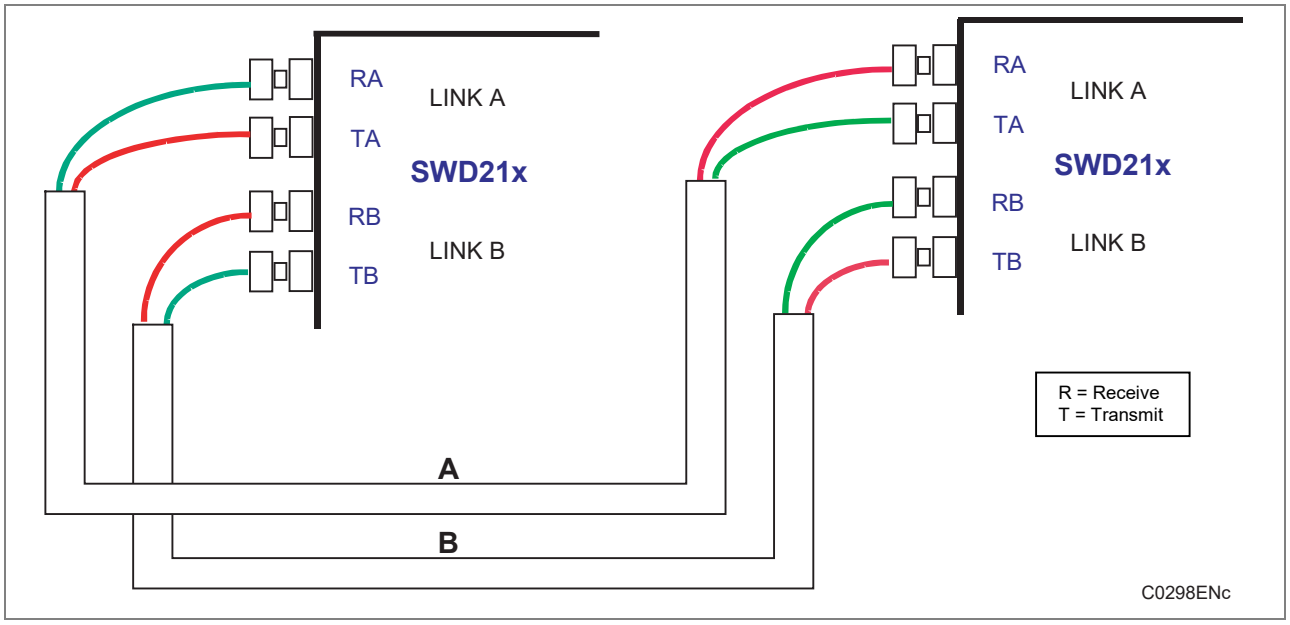
5.4.1 REDUNDANT RING CONNECTION

When using SWR21x boards, the optical ring has to be connected as follows:

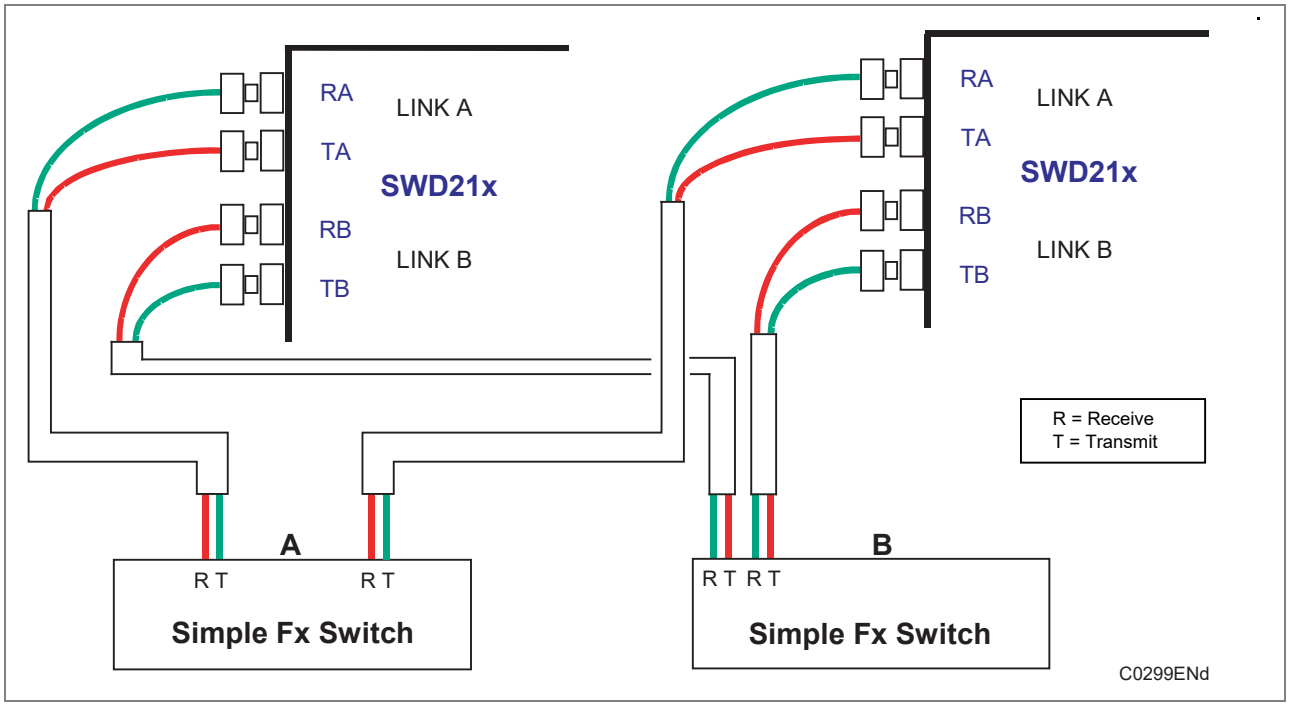


5.4.2 DUAL HOMING CONNECTION

Between 2 Dual Homing SWD21x boards

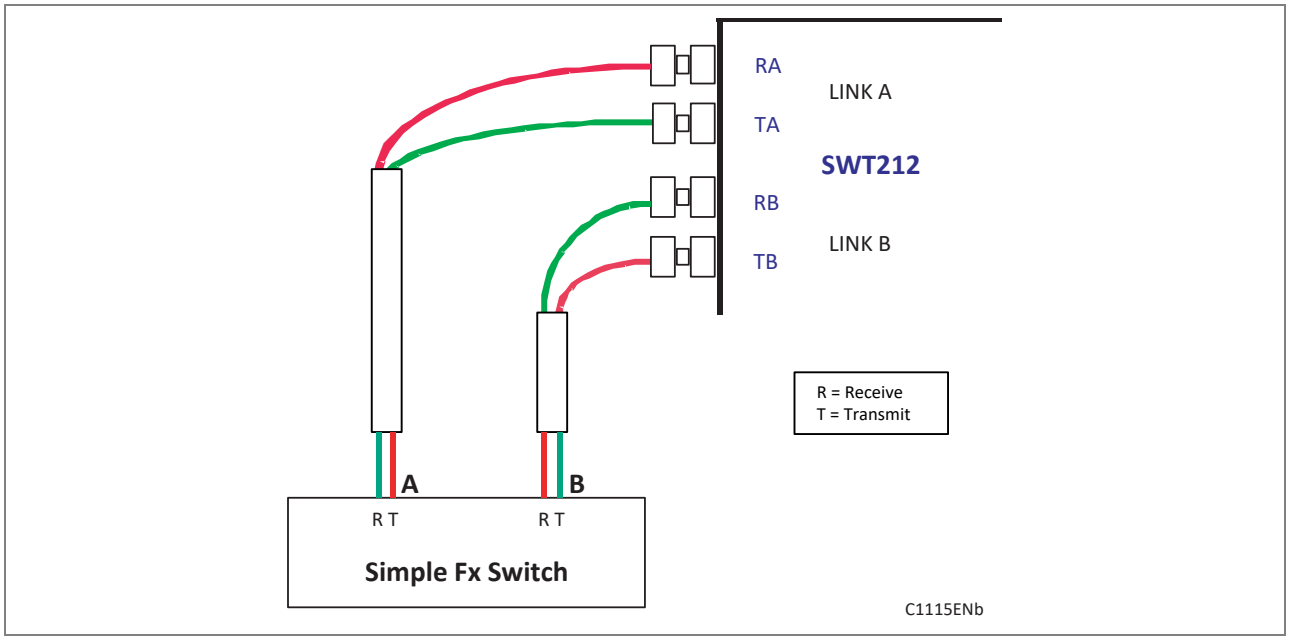


Between more than 2 Dual Homing SWD21x boards

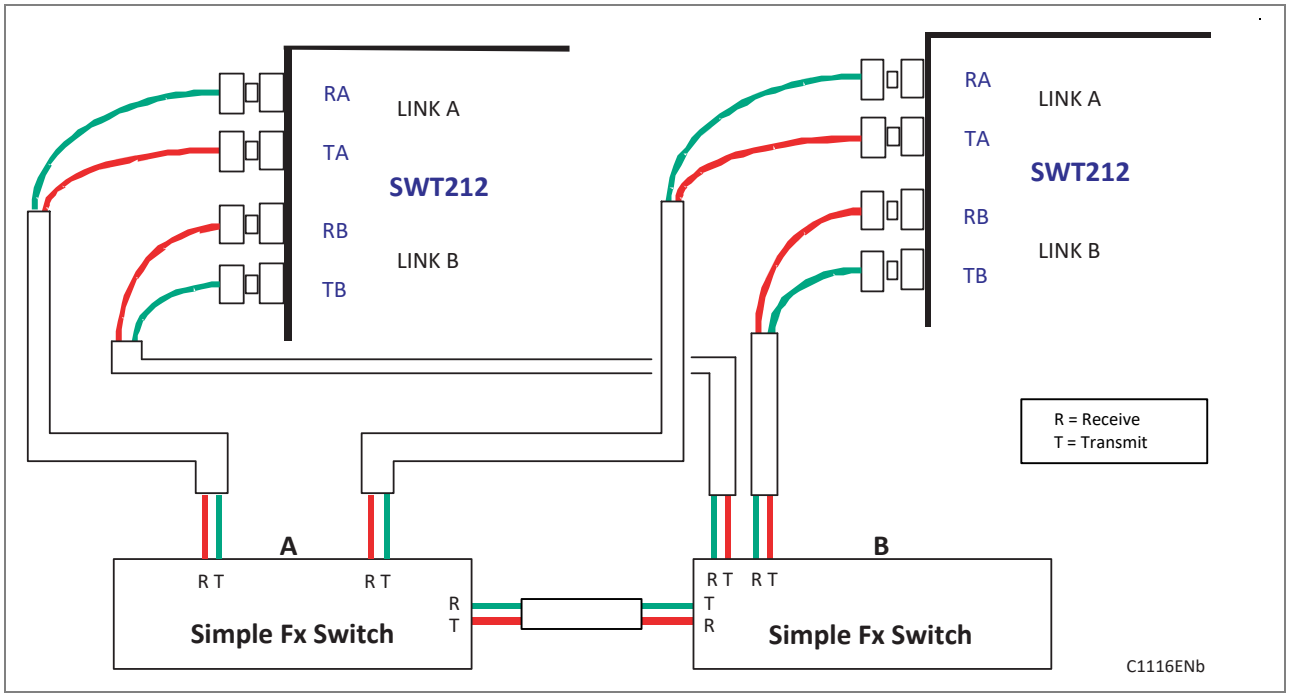


5.4.3 TEAMING CONNECTION FOR HOT STANDBY REDUNDANCY

Between 1 Teaming SWT212 switch board and an Ethernet network

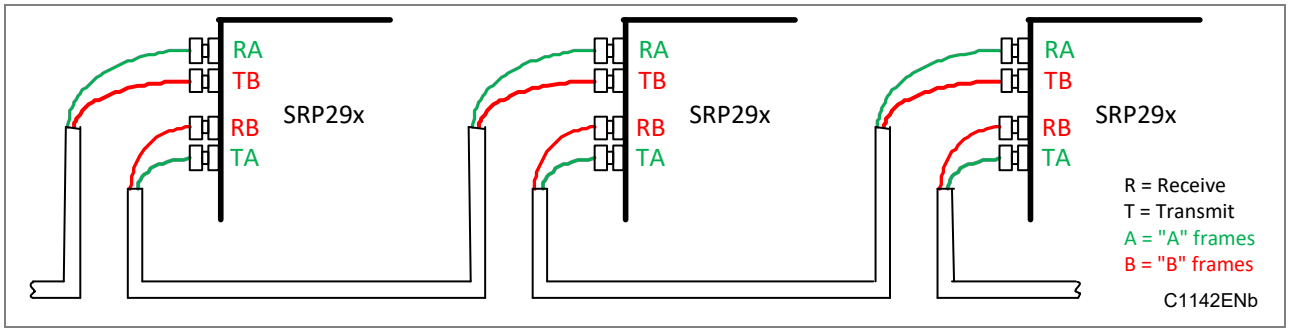


Between 2 Teaming SWT21x switch boards and an Ethernet network



5.4.4 CONNECTION FOR SEAMLESS REDUNDANCY

When using SRP29x boards, the optical rings should be connected as follows:



6 INSTALLING THE COMPUTER MAINTENANCE TOOL

6.1 REQUIREMENTS FOR THE PC

In this chapter, “computer” refers to the DS Agile C26x and “(host) PC” to the PC that hosts the tools.

6.1.1 SECURITY

The CMT shall be installed on a properly secured PC.

Refer to the C264 deployment guide chapter in this manual to know how to secure an engineering workstation.

6.1.2 HARDWARE

- At least 700 MHz
- Windows 10 LTSC 2019 for Enterprise 64-bits edition
- At least 100 MB free space on hard disk
- A serial port (or a USB-serial adaptor)
- An Ethernet port

6.2 INSTALLATION ON THE PC

It is recommended to use default installation parameters. This installs the various applications and sets the C26x application in a directory accessible by the C26x. Several different versions may be installed. Each of them will be installed in a specific directory (e.g build05 version will be installed in a /Build05 directory by default).

6.2.1 INSTALLATION OF MULTIPLE CMT VERSIONS ON THE SAME PC

*Good practice: If there is already a previous version of the CMT installed, uninstall it first using the tool provided in the relevant section of the Start menu (click the icon **Uninstall DS AGILE COMPUTER**).*



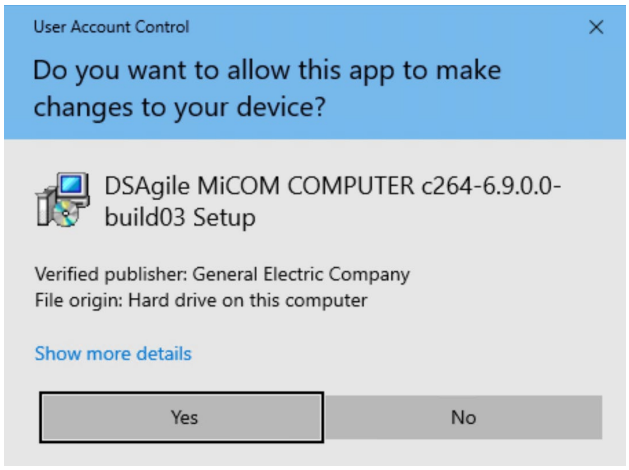
Caution:
Installing several versions of the CMT tool on the same computer may cause unforeseeable problems. It should be done only by experts.

6.2.2 INSTALLING CMT

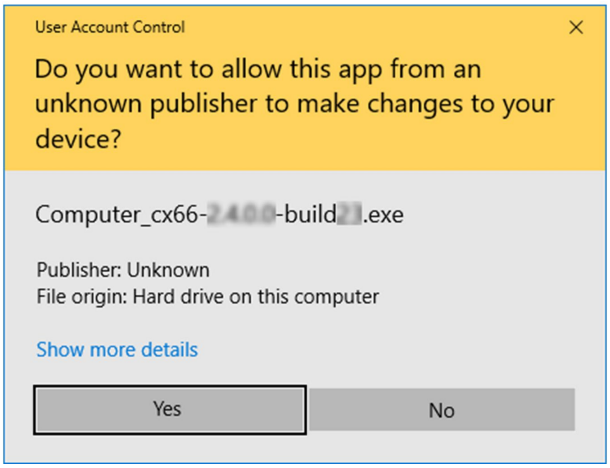
1 Unzip the system delivery file **dsagile-va.b.c.d-base.zip** (a.b.c.d is the system version).

The controller's software is in the `cx6x-a.b.c.d` folder.

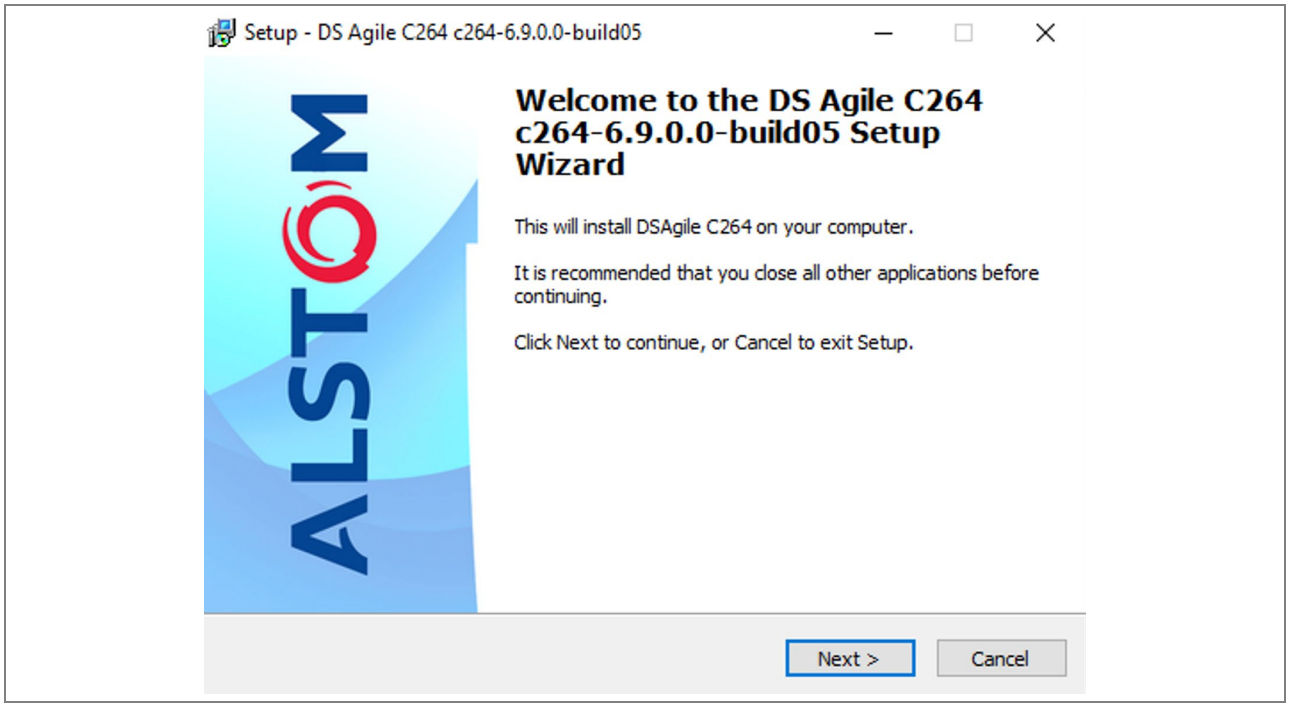
2 In the UAC window, click Yes when prompted:



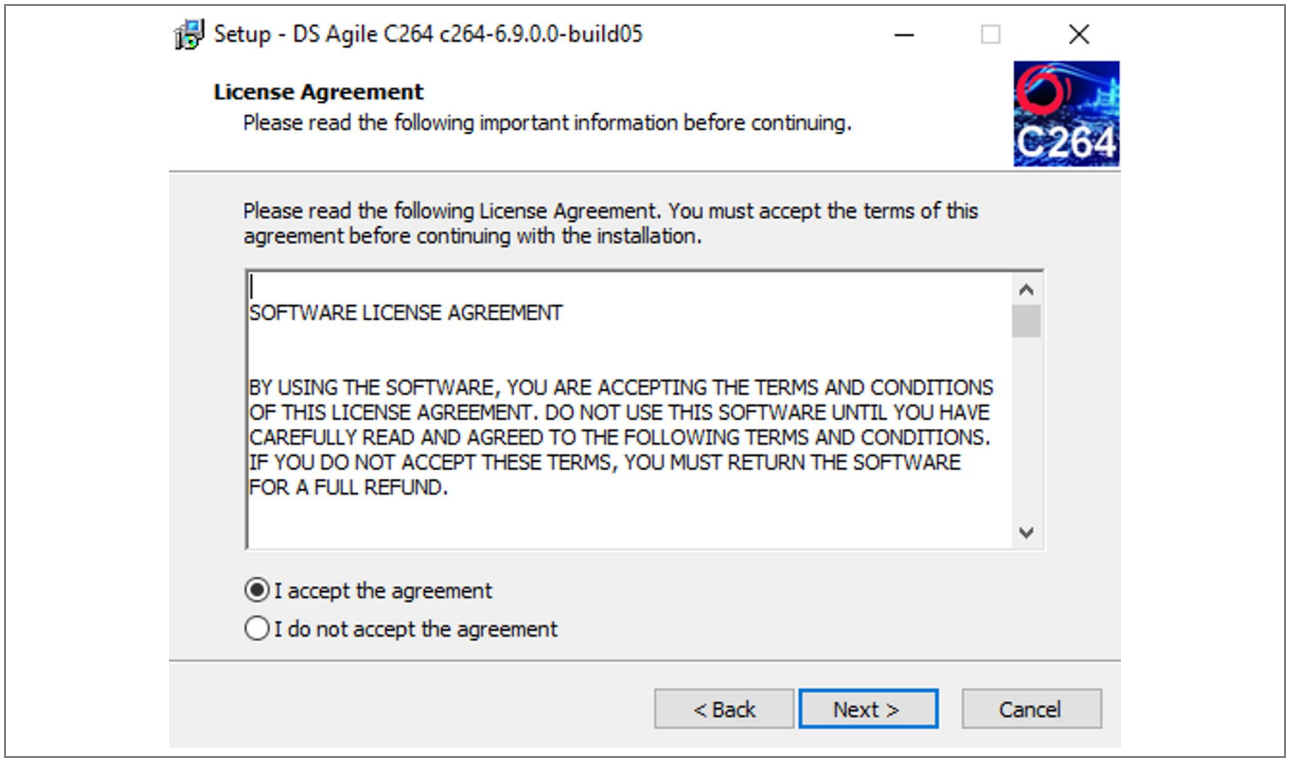
3 Launch the **Computer_cx6x-*.*.*.*-build****.exe file and click **Yes** when prompted:



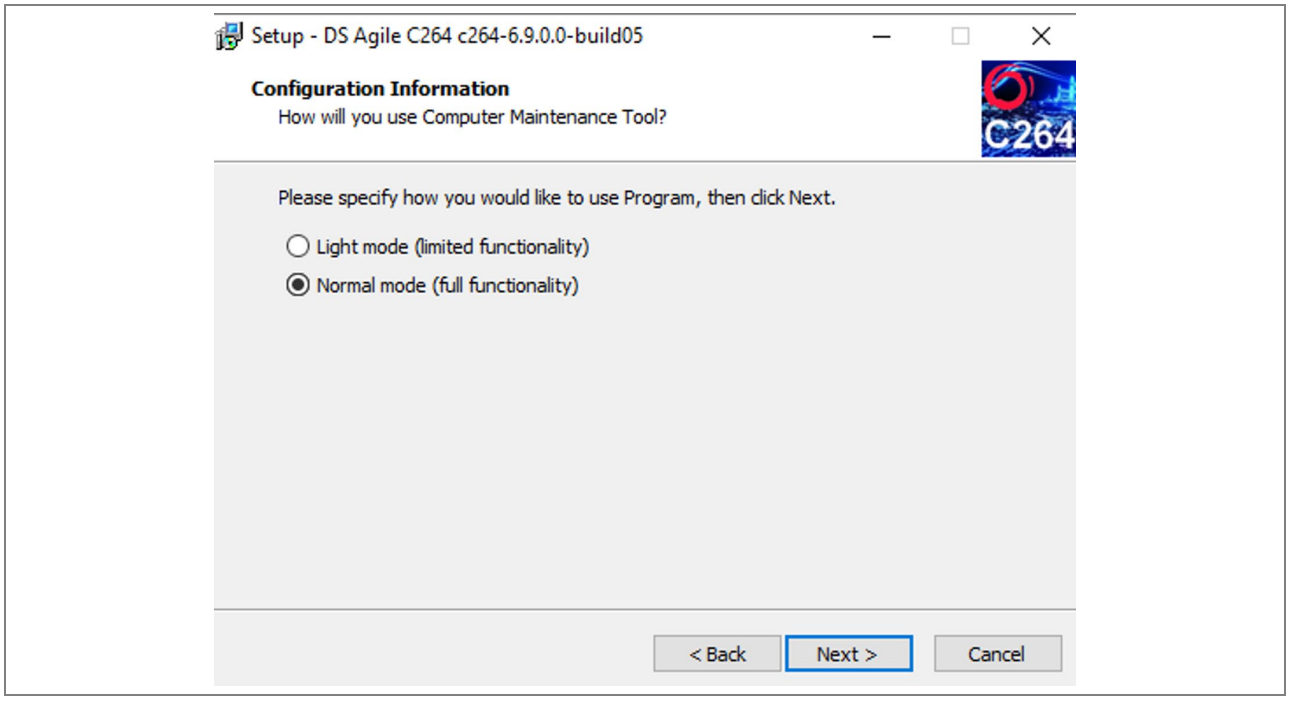
4 The C264 setup wizard is started. Click **Next >**:



5 Accept the **License Agreement**, and then click **Next >**.

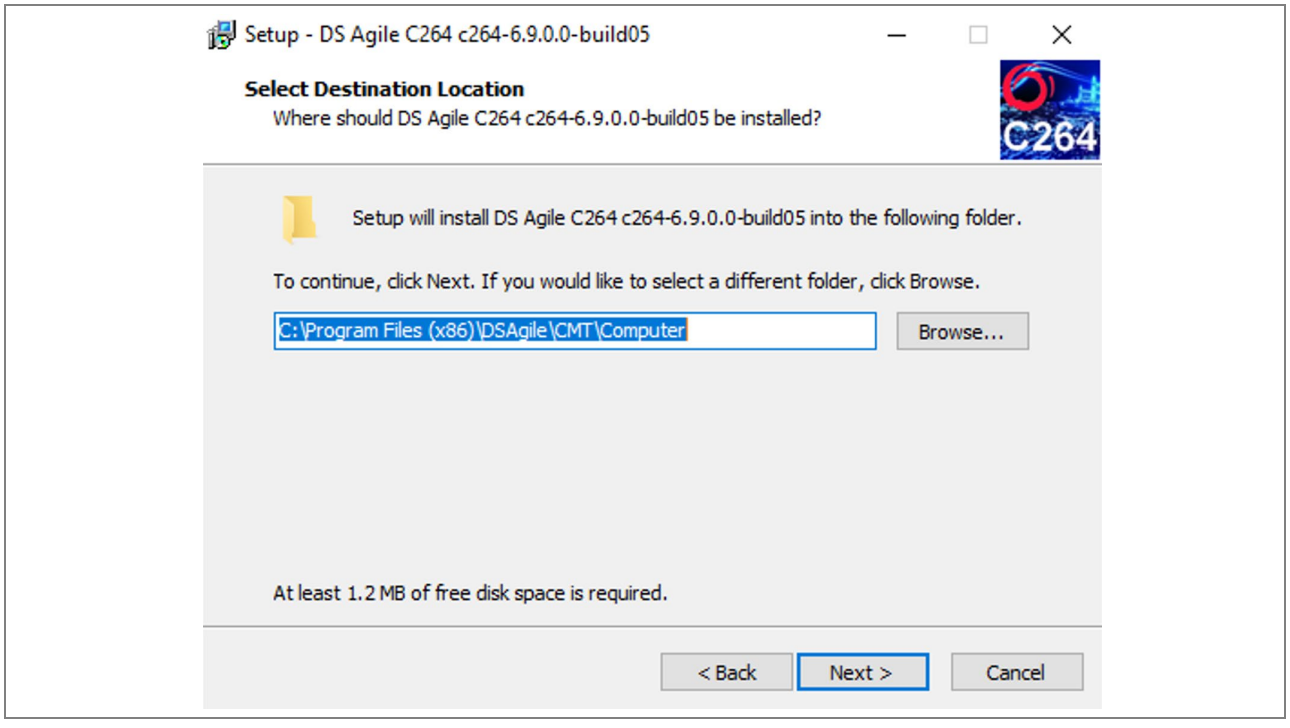


6 Select **Normal mode (full functionality)** and click **Next >**



7 By default, the destination path is `C:\Program Files (x86)\DSAgile\CMT\Computer`. Click **Next >** to proceed with the installation or click **Browse** to change the folder:

***Note**: We recommend keeping the default installation folders.*
If you wish to use a different destination folder, you will need to update the hardening and whitelisting scripts.

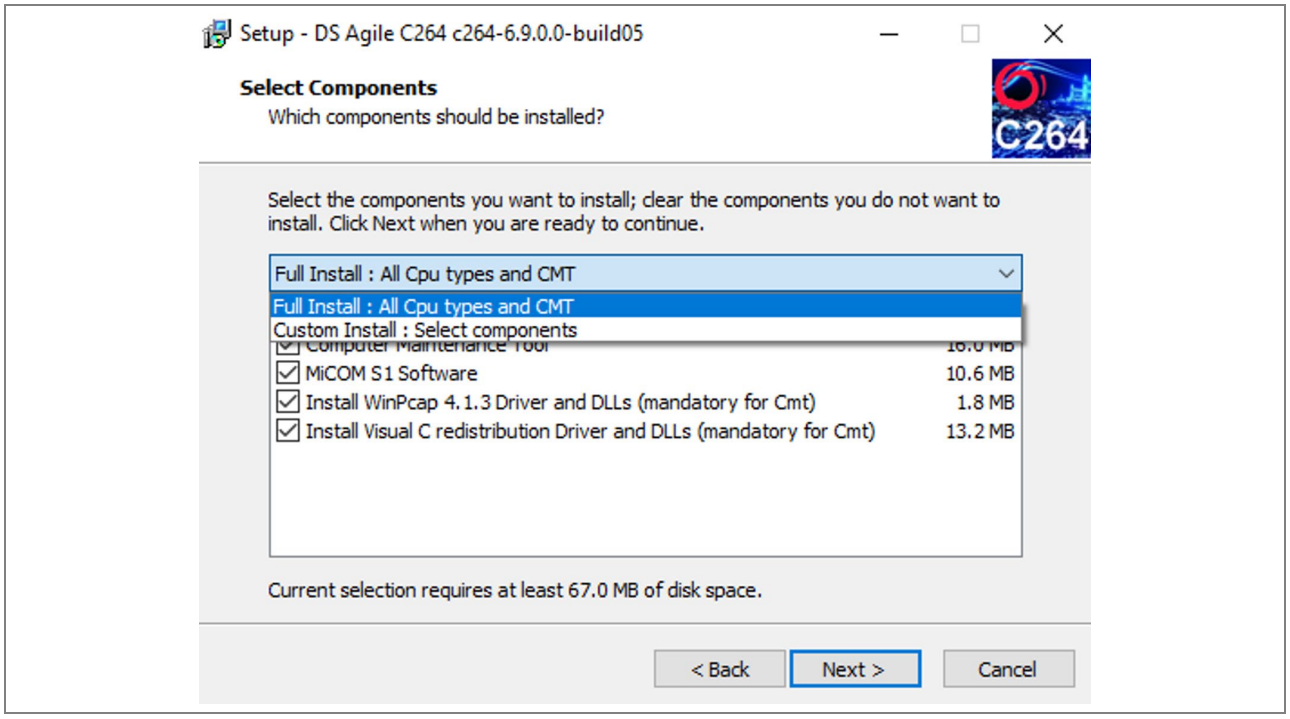


The application files are copied into the folder defined here. In addition, a sub-folder is created in `C:\ProgramData\DCS` to hold extra configuration files. That folder has the same name as the application folder defined above. For instance, if the CMT is stored in `C:\Program Files (86)\DSAgile\CMT\Computer\v6.3.0`, the path of the configuration file folder will be `C:\ProgramData\DCS\v6.3.0`.

This folder also stores the temporary files used to update security certificates in the C26x units.

8 Depending on previous installations, select the components to install: C26x cpu3 (i.e. CPU270) for the C26x, CMT and setting software (MICOM S1) for the host.

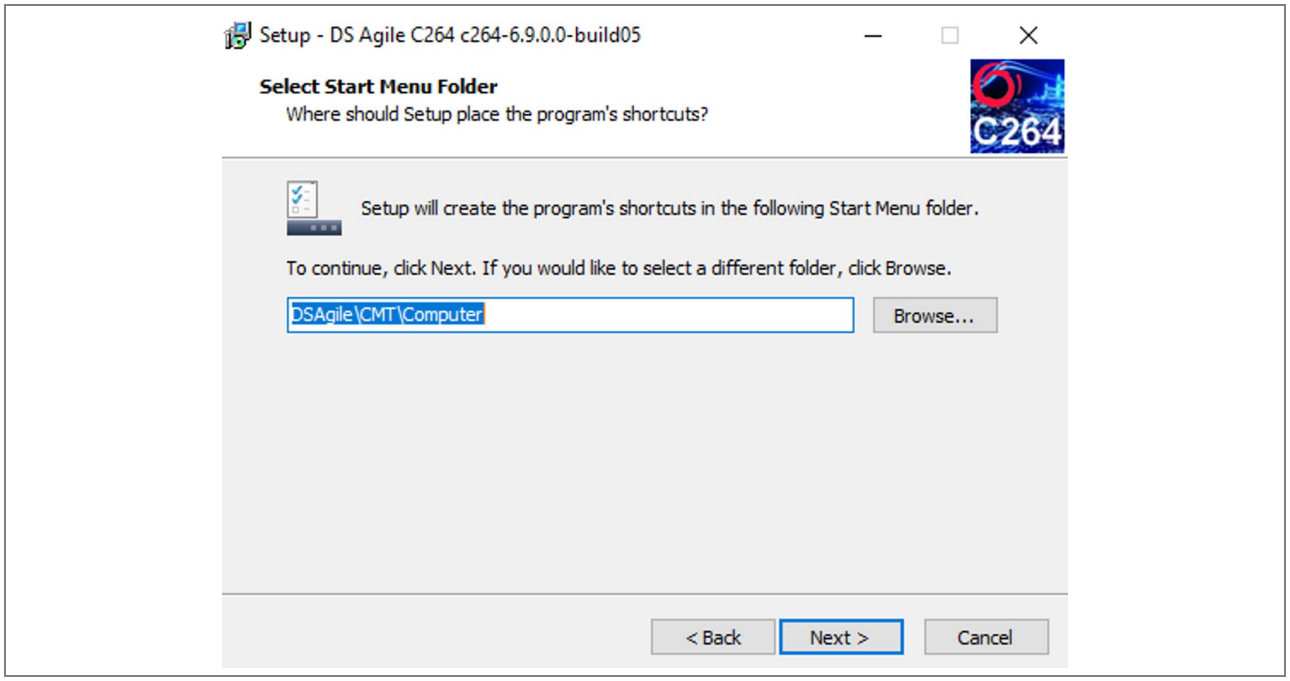
9 Use the drop-down list to select *Full Install…*,



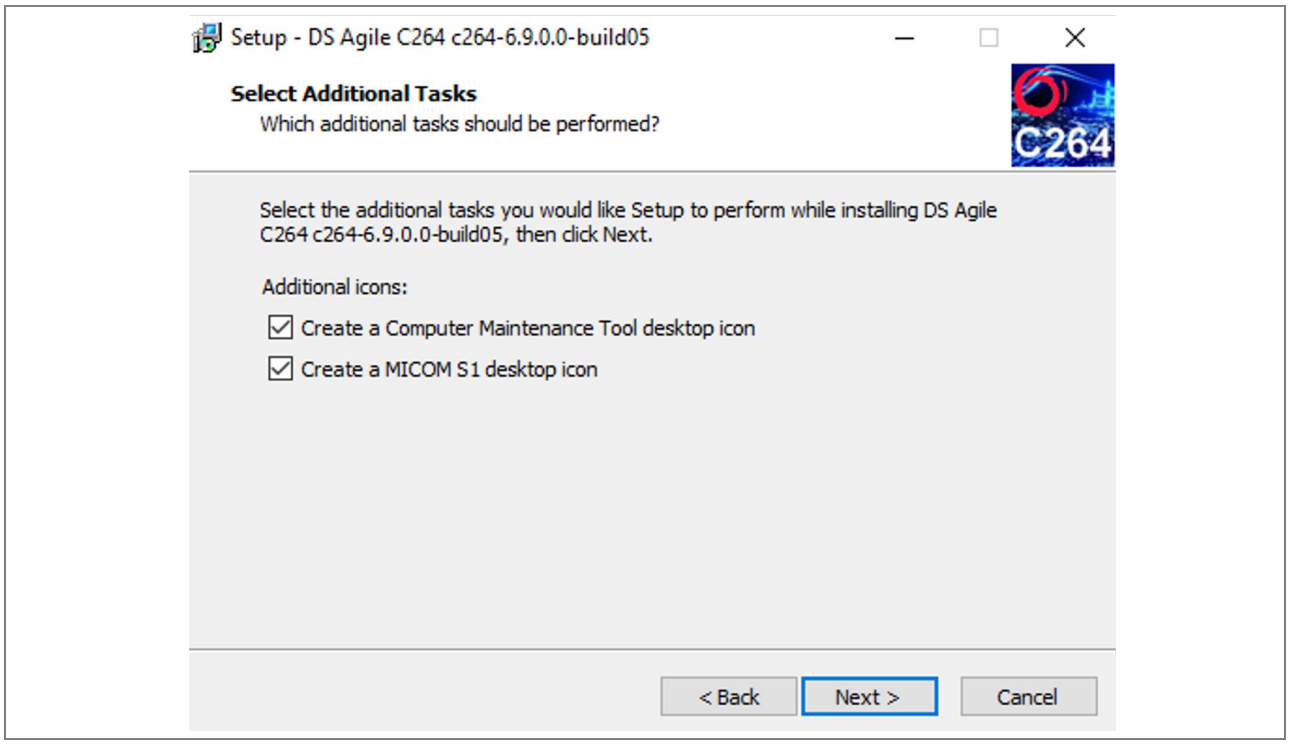
Note:
Custom Install of only some components is not recommended in an operational context.

10 Then, click **Next >**

11 Check that the path shown is correct, especially if several CMTs are installed, and then click **Next >**.

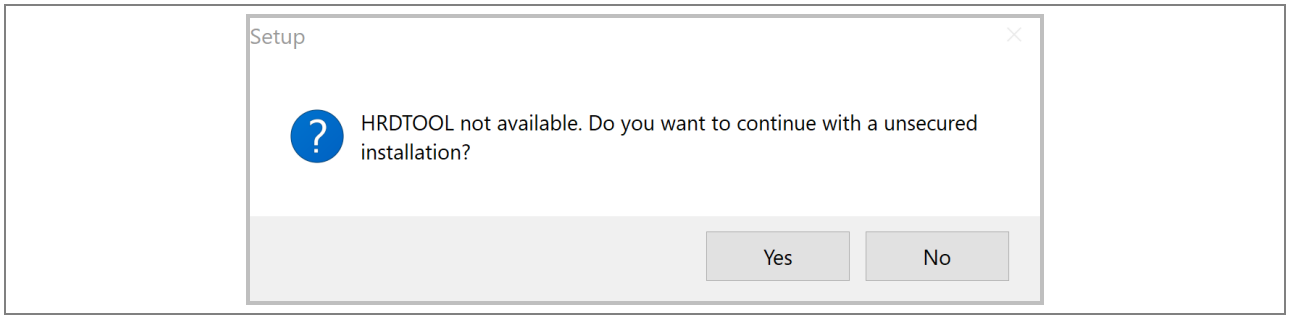


12 In the **Select Additional Tasks** dialog box, select whether to create additional icons and then, click **Next >**:



13 A cyber secure environment is required to install CMT. The installation program checks whether GE's hardening tool (HRDTOOL) is available.

- If GE's hardening tool **is not installed**, the following window appears:

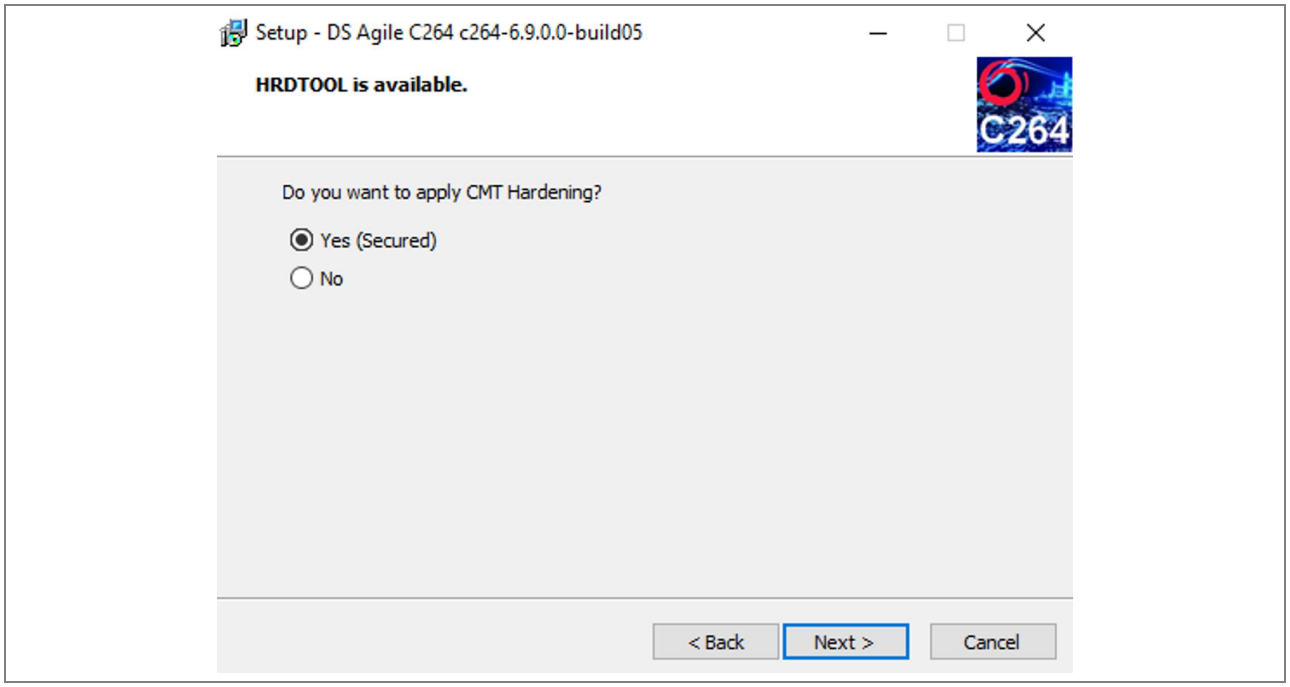


a Click **No** to cancel the installation process of the SMT.

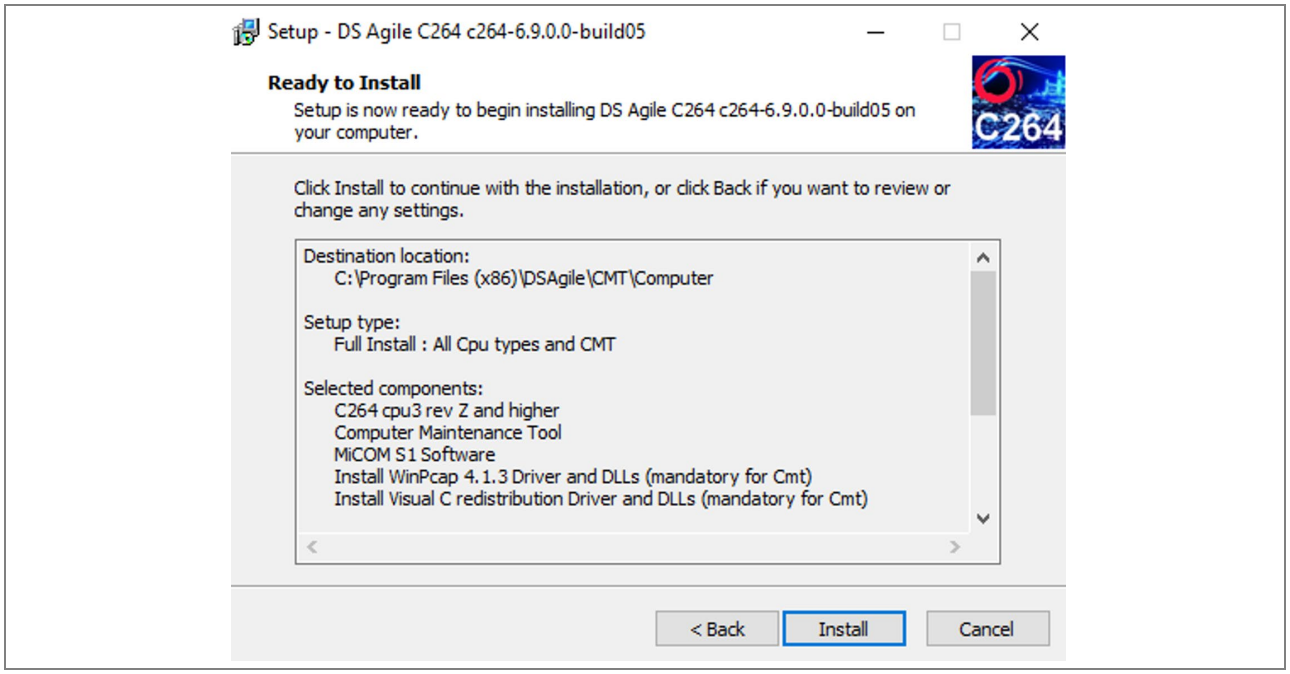
b Install GE's hardening tool as described in the **Installation** chapter of the **DS Agile System Secure Deployment Guide** (SDG_enM_Xxx), section **5.3 OS Hardening**.

c Start over the CMT installation

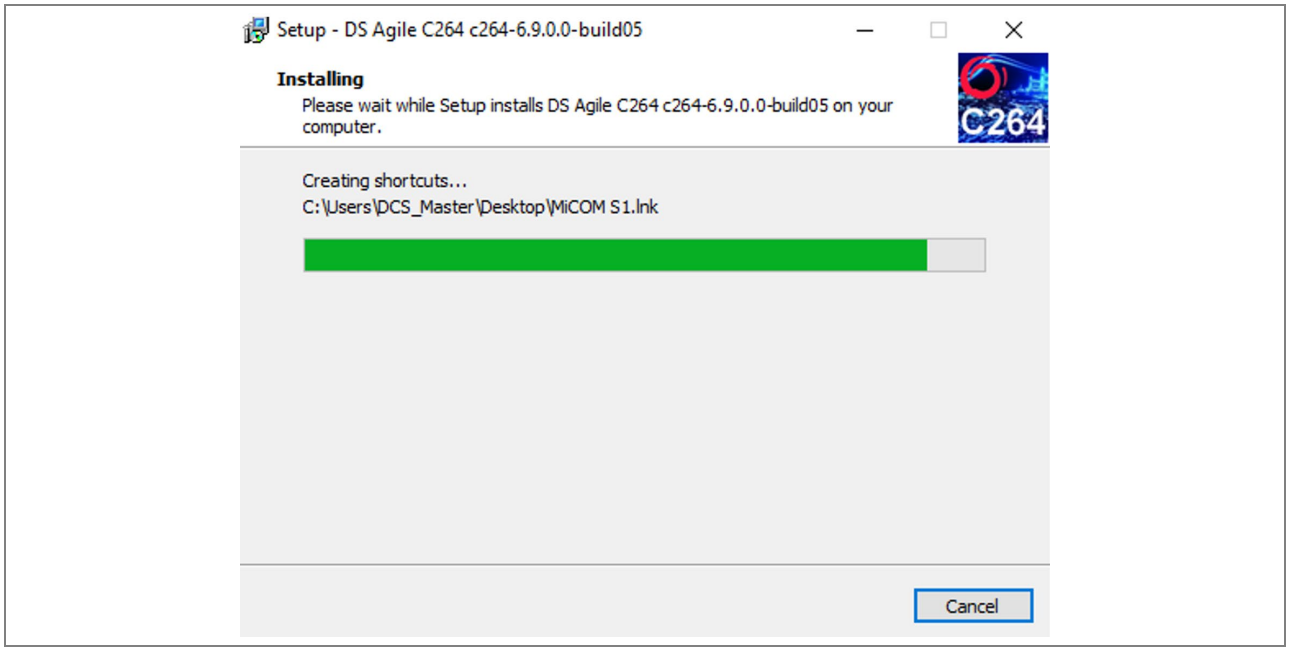
- If GE's hardening tool **is installed**, The following windows prompt. Click **Yes** to install CMT with the required hardening.



14 Check the summary (click **Back** if you need to make changes) and click **Install**:

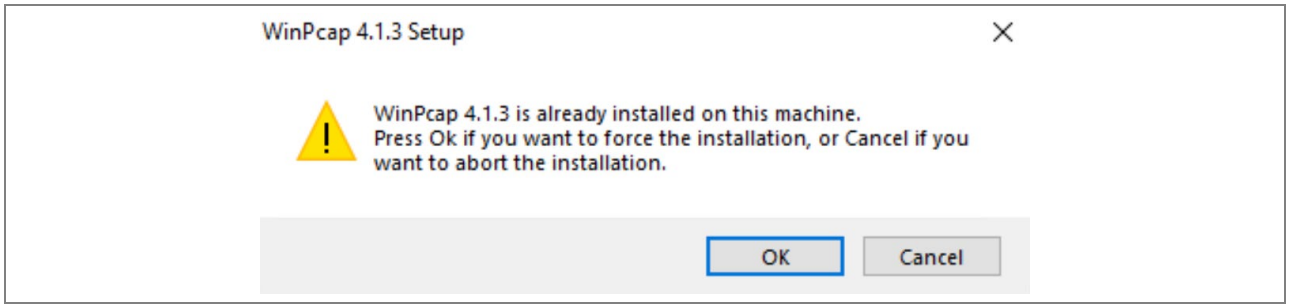


15 The files are being copied:



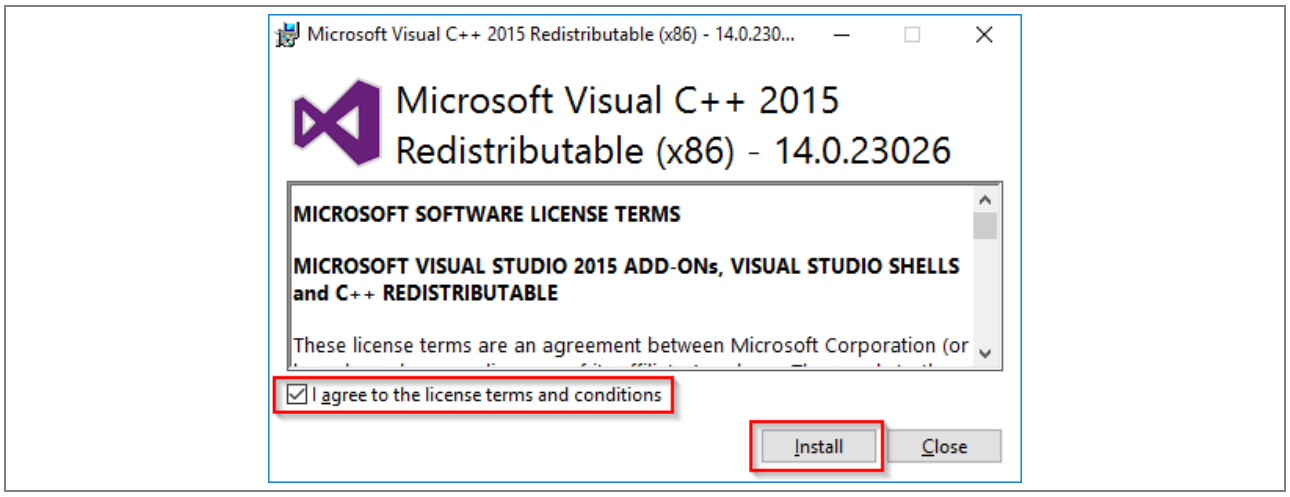
16 The C264 installer program checks whether WinPcap is installed. WinPcap is an open source library of packet capture and network analysis routines required for the agency to run.

- If installer detects the same version of WinPcap is already installed in the system, you may keep the current version or reinstall it.

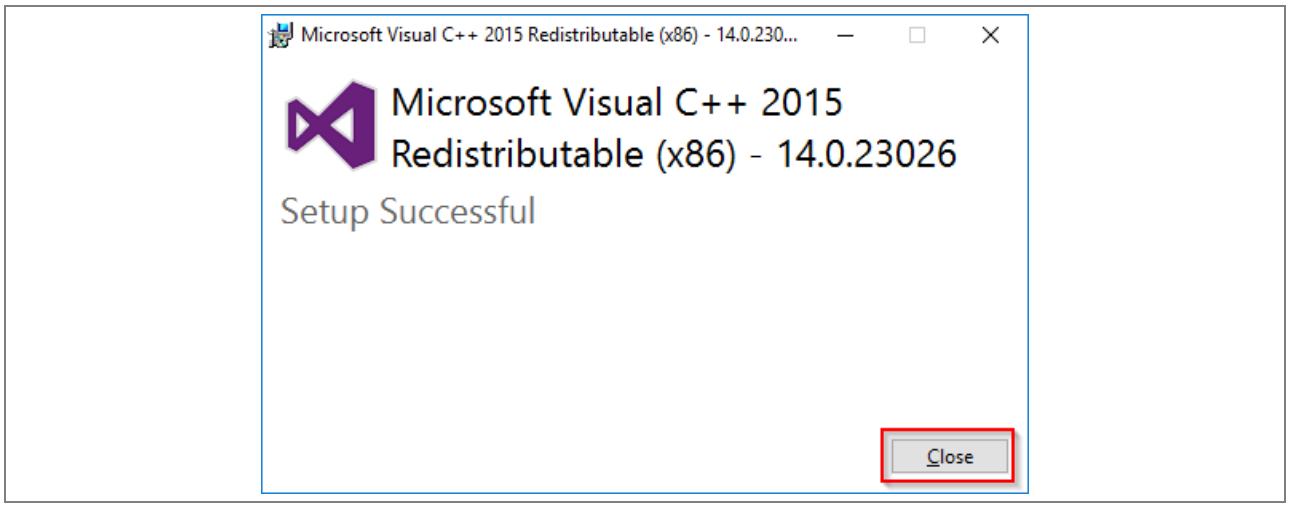


17 If Visual C++ is not installed, you will be prompted to install it:

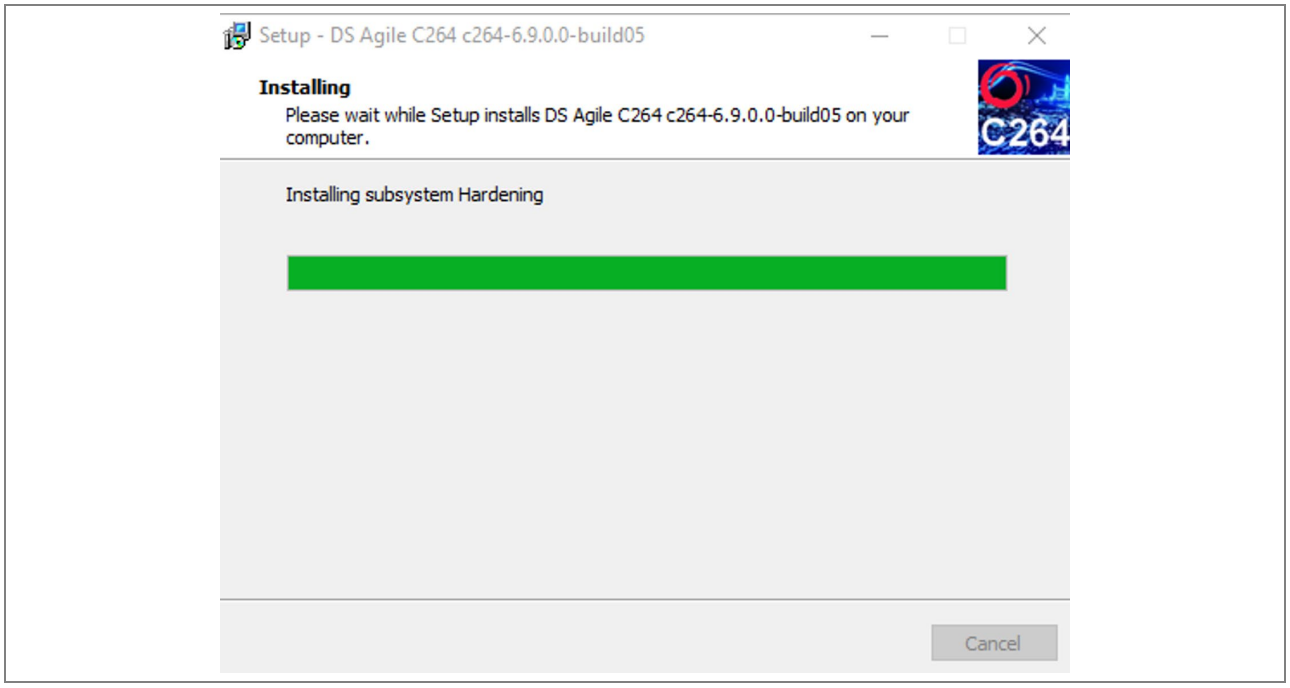
- Accept the License agreement
- Click **Install**



- Click **Close**



18 Wait while subsystem hardening is being installed:



19 Once all files have been copied, tick **Install WinPcap 4.1** if it is not yet installed (older versions should be removed before installation):



Note:
The WinPcap tick-box is not visible if WinPcap is already present on the PC.

20 Click **Finish**.

6.2.3 INSTALLING THE CA ROOT CERTIFICATE

The TLS communications between the PC and the C26x are signed by a digital certificate in order to protect the C26x against data tampering.

It is necessary to pre-install the Certificate Authority (CA) root certificate on the PC before connection.

To find out how to create the CA root public certificate, refer to the **Installation** chapter of the D**S Agile System Secure Deployment guide** (SDG_enM_Xxx.pdf) section "**5.6 Certificates**".

In our example, the CA Root public certificate is CA_DSAgile.pem.

Note: If the PC is part of a Domain, the CA Root certificate may already be installed by the Active Directory. Please check your installation.

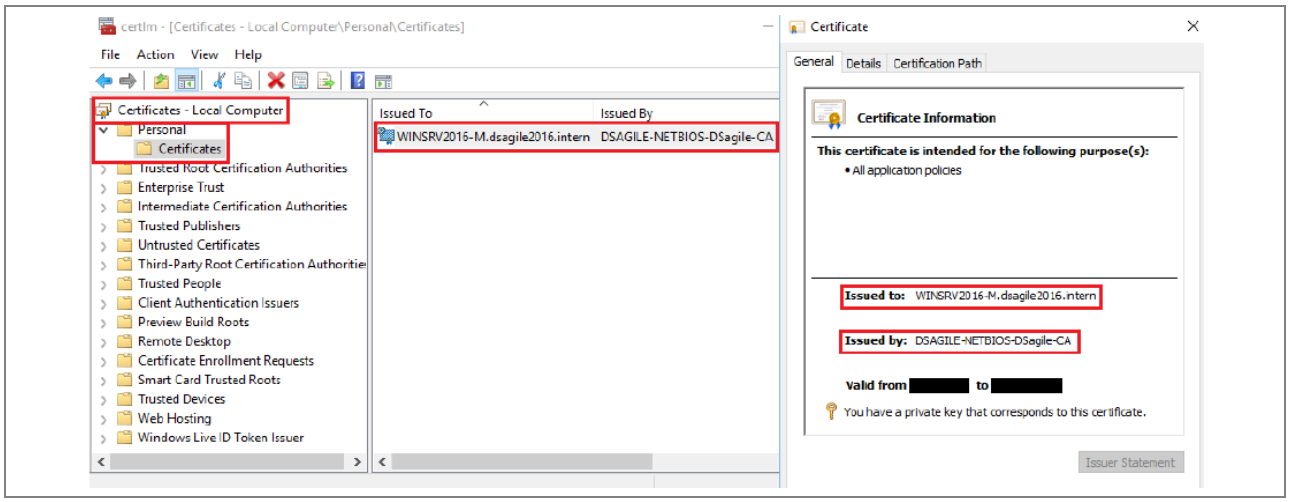
To import the CA Root certificate in "**Local Machine Certificate Store**":

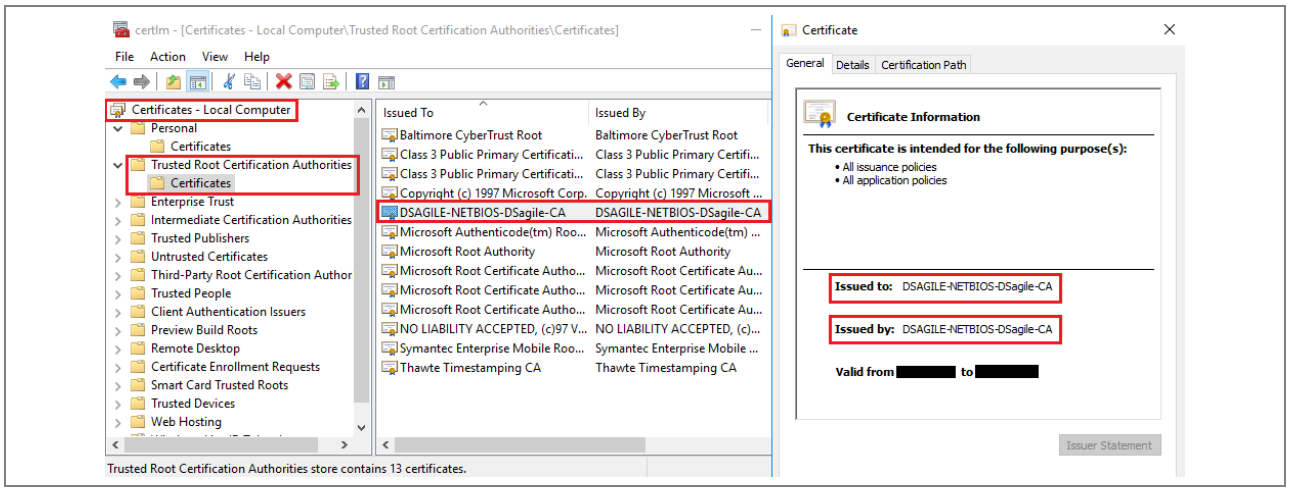
1 Double click on **CA_DSAgile.pem** file.

2 Select "**Local Machine**".

3 Click on "**YES**" or "**Next**" to finishing the import.

4 Run "**certlm.msc**" command to check the certificate in "**Local Machine Certificate Store**":



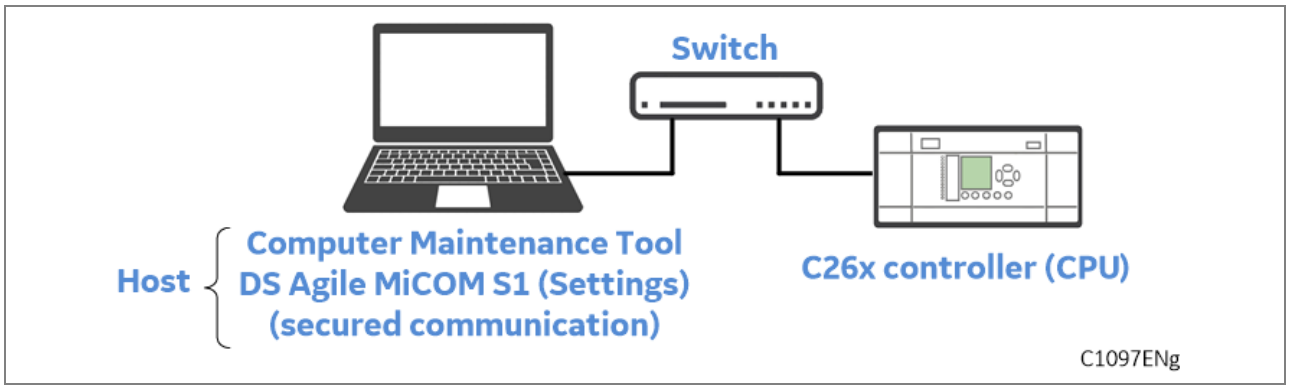


7 C26X MAINTENANCE ENVIRONMENT

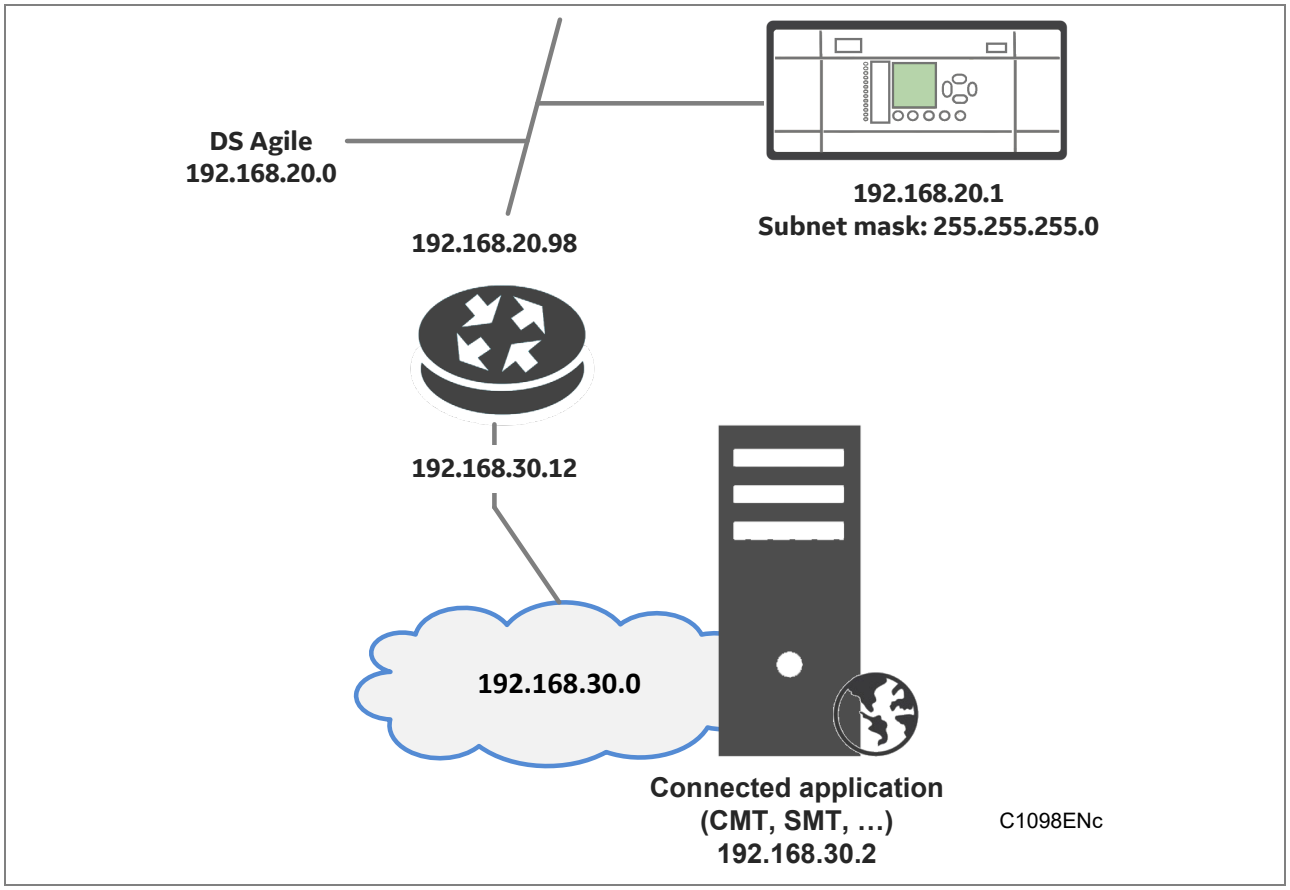
7.1 CONNECTION PC-C26X

The Host PC and the C26x can be IP-connected in various ways:

- point-to-point through a crossover or straight-through Ethernet cable
- through an external Ethernet switch:



- remotely through a router connected to the Station Bus:



The host requires various applications and resources:

Purpose	Application	Protocol	Extra resource	Related chapter
Installation	CMT	–	WinPcap	This chapter
Maintenance		SSH	–	This chapter
Setting	MiCOM S1	socket	–	Setting chapter, in the C624 user manual

The CMT is also used to configure a second Ethernet port on the CPU270 board that can be used for SCADA connection.

A serial (SSH) console can be used to complement the CMT at software installation. Refer to this chapter and the Settings chapter respectively. It uses the serial link (front port and straight-through cable) and provides feedback of installation operations.

7.1.1 COMMUNICATIONS SECURITY

The TLS communications between the maintenance PC and the C26x are signed by a digital certificate in order to protect the C26x against data tampering.

The public certificate is installed on both the PC and the C26x. The private certificate is stored in the C26x's flash memory.

7.2 HOST PC SETTINGS

In the **Control panel**, select **Network connections** and right click to display the **Properties** of the Internet protocol. Type in an IP address and a subnet mask (e.g. 255.255.0.0).

In case of connection through a router, the router IP address and network address are defined in DS Agile SCE (chapter Application of the C264 user manual).

7.3 LAUNCH MODE IN WINDOWS

Once hardening has been applied, the CMT tool is launched with the **DCS_user** account.

8 DS AGILE C26X FIRST POWER UP

Out of factory, the DS Agile C26x has the following default configuration:

- Bootrom start-up software,
- Factory start-up settings

The first step to operations is to upload the target firmware version to the C26x.



Caution:
Before powering up the device all the DI/DO board connectors should be disconnected to avoid unwanted incoming/outgoing signaling.

See the Commissioning Chapter (C26x/EN CM) for tests on how to check that the DS Agile C26x has not been damaged during transport, using its factory settings.

8.1 PREQUISITES

8.1.1 ETHERNET CONNECTIONS

The C26x shall be connected to the network using Ethernet Port #3 for the first power up. Refer to Connection chapter of the C264 user manual.

8.2 FIRMWARE UPDATE

The CPU board must be updated to the version compatible with the system that is being configured, usually the latest firmware version.



Caution:
The procedure to upgrade a CPU270 board to version 6.3.x is different from the procedure that was used to upgrade to version 5.1.x.
ONLY THE UPGRADE TO V6.3.x IS DESCRIBED IN THIS MANUAL.
Refer to *C26x/EN M/C6p* (DS Agile version 5.1.21) if you need to upgrade a board to a previous version.



Caution:
There is no backward compatibility: You cannot “downgrade” a CPU270 board from version 6.3.x to an older version.

In order to upgrade boards, it is necessary to install 2 versions of the CMT software:

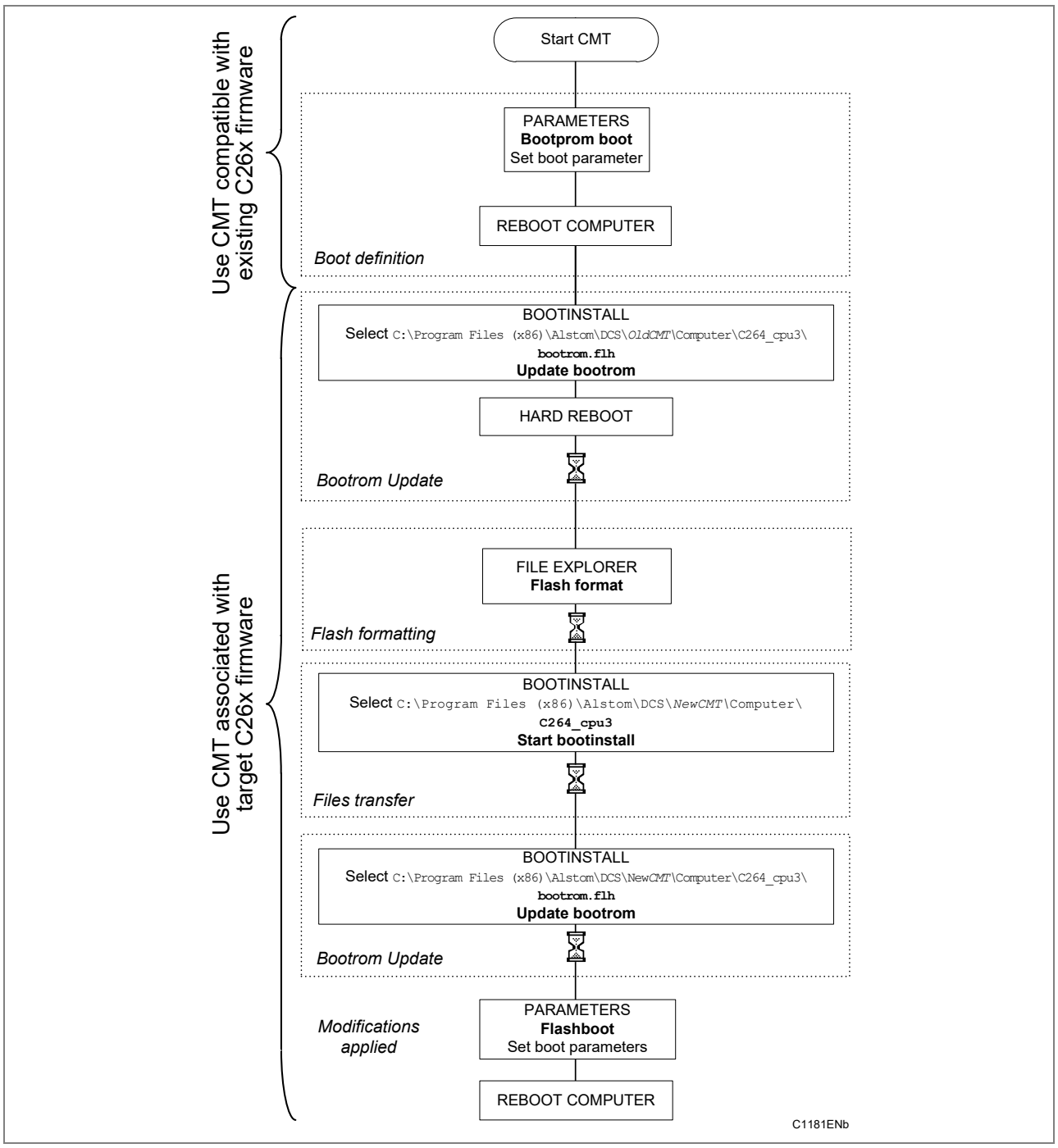
- the CMT version associated with the current C26x firmware,
- the latest CMT version.

For the PC to be able to run 2 different versions of the CMT software, the 2 versions must be installed in different sub-directories of `C:\Program Files (x86)\Alstom\DCS`. The default path is normally called `C:\Program Files (x86)\Alstom\DCS\CMT\Computer`. This can be changed during the installation of the software.

The recommended installation paths are:

- For “old” CMT: `C:\Program Files (x86)\Alstom\DCS\OldCMT\Computer\Cmt`
- For “new” CMT: `C:\Program Files (x86)\Alstom\DCS\NewCMT\Computer\Cmt`

The process is summarized below:



Note:
The user needs to be familiar with the CMT interface in order to proceed with this section.
Refer to section ***11 Appendix: CMT in-depth description*** at the end of this chapter if needed.

8.2.1 BOOTROM/FIRMWARE VERSIONS

If the bootrom version is not already compatible with the firmware to be used, it must be updated.

(Bootrom and Bootprom have the same meaning)

Compatibility matrix

C26x firmware version	Bootrom version
B5.xx: lower than or equal to 13	B0.12 and below
B5.xx: higher than or equal to 14	B0.14 or B0.15 and above
B6.xx: lower than or equal to 32	B0.14 / B0.15 / B0.17 and B0.21B
B6.xx: 33 to 37	B0.21D
B6.xx: 38 to 43	B0.21E and above
B6.xx: 44 to 53	B0.21G and above
B6.xx: higher than or equal to 54	B0.21H and above
c264-5.0.4.0 to c264-5.0.5.0	B0.21J
c264-5.1.0.0 to c264-5.1.10.0	B0.51H
c264-5.1.11.0 to c264-5.1.14.0	B0.51I
c264-5.1.15.0	B0.51K
c264-5.1.16.0 to c264-5.1.17	B0.51L
c264-5.1.18.0	B0.51M
c264-5.1.19.0 to c264-5.1.24	B0.51N
c264-6.0.x	c264_bsp-6.9.0.6
c264-6.1.x	c264_bsp-6.9.1.x

8.2.1.1 CYBER-SECURITY IMPLEMENTATION

Cyber-security is implemented as of c264-5.1.x releases:

C26x release label	Bootrom version label
c264-5.1.x: c264-5.1.0.0 and higher	B0.51H and higher

Therefore:

- CPU270 boards with previous firmware versions can be accessed freely from the compatible CMT application.
- A login and password will be required to access CPU270 boards with cyber-security:
  - Default values for bootrom versions B0.51H and above:
    login: **Root**, password: **psw@C264-1.0**
  - Default values for bootrom versions c264_bsp-6.9.1.9 and above:
    login: **Root**, password: **Root1234#**.

8.2.1.2 CHECK THE BOOTROM VERSION OF THE C26X CPU3 (I.E. CPU270) BOARD

1 Launch the “old” CMT

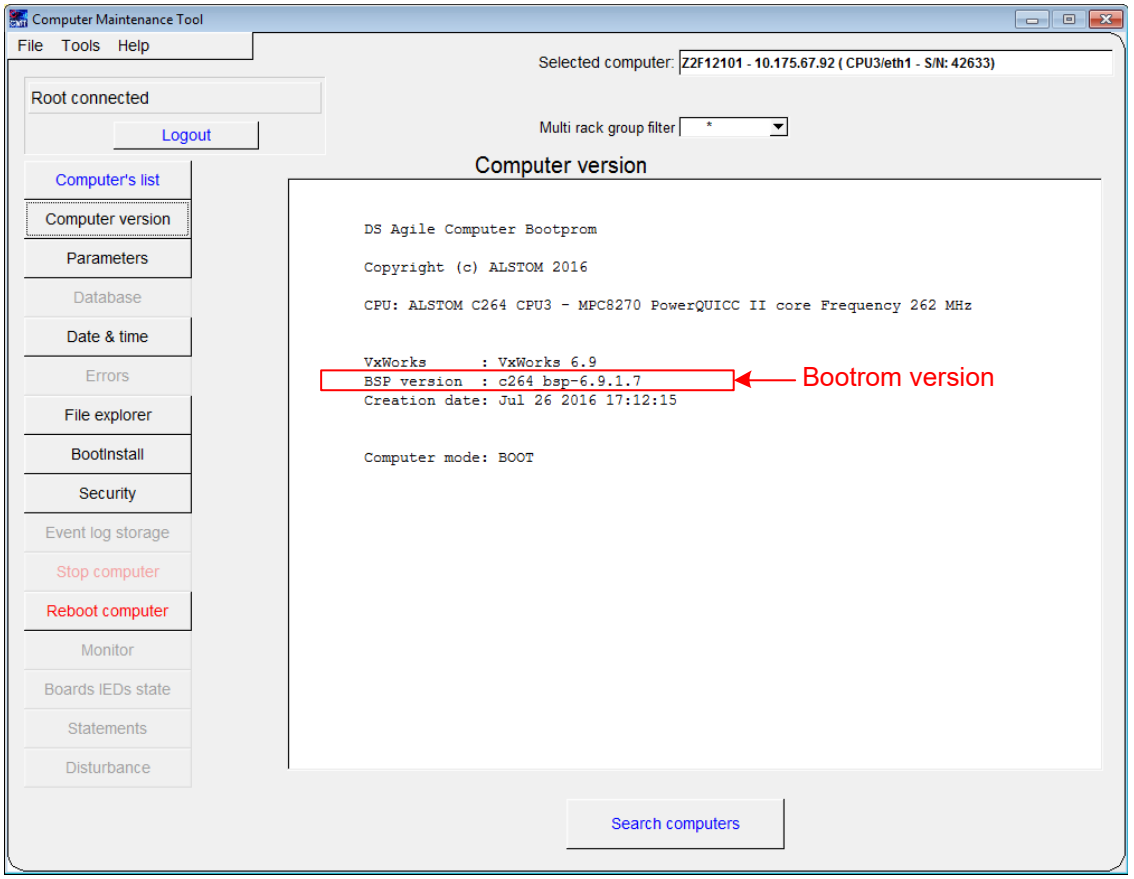
2 Select the C26x in the **Computer's list**

3 Login and accept disclaimer (firmware with cyber-security only)

4 Click the **Computer version** button.

Note:
If you cannot access the C26x, it could be because you are using an incompatible CMT version, for instance you could be trying to login to a non-cyber-secured board from a cyber-secured CMT or vice-versa. Switch to the other CMT version and try again.

The bootrom version is indicated on the line beginning with **BSP version**.



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8.2.1.3 LABEL ON THE CPU BOARD

The CPU board has a label on the solder side, indicating the version of the bootrom installed on it by the manufacturer:



Bootrom version label on CPU board

Note:
If the bootrom version has been changed, it is strongly recommended to replace or cover the label with a new one that indicates the actual bootrom version.

8.2.2 PRELIMINARY CHECKS

Caution:
The checks listed below are important, DO NOT SKIP THEM.

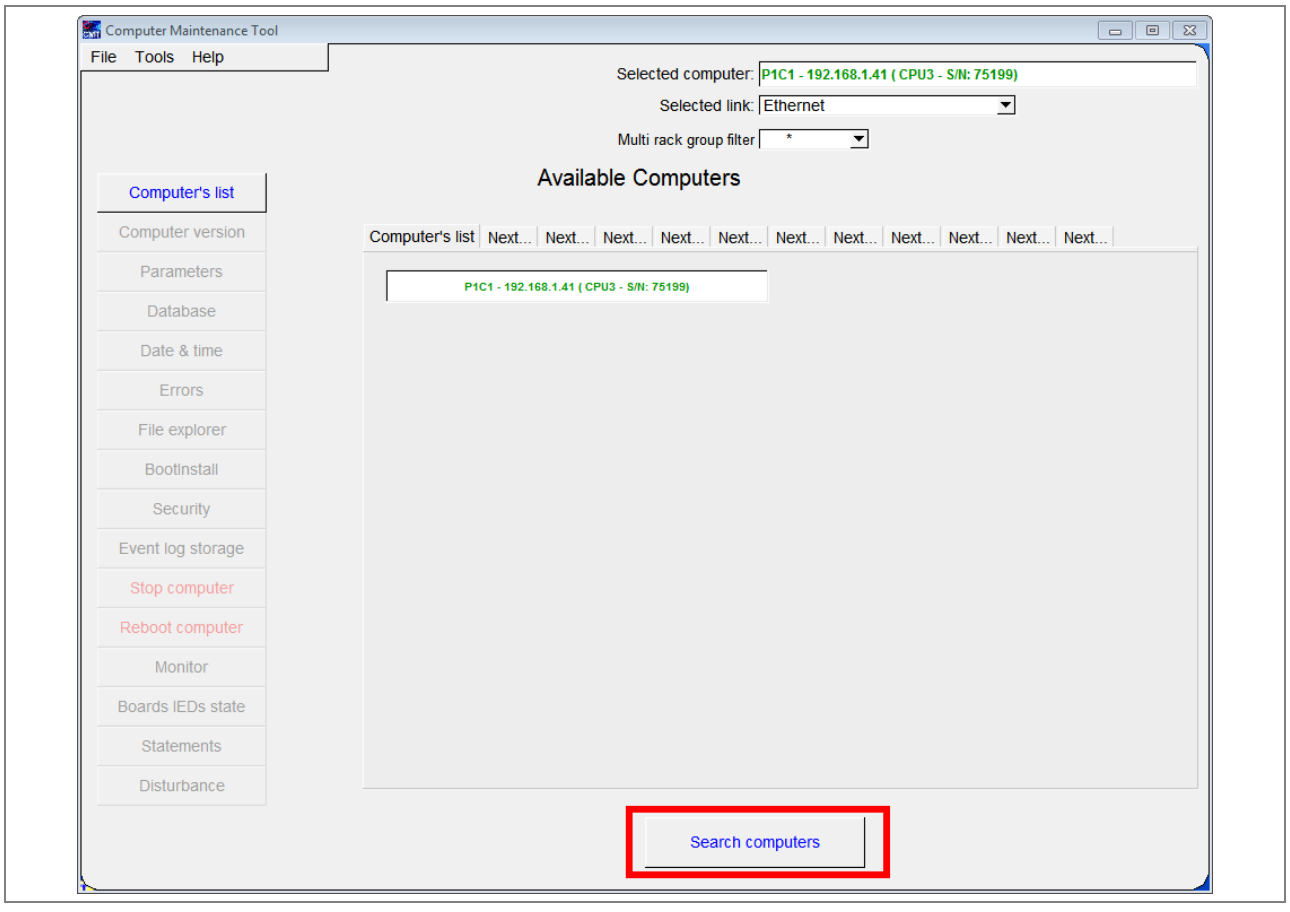
- The IP address of the PC running the CMT application and the IP address of the C26x must be in the same range (the first 3 bytes must be identical).
- Only one Ethernet board must be active. If the PC is fitted with more Ethernet boards, disable them and keep only the board used by the CMT application. To check which Ethernet board is used by the CMT application, press **F3**.

8.2.3 CPU270 BOARD REBOOT AND SET-UP

1 Launch the compatible CMT (“old CMT”) application:

Click the Computer Maintenance Tool shortcut icon  .

2 Click the **Search computers** button and wait a couple of minutes until a label with an IP address is displayed in the **Computer’s list** tab-pane.



If there is no device in the list, the cause may be one of these:

- your PC does not have an IP address
- your PC has several Ethernet cards: In that case, select the menu **File > Network interface** and switch to the correct card.

Note:
Because you will need to perform a Flash Boot, make sure that any other Ethernet cards present on the PC are disabled.

Procedure

1 Select your C26x in the list

2 *For boards with cyber-security only, i.e. bootrom version starting at B0.51H:*

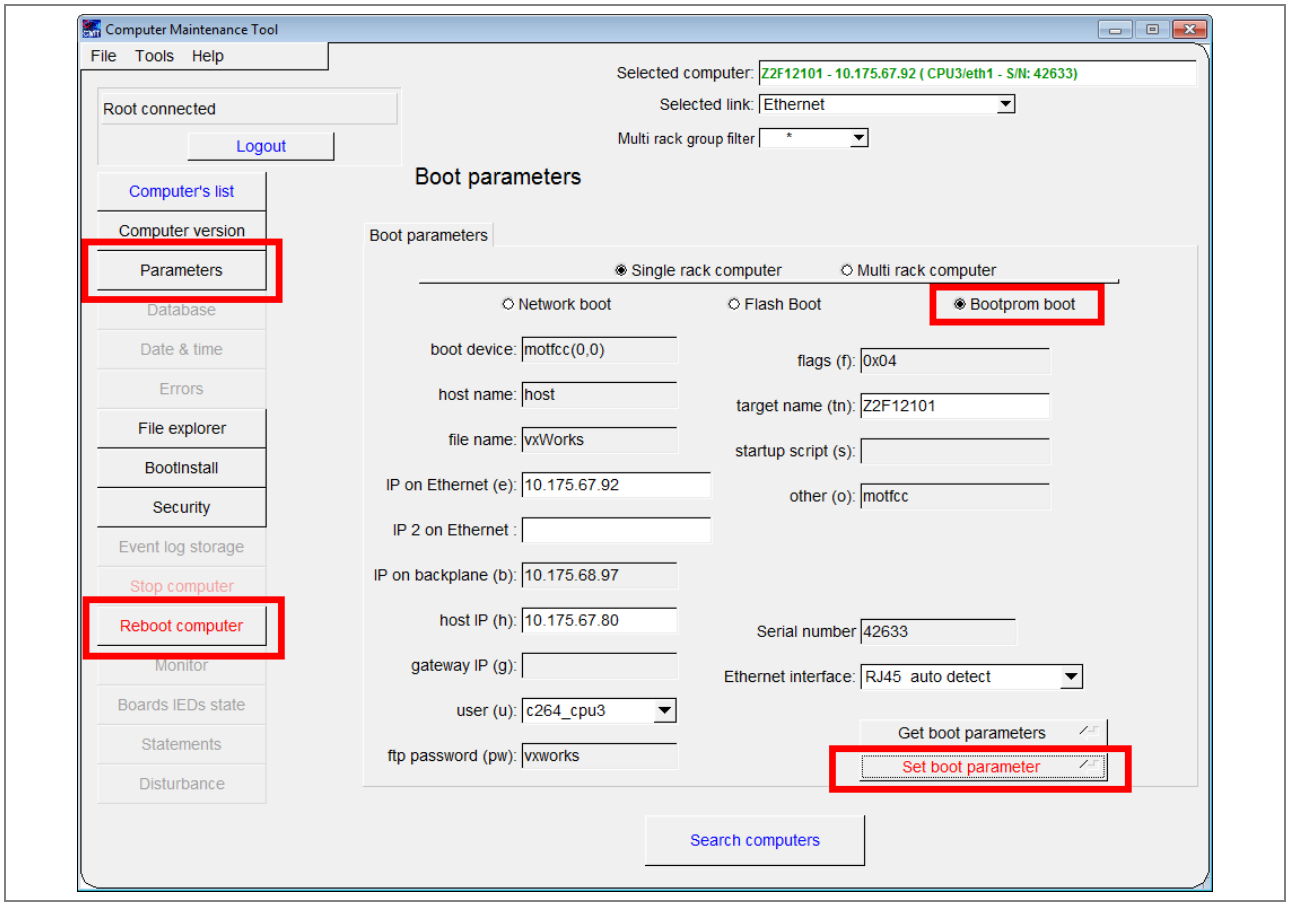
d Login using the login and password of a user with the system administrator role (the default login/password combinations are given in section *8.2.1.1 Cyber-security implementation*).

e Accept the disclaimer.

(Skip these steps if the bootrom version is B0.21 or older.)

3 Click the **Parameters** menu button

4 Select the *Bootprom boot* option



5 Enter:

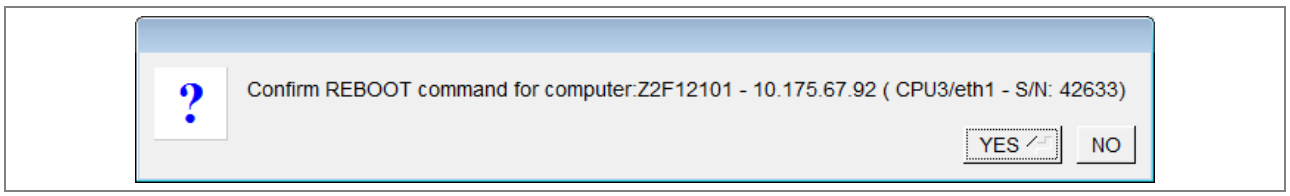
- **IP on Ethernet (e)** and type in the Ethernet address you have chosen for the C26x
- **host IP (h)** and type in the Ethernet address of the PC that hosts CMT. Depending on the firewall configuration, it must be in the same subnetwork as **IP on Ethernet (e)** (firewall disabled) or **IP 2 on Ethernet** (firewall enabled).

  See section ***10 Firewall usage*** for maintenance port configuration, depending on whether the firewall is enabled.
- **target name (tn)** and type in a name for the DS Agile C26x

Note:
Do not use IP addresses with 254 as the last number.
IP on Ethernet (e) *and* ***IP 2 on Ethernet*** *are set in different subnetworks.*

6 Click the button **Set Boot Parameters** in order to send the new parameters to the C26x.

7 Select **Reboot Computer** to restart the C26x.



8 Click **Yes** to confirm.

The label becomes red for a while. The C26x restarts with the software installed on the PC. In the event of a failure, **experts** may type `reboot` in the Telnet or SSH terminal (depending on which version is currently running), and then press any key to prevent the C26x from stopping.

8.2.4 FIRMWARE INSTALLATION (BOOTROM UPDATE)

This procedure applies to all compatible boards, after they have been rebooted and set-up. This procedure should be done using a CMT version associated with the C26x's target firmware.

Note:
The default login/password combinations are given in section 8.2.1.1 Cyber-security implementation.

8.2.4.1 FIRMWARE UPDATE

In the "old" CMT application:

1 *With cyber-security firmware only:* If you are logged in, log out first (click **Logout** under your login name).

2 Click the **Search computers** button to find your C26x.

3 Select your DS Agile C26x in the list.

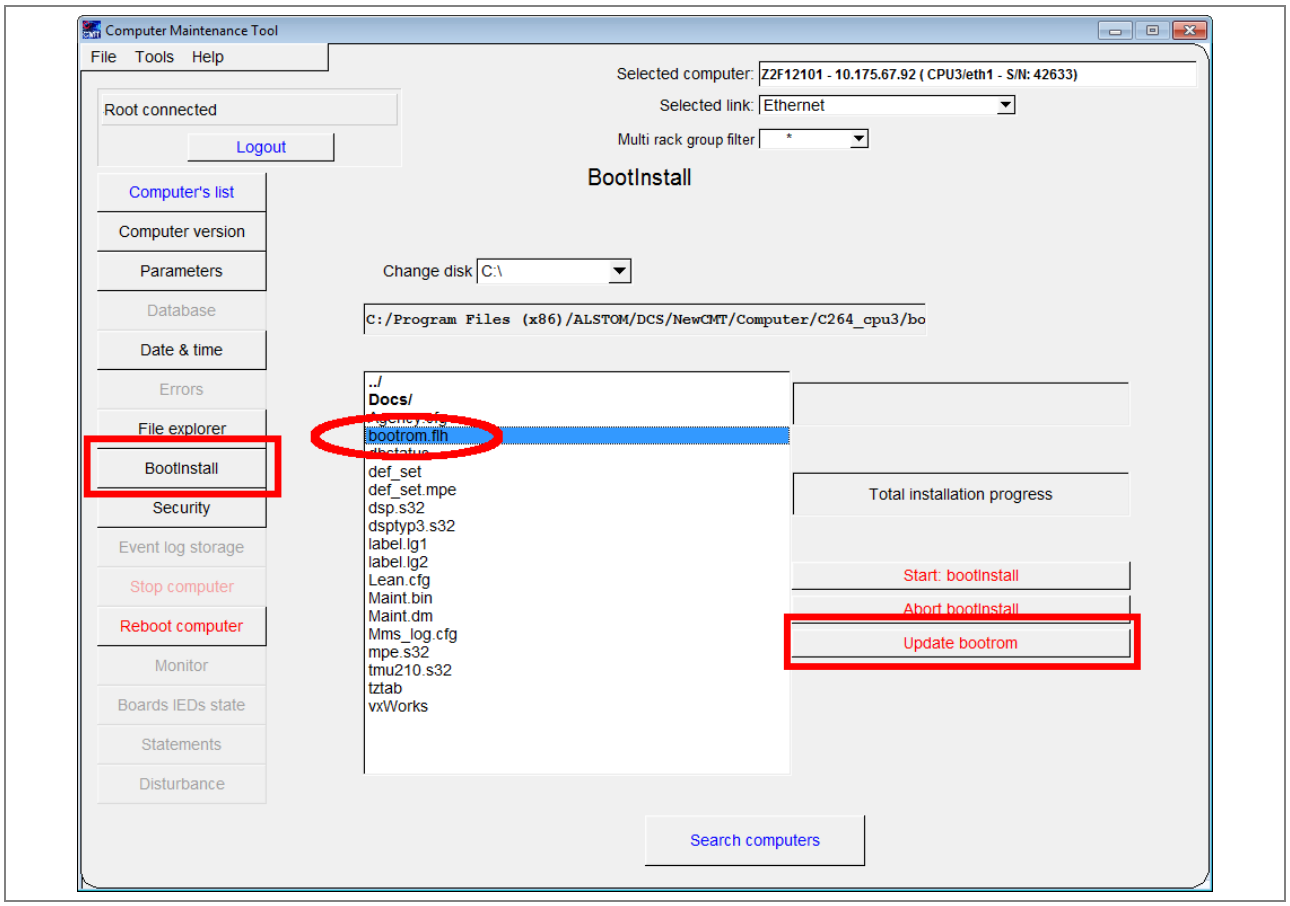
4 *With cyber-security firmware only:*

a Login using an account with the *System administrator* role.

b Read the disclaimer, and then click **Accept**.

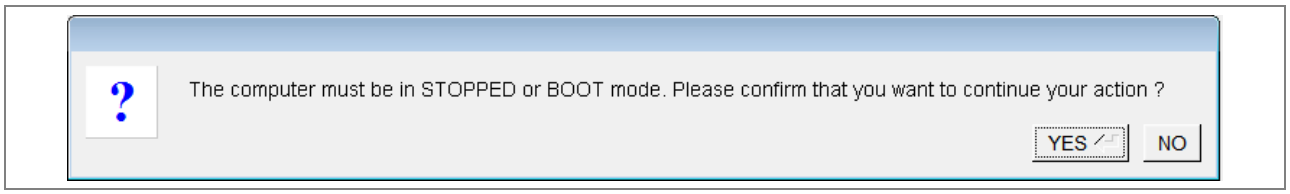
5 Click the **BootInstall** menu button.

6 Locate and open the “new” **C26x_cpu3** directory for the **CPU270** board (in our example: `C:/Program Files (x86)/ALSTOM/DCS/NewCMT/Computer/c264_cpu3`).



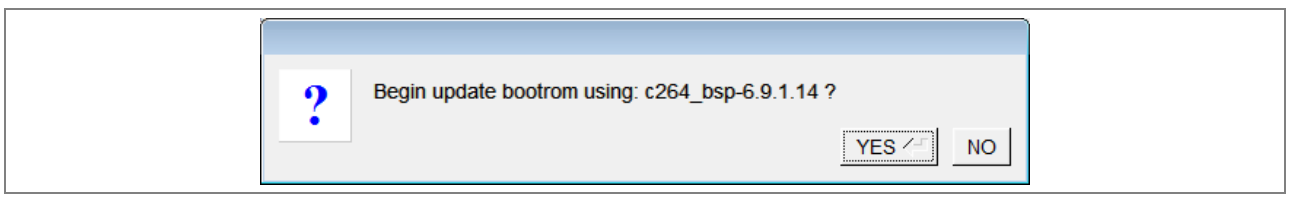
7 Click **Update bootrom**.

This message may be displayed if the board has been used before:



8 Click **YES** if prompted.

This message is displayed:



9 Click **YES**.

Messages indicating the progression of the installation are displayed.

Wait until **Update bootrom: OK** is displayed.

If there were error messages during the update, reboot the C26x and restart the bootrom update.

10 Perform a **"hard reboot"**, i.e. remove the power supply and re-apply it.

The C26x will take several minutes to restart.



Caution:
Clicking the CMT's "Reboot computer" button is NOT sufficient.
You MUST disconnect and then reconnect the power supply.

8.2.4.2 ERASE AND FORMAT FLASH MEMORY

After the C26x has restarted from a **"hard reboot"**:

1 Close the "old" CMT.

2 Launch the "new" CMT.

3 Click the **Search computers** button to find your C26x.

4 Select your C26x in the list.

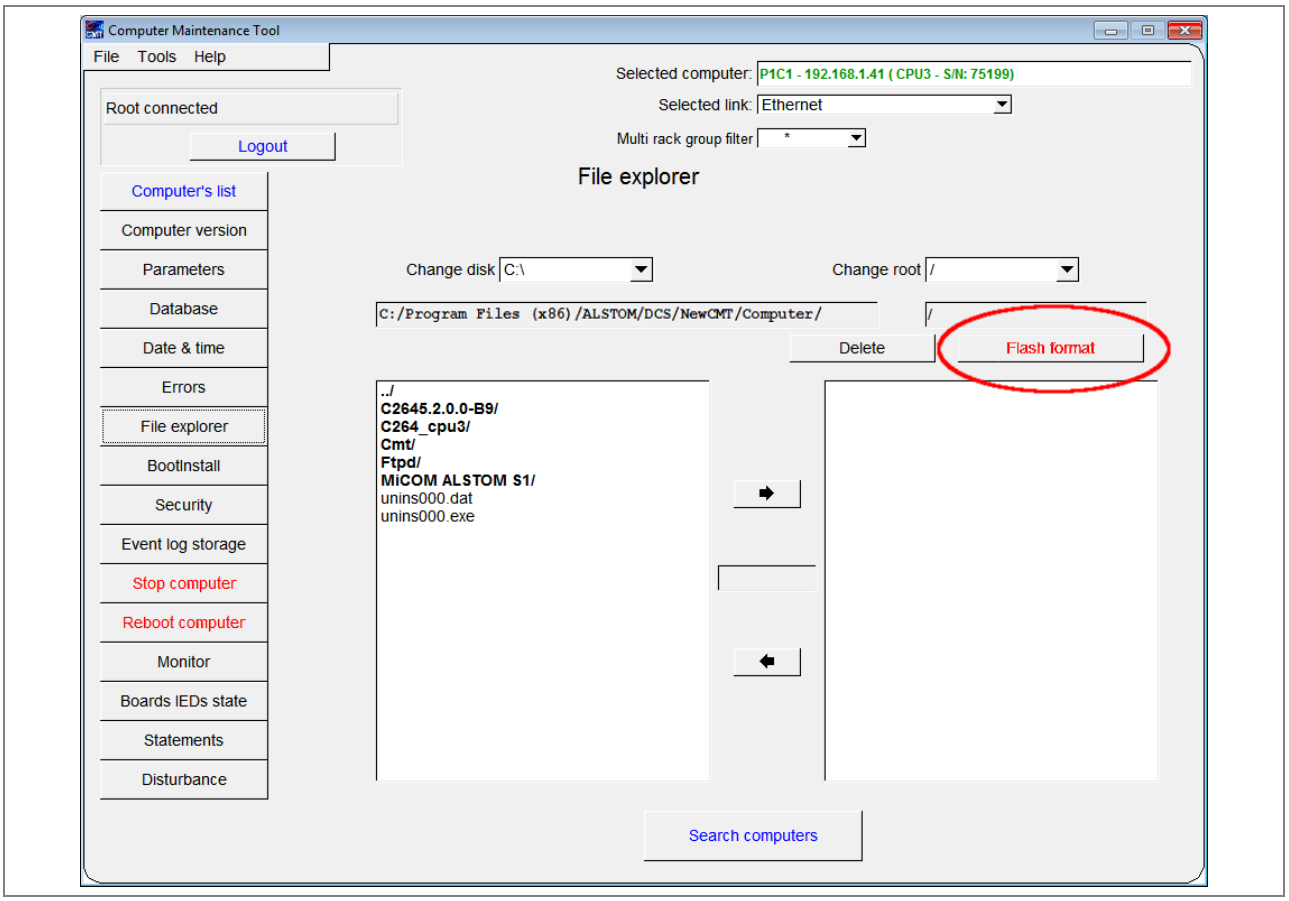
5 Login using an account with the *System administrator* role
(default as of bootrom version *c264_bsp-6.9.1.9*: Login: *Root*, Password: Root1234#).

6 Read the disclaimer, and then click **Accept**.

7 Click the **Computer version** menu button and verify that the C26x's version is as expected the newly installed version.

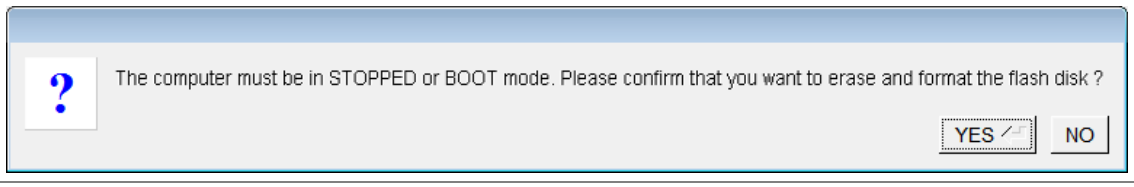
8 Click the **Parameters** menu button and verify that the C26x is in *Bootprom boot* mode:
Select ◉ Bootprom boot and then click **Set boot parameter**.

9 Click the **File explorer** menu button.



10 Click **Flash format**.

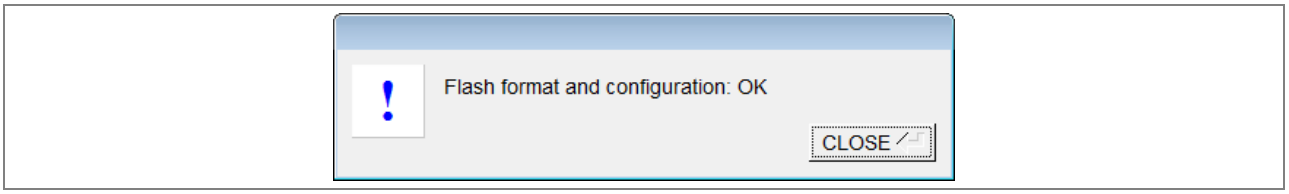
The following message is displayed:



11 Click **YES** to confirm.

Progress information messages are displayed during the update, which takes a few minutes to complete.

Wait until the completion window is displayed:



12 Click **CLOSE** to confirm.

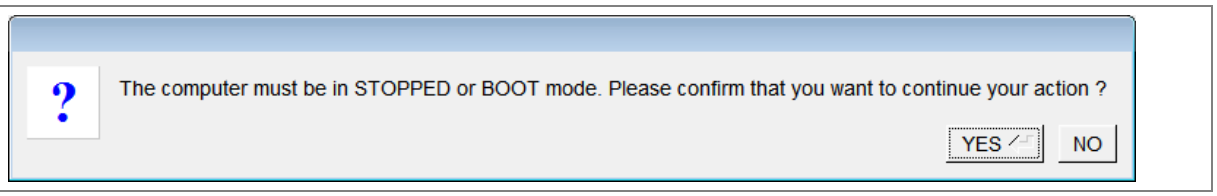
8.2.4.3 BOOTINSTALL

In the CMT application:

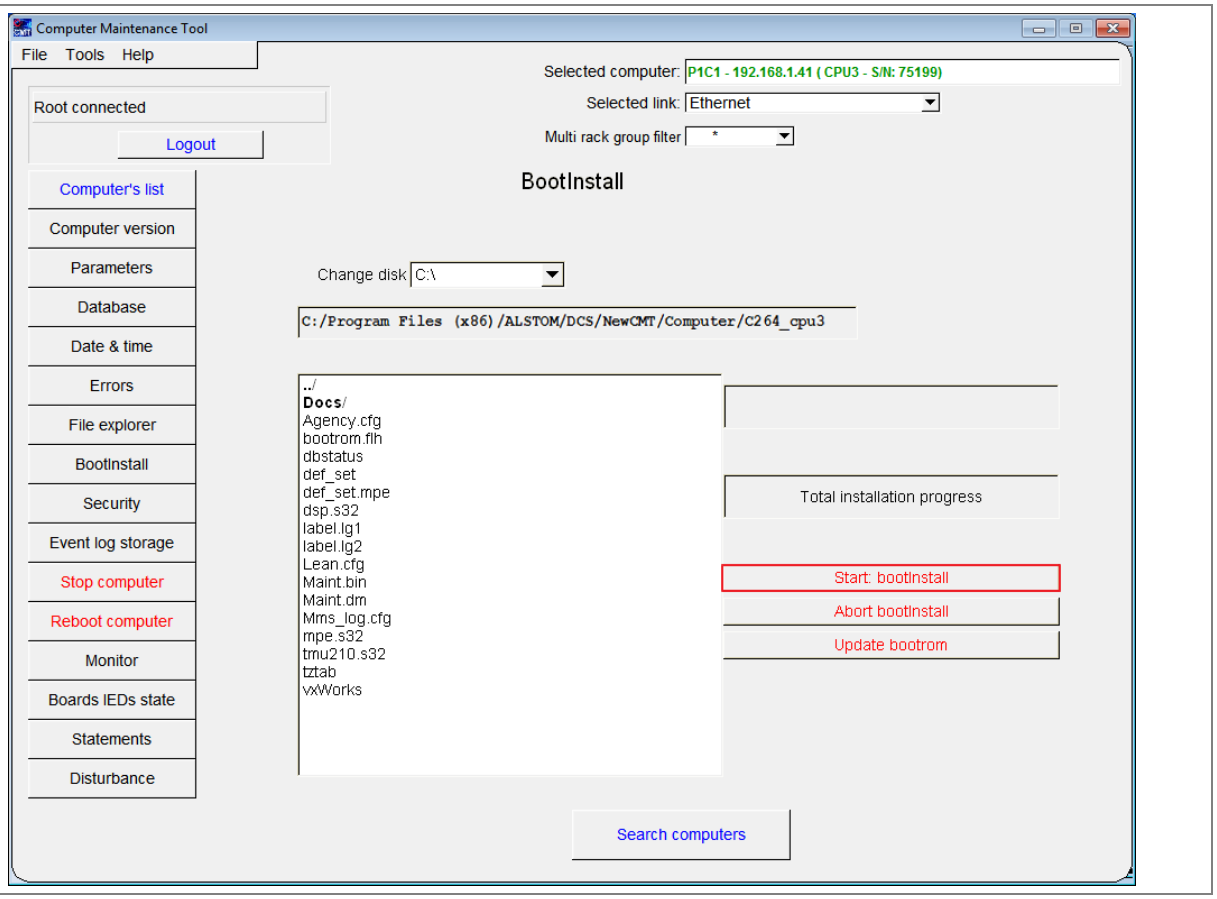
1 Click the menu button **BootInstall**.

2 Find the **C26x_cpu3** directory containing the **CPU270** board's new firmware (in our example: `C:/Program Files (x86)/ALSTOM/DCS/NewCMT/Computer/c264_cpu3`).

If this message is displayed:

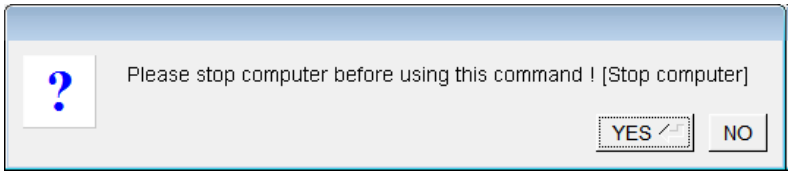


Click **YES**.

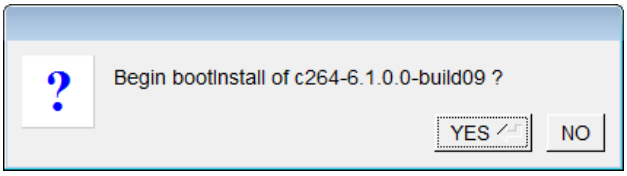


3 Click **Start bootInstall**

This message may appear:



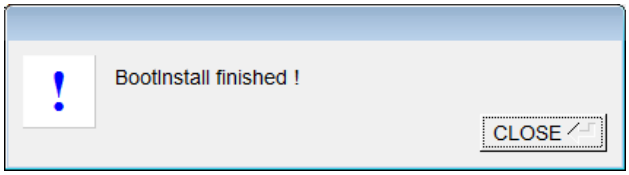
Click **NO**.



4 Click **YES**.

Progress information messages are displayed during the update.

Wait until this completion window is displayed:



5 Click **CLOSE**.

8.2.4.4 BOOTROM UPDATE

Note:
Updating the bootrom again is necessary in order to copy the "hashlistBooFiles" file.

1 Click the **Search computers** button to find your C26x.

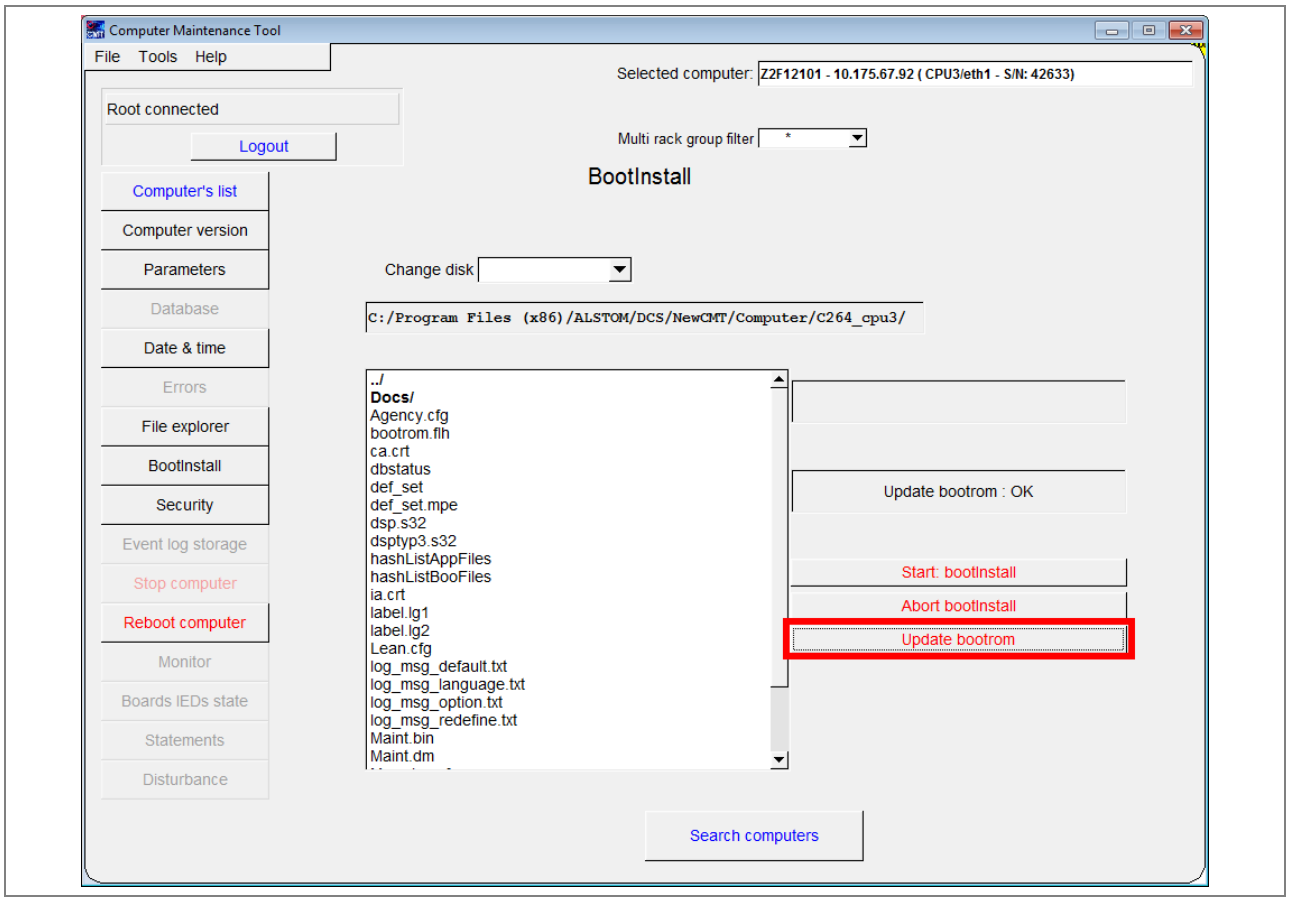
2 Select your C26x in the list.

3 Login using an account with the *System administrator* role
(default as of bootrom version *c264_bsp-6.9.1.9*: Login: *Root*, Password: Root1234#).

4 Read the disclaimer and then click **Accept**.

5 Click the menu button **BootInstall**.

6 The **C26x_cpu3** directory containing the **CPU270** board's new firmware (in our example: `C:/Program Files (x86)/ALSTOM/DCS/NewCMT/Computer/c264_cpu3`) should already be selected.



7 Click **Update bootrom**

Wait until the C26x is ready:

- The service panel is displayed on the front panel LHMI, or
- The CMT displays the message “Update bootrom : OK” above the button **Start: bootinstall**, or
- Experts may also check the shell messages.

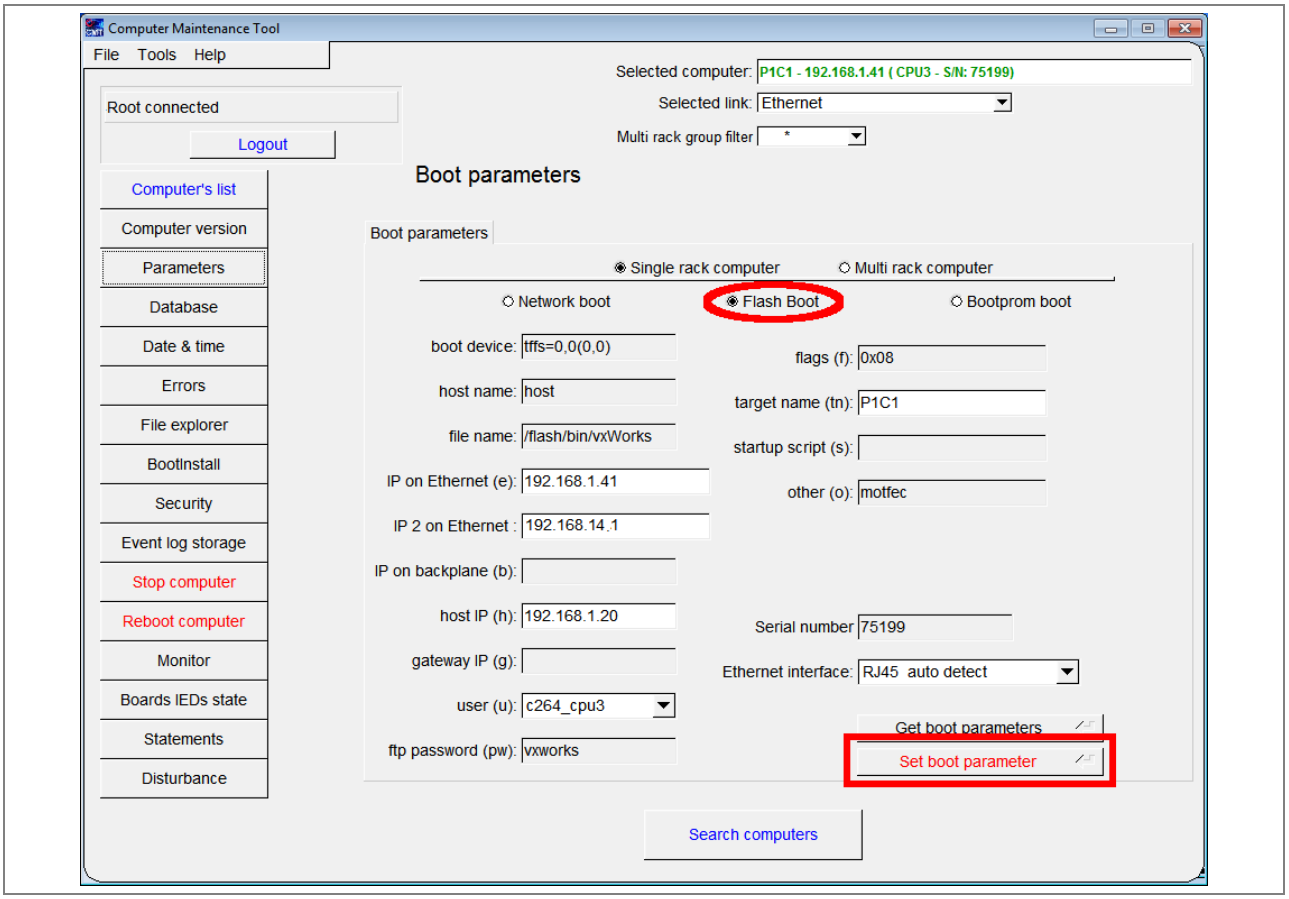
8.2.5 FINAL STEPS

Caution:
If you uninstall the "Old CMT", registry keys needed by the "New CMT" will be deleted and you will need to re-install the "New CMT" afterwards.

8.2.5.1 SET THE C26X PARAMETERS

1 Click the **Parameters** menu button.

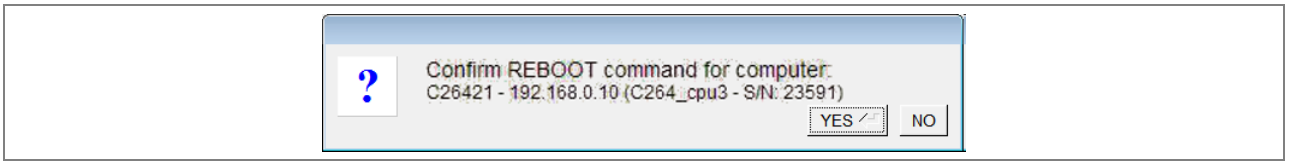
2 Select *"Flash Boot"*, and then click **Set boot parameter**.



Note:
The value of IP 2 on Ethernet may be lost after the restart. Re-enter it if necessary

8.2.5.2 RESTART THE C26X

Reboot the C26x (Click the **Reboot computer** menu button)



8.2.6 CHANGE THE HOST IP ADDRESS

If MiCOM S1 is used, change to Host IP (h) address to the address of the PC hosting MiCOM S1.

8.2.6.1 SECURE THE MAINTENANCE PORT

The bottom flap cover of the front panel must be secured using a numbered, tamper-evident, security seal in order to indicate any unauthorised attempt to access the maintenance serial port located behind it.



Caution:
Some security seals may contain hazardous materials such as soft lead.
Strictly follow the manufacturer's safety instructions when handling them.

9 OPTIONAL INSTALLATION

Optional hardware modules include:

- IRIG B connection
- Printer

9.1 EXTERNAL MASTER CLOCK CONNECTION

With the option of the CPU board, an external standard BNC connection is used to receive external master clock synchronisation. The recommended external master clock is the **hopf** 6870 radio clock.

Installation should follow the standard rules of BNC cable installation including length limit and optional 50 ohm termination.

For installation of the external master clock, refer to its documentation and to the summary in the DS Agile/EN IN chapter.

External IRIG B synchronisation should be configured in the C26x database.

9.2 PRINTER INSTALLATION

A printer can be installed permanently for the SOE, or temporally for commissioning/ maintenance use. Data labelling is defined with DS Agile SCE.

The printer should be connected to port 1, 2, 3 or 4 of the C26x.

If the port is on the BIU board, the board has to be configured for RS232 by using the correct jumper configuration.

Furthermore, a configuration file (included in database) has to be installed onto the C26x with the printer communication parameters.

10 FIREWALL USAGE



Caution:
This feature is not available in C264-Standalone (RTU) configurations.

The configuration database used by the C26x contains a parameter, called “Firewall usage” that, when enabled, changes the purpose of the 2 Ethernet ports on the CPU270 board, so that the Maintenance PC can be connected via a separate network, isolated from the station bus.

Note:
The Firewall usage function cannot be enabled or disabled using the CMT nor using MiCOM S1, that can ONLY be done using the SCE, i.e. A NEW DATABASE MUST BE UPLOADED IF A CHANGE IS REQUIRED.

10.1 ALLOCATION OF CPU270 ETHERNET PORTS

Depending on whether firewall usage is enabled or disabled, the Ethernet ports on the CPU270 have different uses: The maintenance port is normally Ethernet 1 when the firewall is disabled and Ethernet 2 when it is enabled.

However, the switch between maintenance port configurations only occurs after a reboot and if the firewall usage setting in the active (“current”) database does not match the current port configuration. The default port configuration is “firewall disabled”, i.e. the maintenance PC is connected to Ethernet 1.

Cases

- New board: The maintenance port remains Ethernet 1 until a first database with “firewall enabled” is uploaded, activated, and the board has rebooted.
- Between a database switch and a reboot: The port configuration remains unchanged until the C26x reboots (it will take the new database configuration after the reboot).
- After a reboot: The port configuration is as defined in the active (“current”) database.
- After a database clean-up: The port configuration remains unchanged until a new database is uploaded, activated, and the C26x has rebooted.

Note:
If a CPU270 board with Ethernet 2 maintenance port is left without power (stored) for more than 10 days, the maintenance port may revert to its default setting: Ethernet 1, even if the board contains a database in which the firewall is enabled. If that happens, the board must be rebooted for the maintenance port to be set to Ethernet 2 again.

10.1.1 FIREWALL DISABLED

In normal operating mode, i.e. operational database active and maintenance port setting implemented by a C26x reboot,

Ethernet port 1 is used for

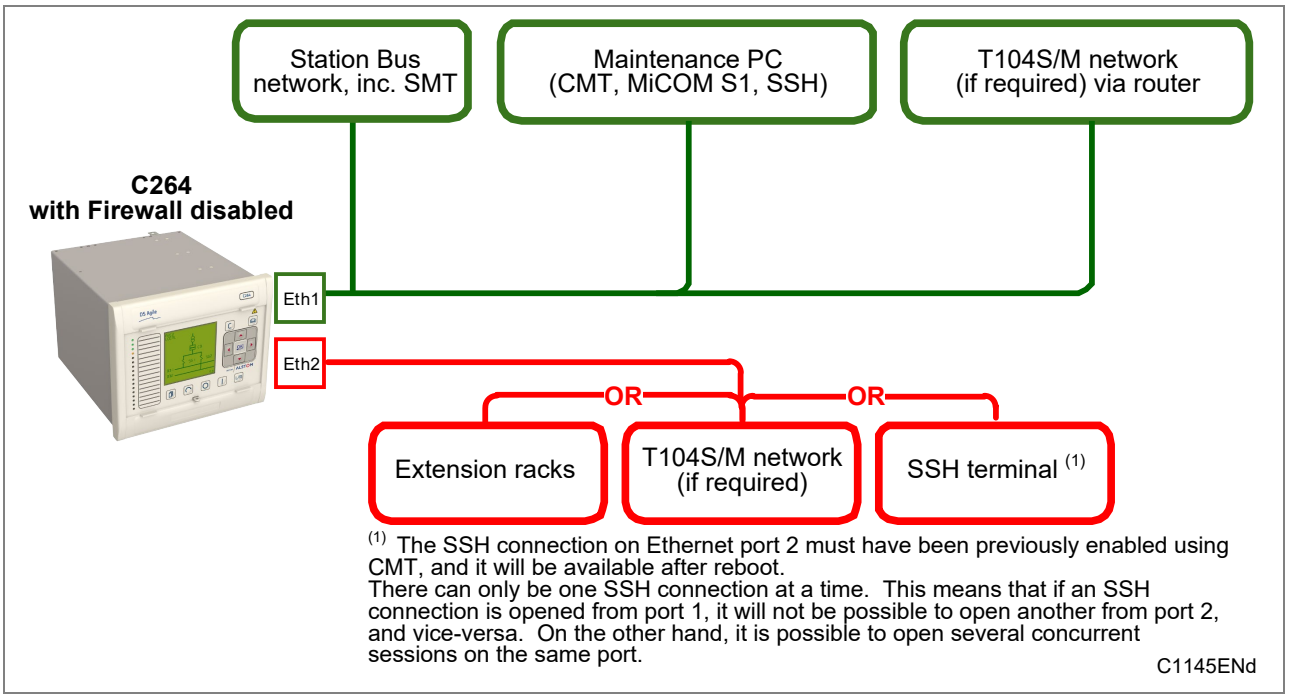
- SBUS connection,
- maintenance operations,
- optionally T104 slave/master connection (through router or station bus),

Ethernet port 2 can be used for

- RTU mode,
- connection of subrack network in a multirack architecture,
- T104 slave/master connection

Note:
Host IP *(address of the maintenance PC) must be set in the same sub-network mask as* ***IP on Ethernet*** *(Ethernet port 1).*

Possible IP connections when the Firewall is disabled in the current database



10.1.2 FIREWALL ENABLED

Note:
When the firewall is enabled, the IP addresses are filtered so that Ethernet port 2 is reserved for maintenance access. Therefore, THE FIREWALL IS NOT COMPATIBLE WITH MULTIRACK ARCHITECTURES.

In normal operating mode, i.e. operational database active and maintenance port setting implemented by a C26x reboot,

Ethernet port 1 is used for

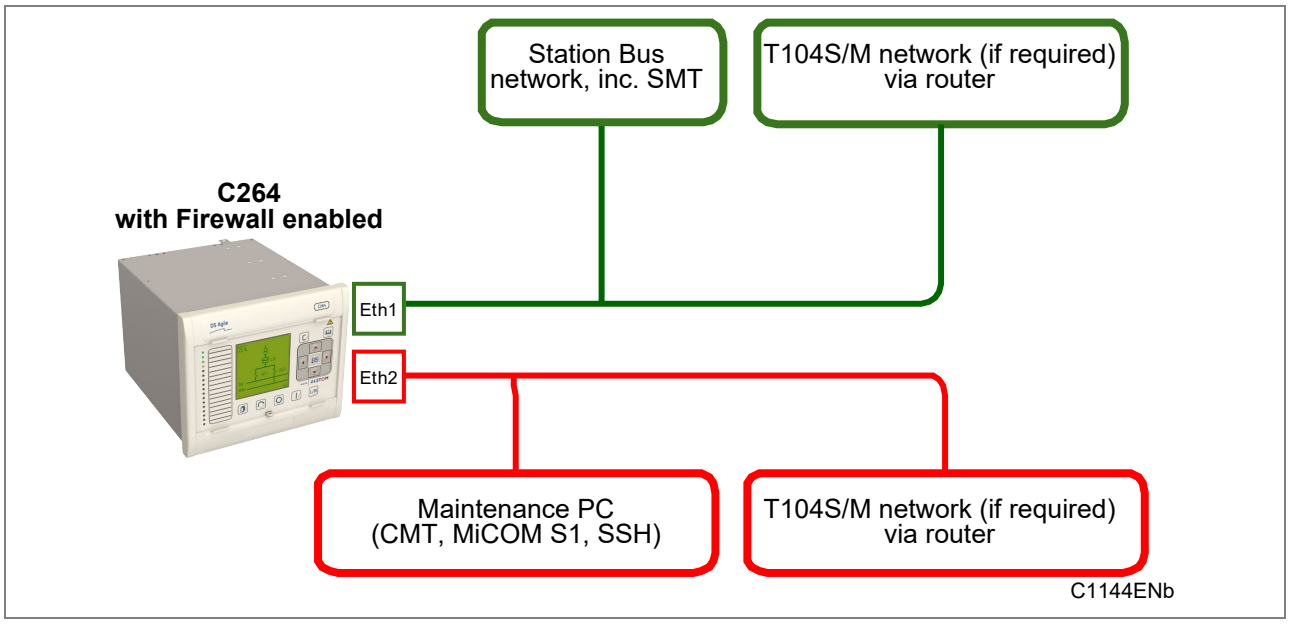
- SBUS connection,
- optionally T104 slave/master connection (through router or station bus),

Ethernet port 2 is used for

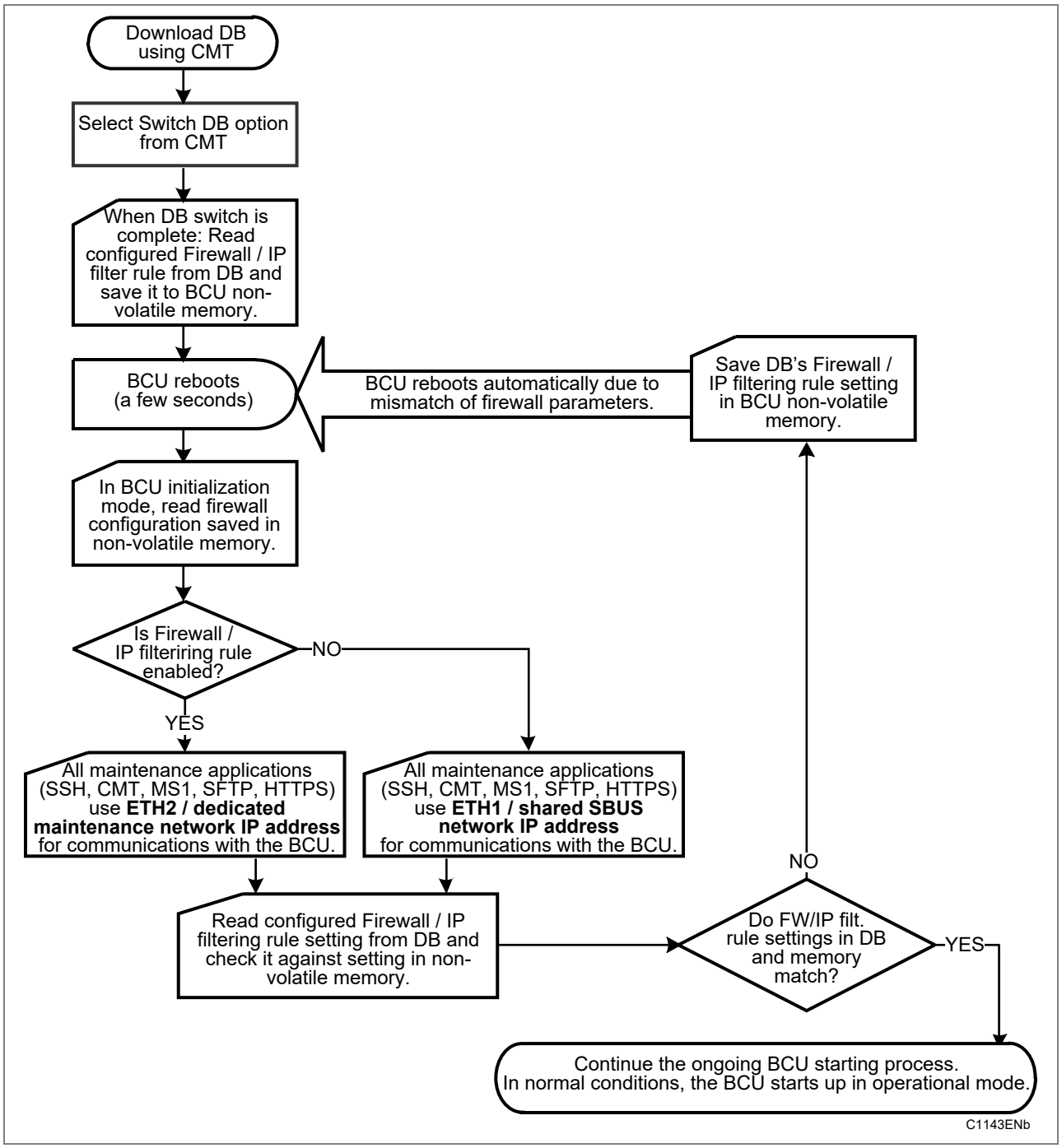
- maintenance PC connection:
  - CMT,
  - SSH,
  - MiCOM S1
- optionally T104 slave/master connection (through router)

Note:
***Host IP** (address of the maintenance PC) must be set in the same sub-network mask as **IP 2 on Ethernet** (Ethernet port 2).*
***IP on Ethernet** (Ethernet port 1) and **IP 2 on Ethernet** (Ethernet port 2) should have different subnet masks so as not to be able to communicate with each other.*

Possible IP connections when the Firewall is enabled in the current database



10.2 START-UP PROCESS WITH REGARD TO FIREWALL USAGE



11 APPENDIX: CMT IN-DEPTH DESCRIPTION

11.1 COMPUTER MAINTENANCE TOOL (CMT) OVERVIEW

11.1.1 GENERAL

The Computer Maintenance Tool provides a user-friendly way to maintain DS Agile C26x devices. Typing commands in the device's shell is not required; the graphical interface does main operations.

The CMT runs on Personal Computers (PC) using Windows 10 LTSB 2016 for Enterprise 64-bits edition.

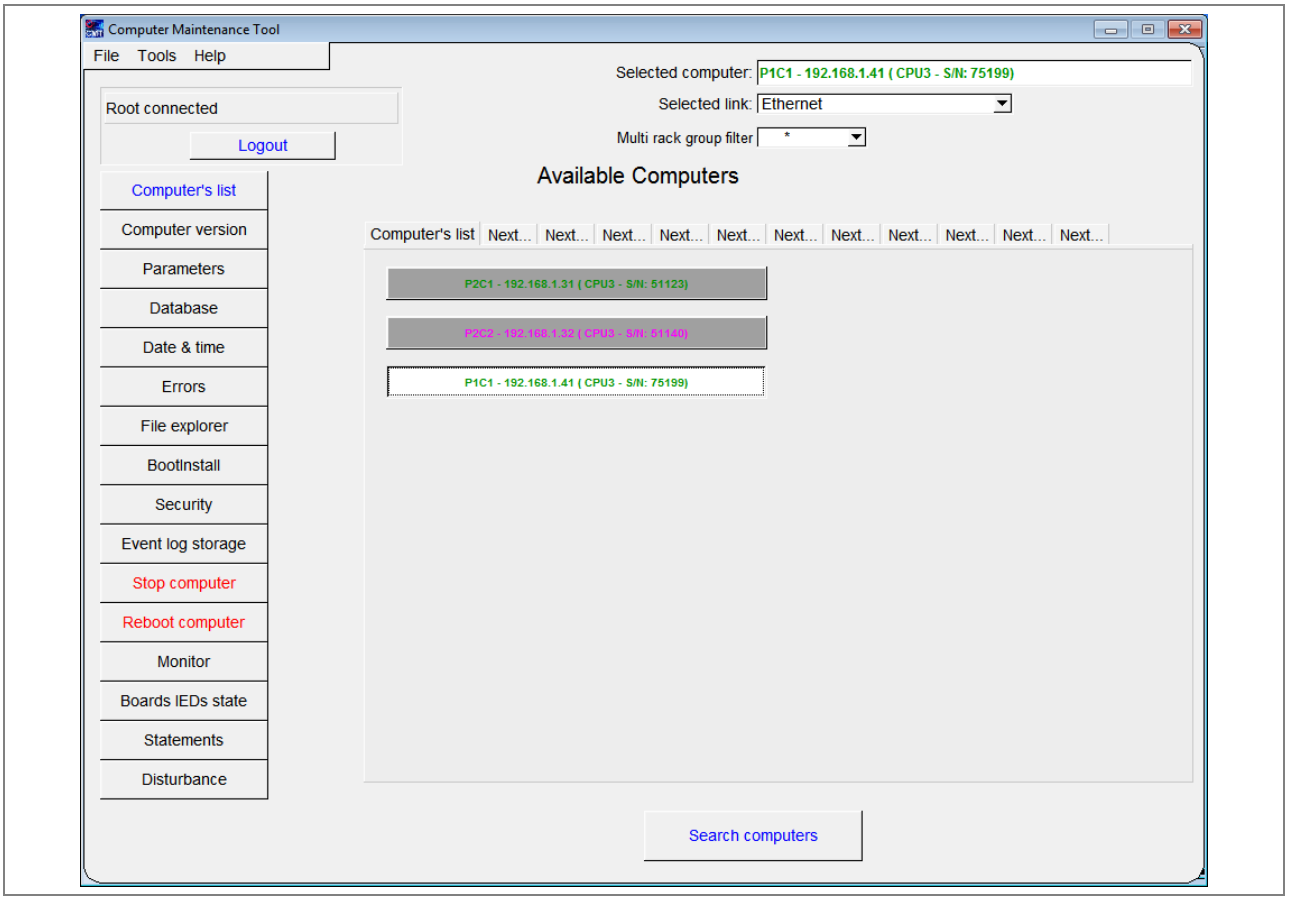
11.1.2 LAUNCHING THE SOFTWARE

CMT is installed with the default installation of the DS Agile C26x software.
The CMT is usually found in `C:\Program Files (x86)\Alstom\DCS\Cmt\Computer`, or by double-clicking the installed icon in the desktop.
When the software is launched, it displays a starting view for 3 seconds.



11.1.3 CMT MAIN WINDOW

The window includes various sections, accessible by clicking the buttons on the left-hand side:



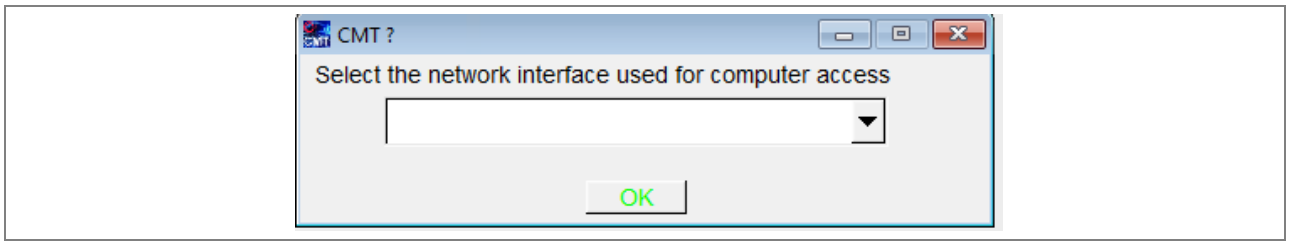
Note:
The pages available to the logged in user depend on the roles associated with the user account. See Security section for details.

11.1.3.1 MENU BAR

11.1.3.1.1 **File** menu

The **File** menu contains two submenus: **Network Interface** and **Quit**.

Network interface submenu (F2)



It is used to select the Network Interface board used by the PC to access the controller Network.

A selection popup window proposes the Network interface board already present on the PC.

Select the relevant board and click **OK**, or simply close the window if the proposed board is the correct one.

For a PC with only one Ethernet board the correct board is automatically selected.

Example:

- MS TCP Loop back interface (not useable by CMT)
- 3Com 3C90x Ethernet Adapter
- 3Com Ether Link PCI
- AT-2500 NDIS Series 4.0 driver
- NdisWan Adapter: (not useable by CMT)

The selection is saved in the Windows Registry.

Quit submenu (CTRL + q)

It is used to exit the software.

11.1.3.1.2 Tools item

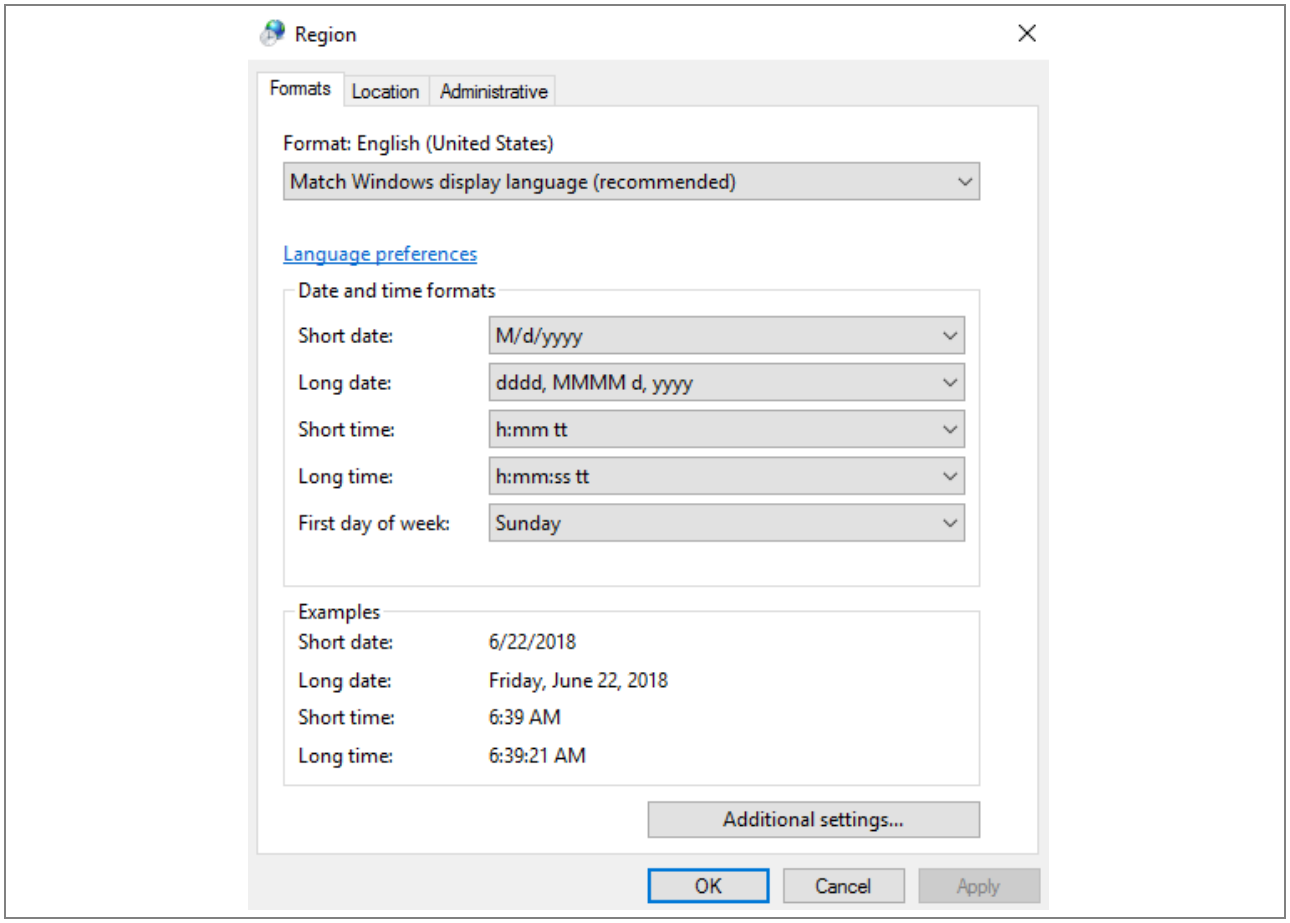
Language submenu

This menu lets you choose the language of the CMT application interface. The default language is English. The following languages can be selected: English (F5), French (F6), German (F7), Spanish (F8), Russian (F9), Simplified Chinese (F10) or Polish (F11).

The selected language is saved in the **Windows Registry**.

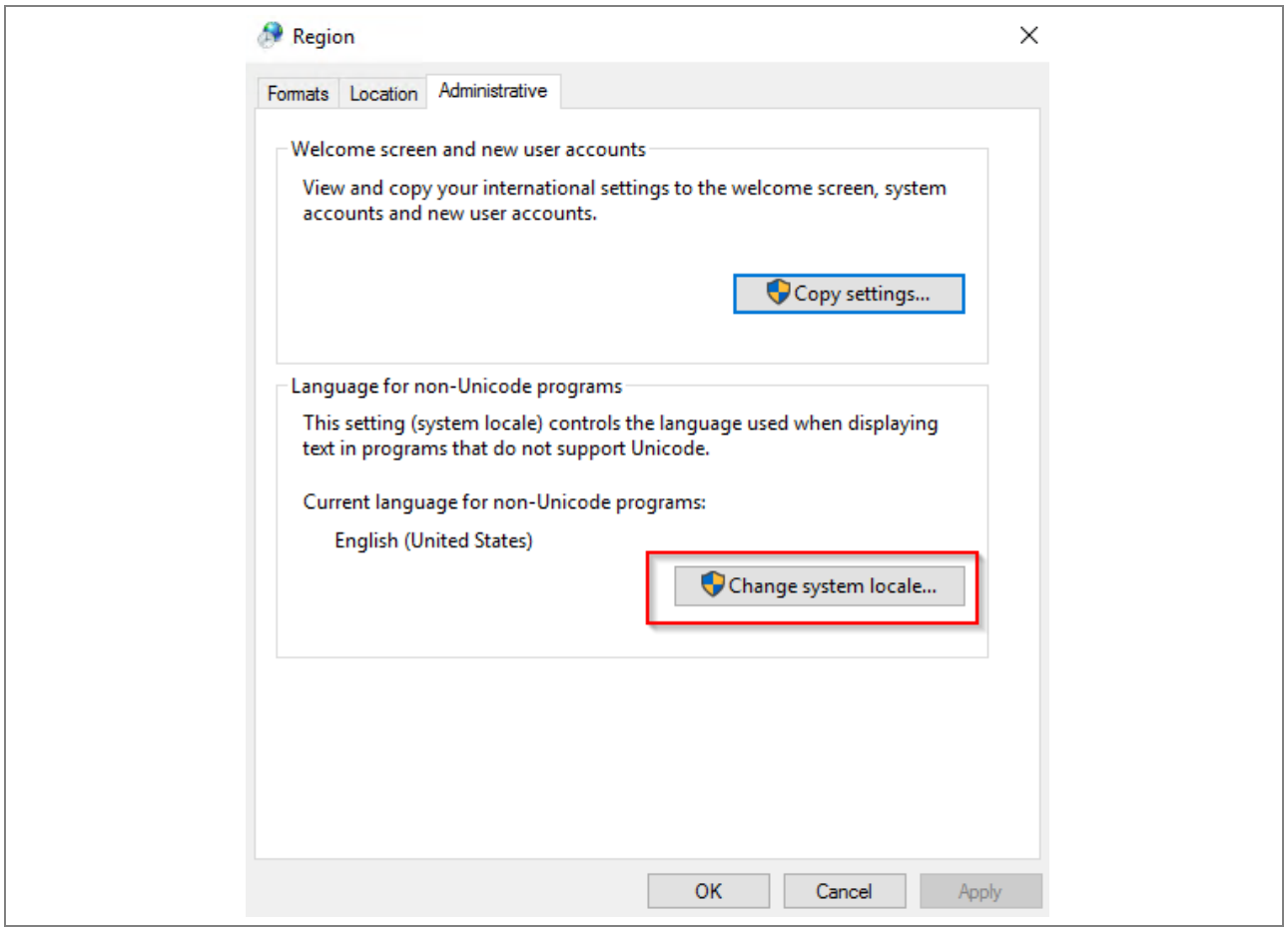
FOR NON-WESTERN LANGUAGES (Russian (Cyrillic) or Chinese or Polish), the PC operating system (MS Windows) has to be configured to support Cyrillic or Simplified Chinese or Polish fonts.

From the menu **Start | Control Panel | Region and Language**:

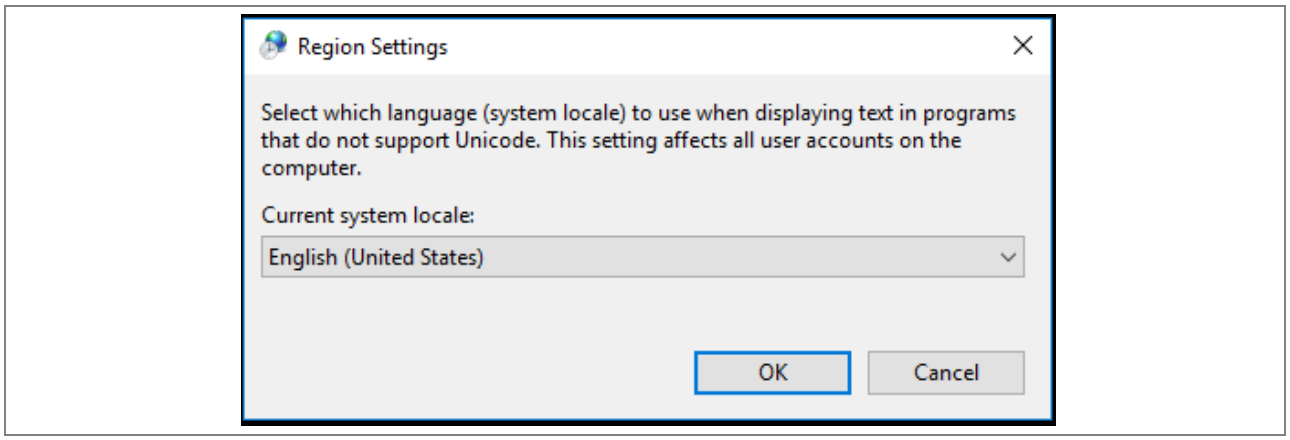


3 Click the **Administrative** tab, and then, under **Language for non-Unicode** programs, click **Change system locale**…

Note:
If you're prompted for an administrator password or confirmation, type the password or provide confirmation.



4 Select the language, and then click **OK**.

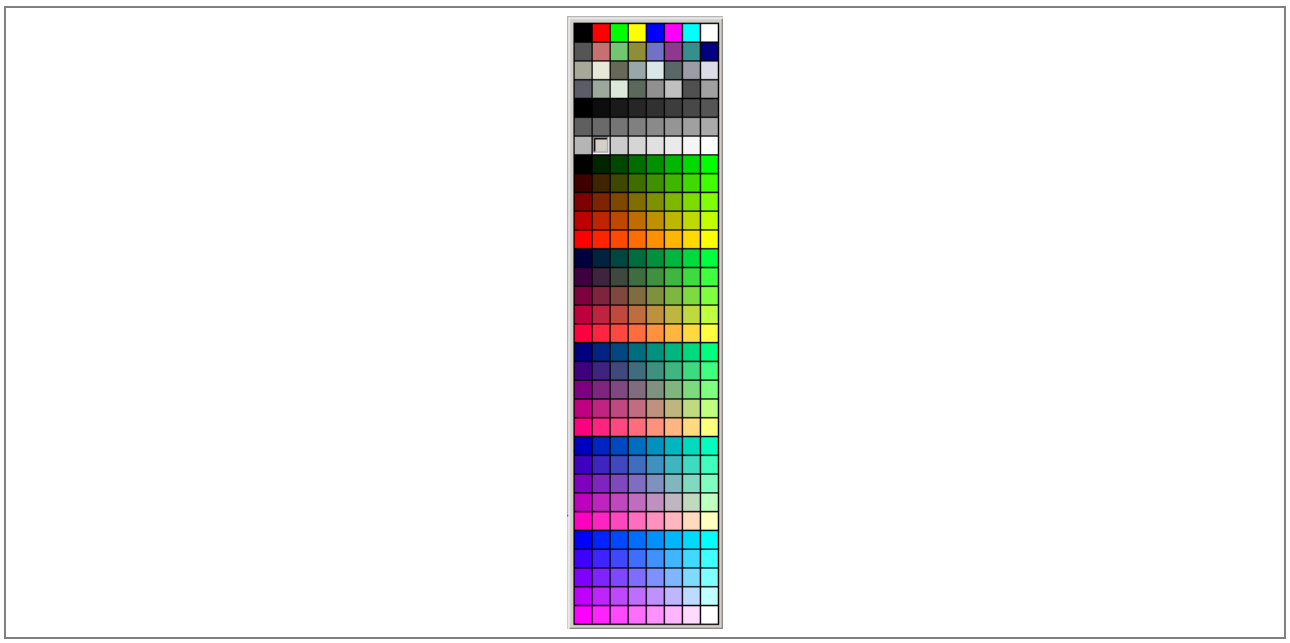


5 Restart the PC for it to take the changes into account. The top part of ASCII table (128 to 256) now points to specific characters of Cyrillic or simplified Chinese alphabet.

Background colour sub-menu

It is used to choose the background colour of the CMT application interface. The default colour is grey.

A 256-colour panel is displayed. Click one the coloured squares. This colour will now be the new background colour. It is recommended to choose a shade in the middle of a line as these will allow the best display of texts with different colours.



The selected colour is saved in the Windows Registry.

11.1.3.1.3 Help menu

File menu contains two submenus: Index and About.

Index submenu (F1)

Displays the operating manual as in this section.

About submenu (F5)

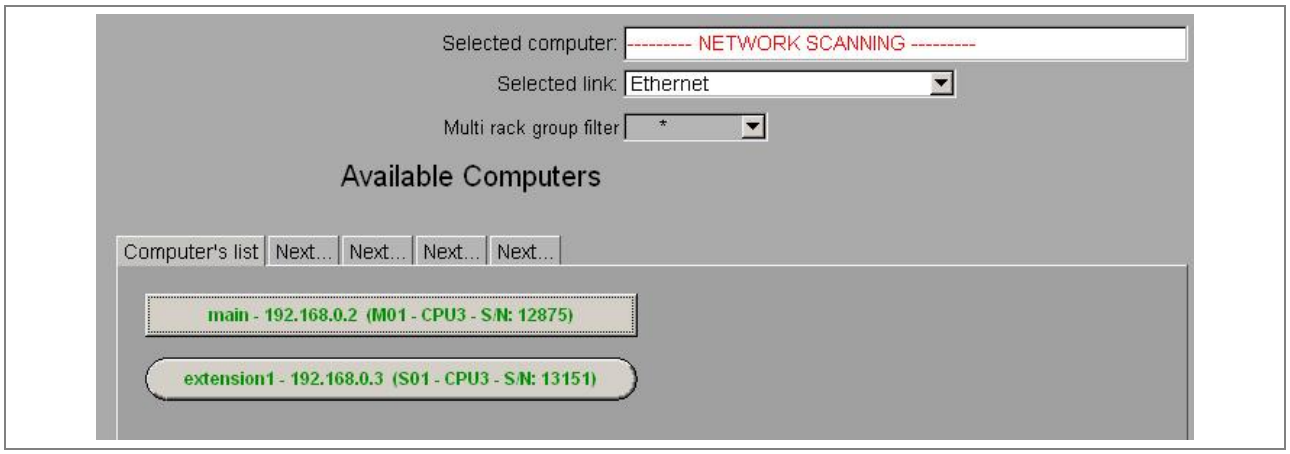
Displays an "about" box: CMT's version and copyrights. Identical to the splash screen.

11.1.3.2 SEARCH COMPUTERS BUTTON

It is used to search for computers, i.e. C26x control units, connected to the current Local Area Network (LAN). Once it is pressed, the application starts the search, and awaits answers for 4 seconds. The search process status is indicated in the **Selected computer** field by the message:

"------- NETWORK SCANNING --------"

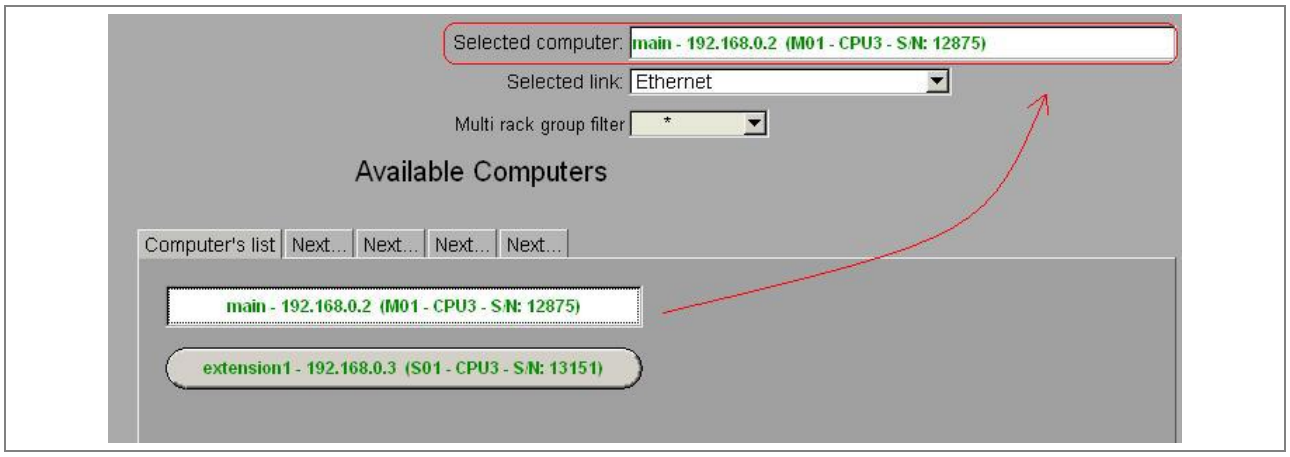
The Multi rack group filter list allows filtering answers using the units' multi rack group addresses (described later in this document).



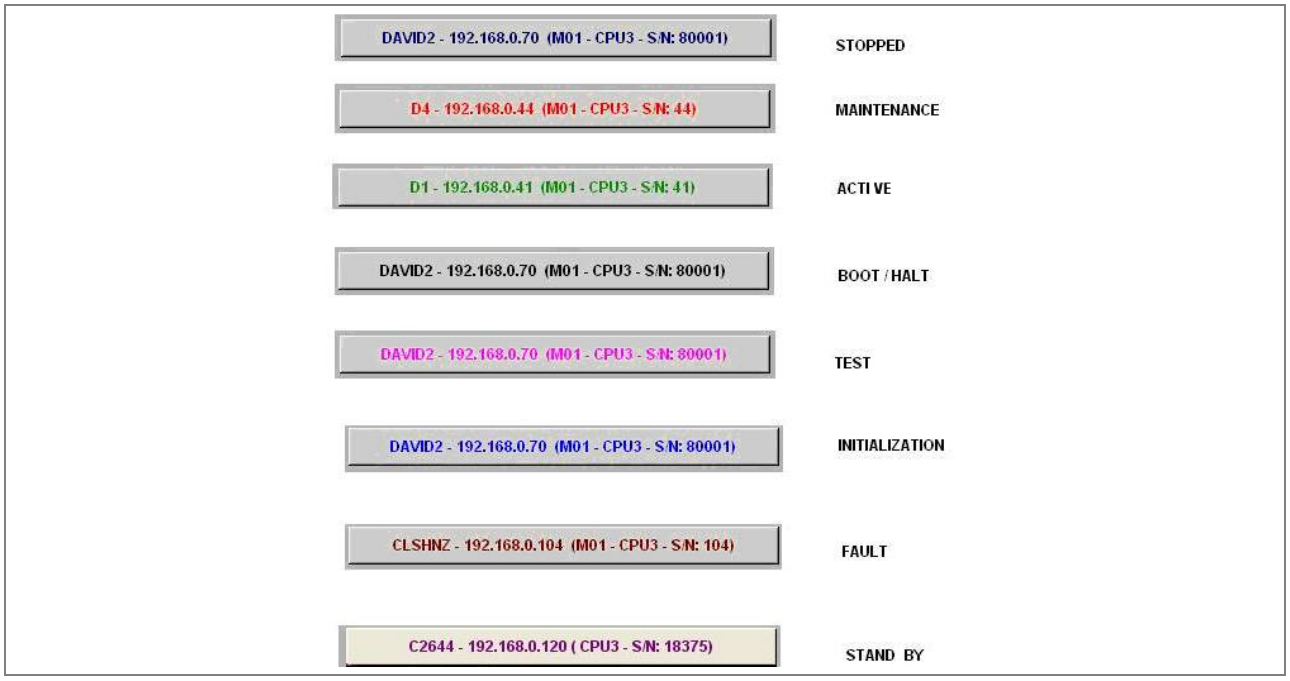
Three situations are possible:

- Waiting until the timer expires; then a list of all the "responding" C26x units displays their *name*, *IP address*, *CPU board type* and *serial number*. The list is sorted according to increasing serial numbers. Scanning goes on repetitively on a 4-second time base.
- Clicking **Search computers** again stops the scanning operation. No C26x is selected.
- Clicking one the units already found stops the scanning and selects the corresponding C26x:

  The selected unit's *name*, *IP address*, *Type* and *serial number* is shown in the top right text area **Selected computer**:

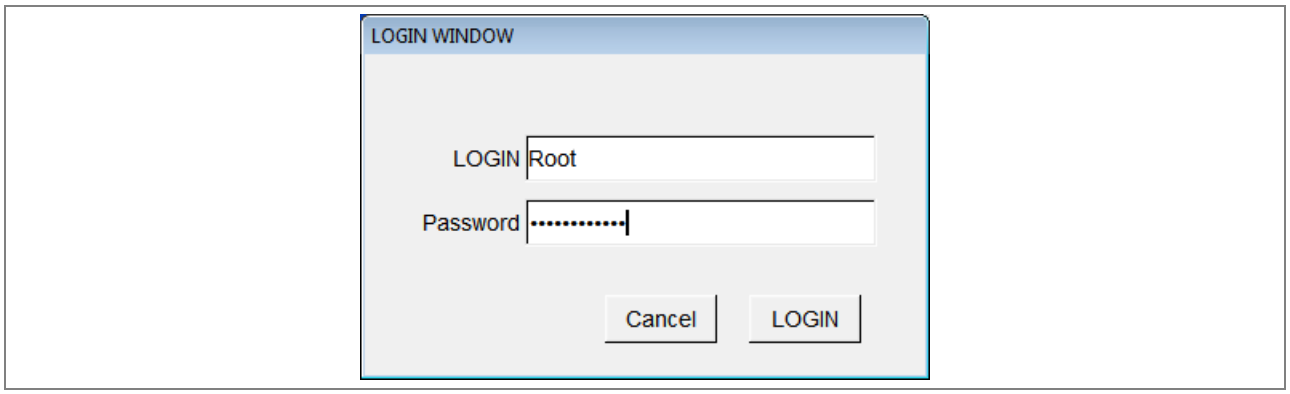


Each button text colour represents a specific operating state or mode:

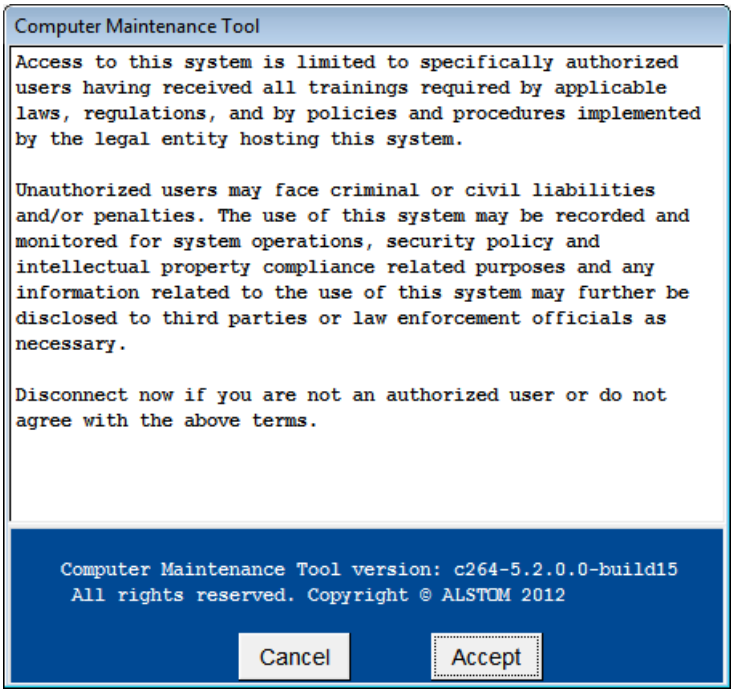


Each tab-pane can contain up to 20 buttons. Therefore, a maximum of one hundred computers can be displayed.

Upon selecting a unit, a security popup window is displayed: Enter a valid account LOGIN name and Password and click **LOGIN** in order to continue and access the memory of the selected DS Agile C26x unit. Click **Cancel** to abort.

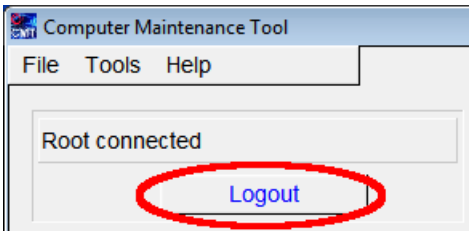


After logging in, an information/disclaimer popup is displayed. Depending on whether a configuration database is present or not, it will contain a text defined in that database, or the default text below.



Click **Accept** to log in or **Cancel** to abort.

To log in to another unit, it is necessary to enter the password again. The login name cannot be changed during a CMT session. In order to use another login name it is necessary to log out first, by clicking the **Logout** button under the current user's login name (top-left of the CMT window):



Note:
*Clicking **Logout** will terminate all the current connections.*

Good practice

Although not compulsory, it is highly recommended that a given login name be assigned the same password and privileges for all the C26x units it is defined in.

11.1.3.3 COMPUTER'S LIST BUTTON

The list of all the "responding" units is displayed, with their *name*, *IP address*, *Type* and *serial number*, without launching a network search.

11.1.3.4 LEFT BAR

The button bar on the left-hand side of the application window contains all the operations that can be performed on the selected C26x:

- Simply click a button to launch the desired task.
- These operations are described later in this chapter.

11.1.4 SELECTED LINK

The **Selected link** drop-down box gives a choice of two types of network to connect to a DS Agile C26x unit, either:

- *Ethernet* (default setting): All the connected DS Agile C26x units are detected, even if they are on different networks. However, some units that are connected through routers, VLANs or firewalls may not be listed.

  or

- A specific *TCP/IP* address or address range, which allows the CMT to connect to any connected unit, even if it is "behind" a firewall, a VLAN or a router. If *TCP/IP* is selected, enter in the text box @:
  - the IP address of a specific DS Agile C26x unit,

    or

  - a range of IP addresses (use *x.y.z.255*).

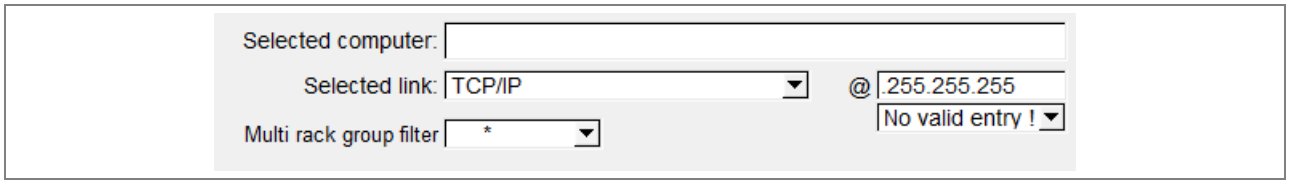
In addition, a single TCP/IP address may be selected in the drop-down list below the text box:



The IP drop-down list is generated by creating a text file called "ip.txt" containing the IP addresses to be displayed in the drop-down list. The text file must be placed in the CMT's folder.

Note:
As it is located in the `C:\Program Files (x86)` *path, only a user with administrator rights will be allowed to manage the "ip.txt" file. Also note that most text editors do not allow users to write directly into the* `C:\Program Files (x86)` *path. To edit the file, modify it in an unprotected folder, and then paste it back into the CMT directory. It is recommended to use Windows Notepad. Do not use a word processing application such as Wordpad.*

If the “ip.txt” file does not exist or is incorrect, the message *No valid entry !* is displayed:



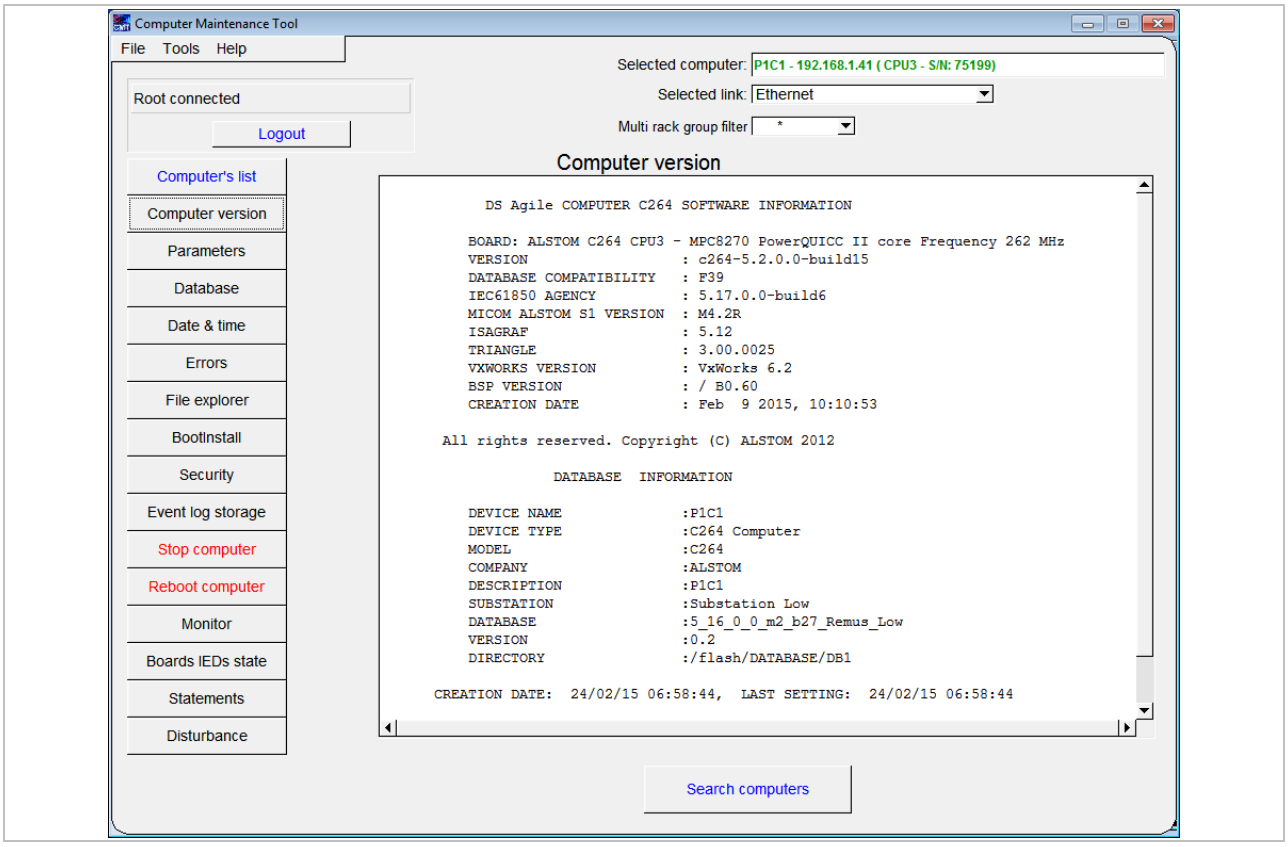
11.1.5 MULTI RACK GROUP FILTER

In a multi-rack system, this opens a list used to filter which units to display according to their Ethernet network address type. The filter "*" must be used for a single rack system (it is the "no filter" selector).



11.1.6 OPERATIONS PERFORMED BY THE BUTTONS IN THE LEFT BAR

11.1.6.1 COMPUTER VERSION



The DS Agile CMT reads the C26x memory and displays three blocks of information:

- Software block:
  - Version
  - Database compatibility
  - IEC 61850-8-1 SBUS Agency version
  - ISaGRAF software version
  - Triangle software version
  - Creation date of the application software

- Database block (if a database is running ...):
  - device name
  - device type
  - model
  - company
  - description
  - substation
  - database name
  - version
  - path of the database
  - database creation date and last setting date
- Information on the C26x state:

ACTIVE / MAINTENANCE / INITIALIZATION / SIMULATION / STANDBY / FAULTY / HALTED / STOPPED

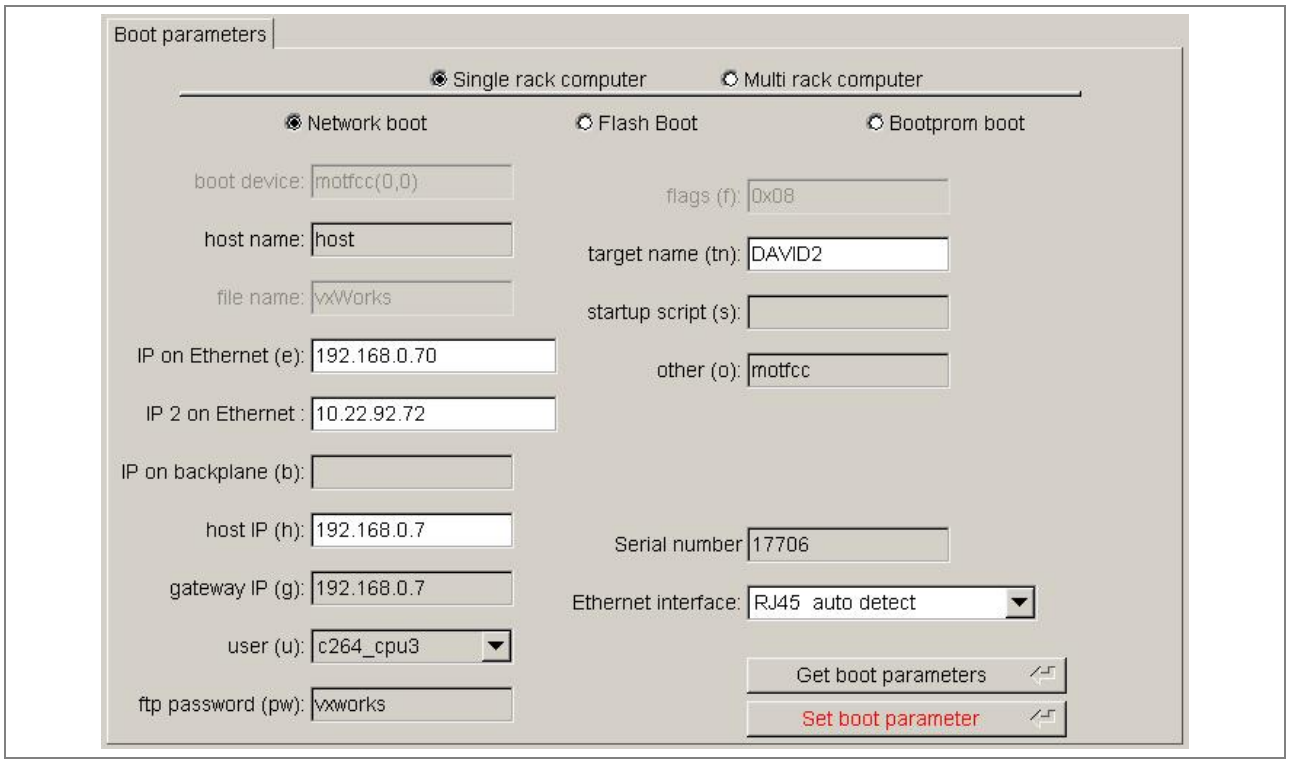
The two information blocks serve as headers in other pages.

11.1.6.2 BOOT PARAMETERS

The **Boot Parameters** button shows the selected unit's boot parameters. They define how to boot (network or flash disk) and set the internet address of the C26x.

Modifications of the values can be done for all the fields displayed in white text areas ("IP on Ethernet", "host IP" and "target name").

When a C26x boots up for the first time, a number of parameters can be defined; such as network addresses, boot device, host, and start-up file.



This information is encoded into a single structure known as the boot parameters. Boot parameters are placed at a known address in flash memory so that the booting system can find the parameters that were used to boot the system. Boot parameters are the only information blocks exchanged from the boot ROMs to the booted system.

The boot parameters are as follows:

- **boot device** (required): type of device to boot from. This must be one of the drivers included in the boot ROMs (motfec(0,0) for Motorola Fast Ethernet Controller or tffs=0,0(0,0) for Flash disk). Due to limited space in the boot ROMs, only few drivers can be included.
  - 1st digit: unit number of the boot device (0..n)
  - 2nd digit: processor number on a multi-rack system (0..n); this identifier, defined for the target, is unique per C26x and can be used to distinguish the C26x type in a multi-rack architecture:
    - Main C26x: 0 (zero) / 1 (1 is used only for main backup rack in case of RTU redundancy)
    - Extension C26x: 2 (two) to 17
    - For a Bay controller single rack application, the processor number is always 0.

- **host name:** name of the host machine to boot from. This is the name by which the host is known to VxWorks; it need not be the name used by the host itself.
- **file name**: full pathname of the VxWorks object module to be booted. This pathname is also reported to the host when you start a target server, so that it can locate the host-resident image of VxWorks.

  For Ethernet boot: vxWorks, for Flash disk boot: "/flash/bin/vxworks"
- **IP on Ethernet**: address of the Ethernet interface. Enter the 1st IP address you have chosen for the C26x.The Internet addresses (IP) are specified in "dot" notation (e.g., 10.22.92.52).

  Then, enter the **optional subnetwork mask**:
  - Default value: 0xFFFFFF00 => subnet mask = 255.255.255.0
  - Examples: enter 10.22.92.52:0xFFFF0000 => subnet mask = 255.255.0.0
  - 10.22.92.52:0xFF000000 => subnet mask = 255.0.0.0
- **IP 2 on Ethernet**: Enter the address of the second CPU3 port. Can be used for:
  - SCADA connection of C26x–Standalone RTU
  - Multi rack architecture later in this document,
  - Maintenance network

The network is different from the network connected to the first port.

Note:
The functions permitted to each Ethernet interface are different depending on whether, if a database is loaded, the "firewall usage" IP filtering featured is enabled or not. See section 10 Firewall usage for details.

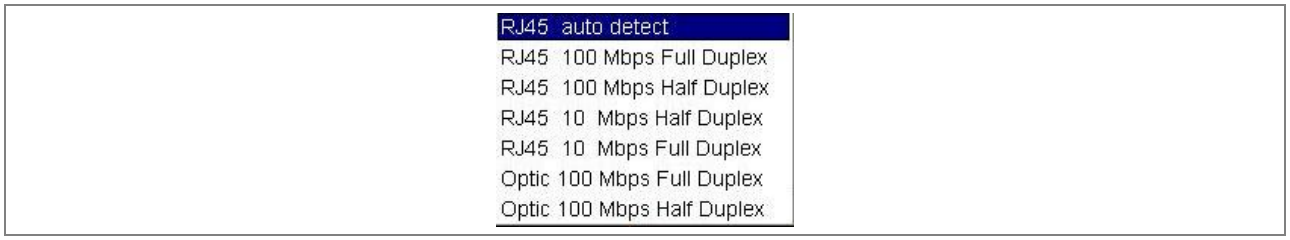
- **IP on backplane**: address of the backplane interface (not used for a C26x). It can have an optional subnet mask and/or lease timing information as "e".
- **host IP**: address of the boot host.
- **gateway IP**: address of the router to the boot host. Leave this parameter blank if the host is on same network.
- **user** & **ftp password**: credentials on the boot host.
- **flags**: system-dependent configuration flags.
  - 0x04 Do not start autoboot sequence => stop before application software loading
  - 0x08 Immediate autoboot (no countdown) => load and start application software
- **target name**: name of the system being booted
- **start-up script**: name of a file to be executed as a start-up script (not used)
- **other**: "other" string for use by the application
- **serial number**: serial number of the processor board, used to set the Ethernet (Mac) address of the board
- **Network boot**, **Flash boot** and **Bootprom boot**. These three radio buttons define the device the C26x boots on (ftp for Network, flash memory for Flash). Bootprom boot stops the C26x after boot (with Network boot, you have to press **Reboot computer** afterwards).

*Note: **Network Boot** option is available only to users with **System Administrator** rights*



The mode for current operations is Flash boot.

- **Ethernet interface**: medium and bitrate. Available values:



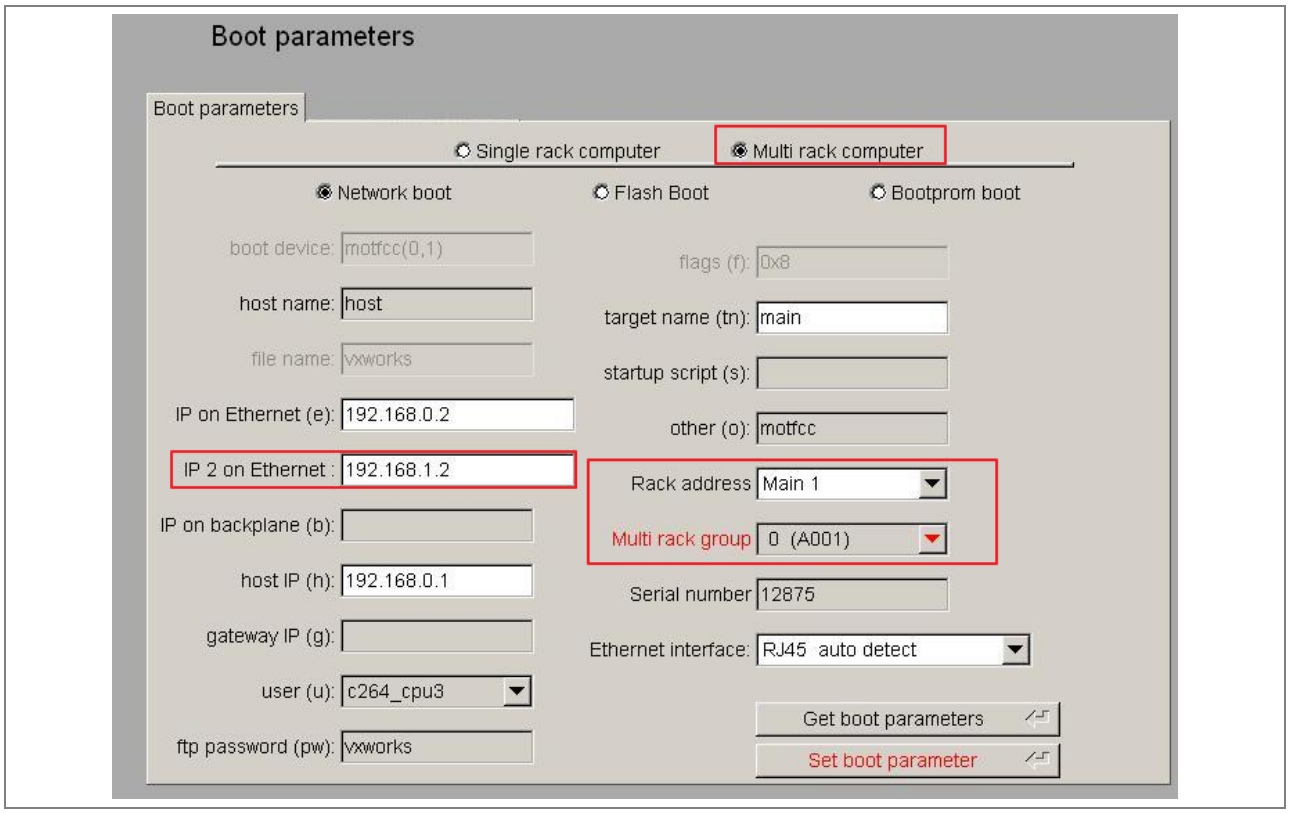
  - Default mode: RJ45 auto detect (auto negotiation between the C26x and the switch).
- **Get Boot parameters** button gets information by reading the C26x flash memory.

Once the modifications are finished, press the **Set boot Parameters** button to apply the changes onto the C26x (if CMT has been installed in Normal mode).

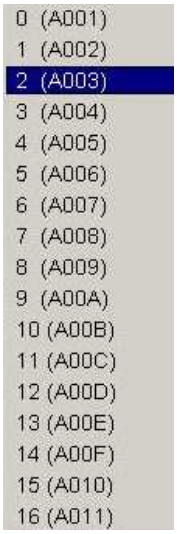
Modifications are saved in the flash memory of C26x and **will be in force only after the next reboot**.

Multi Rack Architecture

The radio button **Multi rack computer** allows configuring a C26x used in a Multi rack system. Once it is selected two new selectors show:



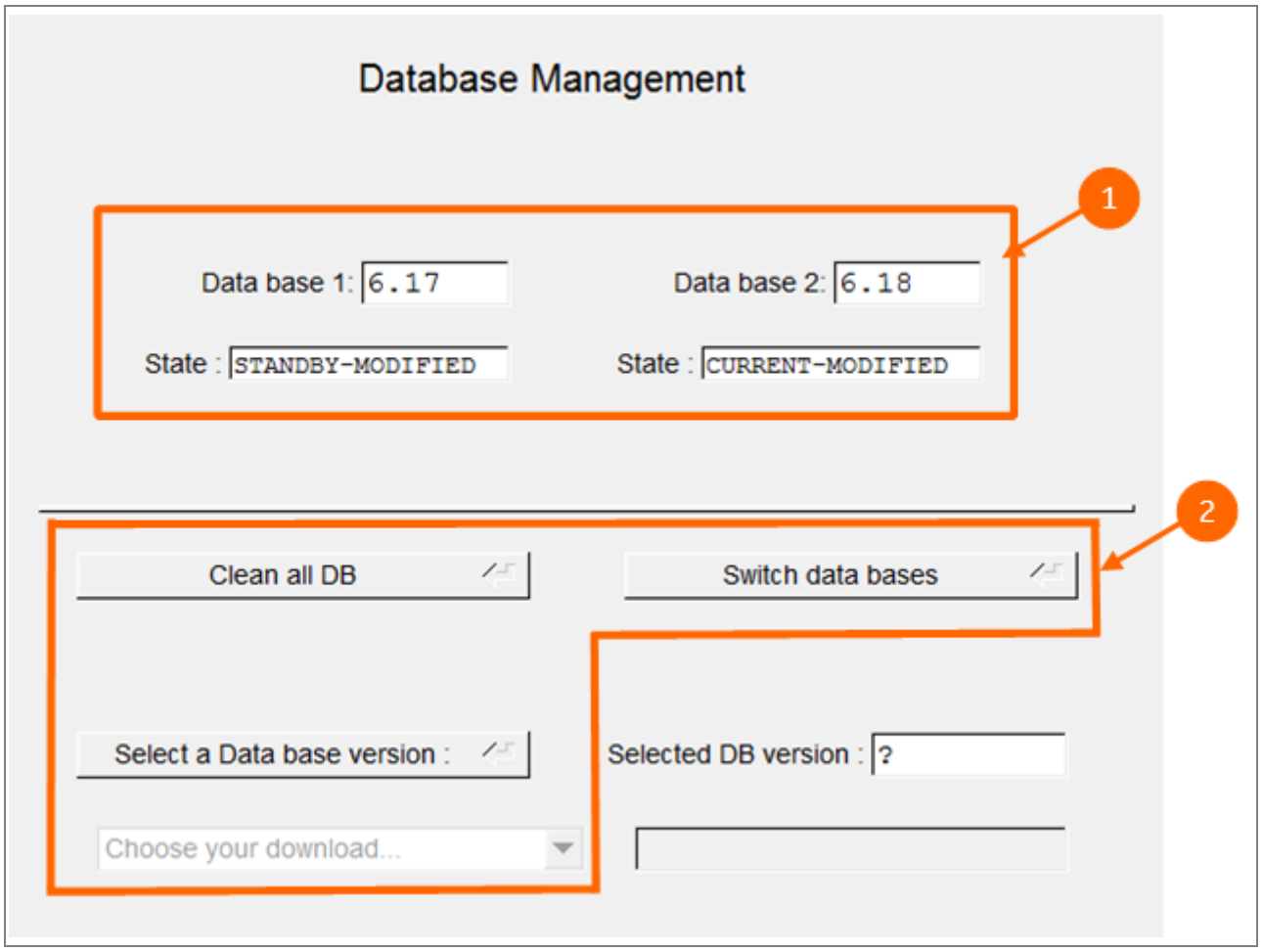
- **Rack address** to select the type Main (1: regular front-end, 2: back-up front-end) or Secondary (extension with the address of the rack in the system 1 to 16).
- **Multi rack group** to select the Ethernet type used to communicate between main and secondary racks. The use of a specific Ethernet type (A000, or A001 ...) allows multi rack systems to co-exist on the same physical network. Available values:



IP2 on Ethernet is the address of the branch networking the extensions.

11.1.6.3 DATA BASE MANAGEMENT

The pane features two areas:



Information 1

Data base 1 shows the first data base version revision and its state CURRENT / STANDBY

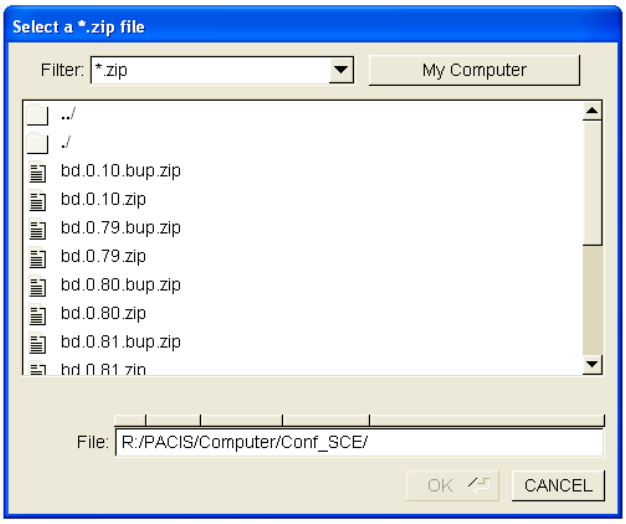
Data base 2 shows the 2nd data base version revision and its state CURRENT / STANDBY

Actions 2

Clean all DB removes the first and the second data bases. As a result, a reboot occurs (since B5.24). To be used ONLY for C26x software update.

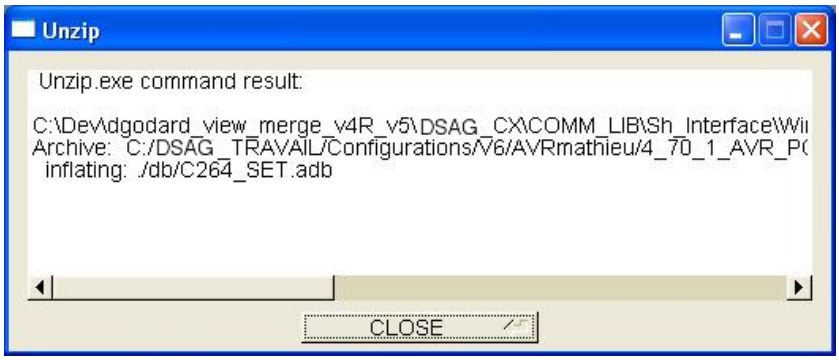
Switch data bases switches the two data bases. As a result, CURRENT becomes STANDBY and STANDBY becomes CURRENT, and a C26x search starts.

Select a Data base version to select a versioned system data base right from SCE; this opens a file chooser that shows all the available zip archives.



Navigate to the archive to load with the buttons **My Computer**, **../** and **./**.

Double click it; this displays the version revision x.yy is saved in the text area **Selected DB version** for the future downloads and extracts the .adb files. The .adb files are saved in <installation folder>/Computer/Cmt/db and displayed in a window:



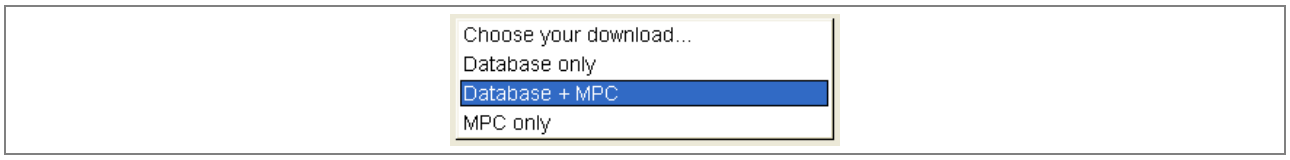
The absence of "inflating: ./db/xxxxx.adb" line indicates that unzip cannot find any *.adb files. Error origin is frequently the use of "space" in file or directory name.

Click Close.

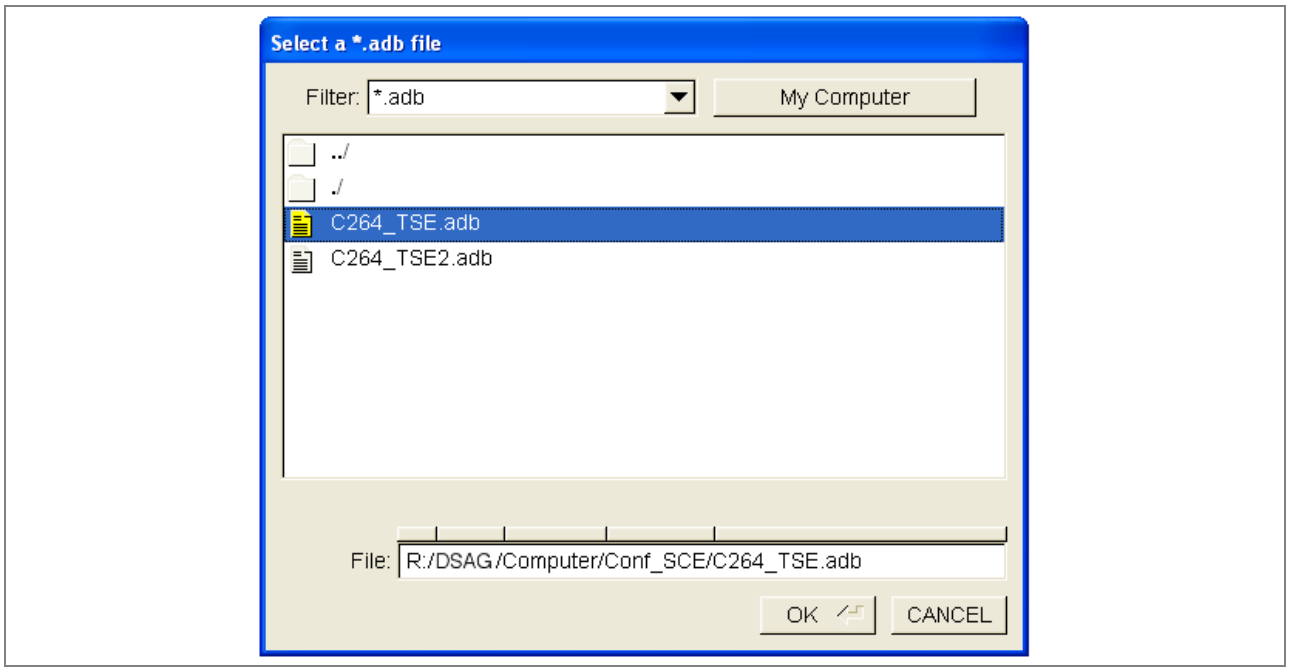
To download the *.adb file into the C26x, click in the list box **Choose your download…**.and select **Database only**.

Note:

With a C26x-Standalone unit (C26x not associated to any other DS Agile IEC 61850-8-1 devices), if you want to store the source database (.mpc file) on the CPU3 (up to 20MB), select Database + MPC in the list:



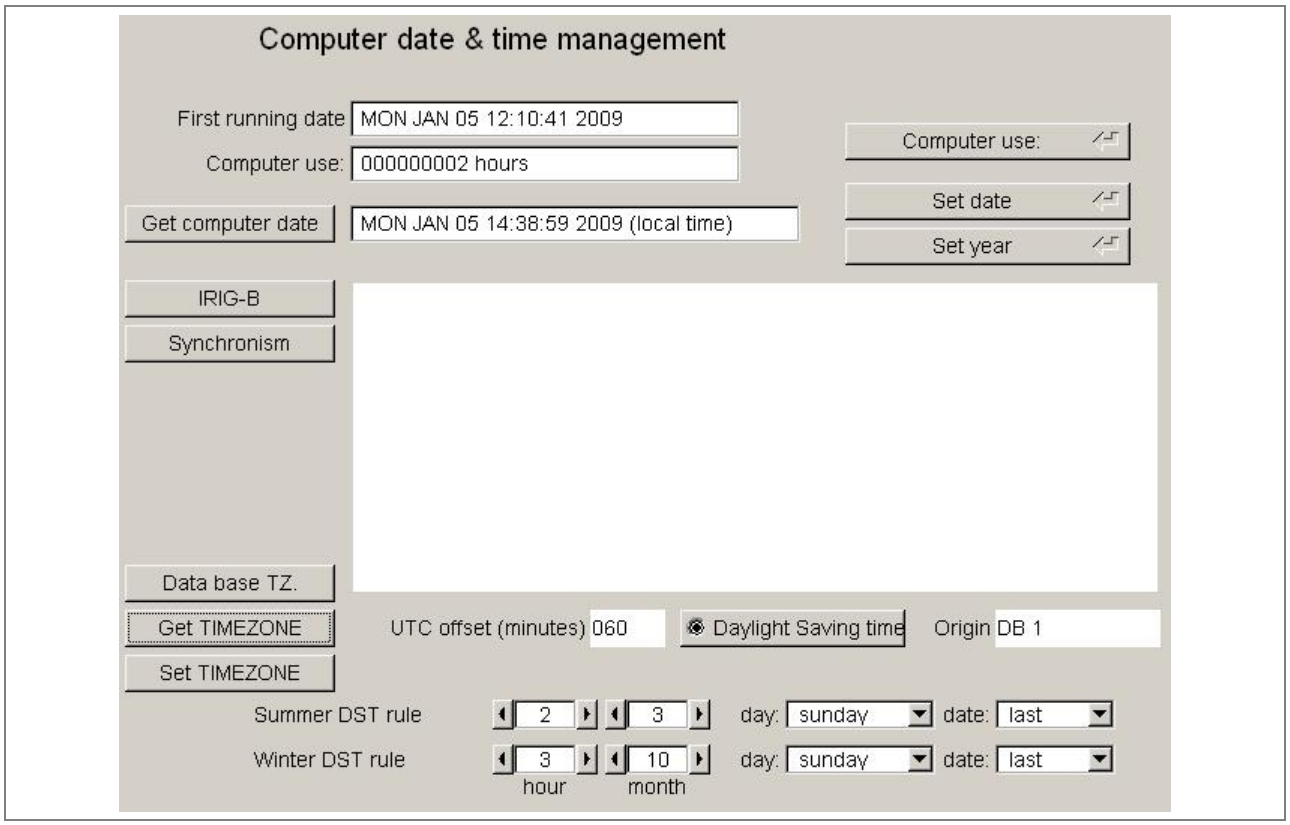
A file chooser lists all the .adb files extracted from the archive; there are as many files as C26x units configured in SCE:



Click **OK** to start downloading database to the previously selected C26x.

11.1.6.4 DATA AND TIME

This section is used to read or change date and time information.



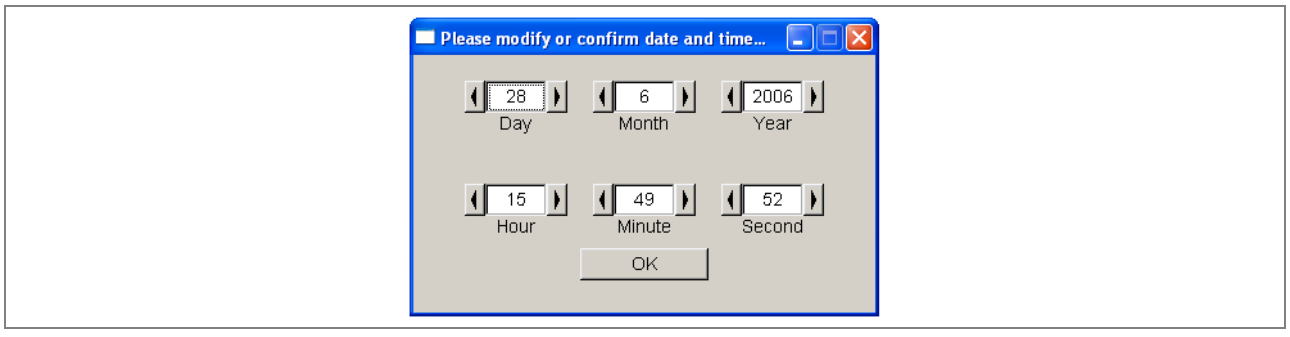
11.1.6.4.1 Main buttons

First running date of the C26x; the value stored in "/flash/MAINT/firstrd" is directly displayed here.

Computer use: number of hours the C26x has been running. This value is read in "/flash/MAINT/ophours".

Get computer date: used to read time on the C26x (local time).

Set date: used to modify the C26x date and time. Windows on the operator PC provides the current date and time. They can be changed if needed.



Click OK to confirm the changes and send time to controller.

11.1.6.4.2 Set year

This section is used to select a Year value from the CMT installed on the PC and send it to a new C26x.

"Set year" acts like "Set date" but you only change the Year. It is useful to set the Year on a new C26x because the IRIG B signal does not include the Year data: the new C26x uses the default Year value from the Windows operating system.

The DS Agile system operates with the SNTP master server connected to the SBUS. The SNTP master server synchronises all of the devices connected to the SBUS.

In the DS Agile system, every 20 seconds the GPS sends an IRIG B signal to the SNTP master server. The IRIG B signal includes the time-date data that follow:

- Second
- Minute
- Hour
- Day
- Month

The IRIG B signal does not include the Year.

Caution:
To change the year or the time-date data, connect the CMT only to the SNTP master server. Do not connect the CMT to the new C26x or to a client. if you change the year or the time-date data on a new C26x or on a client, the DS Agile system receives data from two sources: the IRIG B signal, and the new C26x or client. this can cause a data incoherency.

Make sure that the CMT is connected to the SNTP master server.

In the CMT, in the **Please-modify-or-confirm-date…** window, select the Year.



To close the window, click **OK**.

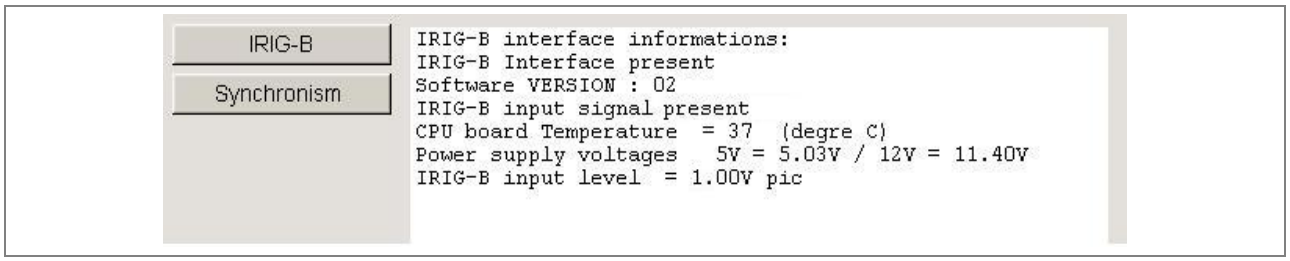
The SNTP master server changes the Year and the Day. Within 20 seconds, when the SNTP master server receives the next IRIG B signal, the SNTP master server keeps the Year you typed and changes the Day to agree with the IRIG B signal.

The SNTP master server sends the time-date data, including the correct year, through the SBUS to all of the devices.

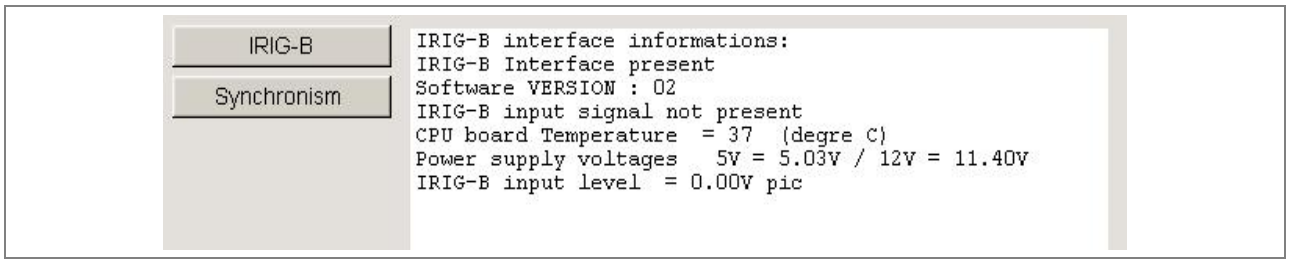
11.1.6.4.3 IRIG-B

This section is used to read IRIG B information from the C26x.

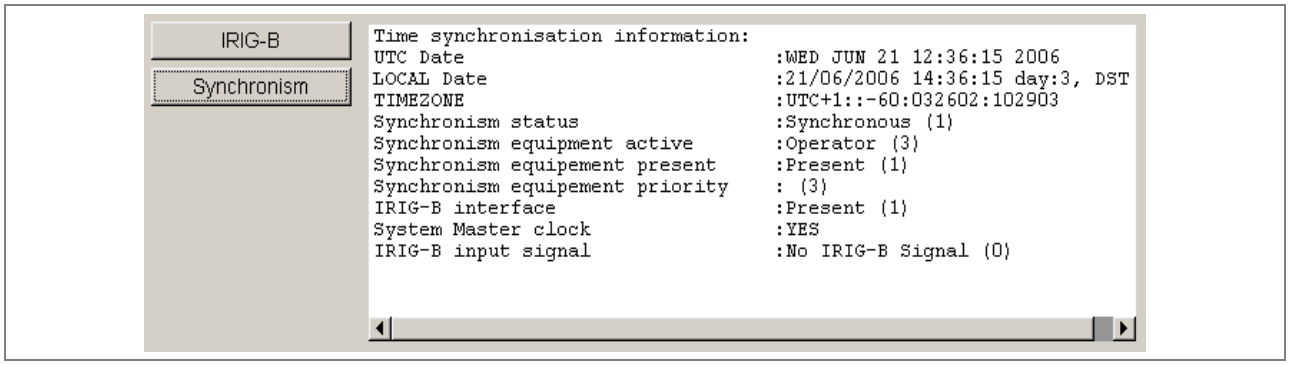
If the IRIG-B is connected:



If the IRIG-B is not connected:

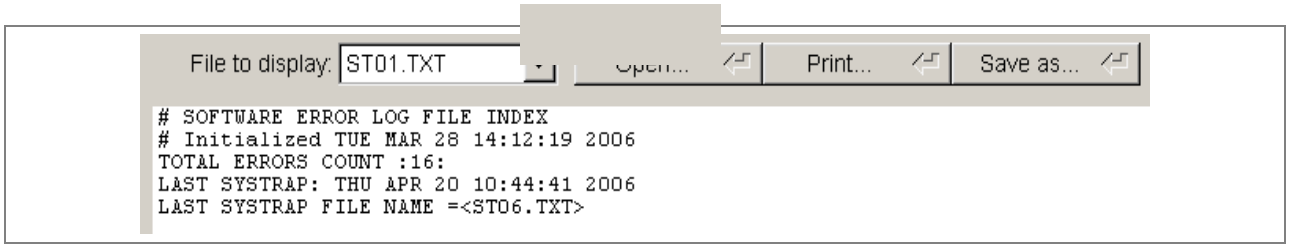


The Synchronism section is used to read synchronism information from the C26x:



11.1.6.5 ERRORS

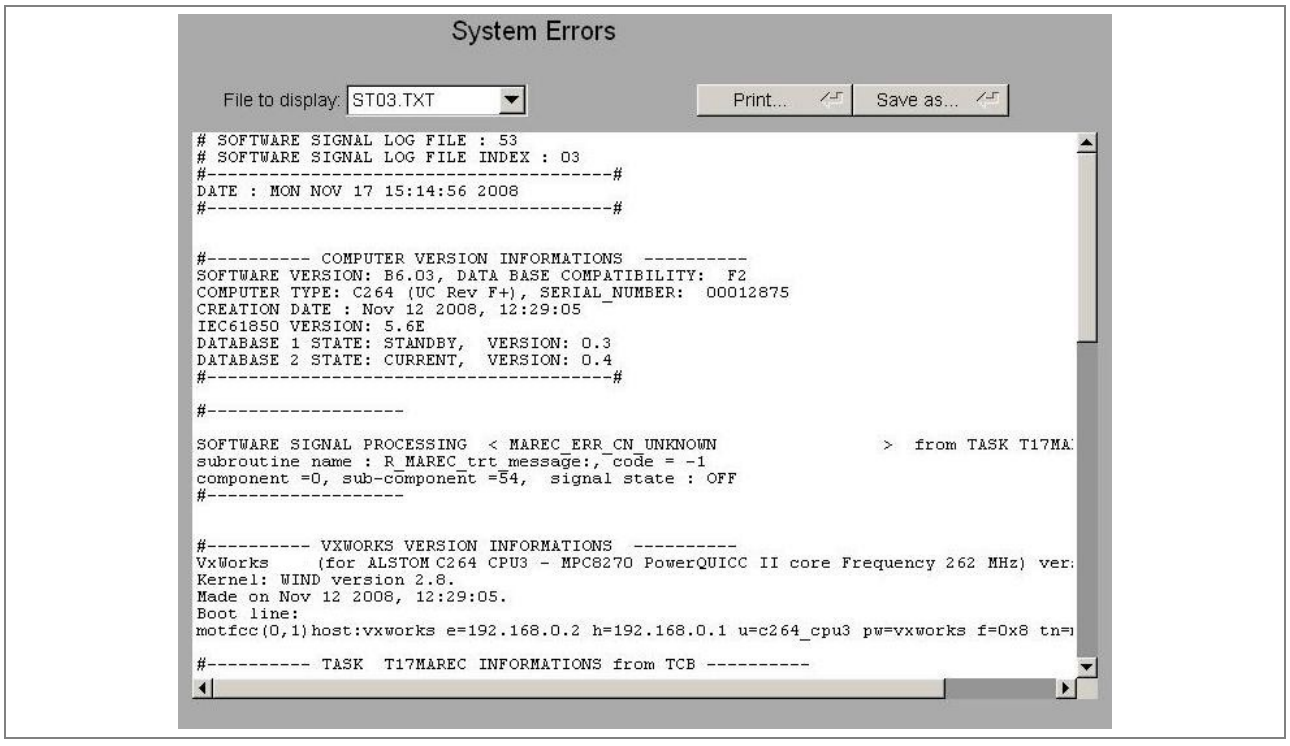
The content of "/flash/systrap/index.txt" is displayed. It shows the number of errors since the initialization of the index, the date and time of the last error and the name of the file containing information on this error.



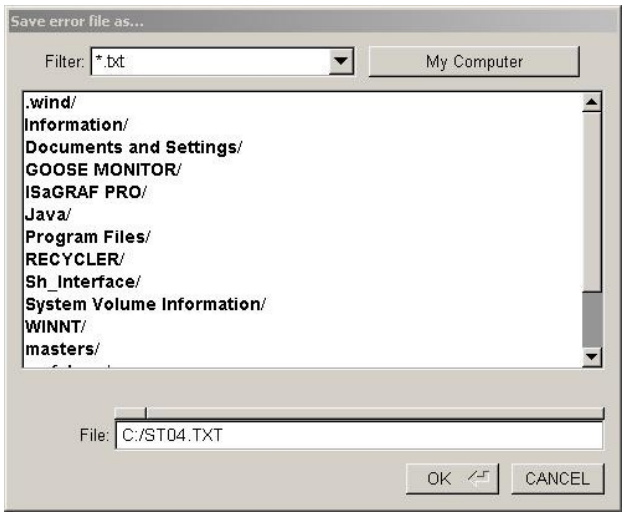
This file (with the latest systrap) is pre-selected in the **File to display** drop-down list.

On a C26x the ten most recent error files are archived, select one of these files using the drop-down list.

Click a file to view it:



- **Print** is used to sends the file to the Windows printer.
- **Save as...** is used to save the file on the PC disk. It opens a file chooser window:

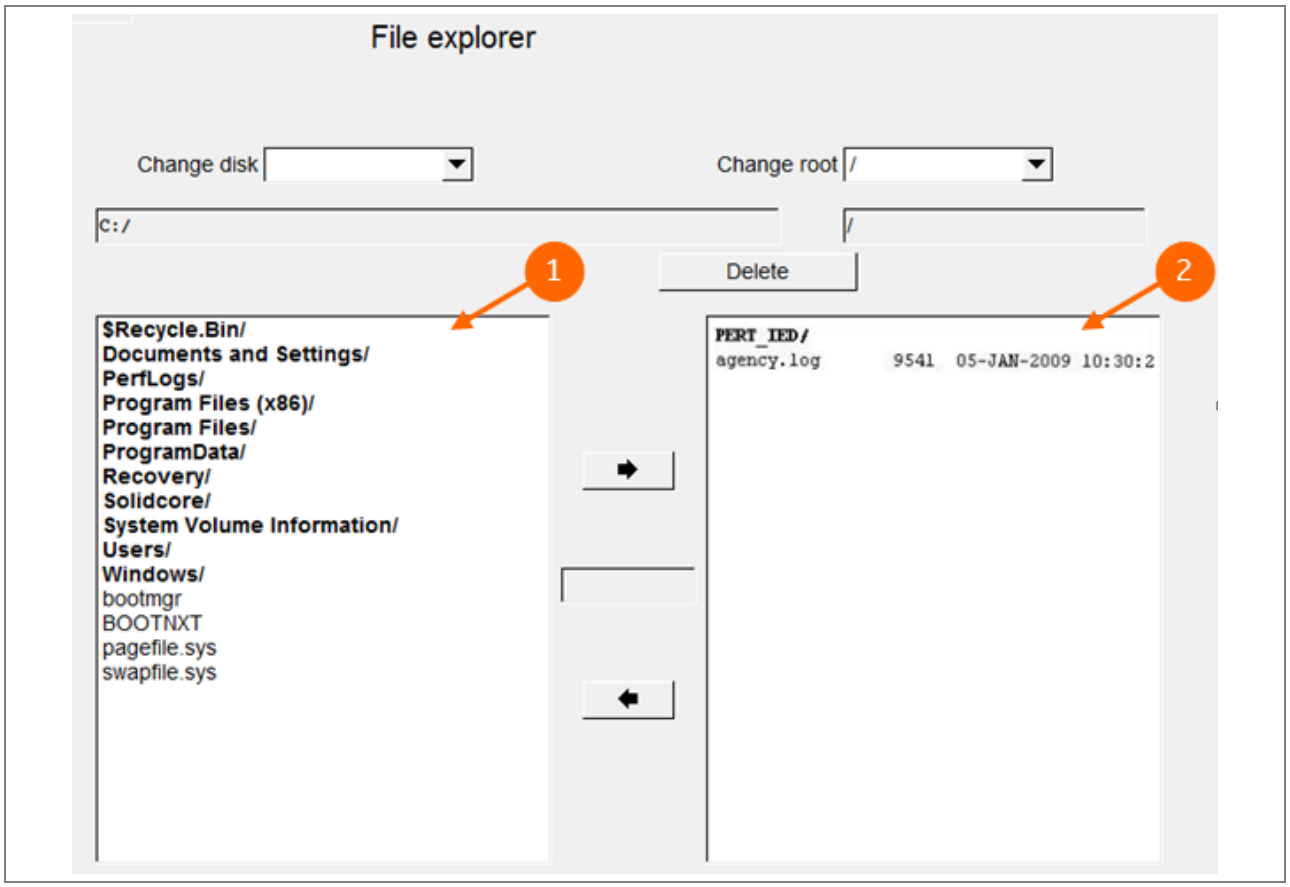


Note that the file *filename* refers to the file "/flash/SYSTRAP/*STxx.TXT*" on the C26x.

11.1.6.6 FILE EXPLORER

This section is designed like many FTP clients or file explorers.

The left part is an image of the local PC file system, the right one an image of the C26x files system.



11.1.6.6.1 Local PC side (left)

On the PC-side 1, the default current directory is the latest selected directory (value saved in the Registry).

Directories are displayed with a bold font. They can be browsed by **clicking them once**. The content of the browser is automatically updated to reflect the new directory files or subdirectories.

Files show with a normal font. To select a file, just **click** on it once (the dark blue background indicates the selection).

The drop-down list **Change disk** lists all the drives of the PC used as root for the browser.

A grey box shows the current path or selected file (bold).

11.1.6.6.2 Remote C26x side (right)

On the right size 2, select the root of the C26x file system in the **Change root** list. /RAMDEV (ramdisk) and /flash (flash memory) are available.

One click on a directory shows its content and **one click** on a file selects it (the dark blue background indicates the selection).

For each file, its size and modification date are also displayed.

The Delete button is used to delete the selected file on the C26x file system. A confirmation window opens showing the full path of the file to be deleted and user can confirm or cancel.

The Format button is used to erase and reformat the C26x file system, **all files are deleted**. This button is only useable while the C26x is stopped or on boot mode. A confirmation window opens and user has to confirm or cancel his click.

11.1.6.6.3 Download (left to right arrow)

To begin a transfer, use the two arrows between the two browsers:

Select ➔ to download the file selected on the PC browser in the directory selected on the C26x.

The name is not changed, only files with a DOS name (8 . 3 character format) can be copied. The file is automatically overwritten if it already exists on the C26x.

The progress bar shows the progression of the transfer in yellow, the write time in flash memory is represented by a fully red progress bar.

11.1.6.6.4 Upload (right to left arrow)

Select ➔ to upload a file. The file selected on the C26x is uploaded on the PC, in the current directory.

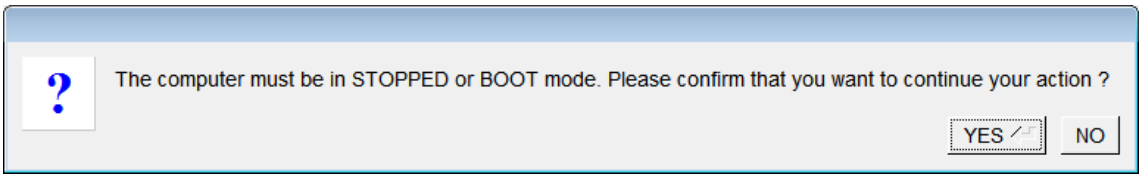
The name is not changed. The file is automatically overwritten if it already exists on the C26x.

The progress bar shows the progression of the transfer in yellow.

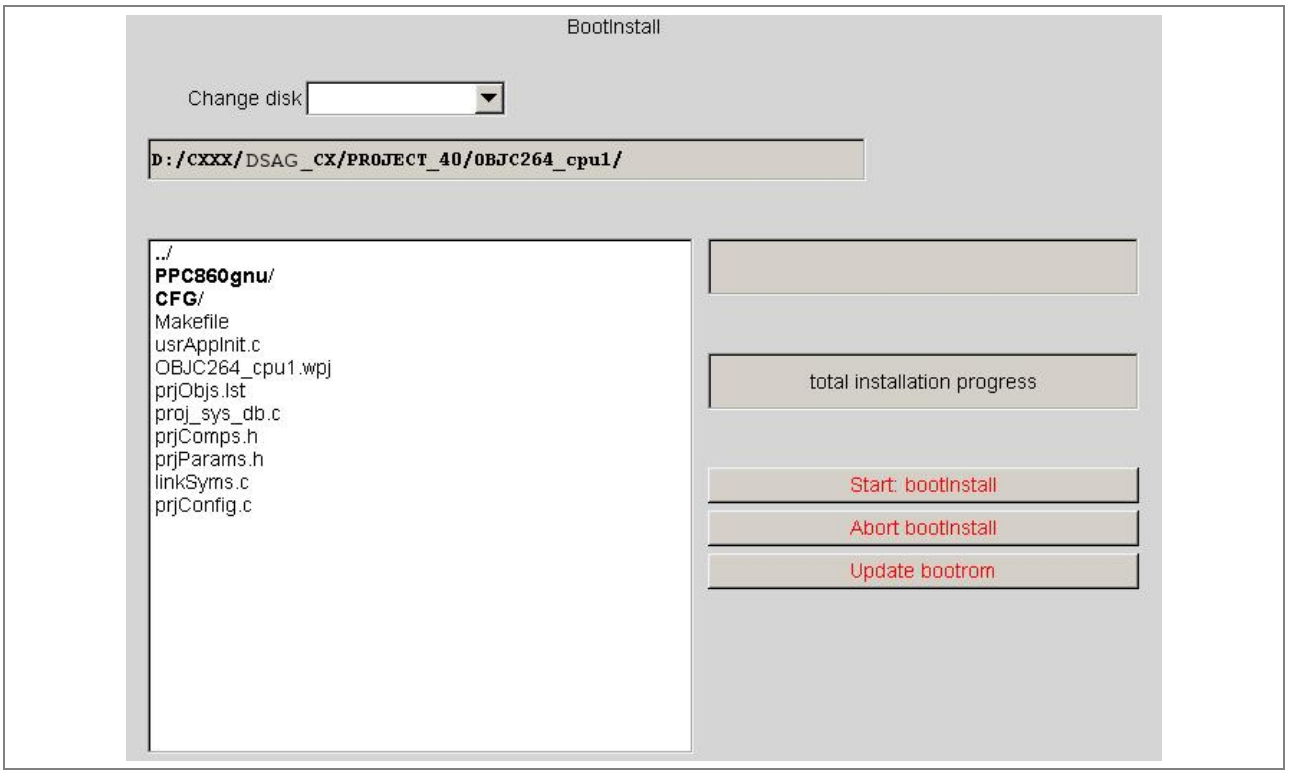
11.1.6.7 BOOTINSTALL

This function is equivalent to the *BootInstall* command, launched from a shell. It downloads automatically a set of files essential to a C26x application.

The unit must first be stopped in order to access this panel.



The directory is selected by the operator. The set of files is automatically selected and must match the type of CPU Board fitted in the C26x.



On the PC-side (left), the default current directory is the latest selected directory (value saved in Registry).

Directories are displayed in bold font. They can be browsed by **clicking them once**. The content of the browser is automatically updated to reflect the new directory files or subdirectories.

Files are shown with a normal font. To select a file, just **click** it once (a dark blue background indicates that it is selected).

The top box "Change disk" lists all the drives of the PC used as root for the browser.

A grey box shows the current path (in bold characters). If a file is selected, only the path is used, the filename is ignored.

- **Start BootInstall**

  The C26x must be in the STOPPED or BOOT mode. After a confirmation window, the BootInstall begins. The top progress bar shows the progression file by file (yellow for transfer, red for write).

  The bottom progress bar shows the progression of the global process (yellow).
  the **Start BootInstall** button is deleted after each use, you have to click **BootInstall** again and select another directory.

- **Abort BootInstall**

  The **Abort BootInstall** button can stop the file transfer process. The click is saved and stop the download after a full file transfer, it cannot stop while a file is being transferred. No confirmation is needed.

- **Update bootrom**

  The **Update bootrom** button is used to update the bootrom part of the C26x flash memory (software executed after a restart). The C26x must be in stopped mode to allow this function.

  The user must first select a directory that contains the "bootrom.flh" file. A confirmation is requested.

  The file is downloaded first into the C26x as /RAMDEV/bootrom.flh and copied afterwards in flash memory.

Caution:
Be sure of your choice, if an incorrect file is selected, the C26x will not reboot at the next restart.

11.1.6.8 SECURITY

The **Security** button opens the **Account Tab**, which is used to

- Define connexion options for external applications (**My Account** sub-tab):
  - Enable/disable serial connexion to the C26x using an SSH terminal and launch it
  - Launch the parameter setting software MiCOM S1
- Disable/Enable LHMI authentication
- Manage access to the C26x (**Administration** sub-tab):
  - Create and administer user accounts
  - Enable and configure the security policy
- Monitor a log of all security-related operations, such as logging attempts (**Security log** sub-tab).

ll these operations apply to a single C26x unit to which the Security Administrator must have logged in beforehand. They apply to all the user accounts defined in that C26x.

As of bootrom version *c264_bsp-6.9.1.9*, DS Agile C26x units are delivered with the following Root account (use exactly the same case):

- LOGIN = *Root*
- Password = *Root1234#*

For security reasons, the Root password must be changed immediately. The user will be prompted to do so upon the first login.

The Root account is granted all administration and access rights.

Note:
*Ignore the tab **PBUS Administration**. The process bus feature is not available with system version 6.1.0.*

Root account management

When a Root account is first used to log in to a C26x unit, the user is immediately asked to change the password. Follow the onscreen prompts:

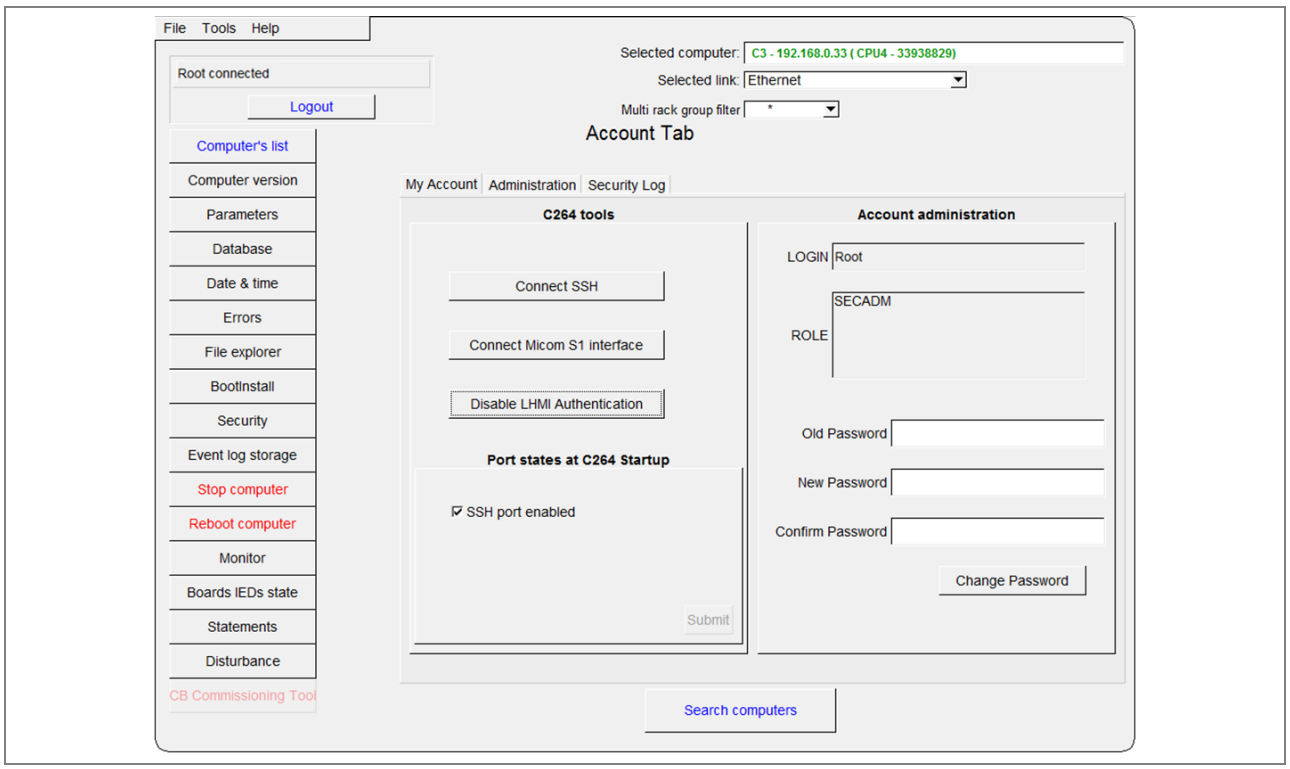
1 First select the **My Account** tab-pane
2 Enter the old password (*Root1234#* by default as of bootrom version *c264_bsp-6.9.1.9*)
3 Enter the new password;
4 Confirm the new password by entering it again,
5 Then click **Change Password**.

Note:
The Root password must have at least 9 characters.

External applications: C264 tools

In order to use a serial console to communicate with DS Agile C26x units, the SSH port must be enabled on the computer.

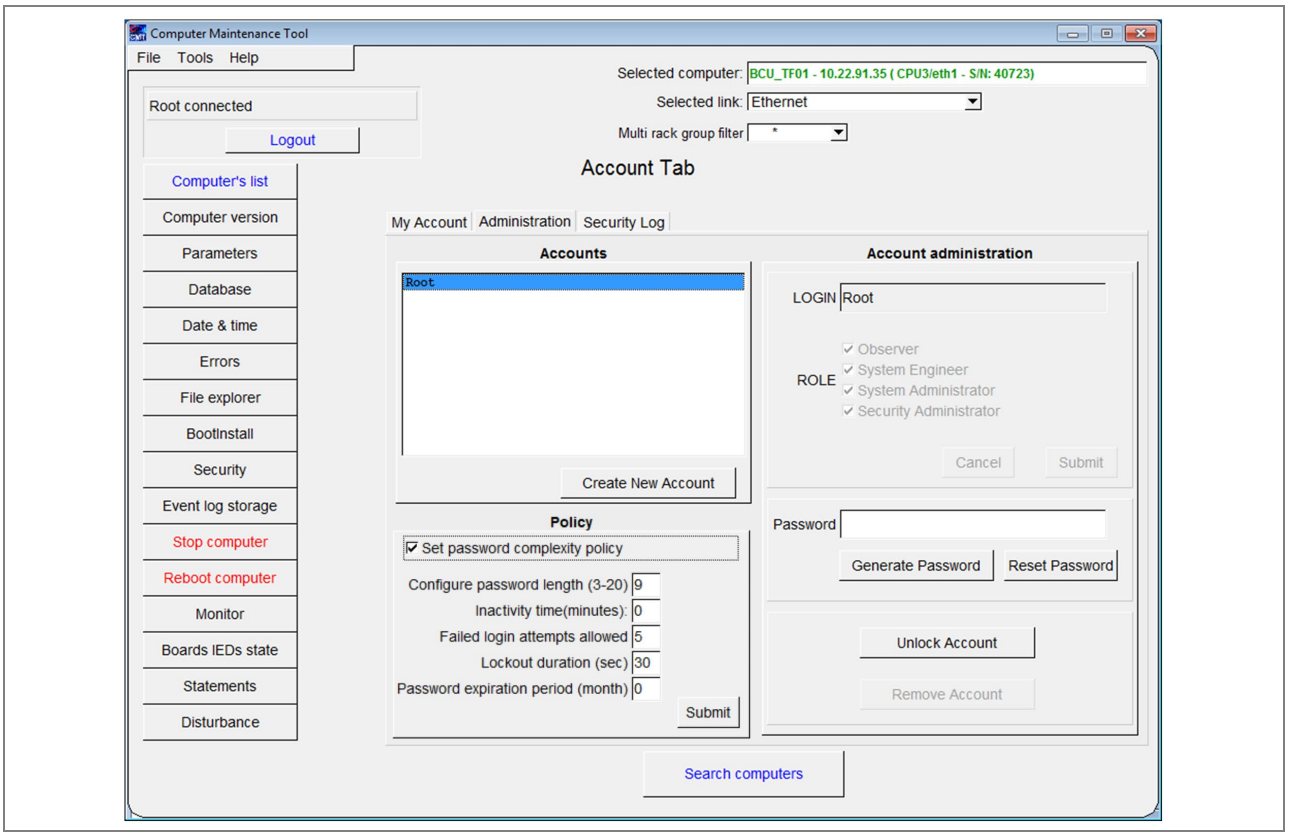
To enable the remote access port, tick the box *SSH port enabled* in the **Port states at C264 Startup** panel in the **My account** sub-tab (you must be logged to the unit with the Root account):



Click **Submit** to update the unit's settings.

11.1.6.8.1 Password, Security and Account management

Select the **Administration** tab:



In the **Policy** panel, enable or configure each required policy.

Password policy:

To impose a minimum, tick the box ***Set password complexity policy*** and set the password parameters:

The password must contain at least 3 different types of characters among the following:

- upper case letters
- lower case letters
- digits
- blank space
- special characters/punctuation marks:

!	"	#	$	%	&	'	(	)	*	+	,	-	.	`	~
/	:	;	<	=	>	?	@	[	\	]	^	_	{	}	|

- and set the password length:
- Enter the minimum number of characters (3 to 20, default setting: 9). When no password policy is enabled (***Set password complexity policy*** option unchecked), the password length is between 1 and 20 characters.

Session timeout

Tick this box to initiate automatic log out at the end of an inactivity timer. Enter that duration as a number of minutes.

Lockout policy

Tick this box to automatically lock out an account after a number of failed logs in attempts.

Failed login attempts allowed:

Enter the number of allowed failed attempts: the account will be locked if there is one more failed attempt than permitted. The number of consecutive login attempts can be set between 0 to 10. The default value is 3 for the “Root” account.

Note that the attempts are cumulative for the front panel LHMI and the DS Agile CMT, i.e., if the number of allowed failed attempts is 3, the account will be locked after 2 attempts on the LHMI and 2 attempts via the CMT, for instance.

Lockout duration:

Enter the duration of the account lockout in seconds. The account locking period is configurable from **0** to **999 minutes**. A value of **0** specifies that the user account will be locked out until an administrator explicitly unlocks it (*not applicable to “Root” account*). By default, the account lockout duration is set to 30 seconds.

Caution:

We highly recommend that you at least set the lockout duration to less than 30 seconds to prevent any brute-force security attack. A value higher than 1 minute increases the risk of:

- A legal user locked outside a critical system after three wrong login/password attempts;

- Access to the entire substation could be blocked by a malicious attacker entering several failed login/password attempts to all the user accounts.

Note that this lockout time is counted on the unit and that if its internal clock time is changed in the meantime, that change will affect the duration of the lockout, either by lengthening it or shortening it by the time difference implemented in the time change.

Password expiration period

Enter *0* if the password should never expire or set the **password expiration time** in months (*1* to *24).*

Default setting: *0*.

User accounts

Access rights for each account are defined using functional "roles", each of which grants a set of rights related to a specific type of activity:

- data viewing,
- engineering,
- system configuration,
- account administration.

Functional role	Associated rights	Access to CMT button views
Observer	The Observer role only allows to display data, i.e. read information. The Observer role does not allow changing any password other than the user's own password or viewing the security log.	Only access to: - the **Available Computers** view, - the **Computer version** view, - the **Security** view (restricted, can only change his/her own password), - the **Event log storage** view, - the **Monitor** view, - the **Boards IED state** view, - the **Statements** view, - the **Disturbance** view.
System engineer	The System engineer role only allows access to data useful to run the system. This user works in the substation and can act on switchgear and plant items. The System engineer role encompasses the Observer's rights, plus additional rights required to execute control commands. It does not allow changing any password other than his/her own or viewing the security log.	Access to all views, with some restrictions on the **Security** view (can only change his/her own password), except: - the **Database** view, - the **File explorer** view, - the **Bootinstall** view.
System administrator	The System administrator is a software specialist: this role allows performing software maintenance for version upgrades. It can display data, load a configuration database and change the operating mode of a subsystem. It does not allow changing any password other than his/her own or viewing the security log.	Access to all views, with some restrictions on the **Security** view (can only change his/her own password).
Security administrator	The Security administrator cannot display any operational data from the DS Agile system. It cannot load a configuration database nor change the operating mode of a subsystem. This user is responsible for the security policy. It can only change passwords, define account security policy and display security logs. It does not give access to the unit's front panel LHMI.	Access to the **Available Computers** view. Full access to the **Security** view.
Root	The Root role contains all the above privileges, plus: Open an SSH port and launch a terminal to send commands via the SSH link.	Access to all views.

A user account can be assigned several roles, and thus granted several sets of rights.

The user accounts created here are used to log into the unit from several access points:

- on the unit's front panel (LHMI),
- from the DS Agile CMT,
- from an SSH terminal.

Note:
Only the Root account can log in to the DS Agile C26x from an SSH terminal.

Account creation

The **Root** account as well as any other account with the Security Administrator role can create user accounts:

- Select the **Administration** tab.
- Click **Create New Account**.
- In the **New Account** panel, enter the LOGIN name and select the associated role(s).
- Click **Generate Password**.
- Keep or change the suggested password and click **Submit** (or **Cancel** to abort).
- Send the LOGIN/Password combination to the relevant user through a secure medium.

Note:
LOGIN and Password are case-sensitive, i.e. "A" is considered a different character from "a".

Good practice:

When creating a security administrator account, add at least the Observer role in addition to the Security Administrator role so that the user can display general information and connect to the device's front panel HMI.

Account management

Once a user account has been created, its LOGIN name cannot be changed.

The **Root** account as well as any other account with the Security Administrator role can **reset a password**:

- Select the **Administration** tab.
- In the **Accounts** panel, select the relevant account name.
- Click **Generate Password**.
- Send the LOGIN/Password combination to the relevant user through a secure medium.

The **Root** account as well as any other account with the Security Administrator role can prematurely **unlock a locked-out account** before the end of the lockout period:

- Select the **Administration** tab.
- In the **Accounts** panel, select the relevant account name.
- In the **Account administration** panel, click **Unlock Account**.

The **Root** account as well as any other account with the Security Administrator role can delete any other account, except the Root account:

- Select the **Administration** tab.
- In the **Accounts** panel, select the relevant account name.
- In the **Account administration** panel, click **Remove Account**.

Password change

Upon their first connexion to a C26x unit, all users are directed to change their password.

No changes can be made to a LOGIN name once the account is created.

All users can change their own password:

- Select the **My Account** tab.
- Enter the current password in the **Old Password** box.
- Enter the new password in the **New Password** box and in the **Confirm Password** box.
- Click **Change Password**.

11.1.6.8.2 C264 tools

Enable/Disable LHMI Authentication

By default, the C264 is configured in **Secure** mode with the disclaimer banner set to TRUE in the SCE database properties. In **Secure** mode, any key that is pressed on the C264 local HMI requires authentication (the Login panel is displayed).

When the CMT is connected to the C264, users with administrator rights (SECADM) can disable or enable the **secure** mode by clicking on the **Disable/Enable LHMI Authentication** button in the **Security\My account** tab. This **Disable/Enable LHMI Authentication** button is greyed out to other users or when no disclaimer banner is configured.

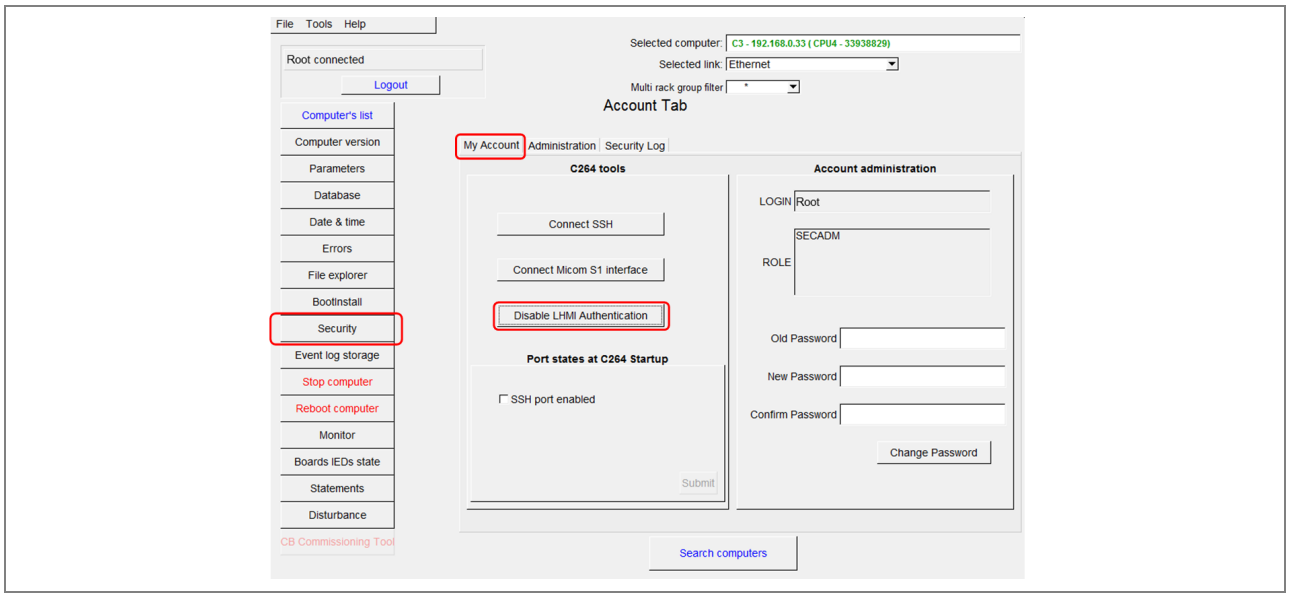


Figure 1: Disable LHMI Authentication when Secure mode is configured

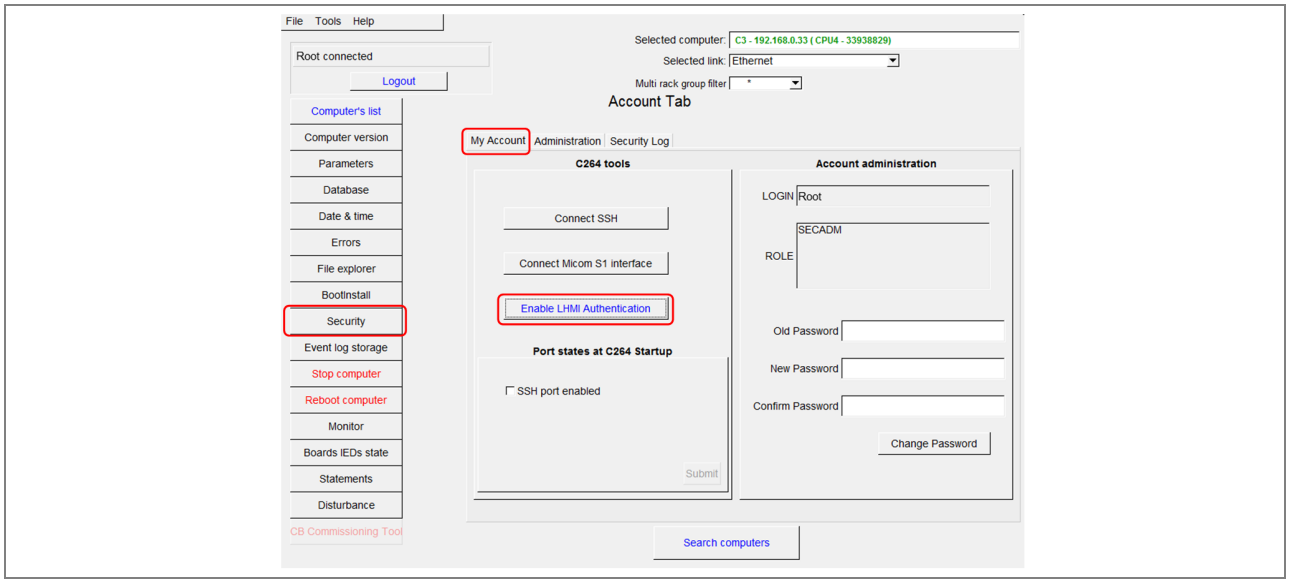


Figure 2: Enable LHMI Authentication when Secure mode is not configured

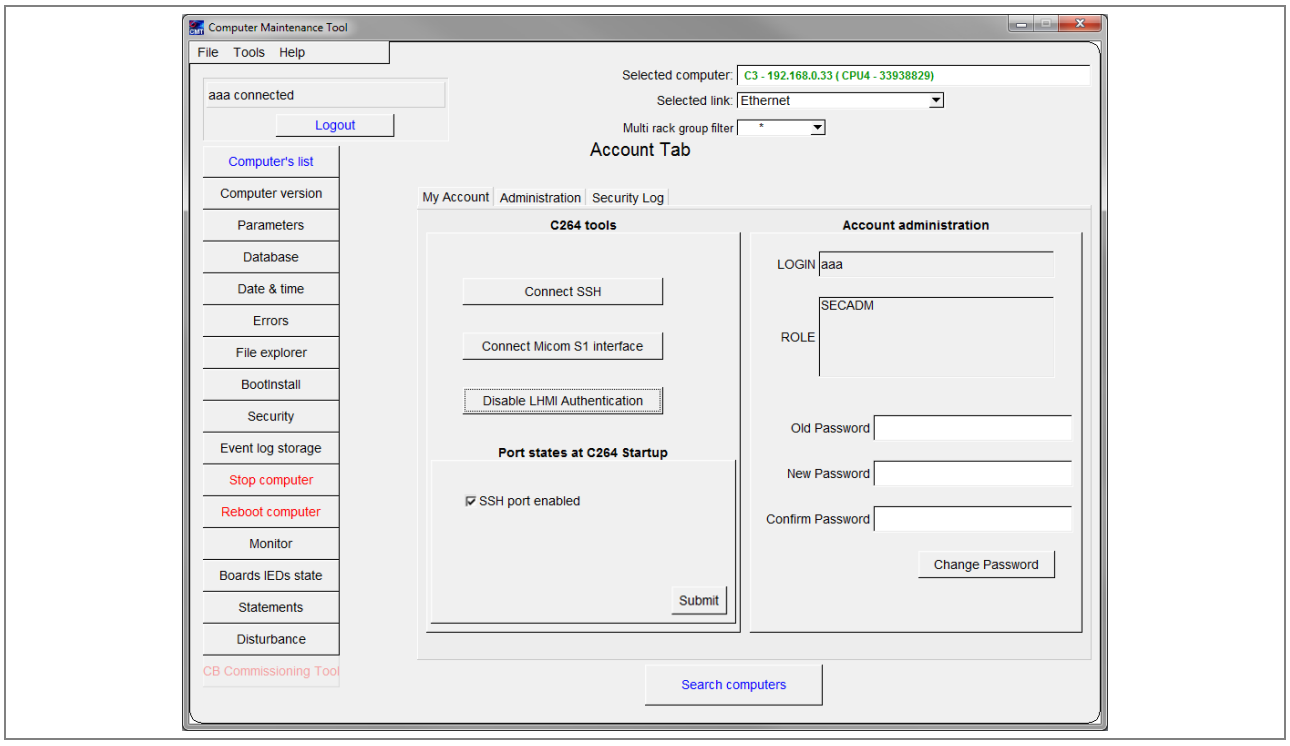
*Note: when the mode is changed through the **Disable/Enable LHMI Authentication** button, the parameter value is saved and restored upon the C264 reboot or DB switch.*

Enable the SSH port

It is possible to manage the C26x from an SSH command line interface. The SSH console can be used to easily get a shell on the C26x, in order to perform tasks that CMT cannot handle Only an operator logged in with the **root** account can connect to the unit using SSH.

To enable the SSH port:

- Open the **My Account** tab-pane,
- Tick the **SSH port enabled** box in the **Port states at C264 Startup** panel to authorize SSH connection (you must be logged to the unit with the Root account),
- Click **Submit** to update the unit's settings.



The console can then either be launched independently or by clicking the button **Connect SSH** in the **C264 tools** panel. It can be used even after the CMT has been closed.

SSH Terminal

Clicking on the **Connect SSH** button, in the **C264 tools** panel, launches the default SSH client on the operator's PC. SSH is connected to the selected C26x.

Note:
You can use any SSH client to establish a connection with the C26x's SSH server.

Enter the login and associated password in the SSH window when asked:

- Login: **Root** (as of bootrom version *c264_bsp-6.9.1.9*)
- Password: C624 Root account's password, by default **Root1234#** (as of bootrom version *c264_bsp-6.9.1.9*)
  (changing the Root's password in DS Agile CMT also changes it for the SSH access)

There is no inactivity timeout. To terminate the connection between the SSH client and the SSH server, enter the command "`logout`" in the SSH terminal (clicking **Logout** in the CMT closes the connection between the CMT and the C26x).

As SSH sessions are launched independently of the CMT, multi-sessions on two or more C26x units are possible. It is not, however, possible to connect to both the Ethernet ports of a C26x simultaneously.

It is possible to start a session directly from the SSH terminal, without using the CMT. In that case, select port *22* to connect to the C26x.

In all cases, access will be denied if the SSH port has not been enabled beforehand.

SSH uses a TCP/IP stack and the C26x has to be accessible from the PC in that mode.

Commands:

- Type `i` to display the list of available commands
- Type `lkup <command name>` to get help on a command
- Type `S_DBTEST_print_bay` or `print_bay` to list the C26x's datapoints

The SSH session times out after 10 minutes of inactivity (no command sent). This setting is configurable.

Connect MiCOM S1 interface

The setting software can only be connected to a C26x unit only via the CMT.

To launch the S1 application, open the **My Account** tab-pane and click **Connect Micom S1 interface** in the **C264 tools** panel.

For more information see the Settings chapter of the C264 user manual.

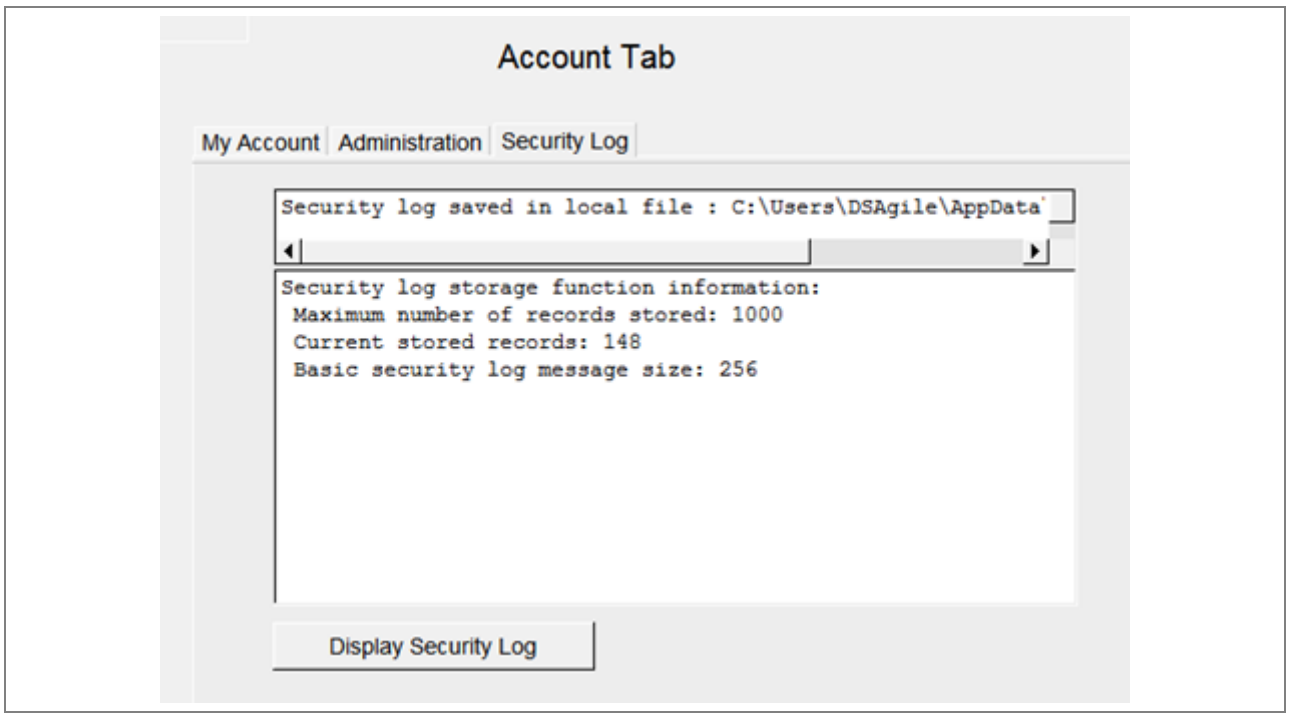
Note:

- Closing MiCOM S1 affects neither the CMT connection nor the SSH communications.
- Closing the SSH terminal affects neither the CMT connection nor the MiCOM S1 connection.
- Logging out from a C26x unit in the CMT (or closing the CMT) terminates the MiCOM S1 connection and make it impossible to upload/download settings. It also closes the S1 application if it was launched from the CMT.
- Logging out from a C26x unit in the CMT (or closing the CMT) does not affect the SSH communications.

11.1.6.8.3 Security Log

The **Security Log** tab-pane displays:

- the number of currently stored messages
- the maximum number of messages
- the date (date and time of the C26x) of the last database modification.



Click the **Display Security Log** button to download a copy of the full security log file. A copy is saved on the PC's hard disk as a text file that can be opened using a standard text editor such as Notepad.

Note:
The security log is saved in flash memory and is preserved when the C26x is rebooted. It is not possible to modify or delete the security log except by erasing the flash memory.

The C26x logs all security-related user activity, such as login attempts and user operations.

Any event linked to security generates an entry in the security log file, with the following details:

- Time and date.
- User interface from which the event originated (CMT, S1, front panel HMI).
- Login name of the user connected when the event occurred, or "SYSTEM" if generated at C26x start-up while no user was logged in.
- Description of the event, for instance "change the observer's password".

The security log is circular: when it is full, the latest event replaces the oldest. It can contain up to 2048 events.

The following operations are logged:

- Start-up of the device: `C264 STARTUP`
- Reboot of the device: `REBOOT`
- Successful login attempt: `LOGIN SUCCESS`
- Override logged user: `STEAL SESSION`
- Failed login attempts:
  - Password error: `BAD PASSWORD`
  - Expired password: `EXPIRED PWD`
  - Account locked after x attempts: `LOGIN LOCKED`
  - Non-existing account: `LOGIN NO ACCOUNT`
  - Another user is already logged in: `LOGIN IN USE`
- Logout: `LOGOUT SUCCESS`
- Logout after timeout: `SESSION TIMEOUT`
- User account changes:
  - New account: `CREATE NEW USER X With ROLE:` |a|b|c| (ex: |OB|SyE|SyA|SeA)
  - Password reset: `RESET PASSWORD FOR X`
  - Password change: `CHANGE PASSWORD FOR X`
  - Change of role: `ROLE CHANGE FOR X NEW ROLE is:` |a|b|c| (ex: |OB|SyE|SyA|SeA)`y`
  - Unlock: `ACCOUNT UNLOCK FOR X`
- Database switch: `SWITCH DB`
- Bootloader update: `UPDATE BOOTROM`
- VxWorks application update: `UPDATE vxWorks file`
- SSH port enabled: `ENABLE SSH`
- SSH port disabled: `DISABLE SSH`
- MiCOM S1 port enabled: `ENABLE MICOM S1`
- MiCOM S1 port disabled: `DISABLE MICOM S1`
- Configuration change in Security tab in CMT: `Configuration changed`
- User access through SSH: `User @login successful login with ssh`
- Access to log file: `User @login accessed log file`
- BCU fails switching the Database because user's privileges are insufficient: `Database switch failure > @dbVersion to @newDbVersion > (optional) @FailureExplanation`
- BCU fails updating the Firmware because firmware's file integrity is incorrect: `Firmware update failure > @firmVersion to @newFirmVersion > (optional) @FailureExplanation`

- Date & time modified: `Date & time modified`

The following operations are NOT logged:

- Device shutdown
- Sensitive information such as passwords

Note:
Although the Security Log tab may appear in the application, it is not used in the current version of DS Agile.

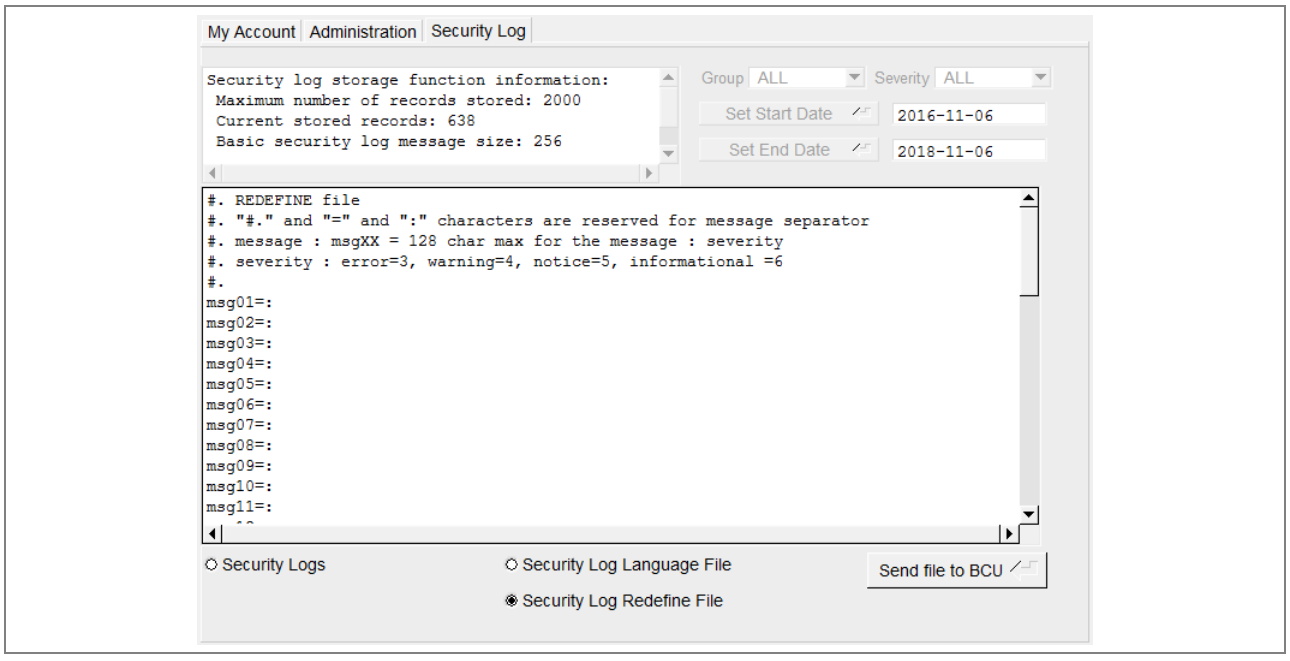
Security Log labels

It is possible to localize the security log language or to customize some of the messages. A copy of the default list of messages can be found in the `C264_cpu3` sub-folder of the CMT installation folder: `log_msg_default.txt`.

In the same folder, there are two other files that can be used to customize or localize the security logs:

- `log_msg_language.txt`: used to localize the security logs in a language other than the default
- `log_msg_redefine.txt`: used to customize some or all messages

Both these files can be updated directly from the CMT interface.



Each log message must have the format: `Msg##=`*<description text>*`:`*<severity level>*.
Example: `msg01=Login successful:6`

Respect the instructions given at the beginning of the file (see screenshot).

Variables can be used to identify the current user, system version, database version, etc. These variables are preceded with the special character @.
Example: `msg10=The user account @login was locked:5`

Caution:
Make sure that the syntax is correct as the CMT does not check the file validity. Incorrect syntax can cause inaccurate or truncated log messages.

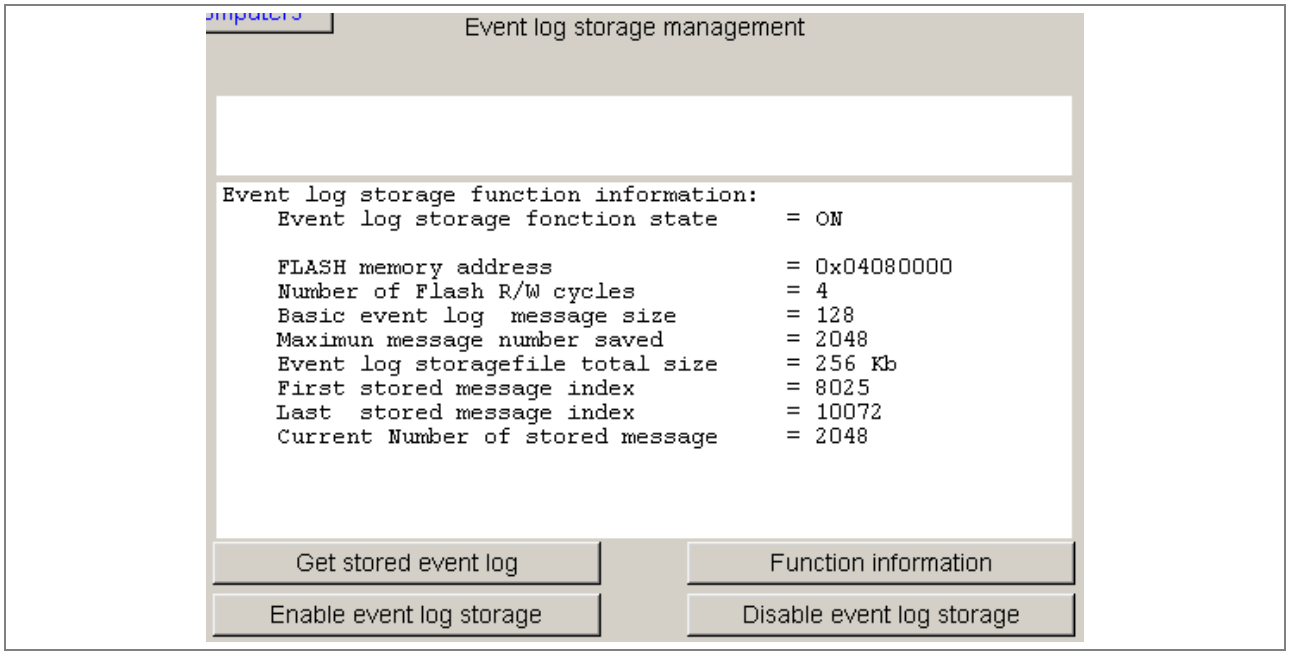
After editing a log message file, click **Send file to BCU** and wait for confirmation.

To fill in the security log, the C26x first checks the Security Log **Language** file. If it does not contain a translation for the message, it then checks the Security Log **Redefine** file. If that file does not contain a customised text, it uses the default label.

11.1.6.9 EVENT LOG STORAGE

This section reads or changes event log storage and printer configuration from or to the C26x.

11.1.6.9.1 Event log storage management



Function Information

"Function information" gives information about event log storage mechanism.

Enable/Disable event log storage

"Disable event log storage" (default state) disables event log storage mechanism. The state is updated in function information window.

```
Event log storage function information:
    Event log storage fonction state     = OFF
```

"Enable event log storage" (default state) enables event log storage mechanism. The state is updated in function information window.

```
Event log storage function information:
    Event log storage fonction state     = ON
```

Get stored event log

"Get stored event log" reads event log saved in the C26x flash memory, transfers it in a "temporary" file: c:\Temp\ArchX.lst

```
Event log saved in local file :  c:\Temp\Arch2.lst
```

and opens a "notepad" window.

Arch2.lst - Bloc-notes

Fichier Edition Format ?

```
        DS AGILE COMPUTER C264 SOFTWARE INFORMATION
        VERSION                  : WORK
        DATABASE COMPATIBILITY   : D17
        UCA2 AGENCY              : 2.23
        ISAGRAF                  : 4.03
        TRIANGLE                 : 3.00.0025
        CREATION DATE            : Feb  5 2004, 15:00:30

      All rights reserved (C) Copyright ALSTOM   2012


------------------------------------------------------------
                  DATABASE  INFORMATION

        DEVICE NAME              :C264JB
        DEVICE TYPE              :C264C Computer
        MODEL                    :C264C
        COMPANY                  :ALSTOM
        DESCRIPTION              :C264C Computer New board
        SUBSTATION               :TEST SUBSTATION
        DATABASE                 :bd
        VERSION                  :0.82
        DIRECTORY                :/flash/DATABASE/DB1

     CREATION DATE:  23/01/04 15:25:55,  LAST SETTING:  23/01/04 15:25:55

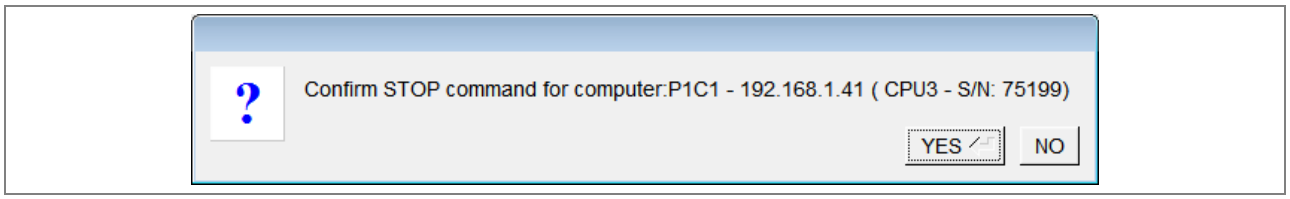

------------------------------------------------------------
     04/02/09 19:57:39.910    BEGIN OF ARCHIVED EVENT PRINT

  * 04/02/05 13:28:52.805   maint                          CHANGED MODE TO  Open
  * 04/02/05 13:28:52.807   maint          /Graph. HMI board GHU status       State0
  * 04/02/05 13:28:52.807   maint          /BIU200           BIU status       OK
  * 04/02/05 15:43:40.810   maint                          CHANGED MODE TO  Open
  * 04/02/05 15:43:40.812   maint          /Graph. HMI board GHU status       State0
  * 04/02/05 15:43:40.812   maint          /BIU200           BIU status       OK
  * 04/02/05 19:12:52.744   maint                          CHANGED MODE TO  Open
  * 04/02/05 19:12:52.745   maint          /Graph. HMI board GHU status       State0
  * 04/02/05 19:12:52.746   maint          /BIU200           BIU status       OK
  * 03/07/14 14:04:37.935   maint                          CHANGED MODE TO  Open
  * 03/07/14 14:04:37.937   maint          /Graph. HMI board GHU status       State0
  * 03/07/14 14:04:37.937   maint          /BIU200           BIU status       OK
```

The file can be edited, printed, saved like a regular PC file.

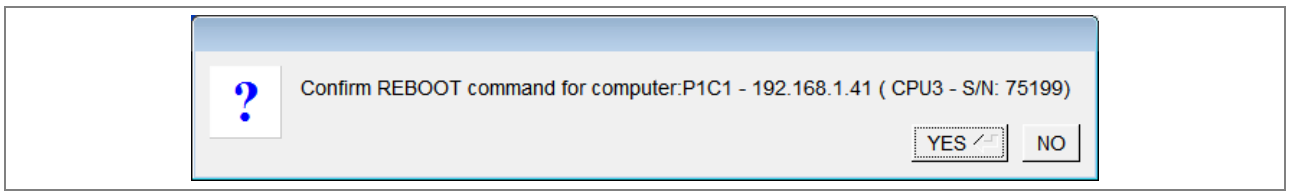
11.1.6.10 STOP COMPUTER

This operation stops the selected C26x application software. It suspends all tasks except "SYNCHRO" and "SUPERV". A confirmation is needed.



11.1.6.11 REBOOT COMPUTER

This operation reboots the selected C26x. A confirmation is needed.



Notes: The output of a PSL automation can be altered by such a reboot; in this case, it is preferable to reboot through the shell.

For versions B6.00 to B6.08 the command reboot can only be issued using the shell interface (reboot shell command) or cycling the power of the C26x when it is in STOPPED mode.

11.1.6.12 MONITOR

This panel displays, for each board, with or without automatically refreshing:

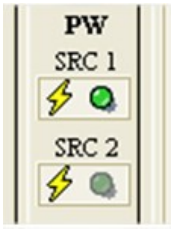
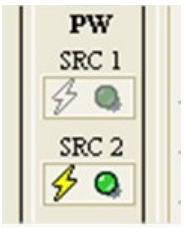
- the board status:
  - Green label for *PRESENT* and *CONFIGURED*
  - Blue label for *MISSING*
  - Grey label for *NOT CONFIGURED*
- the states of the inputs (green virtual LEDs) and outputs (red virtual LEDs):
  - "Lit" for *ON* / *CLOSED*
  - "Extinguished" for *OFF* / *OPEN*
  - None for *NOT CONFIGURED*
- the channel statuses: *VALID* / *INVALID* / *CONFIGURED* / *NOT CONFIGURED*

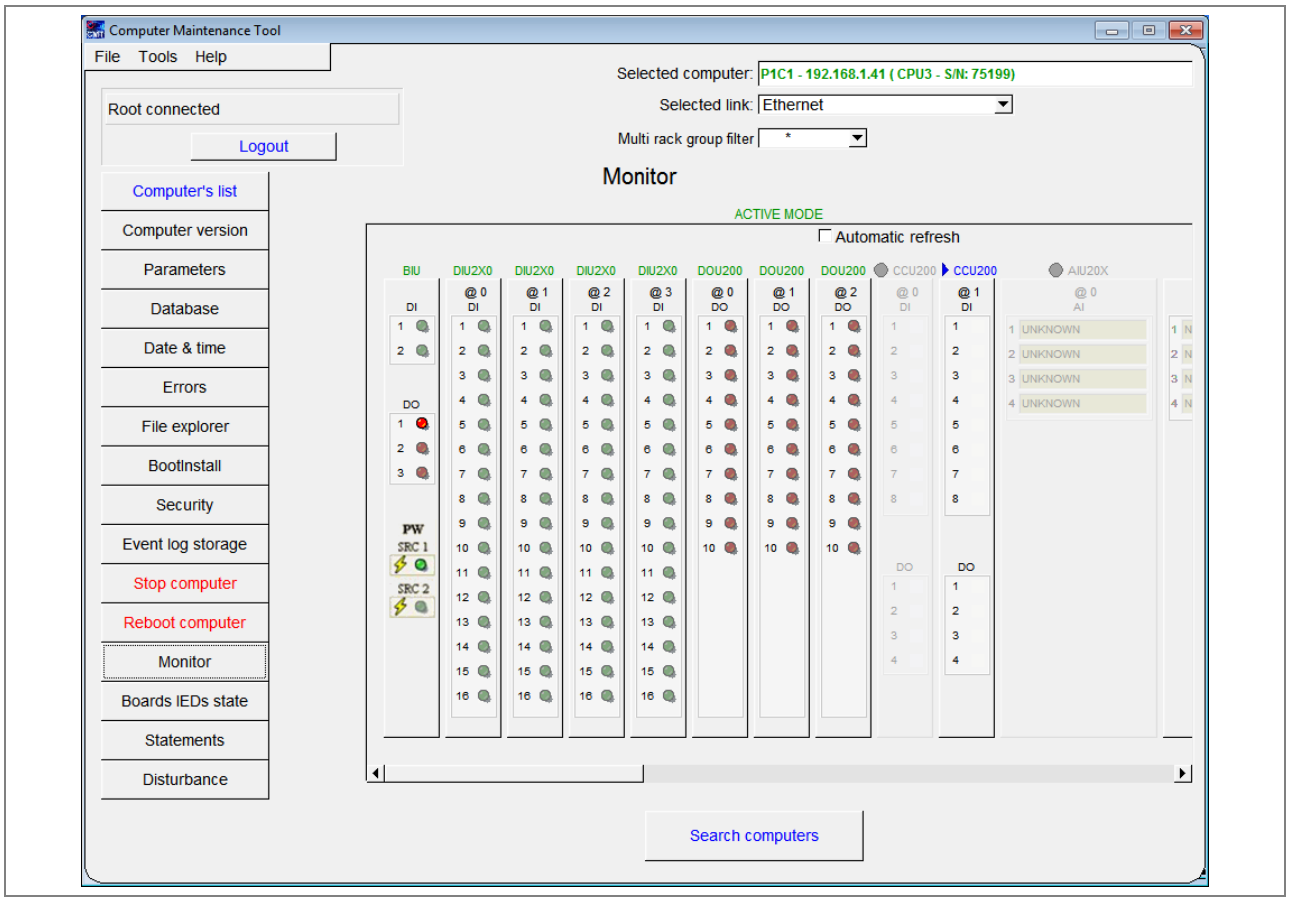
Particular case: BIU261D

If a dual input power supply board (BIU261D) is present, the state of each power supply input is shown in the BIU column, under the state of the board's DOs, in the form of a virtual "LED" with a lightning bolt symbol to the left:

Symbol	Meaning
	The power supply source is not available
	The power supply source is available
	The power supply input is not in use
	The power supply input is in use

Examples:

	
Power supply source 1 is available Power supply source 2 is available ➔ Power supply input **1** is used	Power supply source 1 is not available Power supply source 2 is available ➔ Power supply input **2** is used


Computer Maintenance Tool
File Tools Help
Root connected
Logout
Computer's list
Computer version
Parameters
Database
Date & time
Errors
File explorer
BootInstall
Security
Event log storage
Stop computer
Reboot computer
Monitor
Boards IEDs state
Statements
Disturbance
Selected computer: P1C1 - 192.168.1.41 (CPU3 - S/N: 75199)
Selected link: Ethernet
Multi rack group filter *
Monitor
ACTIVE MODE
Automatic refresh
BIU
DIU2X0
DOU200
CCU200
AIU20X
DI
DO
PW
SRC 1
SRC 2
UNKNOWN
Search computers

11.1.6.13 BOARDS AND IEDS STATE

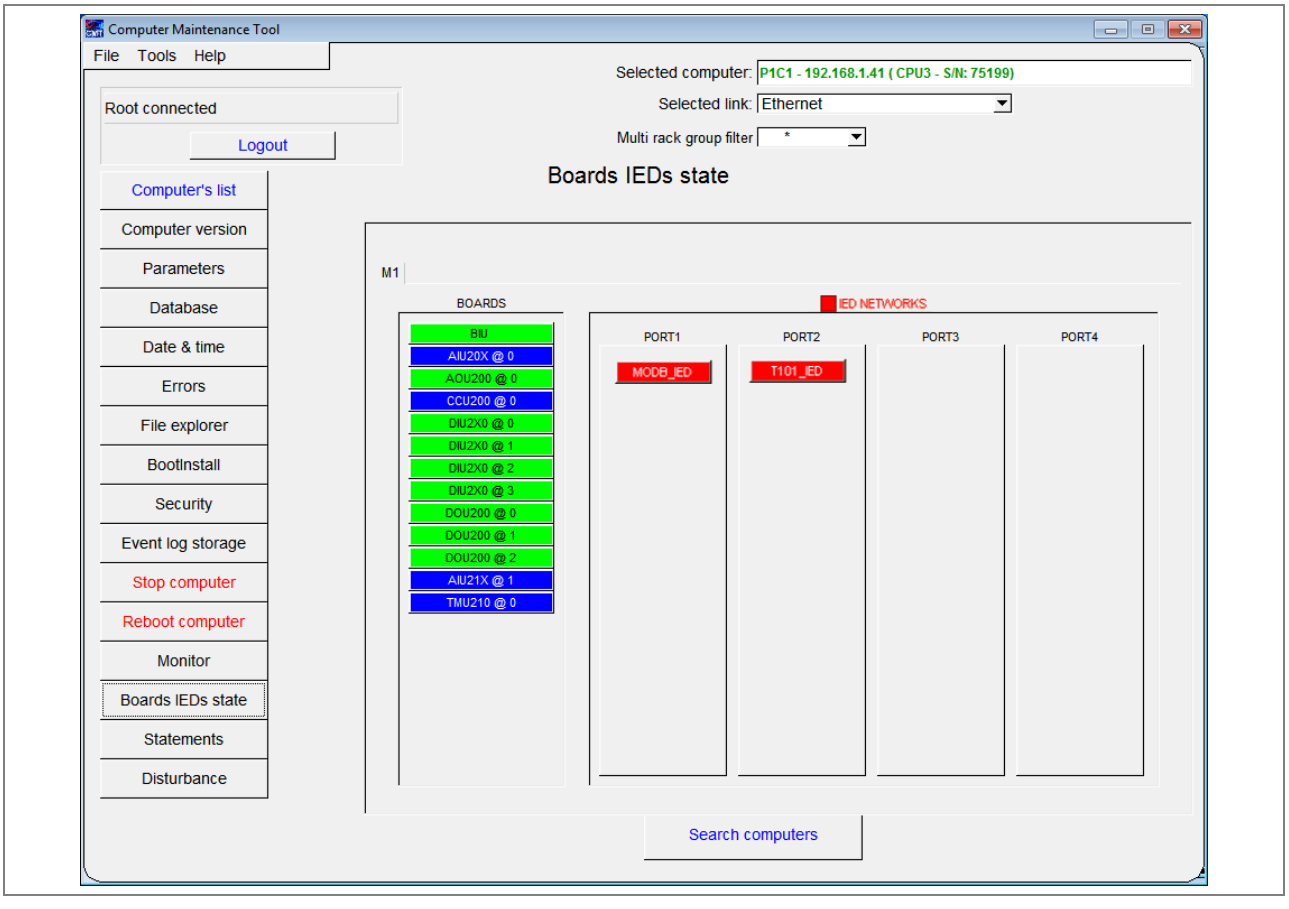
This panel displays:

- the state of the boards and the IED legacy communication link
- the main racks and their extensions (if applicable)
- the data from max 1 main and 32 extensions (version stand-alone multi-rack)
- the configured boards' states:
  - Green for *OK*,
  - Blue for *MISSING/FAILURE*,
  - Red for *BOARD FAILURE*)

  and SCE index (@0, @1, etc)

> *Note:*
> *If two or more boards of the same type have the same address, e.g. "@0", they will be displayed in BLUE, not red.*

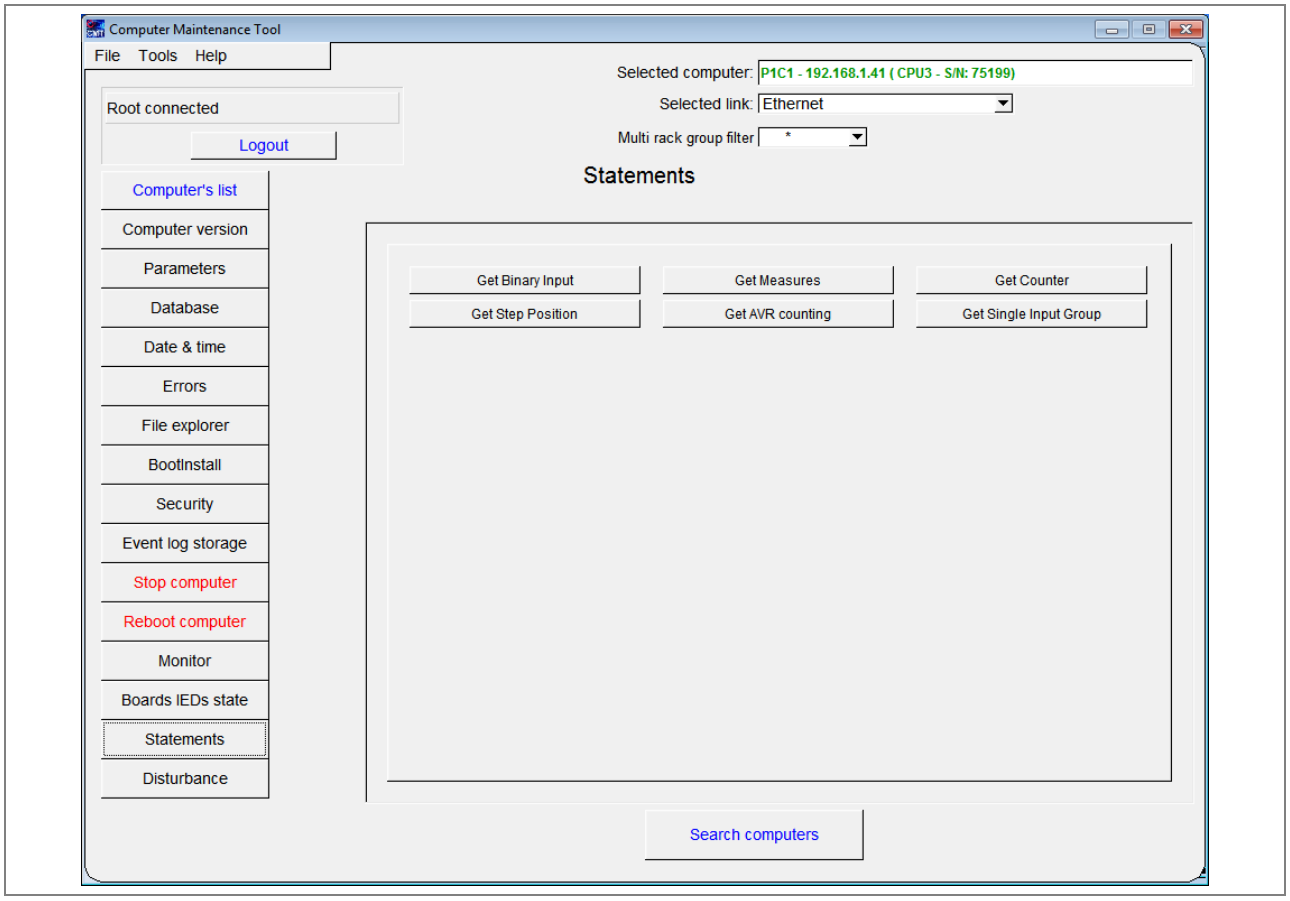
- the communication state of the configured IEDs in the rack / on a serial port (max 16 IEDs x 4 ports):
  - Green for *IED CONNECTED*
  - Red for *IED DISCONNECTED !* and for *IED HAS AN UNKNOWN STATUS*



11.1.6.14 STATEMENTS

This panel displays datapoints current status / values in a Notepad viewer:

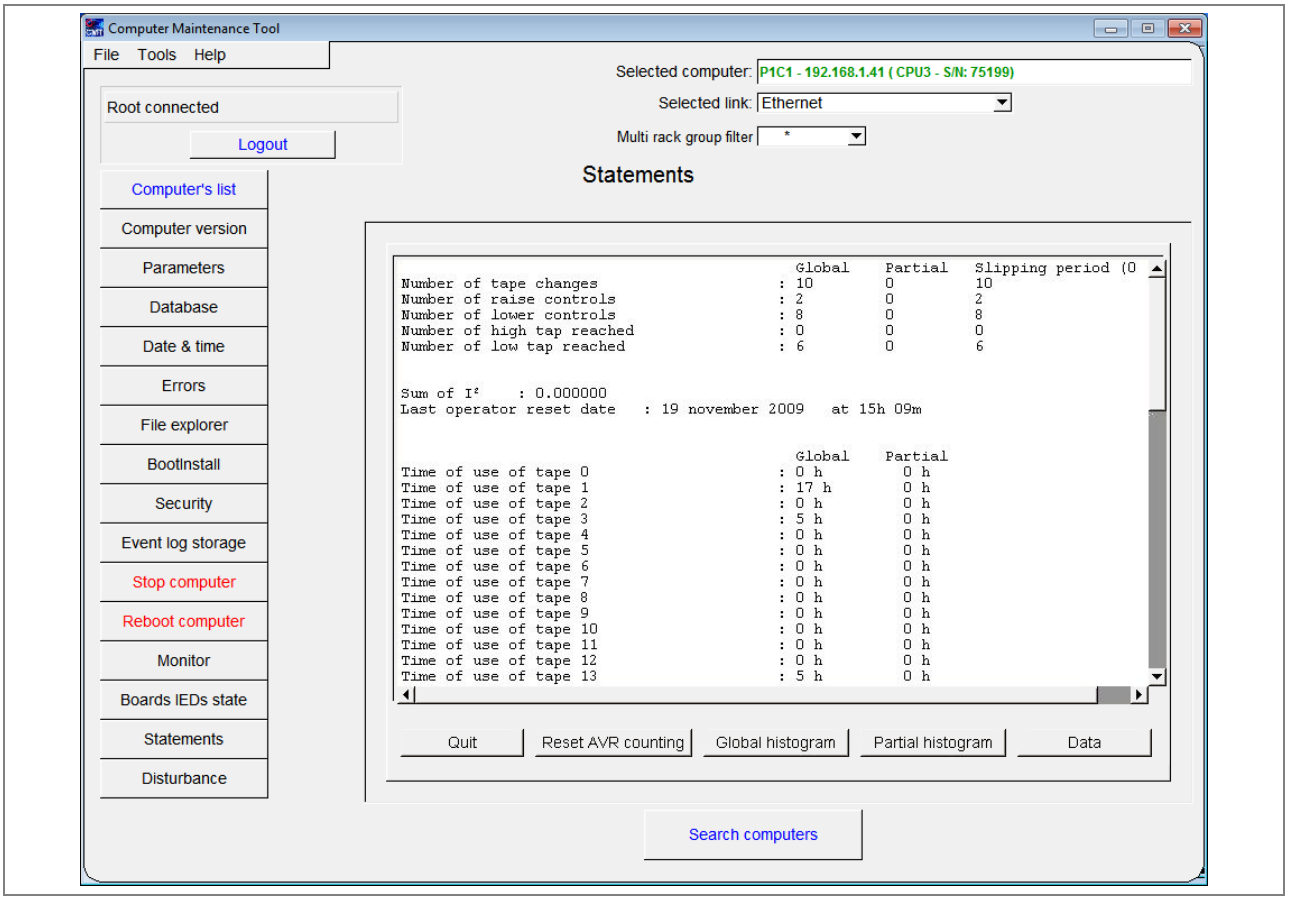
- Binary Inputs
- Measurements
- Counters
- TPI (Step Position Information)



Example: TPI in conjunction with the AVR function.

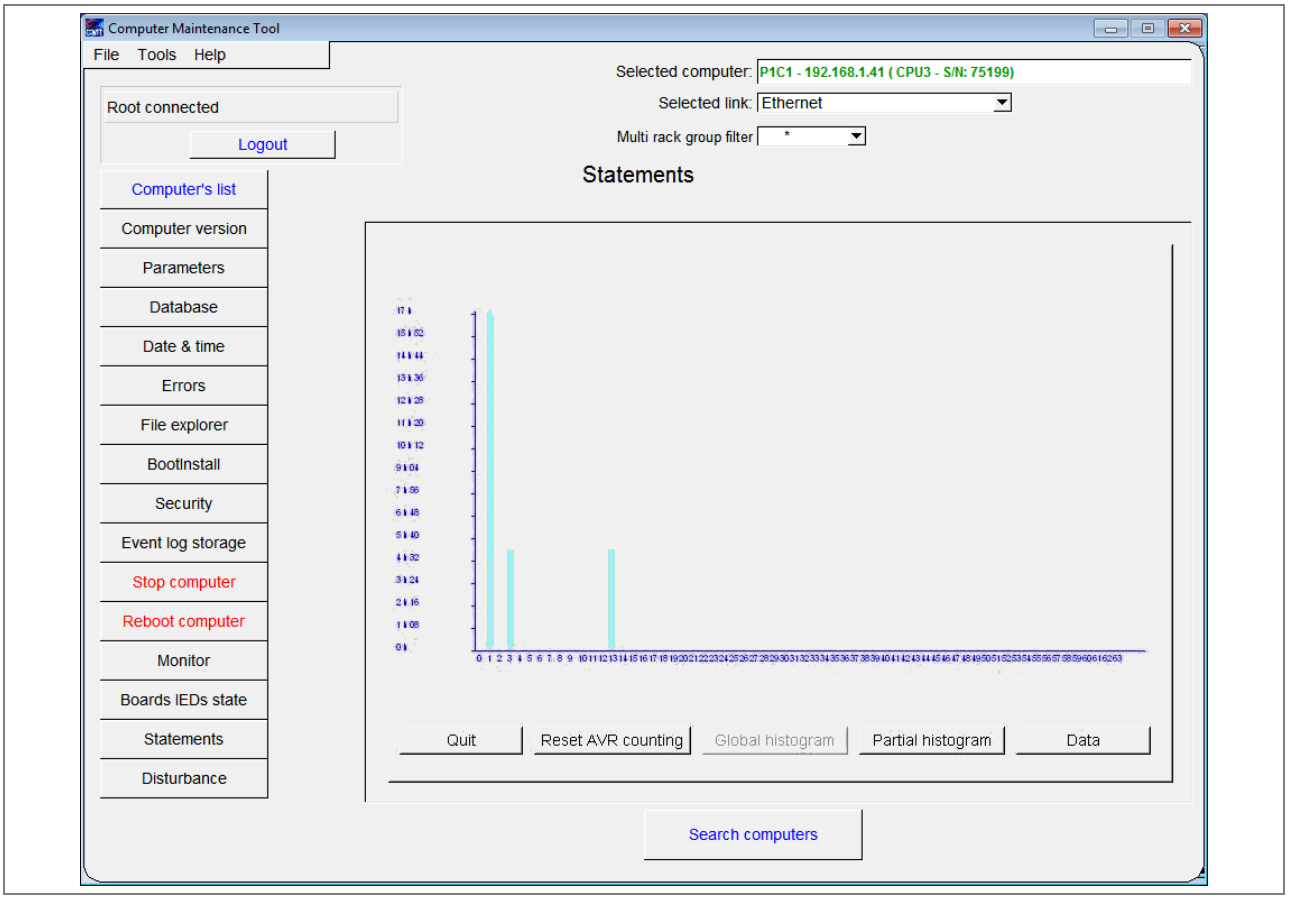
The AVR function (refer to the chapter C26x/EN FT) includes counting the number of tap changes and times of use of tape changers. CMT enables the operator to view them

- since the C26x init (Global)
- since the latest reset time (Partial)
- permanently on a slipping period set in DS Agile S1 (refer to chapter C26x/EN ST):



Press the button **Reset AVR counting**; this refreshes the page and sums the I² and times of use of each tape (0 to 63).

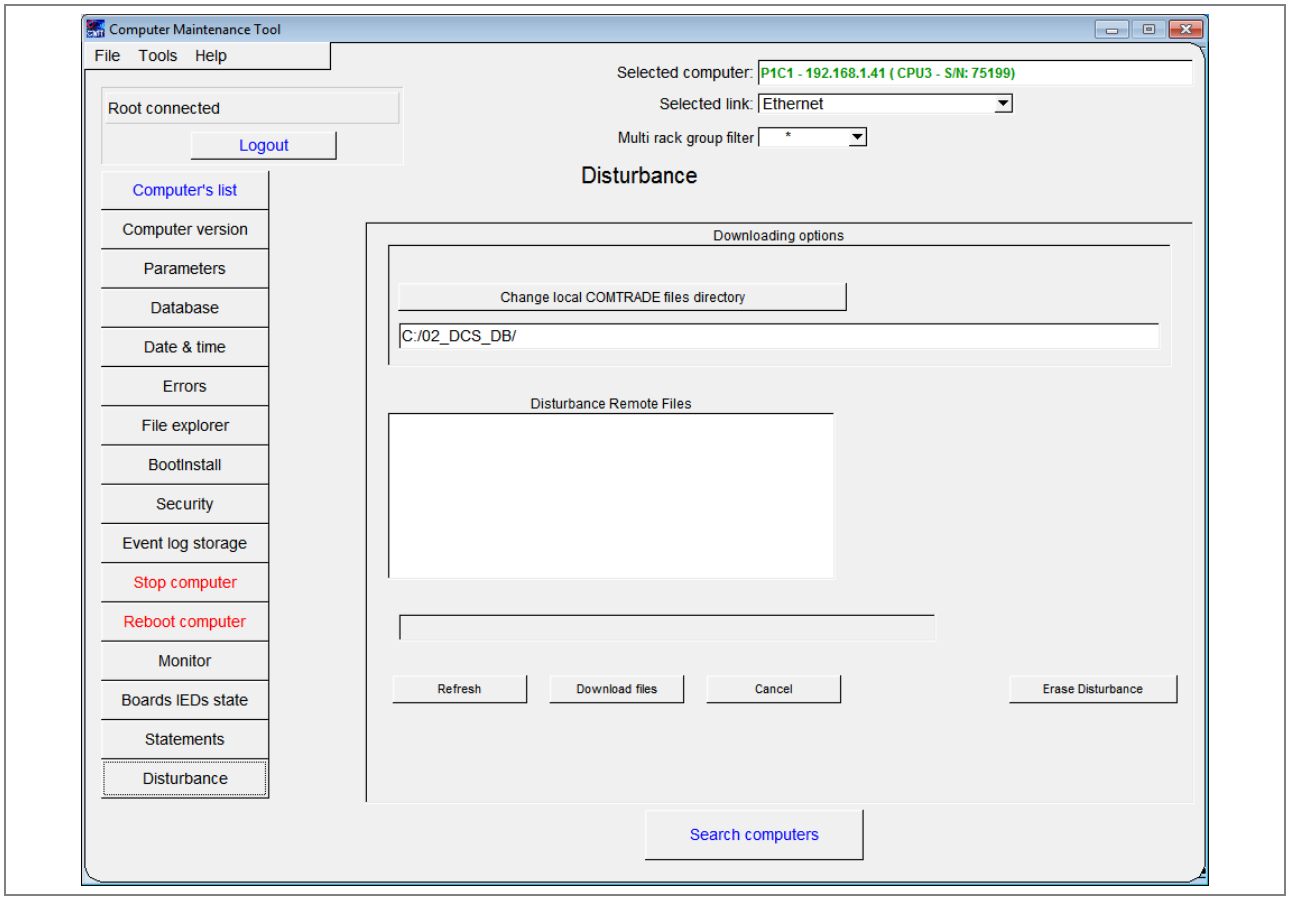
Press either **histogram** button to view the Pareto charts:



11.1.6.15 DISTURBANCE

This allows to:

- display the list of slow and fast waveforms
- download from the C26x to the CMT the slow and fast waveform files
- convert automatically these files to COMTRADE 2001
- optionally delete file(s) after successful transfer



The list of disturbance files is displayed in the central text area.

To refresh it, press **Refresh**.

The button **Erase Disturbance** is used to erase the Fast WaveForm files from the C26x's memory.

APPLICATION

C26X/EN AP/D40

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1 SCOPE OF THE DOCUMENT

This document describes how to configure the C26x unit.

To generate a template from an existing IEC 61850 compliant C26x, refer to the Human Interface chapter of the SCE user manual (section Tools menu).

2 CONFIGURATION SCOPE FOR THE C26X

2.1 GENERAL DS AGILE SYSTEM CONFIGURATION

To define a complete DS Agile system, three aspects must be considered:

The system topology contains de units that manage the customer's electrical process. Generally, these are supplied by GE Grid Solutions and they correspond to GE Grid Solutions' system process definition to meet the customer's needs.

The electrical topology represents the customer's electrical process definition in terms of typed electrical units (transformers, disconnectors, circuit-breakers…) that are connected to one another through busbars or lines. This information is normally provided by the customer.

The graphical topology contains the mimic diagrams and their associated animated graphics that will be displayed at the substation's control points (aView, the system HMI) and bay control points (C26x's front panel HMI).

When a new configuration is created using the SCE, these three topologies are automatically instantiated via root objects:

- A 'Site' object for the electrical topology, containing one 'Substation' object.
- A 'Scs' (acronym for Substation Control System) object for the system topology, containing one 'SBUS network' object and, optionally, one 'PBUS network' object if a process bus is used.
- A 'Graphic' object for the graphical topology.

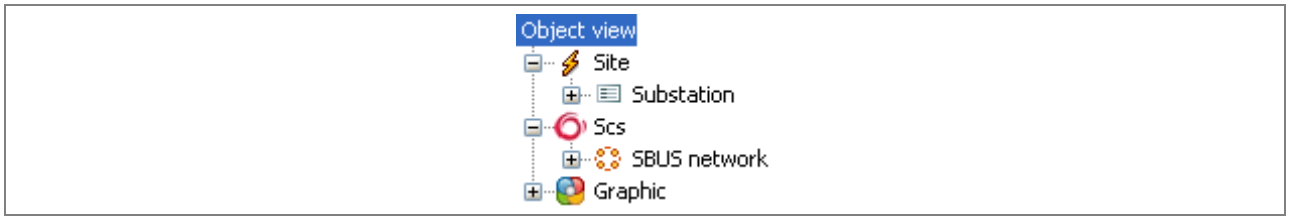


Figure 1: General architecture of a DS Agile configuration in the System Configuration Editor (SCE)

2.2 DS AGILE C26X CONFIGURATION

In the general DS Agile system configuration, the C26x is present in the three topologies:

- Electrical topology (**Site**): The C26x manages the bays and their associated modules or substation information.
- System topology (**Scs**):

  There are 2 default objects at the root of the SBUS network in the System hierarchy:

  - the **SMT** (System Configuration Tool): The **SMT** object is unique. It is automatically added when a database is created and it must be configured (see SMT/EN AP for details),
  - the **System Group**: The **System Group** contains the devices managing, monitoring and/or protecting one or more electrical bays.

    The C26x is a direct sub-component of the System Group.
  - DS Agile aView: a **System HMI** node must be added from the **Object entry** window.
- Graphical topology (**Graphic**): The C26x can be fitted with an LCD HMI to display animated graphics representing the bay's topology as well as information lists such as alarms, measurements, etc.

2.3 SPARE OBJECT

At DS Agile SCE level, a spare object is an object created for possible ulterior use or in order to disable an HMI command.

The label of a spare object is displayed in gray italic text in the Explorer window. The configuration of this object and of its spare attribute is the same as that of any other object and attribute.

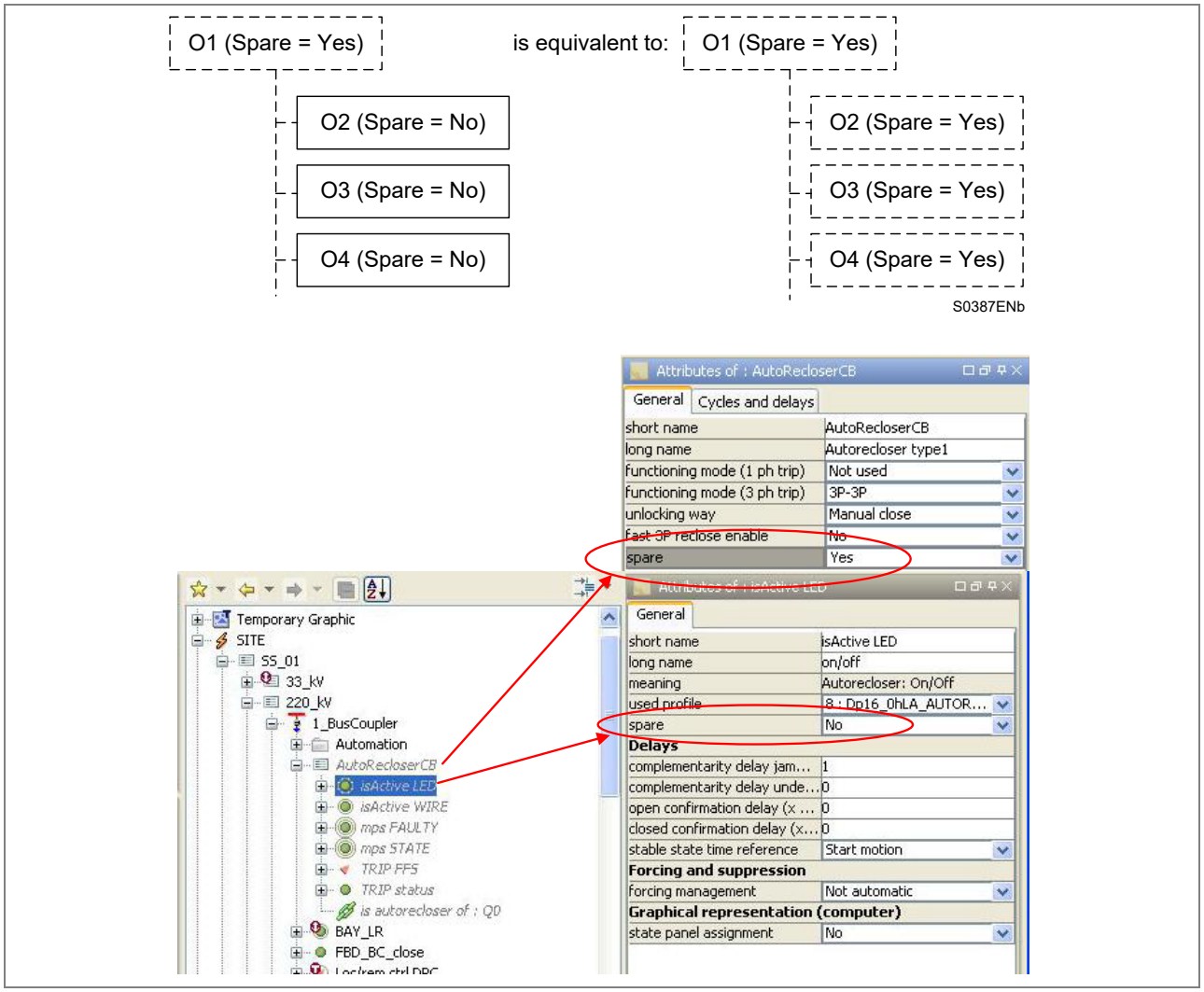
To configure an object as spare, simply set its ‘spare’ attribute to *'Yes'*.

Any object can be spared, including those used in the C26x's configuration.

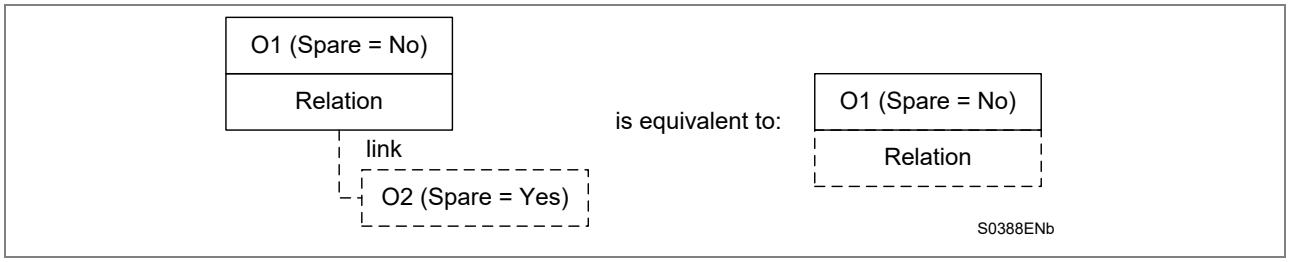
Spare objects are not passed on to the generator tools.

Object sparing follows these two rules:

- Objects O2, O3, O4, etc., not individually spared, are considered as spare objects if they are linked, directly or not, to a spare composite parent object (O1):

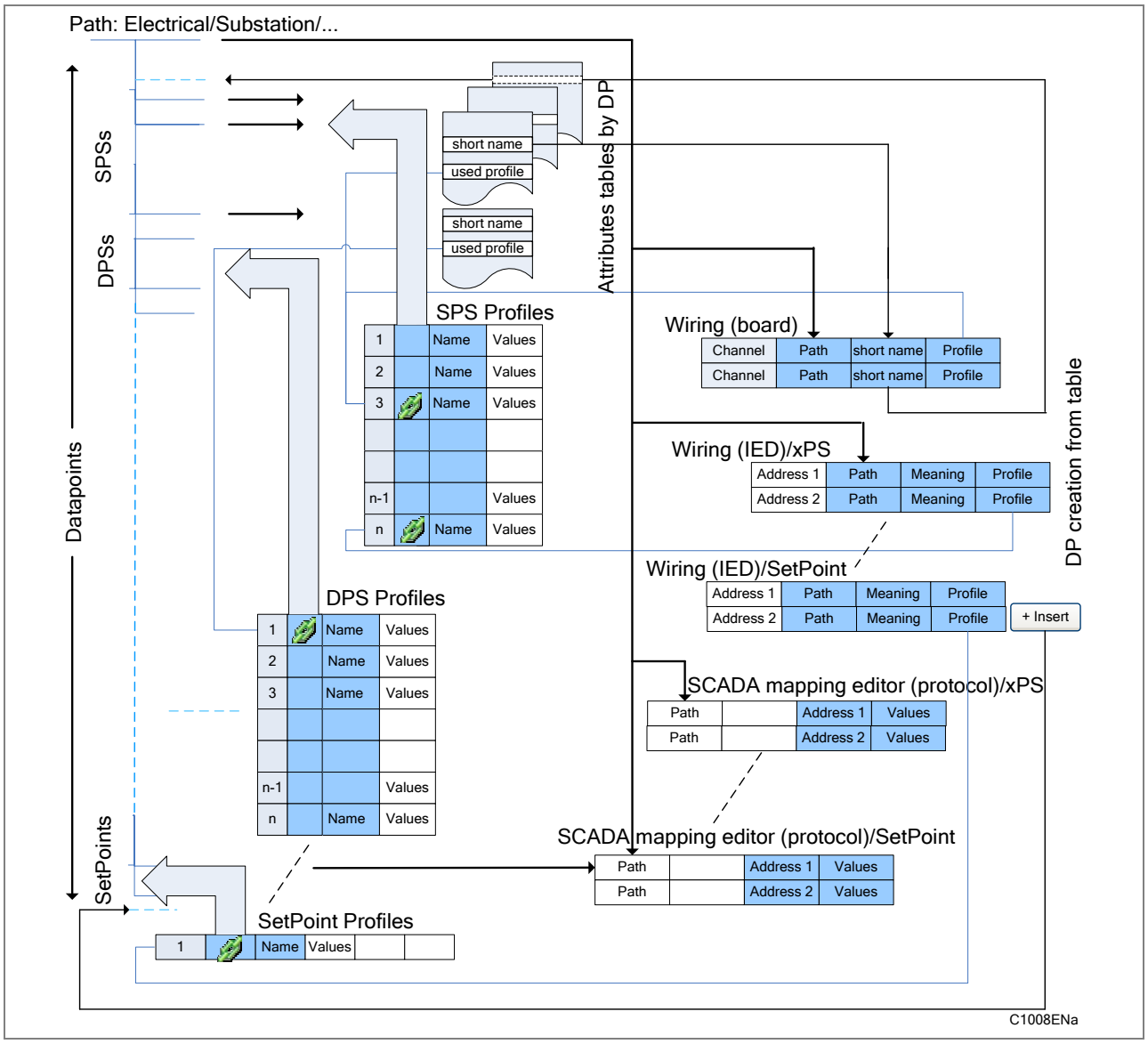


- A relation defined on an object O1, not spare, and linked to a spare object O2, is considered as a relation with no link:



2.4 SMART TABLES

Several autofill tables can be invoked to speed up input. They are detailed in the corresponding sections. The interactions between tables are sketched in this figure:



3 DEFINING A C26X CONFIGURATION IN THE SYSTEM HIERARCHY

3.1 SETTING THE GENERAL SYSTEM'S PARAMETERS RELEVANT TO C26X UNITS

System configuration is done at the Scs root. It defines the global behaviour of DS Agile units.

It encompasses these attributes:

- Common labels used for control acknowledgement, time quality logging, alarm management logging, C26x board management.
- Alarm management characteristics (alarm processing type, sound time-delays, alarm clearing modes per level of gravity).

as well as the relations that define operators' action rights on system datapoints.

3.1.1 GENERAL PARAMETERS

Some Scs object attributes affect all the C26x units defined in the substation network:

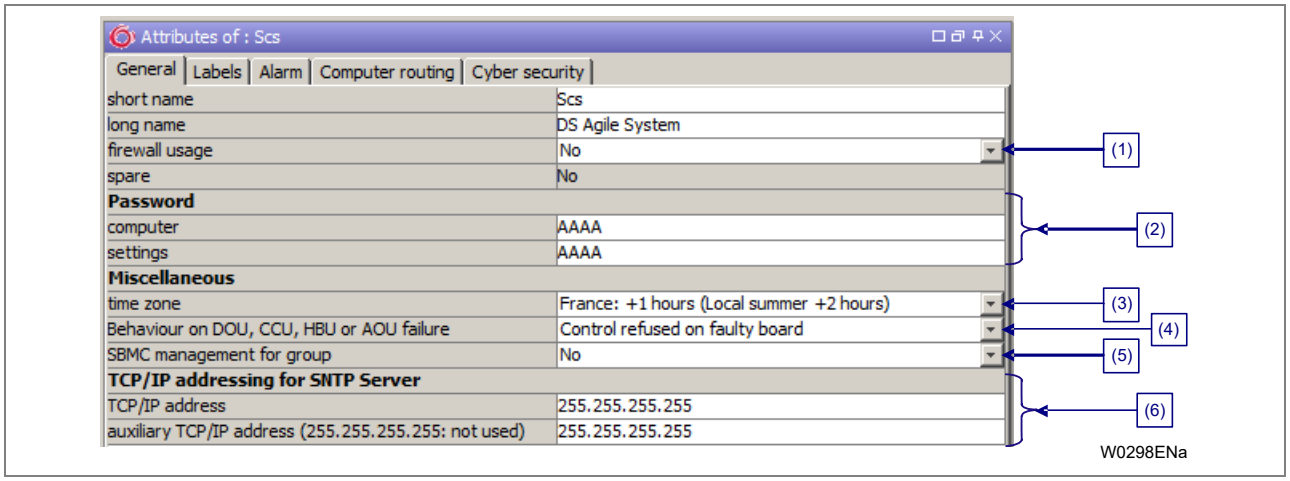


Figure 2: General attributes of Scs objects

(1) **firewall usage**: This feature is used to separate the networks connected to the C26x, in order to improve security and reduce possible intrusions. It is not available in the RTU application.

- *No*: the function is disabled, Eth1 is used for SBUS and maintenance connections and Eth2 can be used for Multirack, RTU connections or SSH connection (provided that the latter has previously been enabled via the CMT).
- *Yes*: The two Ethernet ports on the CPU270 are segregated, and Eth2 is reserved for maintenance PC / applications.

Note:
C26x redundancy is not impacted by this function: it can be used whether the Firewall usage feature is enabled or not.

Note:
T104 master and slave networks are not impacted by this function: they can always be connected to Ethernet port 1 and they may alternatively be connected to Ethernet port 2 as long as it does not support any Extension Rack connection.

(2) **Password:**

- **computer**: general default front panel HMI password
- **settings**: default password to access protection settings on the front panel HMI (only relevant if the C26x is fitted with a TMU210 board)

Note:
*With the implementation of cyber-security, the **computer** and **settings** password attributes are no longer relevant. See Installation chapter for information on default account/password and how to create/change accounts and passwords.*

(3) **time zone**: used for timestamp information.

(4) **Behaviour on DOU, CCU, HBU or AOU failure** (*Control refused on faulty board* / *Computer goes in fault mode*)

(5) **SBMC management for group** (*No* / *Yes*): management of SPS groups when some of the SPS that they contain are managed by a bay in SBMC mode:

- *No*: SPS groups will disregard the fact that some of the SPS that they contain are managed by a bay in SBMC mode and will keep taking their states into account,
- *Yes*: SPS groups will not consider any SPS managed by a bay in SBMC mode and will ignore their states.

(6) **TCP/IP addressing for SNTP Server**: master clock C26x(s) in the system. Up to two C26x units can be declared as System Master Clock. A System Master Clock C26x gives the time reference to all others units connected to the station-bus network through SNTP (Simple Network Time Protocol). A System Master Clock C26x is always located in a substation.

3.1.2 LABELS

(7) **board** and **status Labels**

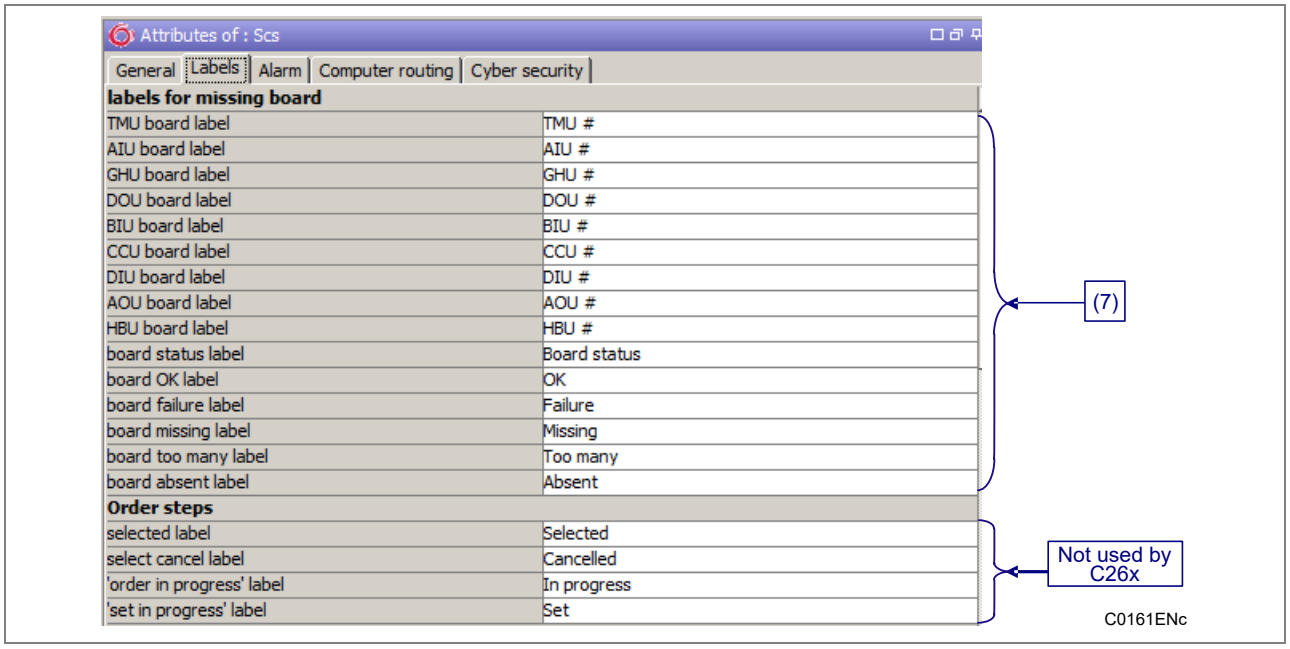
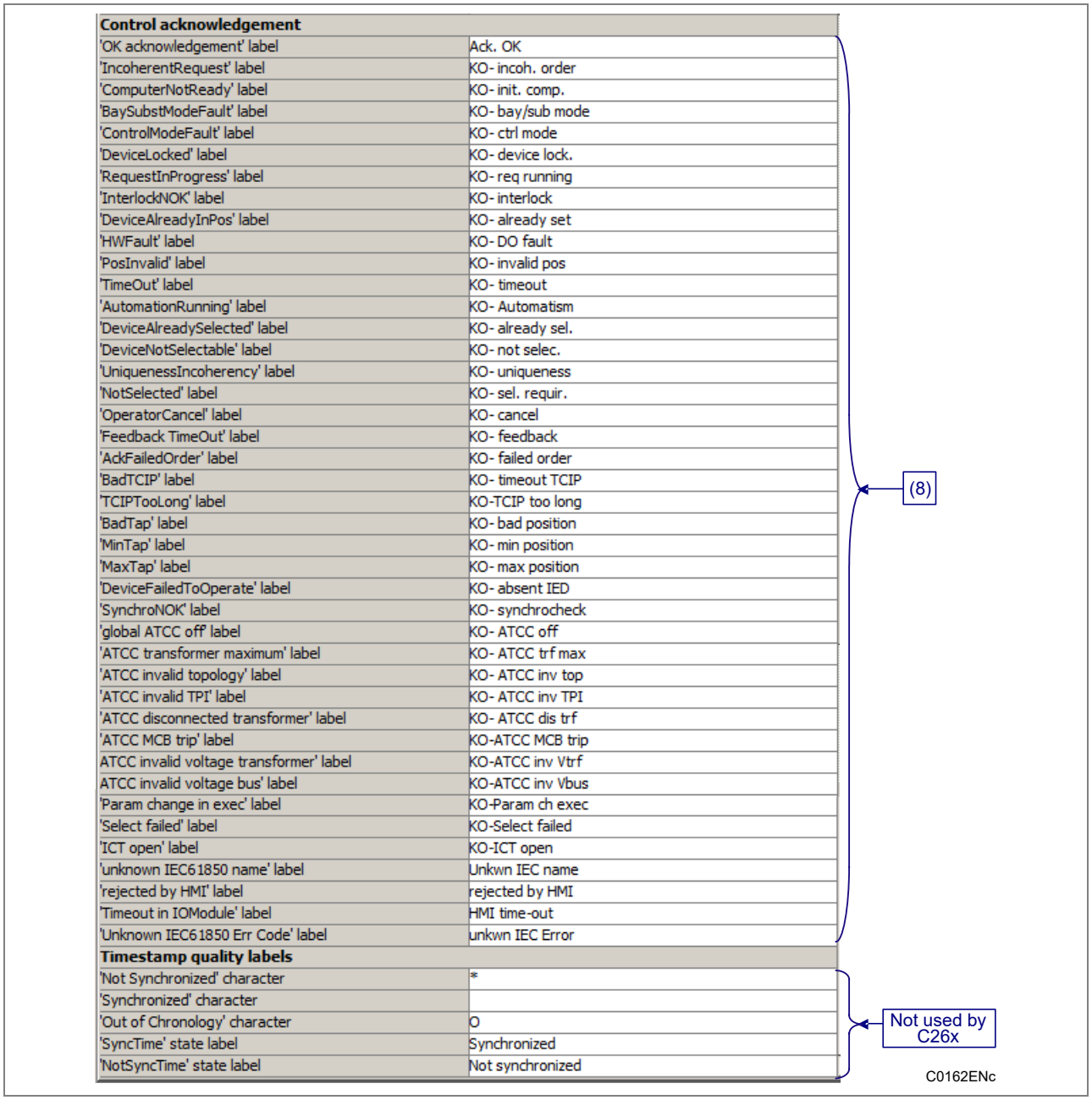


Figure 3: Labels attributes of an Scs object (1/2)

(8) **Control acknowledgement Labels** used for order logging:



Control acknowledgement	
'OK acknowledgement' label	Ack. OK
'IncoherentRequest' label	KO- incoh. order
'ComputerNotReady' label	KO- init. comp.
'BaySubstModeFault' label	KO- bay/sub mode
'ControlModeFault' label	KO- ctrl mode
'DeviceLocked' label	KO- device lock.
'RequestInProgress' label	KO- req running
'InterlockNOK' label	KO- interlock
'DeviceAlreadyInPos' label	KO- already set
'HWFault' label	KO- DO fault
'PosInvalid' label	KO- invalid pos
'TimeOut' label	KO- timeout
'AutomationRunning' label	KO- Automatism
'DeviceAlreadySelected' label	KO- already sel.
'DeviceNotSelectable' label	KO- not selec.
'UniquenessIncoherency' label	KO- uniqueness
'NotSelected' label	KO- sel. requir.
'OperatorCancel' label	KO- cancel
'Feedback TimeOut' label	KO- feedback
'AckFailedOrder' label	KO- failed order
'BadTCIP' label	KO- timeout TCIP
'TCIPTooLong' label	KO-TCIP too long
'BadTap' label	KO- bad position
'MinTap' label	KO- min position
'MaxTap' label	KO- max position
'DeviceFailedToOperate' label	KO- absent IED
'SynchroNOK' label	KO- synchrocheck
'global ATCC off' label	KO- ATCC off
'ATCC transformer maximum' label	KO- ATCC trf max
'ATCC invalid topology' label	KO- ATCC inv top
'ATCC invalid TPI' label	KO- ATCC inv TPI
'ATCC disconnected transformer' label	KO- ATCC dis trf
'ATCC MCB trip' label	KO-ATCC MCB trip
ATCC invalid voltage transformer' label	KO-ATCC inv Vtrf
ATCC invalid voltage bus' label	KO-ATCC inv Vbus
'Param change in exec' label	KO-Param ch exec
'Select failed' label	KO-Select failed
'ICT open' label	KO-ICT open
'unknown IEC61850 name' label	Unkwn IEC name
'rejected by HMI' label	rejected by HMI
'Timeout in IOModule' label	HMI time-out
'Unknown IEC61850 Err Code' label	unkwn IEC Error
Timestamp quality labels	
'Not Synchronized' character	*
'Synchronized' character	
'Out of Chronology' character	O
'SyncTime' state label	Synchronized
'NotSyncTime' state label	Not synchronized

Figure 4: Labels attributes of Scs objects (2/2)

3.1.3 ALARM

(9) **default alarm processing type**: not significant for C26x units as alarm processing is always data-based

(10) **Alarms managed on computer** (*No/Yes*): attribute indicating whether alarms are managed by the C26x. Client-specific, always keep the default value of *Yes*.

(11) **Audibility** features: not applicable to C26x configuration

(12) **Gi (1≤i≤:5) default alarm clearing mode** (*Manual* / *Automatic*)

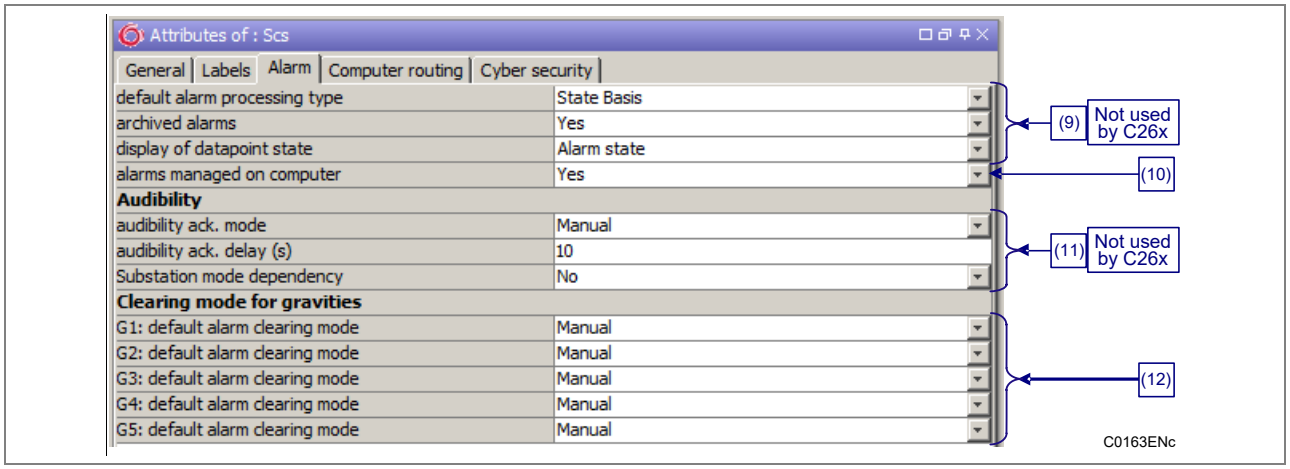


Figure 5: Alarm attributes of Scs objects

3.1.4 COMPUTER ROUTING

(13) **Computer routing** attributes

- **Gateway TCP/IP address**: IP address of the intermediate “Router” (if present)
- **Target TCP/IP address**: IP address of the authorized remote “Client” (Scada, …)

Please see section *3.4 C26x IP address and routing table definition* for further details.

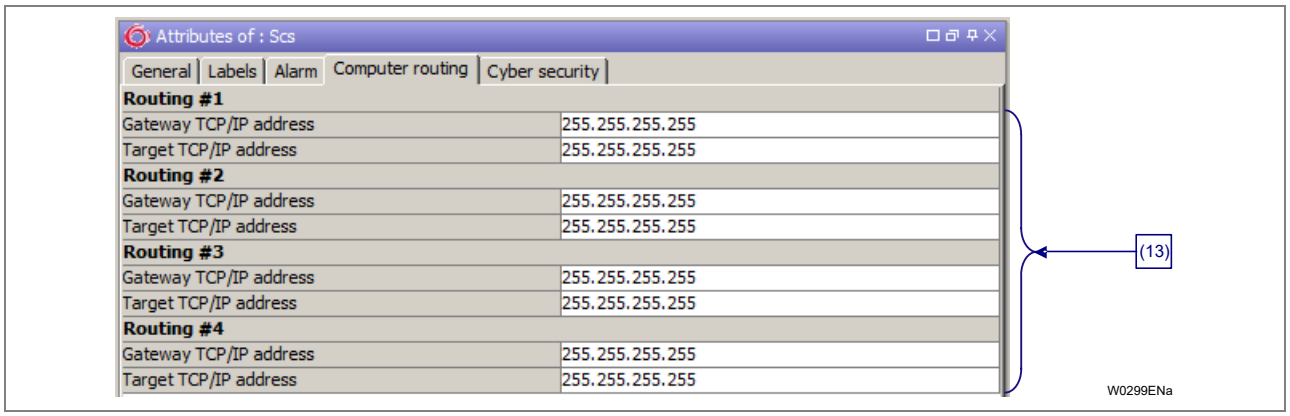


Figure 6: Computer routing attributes of Scs Objects

3.1.5 CYBER SECURITY

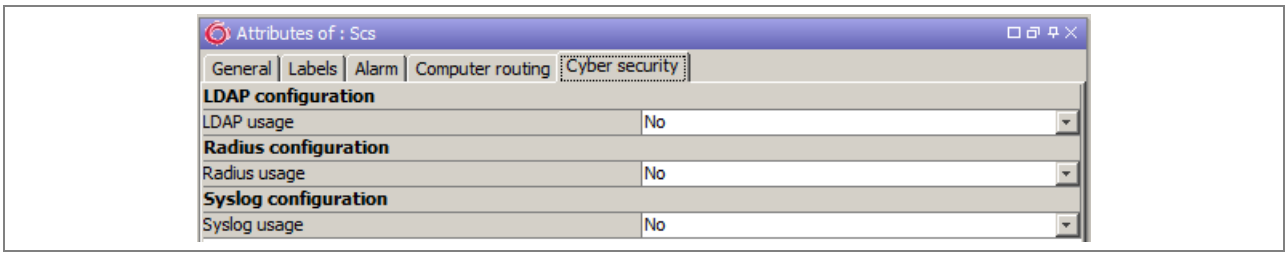


Figure 7: Cyber security attributes of Scs objects

Set **Syslog usage** to *Yes* if the C26x sends its log files to a central log repository.

Then set the corresponding attributes as described in the Secure Deployment Guide user manual (SDG_enM_XXX).

3.2 ADDING AND CONFIGURING A C26X IN THE SYSTEM'S ARCHITECTURE

To add a C26x definition select the **System Group** under the **SBUS network** in the **Object view** then in the **Objects entry** window, open `Physical device > IEC61850 physical device > IEC61850 computer`, and then double-click on "C264" as shown below:

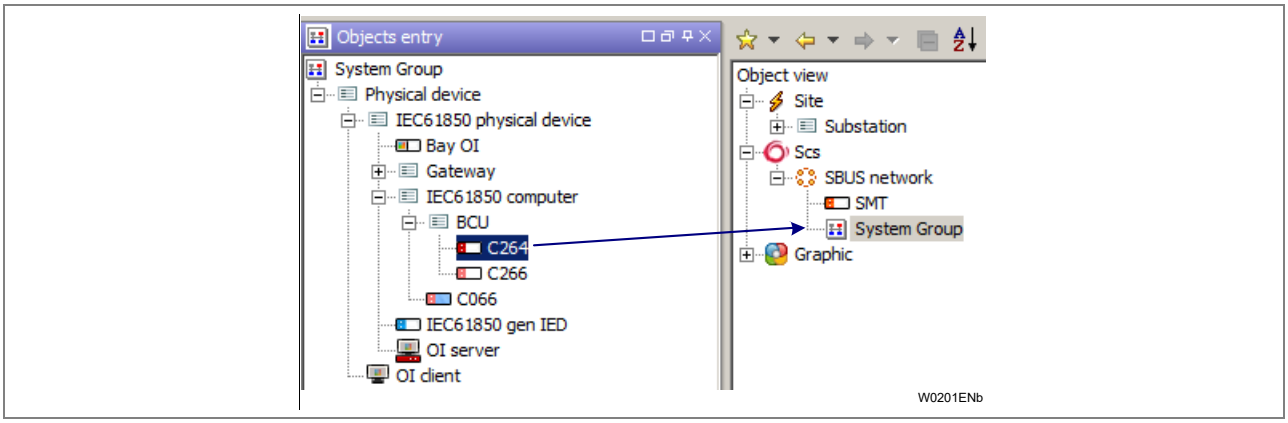


Figure 8: Adding a C26x to the system's architecture

Note:
The C066 and C266 visible in the screenshot above are not available with system version v6.1.x.

Components of a C26x

When you add a device from the **Objects Entry** window, for instance a C26x, the following sub-tree of the C26x definition, with default and optional components, is created:

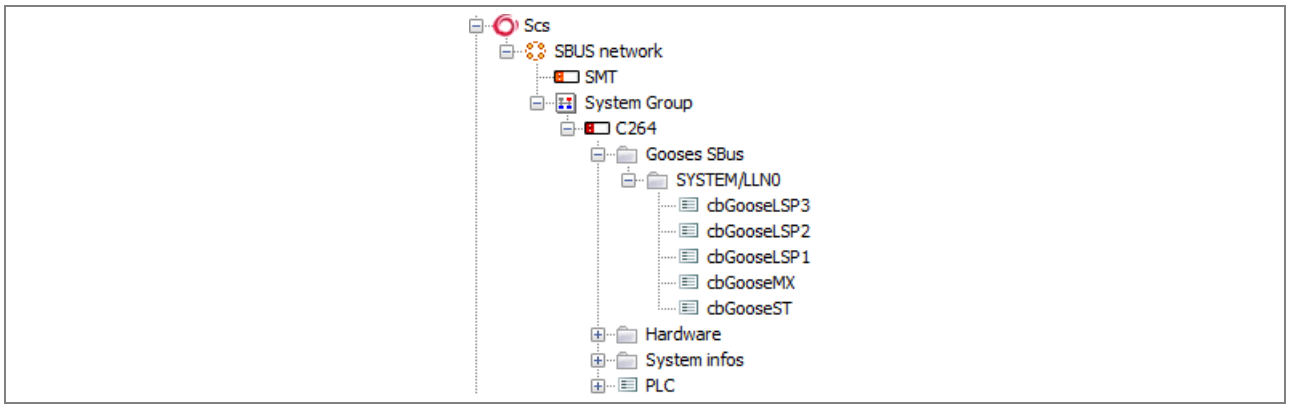


Figure 9: C26x components

- Folders ‘Gooses SBus’ and ‘C26x IEC Map’: describe the station-bus network address mapping of datapoints managed by the C26x (add the second folder for datapoints without automatic addressing)
- Folder ‘Hardware’: contains all the boards and printers defined for the C26x
- Folder ‘Hardware extension’: contains all the boards and printers defined for the extension rack (mutirack option)
- Folder ‘System infos’: contains all the general system (i.e. not wired to boards) datapoints of the C26x
- ‘PLC’ (Programmable Logic Controller): contains the relations and ISaGRAF system information

3.2.1 SETTING THE GENERAL ATTRIBUTES OF A C26X

When adding a C26x to the System Group on the SBUS network, some of its attributes must be set and checked:

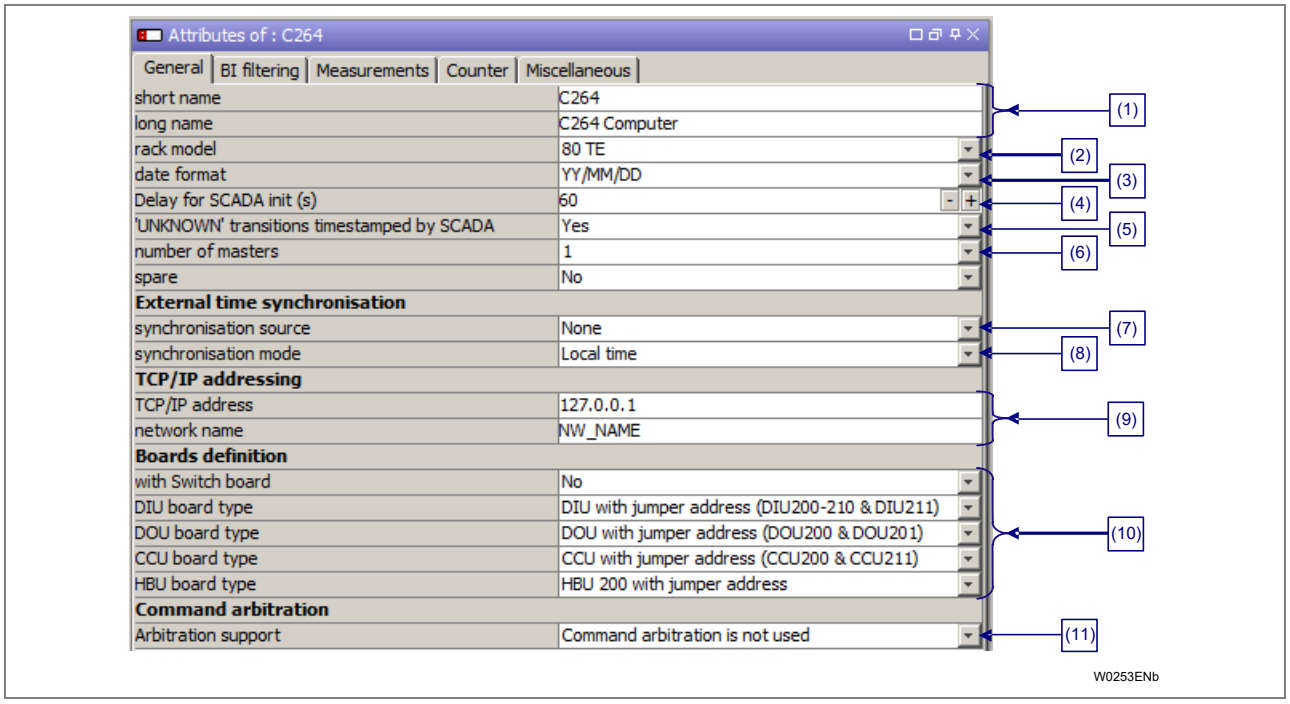


Figure 10: Setting General attributes

(1) **short name** and **long name**: used for logging, alarms, …

(2) **rack model** (80TE / 40TE): there are two C26x variants: wider case (80TE) and compact variant (40TE). The height of both C26x variants is 4U.

(3) **date format**: defines the date format displayed on the C26x's front panel HMI (LCD)

(4) **Delay for SCADA init (s)** (only used for a C26x-Standalone RTU, default value: 60s): elapsed time between two ASDU frames

In order to avoid transmitting transient states to the SCADA whenever the C26x is energized (or switches to operational mode), set a value other than 0.

During the start phase and until the time-delay elapses, no message is sent over the communications network.

When the time-delay elapses, the C26x performs a general check and transmits all the configured data to the protocol tasks. Data belonging to absent units is set to “unknown” state with the time-stamp, which time depends on the next attribute.

(5) **UNKNOWN transitions timestamped by SCADA** (only used for a C26x-Standalone RTU) (*Yes/No*): defines the way datapoints are time-stamped when the C26x connects to a SCADA. If set to:

- *No*, the datapoints are time-stamped with the ACQUISITION time (which can precede the loss of communication)
- *Yes*, the datapoints are time-stamped with the CONNECTION time (in this case the C26x's acquisition time-stamp is lost)

(6) **number of masters**: Reserved for future use.

(7) **synchronisation source** (*None* / *IRIG-B*): defines whether the C26x is synchronized through its IRIG-B input. The relation at SCS level **has for master clock** defines which device is the master clock in the system. A master clock C26x is necessarily synchronized through an IRIG-B input.

(8) **synchronisation mode** (*Local*/*UTC*): defines whether the time used is the local time of the system or the UTC standard time.

(9) **TCP/IP address** and **network name** (limited to 15 characters) of the C26x

(10) **Boards definition**: types of the boards fitted on the C26x and for some of them, whether their location in the rack is defined using jumpers or in their configuration attributes ("slot affectation"). For the DIU211, selecting *…with slot affectation…* also allows to choose the inputs' voltage range.

(11) **Arbitration support** (only used for SCADA protocols T101 and T104 in a C26x-Standalone RTU): flag enabling the transient information "command in progress" to be sent to a SCADA that is issuing a control command while one from another SCADA is already being processed; uniqueness control must be enabled and the substation's L/R and the bay's L/R must both be set to *Remote.*

Configuration rules and checks

- The **TCP/IP address** value of any device must be unique among all the units within an Ethernet Network (except for OI/aView server and OI/aView client).
- The **network name** value of any device must be unique among all the units within an Ethernet Network (except for OI/aView server and OI/aView client).

3.2.2 CONFIGURING BINARY INPUT (BI) FILTERING

There are two types of input signal handling:

- Debouncing: the start transition is signaled with the correct time, the following changes within the debouncing time are ignored. The range of the debouncing time is 0 to 20 ms (1 ms step). The event is time-stamped at the time of the first transition
- Filtering: the transition is only signaled if the signal is stable for at least as long as the filtering time. The range of the filtering time is from 0 to 20 ms (with a 1 ms step). Filtering is allowed only if debouncing is applied (i.e. filtering cannot be applied if there was no debouncing beforehand). The event is time-stamped at the instant of the first transition.

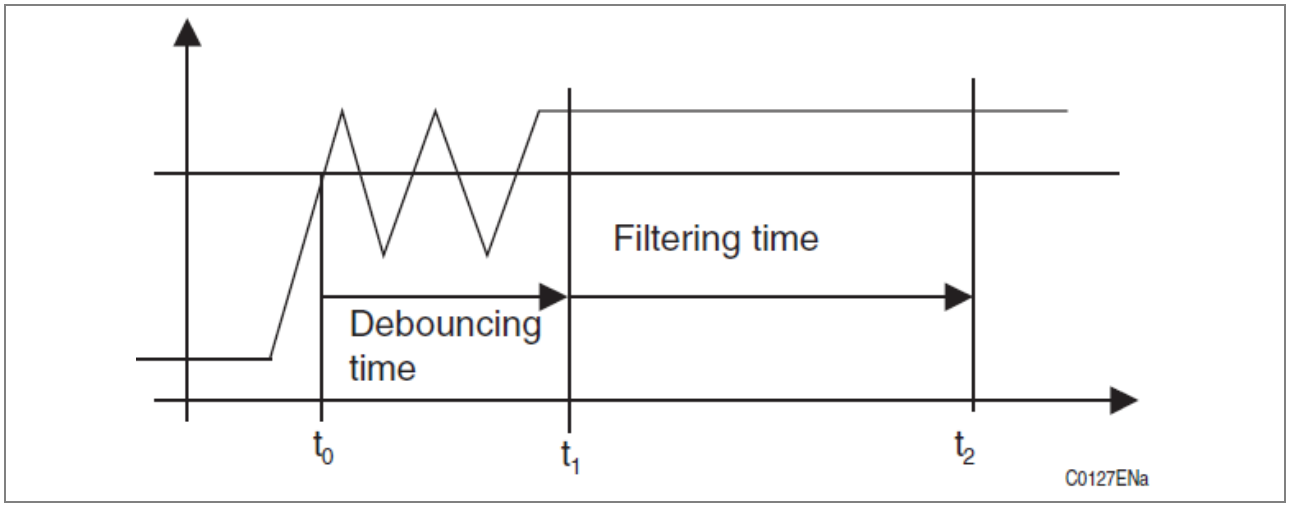


Figure 11: Debouncing and filtering

A value of 0 means that no filter is applied: a change of state is validated as soon as it is detected.

Three pairs of delays (debouncing/filtering) are defined:

- one for all Digital Inputs which will be used as Binary Inputs
- one for all Digital Inputs which will be used as Digital Measurements
- one for all Digital Inputs which will be used as counters

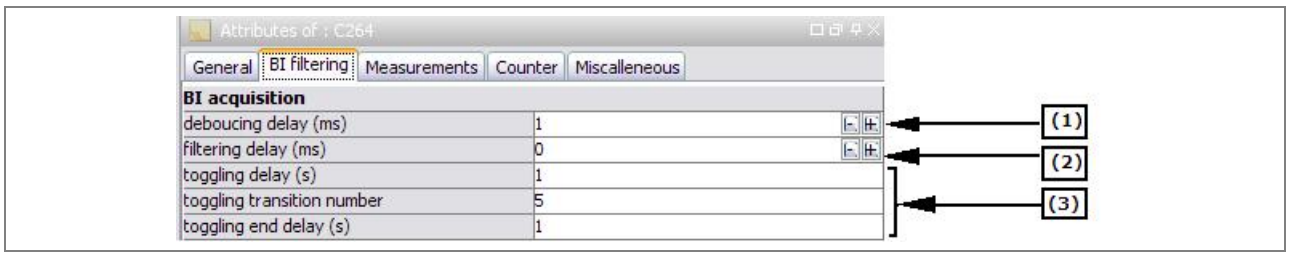


Figure 12: Setting BI acquisition attributes

(1) **debouncing delay** (range [0, 20 ms], step 1 ms)

(2) **filtering delay** (range [0, 20 ms], step 1 ms)

(3) **toggling** attributes are defined as follows:

- A digital input (DI) is said to be toggling if its state has changed more than N times within a given time period, T_1.
- A toggling DI becomes valid again if its state has not changed within another time period, T_2.
- N (**toggling transition number**), T_1 (**toggling delay**) and T_2 (**toggling end delay**) are parameters determined for each C26x during the configuration process.

Configuration rules and checks

- If the attribute **debouncing delay** is set to *0*, then the attribute **filtering delay** must be set to *0* too.

3.2.3 CONFIGURING MEASUREMENT ACQUISITION AND TRANSMISSION

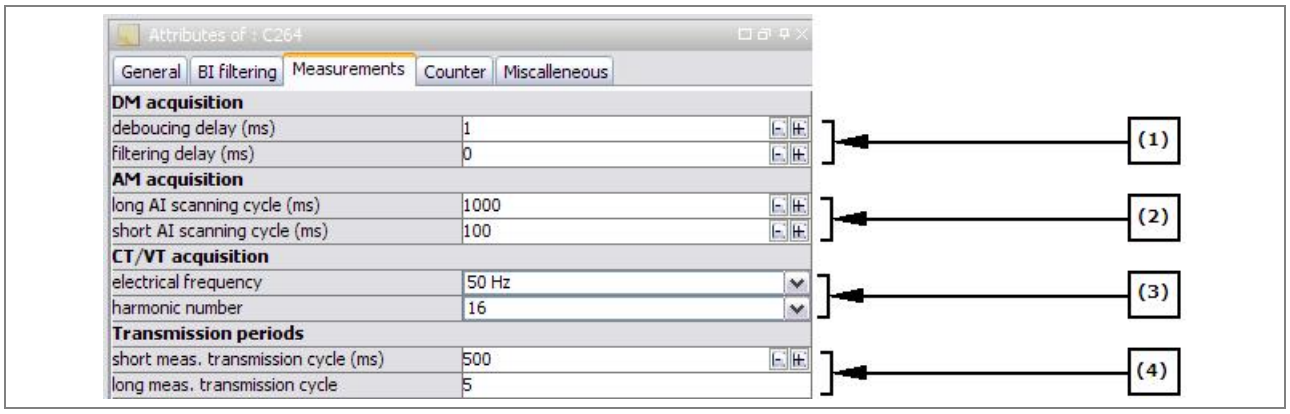


Figure 13: Measurements attributes for a C26x

(1) **Debouncing delay** and **filtering delay**: used for digital measurements

(2) Analogue measurements acquired on AIU boards: **AM acquisition** samples ranges for long scanning (range [500 ms, 10000 ms], step 500 ms) and short scanning (range [100 ms, 1000 ms], step 100 ms). For each AIU board channel, a short or long scanning period chosen (see section *3.3.5 Configuring an AI channel*)

(3) **CT/VT acquisition** on the TMU board with fundamental frequency of either *50* or *60 Hz* (the number of harmonics is fixed to a maximum of 16)

(4) **short meas. transmission cycle (ms)**: Short transmission period on the station bus (range [0, 60 s], step 100 ms) and
long meas. transmission cycle: Long transmission period defined as an integer multiple of the short period ([0..600] x short transmission period)

Setting a period to *0* means periodic transmission is disabled:

- for both short and long periods if it is the short period
- for the long period only if it is the only one set to *0*

Configuration rules and checks

- If the attribute **debouncing delay** is set to *0*, then the attribute **filtering delay** must be set to *0* too.

3.2.4 CONFIGURING COUNTER ACQUISITION

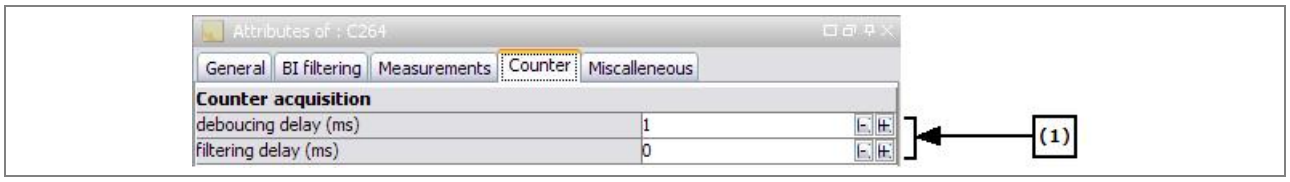


Figure 14: Counter acquisition attributes of a C26x

(1) **debouncing delay** and **filtering delay**: used for digital counters (see section *3.2.2 Configuring binary input (BI) filtering* for details)

Configuration rules and checks

If the attribute **debouncing delay** is set to *0*, then the attribute **filtering delay** must be set to *0.*

3.2.5 MISCELLANEOUS ATTRIBUTES

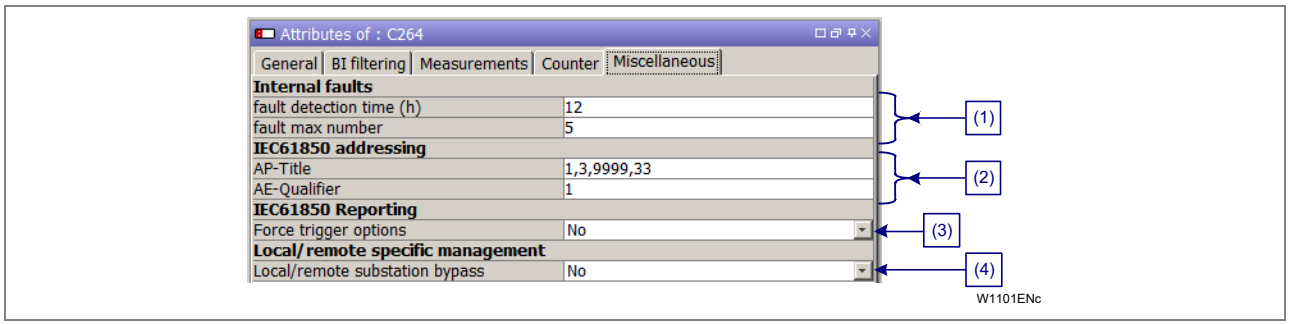


Figure 15: Miscellaneous attributes of a C26x

(1) **Internal faults**: Number of software faults allowed in a given period else the C26x remains in HALT mode. The C26x reboots automatically as long as it does not reach the **fault max number** within the **fault detection time** period. When these criteria are met, the C26x remains in HALT mode.

(2) **AP-Title**: MMS parameter. Always set at the default value.
AE-Qualifier: Extension of the IP address if several server applications are using the same agency. It will start at 1 for the first application, then 2 for the second and so on… up to a maximum of 50.

(3) **Force trigger options** (*No* / *Yes*): This is used to manage which report trigger options the C26x uses for IED polling.

- *Yes*: The C26x first sets the minimum trigger options when activating reports: MVLU_TRGOPS_DATA and MVLU_TRGOPS_GI, before setting all the trigger options in a second step.
- *No*: The C26x directly sets all the trigger options.

Note:
Trigger option compatibility must be maintained throughout the system, i.e. all the polled IEDs must be compatible with the selected option.

(4) **Local/remote substation bypass** (*No* / *Yes*):

- *Yes*: The C26x ignores the L/R substation dependency restrictions to controls and setpoints and process them regardless of their originator and the substation/bay L/R status.
- *No*: The C26x checks the L/R substation dependency restrictions to controls and setpoints and process them according to their originator and the substation/bay L/R status.

3.2.6 LOCATING A C26X IN A SUBSTATION (MANDATORY)

As indicated in section *3.1 Setting the general system's parameters relevant to C26x units*, each system device has to be located in a specific substation. This is done by defining the mandatory relation (1) **is located in** for each device in the system, especially the C26x units.

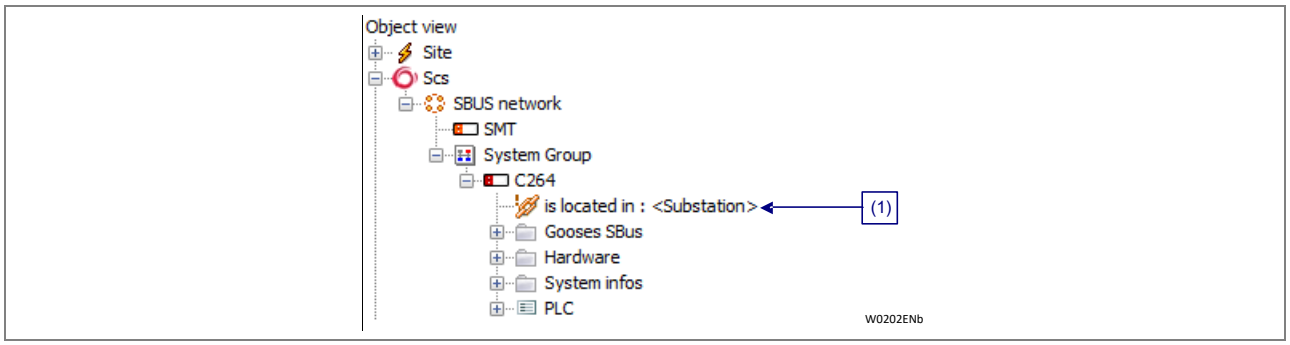


Figure 16: Locating a C26x in a substation

3.2.7 CONFIGURATION OF AN SNTP SERVER

As indicated in section *3.1 Setting the general system's parameters relevant to C26x units*, up to two controllers (C26x or third-party device) can be set as master clock(s) for the system:

(1) A primary controller acts as the main master clock,

(2) A secondary controller acts as back-up master clock in case of primary controller failure.

Define the TCP/IP address of the main master clock controller and the TCP/IP address of the back-up master clock controller in the attributes or the Scs. In the figure below, the controller with the IP address *192.168.0.10* (**TCP/IP address**) acts as the main synchronization source for the system and the controller with the IP address *192.168.0.12* (**auxiliary TCP/IP address**) acts as the back-up synchronization source for the system in case the main controller master clock fails.

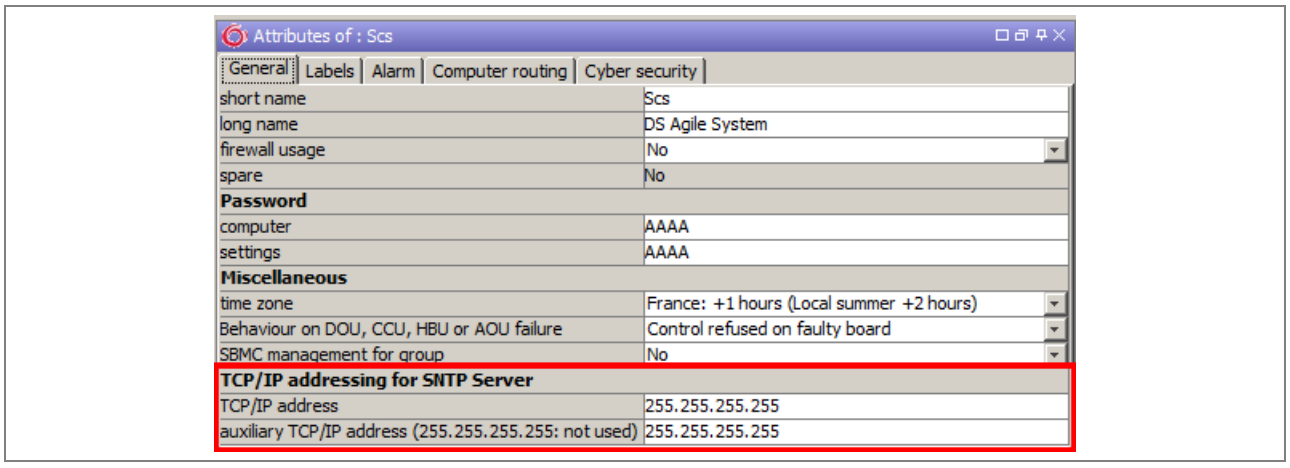


Figure 17: SNTP configuration

3.2.8 DEFINING A C26X REDUNDANCY (OPTIONAL)

Note:
The redundancy mode is not compatible with the TMU210 acquisition board.

To define a redundant C26x:

- Create the main C26x which will act as the master.
- Open the contextual menu of the C26x and select **Create backup** (1).

Then:

- A second C26x (which will act as slave) is automatically created with an implicit relation of backup between the two C26x units.
- A new relation **has for backup** is automatically created under the main C26x.
- When the backup C26x is created, most of its attributes and components are identical to those of the main C26x and cannot be edited. The only exceptions are its short name and long name, as well as its network identification (IP address and network name) that must be correctly updated. When an object is added to (or removed from) the main C26x, the same object is added to (or removed from) the backup C26x but its attributes can only be modified at the main C26x level and those changes will be automatically cascaded to the backup C26x level.

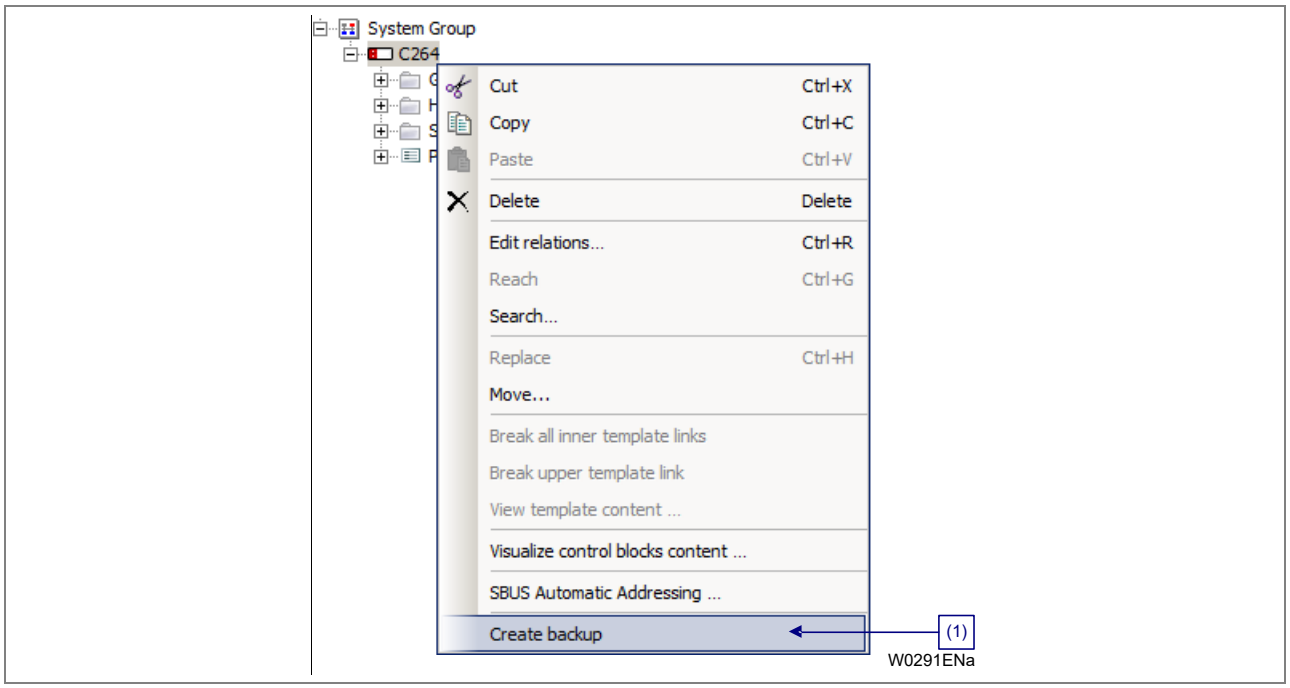


Figure 18: Creating a C26x redundancy

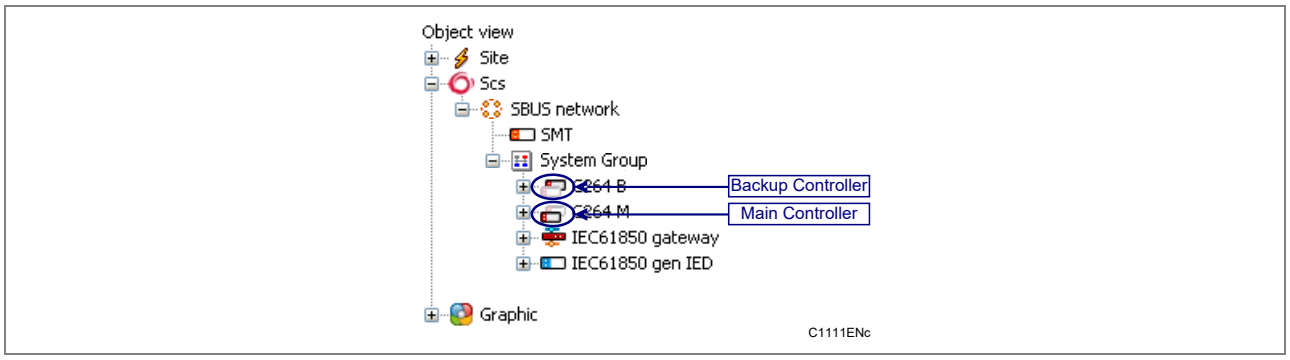


Figure 19: Defining a C26x redundancy

To assign a redundant C26x to a C26x-Standalone (RTU), just set its attribute **number of masters** to *2*.

Such a C26x-Standalone RTU can manage neither ISaGRAF nor PSL functions. Performing a check shall ensure that there is no resulting inconsistency.

If applicable, a wiring report will generate a mapping of the available racks (main and extension). When the main rack of a C26x-Standalone RTU is assigned a redundant C26x, the mapping is generated anew with its name suffixed with “#master 2”.

3.3 ADDING C26X HARDWARE COMPONENTS

3.3.1 ADDING BOARDS

The following boards, each managing specific functions, can be added to the DS Agile C26x units depending on the required functionalities:

- DIU2xx – Digital input boards with 16 digital input channels:
  - digital and counter acquisition
  - digital measurement acquisition
- AIU201 – Analogue input boards with 4 analogue input channels:
  - analogue measurement acquisition
- AIU210-211 – Analogue input boards with 8 analogue input channels:
  - analogue measurement acquisition
- TMU210/TMU220 - CT and VT input boards with 4 CT and 4 VT input channels (5 VT inputs on TMU220):
  - CT/VT sampling acquisition,
  - MV computations based on acquired samples (associated DSP or DSPIO daughter board of the CPU270 processor board)
- DOU2xx – Digital output boards with 10 digital output channels:
  - execution of single or dual, transient or permanent commands
  - setting of digital setpoints
- HBU200 – High Speed/High Break digital output boards with 10 digital output channels:
  - execution of single or dual, transient or permanent commands
- CCU2xx – Mixed digital boards with 8 digital input and 4 digital output channels (make sure that the DOs 4,5,6,7 are defined but not used):
  - Circuit breaker Control Unit
- CPU270 – Processor boards with communication channels: two Ethernet ports and serial communication ports
- BIU2xx – Power Supply board with communication channels (serial communication ports)
- GHU200 – Graphical panel boards with LED channels
- AOU200 – Analogue output board with 4 analogue output channels

The C26x hardware definition is done in SCE by adding typed boards under the C26x object. Mandatory boards (CPU270, GHU200, BIU2xx) are automatically created with the C26x. Implicitly typed channels are created with the corresponding boards.

Note:
Ethernet communications boards (SWU20x, SWR21x, SWD21x, SWT21x, SRP28x) are automatically recognized by the CPU270 processing board and are therefore not added in the SCE configuration.

Linking datapoints to input/output channels is called datapoint "wiring".

To add a board definition, select the C26x level and add the board from the contextual **Objects entry** window: Either double-click on the board's name or right-click on it and then select **Add** as shown below:

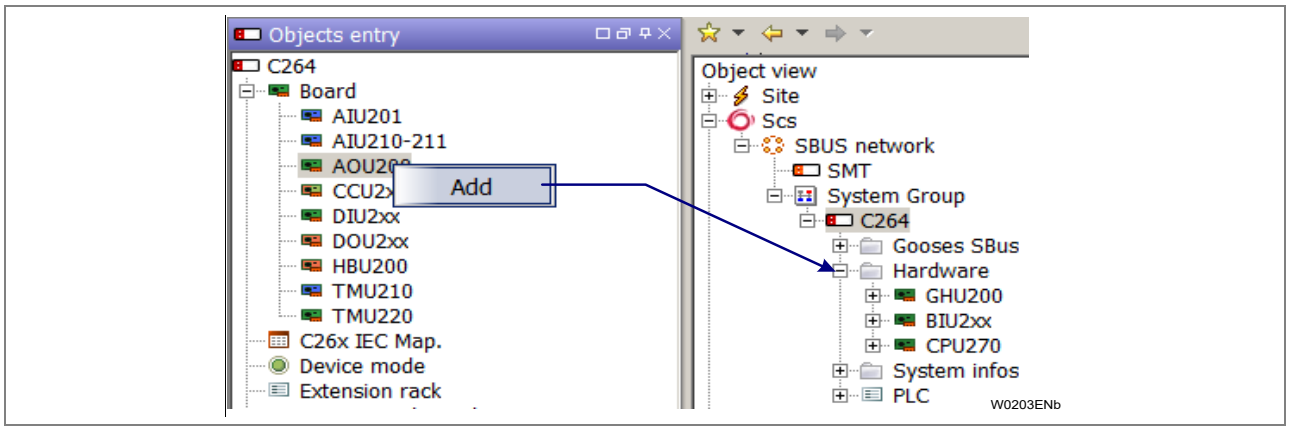


Figure 20: Adding a board to a C26x

Configuration rules and checks

Slots and boards in a C26x 80TE unit

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
BIU	CPU																

- Slots from C to P may contain a board of the following types: AIU201, AIU210-211, AOU200, CCU2xx, DIU2xx, DOU20x, HBU200
- Slot Q may contain one TMU220 or TMU210 board or one board of the above types.
- If a TMU220 or TMU210 board is present, then the number of boards must be ≤ **14**; if not the number of boards must be ≤ **15.**
- If there is an Ethernet board (SWU20x, SWR21x, SWD21x, SWT21x, SRP28x) it must be installed in either slot C or D.

Slots and boards in a C26x 40TE unit

A	B	C	D	E	F	G	H
BIU	CPU						

- Slots C to F may contain a board of the following types: AIU201, AIU210-211, AOU200, CCU2xx, DIU2xx, DOU20x, HBU200
- Slots G and H may either contain one TMU220 or TMU210 board or two boards of the above types
- If a TMU220 or TMU210 board is present, then the number of boards must be ≤ **4**; if not, the number of boards must be ≤ **6**
- If there is an Ethernet board (SWU20x, SWR21x, SWD21x, SWT21x, SRP28x) it must be installed in either slot C or D

Note:
A 40TE or 80TE C26x unit can manage up to 4 AOU boards. AOU boards cannot be used in a C26x redundancy environment

3.3.2 SETTING THE COMMON ATTRIBUTES OF C26X BOARDS

For each board fitted into the C26x the short name attribute (1) may be edited so as to ensure correct logging and alarm discrimination of the board status datapoint.

For the AIU2xx, CCU2xx, DIU2x0, DIU211, DOU200, DOU201, HBU200 and AOU200 boards the **board number** attribute (2) must be set.

For the CPU270, BIU2xx, GHU200, and TMU2x0 boards, this attribute is forced to 0 by the SCE and, except for TMU220, it does not appear in the attributes window:

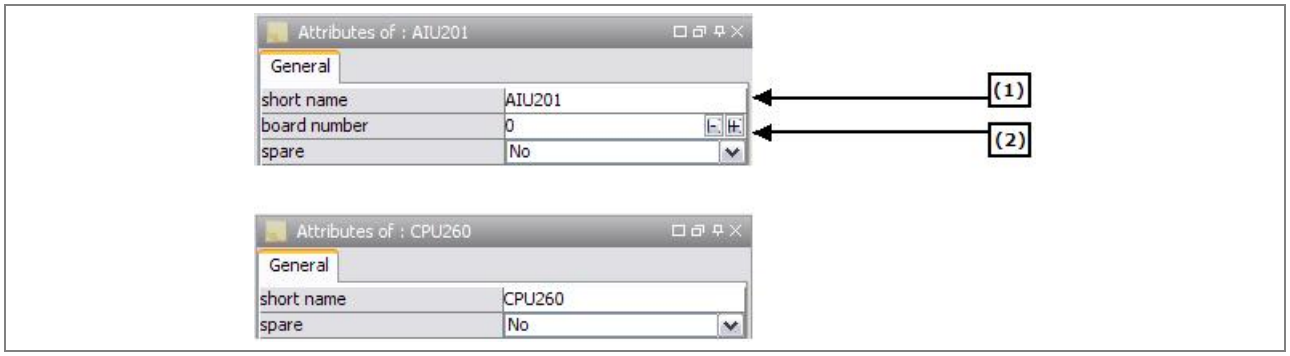


Figure 21: General attributes common to all boards

Configuration rules and checks

- For each board type (AIU201, AIU210/AIU211, AOU200, CCU2xx, DIU2xx, DOU2xx, HBU200), the **board number** attribute values must start at 0, be unique and contiguous.

3.3.3 SETTING THE SPECIFIC ATTRIBUTES OF C26X BOARDS

3.3.3.1 SETTING THE SPECIFIC ATTRIBUTES OF A BIU2XX BOARD

The BIU2xx power supply board can have either a single (BIU241/BIU261S) or a dual (BIU261D) power supply source. For the BIU261, the type of power supply must be indicated by setting the **BIU board type** in the **General** tab-pane:

- *BIU mono source* if the board manages a single input power supply,
- *BIUR dual source* if if the board manages a dual input power supply.

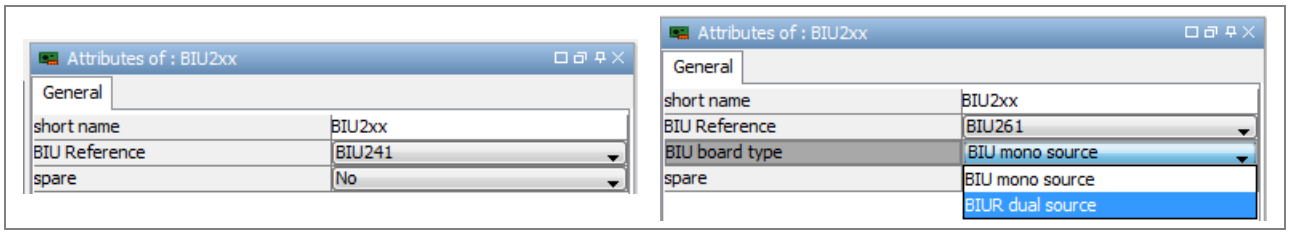


Figure 22: General attributes of BIU2xx boards

Datapoints for dual input power supply board BIU261D (*BIUR dual source* setting)

When *BIUR dual source* is selected, SPS datapoints are available to indicate the available power supply sources and which input is currently used to power the C26x. They are present but spared and non-configurable if *BIU mono source* is selected.

These SPS datapoints can be found in the **System infos** folder under the BIU2xx node:

- *Volt source used*: This datapoint is *SET* while the secondary power supply input is in use. It is *RESET* while the secondary power supply input is NOT used, i.e. the primary input is used or the C26x is not powered at all.
- *Voltage source 1*: This datapoint is *SET* when an adequate voltage is available at the primary input's terminals. It is *RESET* when there is no voltage or when the voltage level is outside the board's range.
- *Voltage source 2*: This datapoint is *SET* when an adequate voltage is available at the secondary input's terminals. It is *RESET* when there is no voltage or when the voltage level is outside the board's range.

All three can be assigned to LEDs on the C26x's front panel by adding the relation **has state displayed on : Led**. They can also be transmitted over the Station Bus network to the system HMI (OI or aView) and to a SCADA via the DS Agile Gateway.

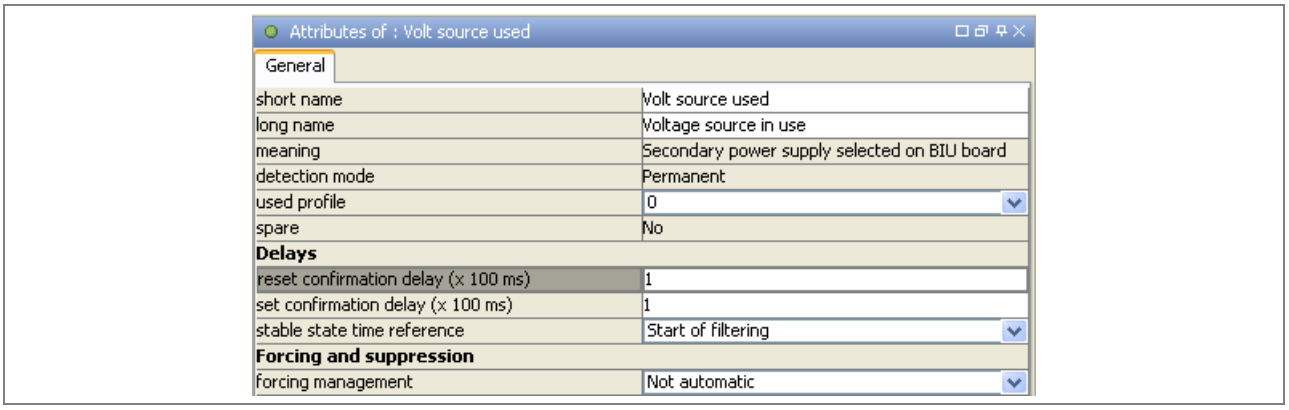


Figure 23: Attributes of a voltage source datapoint (example for *Volt source used*)



Caution:
Both delays: reset confirmation delay (x 100 ms) and set confirmation delay (x 100 ms), should be set to at least *1* (i.e. 100 ms) in order to avoid transitory state changes during the voltage source switching sequence (up to 20 ms).

Note:
These datapoints cannot be spared when BIUR dual source *is selected. A profile must be defined whether they are used or not.*

3.3.3.2 SETTING THE SPECIFIC ATTRIBUTES OF A DIU2XX/DOU2XX/HBU200 BOARD

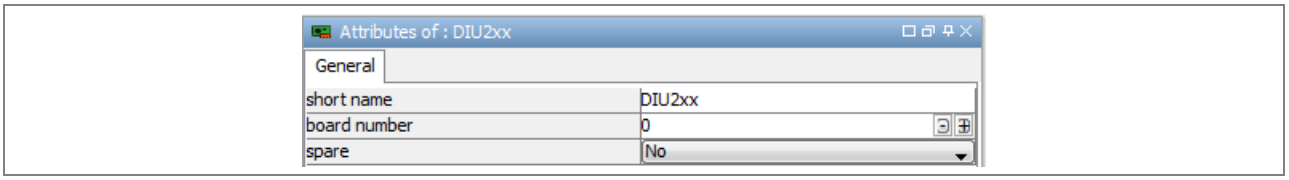


Figure 24: General attributes common to DIU/DOU/HBU boards

Board configuration

If, in the C264's attributes, compatible boards (DIU211, DOU201, CCU211 and HBU200) have been set to *…with slot affectation…*:

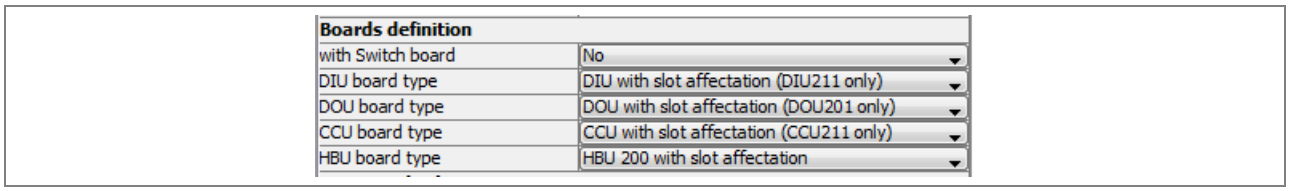


Figure 25: Board definition attributes of a C26x

then there are extra settings in the board's attribute window.

For all the compatible boards, the setting slot number is added. The letter entered in this field takes precedence over the physical jumper setting on the board.

Note:
See section 3.3.1 Adding boards *for slot number configuration rules.*

For boards fitted with digital inputs (DIU211 and CCU211), there is also a setting for the voltage range of the inputs: **input voltage**.

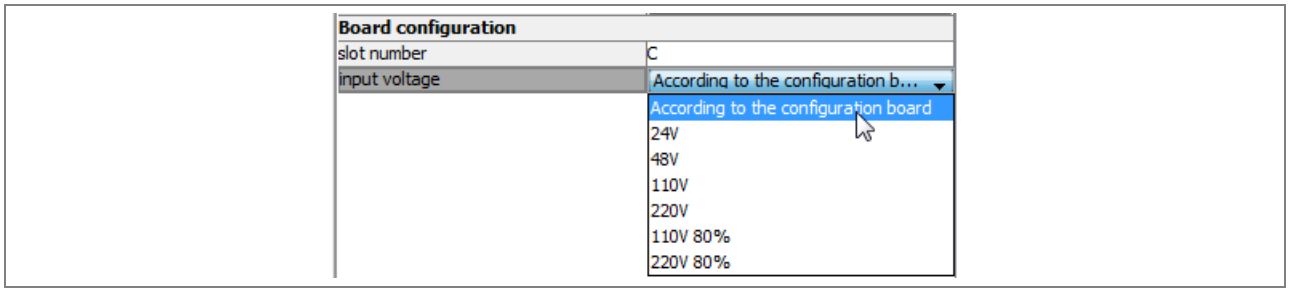


Figure 26: Board configuration attributes specific to a DIU211 board

Selecting *According to the configuration board* means that the range is chosen by positioning jumpers on the board (see *Hardware* chapter).

For specifics on each voltage range, see the *Ratings* section of the *Technical Data* chapter.

board number attribute

- Boards set to *…with slot affectation…*: it is not settable and is automatically calculated when an SBUS automatic addressing is performed.
- Boards that do not support the "slot affectation" feature and compatible boards set to *…with jumper address…*: This number has to be set manually according to this rule: For each board type (DIU2xx, DOU2xx, HBU200), the **board number** attribute values must start at 0, be unique and contiguous.

3.3.3.3 SETTING THE SPECIFIC ATTRIBUTES OF A GHU2X0 BOARD

For the GHU board, the specific attribute **HMI type** (1) has to be set to:

- *Simple* if the C26x is fitted with a GHU board without LCD (GHU210/220)
- *Complete* if the C26x is fitted with a GHU board with LCD (GHU200)

The **default start panel** (2) is the panel that will be displayed when the C264 is booted. The **default inactivity panel** (3) is the panel that will be displayed after the timeout **delay before inactivity** (4) elapses.

(5) **alarm panel present**: *Yes* or *No*

(6) **setting panel present**: *Yes* or *No*. This option is always available but is only relevant if the C26x has protection functions, as otherwise this panel will be empty but for the header.

(7) **AVR panel present**: *Yes* or *No*. Reserved for future use.

(8) **LED allocation**: *Free* (the LEDs on the C26x front panel can be freely assigned to datapoints) or *pre-defined* (factory-set configuration)

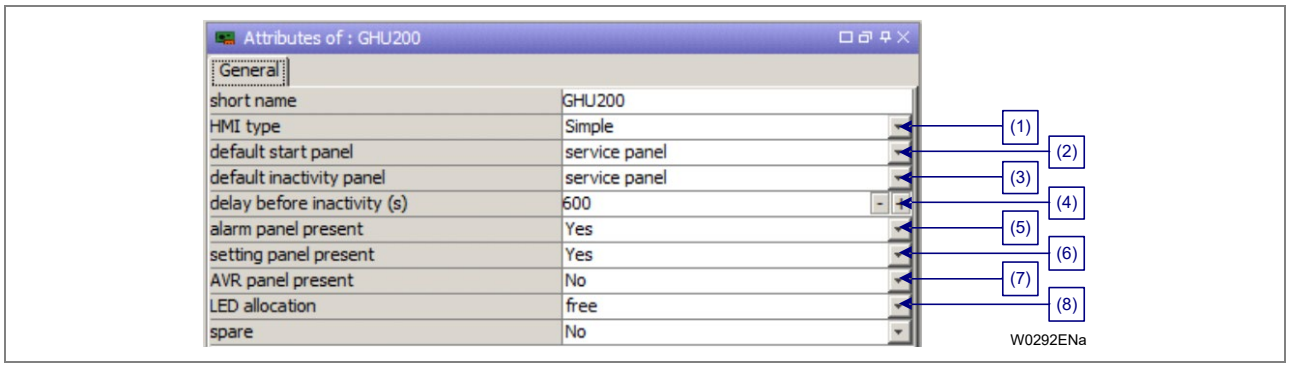


Figure 27: General attributes specific to a GHU200 board

Note:
For a complete HMI, the extra relation ***has for workspace*** *(1) must be filled in at board level. For details about the C26x workspace, see section 6.2.2 Defining a C26x workspace.*

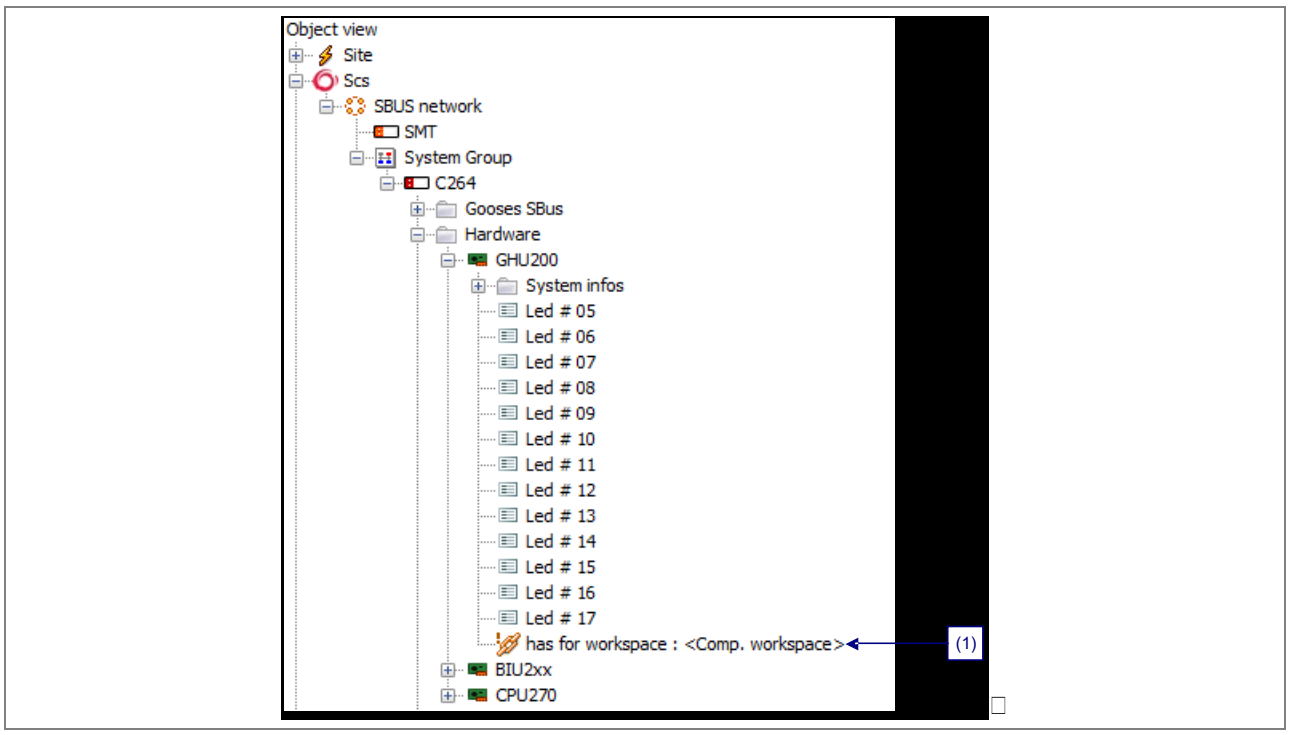


Figure 28: Defining a workspace for a complete GHU200 board

For C26x LED configuration, see section *6.2.4 Displaying a datapoint state through an LED*.

Configuration rules and checks

- If the **HMI type** attribute is set to *Simple*, then **Led#5** must not be assigned (no relation link from **Led#5** to any datapoint) as it is reserved for the Local/Remote indication on that front panel.
- If the **HMI type** attribute is not set to *Complete*, then the relation **has for workspace** must not be linked as there will be no LCD to display the workspace on the front panel.

3.3.3.4 SETTING THE SPECIFIC ATTRIBUTES OF A TMU220 BOARD

For TMU220 board, the following attributes have to be set for correct CT/VT computation of derived measurements.

General tab-pane

(1) **short name**

(2) **physical board number**: set to *0* by default. This setting is fixed and cannot be changed

(3) **electrical network topology** (*Star* / *Delta*): VT arrangement for the three phase or phase-phase voltages, as defined for (6) **reference phase side**.

(4) **earth phase factor** (range [0.0, 2.0], step 0.01): Earth factor $\mathbf{K}_0$ used by the Synchrocheck function to derive the phase-phase voltages from the phase-neutral voltages and vice-versa where there are different VT topologies on the line side and on the busbar side.

(5) **reference phase** (*Phase A or AB* / *Phase B or BC* / *Phase C or CA*): Phase or phase pair used by the Synchrocheck function to compare the line and busbar voltages.

(6) **reference phase side** (*Phase A, B, C wired line side* / *Phase A, B, C wired busbar side*)

Note:
*The **reference phase** and **reference phase side** attributes are not used for Synchrocheck type 3. Their settings will simply not be taken into account if Synchrocheck type 3 is configured.*

(7) **power flow mode** (*Mode 1 (Export power, leading vars)* / *Mode 2 (Import power, leading vars)* / *Mode 3 (Export power, lagging vars)* / *Mode 4 (Import power, lagging vars)*)

(8) **voltage range** (*57 V - 130 V* / *220 V - 480 V*): voltage range of the TMU board's voltage inputs.

(9) **nominal current** (*1000 mA* / *5000 mA*): Rated secondary phase current

(10) **nominal voltage** (range [1 V, 500 V], step 0.00001 V): Rated secondary three-phase voltage

(11) **nominal voltage for busbar (V)** reserved for future use

(12) **period number to compute harmonic** (range [1, 50], step 1): number of electrical periods between consecutive harmonics counts

(13) **period number to compute energy** (range [1, 50], step 1): number of electrical periods between consecutive energy counts

(14) **voltage ref change mode** (*Default voltage reference* / *Current voltage reference*):

- *Default voltage reference*: as soon as the stated reference phase is valid again, the TMU acquisition process locks onto it
- *Current voltage reference*: the TMU acquisition process remains locked onto the phase that has a valid signal

(15) **meas quality when missing** (*value=0; quality=VALID* / *quality=FAULTY*)

- *value=0; quality=VALID*: when the TMU board receives no signal, that absence is considered as a valid 0 value that the C26x transmits over the network: IEC, HMI, GTW…
- *quality=FAULTY*: when the TMU board receives no signal, that absence is considered as an invalid value and the C26x transmits the signal "self-check fault" over the network: IEC, HMI, Gateway…

During TMU frequency synchronization, set the related measurement values to 0 /self-Check fault. Do not set the related measurement values to 0 / Valid.

If the reference phase signal is absent, the values transmitted by the TMU board are set to invalid.

(16) **value after tracking lost** (*value=0; hold current value*): display of MV values after an interruption of frequency tracking.

- *value=0*: when frequency tracking is interrupted the value for the MV displayed on the C26x's LHMI and on the system HMI will be 0 until frequency tracking is re-established.
- *current value is held:* the last recorded value for the MV remains displayed during the frequency tracking interruption, and updating resumes when frequency tracking is re-established.

Note:
With the setting value=0*, an invalid value, "SELF-CHECK", may be displayed for a few seconds while frequency tracking is restarting.*

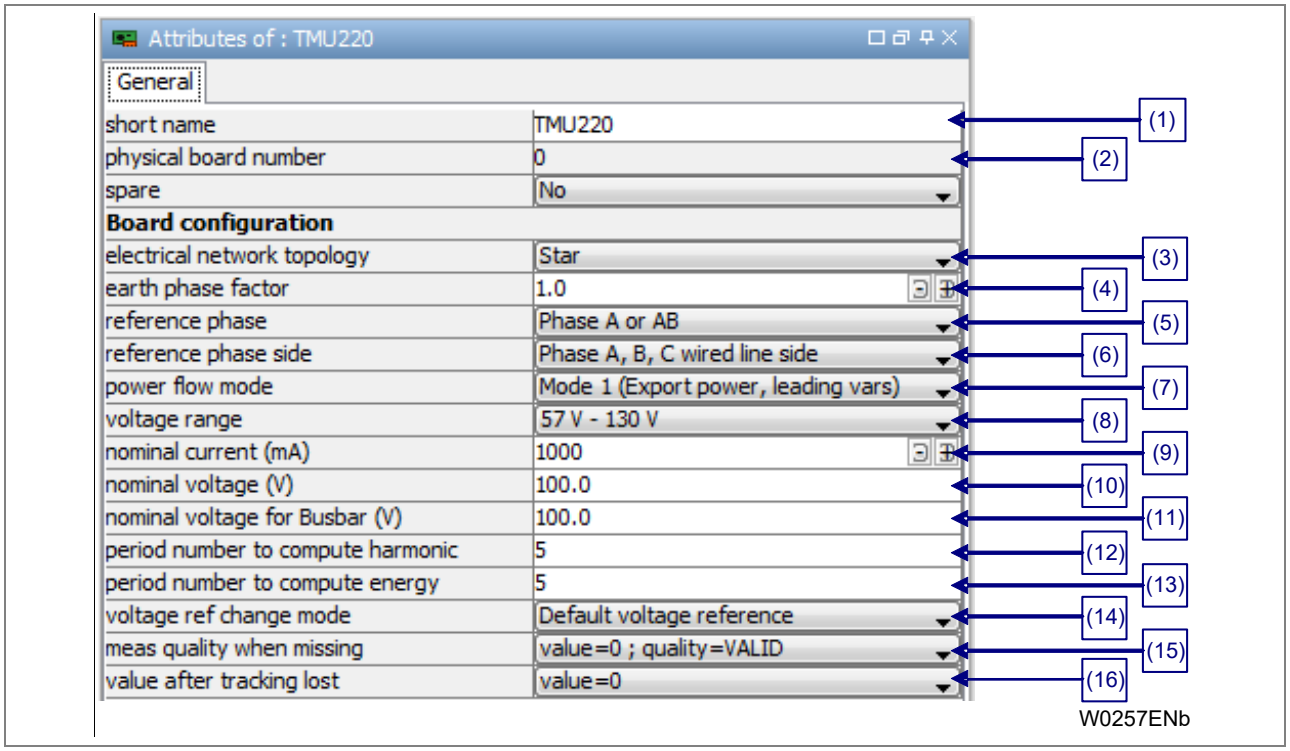


Figure 29: General attributes specific to a TMU220 board

Please refer to the chapter C26x/EN CO (Connections) for the description of the TMU2xx electrical CT/VT inputs and database association.

3.3.3.5 SETTING THE SPECIFIC ATTRIBUTES OF A TMU210 BOARD

For TMU210 board, the following attributes have to be set for correct CT/VT computation of extra measurements:

(1) **type of connection** (*3 Vpn (star)* / *3 Vpn + V0 (star)* / *2 Vpn + V0 (partial star)* / *2 Vpp + V0 (partial delta)* / *3 Vpp + V0 (delta)* / *3 Vpn + Vb (star)* / *3 Vpp + Vb (delta)*) of the voltage transformers.

(2) **earth phase factor** (range [0.0, 2.0], step 0.01): Earth factor $\mathbf{K}_0$ used by the Synchrocheck function to derive the phase-phase voltages from the phase-neutral voltages and vice-versa where there are different VT topologies on the line side and on the busbar side.

(3) **reference phase side** (*Phase A, B, C wired line side* / *Phase A, B, C wired busbar side*).

(4) **voltage range** (*57 V - 130 V* / *220 V - 480 V*): voltage range of the TMU board's voltage inputs.

(5) **reference phase** (*Phase A or AB* / *Phase B or BC* / *Phase C or CA*): Phase or phase pair used by the Synchrocheck function to compare the line and busbar voltages.

(6) **transformer nominal current (A)** (range [1, 9999 A], step 1 A): Rated primary phase current

(7) **nominal current (mA)** (*1000 mA* / *5000 mA*): Rated secondary phase current

(8) **transformer nominal homopolar current (A)** (range [1, 9999 A], step 1 A): Rated primary neutral current

(9) **nominal homopolar current (mA)** (*1000 mA* / *5000 mA*): Rated secondary neutral current

(10) **nominal homopolar current origin** (*acquired* / *computed*): Defines whether the neutral current is measured from a dedicated CT or if it derived from the sum of the three phase currents

(11) **transformer nominal voltage (V)** (range [10, 400000 V], step 0. 01 V): Rated primary phree-phase voltage

(12) **nominal voltage (V)** (range as defined by (4) **voltage range**, step 0.000001 V): Rated secondary three-phase voltage

(13) **transformer nominal homo voltage (V)** (range [10, 100000 V], step 0.000001 V): Rated primary residual voltage

(14) **nominal homopolar voltage (V)** (range as defined by (4) **voltage range**, step 0.000001 V): Rated secondary residual voltage

(15) **MV read cycle (ms)** (range [100, 9900 ms], step 100 ms): time interval at which measured values are refreshed on the local LCD and re-sent over the network (to SCADA etc.)

(16) **transformer sensibility** (sensitivity) (*not sensible* / *sensible* / *very sensible*): setting used to determine the len range for earth fault protection.

(17) **EPATR tore type** (*400/1* / *100* / *80/1* / *not used*): transformer ratio for the resistive earth fault core balance CT (legacy protection function)

Extra attributes such as (18) and (19) are reserved for future use.

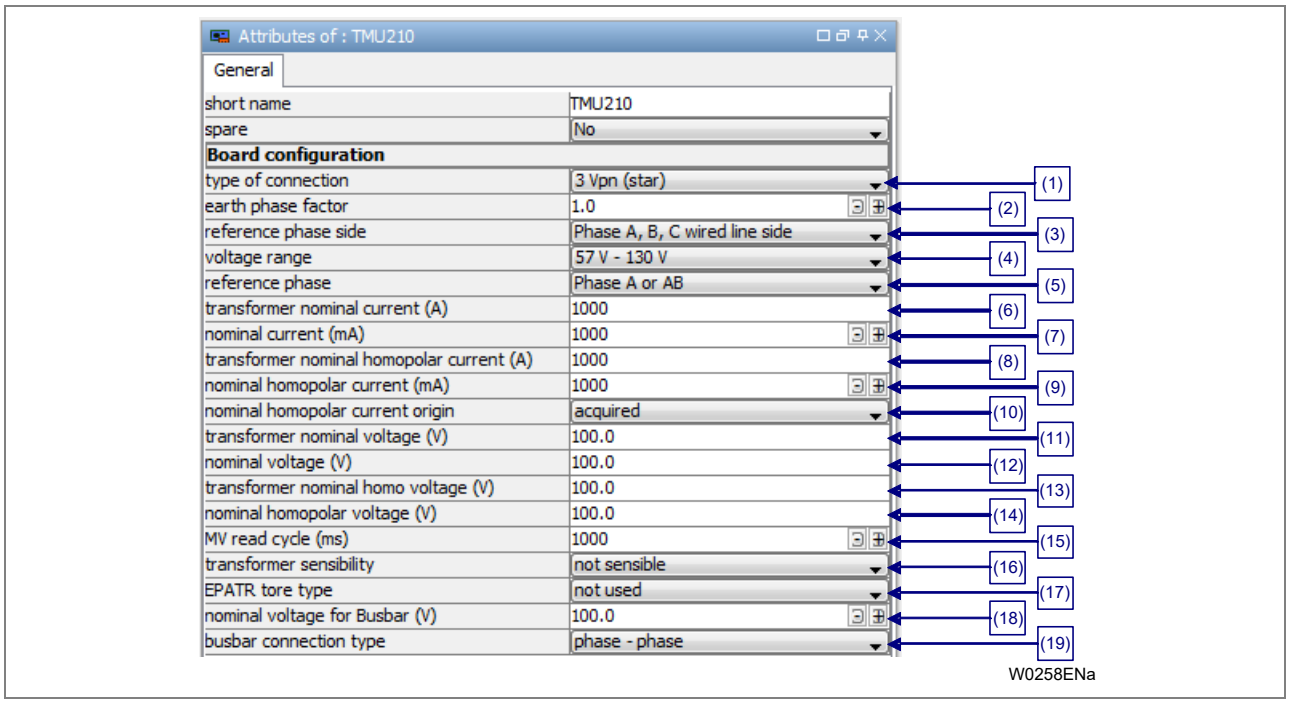


Figure 30: General attributes specific to a TMU210 board

If the reference phase signal is absent, the values transmitted by the TMU210 board are considered invalid.

Please refer to Chapter CO (Connections) for the description of the TMU210 electrical CT/VT inputs and database association.

3.3.4 CONFIGURING A COMMUNICATION CHANNEL

A communication channel is a physical port available on the CPU or the BIU board upon their creation or manually added as an option.

A communication channel can be used exclusively for:

- Communications with an IED legacy network
- Communications with a SCADA network
- Communications with a serial printer

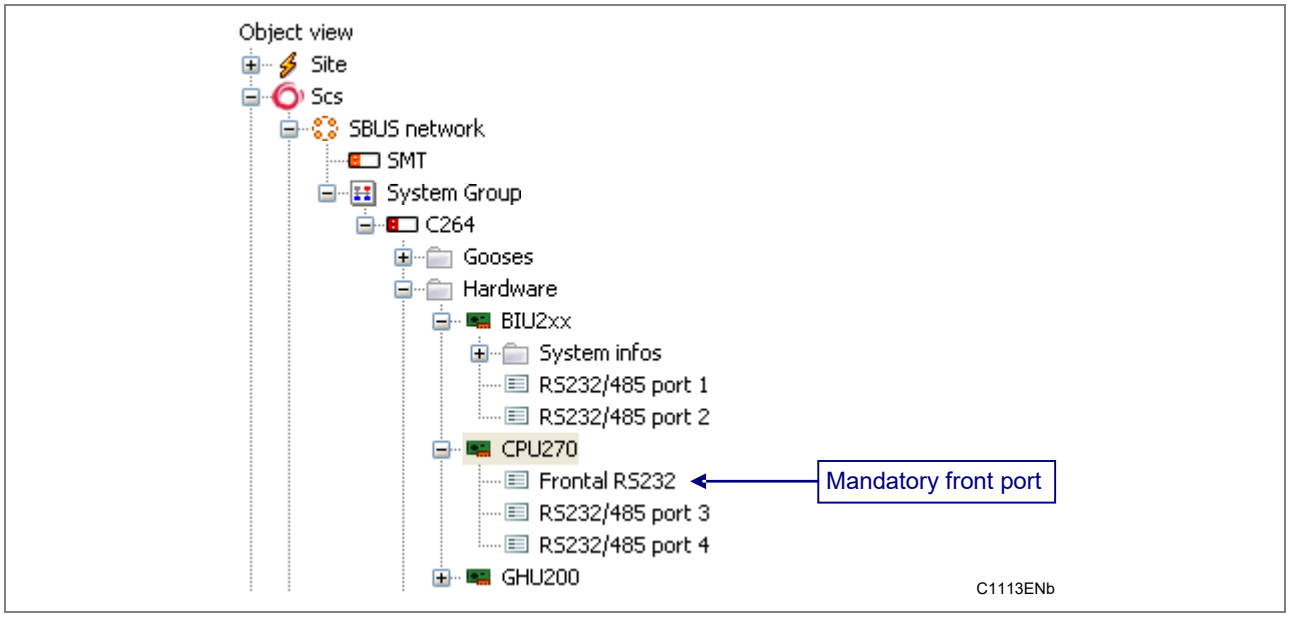


Figure 31: Use of communication channels

The Frontal RS232 port is not configurable and can only be associated with a printer.

The other ports can be associated with SCADA and IED networks as well as with a printer. They need to be set in accordance with the communication link's characteristics:

(1) **RS type** (*RS232* / *RS485*)

(2) **baud rate (bits/s)** (*50* / *100* / *200* / *300* / *600* / *1200* / *2400* / *4800* / *9600* / *19200* / *38400*)

Note:
The settings for this attribute can be different for ports 3 and 4 on the CPU270 boards.

(3) **parity** (*No parity* / *Odd parity* / *Even parity*)

(4) **number of stop bits** (*1 bit* / *2 bits*)

(5) **nb bits per char.** (*7 bits* / *8 bits*)

(6) **Tx carrier management** (*Switched* / *Constant* / *Soft*):

- **Switched**: when the C26x has to send a frame it sets the RTS line and waits for the CTS line to be set by the receiver. Then it waits during a time defined by the attribute **pre TX time** (9) before starting to transmit the frame. When the transmission is complete, the C26x waits during a time defined by the attribute **post TX time** (10) before resetting the RTS line
- **Constant**: the RTS line is always set by the C26x. When it has to send a frame it waits for the CTS line to be set by the receiver before starting to transmit
- **Soft**: the RTS and CTS line are not managed by the C26x

(7) **CTS wired** (*No* / *Yes*), fixed to *No* for port 1: this attribute must be set to *YES* if the **TX carrier management** attribute is set to *Switched* or to *Constant*

(8) **CD wired** (*No* / *Yes*), fixed to *No* for port 1: in order for the DCD line to be managed by the C26x this attribute must be set to *YES* if the **TX carrier management** parameter is set to *Switched*

(9) **pre TX time** (range [0, 1 s], step 1 ms): this attribute is visible and therefore significant only if attribute (6) is set to *Switched*

(10) **post TX time** (range [0, 1 s], step 1 ms): this attribute is visible and therefore significant only if attribute (6) is set to *Switched*

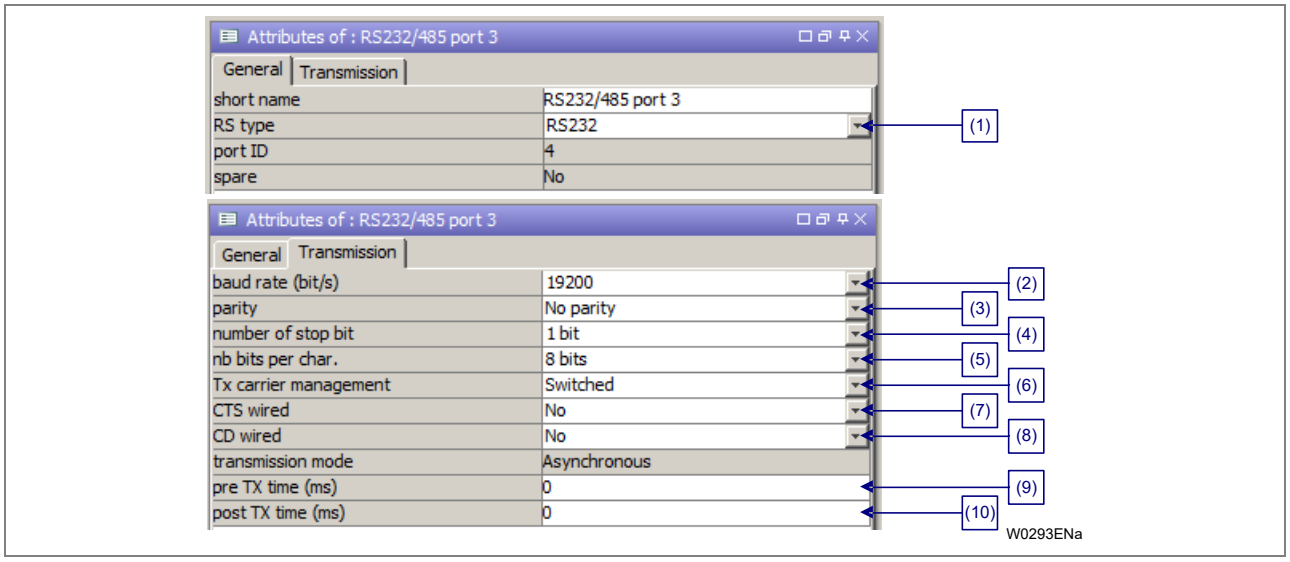


Figure 32: General attributes and Transmission attributes of a communication channel

3.3.5 CONFIGURING AN AI CHANNEL

An AI channel is an analogue input available on the AIU201 and AIU21x boards upon their creation. AI channels are used for analogue measurement acquisition.

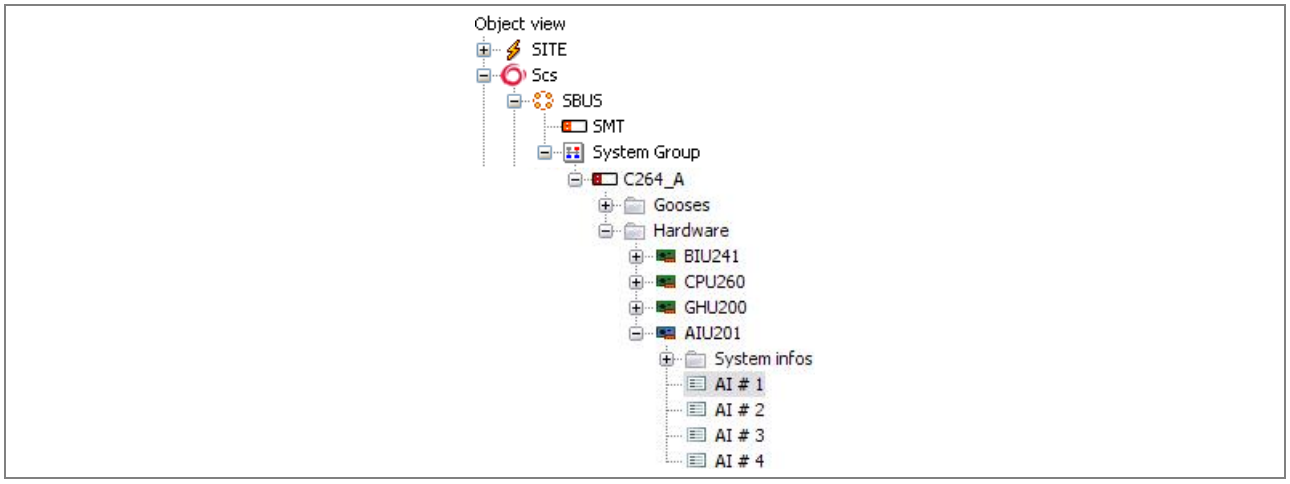


Figure 33: Use of analogue channels

Once associated with an MV, the AI needs to be set in accordance with the acquisition characteristics:

(1) **sensor range for AIU201**: *-20 mA …+20 mA / -10 mA …+10 mA / -5 mA …+5 mA / -1 mA …+1 mA / 0 mA …+1 mA / 0 mA …+5 mA / 0 mA …+10 mA / 0 mA …+20 mA / 4 mA …+20 mA / -10 V…+10 V / -5 V...+5 V / -2.5 V… +2.5 V / -1.25 V …+1.25 V*
sensor range for AIU210/AIU211: *-20 mA …+20 mA / -10 mA …+10 mA / -5 mA...+5 mA / -1 mA…+1 mA / 0 mA…+1 mA / 0 mA…+5 mA / 0 mA…+10 mA / 0 mA...+20 mA / 4 mA …+20 mA*

(2) **acquisition period** (*short period* / *long period*): see section *3.2.3 Configuring measurement acquisition and transmission*.

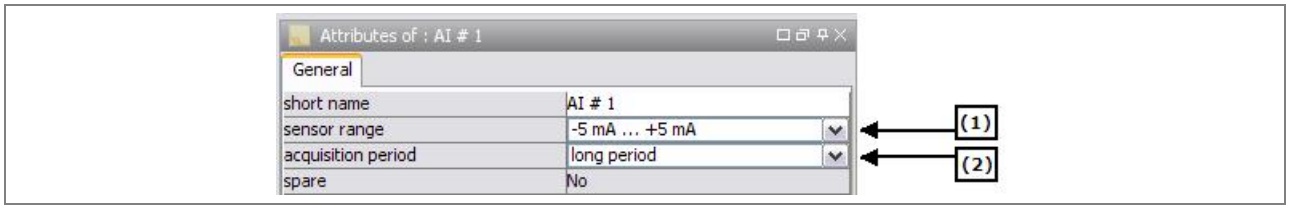


Figure 34: Configuring an AI channel

3.3.6 ADDING A PRINTER

SCE data modeling describes printers used in GE Grid Solutions' DS Agile system for 'sequence of events' and log book functions at the system HMI and C26x levels.

At the C26x level a printer must be serially connected to one of the C26x's communication channels .

To create a C26x printer:

- Select the C26x level and add a serial printer from the contextual **Objects entry** window:

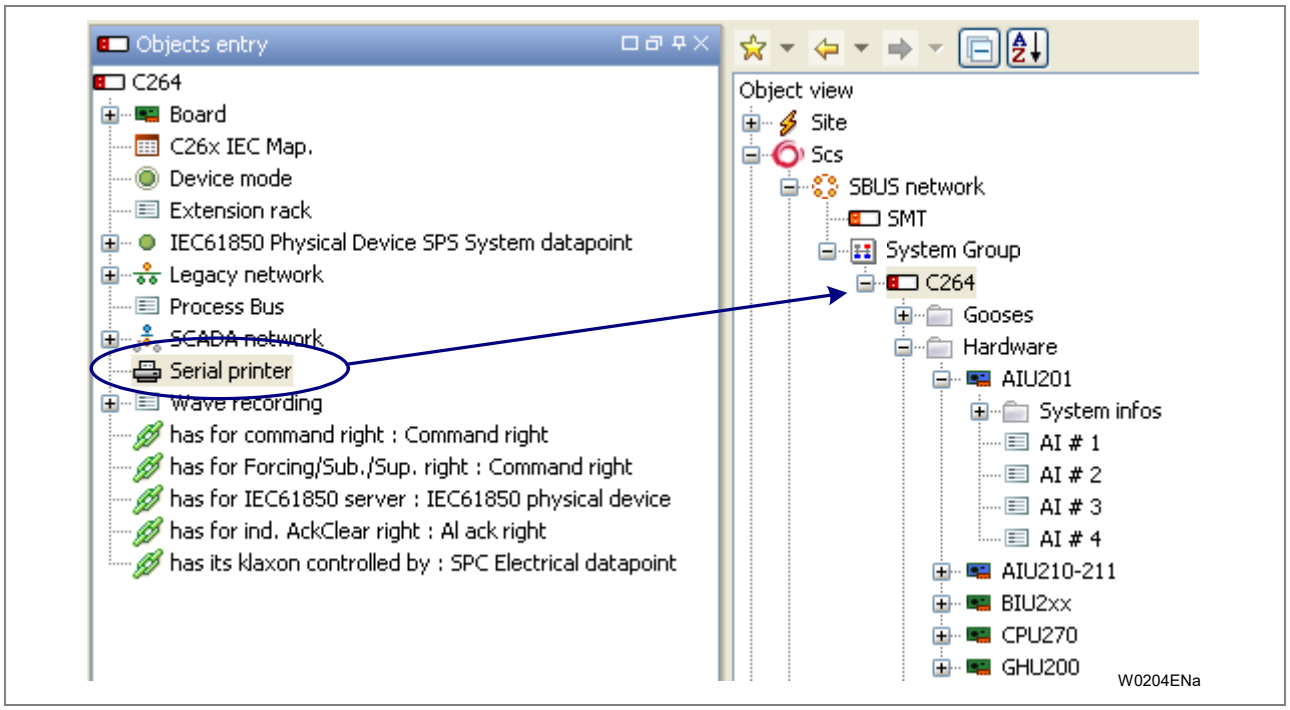


Figure 35: Adding a serial printer

- Configure its **has for communication port** relation (1) and its attribute **printer control** (2)

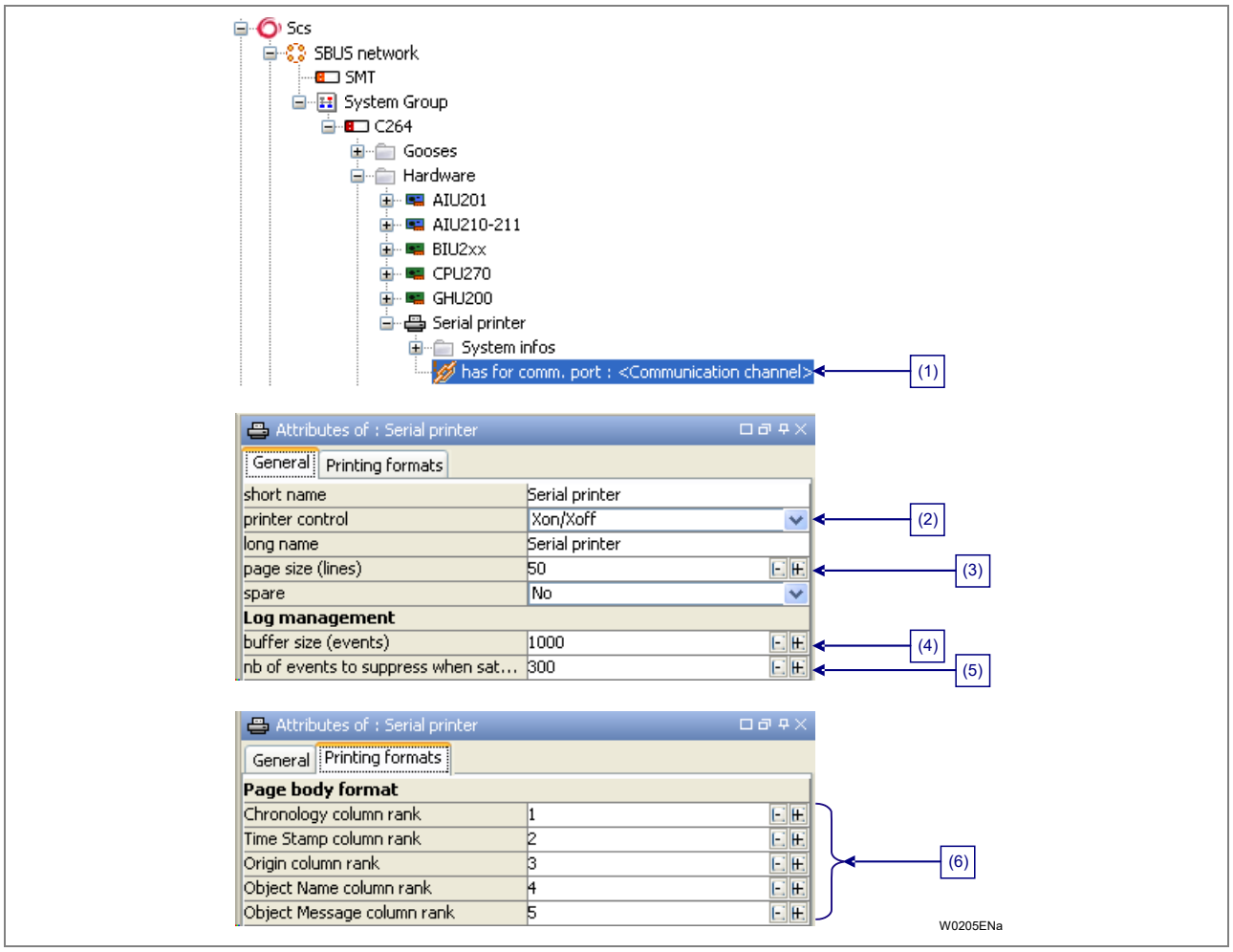


Figure 36: Updating the communication port's relation for a serial printer

To control the way logging is managed and formatted on a serial printer, update the printer's attributes:

(3) **page size** (range [20 lines, 65535 lines], step 1 line).

(4) **buffer size** (range [100 events, 3000 events], step 100 events)

(5) **number of events to suppress when buffer is saturated** (range [30 events, 1000 events], step 10 events)

(6) Rank of the various columns used for printing formats.

Configuration rules and checks

- The following constraint must be respected: **buffer size** > **nb of events to suppress when saturated**

An extract of logging that illustrates the various columns used for printing formats is shown below:

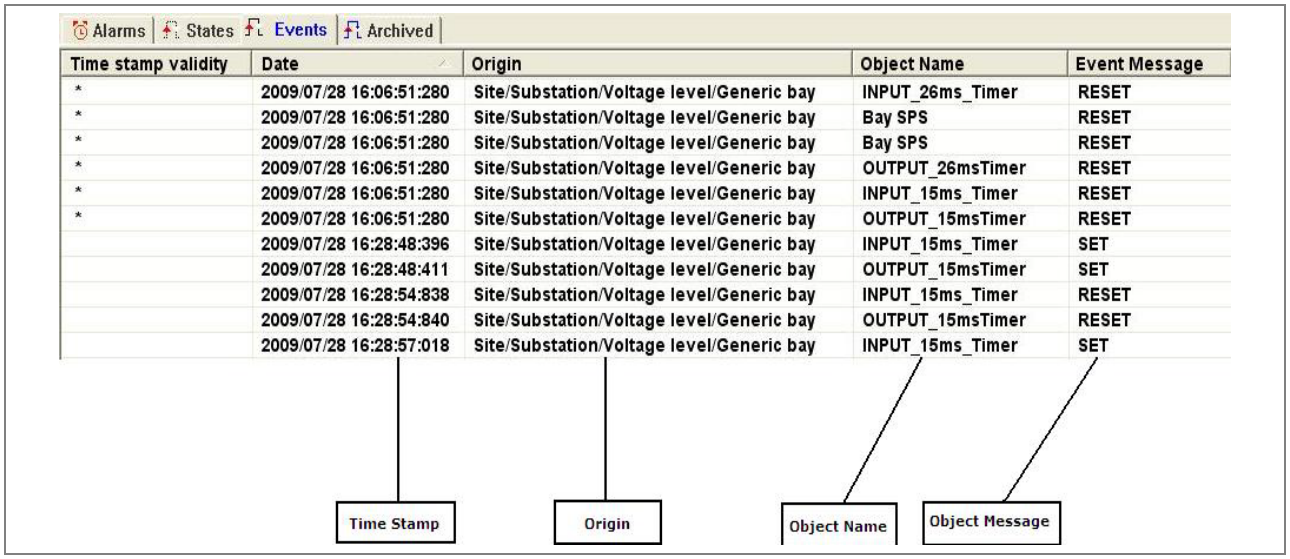


Figure 37: Columns used for printing formats

Configuration rules and checks

The value of each "… column rank" attribute must be unique.

3.3.7 CONFIGURING AN AO CHANNEL

AO channels are analogue outputs generated with an AOU200 board when it is created in SCE.

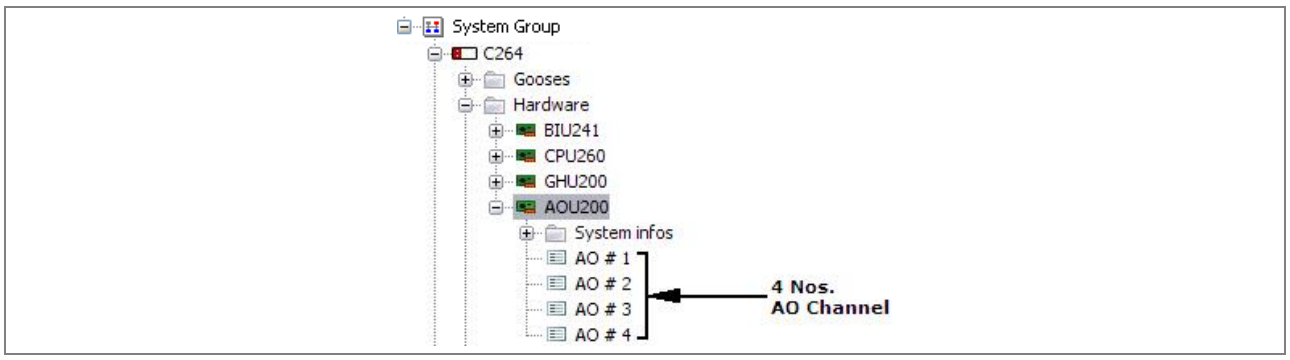


Figure 38: Uses of AO channels

The AO channel has the following attributes:

(1) **Output current maintained** mode: Yes or No

Each current output is individually managed in 2 modes:

- *Maintained mode*: if a C26x is shut down or powered off, the output level is maintained (and the Read inhibit relay is set). The output value will change only when a new setpoint is received.
- *Unmaintained Mode*: if a C26x shuts down, the output is set to 0

(2) **sensor range for AOU200**: *-20 mA …+20 mA / -10 mA …+10 mA / -5 mA …+5 mA / 4 mA …+20 mA / 0 mA …+5 mA /0 mA …+10 mA / 0 mA …+20 mA*

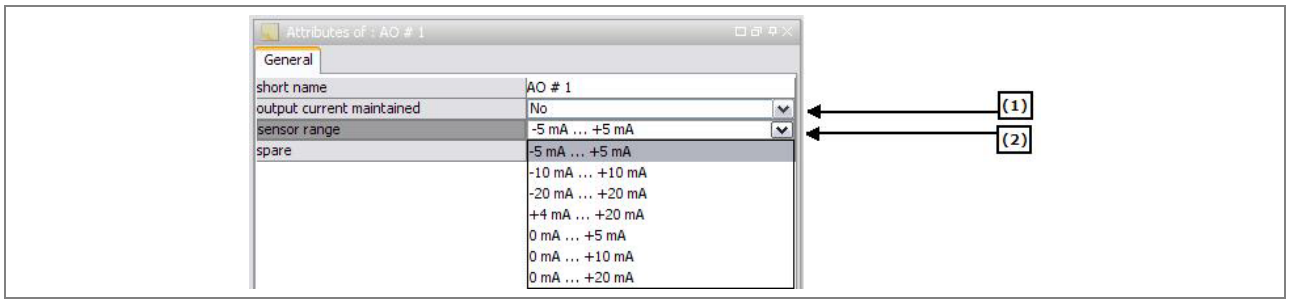


Figure 39: Attributes of AO channels

3.4 C26X IP ADDRESS AND ROUTING TABLE DEFINITION

Below are two examples of C26x addressing and routing table definition in two typical C26x application cases.

3.4.1 C26X AS A GATEWAY CONNECTED TO A ROUTER AND A REMOTE IEC104 SCADA

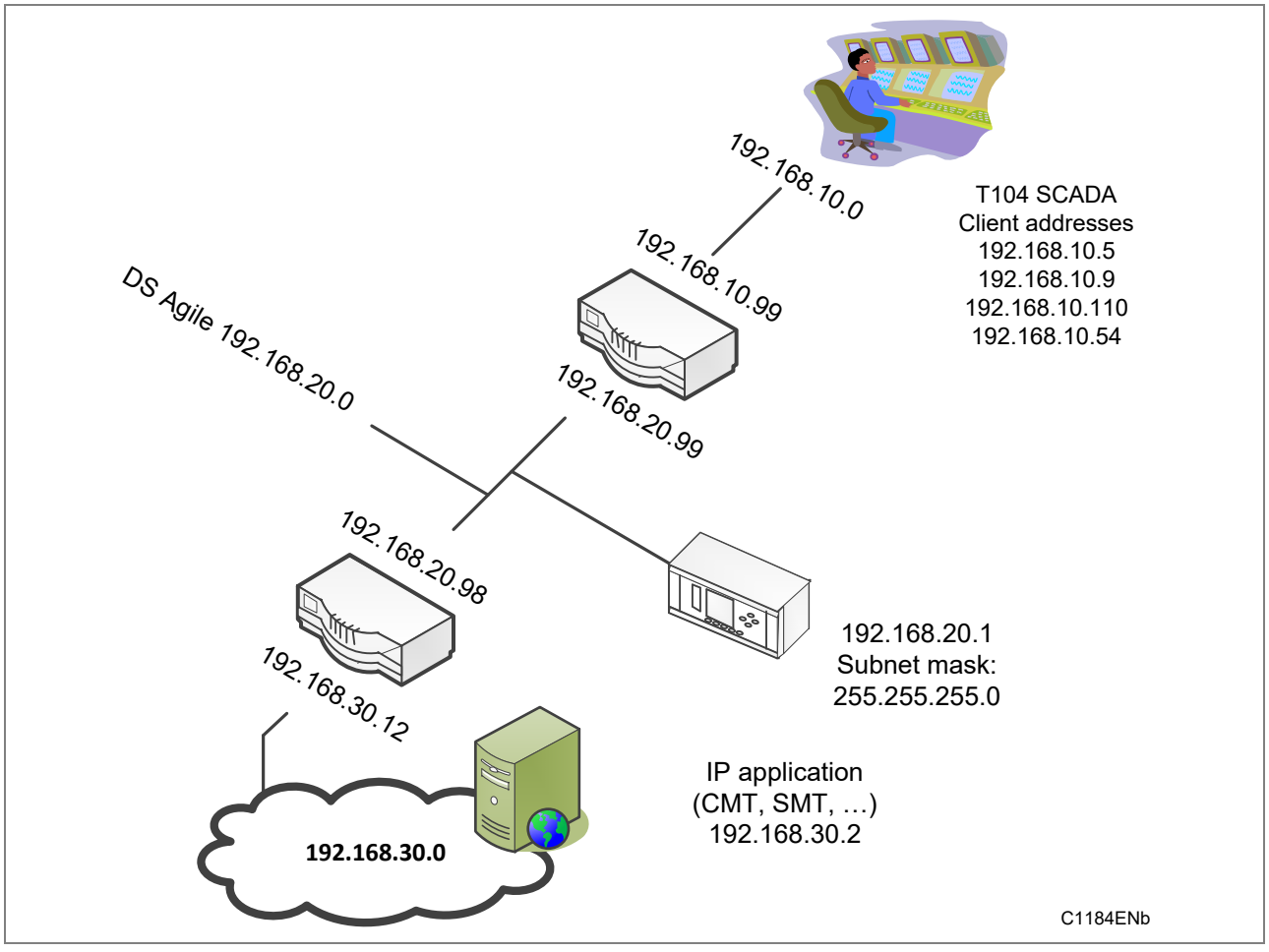


Figure 40: C26x connected to a SCADA via a router

3.4.1.1 C26X ROUTING TABLE PARAMETERS

In the SCE configuration, the C26x's routing table is declared as follows:

- **Gateway TCP/IP address** gives the address of the router.
- **Target TCP/IP address** is the address of the remote "Client" that will be connected through this router.

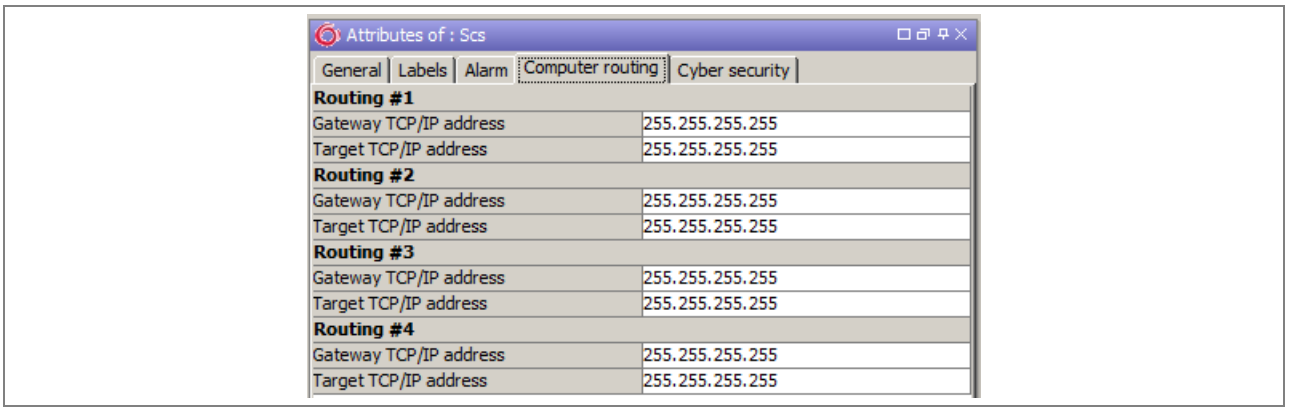


Figure 41: Attributes of an SCS

Example:

192.168.30.0 can be replaced with 192.168.30.2. In that case, the C26x can reply only to the IP address 192.168.30.2.

The label "Gateway TCP/IP address" should be read as "Router IP address" (not linked to the C26x's gateway function) and the label "Target TCP/IP address" should be read as "Target or Network IP address".

3.4.1.2 T104 PROTOCOL CONFIGURATION

It is possible to secure T104 client remote connection by giving a short list of authorized clients.

In this example, the T104 SCADA link configuration is defined as follows:

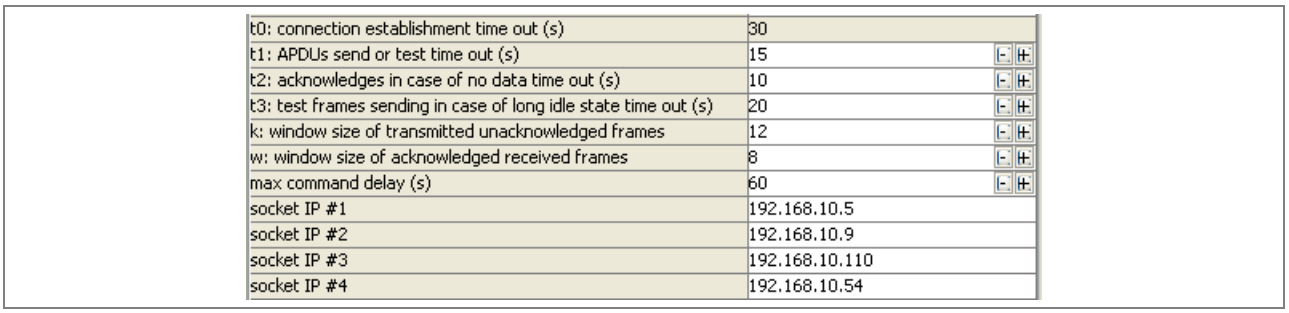


Figure 42: T104 configuration

3.4.1.3 C26X IP ADDRESS DEFINITION

The C26x's IP address is defined:

- locally on the C26x's LCD IHM
- using the CMT maintenance tool (over Ethernet)
- using the C26x's maintenance shell (for Maintenance Experts only)

In this example the C26x has the address 192.168.20.1 and the subnet mask 255.255.255.0 (default value). It can reach all units that have an address in the range 192.168.30.x.

3.4.1.4 C26X IP PARAMETERS USING THE CMT MAINTENANCE TOOL

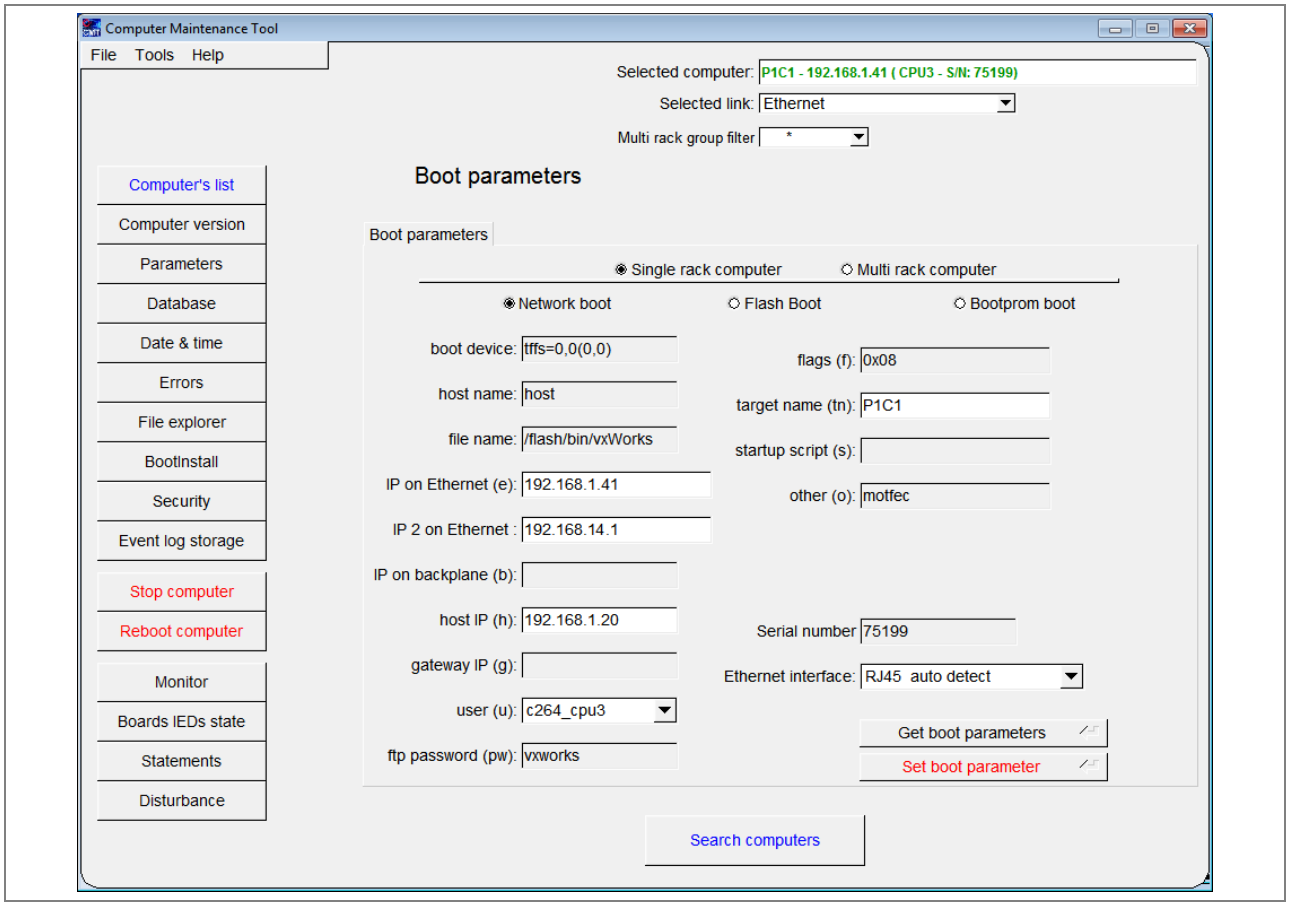


Figure 43: IP on Ethernet: Internet address of the Ethernet interface

The Internet addresses (IP) are specified in "dot" notation (e.g., 10.22.92.52).

Example: 10.22.92.52

This field can have an optional subnet mask in the form inet_adrs:subnet_mask.

Example: 10.22.92.52:0xFFFF0000 ➔ subnet mask = 255.255.0.0

10.22.92.52:0xFF000000 ➔ subnet mask = 255.0.0.0



By default, the subnet mask is set to 0xFFFFFF00 ➔ subnet mask = 255.255.255.0

3.4.1.5 ROUTER-PC CONFIGURATION (CASE OF A PC RUNNING MS WINDOWS)

In the case of a PC with two Ethernet boards, configure the IP addresses of each board and enable IP routing using a registry key.

In the Registry Editor, scroll down to
`HKEY_LOCAL_MACHINE \SYSTEM\CurrentControlSet\services\Tcpip\Parameters`

Select the **IPEnableRouter** entry:

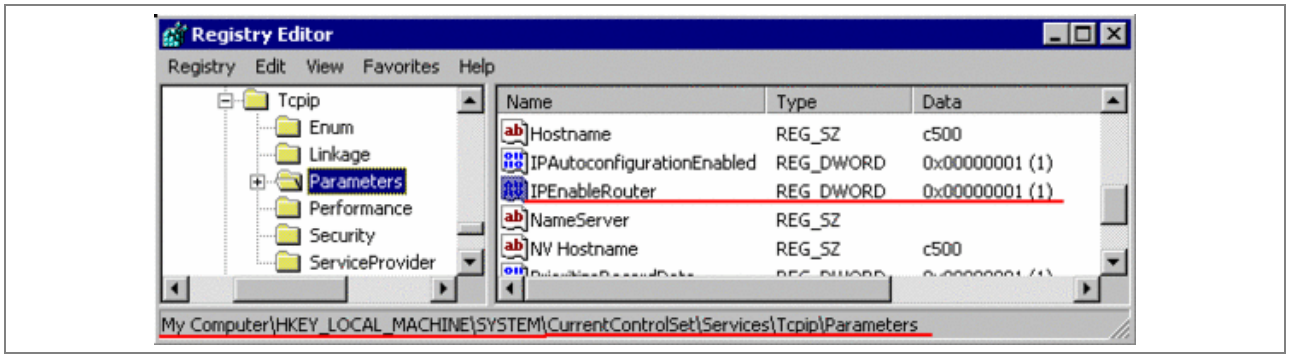


Figure 44: Registry edition

To enable IP routing for all network connections installed on and used by this PC, set its value to 1.

This will be taken into account after rebooting.

3.4.1.6 PARTICULAR CASE OF A DHCP NETWORK

The Dynamic Host Configuration Protocol (DHCP) is based on automatic assignment of IP addresses, subnet masks, default gateway, and other IP parameters.

Caution:
The C26x is designed for fixed IP address networks: IP addressing conflicts could be encountered if the C26x were installed on a network with DHCP addressing.

3.4.2 C26X AS A GATEWAY DIRECTLY CONNECTED TO A REMOTE DNP3 SCADA

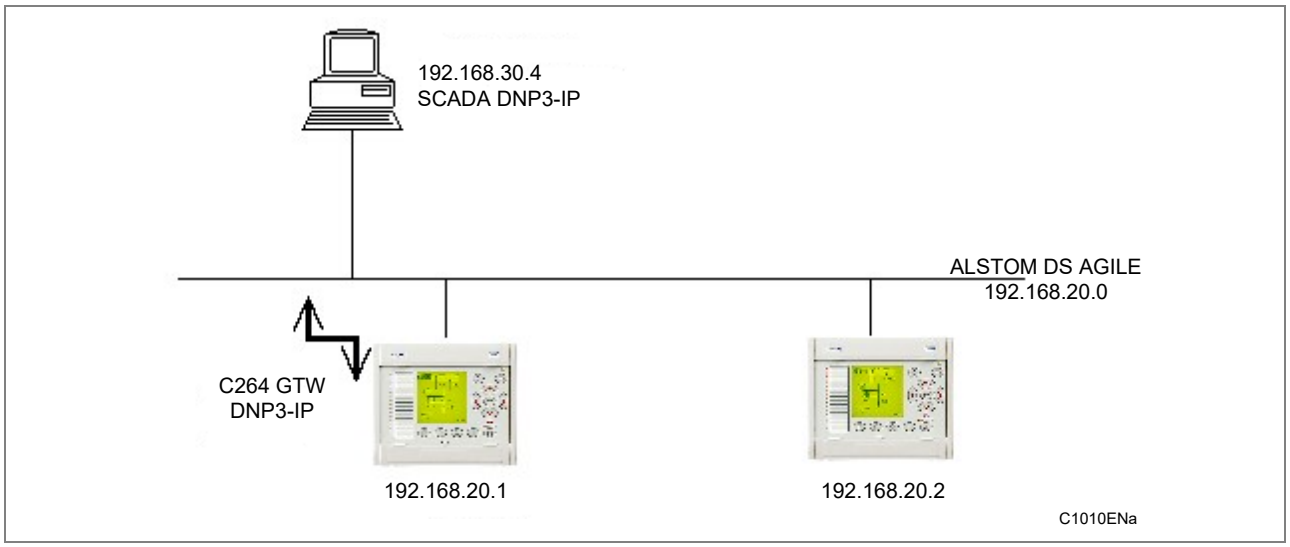


Figure 45: C26X connected to a SCADA

Note:
In the case of a DNP3/IP SCADA connected to a C26x-GTW without using any router, it is not necessary to configure the IP addresses at SCS level (Gateway TCP/IP address, Target TCP/IP address).
In this example, the C26x's address must be 192.168.20.1 and its SubNetwork mask must be set to 255.255.0.0. The C26x will accept a connection from a SCADA with the address: 192.168.30.4.

3.5 NETWORKING A C26X ON THE STATION-BUS NETWORK

The connection of a C26x to the station-bus is implicitly done by adding the C26x hierarchically to the **System Group** of the **SBUS network** (see section *3.2 Adding and configuring a C26x in the system's architecture*) and by setting the IP characteristics of the C26x (see *3.2.1 Setting the general attributes of a C26x*).

3.5.1 CONNECTING A C26X TO OTHER STATION-BUS SUB-SYSTEMS

3.5.1.1 OVERVIEW

The IEC 61850 protocol is used to transmit information between DS Agile sub-systems.

Data modeling according to the IEC 61850 protocol is based on a client-server architecture. Each IEC 61850-communicating DS Agile sub-system (OI/aView server, C26x and remote control gateway) has an IEC 61850 data map of which it is the server. A DS Agile sub-system is the server of a datapoint if it manages it, that is to say if it produces its real-time value (in the case of input datapoints such as states, measurements and counters) or if it executes its real-time controls (in the case of output datapoints such as binary commands and setpoints).

To connect a C26x (A) to a specific IEC 61850-communicating sub-system (B) on the station-bus, an extra relation **has for IEC 61850 server** must be created for (A) and point to (B). This means that the C26x (A) is a client of the sub-system (B) and can access the data managed by the sub-system (B), i.e. read the relevant real-time values from (B) and send real-time commands to (B).

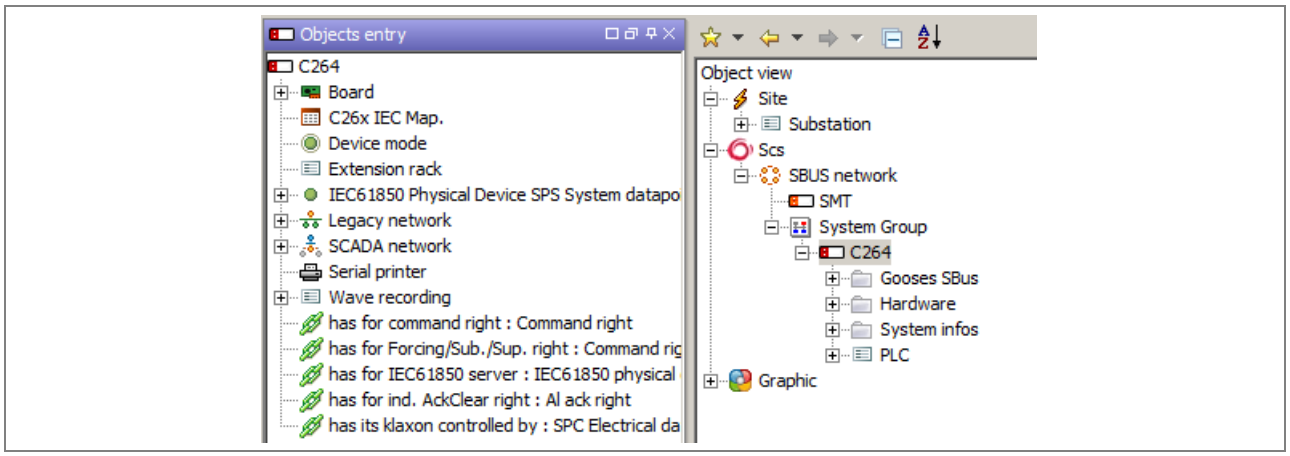


Figure 46: Connecting a C26x to other station-bus sub-systems

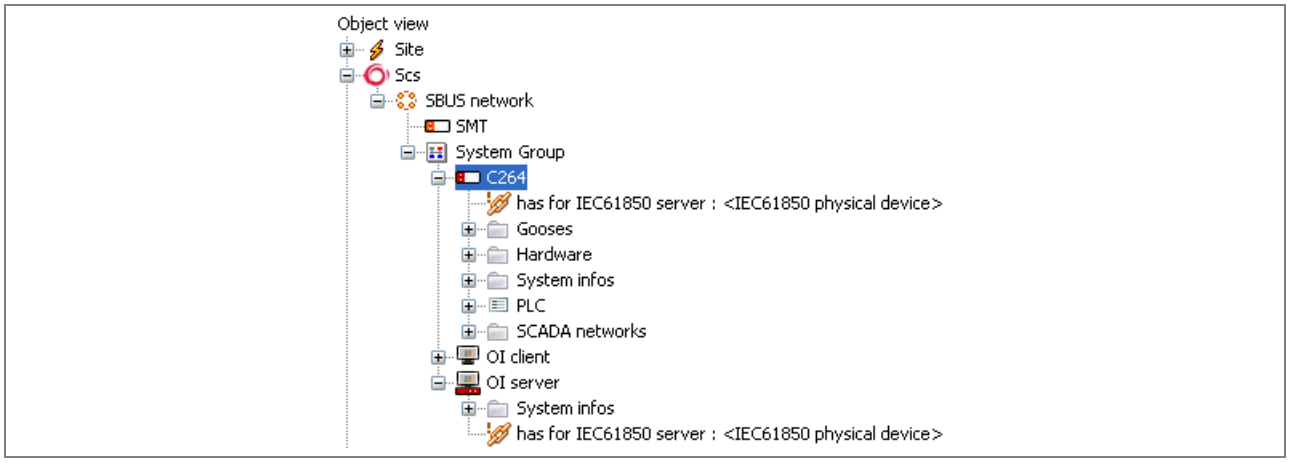


Figure 47: C26x (A) as IEC 61850 client of C26x (B)

When adding the **has for IEC61850 server** relation to C26x (A), a specific attribute of the relation, **modeling/goose usage** (1), can be set to define the way that data is transmitted from the server (B) to the C26x (A). There are three possibilities:

- Data model only (or report mode only)
- Goose only
- Data model and Goose

Basically, the Report mode is used to transmit filtered data for display, printing and archiving. The Goose mode is used to transmit data as soon as possible after its acquisition and as quickly as possible, for automation purposes.

Goose transmission must be used if the C26x (A) uses BIs served by C26x (B), for ISaGRAF, FBD or interlock computation (see section *5.7 Defining an electrical regulation by user function*).

During a loss of communication between a client and a server, all the server's BIs are set to UNKNOWN on the client.

Configuration rules and checks

- A client must not be linked to the same server through multiple relations **has for IEC61850 server**

3.5.1.2 REPORT-BASED MODE

A BI can be configured to be transmitted in Report mode via its IEC 61850 address. In this mode, a confirmed change of state is spontaneously transmitted to the subscribers.

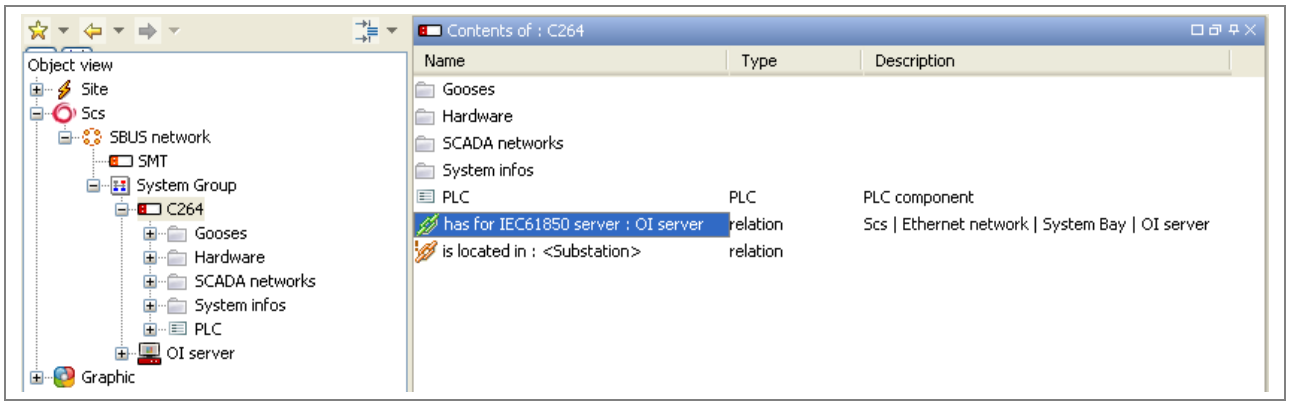
The BI information transmitted in a report is:

- the state and quality (the BI's resulting state is split in state and quality in IEC 61850)
- the time stamp (using GMT time) and time quality
- the reason for change, which could be one of the following:
  - change of data (if the state has changed, before persistence or motion filtering)
  - change of quality (if the quality has changed, before persistence or motion filtering)
  - change due to control (if the state or quality change is due to a control)

BI reports are not transmitted in a chronological order by a server (it is an IEC 61850 client feature to sort, if needed, all the information in a chronological order).

Reports between a C26x and an IEC 61850 server

The relation **has for IEC61850 server** points towards the OI/aView server or a Gateway; its attribute **preferred report type** allows choosing between *Unbuffered report* and *Buffered report*:



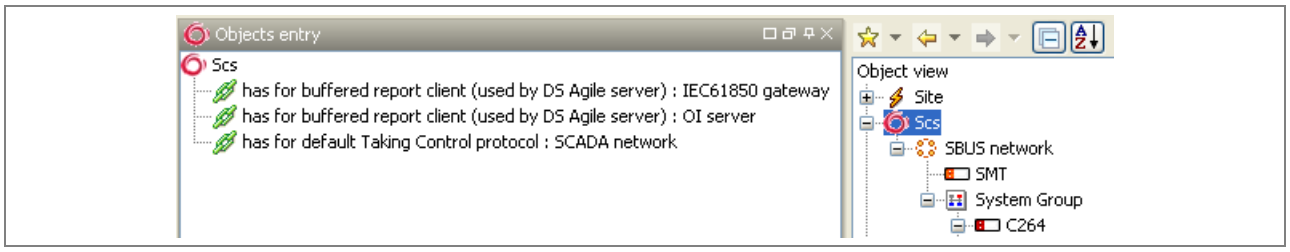
These default values should be kept.

The C26x is reversely an IEC 61850 server for the OI/aView or Gateway.

In the event of a communications loss, the reports are lost.

Buffered reports (option described in DS Agile/EN FT)

To assign the OI/aView server (respectively Gateway) as the recipient of buffered reports, an extra relation must be set: click in the **Objects entry** window at Scs level on the relation **has for buffered report client: OI server** (respectively **has for buffered report client: IEC61850 gateway**).



Then double-click on the relation to select the sub-system.

If the OI is a BRCB client, it is MANDATORY to:

- Set **OI treatment on** for **Unknown** to *No archive, no logging*. Refer to *OI/EN AP, section "Profile OI-specific attributes"*.

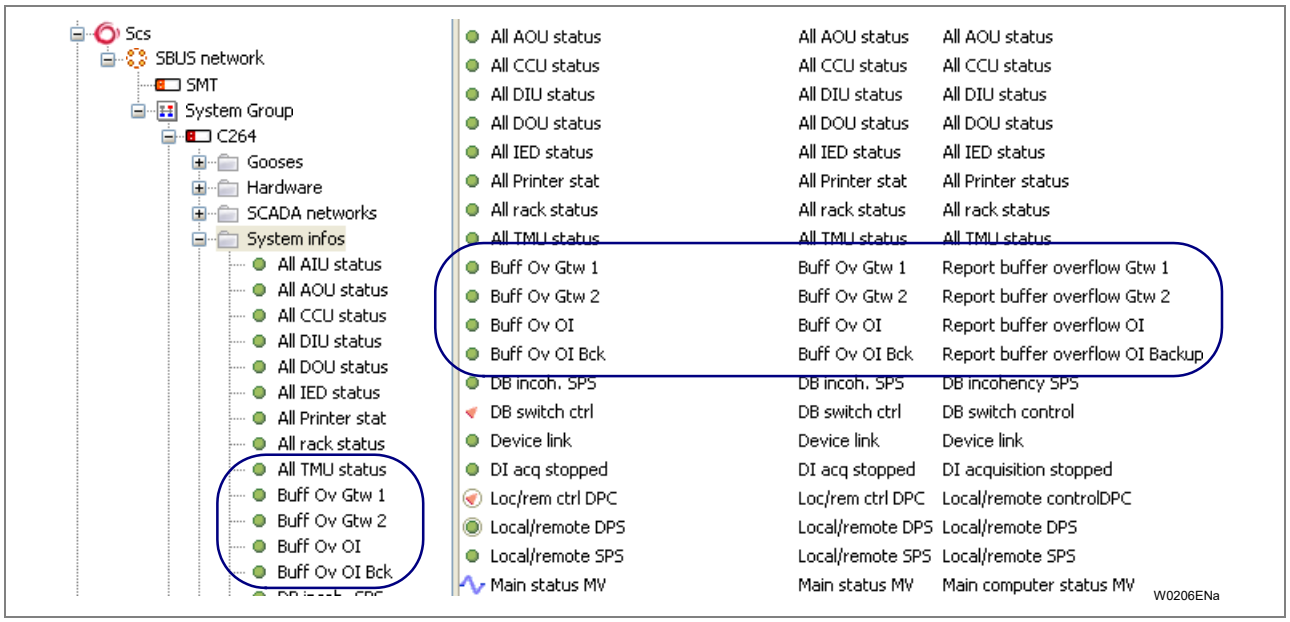
If the GTW is a BRCB client, it is MANDATORY to:

- Leave the attribute **Re-timestamp at server reconnection** set to *No*. Refer to *GTW/EN AP, section "Configuring the Gateway"*.
- Set the register key "maintenance_if_dcnx_ethernet" (Refer to *GTW/EN MF, chapter "Loss of communication"* for information on the resulting behaviour) according to the situation:
  - *1* if the Gateway is in a redundancy architecture
  - *0* if the Gateway is not redunded

Note:
*Setting the attribute **Re-timestamp at server reconnection** to* No *in an IEC/IEC gateway will cause the unknown state of the datapoints transmitted by that gateway to be raised on the upper network's system HMI. Therefore,*
- for OI: set their profile so that their unknown state is not archived by the OI (refer to OI/EN AP, section "OI-Specific Attributes in Datapoint Profiles").
- for aView, configure them in Blend so that their unknown state is not archived by aView.

If a buffer overflow should occur (refer to C26x/EN FT), a system SPS would be raised upon reconnection. In a redundant architecture, there are two SPS to identify which C26x buffer has overflowed, and therefore which sub-system has been disconnected:

- for the OI/aView: **Buff Ov OI** and **Buff Ov OI Bck**
- for the Gateway: **Buff Ov Gtw** and **Buff Ov GtwBck**



3.5.1.3 GOOSE-BASED MODE

A BI (SPS or DPS) can be configured to be transmitted in GOOSE mode. In this mode, the state change is multicasted to the configured subscribers. Only the BI's unfiltered states are transmitted, the time stamp and the reason for change are not.

Because of the GOOSE format, not all BI resulting states given below can be transmitted. The following mapping is therefore applied:

BI Resulting State	GOOSE value
RESET, FORCED RESET, SUBSTITUTED RESET, CLOSE, FORCED CLOSE, SUBSTITUTED CLOSE	01
SET, FORCED SET, SUBSTITUTED SET, OPEN, FORCED OPEN, SUBSTITUTED OPEN	10
JAMMED	00
UNDEFINED, TOGGLING, SELFCHECK FAULTY, SUPPRESSED, UNKNOWN	11

A measurement or an LSP can also be configured to be transmitted in GOOSE mode (refer to chapter C26x/EN FT).

3.5.2 DEFINING THE ADDRESS MAP OF A STATION-BUS NETWORK

An IEC 61850 mapping is an aggregation of logical units, composed of bricks. Generally, a brick corresponds to an electrical device or function. It provides its real-time data (status, measurements, and controls …) and some configuration aspects. To do that, a brick groups data by categories (Status, Measurements, Control, Configuration), called functional components.

A functional component groups data objects. A data object must be seen as a real-time equivalent of a DS Agile datapoint. Therefore, when a DS Agile sub-system (IEC 61850 client) needs the real-time value of a datapoint managed by another sub-system (IEC 61850 server), the latter transmits the information via a data object of its own IEC 61850 mapping. At SCE data modeling level, IEC 61850 clients must indicate which IEC 61850 servers they retrieve information from (see section *3.5.1 Connecting a C26x to other station-bus sub-systems*).

Generally, an IEC 61850 data object has a stereotype, called common class. The structures of these objects are known by all DS Agile IEC 61850-communicating sub-systems. For DS Agile sub-systems, the number and structure of common classes are fixed. They are the terminal description of IEC 61850 DS Agile data modeling.

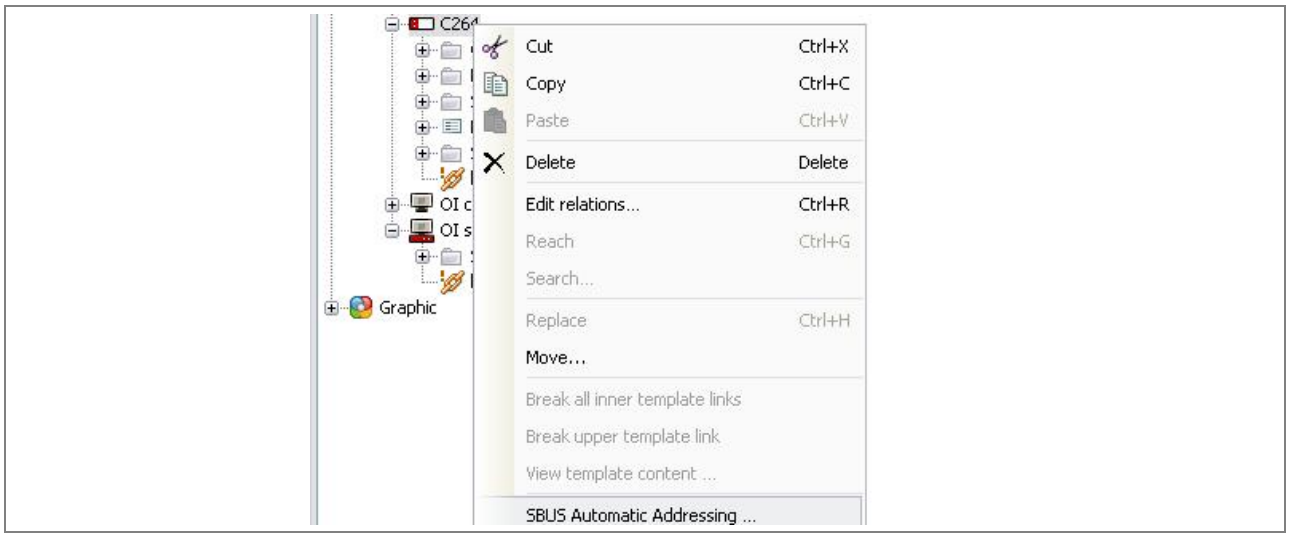
In the IEC 61850 mapping of any DS Agile sub-system, there is a native logical device LD0 with fixed and hard-coded bricks (DBID, LLN0, LPHD).

When creating a DS Agile C26x at SCE level, an IEC 61850 mapping with an LD0 and its default bricks is also created. LD0 is a system logical device that groups all system diagnostics and controls relevant to the C26x. Datapoints addressed in the LD0 brick are only relevant to system topology.

Extra logical units can be created in the IEC 61850 mapping of a C26x. Generally, there is one logical device for each bay managed by the C26x, and, in each logical device, there is one brick for each module or built-in function.

3.5.2.1 SBUS AUTOMATIC ADDRESSING

The “SBUS automatic addressing” function is based on the substation electrical topology and in particular on bays. The easiest way to add application logical units relevant to the electrical bay(s) managed by a C26x, or a DS Agile Gateway, is to run the **SBUS automatic addressing** function for the C26x or Gateway. The contextual menu of the C26x is used to launch this function:



SBUS Automatic Addressing does not process datapoints managed by non-DS Agile IEC 61850 devices (e.g. protection IEDs), since their address map is imported from the import datalist in their IEC 61850 configuration file.

As of version 5.0.5 of the DS Agile System, SBUS Automatic Addressing is incremental: The addresses of non-spared, unmodified datapoints with existing valid addresses (for instance, in case of version upgrade or system extension) are left unchanged and unused addresses are assigned to as yet unaddressed datapoints and datapoints with invalid addresses if there are any. By allowing existing datapoints to keep their IEC 61850 addresses when new datapoints are added (and addressed), this evolution can be especially useful where an existing system is being expanded or to integrate non-DS Agile devices.

Note:
Only non-spared datapoints are taken into account in automatic addressing. If a formerly spared datapoint is "unspared", repeat the automatic addressing process.

Some datapoints are out of the scope of automatic addressing. Theses datapoints are identified by their data model mnemonic and short name:

Parent object	Excluded datapoints	
	mnemonic	**name**
Circuit Breaker module	SynCheck_Close_SPC	Sync CB close
	Select_SPC	Selection SPC
	Switch_SPC_PhA	Switch phA SPC
	Switch_SPC_PhB	Switch phB SPC
	Switch_SPC_PhC	Switch phC SPC
	SwitchPos_PhA (DPS)	Switch PhA pos.
	SwitchPos_PhB (DPS)	Switch PhB pos.
	SwitchPos_PhC (DPS)	Switch PhC pos.
	SwitchPos (DPS)	Switchgear pos.
	PhaseNotTogether_SPS	Ph not together
External automatic synchrocheck built-in function	CS_CtrlOnOff_DPC	on/off ctrl DPC
	CS_CtrlOnOff_SPC	on/off ctrl SPC
Relay [XX] function	XX_thresholdY_trip With: XX = function number Y = threshold number	XX tY trip examples: 46 t1 trip 67 t3 trip
	XX_thresholdY_inst_dir_rev With: XX = function number Y = threshold number	XX tY in di rev examples: 67 t1 in dir rev 67 t3 in dir rev
	XX_thresholdY_interlock With: XX = function number Y = threshold number	XX tY interlock example: 67 t1 interlock
Relay [automatism]	start_disturbance	start dist ctrl
Relay [49] function	49_trip_th_overload	49 trip th over.

- Some of the measurements computed by a TMU210 are out of the scope of automatic addressing if the measurement type (**measure type** attribute of the relation **is computed by** linked to the related MV) is one of the following states:
  - mod Vo (ADC)
  - mod I1 (ADC)
  - mod I2 (ADC)
  - mod V1 (ADC)
  - mod V2 (ADC)
  - thermal status

Note:
*Datapoints excluded from automatic addressing can be addressed manually by adding and configuring the relation **has for IEC address**.*

3.5.2.2 MANUALLY UPDATING A C26X UNIT'S IEC 61850 MAPPING

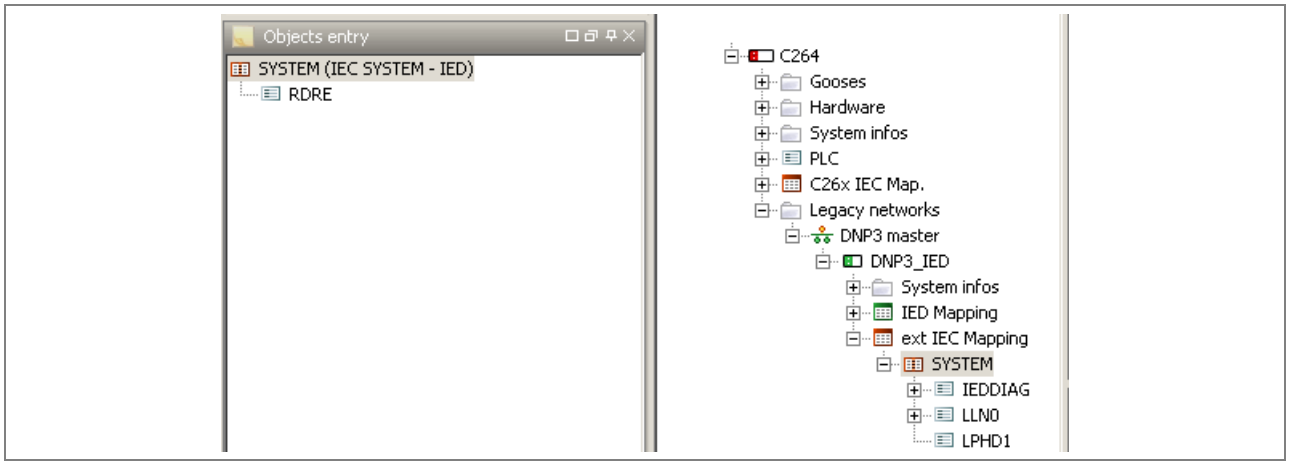
For a DS Agile C26x, the fixed part is composed of an LD0 folder containing:

- a C26xDIAG diagnostic brick
- a DBID (DataBase IDentity) brick used for C26x database identification and management
- an LLN0 brick
- an LPHD brick

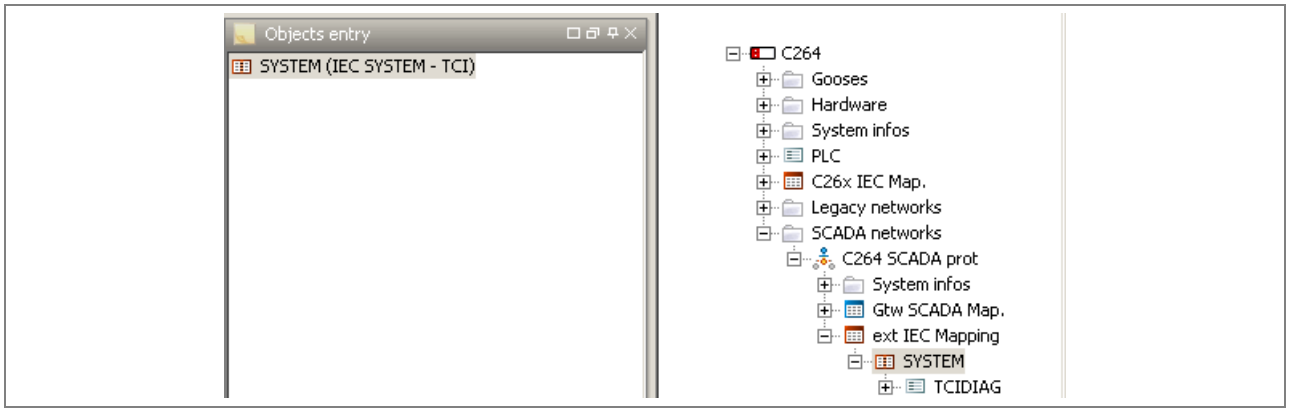


When adding the IECxLD brick, it can be supplemented with RDRE (if the C26x manages its own disturbance recording file) and C26xDIAG1.

- For each IED connected to a DS Agile C26x via an IED legacy network, an implicit IEDDIAG (diagnostic for the IED) brick exists, and an extra RDRE brick (for disturbance information) can be added.
  Be careful, when creating an IED on a C26x legacy network, its IEDDIAG brick name must be updated in order to avoid creating double values for bricks.



- For each SCADA network connected to a C26x, an implicit TCIDIAG (diagnostic for the SCADA network) brick exists.
  Be careful, when creating a SCADA network on a C26x, its TCIDIAG brick name must be updated in order to avoid creating double values for bricks.



Objects description

- C26xDIAG brick:

Object name	CDC	Description	Comment
Mod	INC	Operating Mode (status only)	Mandatory
SyncSt	SPS	Device Synchronization status	stVal =0= non-synchronized stVal =1= synchronized
AllTMUSt	SPS	All boards (TMU2xx) synthetic status	
AllCCUSt	SPS	All boards (CCU2xx) synthetic status	
AllDIUSt	SPS	All boards (DIU2xx) synthetic status	
AllDOUSt	SPS	All boards (DOU20x) synthetic status	
AllAIUSt	SPS	All boards (AIU2xx) synthetic status	
AllAOUSt	SPS	All boards (AOU20x) synthetic status	
AllHBUSt	SPS	All boards (HBU200) synthetic status	
AllCOMMSt	SPS	All rack synthetic status	
AllIEDSt	SPS	All IED synthetic status	
GHUSt	INS (INS8_ST)	Local HMI (GHU200) Status	stVal =0= OK stVal =1= self-check failure stVal =2= configured but missing stVal =3= not configured but present stVal =4 = missing
BIUSt	INS (INS8_ST)	BIU240 status	Idem GHUSt
CCUSt<15>	INS (INS8_ST)	I/O board (CCU20x) status	Idem GHUSt
DIStop	SPS	Digital input acquisition stopped	
DIUSt<15>	INS (INS8_ST)	DI board (DIU20x) status	Idem GHUSt
DOUSt<15>	INS (INS8_ST)	DO board (DOU20x) status	Idem GHUSt
AIUSt<6>	INS (INS8_ST)	AI board (AIU200) status	Idem GHUSt
AOUSt<4>	INS (INS8_ST)	AO board (AOU) status	Idem GHUSt
TMUSt	INS (INS8_ST)	CT/VT board (TMU) status	Idem GHUSt
PrintSt	INS (INS8_ST)	Printer Status	stVal = 0 => OK stVal = 1 => communication loss

Object name	CDC	Description	Comment
RedSt	SPS	Redundancy Mode	stVal = 0 => StandBy stVal = 1 => Active
FailSt	INS (INS8_ST)	Failure Status	
PLCSt	INS (INS8_ST)	PLC Status	
urcbST	URCB	Basic report control block for C26xDiag status	Unbuffered

- C26xEDIAG brick for extension C26x units:

Object name	CDC	Description	Comment
Mod	INC	Operating Mode (status only)	Mandatory
BIUSt	INS (INS8_ST)	BIU 240 status	stVal =0= OK stVal =1= self-check failure stVal =2= configured but missing stVal =3= not configured but present stVal =4 = missing
CCUSt<15>	INS (INS8_ST)	I/O board (CCU 20x) status	Idem GHUSt
DIStop	SPS	Digital input acquisition stopped	
DIUSt<15>	INS (INS8_ST)	DI board (DIU 20x) status	Idem GHUSt
DOUSt<15>	INS (INS8_ST)	DO board (DOU 20x) status	Idem GHUSt
HBUSt<15>	INS (INS8_ST)	High Break DO board (HBU 20x) status	Idem GHUSt
AIUSt<6>	INS (INS8_ST)	AI board (AIU 200) status	Idem GHUSt
AOUSt<4>	INS (INS8_ST)	AO board (AOU) status	Idem GHUSt
TMUSt	INS (INS8_ST)	CT/VT board (TMU 200) status	Not managed.
CommIRSt	SPS	Communication status with the extension rack	stVal = 0 => failure stVal = 1 => OK
PLCSt	INS (INS8_ST)	PLC Status	
urcbST	URCB	Basic report control block for status	Unbuffered

- LLN0:

Object name	CDC	Description	Comment
Mod	INC	Device Mode (status only)	Mandatory
Beh	INS	Behaviour	Mandatory
Health	INS	Health	Mandatory
NamPlt	LPL	Name plate	Mandatory
brcbST	BRCB	Buffer report control block for all status of LD	Buffered

3.5.2.3 MANUALLY CREATING AN APPLICATION LOGICAL DEVICE

Real-time data exchange between DS Agile sub-systems is required for many purposes:

- At DS Agile HMI (OI/aView) level:
  - System and electrical process supervision and control (mimic animation, control popup),
  - Alarm management (generation, viewing, acknowledgement, clearing …),
  - Logging (Sequence of event, log book),
  - Event and value archiving (curve viewing, event analysis).

- At DS Agile SMT level:
  - System management (database loading and switching, device mode supervision and control)
  - Waveform file storing.
- At DS Agile C26x level:
  - Sharing datapoints for automation and built-in functions,
  - Feeding acquired data to the system HMI (OI/aView) to ensure system functionality,
  - Feeding acquired data to the DS Agile Gateway to exchange data between the DS Agile system and the SCADA,
  - Responding to system specific needs (command uniqueness).
- At DS Agile Gateway level:
  - Sharing datapoints for automation and built-in functions,
  - Exchange data between DS Agile system and SCADA.

To ensure real-time data exchange on the station-bus, specific logical units (called here application logical units) must be created in the IEC 61850 mapping of the DS Agile sub-system that is server of the exchanged data (for client/server definition, see section *3.5.1 Connecting a C26x to other station-bus sub-systems*). The DS Agile C26x is the only DS Agile sub-system that allows user-defined application logical units.

The general philosophy to manually create application logical units is:

- one application logical device per bay managed by a DS Agile C26x, DS Agile Gateway or non-DS Agile IEC 61850-compatible IED
- in each application logical device, one brick per module or function contained in the bay
- for each brick, one data object per datapoint contained in the module/function that needs to be exchanged on the station-bus. In a brick, data object are grouped by functional component. Datapoint addressing on station-bus network is done by linking a datapoint to the relevant IEC 61850 data object.

Manual creation of an application Logical Device

To manually create an application logical device:

- Select the IEC 61850 mapping level and add an **IECxLD** from the contextual **Objects entry** window.
- Update its **IEC name** attribute (1) (it must be unique for a given IEC 61850 mapping).

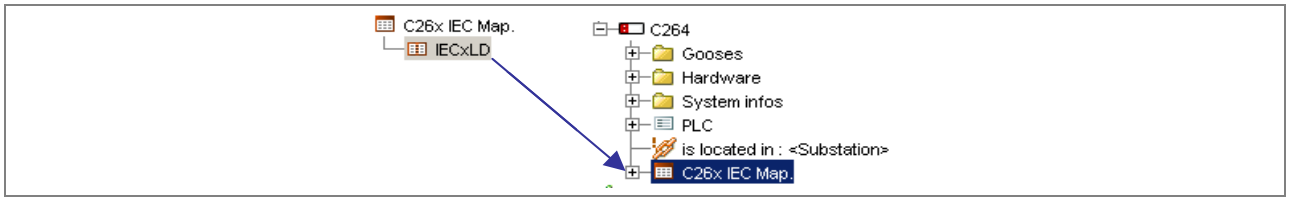


Figure 48: Adding an application logical device

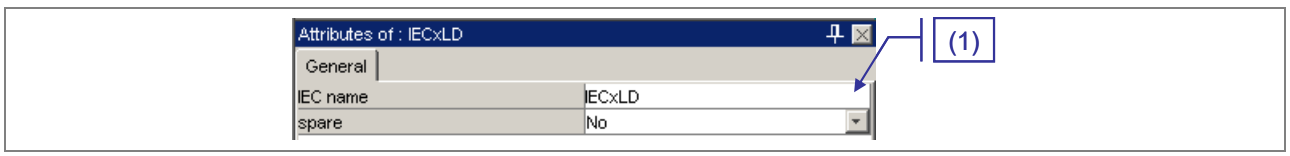


Figure 49: Updating the IEC 61850 name of an application logical device

Naming rule

IEC name is a free label of up to 32 characters, made with the following characters: 0-9, a-z, A-Z. It can not begin with a digit.

Configuration rules and checks

- The name of each Logical Device defined under the IEC 61850/IEC mapping must be unique within the mapping.
- If the Logical Device is a generic one, its name must not contain the sub-string "LD0" (reserved for system Logical Units).

Manual creation of an IEC 61850 Logical Node

To manually create an IEC 61850 LN:

- Select the IEC 61850 logical device level and add a **GenLNxx** from the contextual **Objects entry** window at; do not use an RDRE brick reserved for non-DS Agile IEC 61850 IEDs.
- Update its **IEC name** attribute (1) (it must be unique for a given IEC 61850 logical device).

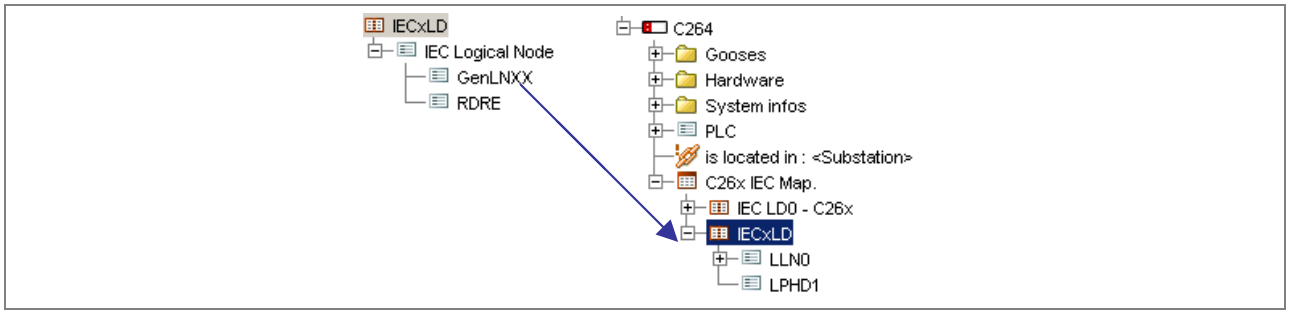


Figure 50: Adding an IEC 61850 Logical Node

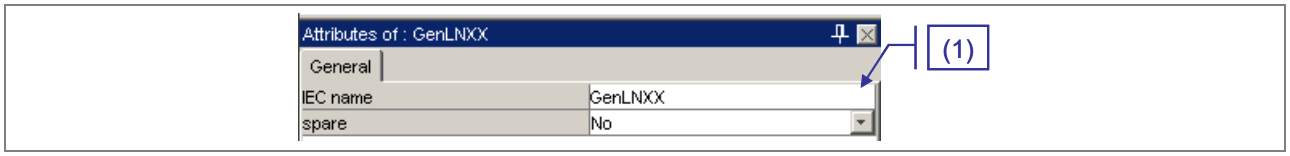


Figure 51: Updating the IEC 61850 name of a brick

Naming rule

'IEC name' is a name made with 3 parts:

- optional wrapper (up to 6 characters), it cannot begin with a digit,
- standard brick name (4 upper case characters),
- optional index (1 character).

Each part can contain the following characters: 0-9, a-z, A-Z.

Configuration rules and checks

- The name of each Brick defined under a Logical Device must be unique within the *Logical Device.*

Manual creation of an IEC 61850 functional component

To manually create an IEC 61850 functional component, select the DS Agile C26x IEC 61850 brick level and add a specific functional component from the contextual **Objects entry** window. The useable functional components for the DS Agile C26x are:

- ST to group statuses (SI, SIT, SIG)
- CO to group controls
- MX to group measurements (MV)
- SV to group substituted values (FSS indication)
- CF to group configuration information relevant to CO or SP data objects

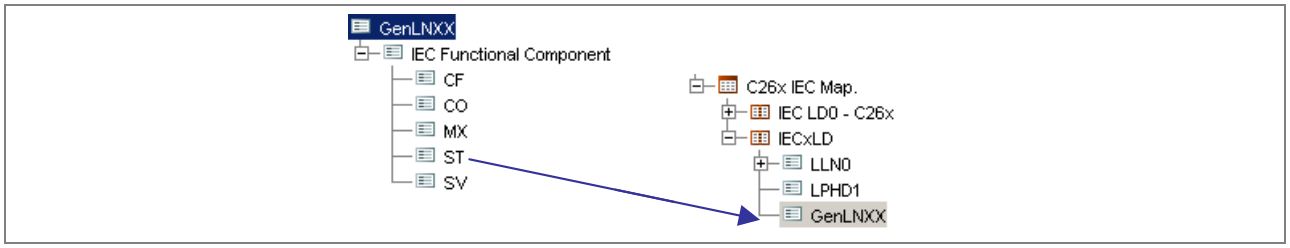


Figure 52: Adding an IEC 61850 functional component

Manual creation of an IEC 61850 data object

To manually create an IEC 61850 data object:

- Select the IEC 61850 functional component leve and add a specific data object from the contextual **Objects entry** window. Each type of functional component has its own list of available data objects. The following table shows the different lists useful for the DS Agile C26x IEC 61850 mapping:

Functional component	Available data object
ST	ACDxST ACDxSTPhs ACTxST ACTxSTPhs BCRxST BCSxST BCSxORxST DPCxST DPCxORxST DPSxST INC8xST INCxST INCxORIGxST INS8xST INSxST SPCxORxST SPCxST SPSxST
MX	APCxMX APCxORxMX CMVxMX DELxMX MVxMX WYExMX

Functional component	Available data object
CO	APCxDir APCxSBOxS BSCxDir BSCxSBOxS INCxDir SPCDPCxDir SPCDPCxSBO
SV	BSCxSV CMVxSV DELxSV SPCxSV DPSxSV INSxSV MVxSV SPCxSV SPSxSV WYExSV
CF	APCxCF BCRxCF BSCxCF DELxCF DirectxCF DPCxCF MVxCF SPCxCF WYExCF

- Update its IEC 61850 name attribute (1) that must be unique for a given IEC 61850 functional component.

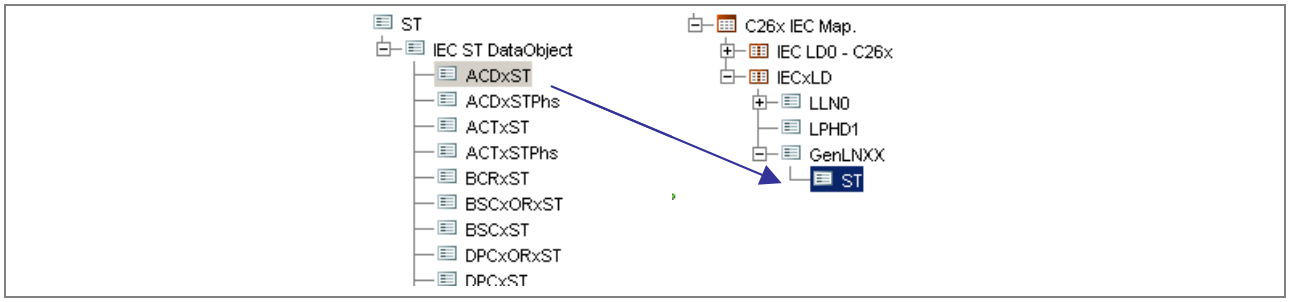


Figure 53: Adding an IEC 61850 data object

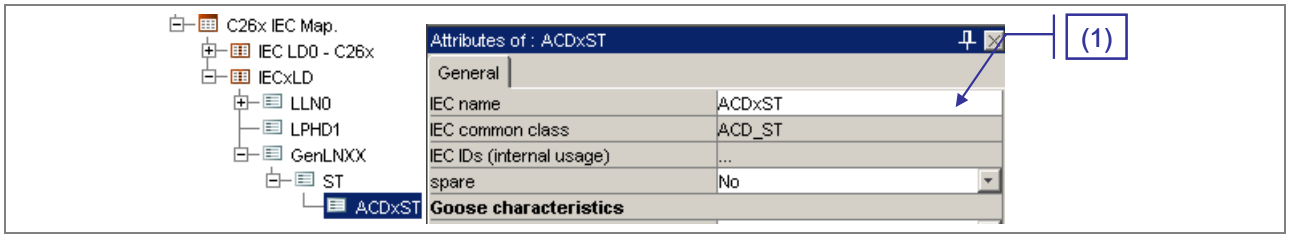


Figure 54: Updating the IEC name of a data object

Naming rule

IEC name is a free name of up to 9 characters, made with the following characters: 0-9, a-z, A-Z. It cannot begin with a digit.

Configuration rules and checks

- The name of each Data Object defined under a Functional Component (CO) must be unique within the Functional Component.
- The maximum count of Data Objects is **50** for the following DS Agile C26x unit's Functional Component types: CO, MX and ST.

3.5.2.4 AUTOMATICALLY CREATING AN APPLICATION LOGICAL DEVICE USING SBUS AUTOMATIC ADDRESSING

The IEC 61850 automatic addressing function is based on the substation electrical topology and in particular on bays. For details on how to configure this topology, see section *5 Defining a C26x configuration in the electrical hierarchy*).

The easiest way to create application logical units relevant to the electrical bays managed by a DS Agile C26x is to use the IEC 61850 automatic addressing function. To do so, right-click the C26x icon and select **SBUS Automatic Addressing** (1).

IEC 61850 automatic addressing for any given DS Agile C26x is applicable only to the bays and ATCC function that it manages, i.e. whose relations **is managed by** have been linked to the DS Agile C26x. Thus, if IEC 61850 addresses are required for non-ATCC datapoints with a higher level than bay (substation, site or voltage levels), the application logical units must be created manually (see section *3.5.2.3 Manually creating an application logical device*).

The IEC 61850 automatic addressing procedure includes GOOSE addressing: GOOSE bit-pair buffers states are sequentially filled with automation datapoints exchanged between servers. With regards to GOOSE manual addressing, the corresponding result of GOOSE automatic addressing is to set the datapoint to *Manual attachment*, i.e. as a User status bit-pair, thus preserving this association through any new automatic addressing processes.

The size limit of the buffers makes it necessary to establish priority levels for GOOSE addressing: Existing “Manual attachments” (operator’s manual selections and previous GOOSE addressing results) are taken into account first and left unchanged, then fast automation datapoints are processed and finally slow automation datapoints. Any valid pre-existing attachments are left unchanged. A GOOSE buffer overflow event is signaled and stops the process of GOOSE addressing. For details about Goose modeling / configuration see below.

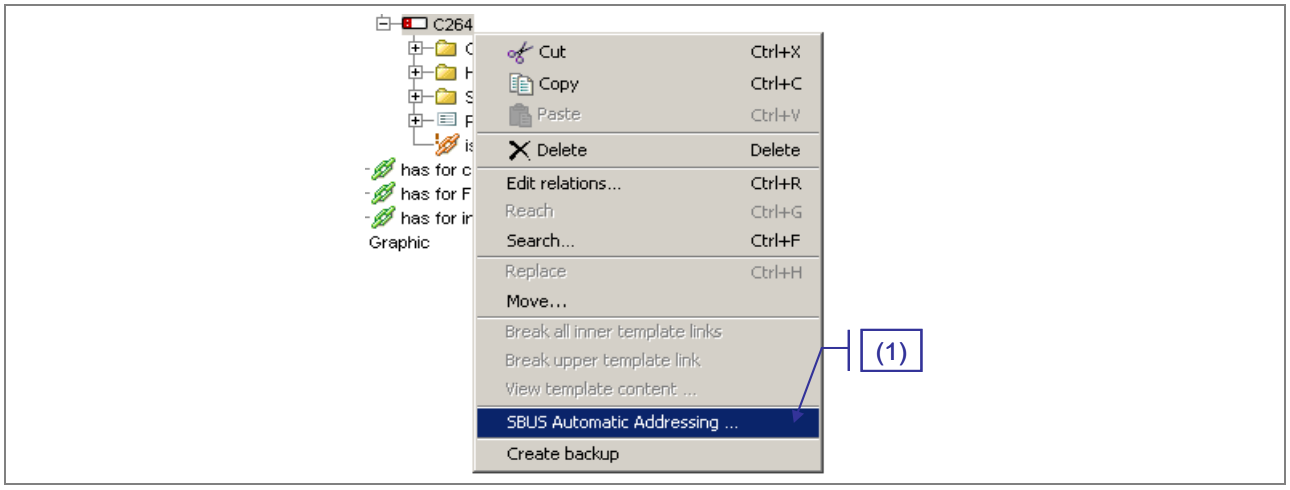


Figure 55: IEC 61850 automatic addressing

3.5.2.5 MANUALLY CONFIGURING GOOSE

GOOSE is a means given by IEC 61850 protocol to send and take into account faster the changes of binary states. That is very useful for time-critical fast automation or interlocking. In a given IEC 61850 mapping, only

its ST / MX data objects may be goosed (in addition to the LSPs used for fast load shedding). Goose is attached to and managed by the IEC 61850 server of the goosed data objects.

Goose configuration is done at the data object level using specific attributes:

- **Goose transmission (Auto)** (*Yes* / *No*): indicates whether the data object is transmitted in a Goose message and automatically addressed or not (this flag, raised to *Yes* by the SBUS automatic addressing process, can be changed back afterwards).
- **Goose transmission (Manu)** (*Yes* / *No*): specifies whether the mapping is done manually or not:

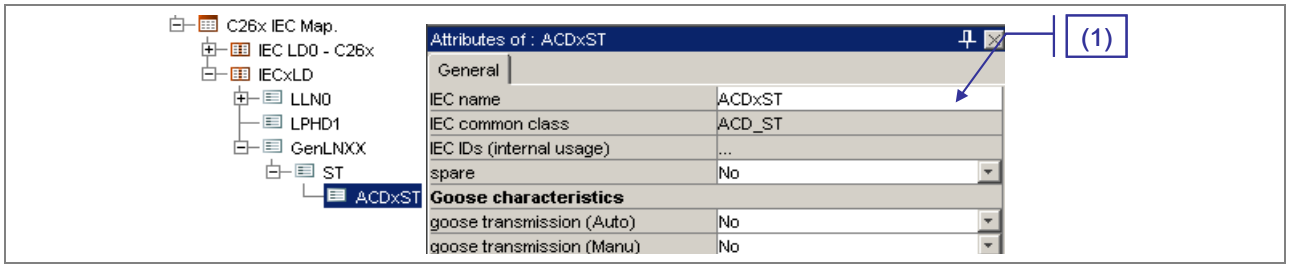


Figure 56: Manually configuring GOOSE

3.5.2.6 MANUALLY RANKING GOOSE

In addition to these two Goose transmission attributes, the Goose rank is used to manually modify the position of Data Object in the Goose messages.

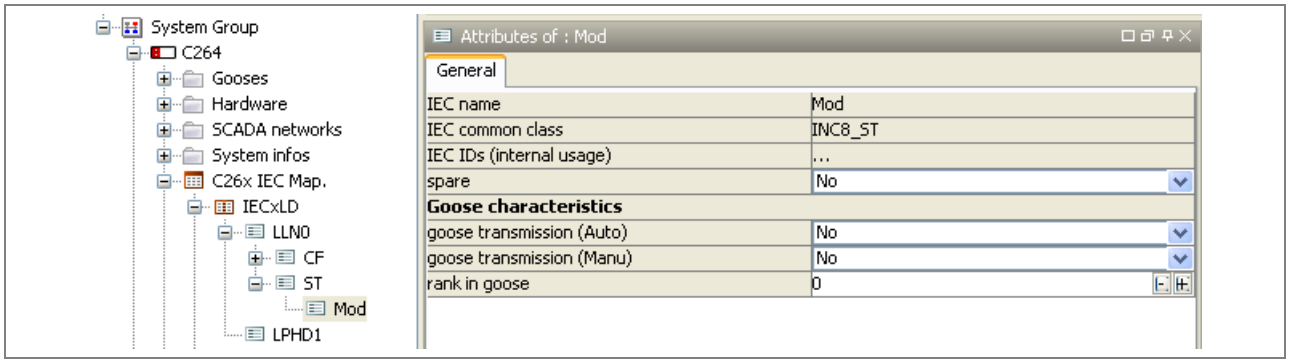


Figure 57: GOOSE rank

Note:
If a Goose datapoint with an IEC 61850 address is deleted or removed from a GOOSE, it is possible to replace that datapoint with a virtual GOOSE datapoint of the same type (SPS, DPS, etc...) and same GOOSE rank in order to maintain the system's compatibility with third party devices.

Suppose you have generated the database 1.0 for IED1 only. After adding IED2, you generate a version 1.1.

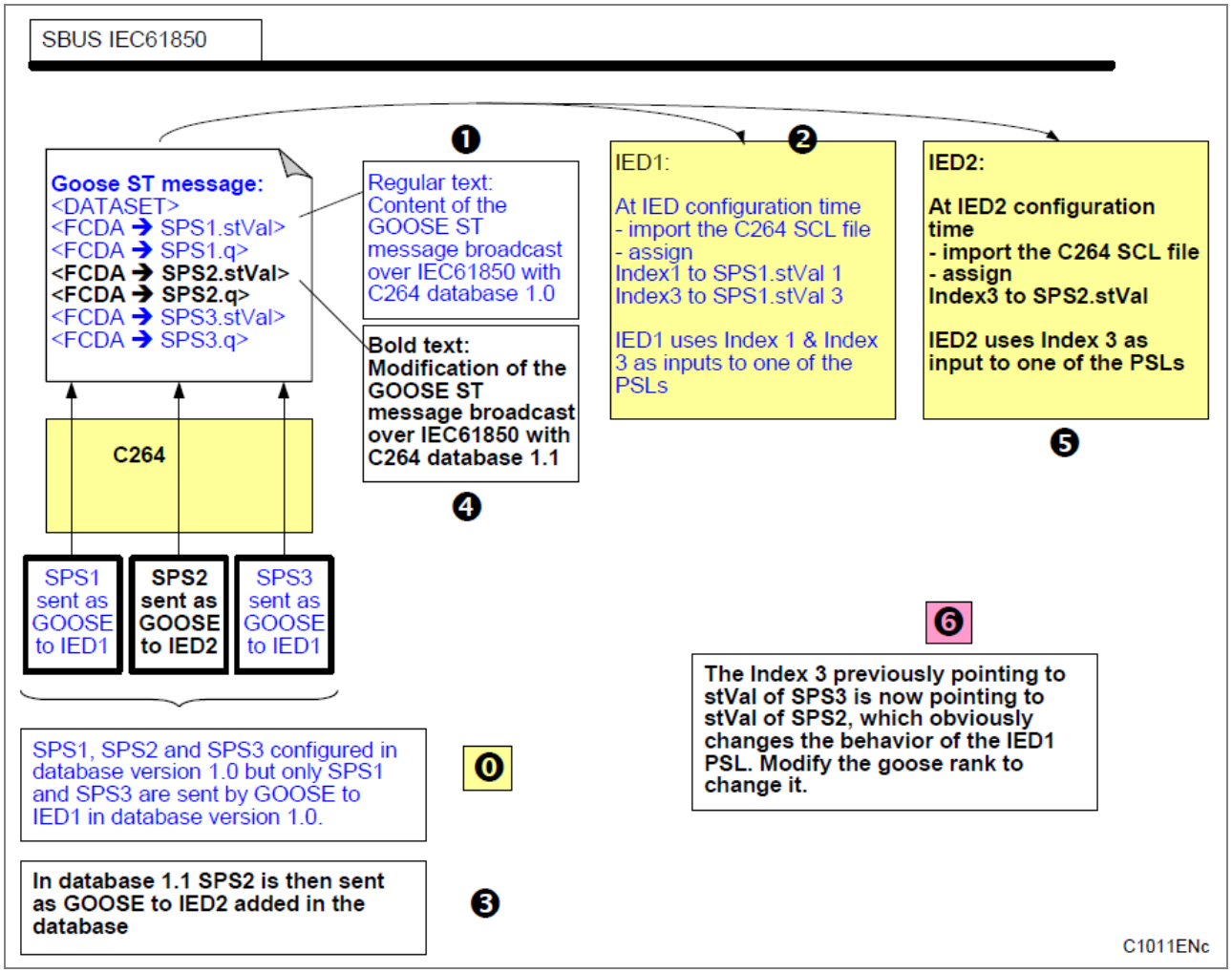


Figure 58: GOOSE rank possible problem

To resolve the conflict, change the position of SPS1.stVal3.

The aim is to have goose messages from C26x with new DataObject (DtObj) at the end of the messages to keep the rank of the other DtObjs inside the goose messages.

The attribute is set to 0 by default. This value indicates that the position is undefined. You can modify this attribute to the desired rank.

When the SCE auto-addresses all subsystems, these events occur for each DtObj:

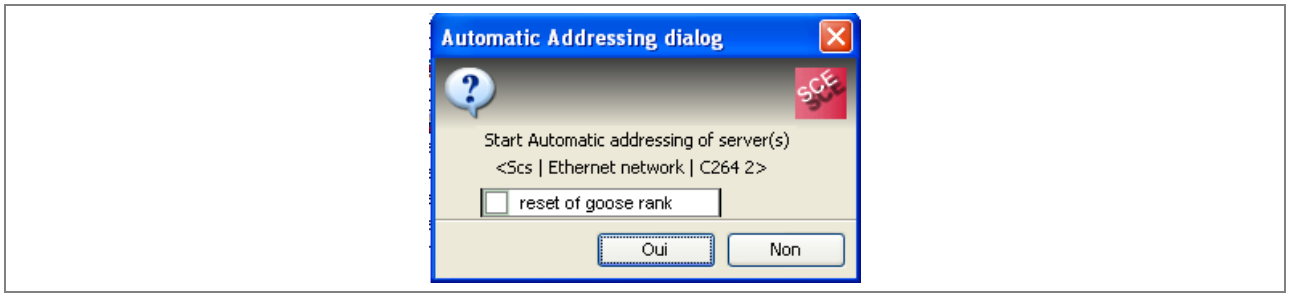
- The defined 'goose rank' is not updated if the DtObj is still 'transmitted by goose' (that is either ‘goose transmission’ attribute is set to Yes),
- The undefined 'goose rank' is ranked after the last used rank for the whole IEC 61850 mapping,
- The defined 'goose rank' is reset with an undefined value (0) if the DtObj is NOT 'transmitted by goose'.

If gaps show in the goose ranking, the pop-up message shows:



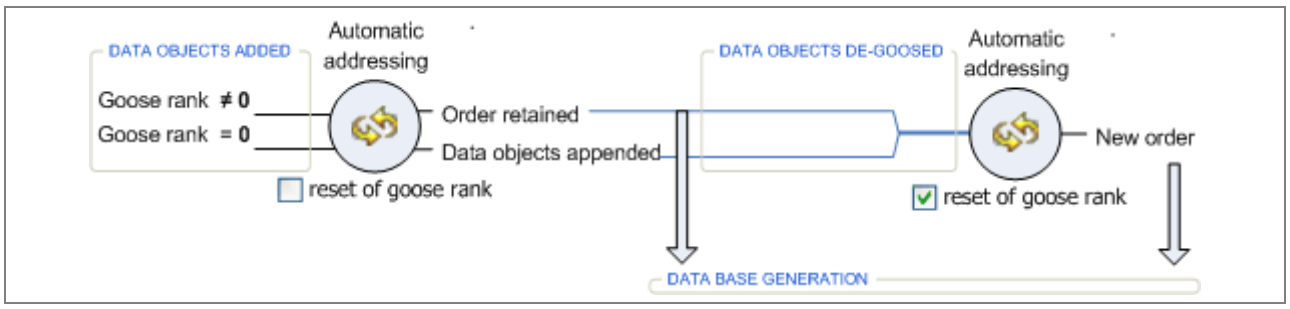
In this event, do a check of the configuration and fix it manually (see the SCE/EN MF chapter)

Note:
The SBUS Automatic addressing function displays a dialog box that can be used to re-address the goose links of some data objects that have been removed.



You can check the box ‘reset of goose rank' to forcefully reset ALL of the Goose ranks of IEC 61850 mapping at the current level in the treelike structure: they are reset with an undefined value (as they are not goosed anymore) & all the remaining goose ranks are re-computed in a new order.

Typical update cycle of data objects:



3.5.3 ADDRESSING A DATAPOINT ON THE STATION-BUS NETWORK

For details about datapoints, see section *4 Defining a datapoint*.

To exchange datapoint values between station-bus sub-systems, datapoints should be linked to specific IEC 61850 data objects. There are 2 ways to resolve this link:

- Doing a manual addressing, by adding at datapoint level the relation **has for IEC61850 address** (1) and filling it with the corresponding IEC 61850 data object in a pre-configured IEC 61850 address mapping:

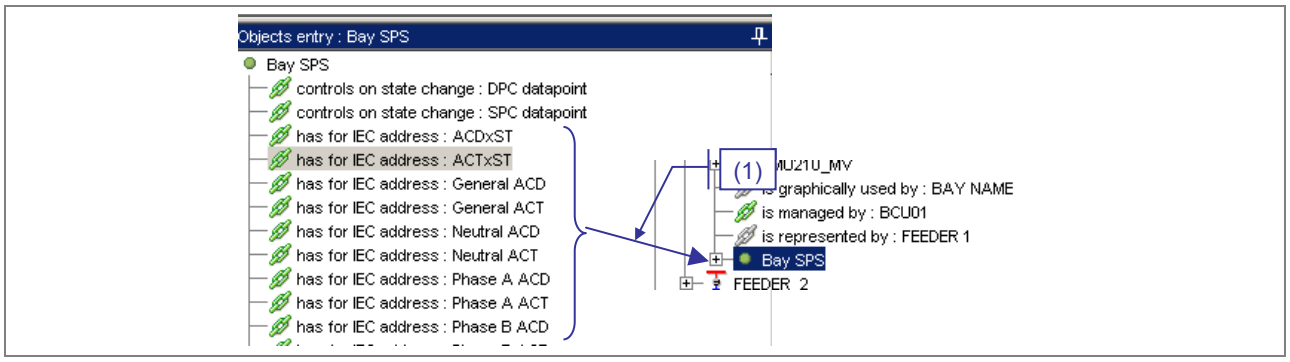


Figure 59: Manual IEC61850 addressing of a datapoint (example for a Bay SPS datapoint)

- Using the automatic SBUS addressing function available at SCE level (see section *3.5.2.1 SBUS automatic addressing*), which performs:
  - automatic IEC 61850 mapping creation at DS Agile C26x level,
  - automatic linking between data objects in this IEC 61850 mapping and datapoints managed by the DS Agile C26x.

3.6 NETWORKING IEDS ON A C26X'S LEGACY NETWORK

3.6.1 CREATING A LEGACY NETWORK OF IEDS

Generally, specific units called protection relays or IEDs are used to protect electrical modules and bays. A legacy network managed by a C26x can connect these IEDs to the DS Agile system.

In the SCE data model, up to four IED legacy networks (associated with specific protocols) can be placed under a DS Agile C26x unit. Each IED legacy network must be linked to a communication port on a C26x board. Up to sixteen IEDs can be added under each legacy network.

3.6.1.1 ADDING A LEGACY NETWORK

To create a legacy network under a C26x:

- Select the C26x level and add a legacy network, associated with the corresponding protocol, from the contextual **Objects entry** window.
- Update the legacy network attributes relevant to its protocol characteristics.
- Update its **has for main comm. port** relation and the communication port characteristics (see section *3.3.4 Configuring a communication channel*).

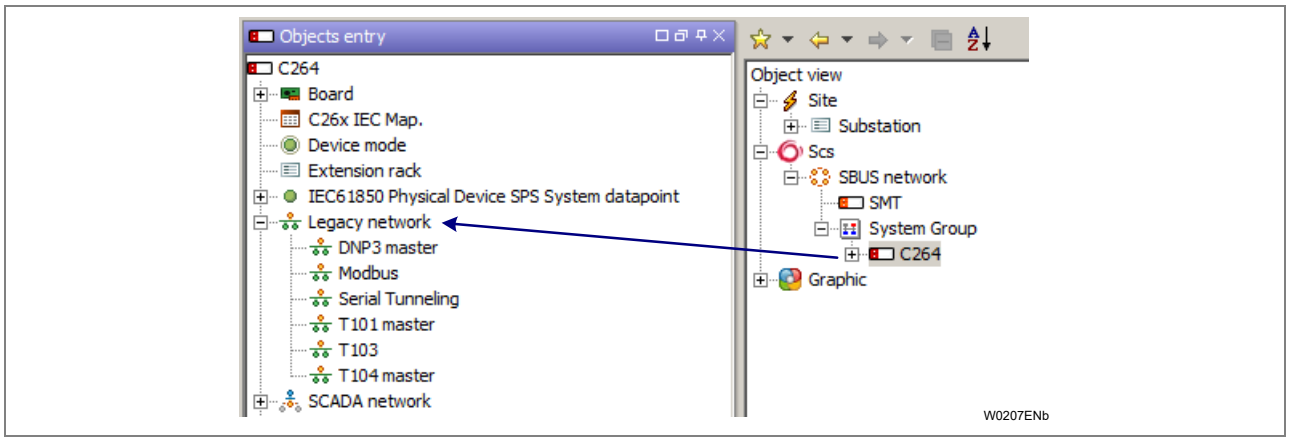


Figure 60: Adding a legacy network

3.6.1.2 SETTING THE GENERAL ATTRIBUTES OF A LEGACY NETWORK

Regardless of the type of legacy network, its **short name** and **long name** (1) attributes must be set in order to ensure correct logging and alarm discrimination of the status datapoints for the IEDs connected to the legacy network.

The time reference (2) must be set to either *UTC* or *Local* time.

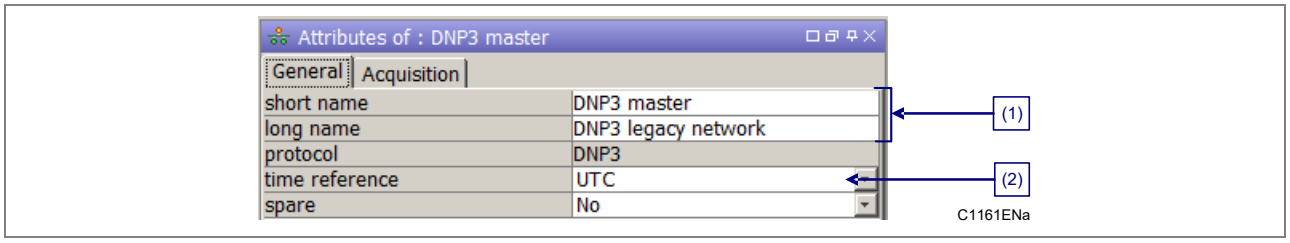


Figure 61: General attributes of a Serial legacy network (DNP3 example)

Ethernet T104 master Legacy Network

In addition to the time reference, the T104 master network also has these general attributes:

(3) **frame max length** (range [0, 255], step 1): maximum frame length of the ASDU

(4) **synchronization period** (range [1, 3600 s], step 1 s): T104 master clock synchonisation period.

(5) **master IP address** (***.***.***.***): TCP/IP address of the C26x on the T104 network. It must be one of the 2 IP addresses of the C26x.

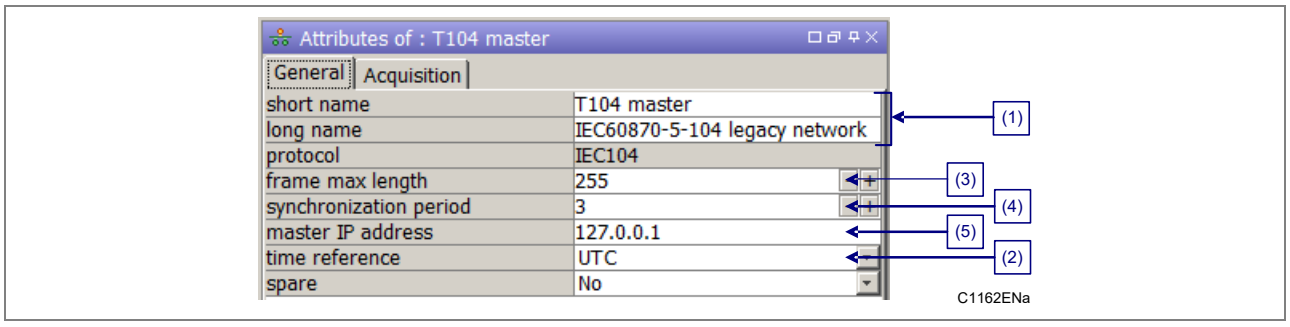


Figure 62: General attributes of an Ethernet legacy network (T104 master)

3.6.1.3 SETTING THE ACQUISITION ATTRIBUTES OF A T103 LEGACY NETWORK

When adding a T103 legacy network, set the following attributes (they will be used for all its IEDs):

(1) **number of retries** (range [1, 10]): number of retries of the same frame without IED response that the C26x will send before declaring the IED as disconnected.

(2) **acknowledgement time-out** (range [100 ms, 30 s], step 100 ms): maximum waiting time for an IED answer to a C26x's information request.

(3) **synchronization cycle** (range [10 s, 655350 s]): time synchronization period of the IED by the C26x.

(4) **downgraded cycle** (range [1 s, 10 s], step 100 ms): time interval at which the C26x regularly tries to re-connect to an IED after it has declared it as disconnected.

(5) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames.

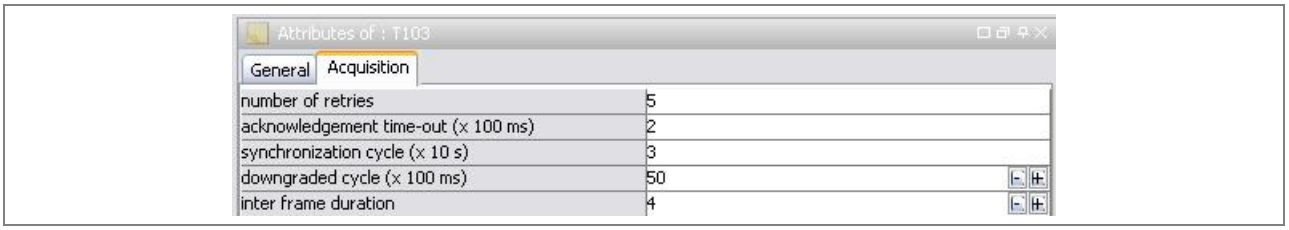


Figure 63: Setting the Acquisition attributes of a T103 legacy network

3.6.1.4 SETTING THE ACQUISITION ATTRIBUTES OF A T101 MASTER LEGACY NETWORK

When adding a T101 master legacy network, set the following attributes (they will be used for all its IEDs):

(1) **number of retries** (range [1, 10]): number of retries of the same frame without IED response that the C26x will send before declaring the IED as disconnected

(2) **station address size** (range [1 byte, 2 bytes]): length of the IED addresses

(3) **ASDU address size** (range [1 byte, 2 bytes]): length of the ASDU

(4) **info address size** (range [1 byte, 3 bytes]): length of the information addresses

(5) **transmission cause size** (range [1 byte, 2 bytes]): length of the transmission cause

(6) **frame length** (range [64 bytes, 255 bytes]): if an IED cannot manage frames with a length above 255, the **frame length** attribute must be set to the length manageable by the IED

(7) **acknowledgement time-out** (range [100 ms, 30 s], step 100 ms): maximum waiting time for an IED answer to a C26x's information request

(8) **synchronization cycle** (range [10 s, 655350 s], step 10 s): time synchronization period of the IED by the C26x

(9) **downgraded cycle** (range [1 s, 10 s], step 100 ms): time interval at which the C26x regularly tries to re-connect to an IED after it has declared it as disconnected

(10) **Type of link** (*Balanced* / *Unbalanced*): In an unbalanced link, only the master (here the C26x) interrogates the IED. In a balanced link, the IED can also interrogate the master (here the C26x) without solicitation.

(11) **test frame time-out** (range [1 s, 255 s], step 1 s): in the case of a 'balanced link' (see attribute **Type of link**), a life message (test frame) is transmitted periodically between C26x and IED. This attribute corresponds to the maximum time allowed to receive this life message, from the C26x's point of view. If no life message is received within this time, the IED is declared disconnected.

(12) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames

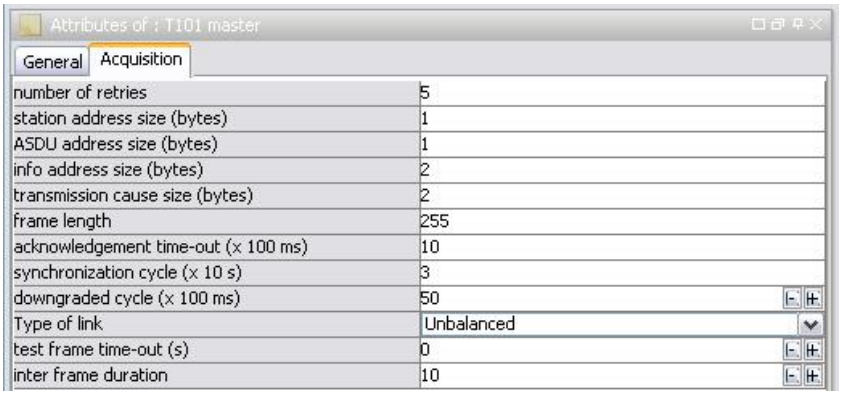


Figure 64: Setting the Acquisition attributes of a T101 master legacy network

Caution:
Add SCADA addresses, otherwise LED12 does not operate correctly

3.6.1.5 SETTING THE ACQUISITION ATTRIBUTES OF A T104 MASTER LEGACY NETWORK

When adding a T104 master legacy network, set the following attributes (they will be used for all its IEDs):

(1) **t0: connection establishment time out (s)** (range [1 s, 255 s], step 1 s): Time-out of connection establishment

(2) **t1: APDUs send or test time out (s)** (range [1 s, 255 s]): Time-out of send or test APDUs

(3) **t2: acknowledges in case of no data time out (s)** (range [1 s, 255 s], step 1 s): Time-out for acknowledges in case of no data messages $t_2 < t_1$

(4) **t3: test frames sending in case of long idle state time out (s)** (range [1 s, 255 s], step 1 s): Time-out for sending test frames in case of a long idle state

(5) **k: window size of transmitted unacknowledged frames** (range [1, 255], step 1): Maximum difference receive sequence number to send state variable

(6) **w: window size of acknowledged received frames** (range [1, 255], step 1): Latest acknowledge after receiving w I format APDUs

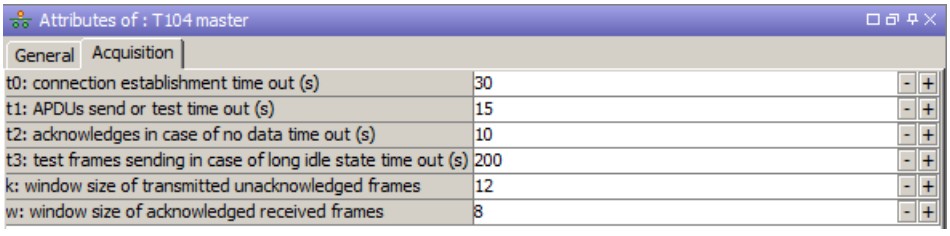


Figure 65: Setting the Acquisition attributes of a T104 master legacy network

Caution:
Add SCADA addresses, otherwise LED12 does not operate correctly

3.6.1.6 SETTING THE ACQUISITION ATTRIBUTES OF A MODBUS LEGACY NETWORK

When adding a Modbus legacy network, set the following attributes (they will be used for all its IEDs):

(1) **number of retries** (range [1, 10], step 1): number of retries of the same frame without IED response that the C26x will send before declaring the IED as disconnected

(2) **acknowledgement time-out** (range [100 ms, 30 s], step 100 ms): waiting time for an IED answer to a C26x's information request

(3) **synchronisation** (*none* / *ALSTOM* / *SEPAM* / *Flexgate*): refer to C26x/EN CT and the reference document of the connected IED

(4) **synchronization cycle** (range [10 s, 655350 s], step 10 s): time synchronization period of the IED by the C26x. Only significant if the attribute **synchronisation** is set to *'ALSTOM'*, *'Flexgate'* or to *'SEPAM'*. To keep a Px4x synchronized, the C26x must send the frame at least every 5 minutes; therefore the value must be lower than 30 in that case.

(5) **downgraded cycle** (range [1 s, 10 s], step 100 ms): time interval at which the C26x regularly tries to re-connect to an IED after it has declared it as disconnected

(6) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames

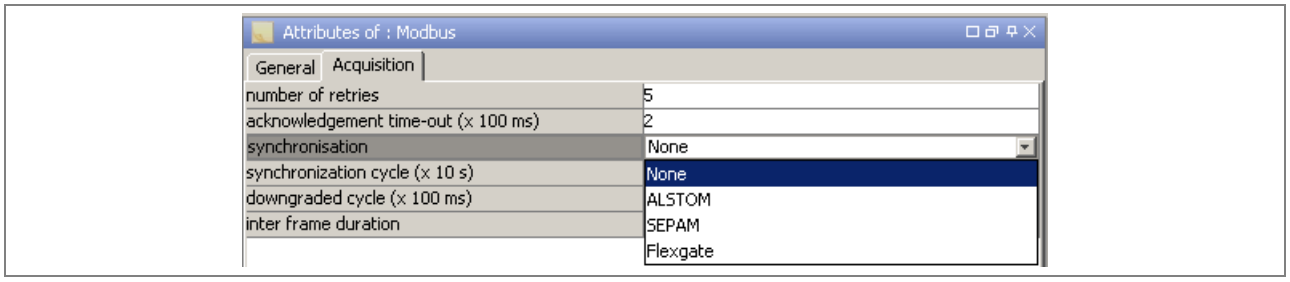


Figure 66: Setting the Acquisition attributes of a Modbus legacy network

3.6.1.7 SETTING THE ACQUISITION ATTRIBUTES OF A DNP3 MASTER LEGACY NETWORK

When adding a DNP3 master legacy network, set the following attributes (they will be used for all its IEDs):

(1) **master address**: C26x address on the DNP3 legacy network

(2) **acknowledgement time-out** (range [100 ms, 30 s], step 100 ms): maximum waiting time for an IED answer to a C26x's information request

(3) **number of retries** (range [1, 10], step 1): corresponds to the number of tries of the same frame without IED response, C26x sends it before setting it disconnected

(4) **application time-out** (range [0 s, 255 s], step 1 s): time-out used by the C26x, at application layer of DNP3 protocol

(5) **class 0 polling period** (range [0 s, 3600 s], step 1 s): transmission interval of the general interrogation message. If this attribute is set to *0*, no general interrogation message is transmitted

(6) **synchronization cycle** (range [10 s, 655350 s], step 10 s): time synchronization period of the IED by the C26x

(7) **downgraded cycle** (range [1 s, 10 s], step 100 ms): time interval at which the C26x regularly tries to re-connect to an IED after it has declared it as disconnected

(8) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames

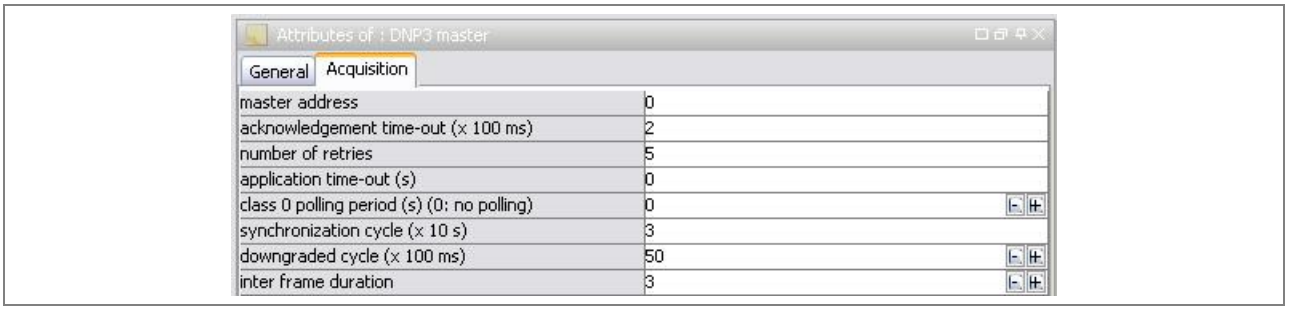


Figure 67: Setting the Acquisition attributes of a DNP3 legacy network

3.6.1.8 ADDING AN IED TO A LEGACY NETWORK

To create an IED on a legacy network:

1 Select the **Legacy networks** level and add an IED from the contextual **Objects entry** window.

2 Update the IED attributes relevant to its protocol characteristics

3 For DNP3, T103, or Modbus IEDs, update the **has for acquisition profile** relation with a previously created IED acquisition type

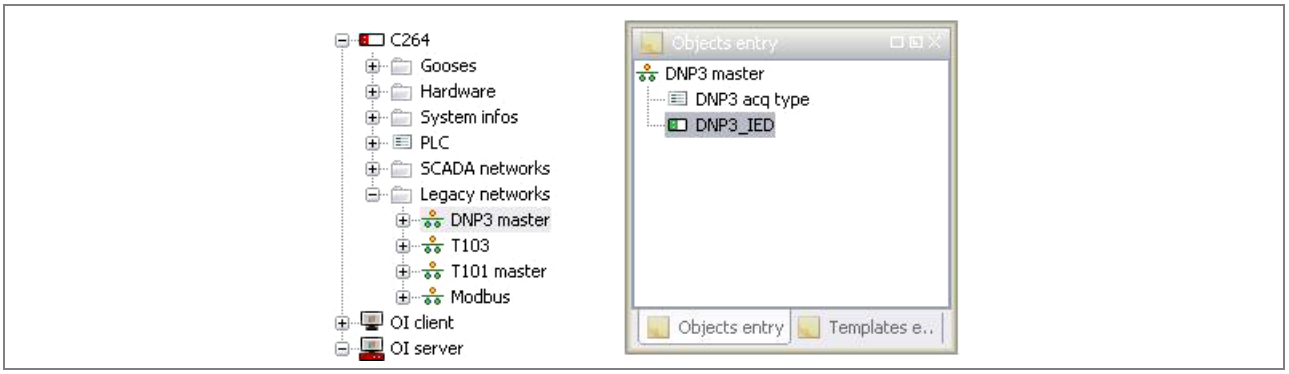


Figure 68: Adding an IED to a legacy network

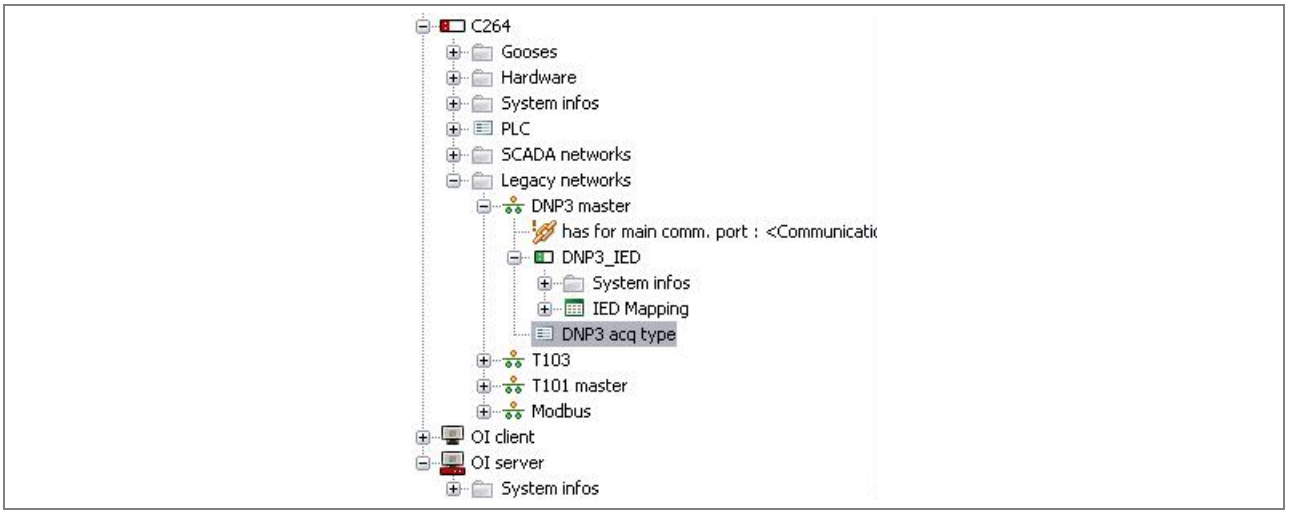


Figure 69: Linking an IED acquisition profile to an IED

3.6.1.9 SETTING THE ATTRIBUTES OF A LEGACY IED

Whatever the type of IED, the attributes below must be updated.

For Serial networks (DNP3, Modbus, T101 and T103):

(1) **short name** and **long name**: used for correct logging and alarm discrimination of IED status datapoint.

(2) **network address** of the IED on the legacy network (4-byte address).

(3) **automatic disturbance** (*No* / *Yes*) - not available for DNP3 IEDs.

(4) **localisation for disturbance file** (non-significant for DNP3 IED): used by the SMT to name the uploaded file on the OWS hard disk: <localisation>_N#.

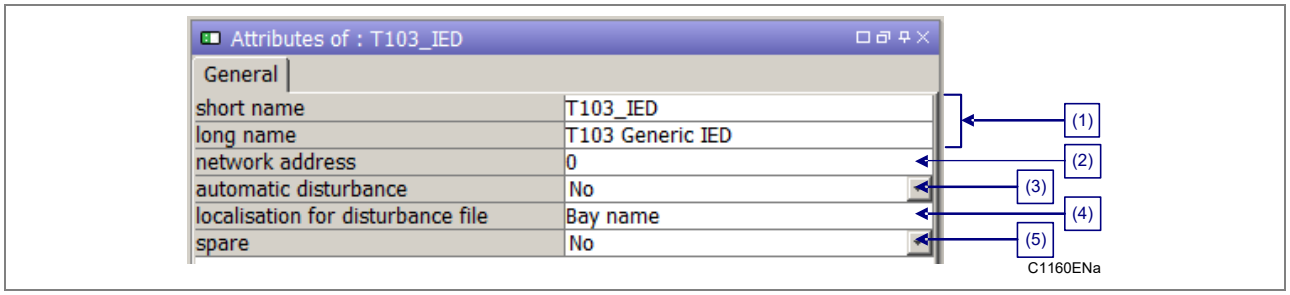


Figure 70: Setting the general attributes of a Serial legacy IED

For Ethernet networks (T104):

(1) **short name** and **long name**: used for correct logging and alarm discrimination of IED status datapoint.

(2) **network address** of the IED on the legacy network (4-byte address).

(3) **IP address**: IP address of the IED on the T104 master network, used by the C26x to establish TCP communications with the IED.

(4) **common address of ASDU**: Reserved for future use.

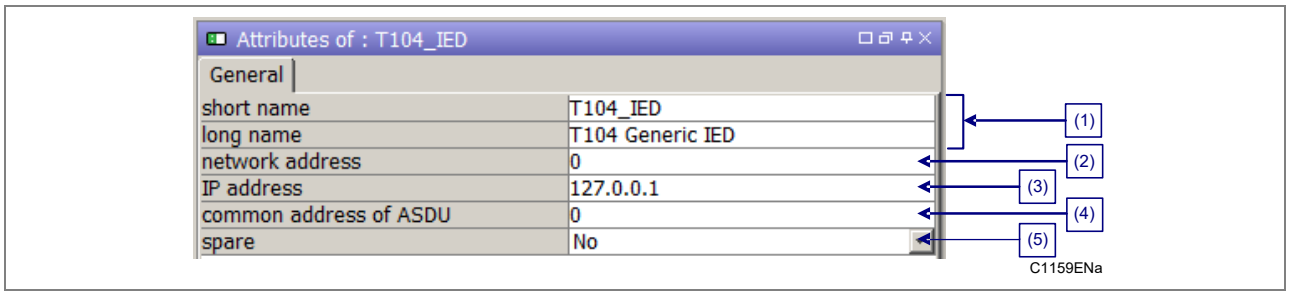


Figure 71: Setting the general attributes of an Ethernet legacy IED

Configuration rules and checks

- The settings for the **network address** and **short name** attributes of each IED must be unique within a Legacy Network.

3.6.1.10 ADDING AN IED ACQUISITION TYPE TO A LEGACY NETWORK

Common acquisition and communication characteristics are shared by IEDs. These characteristics are grouped in an object called **IED acquisition type**, similar to an acquisition profile. It is available for the DNP3, T103 and Modbus protocols.

To create an IED acquisition type on a legacy network:

1 Select the **Legacy networks** level and add an IED acquisition from the contextual **Objects entry** windows.

2 Update the IED acquisition type attributes relevant to its protocol characteristics.

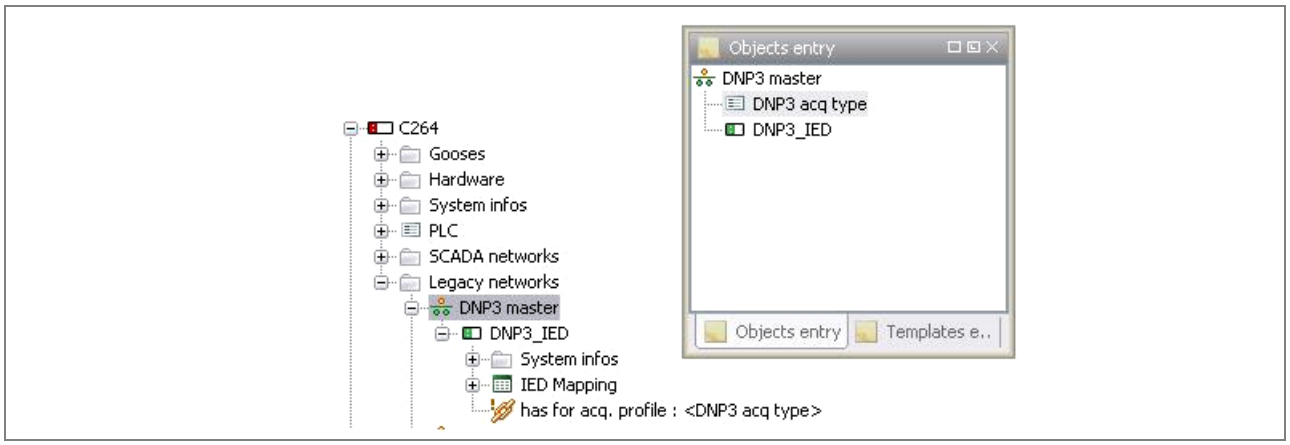


Figure 72: Adding an IED acquisition type to a legacy network (example for DNP3)

Configuration rules and checks

- For each C26x and all its Legacy Networks, the maximum number of "xxx acq type" components is **10**.

3.6.1.11 SETTING THE ATTRIBUTES OF A T103 ACQUISITION TYPE

When adding a T103 acquisition type, set the following attributes (they will be used for all its associated IEDs):

(1) **IED type** (*T103 standard IED* / *(Schneider) Px3x Series* / *(Schneider) Px2x Series* / *REG-D* / *Tapcon 240*)

(2) **function type** (range [0, 255]: function type number used for acquisition: see IED documentation to correctly set this attribute

(3) **general interrogation period** (range [0, 24 h], step 1 s): cycle used to regularly retrieve states and measurements from IED and to avoid losing event information

(4) **MV reduction coefficient** (*1.2* / *2.4*): used for scaling (ASDU 3 usage): refer to T103 documentation for details about this scaling

(5) Four **sets** of three **nominal values** (voltage, current and frequency) used for scaling. Refer to International Standard IEC 60870-5-103 for details about this scaling.

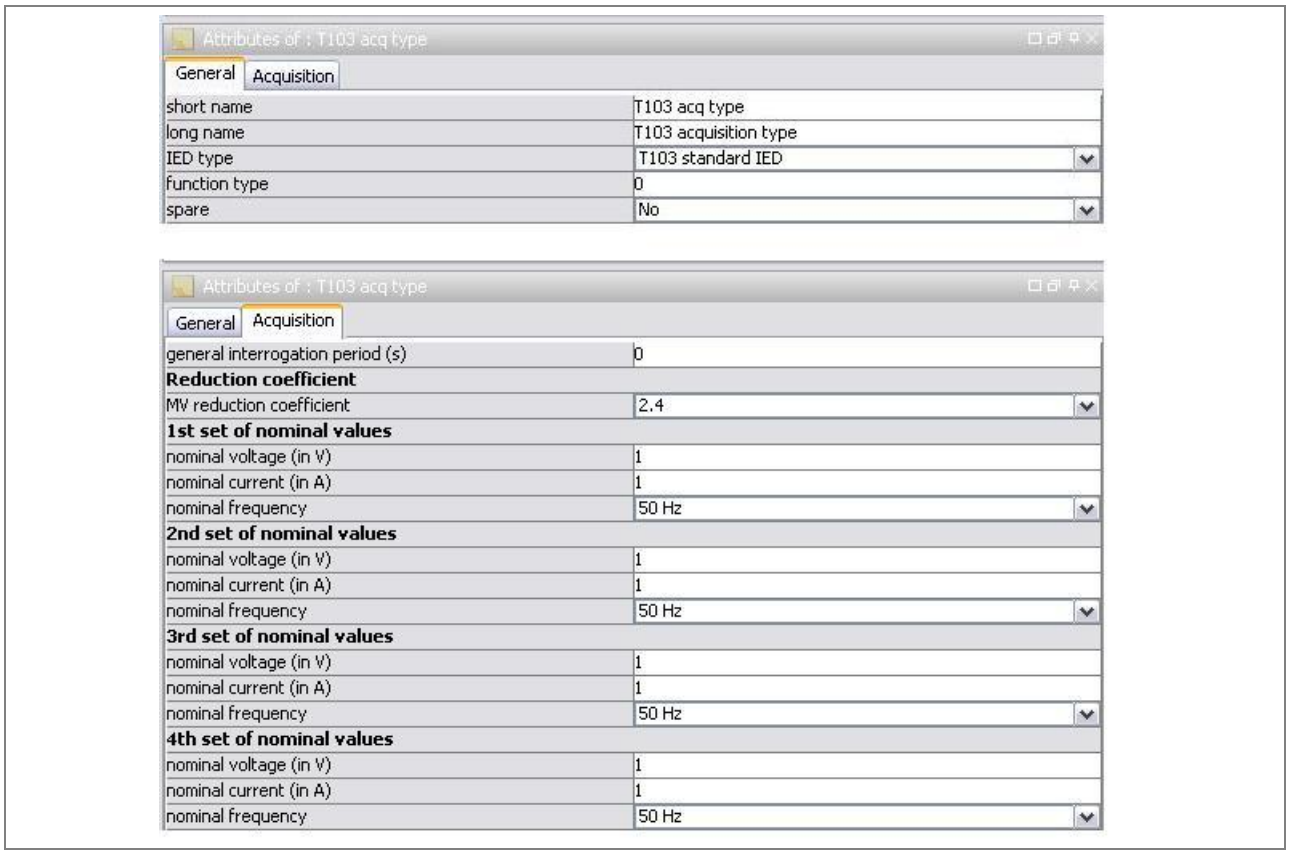


Figure 73: Setting the attributes of a T103 acquisition type

3.6.1.12 SETTING THE ATTRIBUTES OF A MODBUS ACQUISITION TYPE

When adding a Modbus acquisition type, the following attributes, available for all its linked IEDs, must be updated:

(1) **IED type**:

- Modicon to use the generic Modbus communications (refer to C26x/EN CT)
- M300, Px2x series, MiCOM Alstom S40 (MiCOM Modbus communications)
- M230, Wago, Rish Pro M10, ABB Flexgate, SEPAM (specific Modbus communications)

(2) **MODBUS function** (1 / 2 / 3 / 4 / 7 / 8): function number used for the polling frame: When testing the IED connection, this attribute indicates which Modbus function is used. For GE Grid Solutions IEDs, the function 7 is generally used.

(3) **mapping address** (range [0, 2^{32}-1]): associated with attribute (2), it indicates which start address is used to test the IED connection

- if **MODBUS function** is set to 1 or 2 this attribute defines a bit address
- if **MODBUS function** is set to 3 or 4 this attribute defines a word address
- if **MODBUS function** is set to 7 this attribute is not significant
- if **MODBUS function** is set to 8 this attribute defines a sub-code

(4) **size to read** (range [0, 2048]: associated with attribute (3), it indicates which length of frame is used to test the IED connection.

- if **MODBUS function** is set to 1 or 2 this attribute defines a number of bits
- if **MODBUS function** is set to 3 or 4 this attribute defines a number of words
- if **MODBUS function** is set to 7 or 8 this attribute is not significant

(5) **data frame length** (range [2 bytes, 256 bytes]): if an IED cannot manage frames longer than 256 bytes, this attribute must be set to the length manageable by the IED.

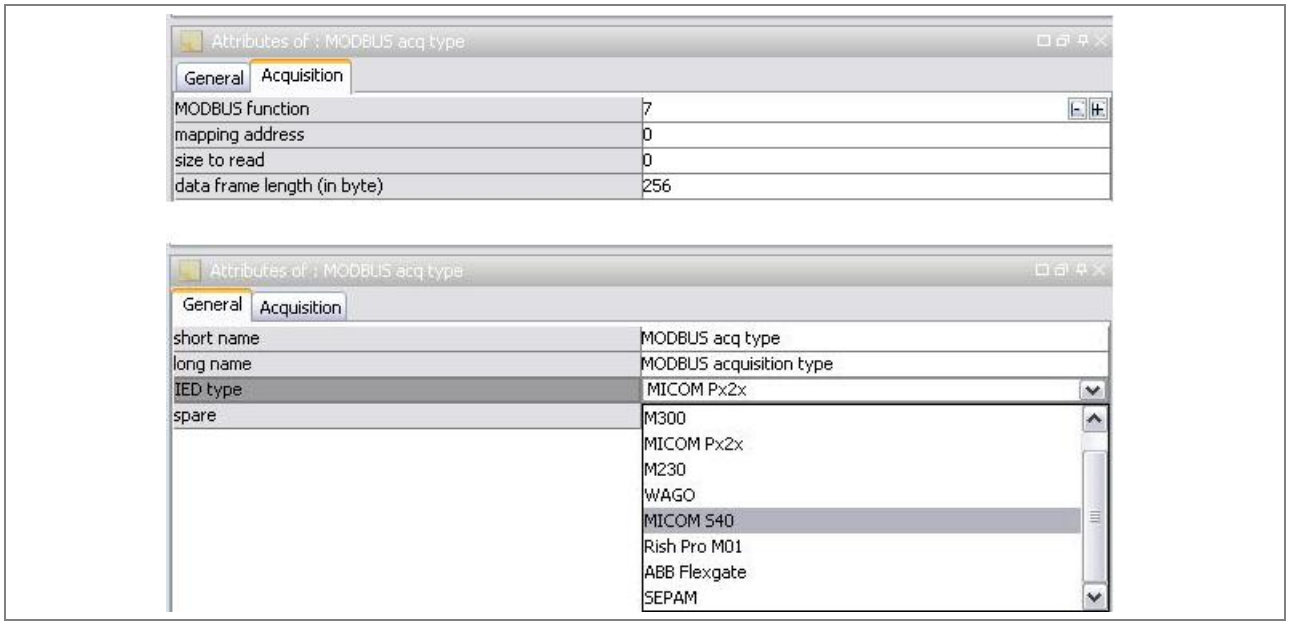


Figure 74: Setting the attributes of a Modbus acquisition type

3.6.1.13 SETTING THE ATTRIBUTES OF A DNP3 ACQUISITION TYPE

When adding a DNP3 acquisition type, some attributes available for all its linked IEDs must be updated:

(1) **global class usage** (*No* / *Yes*): used for addressing. Not yet implemented. Always considered as 'yes' at C26x level.

(2) **synchronisation type** (*Network synchronisation* / *External synchronisation*): in case of network' synchronization, C26x synchronizes the time of the IED, otherwise the synchronization is assumed independently by an external equipment directly connected to the IED. Not yet implemented. Always considered as *'Network synchronisation'* at C26x level.

(3) **CROB parameters** (*Usage of 'code' field* / *Usage of 'Trip/Close' field* / *Usage of 'code' and 'trip/close' fields*):

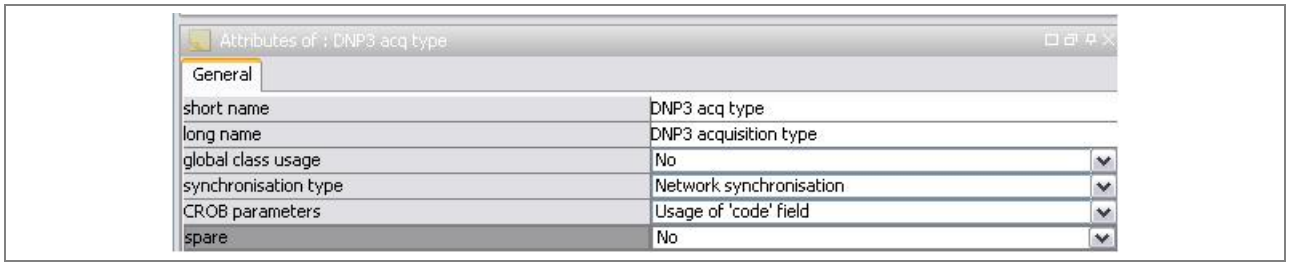


Figure 75: Setting the attributes of a DNP3 acquisition type

3.6.1.14 SERIAL TUNNELING

Caution:
Do not use serial tunnelling with system version 6.1.0.

3.6.2 DEFINING THE ADDRESS MAP OF A LEGACY IED

To transmit information between IEDs and the DS Agile system, an IED legacy network connected to a DS Agile C26x is used.

In order for information to be exchanged between a legacy IED and the DS Agile system, each relevant data must have a specific address on the legacy network that must be compliant with its protocol. General modeling of legacy network address mapping can be done. At SCE level, an IED of a legacy network owns an “IED mapping” object, that is split in categories of mapping on a per datapoint type basis. In each category of mapping, elementary IED addresses can be created. For information on datapoints, see section *4 Defining a datapoint*. This mapping is implicitly created when an IED is added at the legacy network level. It is not possible to address an MPS datapoint on a legacy IED.

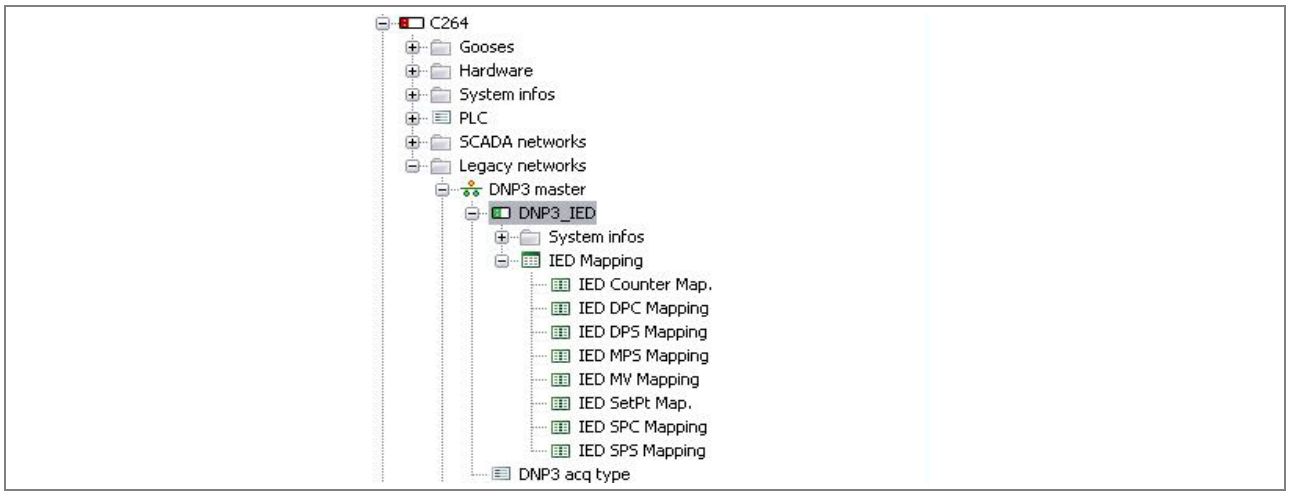


Figure 76: Address mapping structure for a legacy IED (example for a DNP3 IED)

For details about address mapping of a given IED on a specific protocol, refer to the protection IED documentation.

Configuration rules and checks

In the IED Mapping, the address identification of each "xxx addr. on IED" must be unique.

- DNP3: The address identifier is given by the attribute "address" of "xxx addr. on IED".
- MODBUS: The address identifier is made of the following combination of its attribute values:
  - {**mapping address** , **function**}
- T103: The address identifier is made of either of the following combinations of its attribute values:
  - {**ASDU number**, **function type**, **information number**, **common address of ASDU**}
  - {**ASDU number** , **function type** , **information number**}
- T101: The address identifier is made of the following combination of its attribute values:
  - {**information object address**}

There are two ways to map the datapoints

- Set the attributes of the subnodes of the various IED xxx Mapping folders
- To save time, especially after a file import from MS Excel, use in the Wiring editor's smart table, linking the individual tables to the hierarchy

3.6.2.1 SMART TABLE

Select a node <protocol name>_IED in the browser as shown in the screenshot below.

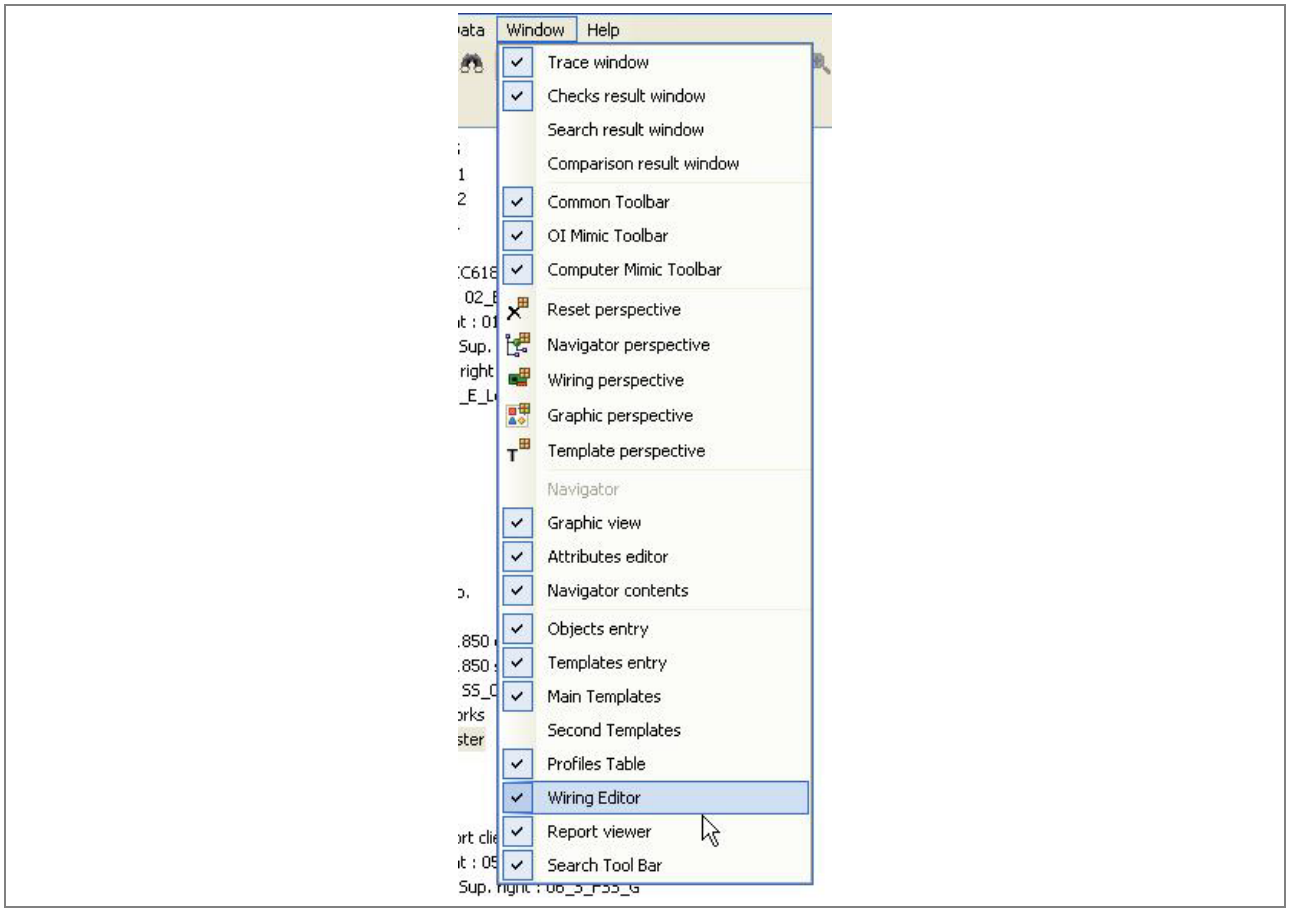


Figure 77: Wiring editor selection

Select **Wiring editor** in the **Window** menu. If it is grayed out, click the **Wiring** button in the lower area. If that button is not present, click the button **Reset perspective** in the toolbar. The window **Wiring: …** is displayed. It allows to enter all datapoint addresses for the IED mapping. The datapoints are tabbed by type; there are 5 types:

- xPS for SPS / DPS addresses
- xPC for SPC / DPC addresses
- MV for measurement addresses
- SetPoint for SetPoint addresses
- Counter for Counter addresses

Each tab contains a table featuring:

- on the left hand side (white background), the variants (pictogram) and the attributes needed for address uniqueness (they depend on the protocol, see sections *3.6.2.2 to 3.6.2.8*); copy/paste is enabled
  - in the middle, other attributes (**Contact**, **Label**); copy/paste is enabled
  - on the right hand side (blue background), other attributes (**path**, **short name**, **meaning**, **profile**, **long name**)

To adjust a column width, move the cursor over the border in the header until the cursor becomes ↔; then "drag and drop".

If the table is empty, click **Insert** in the upper left corner; this creates a row with **Addr** at *0*.

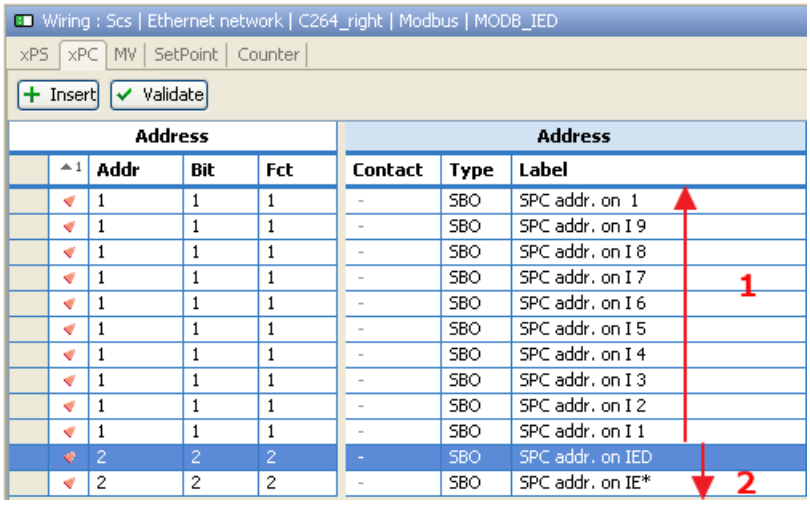
To populate the table with default values, select one or several contiguous rows, then:

- click **Insert**; this adds as many rows below with the same **Addr**; this copies the DEFAULT values as **Address** attributes and duplicates the path

Note:
The Label field is automatically filled in various ways; in the picture, the first created row is in blue

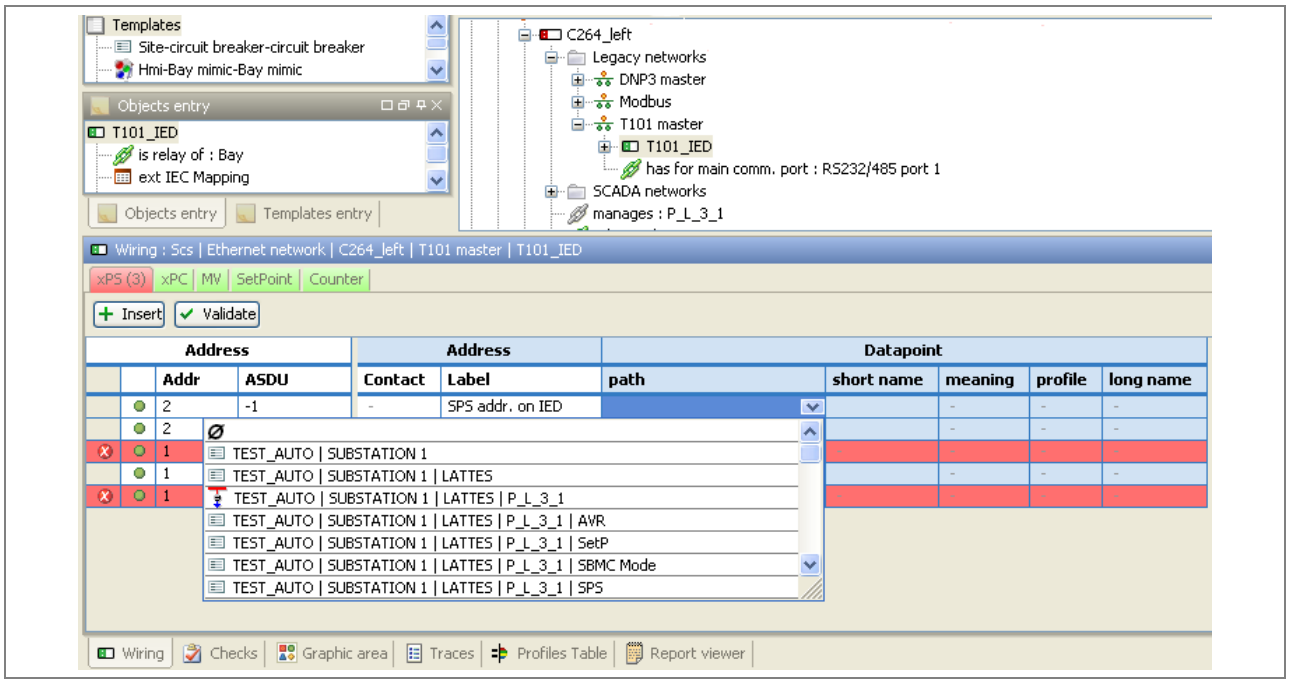
1: no row selection (click the sub-header to deselect): the rows pile up; the last characters are replaced by digits and incremented

2: the row is selected: the Label last character is incremented if it is a digit, replaced with * if it is a letter



Procedure to fill in the blue part

- Click in a cell to fill in
- Type one character or click two more times; click the bottom arrow button v overlaid at the right of the cell and select one value in the drop-down list (it contains all the created datapoint values); ∅ refers to a void value; the type can be changed in this manner.



- To check the address uniqueness, click **Validate** in the upper left corner:
  - The errored lines turn red and a red pictogram is displayed in the first column
  - If there are errors, the tab tag becomes red and indicates the number of errored lines. To display a tooltip, move the cursor over a red line:

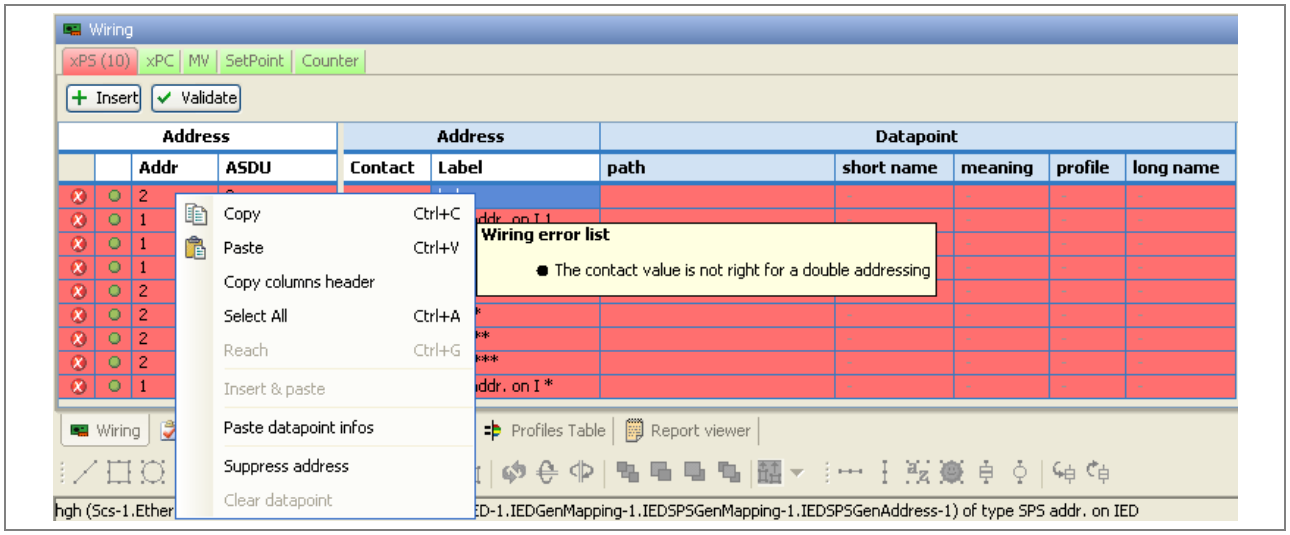
Possible errors

- An address is not unique in the mapping
- A datapoint has more than one acquisition source
- An address is 0 (invalid)
- The **Contact** attribute for a DPS/DPC address does not have the correct value. If one DPS/DPC uses 2 addresses, the **Contact** value must be *Open* for one address and *Close* for the other.

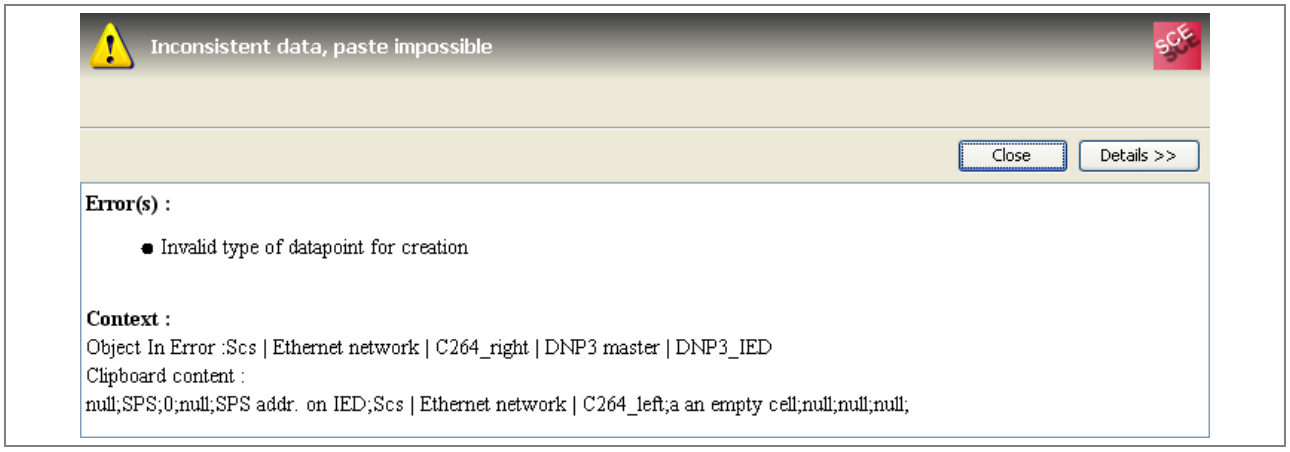
Only the address attributes can be edited in errored lines.

The tag tab becomes green again when all the errors have been corrected.

- To delete a set of addresses in contiguous rows, click on the first column and drag to select the rows, right click and select **Suppress address.**



- To sort the rows alphabetically/numerically, click on any column sub-header once (ascending order, symbol ▲1 after the column label) or twice (descending order, symbol ▼1)
- To export the table into a spreadsheet editor such as Excel, select the rows and copy/paste them; the empty cells are filled with the word 'null' (for the headers, use the menu item **Copy columns header**)
- To import a table from a spreadsheet editor such as Excel, select and copy the rows in the editor; select a row in the table, right click and select **Insert & paste**. Restrictions: the source must be free of any information in the blue part, otherwise a message like this pops up:



with three items:

- Error(s): a diagnostic on the possibility of pasting
- Context: the path of the selected IED
- Clipboard content: the values copied from the contiguous columns separated with a semi-colon (an empty cell produces 'null')

- Click the button **x** in the upper right corner: When you resume the procedure, the entered values are retrieved.

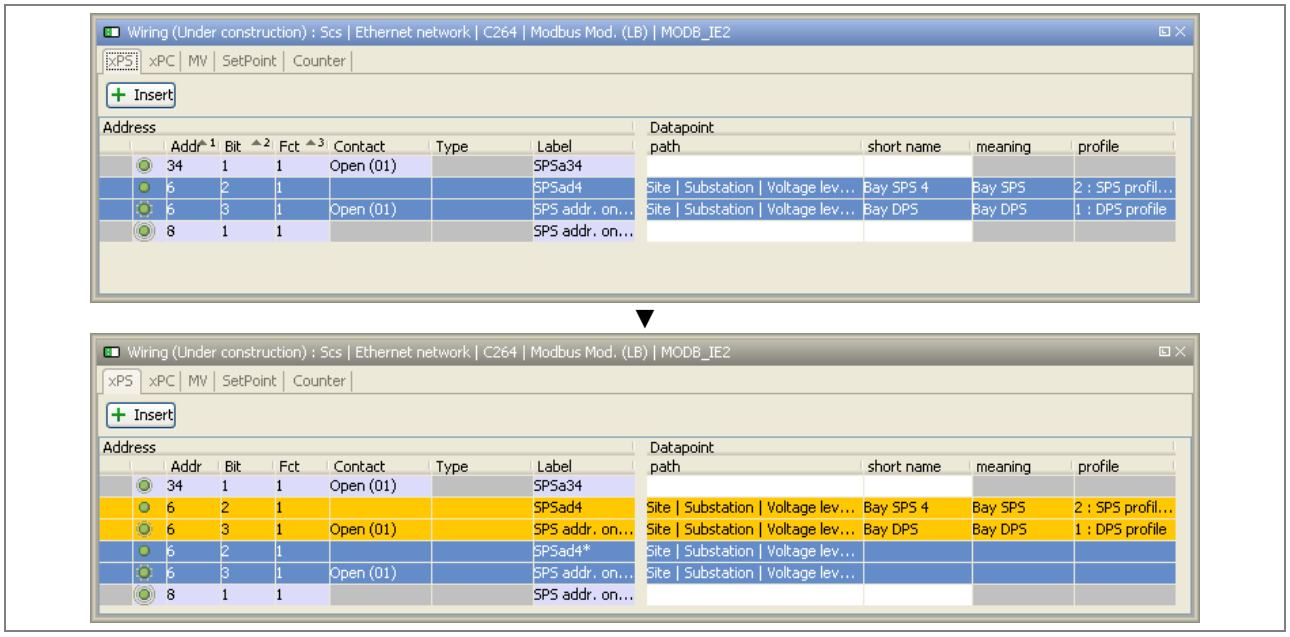
The smart table is flexible and allows a variety of time-saving operations:

3.6.2.1.1 Insert a new address in the address map

Click the button **+ Insert** to insert a new line in the address map:

- If no lines are selected, a new address of the default type is created.
- If one or several lines are selected, the same number of lines of the same types are added to the map and the address information is duplicated as much as possible.

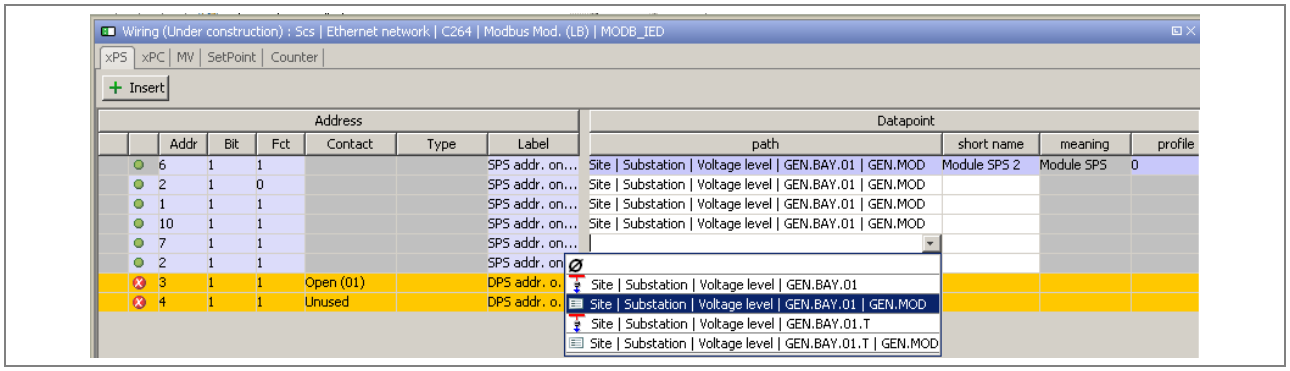
For example, if a DPS address is selected at the time you click **+ Insert**, this will add a DPS address with the same **Address** attribute values. For the **Datapoint** part, only the path is duplicated from the selected lines.



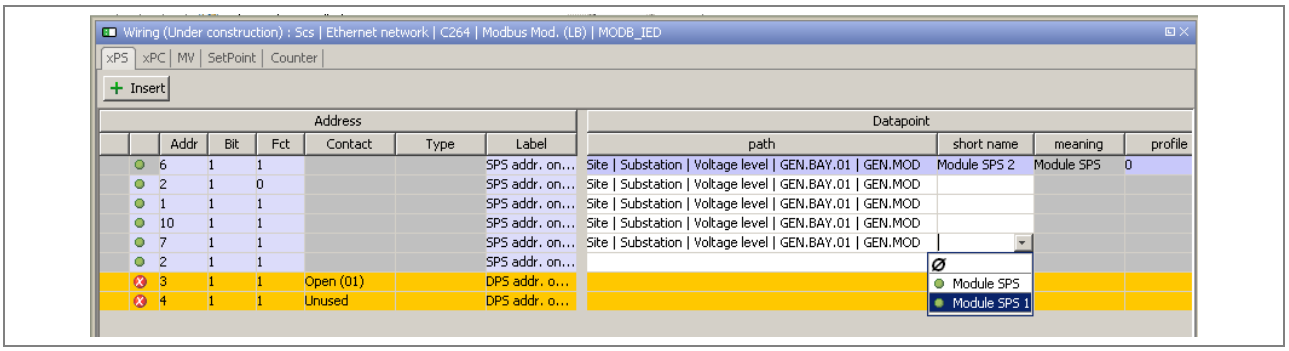
3.6.2.1.2 Edit an existing address in the address map

To set the address of a datapoint in the IED table follow this two steps:

- Select a path

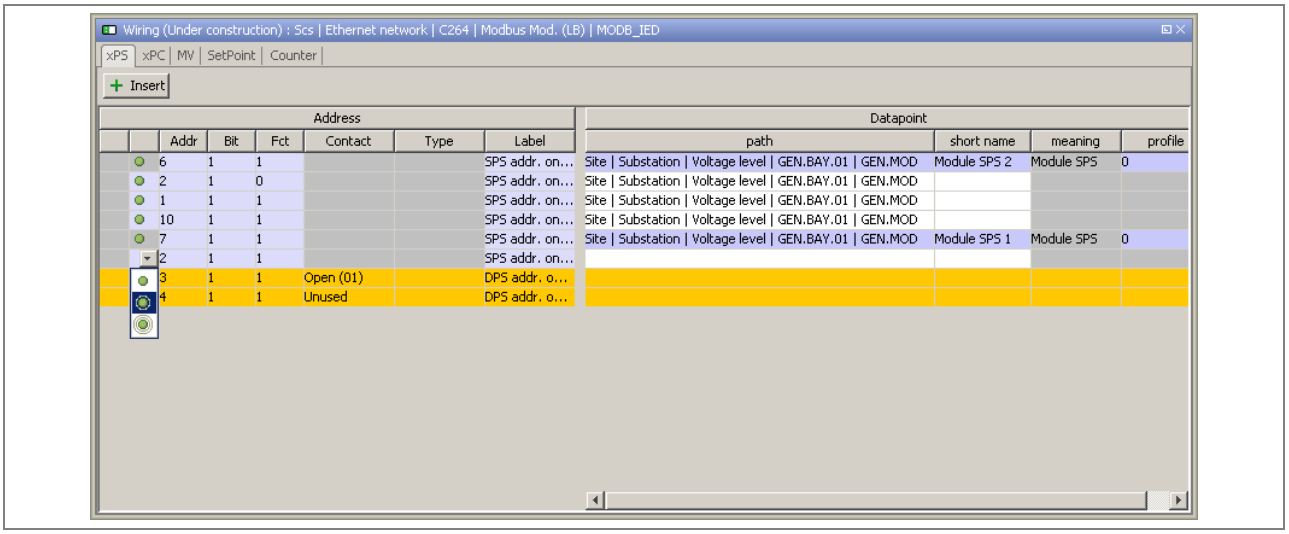


- Select a Short name



3.6.2.1.3 Change the datapoint type of an address

If an address is not used by a datapoint it's possible to change the type of the address, for example user can transform SPS address into a DPS address by changing its datapoint type icon at the beginning of the line. In the example below, SPS address 2/1/1 can be transformed into a DPS or MPS address:



The other values of the address are not updated, only the datapoint type of the address is changed.

3.6.2.1.4 Copy / Insert and Paste

It is possible to insert copied rows into the IED table.

Copy of rows

To copy one or several selected address rows, right-click the left-hand side cell of one of them. Select **Copy**.

The copied rows are stored in the operating system's clipboard. They can then be pasted into an external spreadsheet editor (such as MS Excel). Any empty cells will be filled with the word "null".

Excel offers more cell manipulation features than the SCE smart table editor: cells can be more easily copied, modified or moved around; formulas may be used, etc. However, always make sure that the format remains compatible and to type the word "null" into any empty cells before copy-pasting back into the SCE smart table.

Insert and Paste rows

Assuming the clipboard contains well formed data (such as rows directly copied from the SCE smart table), select the row after which the copied rows must be inserted. Right-click the left-hand side cell of that row. Select **Insert & paste**.

After a paste operation, any unused datapoints and/or addresses are kept and it is up to the user to manually update or remove them.

The behaviour of a row insertion into the IED table is based on the key (address + datapoint) present in that row:

- If the key already exists in the table, the existing address is moved to its new insertion point. Some attributes of the associated address and datapoint may be updated using attribute values from the clipboard if they are different from the original's.
- If the address already exists in the table, but the datapoint does not, a new row is inserted in the table for the address and datapoint from the clipboard, with their clipboard attribute values. The already existing address is set to its default value and its associated datapoint is kept.
- If the datapoint already exists in the table, but the address does not, a new row is inserted in the table for the address and datapoint from the clipboard, with their clipboard attribute values. The already existing address row is kept, but without datapoint.
- If the address of a datapoint is assigned another datapoint, the previous datapoint is kept with a default address, but the other address attributes remain unchanged.
- If neither the address nor the datapoint already exist in the table, a new row is inserted in the table for the address and datapoint from the clipboard, with their clipboard attribute values.

When inserting and pasting from clipboard, the user may refer to datapoints that no longer exist in the database. In that case, they are automatically created upon insertion.

The insert and paste operation is disabled for template instances or cloned IEDs.

Possible errors on Insert & Paste operations

The error mechanism is the same as for the other mapping tables.

General errors:

- The clipboard structure is invalid

Address errors:

- The address type is invalid
- The address for 'xxx address on IED' is not unique in the address map
- Updating mapping address attributes is not permitted
- The map address is an instance/clone of a template, but the mapped object is not

Datapoint errors:

- Creation of an invalid type of datapoint
- It is impossible to create a datapoint under the path object
- The path is invalid for this mapping
- The datapoint mapping relations do not comply with the relations from the clipboard
- The datapoint has several acquisition sources
- The contact value is not permitted for a double addressing
- The datapoint profile is a read-only attribute
- The datapoint mapping relations are read-only

3.6.2.1.5 Copy/Paste datapoint information

It is not possible to copy datapoint information cells only in the IED table. Only entire rows can be copied.

Copy action

By row selection, user can copy one or more datapoint information. The result of the copy is stored in the system clipboard that can be pasted into an external editor (like Excel). In this clipboard, empty cells are filled with keyword “null”.

Excel offers more cell manipulation features than the SCE smart table editor: cells can be more easily copied, modified or moved around; formulas may be used, etc. However, always make sure that the format remains compatible and to type the word "null" into any empty cells before copy-pasting back into the SCE smart table.

Paste datapoint information cells

Assuming the clipboard contains well formed data (such as rows directly copied from the SCE smart table), select the row after which the copied rows must be inserted. Right-click the left-hand side cell of that row. Select **Paste datapoint infos**.

The copy-paste operation is disabled for template instances or cloned IEDs.

3.6.2.1.6 Copy/Paste of cells

The copy operation is available for all the cells in the table, but not all of them can be pasted INTO: Pasting is possible only into **Type** and **Label** cells in the **Address** part and into **Path** and **Profile** cells in the **Datapoint** part.

3.6.2.1.7 Deleting a set of IED addresses

By selecting a set of rows, the user can delete one or more addresses via the contextual menu, using the command **Suppress address**.

3.6.2.2 DEFINING A LEGACY IED ADDRESS FOR AN SPS DATAPOINT

To add an IED address to an SPS datapoint, select the IED SPS mapping level and add the address from the contextual **Objects entry** window.

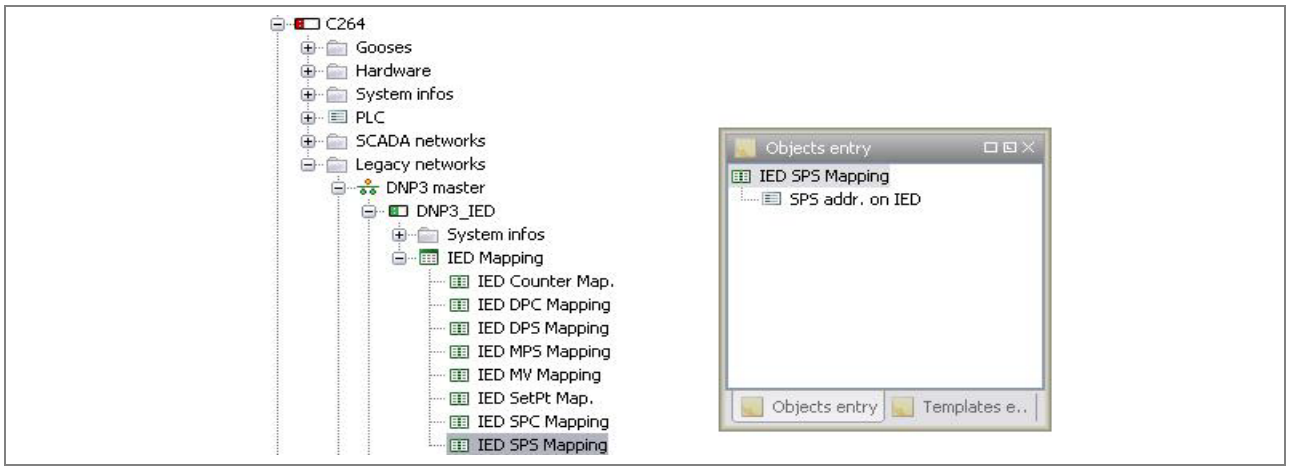


Figure 78: Adding a legacy IED SPS address (example for a DNP3 IED)

Once added, the IED SPS address attributes must be set:

(1) **short name**: used for internal SCE identification

For DNP3 master protocol:

(2) **address** (range [0, 65534], step 1).

For Modbus protocol:

(3) **mapping address** (range [0, 65534], step 1): word address or bit address depending on the function

(4) **bit number** (range [0, 65534], step 1): used only if *read word* or *read status* is selected

(5) **function** (range [0, 65534], step 1): number of the Modbus function used to read the SPS:
- 1, 2: *read bit*,
- 3, 4: *read word*,
- 7 : *read status*

(6) **event - slave number** (range [-1, 99], step 1), -1 = not used

(7) **event - channel number** (range [-1, 999], step 1), -1 = not used

(8) **event - event number 'Change 0 to 1'** (range [-1, 999], step 1), -1 = not used

(9) **event - event number ' Change 1 to 0'** (range [-1, 999], step 1), -1 = not used

For T101 master protocol:

(10) **information object address** (range [0, 16777215], step 1).

(11) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.9 Setting the attributes of a legacy IED*).

For T103 protocol:

(12) **ASDU number** (range [0, 65534], step 1):
- 1, 2 (for all IEDs)
- 65,66,67,68 (Only for Schneider Px3x)

(13) **function type** (range [0, 65534], step 1).

(14) **information number** (range [0, 65534], step 1).

(15) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.9 Setting the attributes of a legacy IED*).

For T104 master protocol:

(16) **information object address** (range [0, 16777215], step 1).

(17) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.9 Setting the attributes of a legacy IED*).

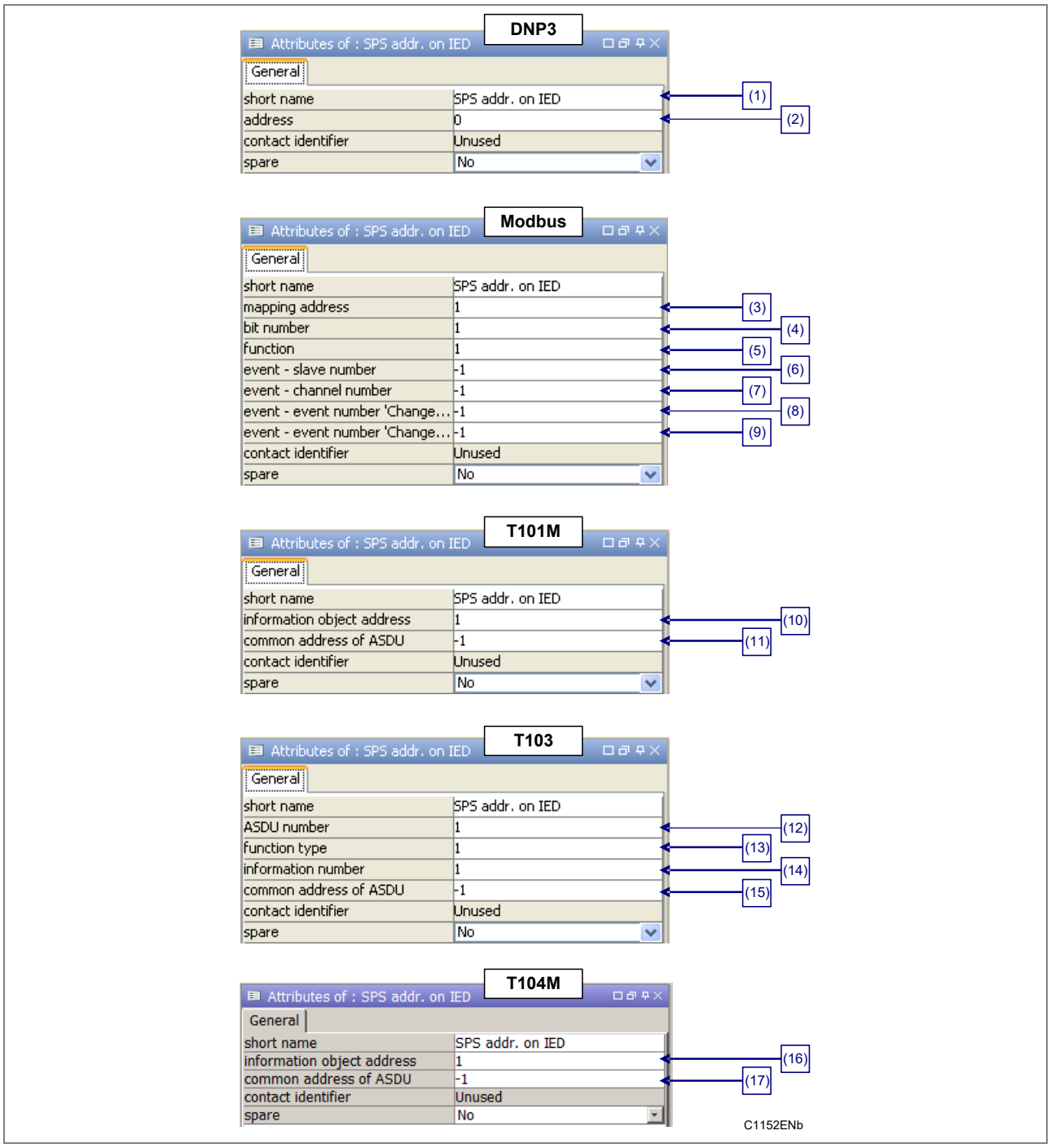


Figure 79: Defining a legacy IED address for an SPS datapoint

3.6.2.3 DEFINING A LEGACY IED ADDRESS FOR A DPS DATAPOINT

To add an IED address to a DPS datapoint, select the IED DPS mapping level and add the address from the contextual **Objects entry** window.

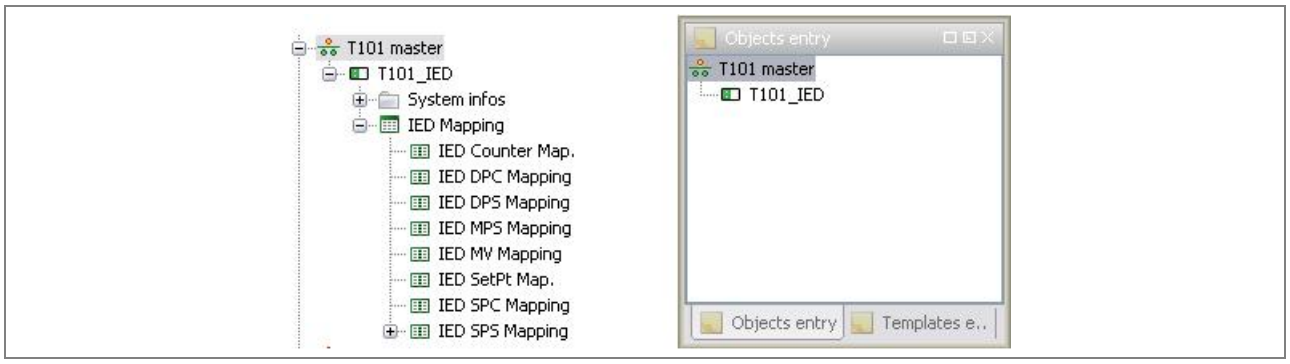


Figure 80: Adding a legacy IED DPS address (example for a T101 IED)

Once added, IED DPS address attributes must be set:

(1) **short name** of the address: used for internal SCE identification

For DNP3 master protocol:

(2) **address** (range [0, 65534], step 1)

For Modbus protocol:

(3) **mapping address** (range [0, 65534], step 1): Word address or Bit address depending on the function

(4) **bit number** (range [0, 65534], step 1): Used only if *read word* or *read status* is used

(5) **function** (range [0, 65534], step 1): Modbus function to use to read the DPS:
- 1, 2: *read bit*
- 3, 4: *read word*
- 7 : *read status*

(6) **event - slave number** (range [-1, 99], step 1), -1 = not used

(7) **event - channel number** (range [-1, 999], step 1), -1 = not used

(8) **event - event number 'Open(10)'** (range [-1, 999], step 1), -1 = not used

(9) **event - event number 'Close(01)'** (range [-1, 999], step 1), -1 = not used

(10) **event - event number 'Start Moving(11)'** (range [-1, 999], step 1), -1 = not used

(11) **event - event number 'Get error status (11)'** (range [-1, 999], step 1), -1 = not used

For T101 master protocol:

(12) **information object address** (range [0, 16777215], step 1)

(13) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.9 Setting the attributes of a legacy IED*)

For T103 protocol:

(14) **ASDU number** (range [0, 65534], step 1):
- 1, 2 (for all IEDs)
- 65,66,67,68 (Only for Schneider Px3x)

(15) **function type** (range [0, 65534], step 1): refer to IED documentation

(16) **information number** (range [0, 65534], step 1): refer to IED documentation

(17) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.9 Setting the attributes of a legacy IED*)

For T104 master protocol:

(18) **information object address** (range [0, 16777215], step 1)

(19) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.9 Setting the attributes of a legacy IED*)

For all protocols:

The acquisition of the DPS on the IED can also be done via two different addresses. In that case, two **DPS address on IED** fields must be created for this DPS. For each of them, the attribute **contact identifier** (20) must be set to *'Open'* or *'Closed'*, to indicate which state of the DPS is assigned to the IED address. If the DPS state is given by only one IED address, set **contact identifier** to *'unused'*.

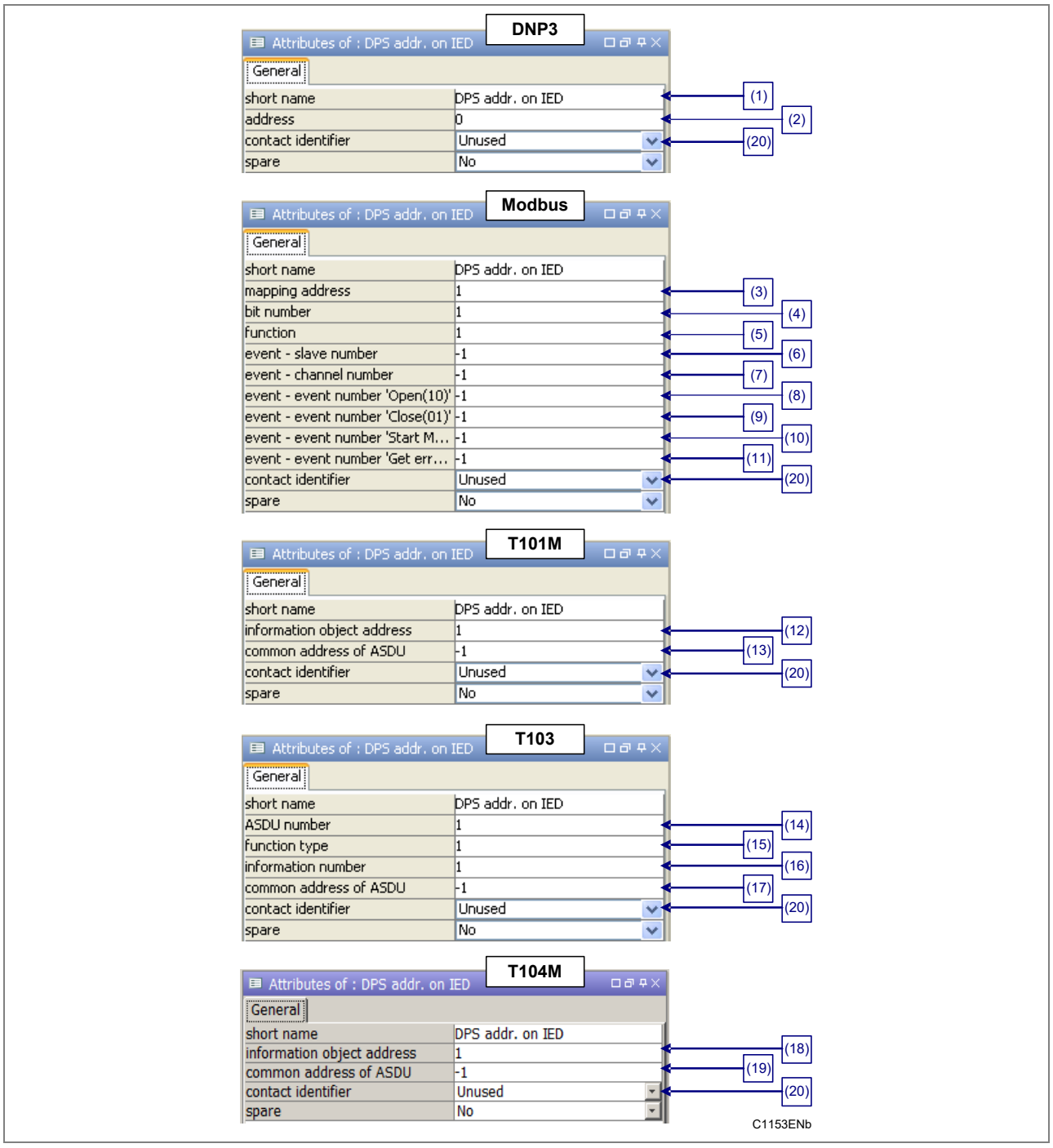


Figure 81: Defining a legacy IED address for a DPS datapoint

3.6.2.4 DEFINING A LEGACY IED ADDRESS FOR AN MV DATAPOINT

To add an IED address to an MV datapoint, select the IED MV mapping level and add the address from the contextual **Objects entry** window.

Once added, the IED MV address attributes must be set:

(1) **short name** of the address: used for internal SCE identification

For DNP3 master protocol:

(2) **address** (range [0, 65534], step 1)

For Modbus protocol:

(3) **mapping address** (range [0, 65534], step 1): Word address

(4) **function** (range [0, 65534], step 1): Modbus function to use to read the MV:
- 3, 4: read word
- 7 : read status

(5) **data format**: see section *3.6.2.4.1 Measurement formats that can be used with the MODBUS protocol*.

For T101 master protocol:

(6) **information object address** (range [0, 16777215], step 1)

(7) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.9 Setting the attributes of a legacy IED*).

(8) **output format** (*Short float*, *Normalized*, *Scaled*)

For T103 protocol:

(9) **ASDU number** (range [0, 65534], step 1):
- 3, 4, 9 (for all IEDs)
- 10 (for acquisition of measurement with "generic Services")
- 77 (Only for Schneider Px2x)
- 73 (Only for Schneider Px3x)

(10) **function type** (range [0, 65534], step 1)

(11) **information number** (range [0, 65534], step 1)

(12) **index in the ASDU** (range [0, 65534], step 1)

(13) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(14) **unit of the MEAS** (*Voltage* / *Current* / *Power* / *Frequency* / *No Unit*)

(15) **substituted if unknown** (*No* / *Yes*)

For this protocol it is possible to perform acquisition of measurements only using the Generic Services of IEC 60870-5-103 protocol by polling. This can be done by setting some parameters as follows:

- ASDU number: 21
- function type: 254
- information number: 244
- index in the ASDU: Generic Identification Number given by the mapping of the IED

For T104 master protocol:

(16) **information object address** (range [0, 16777215], step 1)

(17) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address** (see section *3.6.1.9 Setting the attributes of a legacy IED*).

(18) **output format** (*Short float*, *Normalized*, *Scaled*)

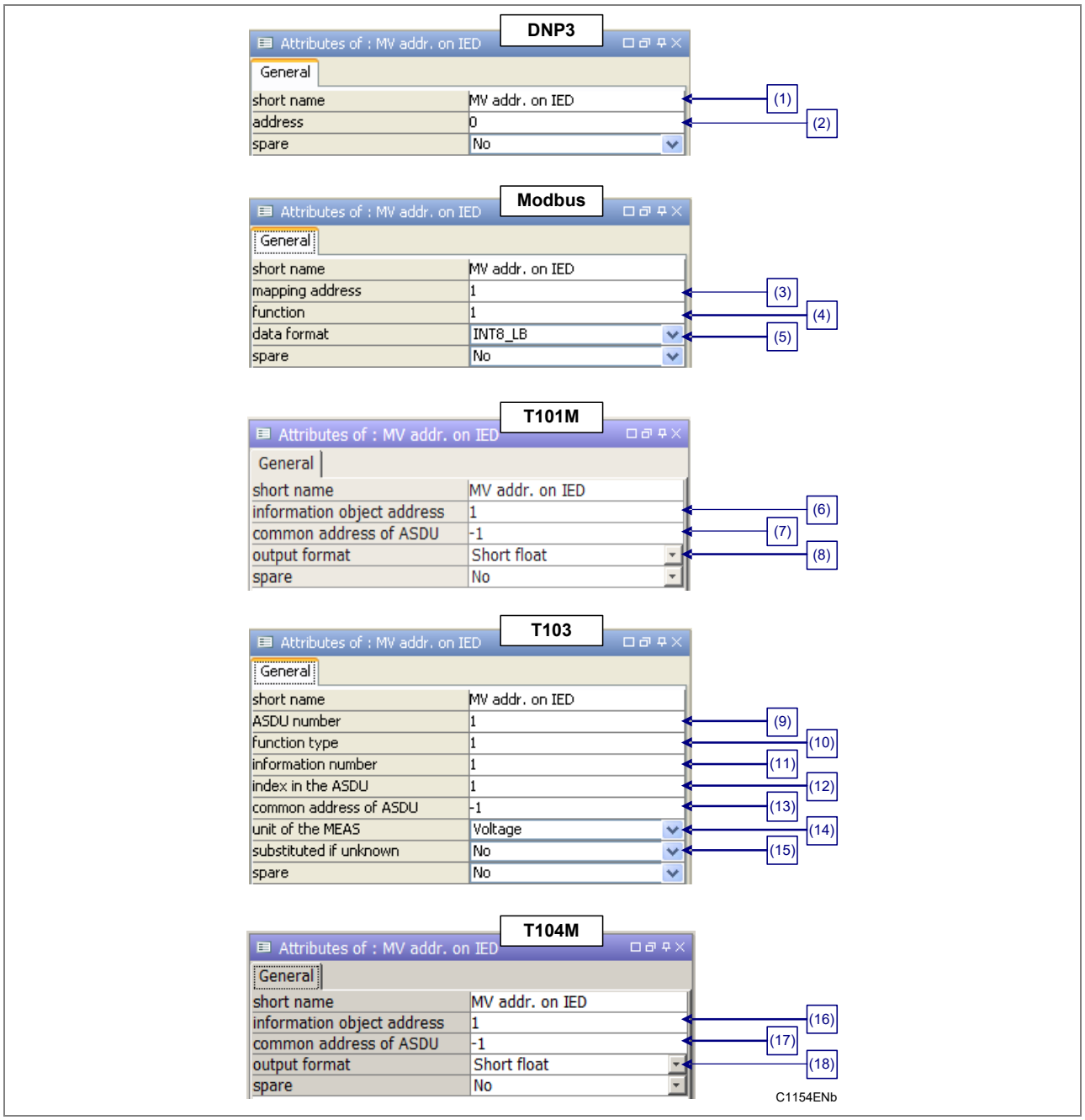


Figure 82: Defining a legacy IED address for an MV datapoint

3.6.2.4.1 Measurement formats that can be used with the MODBUS protocol

Because the Modbus standard only describes the transmission of 16-bit values (transmission of the high order byte first), other formats must be defined to describe the different ways to transmit 32-bit values (whatever their type: signed or unsigned integers, real values) or 8-bit values.

Thus the format to apply to an analog input depends on the way it is transmitted and consequently on the representation of the value in the memory of the device.

In the following table, the “transmission order” column (4) indicates the way a value is transmitted, i.e. the order in which the bytes of the value are transmitted. The bytes are numbered from 1 (lowest order byte) to 4 (highest order byte).

Format	Description	Transmission order
INT8_LB	Transmission of an 8-bit signed integer in a 16-bit value. The significant byte is the low order byte of the word.	/
INT8_HB	Transmission of an 8-bit signed integer in a 16-bit value. The significant byte is the high order byte of the word.	/
UINT8_LB	Transmission of an 8-bit unsigned integer in a 16-bit value. The significant byte is the low order byte of the word.	/
UINT8_HB	Transmission of an 8-bit unsigned integer in a 16-bit value. The significant byte is the high order byte of the word.	/
INT16	Transmission of a 16-bit signed integer. The high order byte is transmitted first (see Modbus standard)	2-1
UINT16	Transmission of a 16-bit unsigned integer. The high order byte is transmitted first (see Modbus standard)	2-1
INT32_LW_LB	Transmission of a 32-bit signed integer. The low order word of the long value is transmitted first. The low order byte of each word is transmitted first.	1-2-3-4
INT32_LW_HB	Transmission of a 32-bit signed integer. The low order word of the long value is transmitted first. The high order byte of each word is transmitted first.	2-1-4-3
INT32_HW_LB	Transmission of a 32-bit signed integer. The high word of the long value is transmitted first. The low byte of each word is transmitted first.	3-4-1-2
INT32_HW_HB	Transmission of a 32-bit signed integer. The high order word of the long value is transmitted first. The high order byte of each word is transmitted first.	4-3-2-1
UINT32_LW_LB	Transmission of a 32-bit unsigned integer. The low order word of the long value is transmitted first. The low order byte of each word is transmitted first.	1-2-3-4
UINT32_LW_HB	Transmission of a 32-bit unsigned integer. The low order word of the long value is transmitted first. The high order byte of each word is transmitted first.	2-1-4-3
UINT32_HW_LB	Transmission of a 32-bit unsigned integer. The high order word of the long value is transmitted first. The low order byte of each word is transmitted first.	3-4-1-2
UINT32_HW_HB	Transmission of a 32-bit unsigned integer. The high order word of the long value is transmitted first. The high order byte of each word is transmitted first.	4-3-2-1
REAL32_LW_LB	Transmission of a 32-bit real value. The low order word is transmitted first. The low order byte of each word is transmitted first.	1-2-3-4
REAL32_LW_HB	Transmission of a 32-bit real value. The low order word is transmitted first. The high order byte of each word is transmitted first.	2-1-4-3

Format	Description	Transmission order
REAL32_HW_LB	Transmission of a 32-bit real value. The high order word is transmitted first. The low order byte of each word is transmitted first.	3-4-1-2
REAL32_HW_HB	Transmission of a 32-bit real value. The high order word is transmitted first. The high order byte of each word is transmitted first.	4-3-2-1
M230_T5_TYPE	Transmission of a 32-bit value: Unsigned Measurement Bit 31 to 24: decimal exponent (signed 8 bytes) Bit 23…00: binary unsigned value 24 bytes	4-3-2-1
M230_T6_TYPE	Transmission of a 32-bit value: Signed Measure Bit 31 to 24: decimal exponent (signed 8 bytes) Bit 23…00: binary signed value 24 bytes	4-3-2-1
M230_T7_TYPE	Transmission of a 32-bit value: power factor Bit 31 to 24 Signed: Import / Export (00/FF) Bit 23…16 Signed: Inductive / capacitive (00/FF) Bit 15…00 Unsigned value (16 bytes)	4-3-2-1
ION_MODULUS_ 10000_unsigned	Transmission of a 32-bit value: ION Energy values Bit 31 to 16: High reg: HR = unsigned value/10000 Bit 15…00: Low reg: LR = unsigned value modulus 10000 Value = RH*10000+LR	4-3-2-1
ION_MODULUS_ 10000_signed	Transmission of a 32-bit value: ION Energy values Bit 31 to 16: reg High: RH= signed value/10000 Bit 15…00: reg Low: RL = signed value modulus 10000 Value = RH*10000+RL; Both high and low reg are signed	4-3-2-1

3.6.2.5 DEFINING A LEGACY IED ADDRESS FOR A COUNTER DATAPOINT

To add an IED address to a Counter datapoint, select the IED Counter mapping level and add the address from the contextual **Objects entry** window.

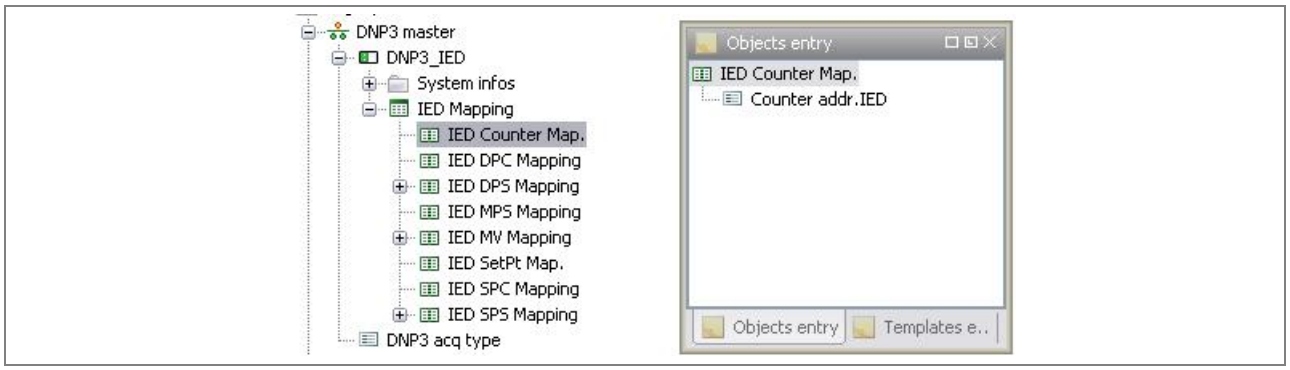


Figure 83: Adding a legacy IED counter address (example for a DNP3 IED)

Once added, an IED Counter address attributes must be set at SCE level:

(1) **short name** of the address: used for internal SCE identification

For DNP3 master protocol:

(2) **address** (range [0, 65534], step 1)

For Modbus protocol:

(3) **mapping address** (range [0, 65534], step 1): word address

(4) **function** (range [0, 65534], step 1): Modbus function used to read the MV:
- 3, 4: read word

(5) **data format**: similar to MV

For T101 master protocol:

(6) **information object address** (range [0, 16777215], step 1)

(7) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(8) **output format** (*Short float* / *Normalized* / *Scaled*)

For T103 protocol:

(9) **ASDU number** (range [0, 65534], step 1)

(10) **function type** (range [0, 65534], step 1)

(11) **information number** (range [0, 65534], step 1)

(12) **index in the ASDU** (range [0, 65534], step 1)

(13) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

For T104 master protocol:

(14) **information object address** (range [0, 16777215], step 1)

(15) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(16) **output format** (*Short float* / *Normalized* / *Scaled*)

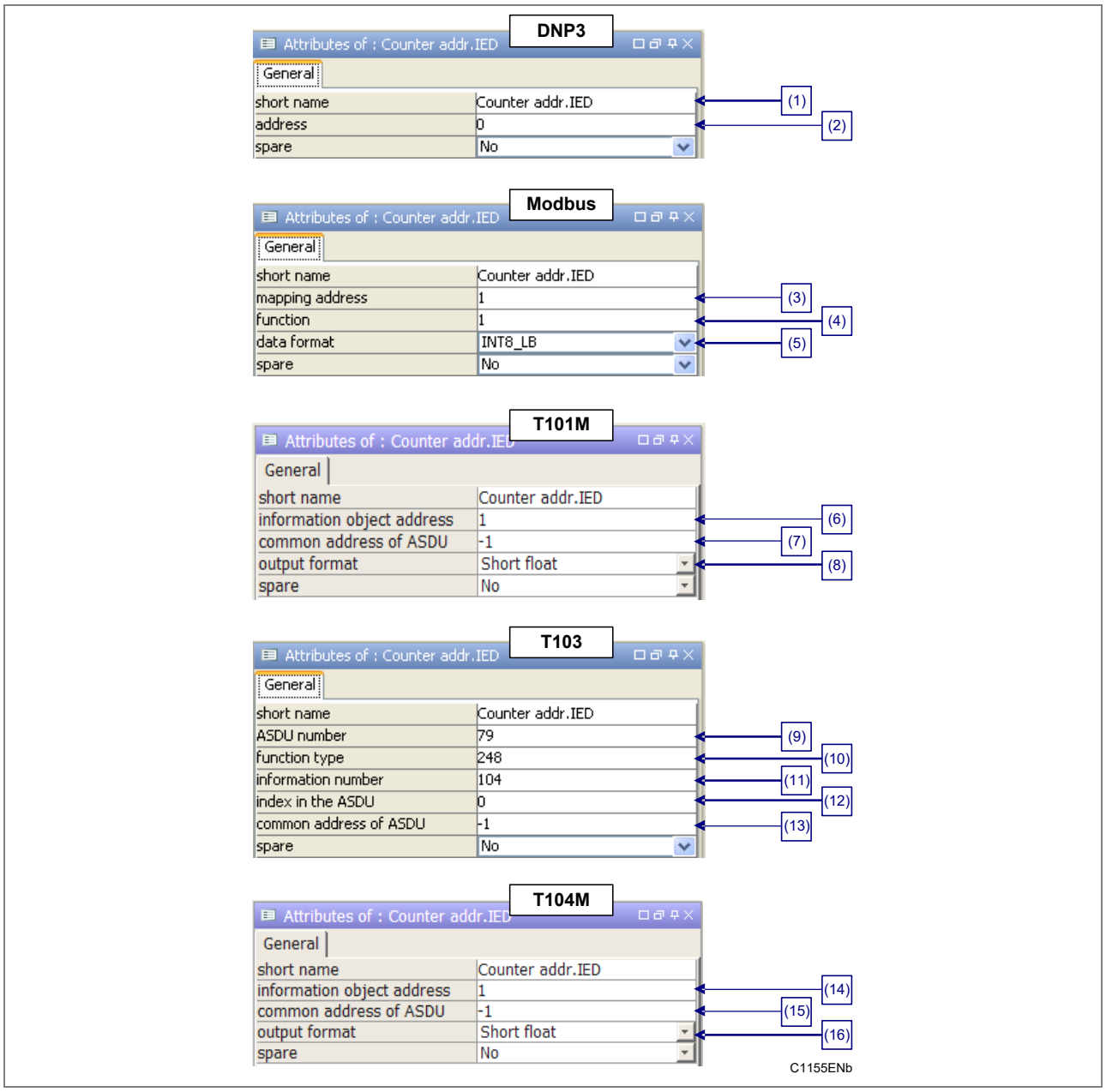


Figure 84: Defining a legacy IED address for a Counter datapoint

3.6.2.6 DEFINING A LEGACY IED ADDRESS FOR AN SPC DATAPOINT

To add an IED address to an SPC datapoint, select the IED SPC mapping level and add the address from the contextual **Objects entry** window.

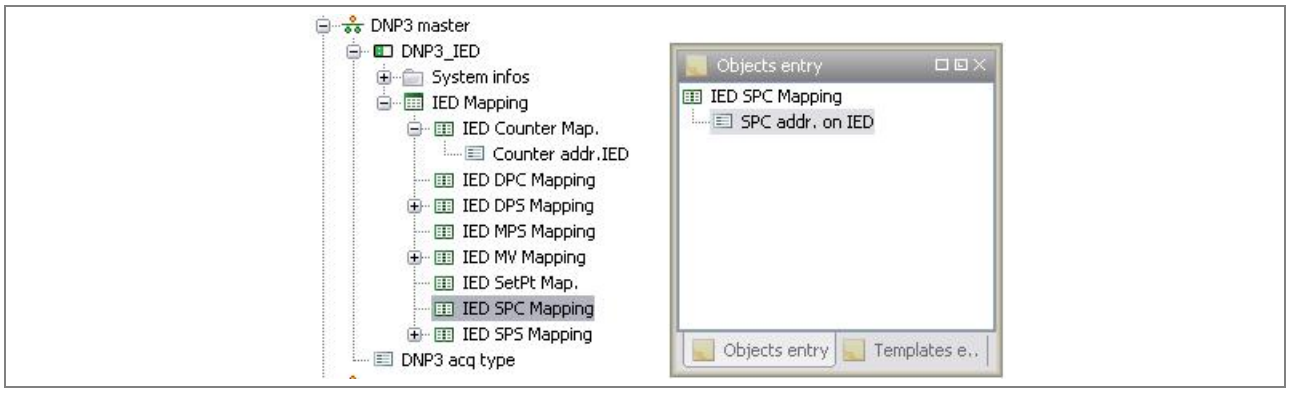


Figure 85: Adding a legacy IED SPC address (example for a DNP3 IED)

Once added, the IED SPC address attributes must be set:

(1) **short name** of the address: used for internal SCE identification

For DNP3 master protocol:

(2) **address** (range [0, 65534], step 1)

For Modbus protocol:

(3) **mapping address** (range [0, 65534], step 1): Bit address for function 5 or 15, Word address for function 6

(4) **bit number** (range [0, 65534], step 1): Used only if Function **6** is used (see function attribute)

(5) **function** (range [0, 65534], step 1): Modbus function to use to send the SPC:
- 5: write 1 bit (**mapping address** is the address of the bit)
- 6: write 1 word (**mapping address** is the address of the word, **bit number** is the position of the bit in the word)
- 15: write N bits (used to set only 1 bit at a time, **mapping address** is the address of the bit)

For T101 master protocol:

(6) **information object address** (range [0, 16777215], step 1)

(7) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

For T103 protocol:

(8) **ASDU number** (range [0, 65534], step 1):
- 20 (for all IEDs)
- 45,46 (Only for Px3x)

(9) **function type** (range [0, 65534], step 1): refer to IED documentation

(10) **information number** (range [0, 65534], step 1): refer to IED documentation

For T104 master protocol:

(11) **information object address** (range [0, 16777215], step 1)

(12) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(13) **command type** (*no information*, i.e. IED-dependant / *short pulse* / *long pulse* / *persistant*): type of command transmission

For all protocols:

(14) **order type** (*SBO* / *Direct execute*)

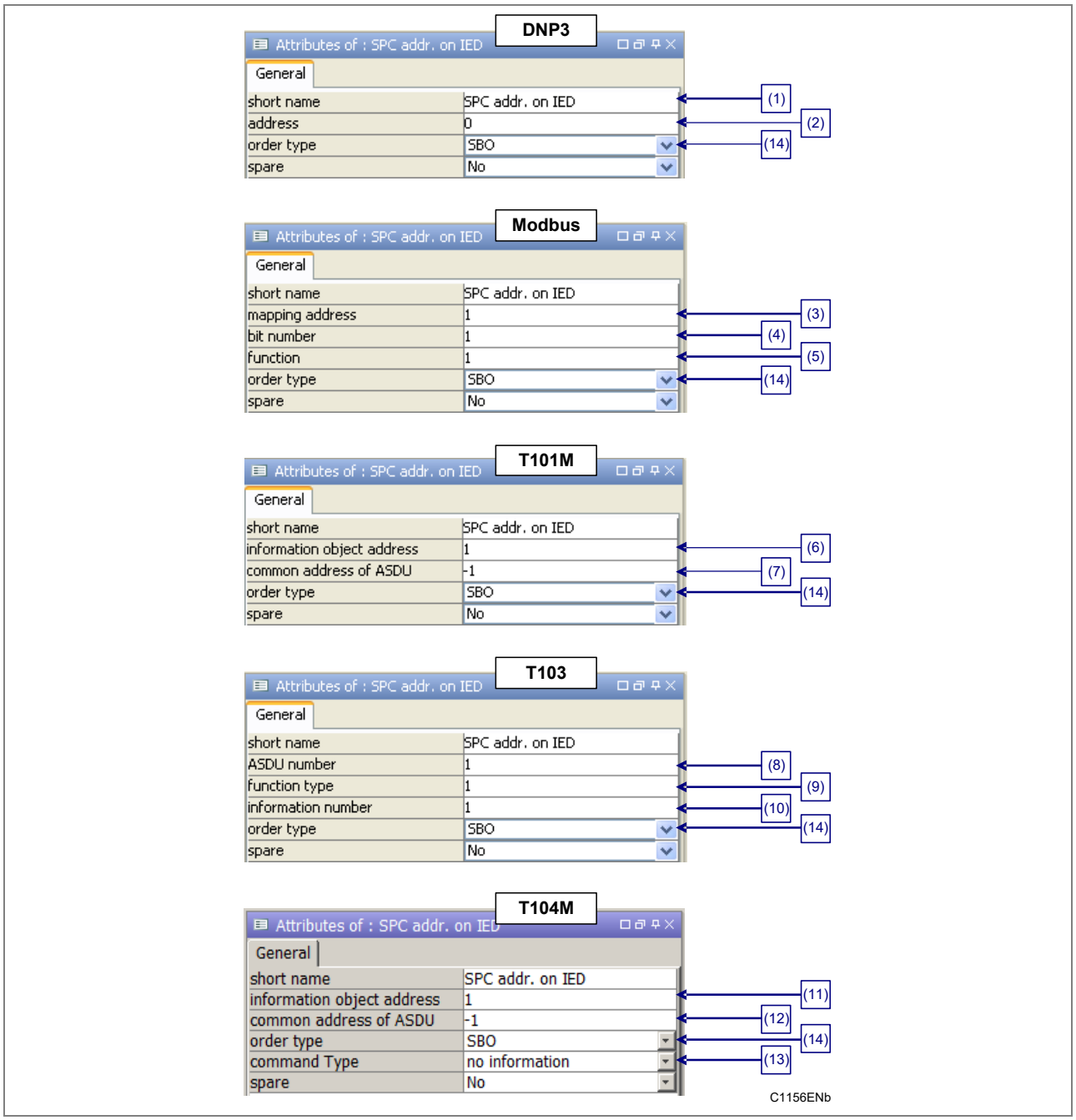


Figure 86: Defining a legacy IED address for an SPC datapoint

3.6.2.7 DEFINING A LEGACY IED ADDRESS FOR A DPC DATAPOINT

To add an IED address to a DPC datapoint, select the IED DPC mapping level and add the address from the contextual **Objects entry** window.

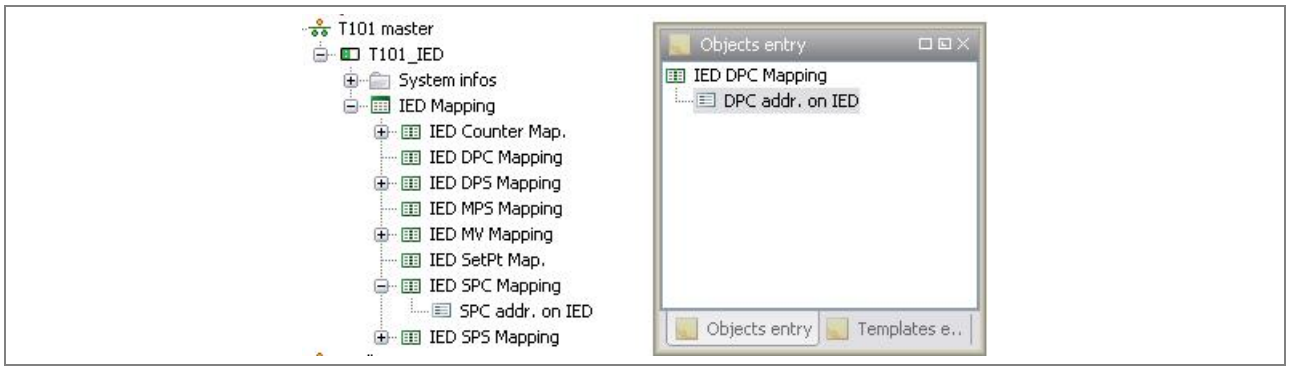


Figure 87: Adding a legacy IED DPC address (example for a T101 IED)

Once added, the IED DPC address attributes must be set:

(1) **short name**: used for internal SCE identification

For DNP3 master protocol:

(2) **address** (range [0, 65534], step 1)

For Modbus protocol:

(3) **mapping address** (range [0, 65534], step 1): Bit address for function 5 or 15, Word address for function 6

(4) **bit number** (range [0, 65534], step 1): used only if Function **6** is used (see function attribute)

(5) **function** (range [0, 65534], step 1): Modbus function to use to send the DPC:
- 5: write 1 bit (**mapping address** is the address of the bit)
- 6: write 1 word (**mapping address** is the address of the word, **bit number** is the position of the bit in the word)
- 15: write N bits (used to set only 1 bit at a time, **mapping address** is the address of the bit)

For T101 master protocol:

(6) **information object address** (range [0, 16777215], step 1)

(7) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

For T103 protocol:

(8) **ASDU number** (range [0, 65534], step 1):
- 20 (for all IED)
- 45,46 (Only for Schneider Px3x)

(9) **function type** (range [0, 65534], step 1): refer to IED documentation

(10) **information number** (range [0, 65534], step 1): refer to IED documentation

For T104 master protocol:

(11) **information object address** (range [0, 16777215], step 1)

(12) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(13) **command type** (*no information*, i.e. IED-dependant / *short pulse* / *long pulse* / *persistant*): type of command transmission

For all protocols:

(14) **order type** (*SBO* / *Direct execute*)

(15) **contact type** *(open* / *close* / *unused*): For all protocol types, DPC control on an IED can also be done via two different addresses. In that case, two **DPC address on IED** must be created for that DPC. For each of them, this attribute must be set to *'Open'* or *'Close'*, to indicate which order of the DPC is concerned by the IED address. If the DPC control is given by only one IED address, set **contact type** to *'unused'*.

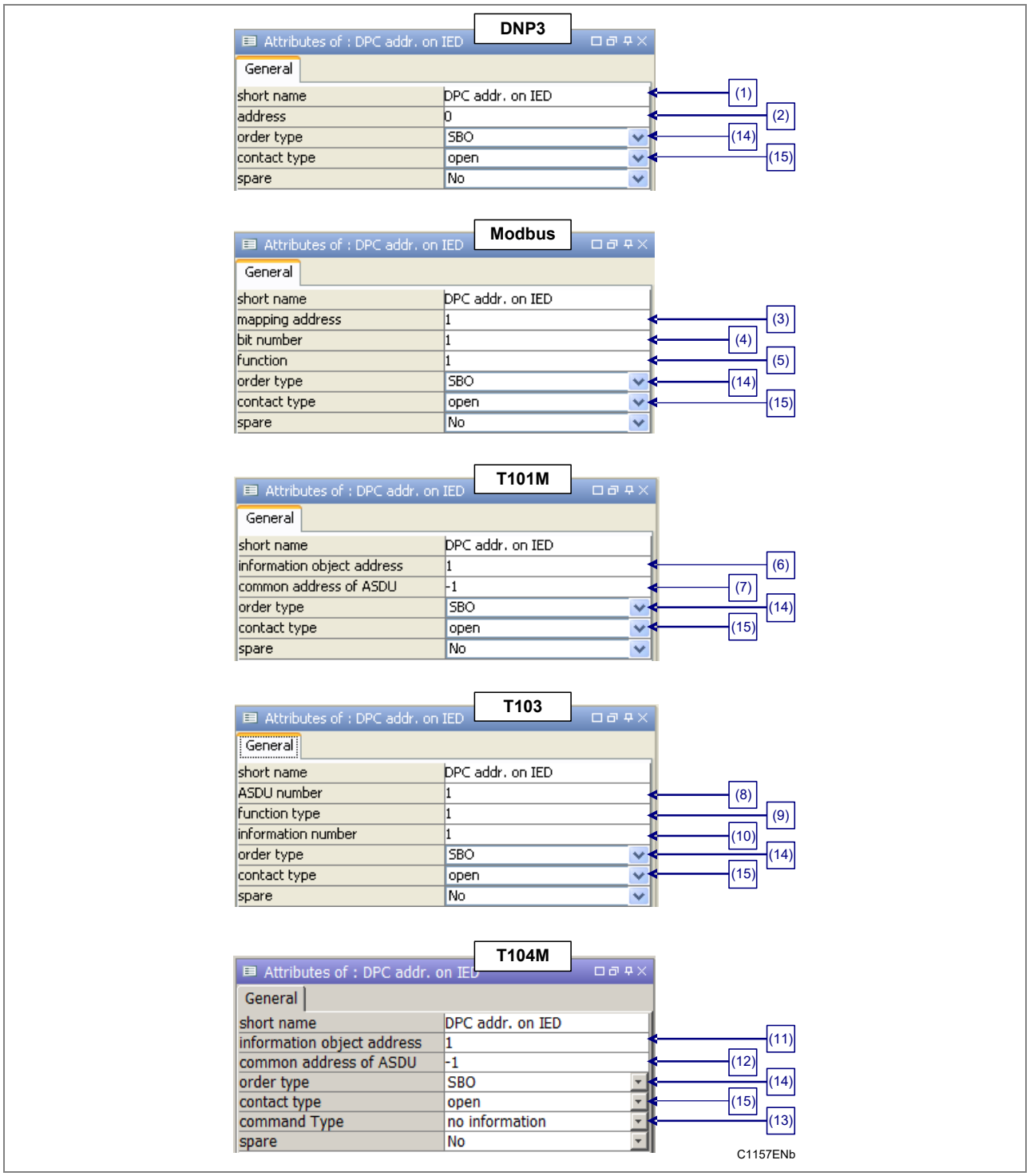


Figure 88: Defining a legacy IED address for a DPC datapoint

3.6.2.8 DEFINING A LEGACY IED ADDRESS FOR A SETPOINT DATAPOINT

To add an IED address to a SetPoint datapoint, select the IED SetPoint mapping level and add the address from the contextual **Objects entry** window.

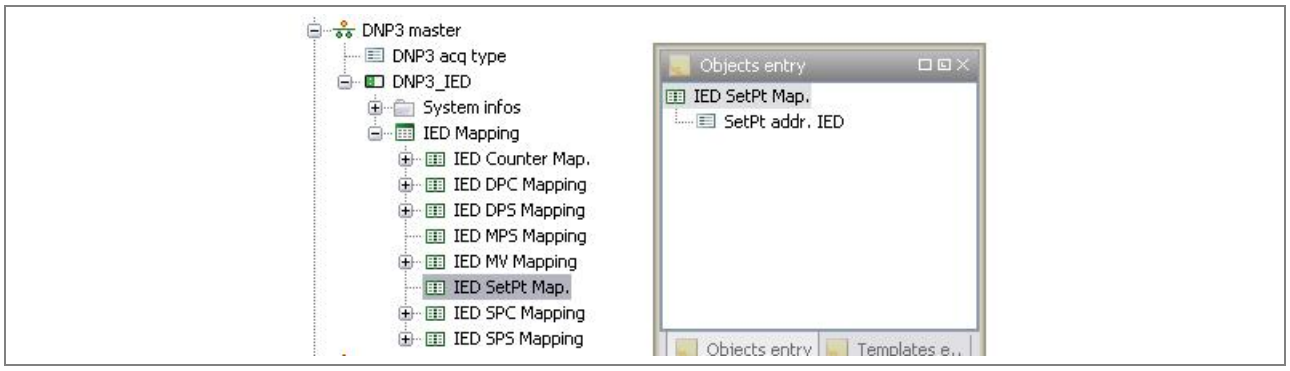


Figure 89: Adding a legacy IED SetPoint address (example for a DNP3 IED)

Once added, IED SetPoint address attributes must be set at SCE level:

(1) **short name** of the address: used for internal SCE identification

For DNP3 master protocol:

(2) **address** (range [0, 65534], step 1)

For Modbus protocol:

Note:
SetPoint addresses on Modbus are only available for WAGO IEDs, for which the output format is fixed to UINT15 (unsigned integer, only 15 out of 16 bits are used). The IED type must be set to WAGO.

(3) **mapping address** (range [0, 65534], step 1): Word address for function 6

(4) **function** (range [0, 65534], step 1): Modbus function to use to send the SetPoint:
- 6: write 1 word (**mapping address** is the address of the word, **bit number** is the position of the bit in the word)

For T101 master protocol:

(5) **information object address** (range [0, 16777215], step 1)

(6) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(7) **output format** (*Short float* / *Normalized* / *Scaled*)

For T103 protocol:

(8) SetPoint **address** on T103 is only available for REGD IEDs, for which the output format is configurable

(9) **ASDU number** (range [0, 65534], step 1): refer to IED documentation

(10) **function type** (range [0, 65534], step 1): refer to IED documentation

(11) **information number** (range [0, 65534], step 1): refer to IED documentation

(12) **output format** (*INT8* / *UINT8* / *INT16* / *UNIT16* / *REAL32 (IEEE754)*)

For T104 master protocol:

(13) **information object address** (range [0, 16777215], step 1)

(14) **common address of ASDU** (range [-1, 65534], step 1): the default setting (-1) forces the datapoint's address to the same value as the IED's **network address**

(15) **output format** (*Short float* / *Normalized* / *Scaled*)

For all protocols:

(16) **order type** (*SBO* / *Direct execute*)

(17)-(18) For *Scaled* and *Normalized* output formats: The values of a SetPoint control on an IED must be checked and scaled according to the output format, before transmission. This is done via two extra attributes **minimal value** (17) and **maximal value** (18).

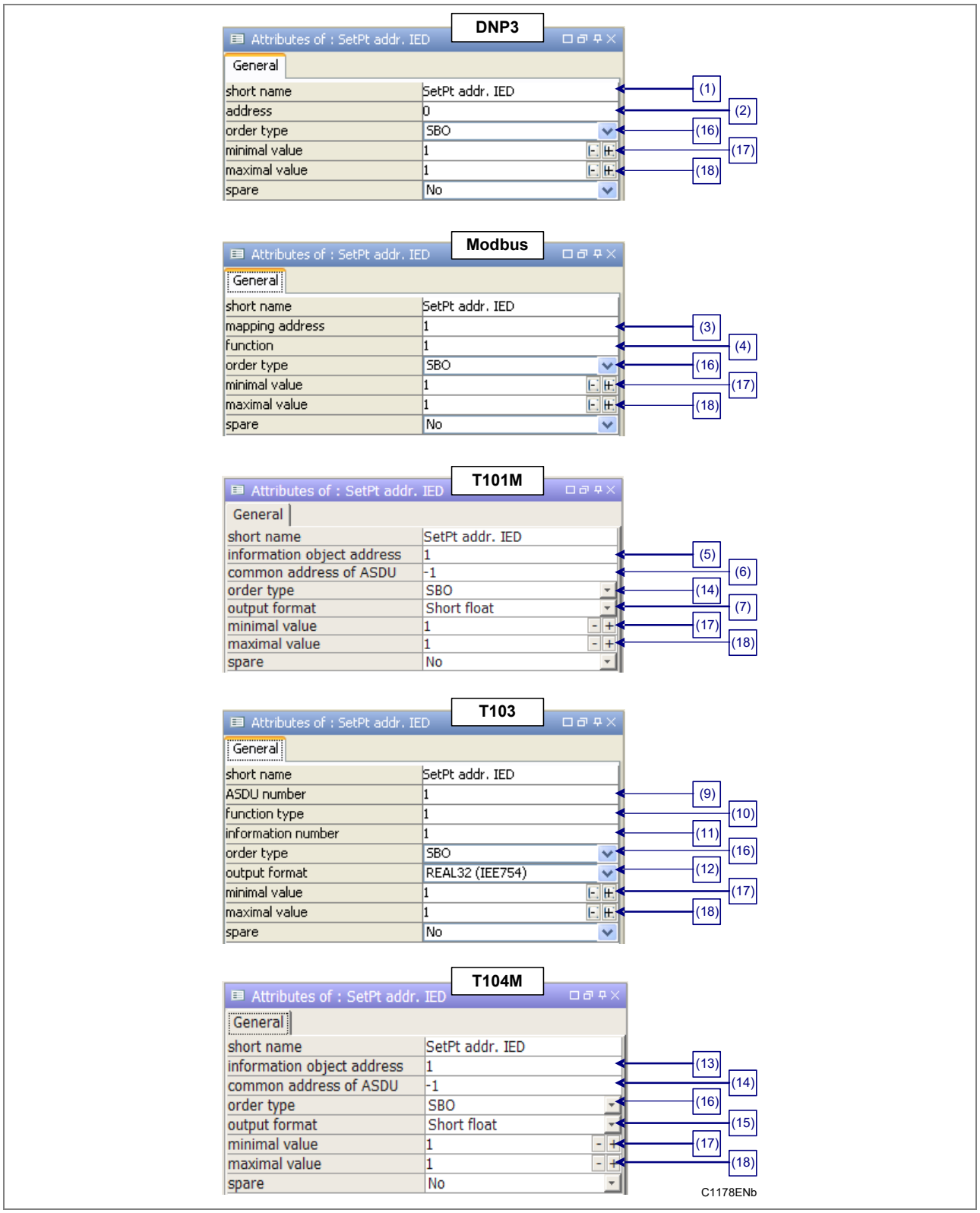


Figure 90: Defining a legacy IED address for a SetPoint datapoint

3.6.3 ADDRESSING A DATAPOINT ON AN IED LEGACY NETWORK

		Protocol			
DP type	**Identifier**	**DNP3**	**Modbus**	**T103**	**T101**
Counter	basic address default	address	Mapping address	ASDU number	Not used
	extra address #1 default	Not used	Not used	function type	Not used
	extra address #2 default	Not used	function	information number	Information object address
	extra address #3 default	Not used	Not used	index in the ASDU	common address of ASDU
	extra address #4 default	Not used	Not used	common address of ASDU	Not used
xPC	basic address	address	Mapping address	ASDU number	Not used
	extra address #1 default	Not used	bit number	function type	Not used
	extra address #2 default	Not used	function	information number	Information object address
	extra address #3 default	Not used	Not used	Not used	common address of ASDU
xPS	basic address	address	Mapping address	ASDU number	Not used
	extra address #1 default	Not used	bit number	function type	Not used
	extra address #2 default	Not used	function	information number	Information object address
	extra address #3 default	Not used	Not used	common address of ASDU	common address of ASDU
MV	basic address	address	Mapping address	ASDU number	Not used
	extra address #1 default	Not used	Not used	function type	Not used
	extra address #2 default	Not used	function	information number	Information object address
	extra address #3 default	Not used	Not used	index in the ASDU	Not used
	extra address #4 default	Not used	Not used	common address of ASDU	common address of ASDU
Setpoint	basic address	address	Mapping address	ASDU number	Not used
	extra address #1 default	Not used	bit number	function type	Not used
	extra address #2 default	Not used	function	information number	Information object address
	extra address #3 default	Not used	Not used	common address of ASDU	common address of ASDU

3.7 NETWORKING A SCADA ON A C26X SCADA NETWORK

3.7.1 CREATING A SCADA NETWORK

An electrical substation can be supervised and controlled from many points inside the substation via DS Agile system HMIs (Substation Control Point or SCP) and/or DS Agile C26x bay panels (Bay Control Point or BCP), and outside the substation. Generally, the distant control of the substation (Remote Control Point or RCP) is done via a specific network called SCADA legacy network.

Several SCADA legacy networks can be connected to a DS Agile system, via DS Agile C26x or DS Agile remote control gateway sub-systems. SCADA legacy networks are managed as master by the distant SCADA and can be redunded for safety reasons. A DS Agile C26x can manage up to two SCADA networks.

At SCE data modeling level, only SCADA legacy networks and their protocol are modeled and connected to gateway sub-systems. Each SCADA network has to be linked to a main communication port and an optional auxiliary communication port in case of redundancy.

3.7.1.1 ADDING A SCADA NETWORK

To create a SCADA network on a C26x:

- Add a SCADA network from the **Objects entry** window associated with the C26x level.
- Update the SCADA network attributes relevant to its protocol characteristics (see section *3.7.2 Defining the address map of a SCADA network*).
- If the SCADA does not use the substation network to communicate with the C26x, update its **has for main communication port** relation and the communication port characteristics.
- For DNP3 and T101 protocols on serial links, SCADA links can be redundant. To create a redundant SCADA link, add the extra relation **has for auxiliary communication port** (2) to the C26x SCADA network and fill it in with the relevant serial port.
- A C26x can manage up to 4 Ethernet (T104 or DNP3) SCADA protocol connections. They are configured separately but may have the same data.
- T104 only: For each SCADA protocol connection, up to four front end ports can be defined: one active port and three standby ports. Thus, up to four IP addresses will be defined during the configuration of each T104 protocol connection (attribute (13) in section *3.7.1.7 Setting specific attributes of a T104 SCADA network*). If two SCADAs are communicating with the C26x, they must manage their own redundancy to ensure command consistency.

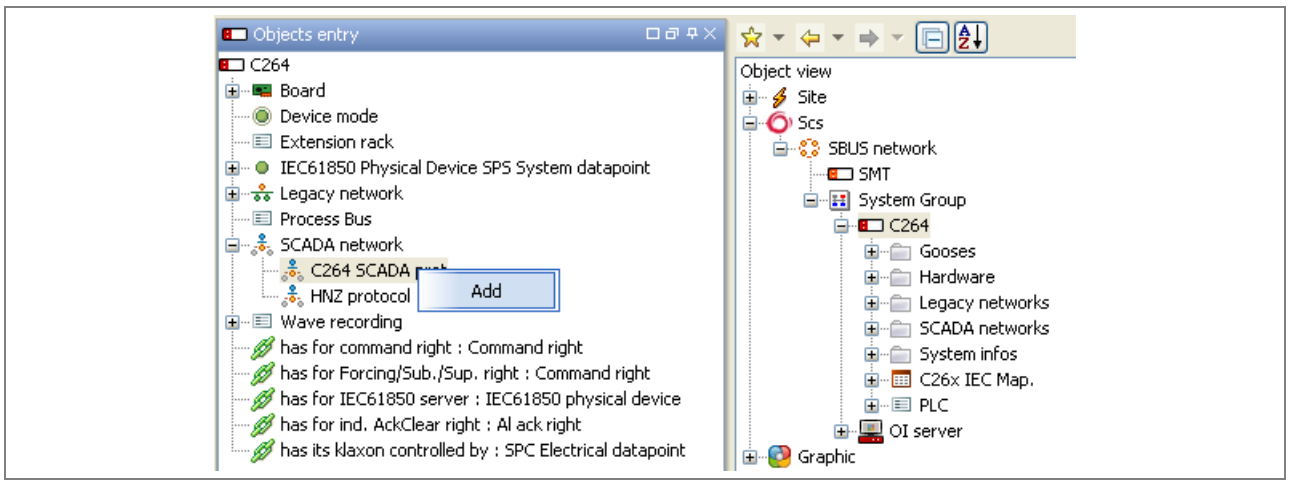


Figure 91: Adding a SCADA network

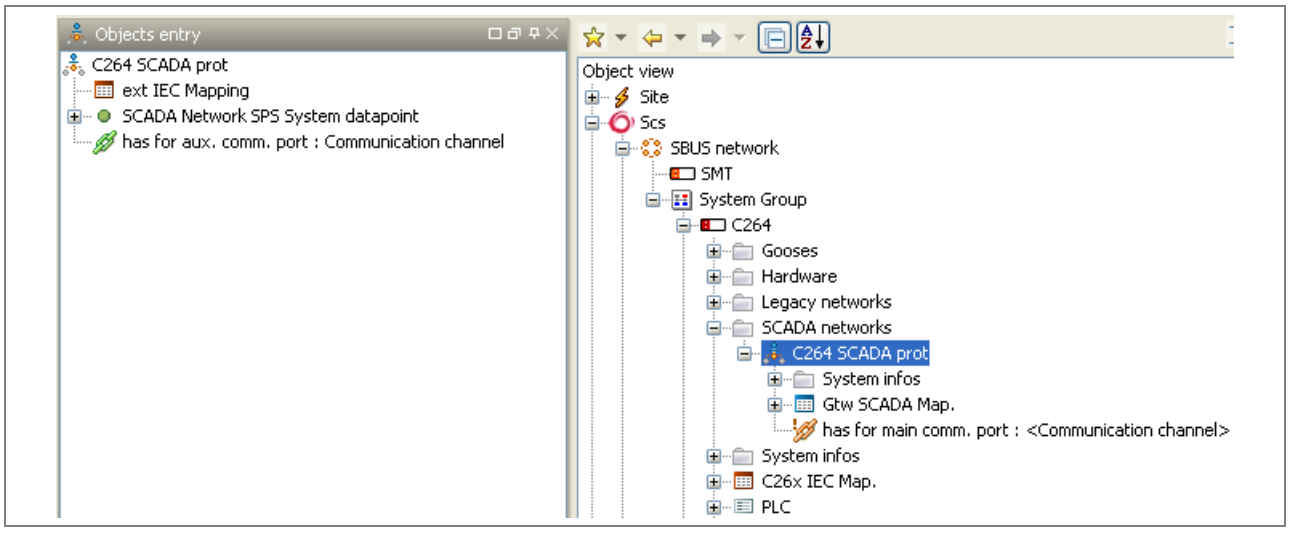


Figure 92: redundant SCADA link

3.7.1.2 COMPONENTS OF A SCADA NETWORK

When a SCADA network is added, the following sub-tree is automatically created with implicit components and optional components that can be added from the contextual **Objects entry** window:

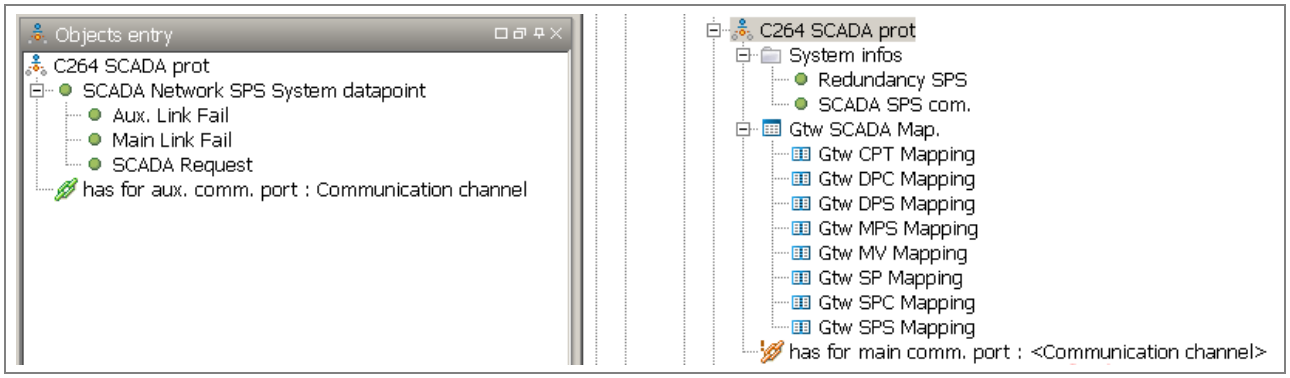


Figure 93: Optional and default components of a SCADA network

- Folder **System infos**: contains SPS system datapoints relevant to the communications channel with the SCADA. Two datapoints are implicitly added along with the SCADA network:
  - **Redundancy SPS**: communications port redundancy status
  - **SCADA SPS com.**: state of the communication link between the C26x and the SCADA

An additional 3 SPS datapoints can be added from the contextual **Objects entry** window:

- **Aux. Link Fail** (T101 only): *SET* when the redundant SCADA link is lost, whether this is due to equipment failure or to a C26x reboot. This signal is sent to the SCADA over the main link.
- **Main Link Fail** (T101 only): *SET* when the main SCADA link is lost, whether this is due to equipment failure or to a C26x reboot. This signal is sent to the SCADA over the auxiliary link.
- **SCADA Request** (T101/T104 only): *SET* while a request is being received from the SCADA

- Mapping **Gtw SCADA Map.**: set of datapoints sent to the SCADA. Their definition is described in section *3.7.2.8 Defining a SCADA address for a SetPoint datapoint*.
- Relation **has for main comm.port : <Communication channel>**: double-click this relation to display the **Relation link editor** window and select the appropriate communications port on the C26x.

A second relation, **has for aux. comm. port : Communication channel**, is available for use with a redundant SCADA link: double-click this relation to display the **Relation link editor** window and select the appropriate communications port on the C26x.

3.7.1.3 SETTING THE GENERAL ATTRIBUTES OF A SCADA NETWORK

Regardless of the type of SCADA network, its **short name** and **long name** attributes must be set in accordance with each connected SCADA network in order to ensure correct logging and alarm discrimination of the status datapoints managed by the C26x. Then the supported **protocol** (2) must be selected (T101 in the example given below). The contents of the SCADA attributes tab-panes (Protocol, SOE and Disturbance) depend on the selected protocol.

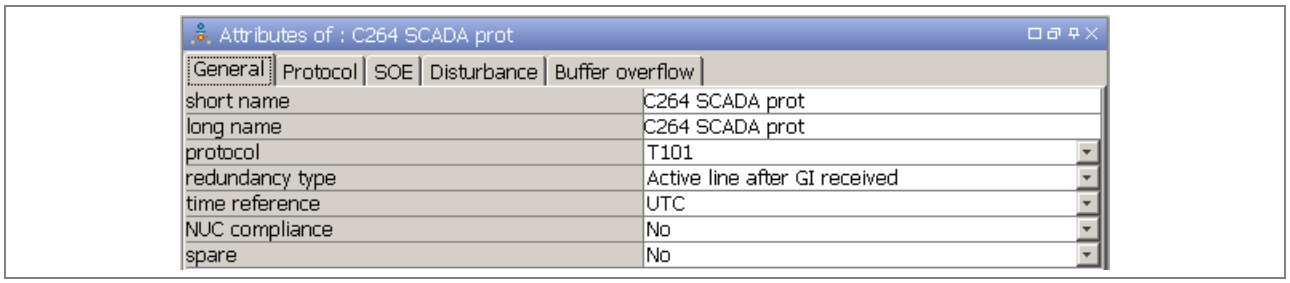


Figure 94: Setting the general attributes of a SCADA network

3.7.1.4 SETTING THE GENERAL ATTRIBUTES OF A T101 SCADA NETWORK

When adding a T101 SCADA network its general attributes must be set:

(1) **redundancy type** (*Active line after GI received* / *Active line after Reset Line received* / *Active line on traffic*)

(2) **time reference** (*UTC* / *local*)

(3) **NUC compliance** (*No* / *Yes*): Compliance with the Norvegian IEC 870-5-101 User Conventions

3.7.1.5 SETTING THE SPECIFIC ATTRIBUTES OF A T101 SCADA NETWORK

When adding a T101 SCADA network, the following attributes, available for this protocol, must be set (Protocol and SOE tab-panes):

(1) **link address length** (1 byte / 2 bytes)

(2) **link address** (range [1, 65534], step 1)

(3) **ASDU common address length** (1 byte / 2 bytes)

(4) **ASDU common address** (range [1, 65534], step 1)

(5) **address structure** (*Address on 8 bits (1 byte)* / *Address on 16 bits (2 bytes)* / *Address on 8 bits.8 bits* / *Address on 8 bits.16 bits* / *Address on 16 bits.8 bits* / *Address on 8 bits. 8 bits. 8 Bits* / *Address on 24 bits (3 bytes)*)

(6) **frame max length** (range [1, 255], step 1)

(7) **cause of transmission length** (*Address on 8 bits* / *Address on 16 bits*)

(8) **MV periodic cycle** (range [0 s, 65534 s], step 1 s)

(9) **binary time size** (*CP24Time2A (3 bytes)* / *CP56Time2A (7 bytes)*)

(10) **background scan cycle (s)** (range [0 s, 65535 s], step 1 s)

(11) **Type of link** (*unbalanced* / *balanced*)

(12) **test link period (s)** (range [1 s, 65535 s], step 1 s)

(13) **SBO time-out** (range [0 s, 65535 s], step 1 s)

(14) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames

(15) **quality value for 'Jammed' state** (*Valid* / *Invalid*)

(16) **quality value for 'Undefined' state** (*Valid* / *Invalid*)

(17) **quality value for toggling xPS** (*BL only (blocked)* / *IV only (invalid)*)

(18) **quality value for 'unknown' state** (*Not topical only* / *Not topical and IV (invalid)*)

(19) **SOE file support** (*No* / *Yes*)

(20) **SOE file address**: this attribute is visible and significant only if the attribute **SOE file support** is set to *Yes*

(21) **SOE file format** (*T101* / *S900*): this attribute is visible and significant only if the attribute **SOE file support** is set to *Yes*

(22) **SOE file nb of events** (range [0, 1000], step 1): this attribute is visible and significant only if the attribute **SOE file support** is set to *Yes*

(23) **'full' SOE file nb of events** (range [0, 1000], step 1): file message sent to SCADA (this attribute is visible and significant only if the attribute **SOE file support** is set to Yes)

Tab-pane **Disturbance**: the addresses of the IED disturbance files are defined in this tab-pane

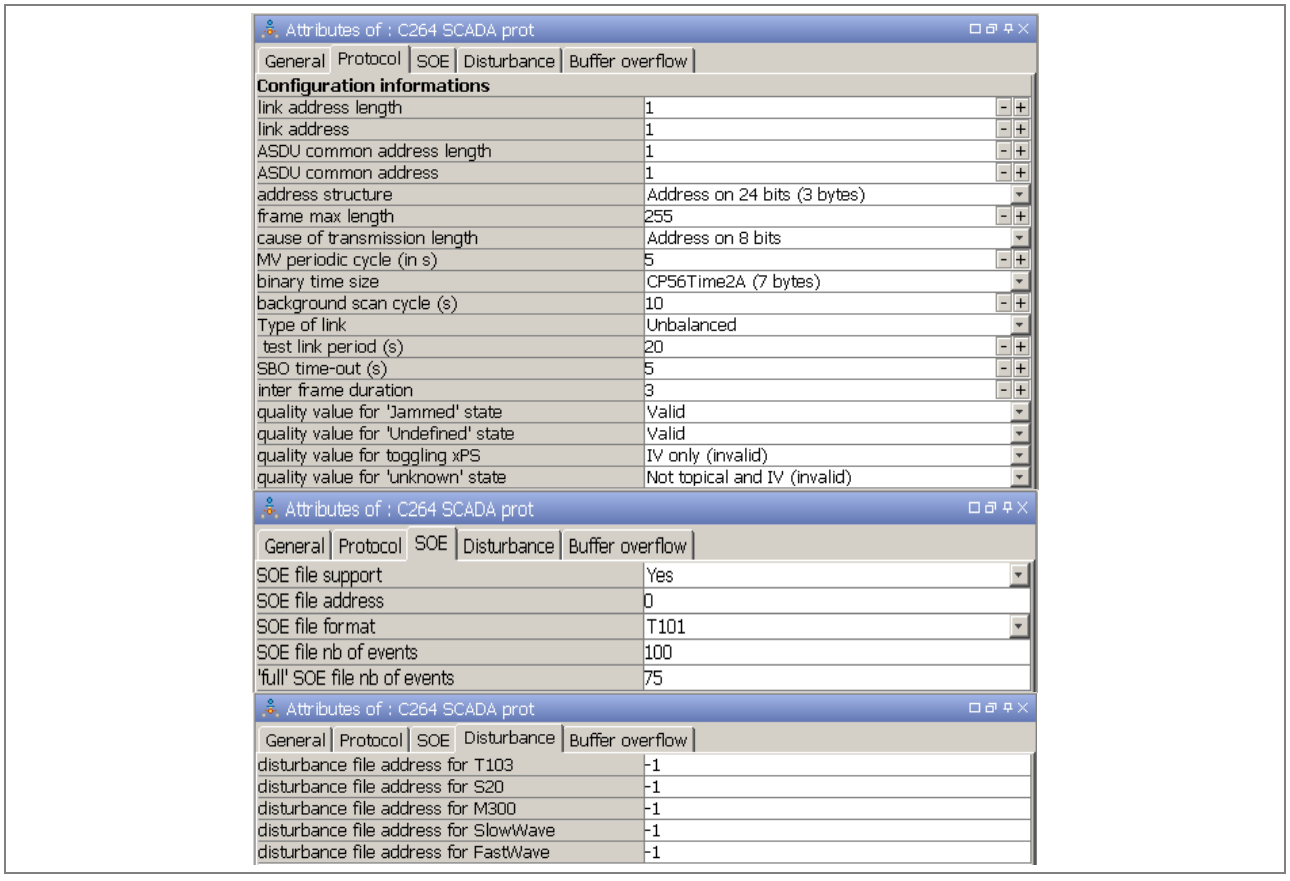


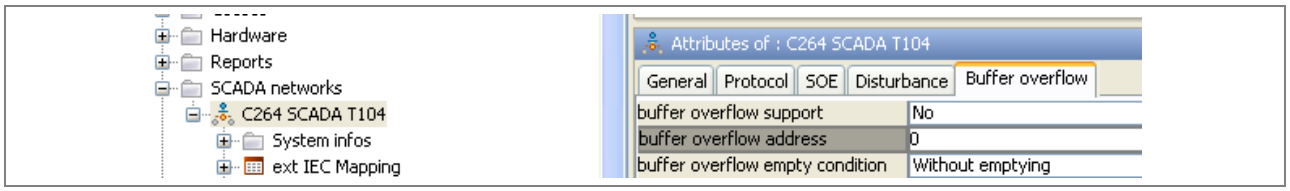
Figure 95: Setting the protocol and SOE/disturbance recording attributes of a T101 SCADA network

Configuration rules and checks

The following constraints between the attributes must be respected:
"SOE file nb of events" > "'full' SOE file nb of events".

Note:
For several T101/T104 SCADA links, refer also to the C26x attribute Arbitration support

Tab-pane **Buffer overflow**:



(1) **Buffer overflow support**: activates the SPS Buffer overflow

(2) **Buffer overflow address**: defines the SPS Buffer overflow address in Scada

(3) **Buffer overflow empty condition**: defines the way the 1000-event buffer is managed:

- *Without emptying*: the buffer is circular; when it is full, the “Last in” event replaces the “First in” event. The buffer is never flushed.
- *FIFO full / SCADA (re)connection*: when the buffer is full, the overflow indication is recorded and new events are not recorded in the buffer. At SCADA reconnection:
  - the buffer overflow information is sent to the SCADA
  - the buffer is flushed without any event transfer to the SCADA
- *FIFO full only*: when the buffer is full, the overflow indication is recorded and new events are not recorded in the buffer. At SCADA reconnection:
  - the buffer overflow information is sent to the SCADA
  - all the events recorded are sent to the SCADA
  - the buffer is flushed

3.7.1.6 SETTING THE GENERAL ATTRIBUTES OF A DNP3 SCADA NETWORK

In the following figure the selected protocol for the SCADA link is ‘DNP3’ (1).

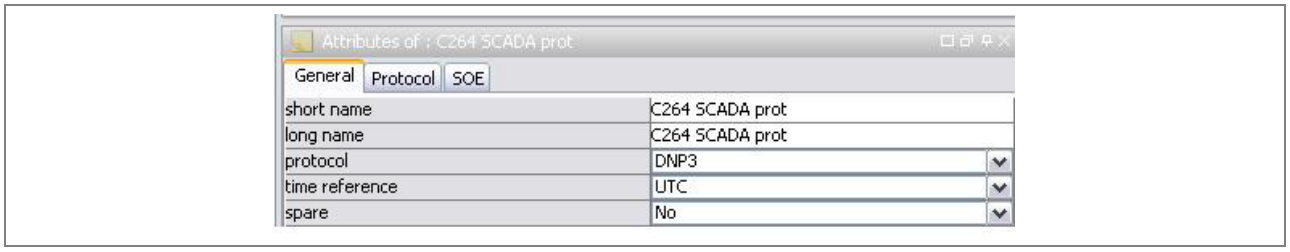


Figure 96: Setting the general attributes of a SCADA network

When setting a DNP3 SCADA network, some specific attributes, available for the protocol, must be updated (Protocol tab-pane):

(1) **TCP/IP usage** (*No* / *Yes*): set to *Yes* if the substation network is used by the DNP3 SCADA to communicate with the C26x

(2) **Link address** (1..65534)

(3) **SPS/DPS class** (1 / 2 / 3)

(4) **MV class** (1 / 2 / 3)

(5) **Counter** (1 / 2 / 3)

(6) **MV format** (*32 bits* / *16 bits*)

(7) **static MV** (*without flag* / *with flag*)

(8) **event MV** (*without time* / *with time*)

(9) **counter format** (*32 bits* / *16 bits*)

(10) **static counter** (*without flag* / *with flag*)

(11) **event counter** (*without time* / *with time*)

(12) **SBO time-out**: maximum time between select order and execute order

(13) **inter frame duration** (range [1 , 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames

(14) **spontaneous message enable** (*No* / *Yes*): this attribute defines if the unsolicited mode is allowed or not for the protocol. If this attribute is set to *No* there is possibility to allowed it from the SCADA. If this attribute is set to *Yes* the C26x can send unsolicited messages as soon as the SCADA is initialized. Furthermore the SCADA may disable or enable this unsolicited mode.

(15) **spontaneous message class** (*none* / *class 1* / *class 2* / *class 1 & 2* / *class 3* / *class 1 & 3* / *class 2 & 3* / *class 1 & 2 & 3*): This attribute is only significant if the previous attribute is set to *Yes*. This attribute defines which class(es) is (are) concerned by this unsolicited mode.

(16) **on-line bit management** (*unknown forced to 1*: mode = 1 which is backward compatible, *unknown forced to 0*: mode = 2, which is NOT backward compatible)

Setting SOE information SOE tab-panes, for DNP3 SCADA network is not significant (not implemented).

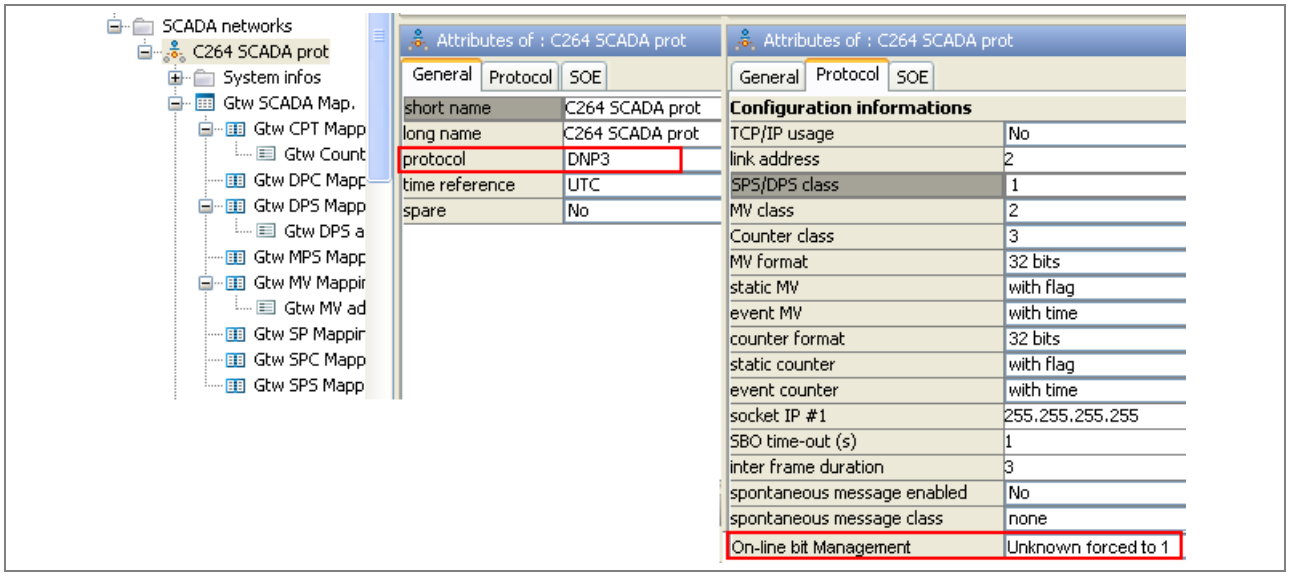


Figure 97: Setting the protocol attributes of a DNP3 SCADA network

3.7.1.7 SETTING SPECIFIC ATTRIBUTES OF A T104 SCADA NETWORK

In the following figure the selected protocol for the SCADA link is 'T104' and the selected time reference is UTC.

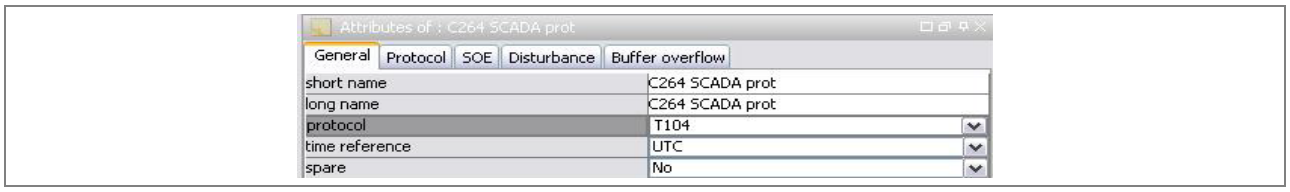


Figure 98: Setting the general attributes of a SCADA network

When setting a T104 SCADA network, some attributes specific to the protocol must be updated (Protocol and SOE tab-panes):

(1) **ASDU common address** (range [1, 65534], step 1)

(2) **address structure** (Address on 8 bits.16 bits / Address on 16 bits.8 bits / Address on 8 bits.8bits.8bits / Address on 24 bits (3 bytes)):

(3) **frame max length** (range [1, 255], step 1)

(4) **MV periodic cycle** (range [0 s, 65534 s], step 1 s)

(5) **binary time size** (*CP24Time2A (3 bytes)* / *CP56Time2A (7 bytes)*)

(6) **background scan cycle** (range [0 s, 65535 s], step 1 s)

(7) **T1: APDU time-out** (range [1 s, 255 s], step 1 s)

(8) **T2: acknowledgement time-out** (range [1 s, 255 s], step 1 s)

(9) **T3: test frame time-out** (range [1 s, 255 s], step 1 s)

(10) **K: sent unack. frames (APDU)** (range [1, 255], step 1)

(11) **W: ack. received frames (APDU)** (range [1, 255], step 1)

(12) **max command delay** (range [0 s, 32767 s], step 1 s)

(13) **socket IP #i** ($i \in [1, 4]$)

(14) **SBO time-out** (range [0 s, 65535 s], step 1 s)

(15) **validity for 'Jammed' state** (*Valid* / *Invalid*)

(16) **Switchover** (*Automatic switchover* / *Manual switchover*)

(17) **SOE file support** (*No* / *Yes*)

(18) **SOE file address** (this attribute is visible and significant only if attribute **SOE file support** is set to Yes)

(19) **SOE file format** (T101 / S900) (this attribute is visible and significant only if attribute SOE file support is set to Yes)

(20) **SOE file nb of events** (range [0, 1000], step 1) (this attribute is visible and significant only if attribute SOE file support is set to Yes)

(21) **'full' SOE file nb of events** (range [0, 1000], step 1) file message sent to SCADA (this attribute is visible and significant only if attribute SOE file support is set to Yes)

Configuration rules and checks

- The following constraints between the attributes must be respected:
  SOE file nb of events > 'full' SOE file nb of events
  T2 < T1
  T3 > T1
  W ≤ K

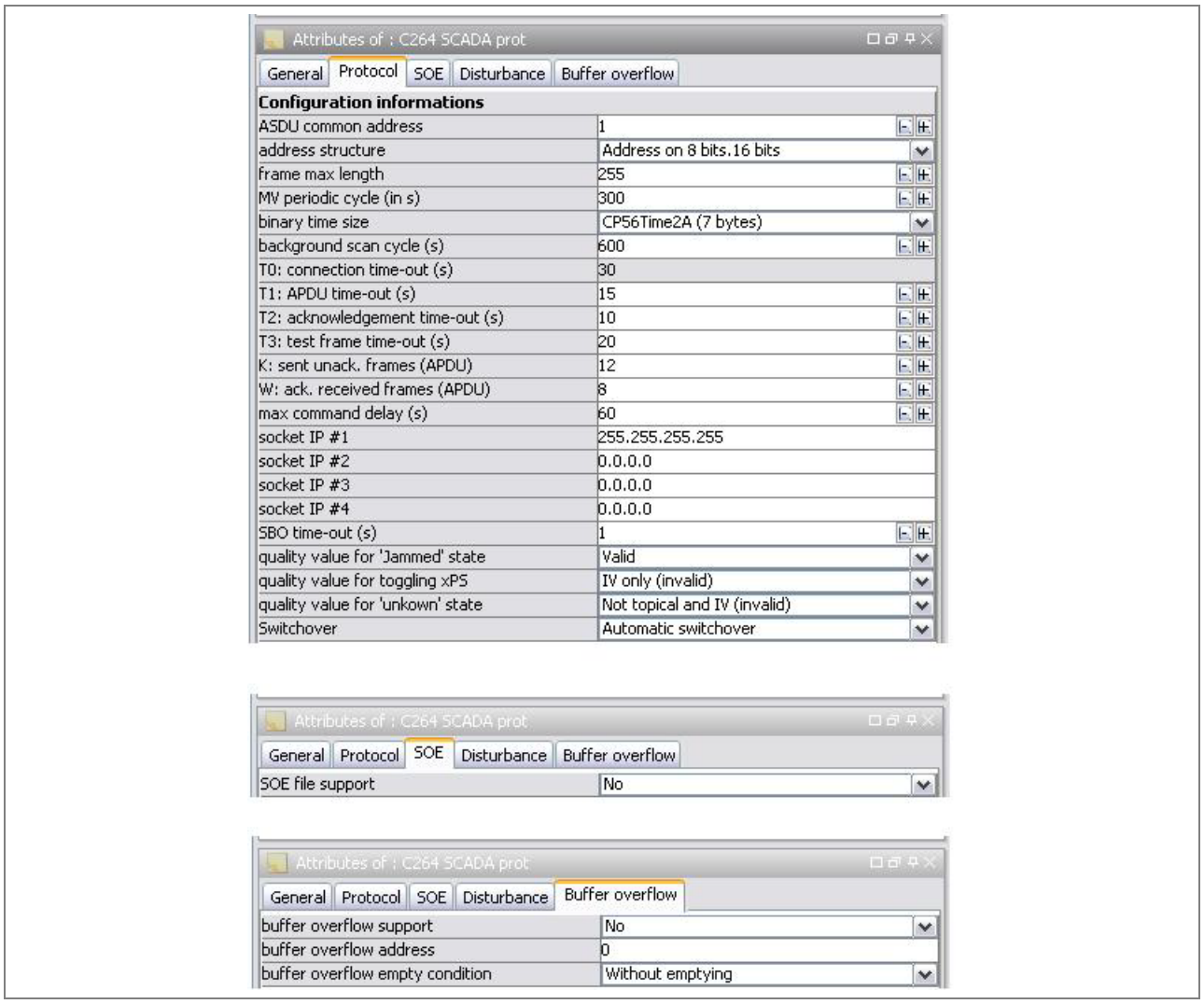
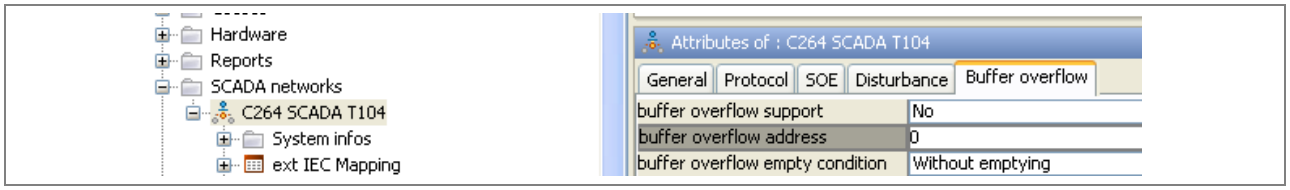


Figure 99: Setting the specific attributes of a T104 SCADA network

Tab-pane **Disturbance**: the IED disturbances files addresses are defined.

Tab-pane **Buffer overflow**:



- **Buffer overflow support**: activates the SPS Buffer overflow
- **Buffer overflow address**: defines the SPS Buffer overflow address in Scada
- **Buffer overflow empty condition**: defines the way the buffer is managed:
  - Without emptying: the buffer is circular; when it is full, the “Last in” event replaces the “First in” event. The buffer is never flushed.
  - FIFO full / SCADA (re)connection: when the buffer is full, the overflow indication is recorded; new events are not recorded in the buffer. At SCADA reconnection:
    - the buffer overflow information is sent to the SCADA
    - the buffer is flushed without any event transfer to the SCADA
  - FIFO full only: when the buffer is full, the overflow indication is recorded and new events are not recorded in the buffer. At SCADA reconnection:
    - the buffer overflow information is sent to the SCADA
    - all the events recorded are sent to the SCADA
    - the buffer is flushed

3.7.1.8 SETTING SPECIFIC ATTRIBUTES OF A MODBUS SCADA NETWORK

In the following figure the selected protocol for the SCADA link is ‘Modbus’.

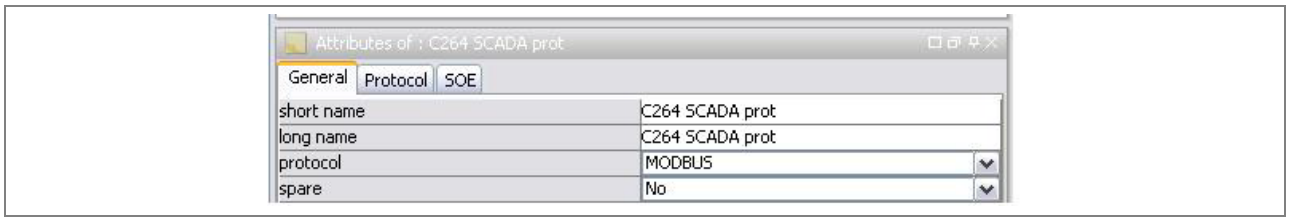


Figure 100: Setting the protocol type of a SCADA network

When setting a MODBUS SCADA network, some attributes specific to the protocol must be updated (Protocol tab-pane):

(1) **TCP/IP usage** (*No* / *Yes*): no choice for Modbus: SET IT TO ‘*No*’.

(2) **link address**.

(3) **inter frame duration** (range [1, 50], step 1): this attribute represents the minimum time, expressed in number of characters, that must exist between two frames.

For a MODBUS SCADA network, the SOE tab-panes attributes are not significant (not implemented).

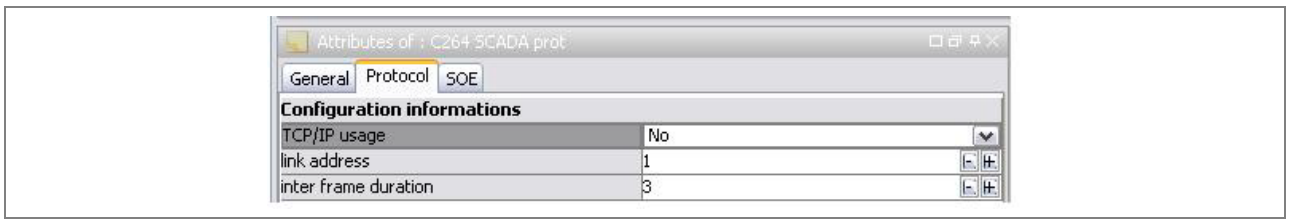


Figure 101: Setting the protocol attributes of a Modbus SCADA network

3.7.2 DEFINING THE ADDRESS MAP OF A SCADA NETWORK

To transmit information between DS Agile system and SCADA, a SCADA legacy network is used. To receive or send information between legacy IED and DS Agile system, each concerned data must have a specific address on the legacy network relatively to its protocol. General modeling of SCADA legacy network address mapping can be done.

At SCE level, a SCADA legacy network owns a “Gtw SCADA mapping” object, that is split into categories of mapping on a per datapoint type basis. In each category of mapping, elementary SCADA addresses can be created. For details about datapoint, see section *4 Defining a datapoint*. This mapping is implicitly created during IED adding at legacy network level.

Warning:
Addressing an MPS datapoint on a SCADA network is not possible.

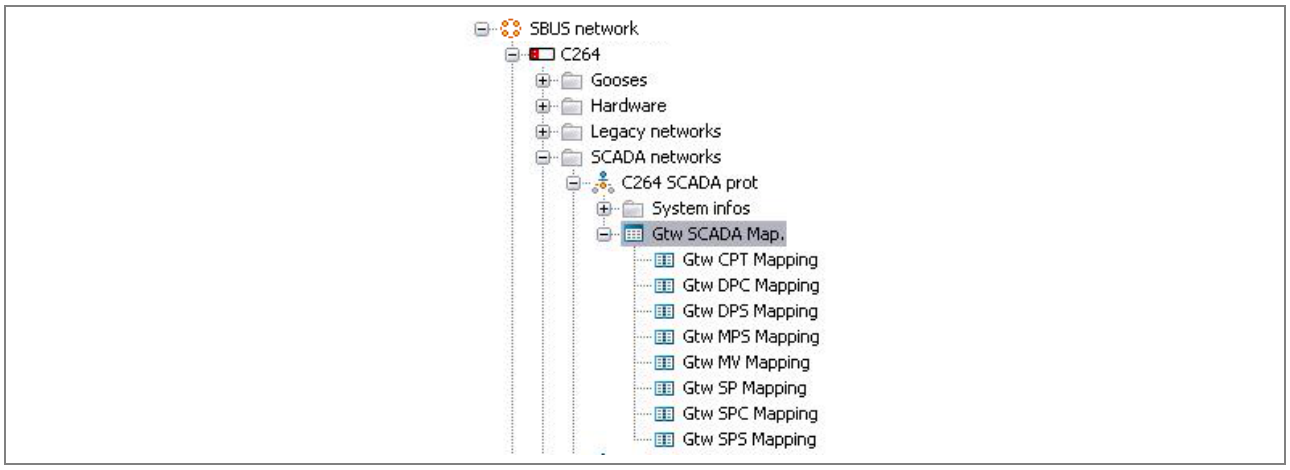


Figure 102: Structure of the address map of a SCADA network

There are two ways to map the datapoints:

- Select the attributes of the subnodes of the various Gtw xxx Mapping folders
- To go faster (or import a file from Excel), use a smart table, linked to the individual tables (see sections *3.7.2.2, 3.7.2.4*, and *3.7.2.5* for details on attributes)

Configuration rules and checks

- In the SCADA Mapping, the address identification of each "Gtw xxx addr." must be unique. In the particular cases of T101 and T104 protocols, the uniqueness constraint is applicable only for addresses of the same type. Addresses of different types can have identical addresses and therefore this does not lead to an error but to a warning.
- On a DNP3 protocol, a "Gtw MV addr.", which is the SCADA address of a "Tap pos ind" datapoint, must have its "Format" attribute set to the "Natural" value.

3.7.2.1 SMART TABLE

When a SCADA network is selected in the browser, an extra item is present in the contextual menu: “Edit Scada mapping”. When selected, a window appears. It allows to enter all datapoint addresses for the SCADA mapping. The datapoints are tabbed by type; 5 types exist:

- xPS for SPS / DPS addresses
- xPC for SPC / DPC addresses
- MV for measurement addresses
- SetPoint for SetPoint addresses
- Counter for Counter addresses

Each tab presents a table featuring:

- in the left part (white background), the predefined list of datapoints
- in the right part (blue background), empty cells for addresses, labels and protocol-dependent attributes

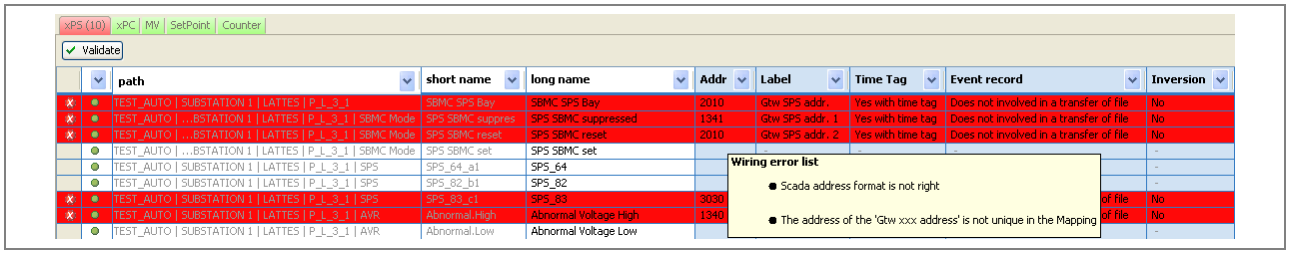
The white part indicates for each datapoint of the type:

- Variants (pictogram)
- Path (read only)
- Short name (read only)
- Long name (editable, copy/paste enabled)

To adjust a column width, pass the cursor over the border in the header till the cursor turns to ↔; then drag and drop.

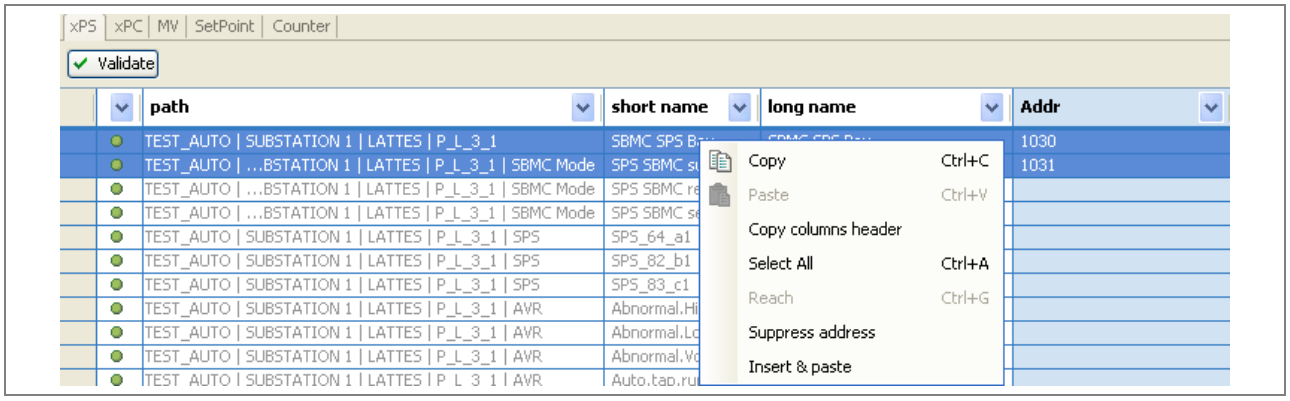
Procedure to fill the blue part

- Click in an address cell
- Enter the address
- Click another cell to change the selection; the other cells in the row are automatically filled with default values (an address which contains letters is corrected to 255)
- Click two times a cell in the column Label and edit the text
- Click three times a cell in a column different than Addr or Label; click the button [v] and select one value in the drop-down list
- Select a cell or several contiguous cells with at least one Addr cell; copy, select target, paste the label is recomputed; if the Addr is void, 255 is pasted
- To check the address uniqueness, click button Validate in upper left corner:
- the wrong lines turn red and show a red pictogram in the first column
- the tab tag turns red (resp. green) if it contains errors (resp. it is error-free); to display a tooltip, pass the mouse over a red line:

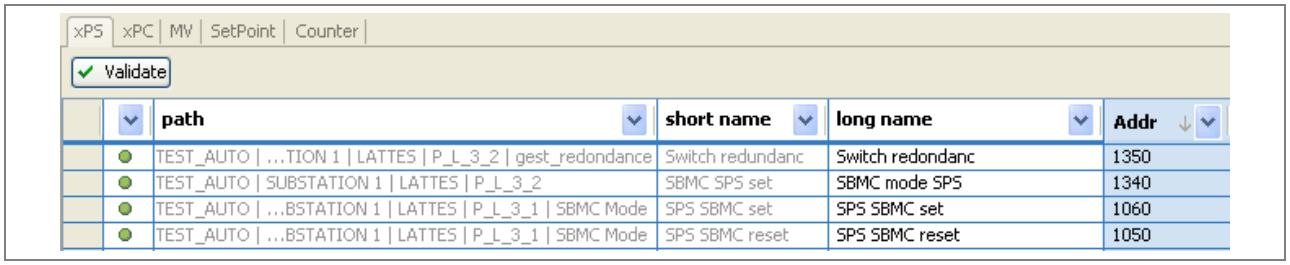


Possible errors

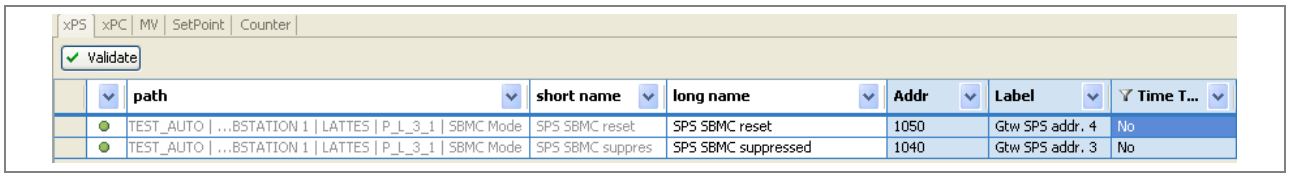
- Address is not unique in the mapping
- Address is not associated with a datapoint (delete the address)
- Address value doesn't respect the predefined format
- Datapoint is not visible by the SCADA equipment
- To delete a set of addresses in contiguous rows, click in the first or Addr column and drag to select the rows, right click and click Suppress address



- To sort out the rows alphabetically/numerically/hierarchically in decreasing order, click each column header several times till the arrow ↓ shows after the column label

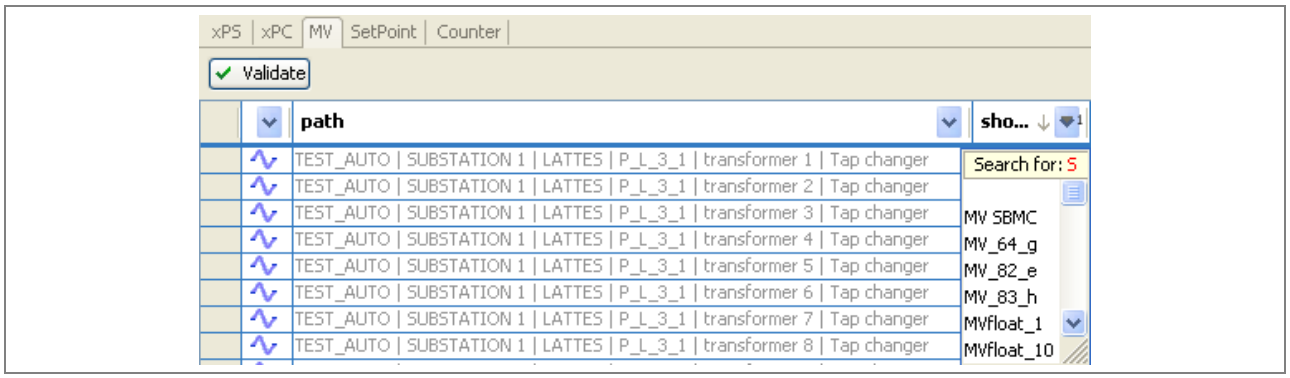


- To filter the rows according to a column field, click [v] and select one value in the combo list; as a result, a funnel shows before the column label. To suppress the filter, select the value (All).



For the path column, the sub-nodes of the selected nodes are displayed as well.

If the desired value is not in the list, stop the cursor on any value and type in the value (in red):



- Click the button Close; when you resume the procedure, click [v] in the Addr header and select Defined address to retrieve the entered values

3.7.2.2 DEFINING A SCADA ADDRESS FOR AN SPS DATAPOINT

A SCADA address is added to an SPS datapoint from the contextual **Objects entry** window at the SCADA SPS mapping level:

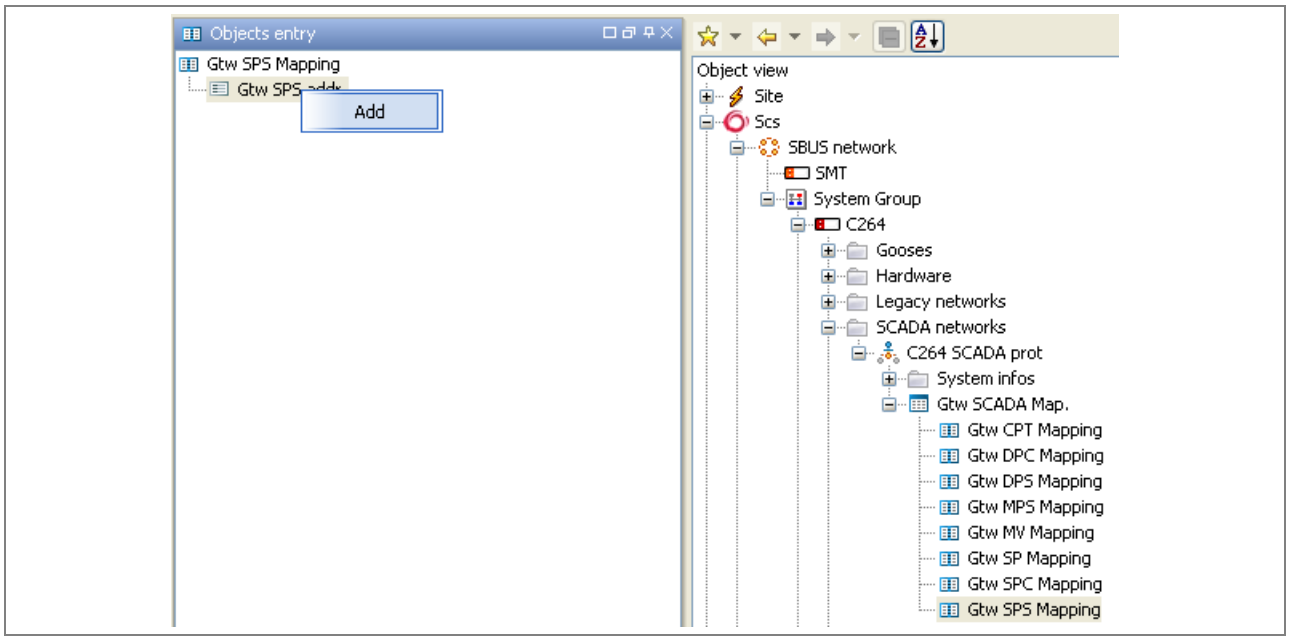


Figure 103: Adding a SCADA SPS address

Once added, SCADA SPS address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification.

For T101/T104 protocol:

(2) **object address**

(3) **Event** (*No* / *Yes with time tag* / *Yes without time tag*): when set to *'Yes with time tag'*, indicates that change of state of the datapoint are transmitted spontaneously with time tag

(4) **Event record** (*Does not involved in a transfer of file* / *Create a RECORD EVENT if there is not it current* / *Add to the current record EVENT* / *Create a RECORD EVENT and adds to the current record EVENT*): when set to a value different from 'Does not involved in a transfer of file', indicates if change of state of the datapoint must be saved in Sequence of Event file. At C26x level, values different from 'Does not involved in a transfer of file' are associated with the same treatment, because only one SOE file is managed by C26x. The set of available values is maintained for compatibility with DS Agile gateway addressing in a DS Agile gateway

(5) **Inversion** (*No* / *Yes*): Indicates that the datapoint value needs to be inverted before transmission

(6) **Background scan** (*No* / *Yes*): indicates if the datapoint belongs to the background scan cycle

(7) **Group ([0..16)] / 0=no group)**: indicates to which "T101/T104 General Interrogation group" the datapoint is assigned. 0 means 'no group' assignation

For DNP3 protocol:

(8) object address - index

(9) **Event** (*No* / *Yes with time tag*): when set to *'Yes with time tag'*, indicates if change of state of the datapoint are transmitted spontaneously with time Tag

(10) **Inversion** (*No* / *Yes*): indicates that the datapoint value needs to be inverted before transmission

For Modbus protocol:

(11) **object address – register**

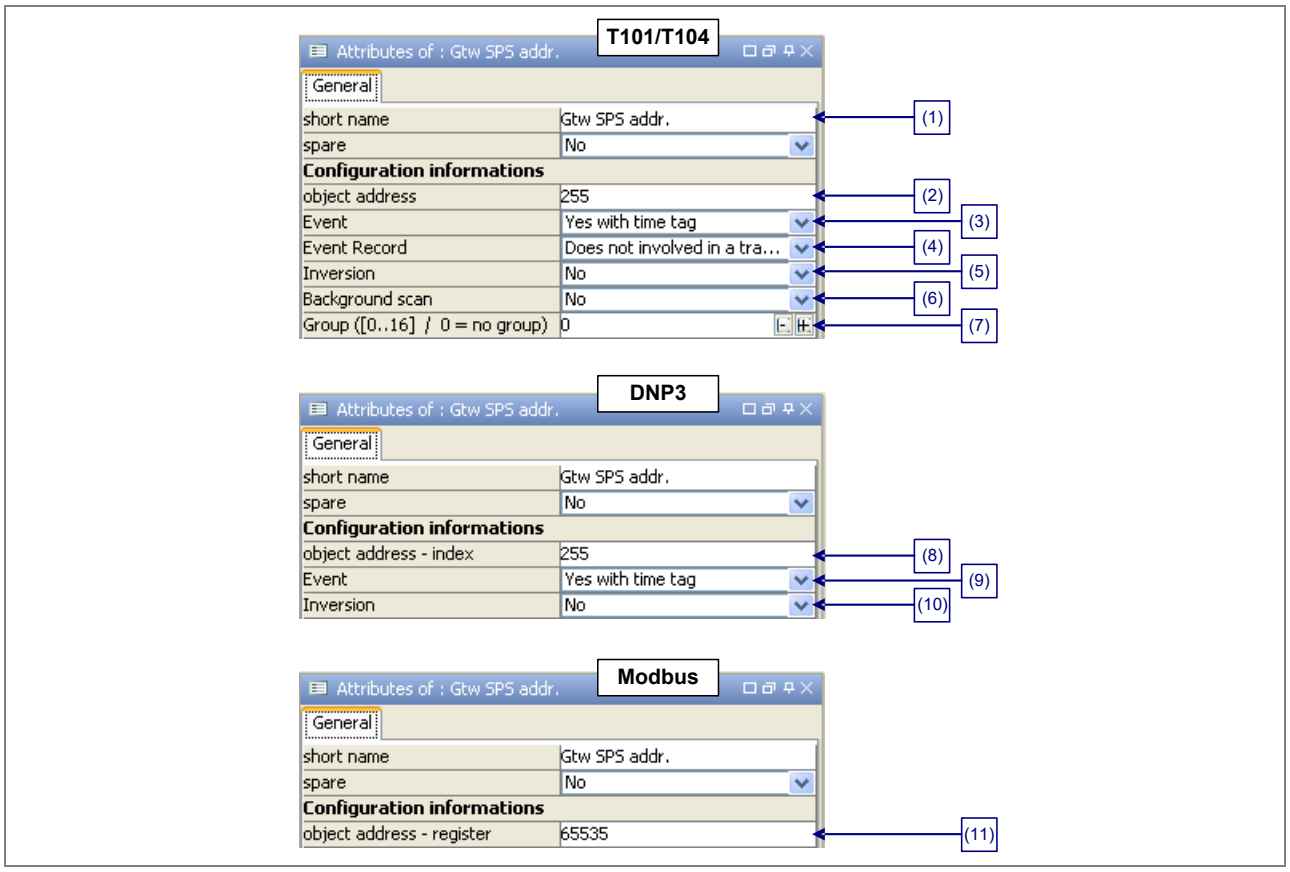


Figure 104: Defining a SCADA address for an SPS datapoint

3.7.2.3 DEFINING A SCADA ADDRESS FOR A DPS DATAPOINT

A SCADA address is added to a DPS datapoint from the contextual **Objects entry** window at the SCADA DPS mapping level:

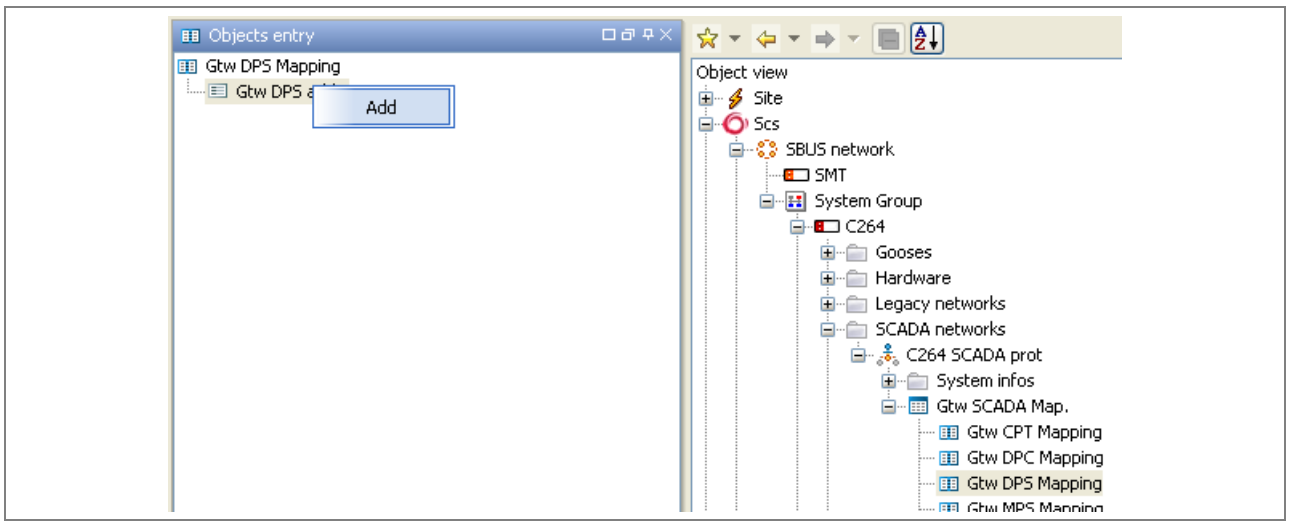


Figure 105: Adding a SCADA DPS address

Once added, SCADA DPS address attributes must be set at SCE level:

(1) **short name**: used for internal SCE identification

For T101/T104 protocol:

(2) **Event** (*No* / *Yes with time tag* / *Yes without time tag*): when set to *'Yes with time tag'*, indicates if change of state of the datapoint are transmitted spontaneously with time Tag

(3) **Event record** (*Does not involved in a transfer of file* / *Create a RECORD EVENT if there is not it current* / *Add to the current record EVENT* / *Create a RECORD EVENT and adds to the current record EVENT*): when set to a value different from 'Not involved in a transfer of file', indicates if change of state of the datapoint must be saved in Sequence of Event file. At C26x level, values different from 'Not involved in a transfer of file' are associated with the same treatment, because only one SOE file is managed by C26x. The set of available values is maintained for compatibility with DS Agile gateway addressing in a DS Agile gateway.

(4) **Inversion** (*No* / *Yes*): indicates that the datapoint value needs to be inverted before transmission

(5) **Background scan**: (*No* / *Yes*): indicates if the datapoint belongs to the background scan cycle.

(6) **Group** (0..16): indicates to which "T101/T104 General Interrogation group" the datapoint is assigned. 0 means 'no group' assignation

(7) **object address** (index)

For DNP3 protocol:

(8) **Event** (*No* / *Yes with time tag*): when set to *'Yes with time tag'*, indicates if change of state of the datapoint are transmitted spontaneously with time Tag

(9) **Inversion** (*No* / *Yes*): indicates that the datapoint value needs to be inverted before transmission

(10) **object address - index**

For Modbus protocol:

(11) **double address usage** (*No* / *Yes*): only available for Modbus SCADA protocol. If set to Yes, DPS is transmitted to SCADA via two distinct SCADA address, one for the open state, the other one for the close state

(12) **object address - register**: used if **Double address usage** is set to *No*

(13) **open state address**: used if **Double address usage** is set to *Yes*. This attribute defines the SCADA address for the open state of the DPS

(14) **Closed state address**: used if **Double address usage** is set to *Yes*. This attribute defines the SCADA address for the closed state of the DPS

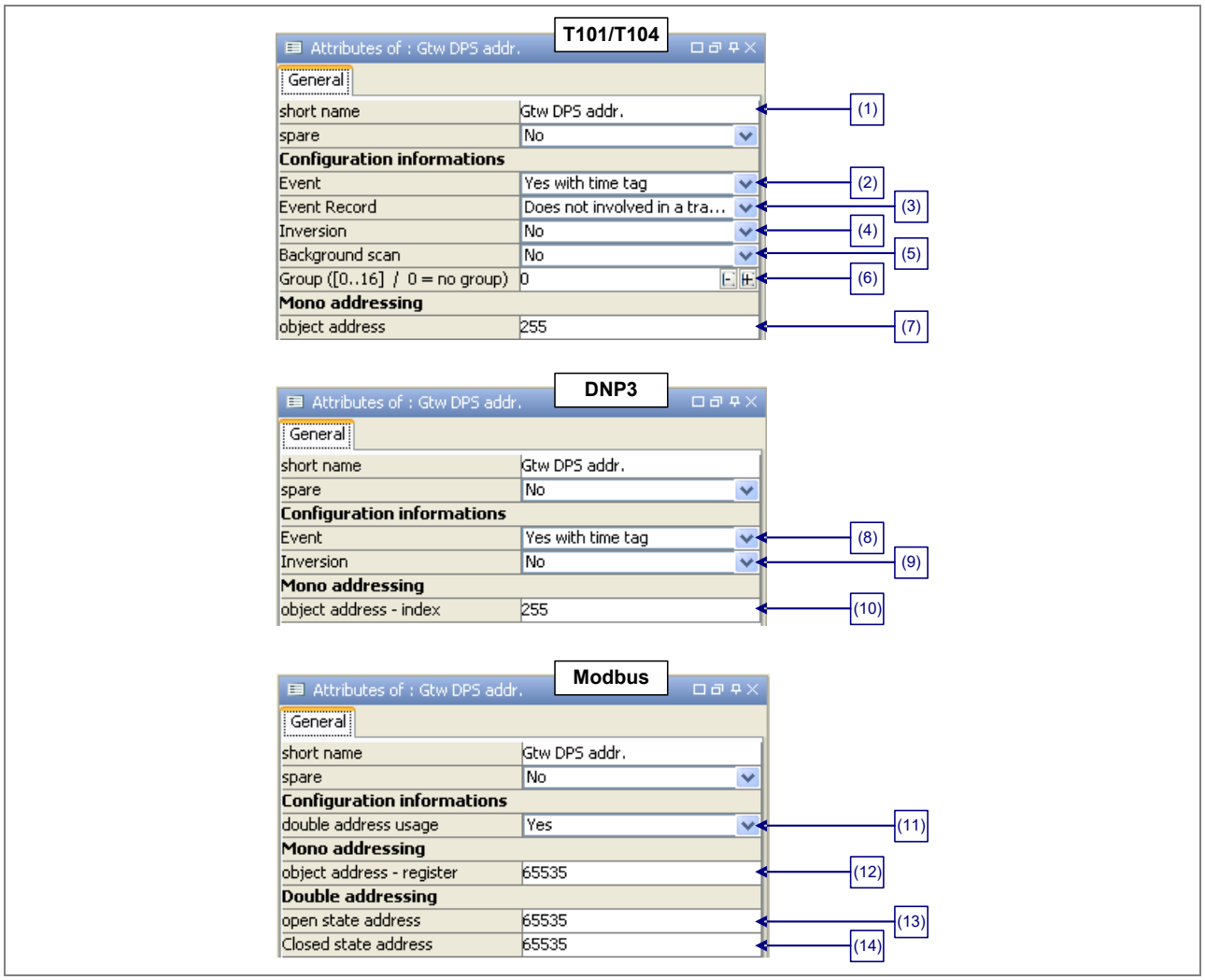


Figure 106: Defining a SCADA address for a DPS datapoint

3.7.2.4 DEFINING A SCADA ADDRESS FOR AN MV DATAPOINT

A SCADA address is added to an MV datapoint from the contextual **Objects entry** window at the SCADA MV mapping level:

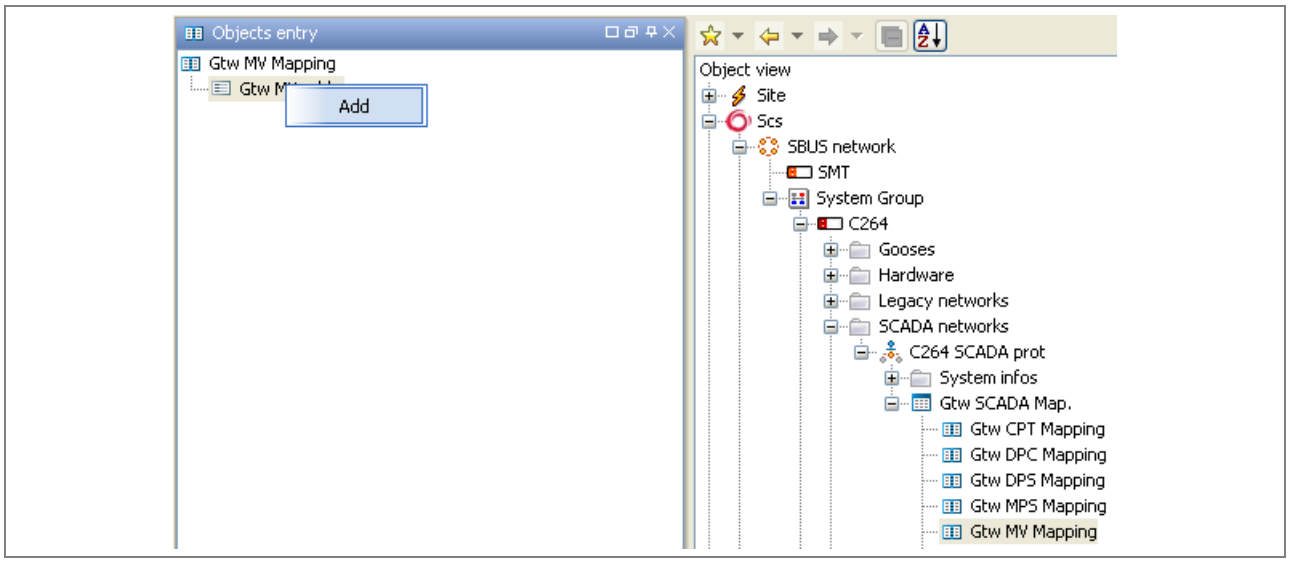


Figure 107: Adding a SCADA MV address

Once added, SCADA MV address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification.

For T101/T104 protocol:

(2) **object address**.

(3) **Event** (*No* / *Yes with time tag* / *Yes without time tag*): when set to *Yes with time tag*, indicates that change of state of the datapoint are transmitted spontaneously with time Tag.

(4) **Event record** (*No* / *Yes*): indicates if change of state of the datapoint must be saved in Sequence of Event file or not..

(5) **Format** (*Normalized* / *Scaled* / *Short float* / *Normalized unipolar*): transmission format.

(6) **cycle type** (*None* / *Periodic* / *Background scan*): indicates which transmission cycle the MEAS belongs to.

(7) **Group ([0..16)] / 0=no group)**: indicates which “T101/T104 General Interrogation group” the datapoint is assigned to. 0 means ‘no group’ assignation.

For DNP3 protocol:

(8) **object address**

(9) **Event** (*No* / *Yes with time tag*): when set to *Yes with time tag*, indicates if change of state of the datapoint are transmitted spontaneously with time Tag.

(10) **Format** (*Natural* / *Adjusted*).

For Modbus protocol:

(11) **object address** - register

(12) **Format** (*Natural* / *Unsigned normalized* / *Signed normalized /Real IEEE754 – little endian* / *Real IEEE754 – big endian*): transmission format.

(13) **Precision (8..16)**: number of transmitted bits.

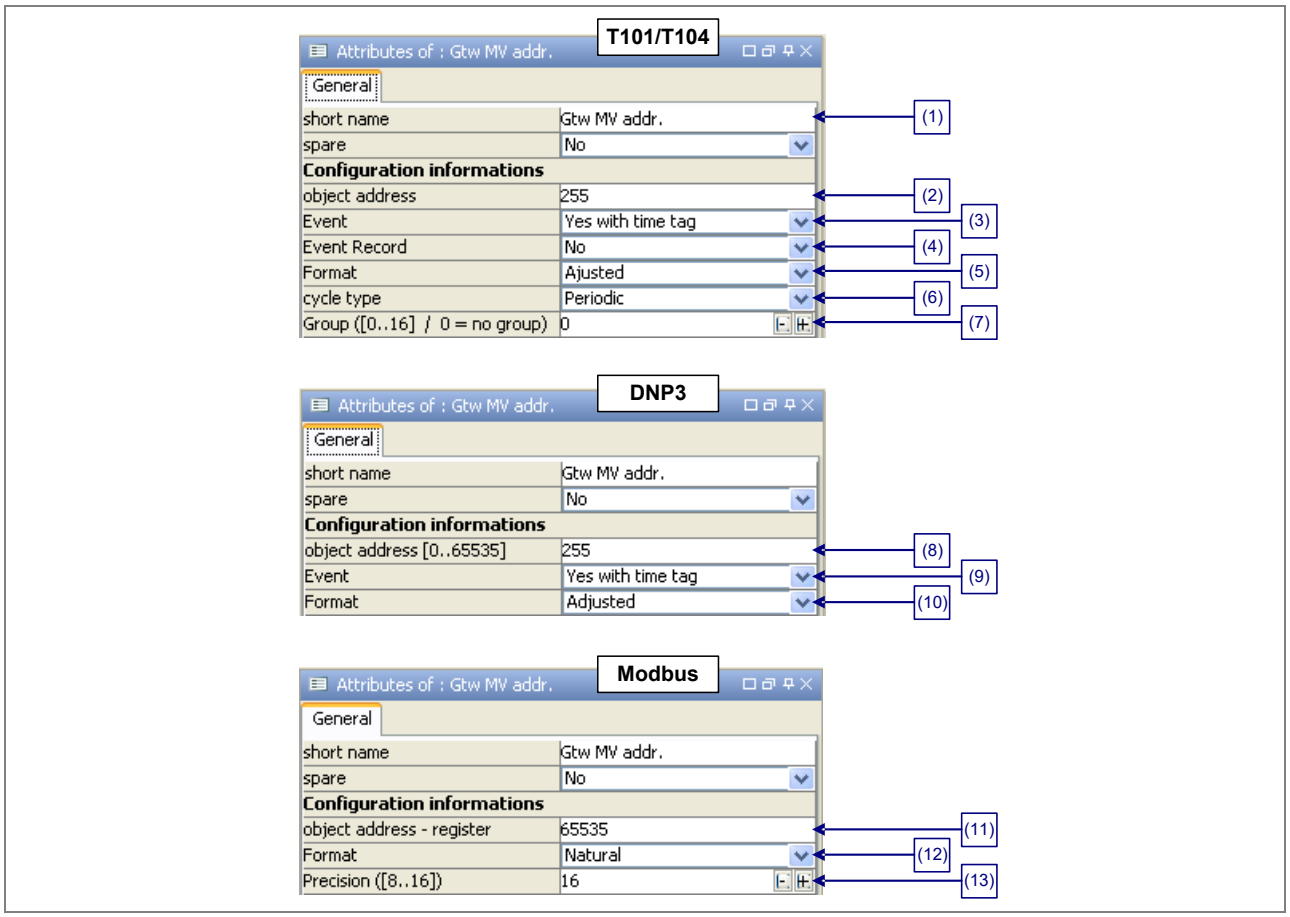


Figure 108: Defining a SCADA address for an MV datapoint

3.7.2.5 DEFINING A SCADA ADDRESS FOR A COUNTER DATAPOINT

A SCADA address is added to a Counter datapoint from the contextual **Objects entry** window at the SCADA Counter mapping level:

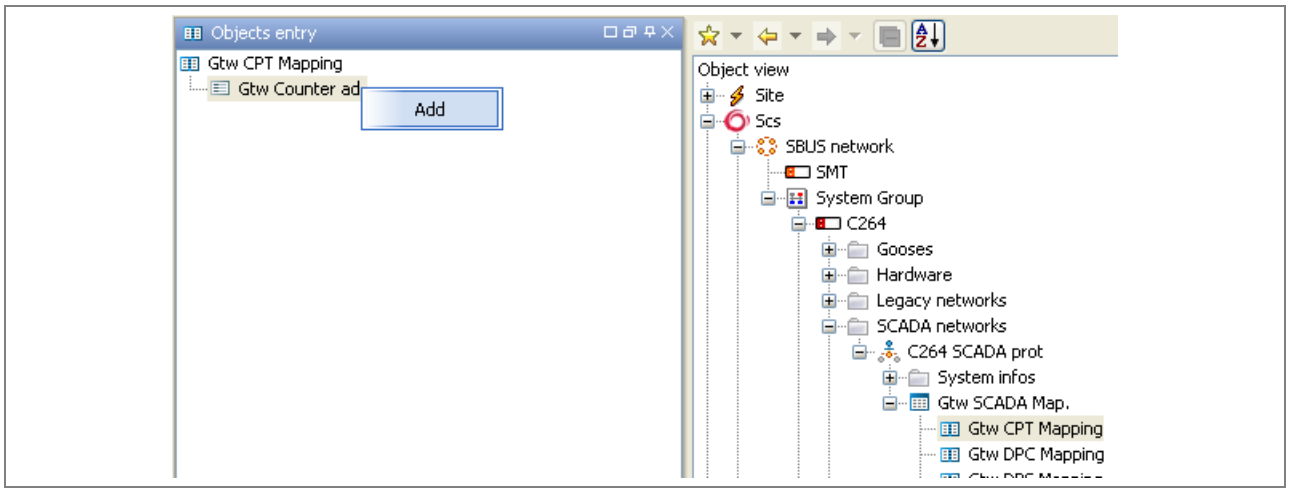


Figure 109: Adding a SCADA counter address

Once added, SCADA Counter address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification.

For T101/T104 protocol:

(2) **object address**.

(3) **Event** (*No* / *Yes with time tag* / *Yes without time tag*): when set to 'Yes with time tag', indicates if changes of state of the datapoint are transmitted spontaneously with time Tag.

(4) **Group ([0..4] / 0=no group)**: indicates which "T101/T104 General Interrogation group" the datapoint is assigned to. 0 means 'no group' assignation.

For DNP3 protocol:

(5) **object address**.

(6) **Event** (*No* / *Yes with time tag*): when set to *'Yes with time tag'*, defines if change of state of the datapoint are transmitted spontaneously with time Tag.

For Modbus protocol:

(7) **object address - register**

(8) **Format** (*Natural* / *Unsigned normalized* / *Real IEEE754 – little endian* / *Real IEEE754 – big endian*): transmission format.

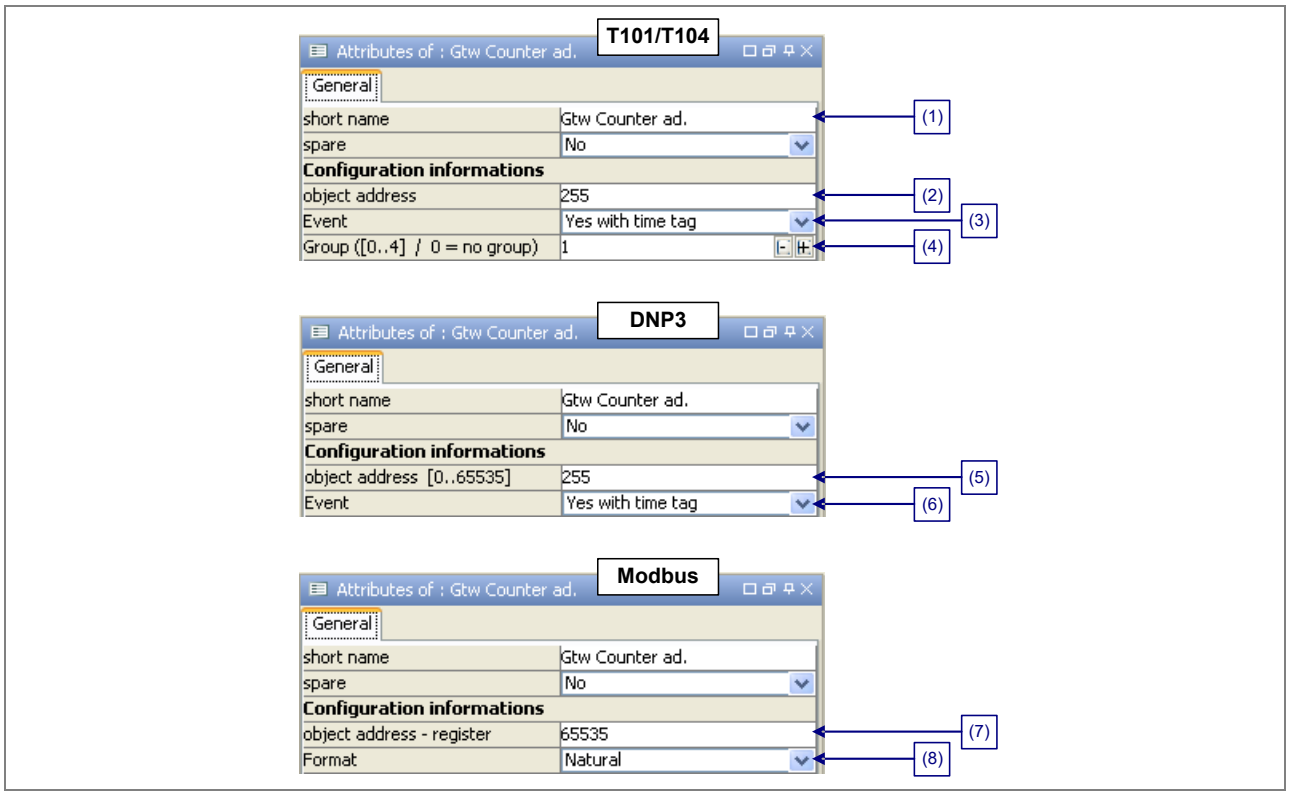


Figure 110: Defining a SCADA address for a Counter datapoint

3.7.2.6 DEFINING A SCADA ADDRESS FOR AN SPC DATAPOINT

A SCADA address is added to an SPC datapoint from the contextual **Objects entry** window at the SCADA SPC mapping level:

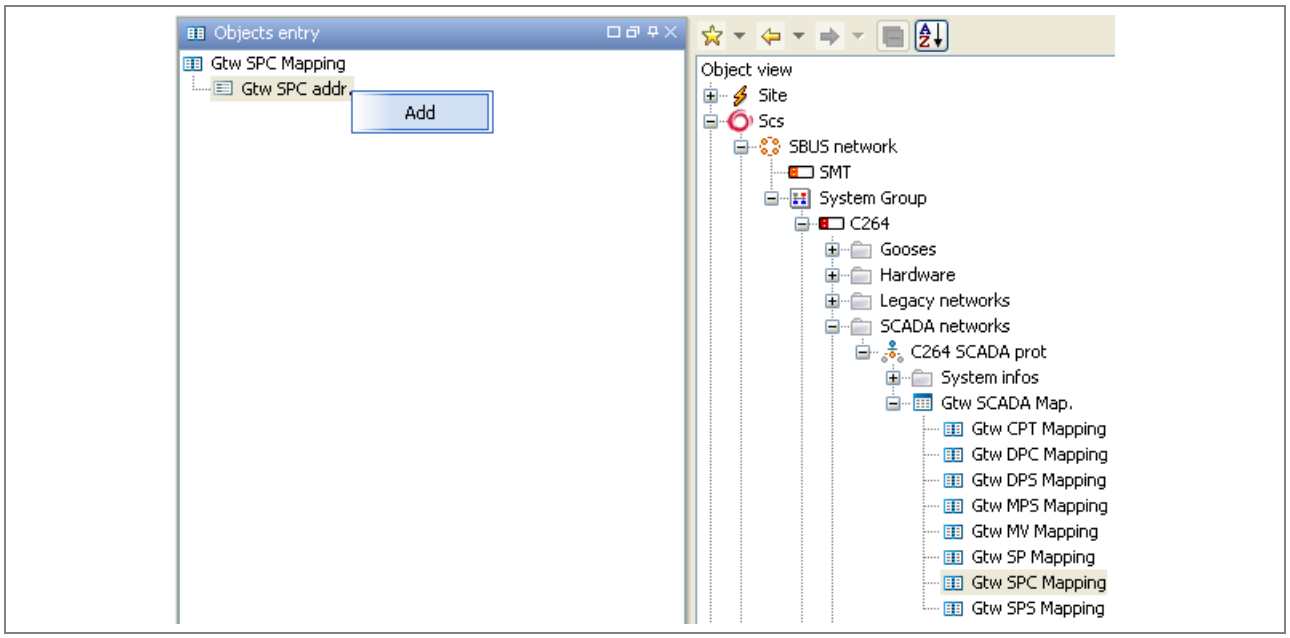


Figure 111: Adding a SCADA SPC address

Once added, SCADA SPC address attributes must be set at SCE level:

(1) **short name**: used for internal SCE identification.

For T101/T104 protocol:

(2) **object address**

(3) **SCADA execute order type** (*Select execute* / *Direct execute*): defines if SCADA uses a *'Select execute* or a *'Direct execute'* sequence to send a control to the datapoint.

For DNP3 protocol:

(4) **object address**

(5) **SCADA execute order type** (*Select execute* / *Direct execute*): defines if SCADA uses a *'Select execute* or a *'Direct execute'* sequence to send a control to the datapoint.

For Modbus protocol:

(6) **object address - register.**

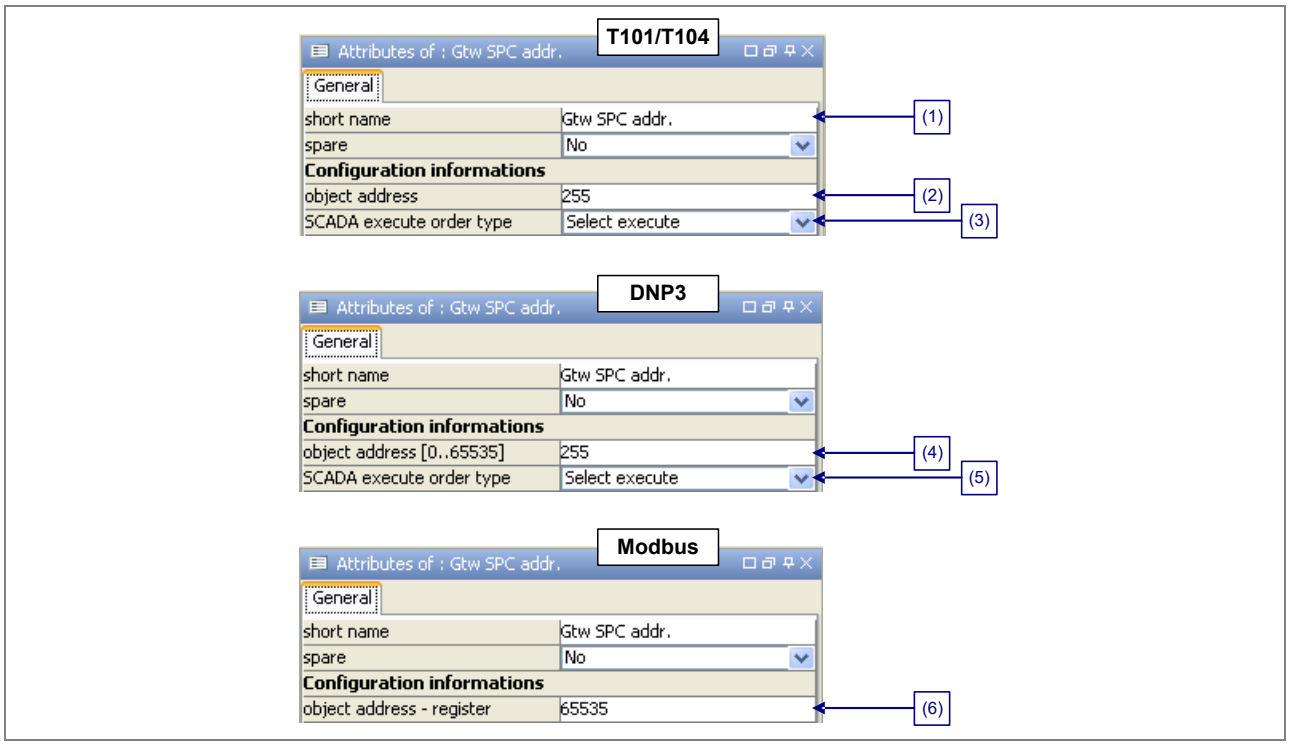


Figure 112: Defining a SCADA address for an SPC datapoint

3.7.2.7 DEFINING A SCADA ADDRESS FOR A DPC DATAPOINT

A SCADA address is added to a DPC datapoint from the contextual **Objects entry** window at the SCADA DPC mapping level:

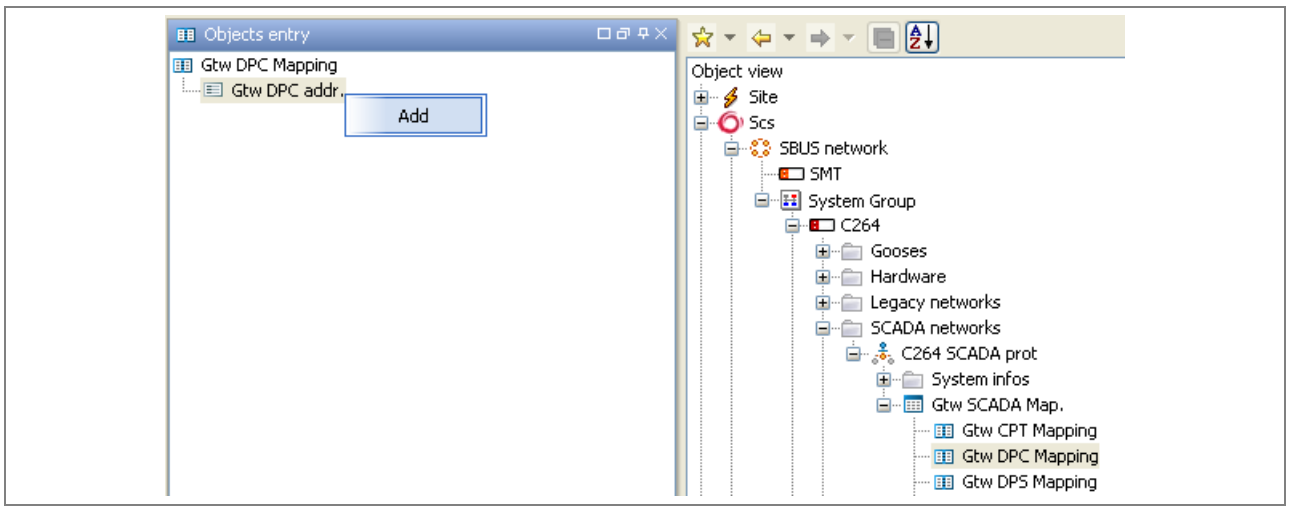


Figure 113: Adding a SCADA DPC address

Once added, SCADA DPC address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification

For T101/T104 protocol:

(2) **object address**

(3) **SCADA execute order type** (*Select execute* / *Direct execute*): defines if SCADA uses a *'Select execute* or a *'Direct execute'* sequence to send a control to the datapoint

For DNP3 protocol:

(4) **object address in [0..65535]**

(5) **SCADA execute order type** (*Select execute* / *Direct execute*): defines if SCADA uses a *'Select execute* or a *'Direct execute'* sequence to send a control to the datapoint

For Modbus protocol:

(6) **object address - register**

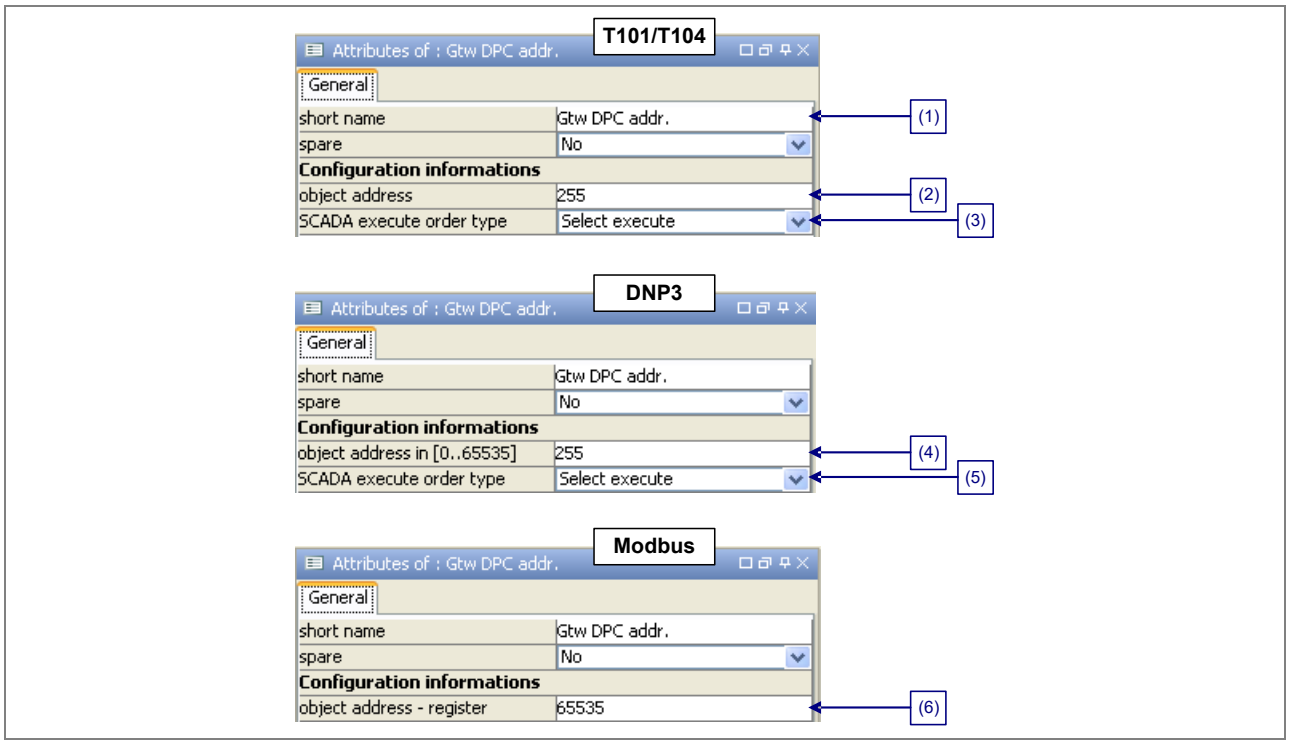


Figure 114: Defining a SCADA address for a DPC datapoint

3.7.2.8 DEFINING A SCADA ADDRESS FOR A SETPOINT DATAPOINT

A SCADA address is added to a SetPoint datapoint from the contextual **Objects entry** window at the SCADA SetPoint mapping level:

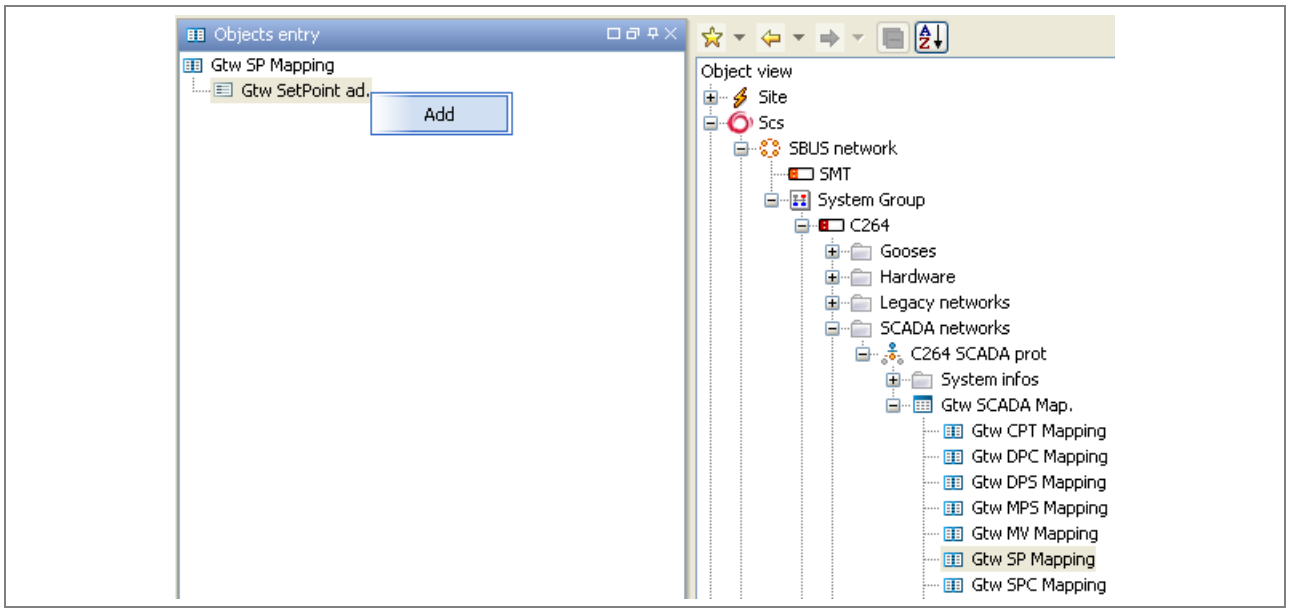


Figure 115: Adding a SCADA setpoint address

Once added, SCADA SetPoint address attributes must be set at SCE level:

(1) **short name** of the address used for internal SCE identification

For T101/T104 protocol:

(2) **object address**

(3) **SCADA execute order type** (*Select execute* / *Direct execute*): this attribute defines if SCADA uses a *'Select execute* or a *'Direct execute'* sequence to send a control to the datapoint

(4) **Minimal value**: available minimal value on the protocol (used for scaling and checks)

(5) **Maximal value**: available maximal value on the protocol (used for scaling & checks)

(6) **Format** (*Normalized* / *Scaled* / *Short float*)

For DNP3 protocol:

(7) **object address [0..65535]**.

(8) **SCADA execute order type** (*Select execute* / *Direct execute*): defines whether SCADA uses a *'Select execute* or a *'Direct execute'* sequence to send a control to the datapoint

(9) **minimal value**: available minimal value on the protocol (used for scaling and checks)

(10) **maximal value**: available maximal value on the protocol (used for scaling and checks)

(11) **format** (*Natural* / *Adjusted*)

For Modbus protocol:

(12) **object address - register**.

(13) **format**.(*signed 16 bits* / *Real IEEE754 – little endian: the lower byte is transmitted first* / *Real IEEE754 – big endian: the higher byte is transmitted first*)

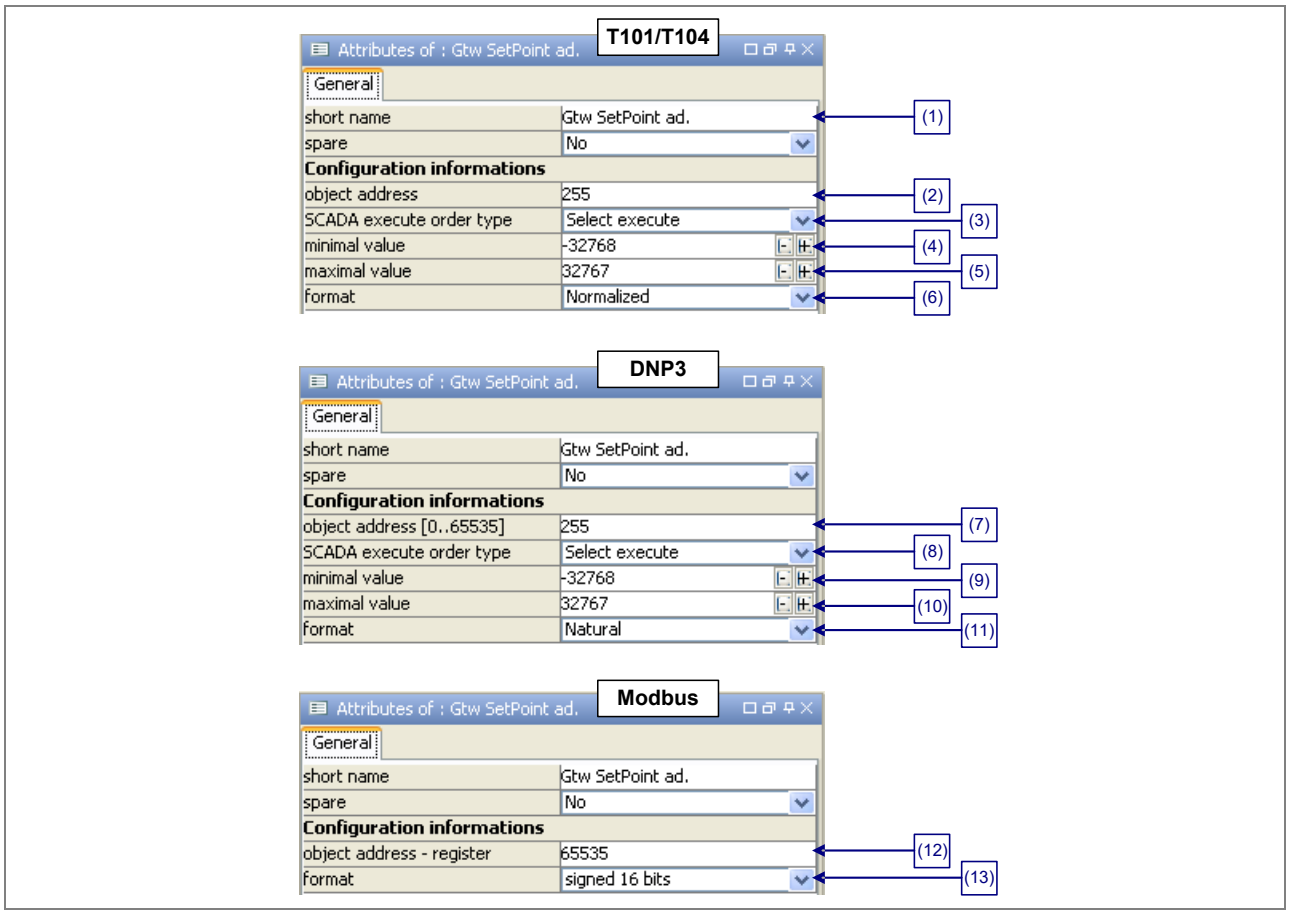


Figure 116: Defining a SCADA address for a SetPoint datapoint

3.7.2.9 DEFINING A SCADA ADDRESS FOR SYNCHROCHECK BYPASS

For details on synchronized circuit-breakers, see section *5.2 Defining a Synchrocheck function*.

A synchronized circuit-breaker can be controlled through a SCADA network. In this case, the SPC (resp. DPC) control of the synchronized breaker is linked to a SCADA SPC (resp. DPC) address. As bypassing synchrocheck is not implemented in SCADA protocol, an extra SCADA SPC (resp. DPC) address that bypasses the synchrocheck must be given to the SPC (resp. DPC) control of the breaker. At SCE level, this extra address is linked to the SCADA address of the SPC (resp. DPC) of the synchronized breaker.

To define a SCADA address for bypass synchrocheck:

- Create the SCADA SPC/DPC address (A) to send SPC/DPC to the synchronized CB
- Create a SCADA SPC/DPC address (B) to bypass synchrocheck in the SCADA mapping
- Add the relation **has for bypass synchrocheck address** via the **Objects entry** window at SCADA address (A) and fill it with the SCADA address (B)

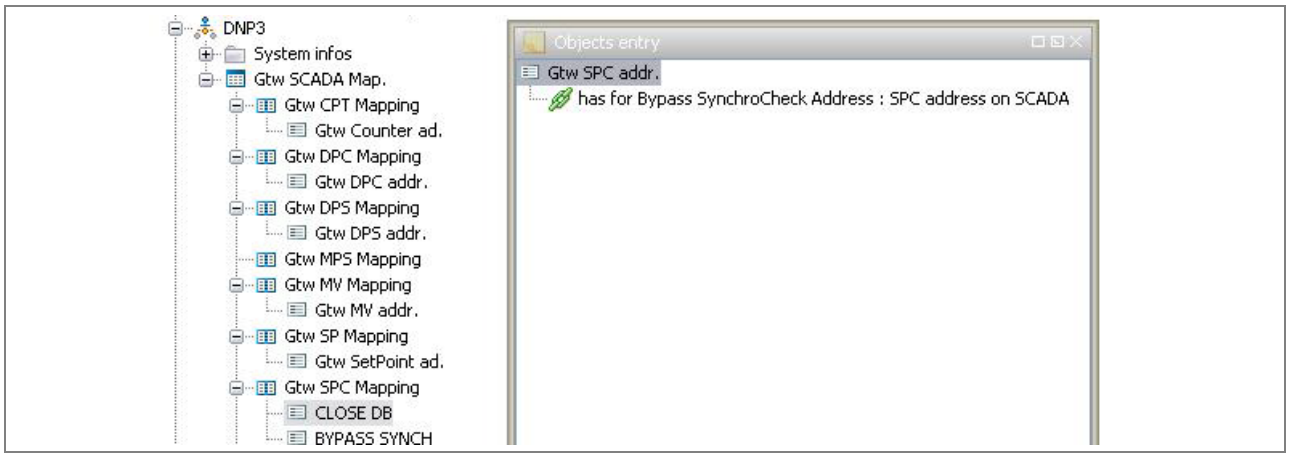


Figure 117: Linking a synchrocheck bypass address to a SCADA SPC/DPC address (example for a DPC datapoint)

3.7.3 ADDRESSING A DATAPOINT ON A SCADA LEGACY NETWORK

For details about datapoints, see section *4 Defining a datapoint*.

To exchange datapoint values between station-bus sub-systems and a SCADA, datapoints must be linked to specific SCADA addresses, by adding at datapoint level the relation **has for SCADA address** (1) and filling it with the corresponding SCADA address in a pre-configured SCADA address mapping (see section *3.7.2 Defining the address map of a SCADA network*, for SCADA mapping definition).

Addressing an MPS datapoint on the SCADA legacy network is not available.

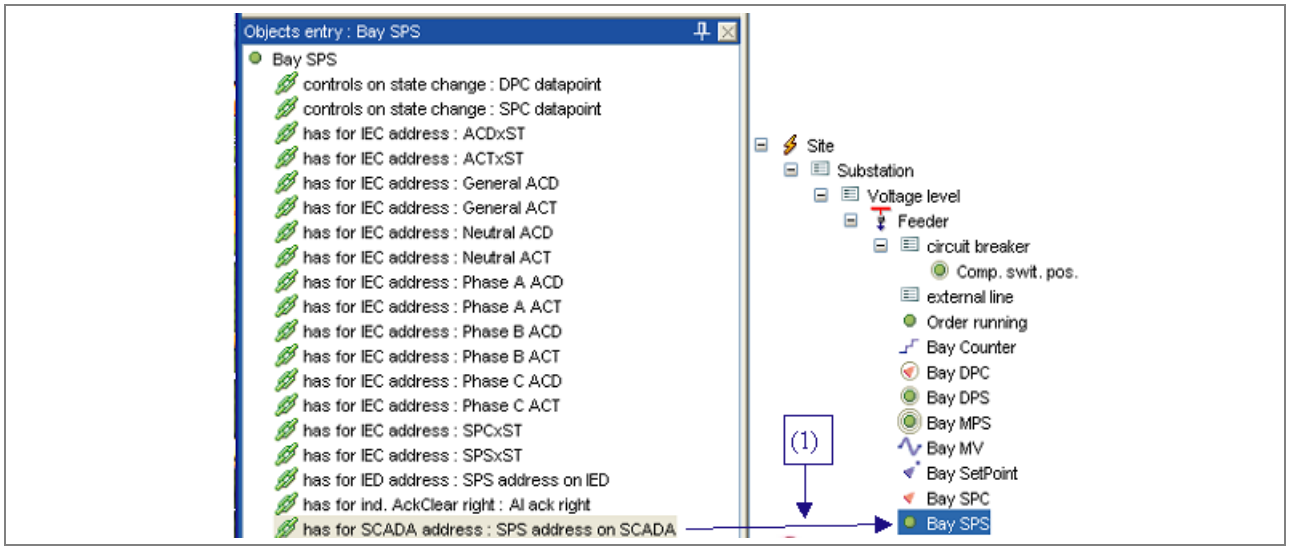


Figure 118: SCADA addressing of a datapoint (example for Bay SPS datapoint)

3.8 DEFINING THE MANAGEMENT OF WAVEFORM RECORDS

The C26x units manage two types of wave recording files:

- IED connected to C26x legacy network can produce disturbance files. In that case, C26x monitors their availability. As soon as available, they are uploaded and stored at C26x level. The C26x computes for System Management Tool (SMT) a real-time data on a per IED basis that gives the availability of a disturbance file, via station-bus network. Then, SMT downloads it from C26x. At the end of successful downloading, C26x erases the real-time data of availability.
- Via a CT/VT board (TMU210/220), C26x can manage its own waveform record files. Waveform channels are directly acquired on CT/VT board channels and buffered. Triggered by pre-defined change of state, associated buffers are flushed on files that correspond to waveform record files. In that case C26x computes for SMT a real-time data that gives the availability of a C26x waveform record file, via station-bus network. Then processing is similar to the IED's file.

3.8.1 DEFINING THE MANAGEMENT OF IED DISTURBANCE RECORDS

Allowing C26x to manage IED disturbance is done at IED configuration level by:

- Setting its 'automatic disturbance' attribute to yes.
- Adding RDRE brick (1) for the IED in LD0 logical device of the IEC 61850 mapping of the C26x.
- Adding the system SPS datapoint 'DREC ready' (2) at IED level, linked to a pre-defined datapoint profile.
- Fill the mandatory IEC address for this datapoint, with the relevant data object of the RDRE brick (3).

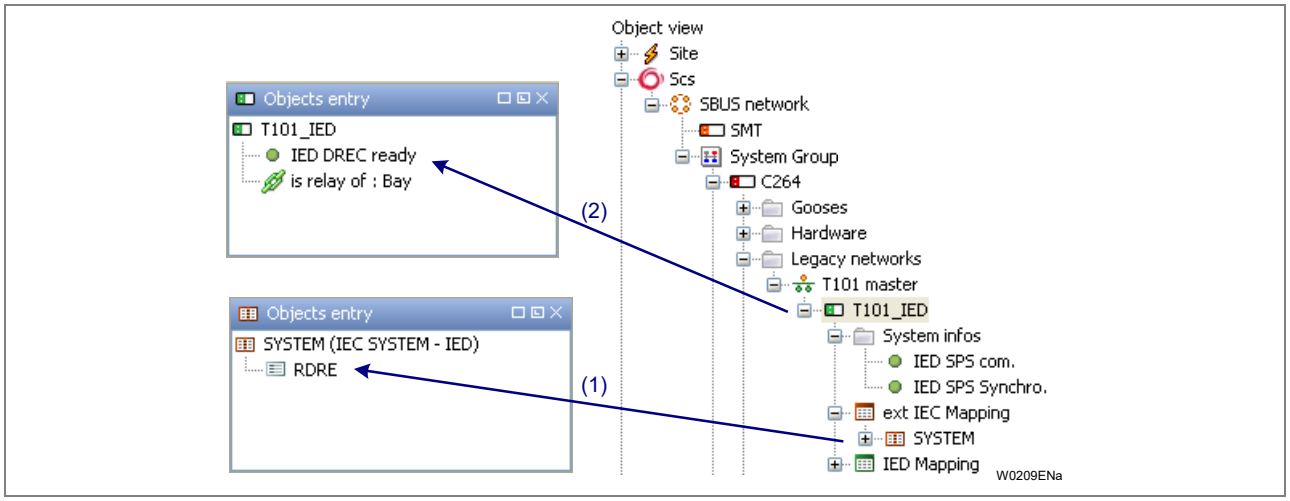


Figure 119: Adding an RDRE brick and a DREC ready datapoint to an IED

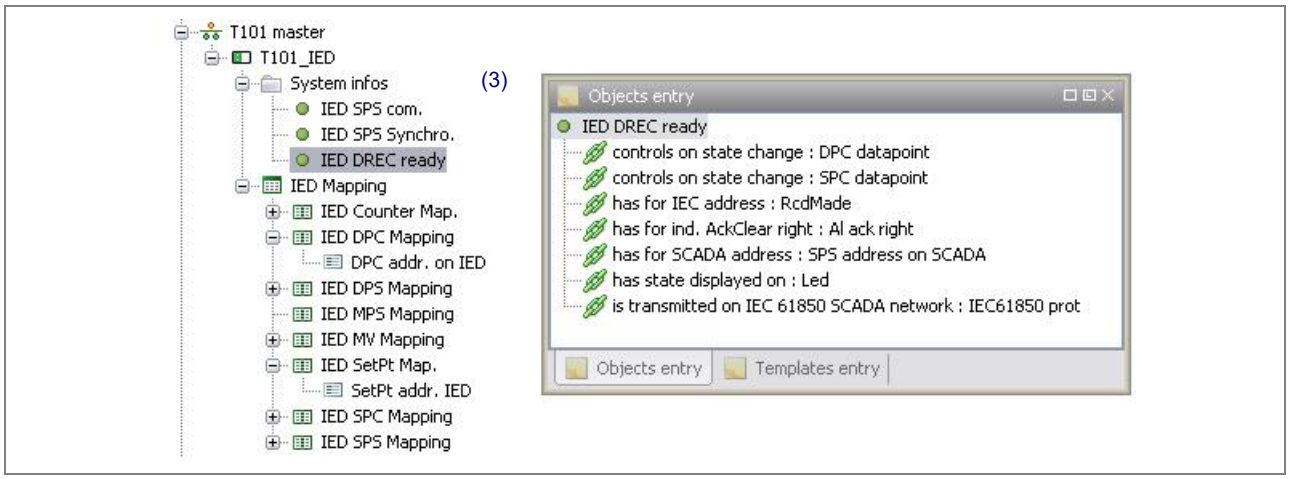


Figure 120: Setting the IEC 61850 address of an IED's DREC Ready datapoint

For T103 IEDs, extra information must be configured to process correct disturbance file COMTRADE structure at C26x level (see following section).

3.8.2 DEFINING T103 IED EXTRA INFORMATION FOR DISTURBANCE RECORDS

T103 extra information for disturbance files is located at the T103 acquisition type and concerns the definition of analog/digital channels, stored in disturbance files, relatively to the COMTRADE format.

3.8.2.1 ADDING AN ANALOG CHANNEL

To add an analog channel definition under a T103 network, select the T103 acquisition type level and add an analog channel from the contextual **Objects entry** window. Up to 15 analog channels can be created under a T103 acquisition type.

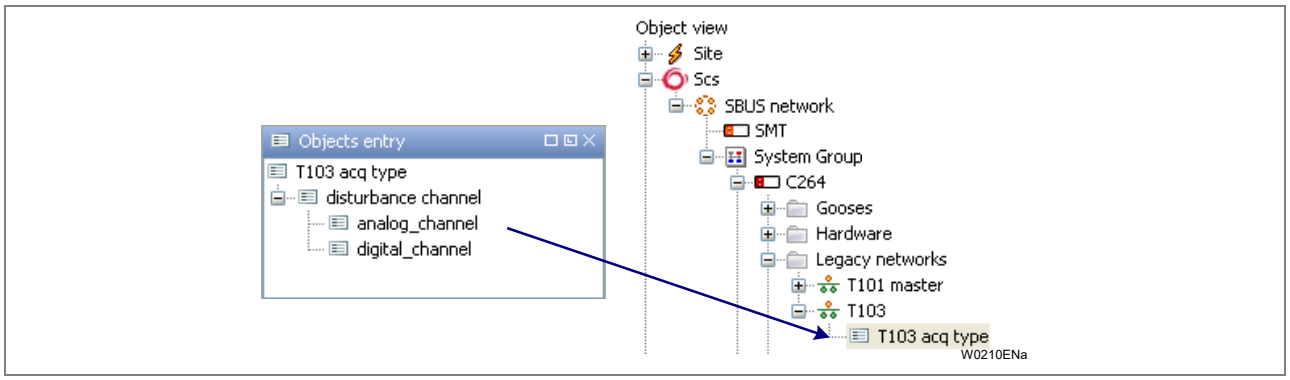


Figure 121: Adding a T103 analog channel

Once added, channel definition attributes must be set at SCE level:

(1) **channel label**

(2) **long name** of the channel used for internal SCE identification

(3) **phase name**: label of the phase corresponding to the channel

(4) **channel number**: (cf. mapping IED– field *ACC* in IEC 60870-5-103 documentation)

(5) **unit**: unit corresponding to the channel

(6) **coefficient (0: not used)**: value which the samples must be multiplied by in order to get the real value (0: not used). Generally, data uploaded from IED allows to compute this 'multiply coefficient'. Unfortunately, some IED don't give correct data. In this case, this coefficient must be set here

(7) **shift time** (range [0 s, 1 s], step 1 µs): elapsed time since the beginning of the sampling period

(8) **maximal sample value** (range [0 , 32767], step 1)

(9) **minimal sample value** (range [-32768, 0], step 1)

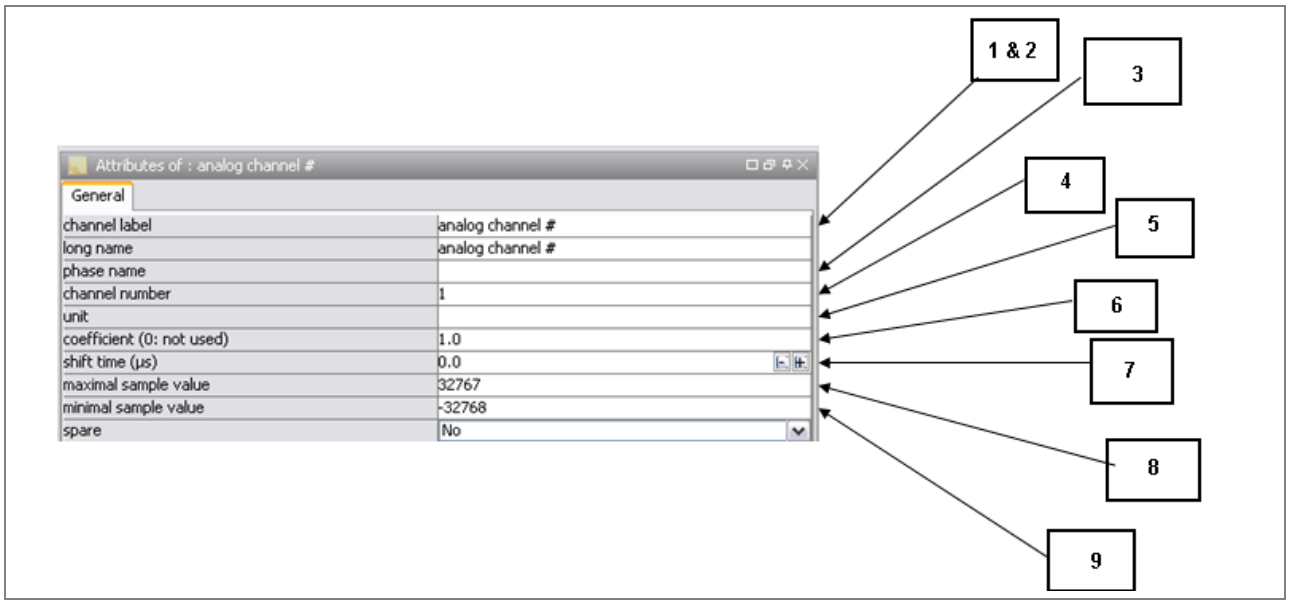


Figure 122: Setting a T103 analog channel

For details about analog channel definition, refer to COMTRADE (IEEE C37.11) document.

3.8.2.2 ADDING A DIGITAL CHANNEL

To add a digital channel definition under a T103 network, select the T103 acquisition type level and add a digital channel from the contextual **Objects entry** window. Up to 255 digital channels can be created under a T103 acquisition type.

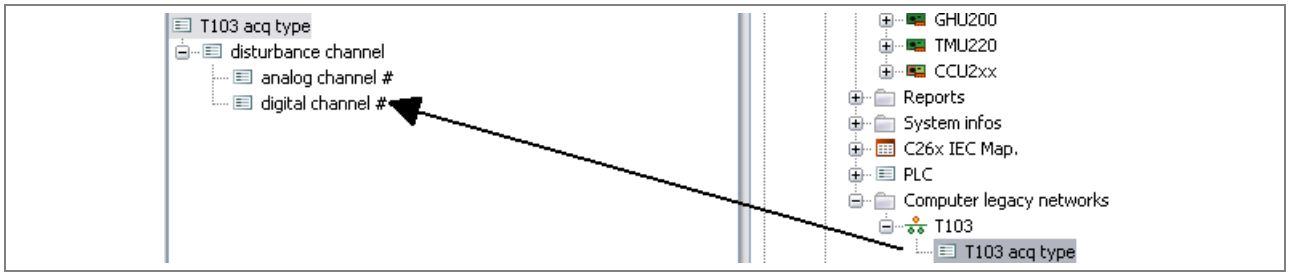


Figure 123: Adding a T103 digital channel

Once added, channel definition attributes must be set at SCE level:

(1) **channel label**

(2) **long name** of the channel used for internal SCE identification

(3) **function number** (range [0 , 255], step 1): corresponds to function type of the channel in T103 protocol

(4) **information number** (range [0 , 255], step 1): corresponds to information number of the channel in T103 protocol

(5) **default state** (*Off* / *On*)

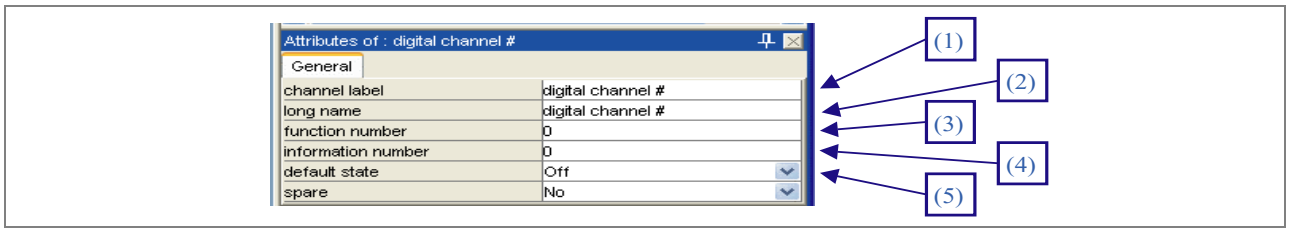


Figure 124: Setting a T103 digital channel

For details about digital channel definition, refer to COMTRADE (IEEE C37.11) document.

3.8.3 DEFINING THE MANAGEMENT OF WAVEFORM RECORDS ACQUIRED VIA THE C26X'S CT/VT BOARD

Allow the C26x to manage its own wave record file at C26x configuration level by:

- defining a fast and/or slow waveform recording (see following sections):
  - fast waveform recording gives access to samples acquired via the CT/VT board.
  - slow waveform recording gives access to analogue (MV) and digital values (SPS, DPS, SPC, DPC) file recording.
- adding the system SPS datapoint 'DREC ready' (1) at C26x level, linked to a pre-defined datapoint profile.

The RDRE brick (2) for the C26x in LD0 logical device of the IEC 61850 mapping of the C26x and the address (3) are added automatically.

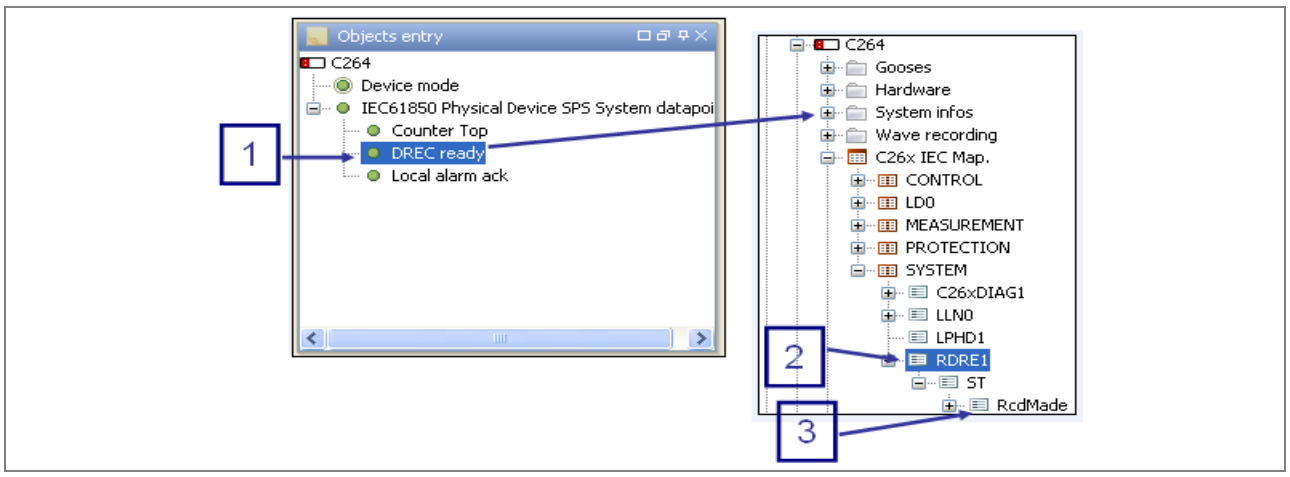


Figure 125: RDRE IEC 61850 brick and its address

3.8.3.1 DEFINING FAST WAVEFORM RECORDING

The inputs for the fast waveform records are up to 4 CT samples and 4 VT samples, and the values of selected digital SPS, DPS, SPC or DPC datapoints (for more details about datapoints, see section *4 Defining a datapoint*). Up to 128 digital datapoints can be captured. The choice of selected inputs/outputs is defined in configuration.

The waveform recorder provides up to 8 CT/VT channels and up to 128 digital datapoints for extraction by SMT.

A maximum of 480 cycles (9.6 seconds at 50 Hz) of measurements samples, with 32 samples per cycle, can be stored, divided in 1, 2, 4 or 8 files saved in flash disk.

A timer channel is also required to provide accurate timing information for each sample. The time between two samples is assumed constant over a single cycle.

Number of files	Number of cycles
8	60
4	120
2	240
1	480

The waveform recorder can be triggered by the following events, each of which is user-configurable:

- Changes in state of binary inputs (SPS or DPS datapoint)
- Changes in state of digital outputs (SPC or DPC datapoint)
- Measurement threshold violations (MV datapoint)
- Operator request

Only one re-trigger is allowed: it means that a new trigger can only be accepted after the end of recording of the current waveform.

Waveform records are available in COMTRADE 2001 format.

To add fast waveform recording to a C26x, select the C26x level and add a **Wave fast record** field from the contextual **Objects entry** window. Only one fast waveform recording item can be created under a C26x.

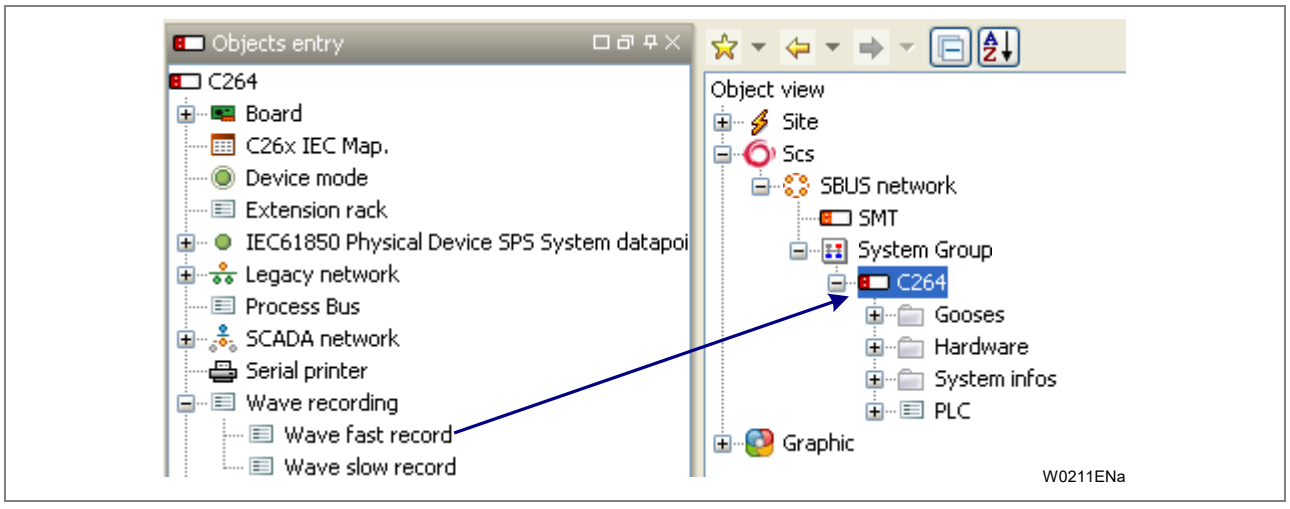


Figure 126: Adding a fast waveform recording

Once added, fast waveform recording attributes must be set at SCE level:

(1) **short name** and **long name**: used for internal SCE identification

(2) **pre-trigger cycle** (range [1, 480], step 1): number of cycles (up to 480), that are stored before triggering

(3) **total cycles** (range [1 , 480], step 1): see previous description

(4) **number of files** (1 / 2 / 4 / 8): see previous description

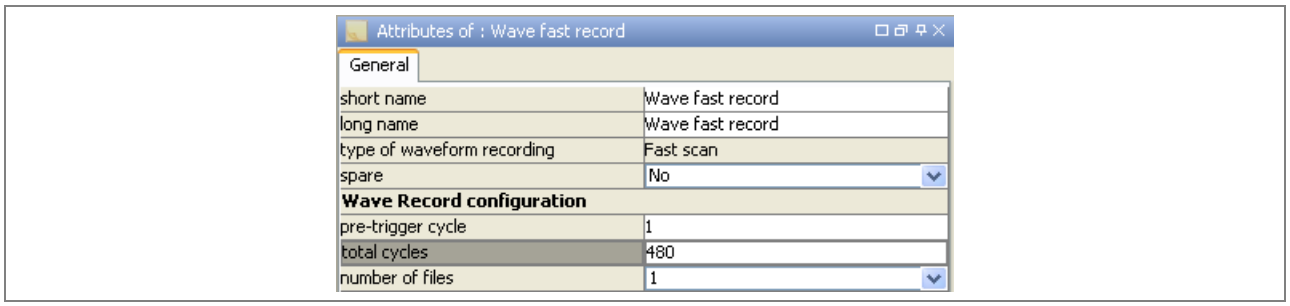


Figure 127: Setting a fast waveform recording

To define the inputs of a fast waveform recording, select the recording level, add the relevant relation and fill in the relation with the proper CT/VT channel or datapoint. Be careful, only CT/VT channels and datapoints acquired on the C26x can be defined as inputs of its fast waveform recording.

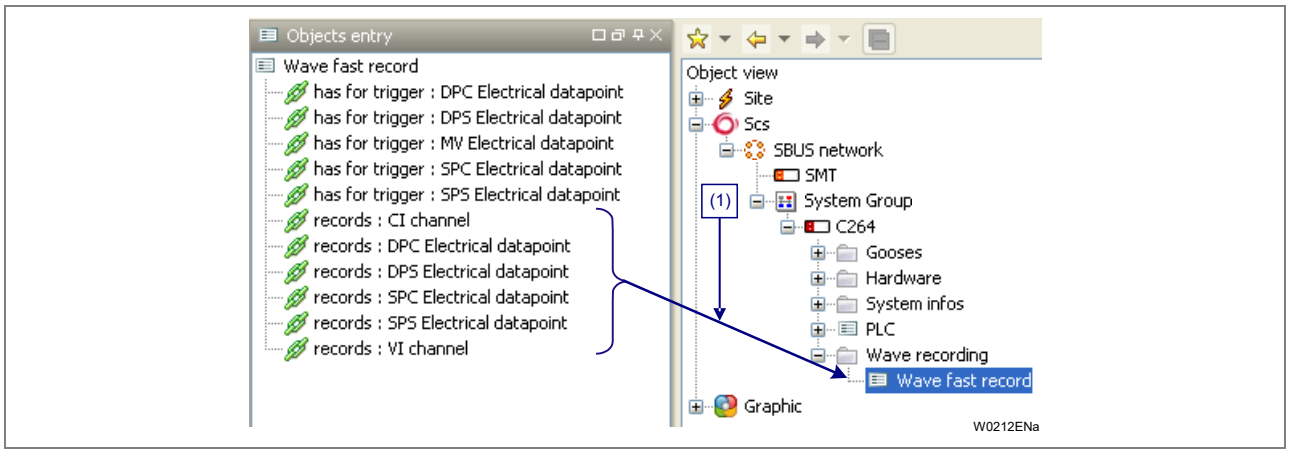


Figure 128: Defining inputs for fast waveform recording

To define the triggers of a fast waveform recording, select the recording level, add the relevant relation (2) and fill in the relation with proper datapoint. Be careful, only datapoints acquired on the C26x can be defined as input of its fast waveform recording.

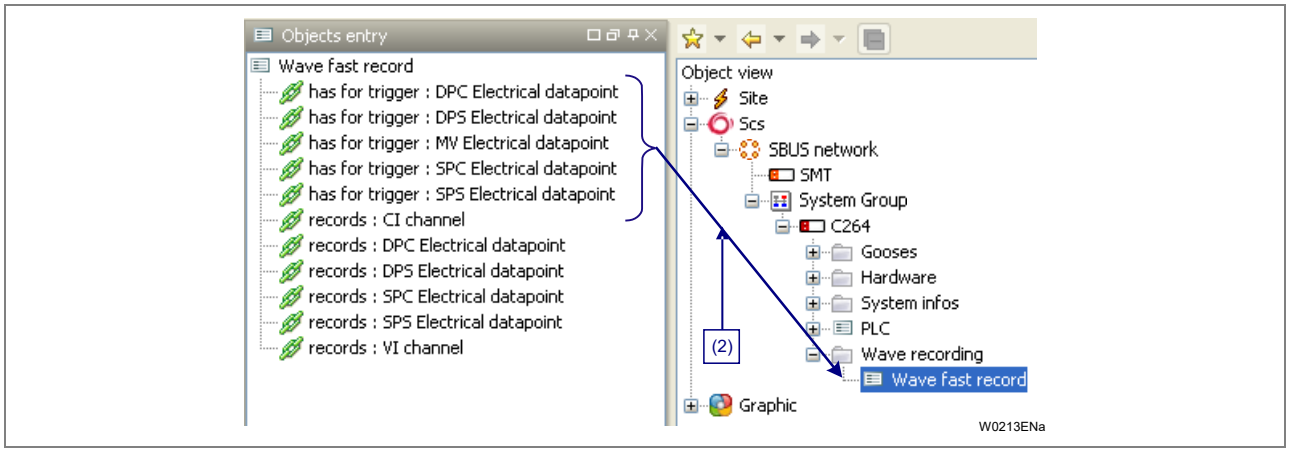


Figure 129: Defining triggers for fast waveform recording

Depending on the datapoint type, extra attributes must be set for **has for trigger** relation. These attributes give the datapoint states (or thresholds for MV) that trigger the record:

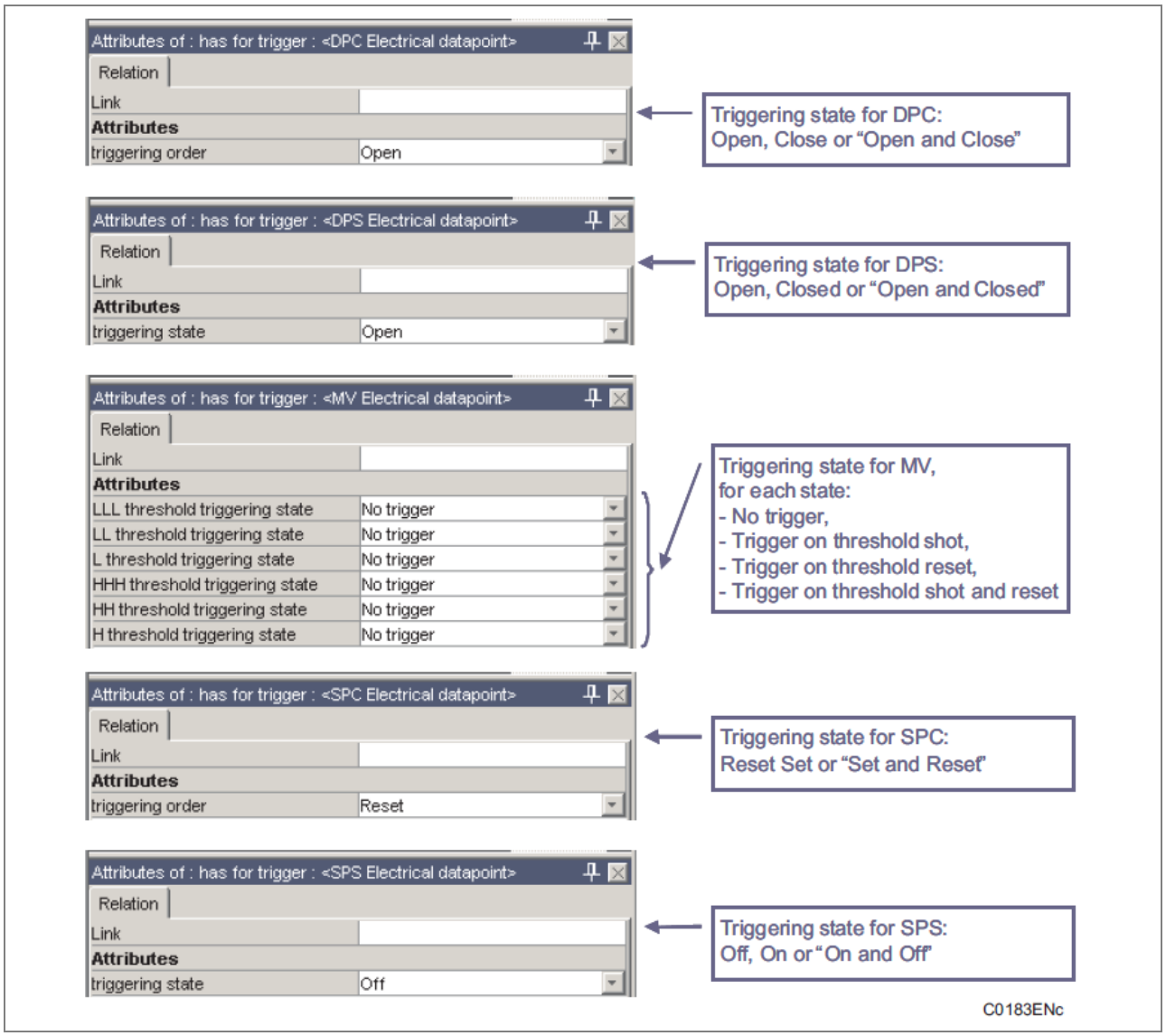


Figure 130: Defining trigger conditions for fast waveform recording

Configuration rules and checks

- The following constraints between the attributes must be respected:
  - "pre-trigger cycle" ≤ "total cycles"
  - "number of files" ∗ "total cycles" ≤ 480 cycles

3.8.3.2 DEFINING SLOW WAVEFORM RECORDING

The inputs for the slow waveform records are:

- MV datapoint coming from CT VT computation.
- MV datapoint coming from AIU boards.
- SPS or DPS datapoints.
- SPC or DPC datapoints.

The slow wave form manages up to 24 analogues (MV) and 48 digital values (SPS, DPS, SPC, DPC).
DS Agile C26x stores at most 5000 integrated values as follows:

Number of Files	Number of integrated values
1	5000
2	2500
5	1000
10	500
20	250
50	100

The integrated value has a duration of up to one hour. It is defined in configuration.

For analogue samples, the stored value is the average value of the signal during the integration time.

In order for the value to be 1, the signal must remain at 1 for at least the duration of the arbitration period, if it drops off before, the value will be 0.

The slow waveform recorder can be triggered by the following events, each of which is user configurable:

- Changes in state of binary inputs (SPS or DPS datapoint)
- Changes in state of digital outputs (SPC or DPC datapoint)
- Measurement threshold violations (MV datapoint)
- Operator request (controls)

To add slow waveform recording to a C26x, select the C26x level and add a **Wave slow record** field from the contextual **Objects entry** window. Only one slow waveform recording item can be created under a C26x.

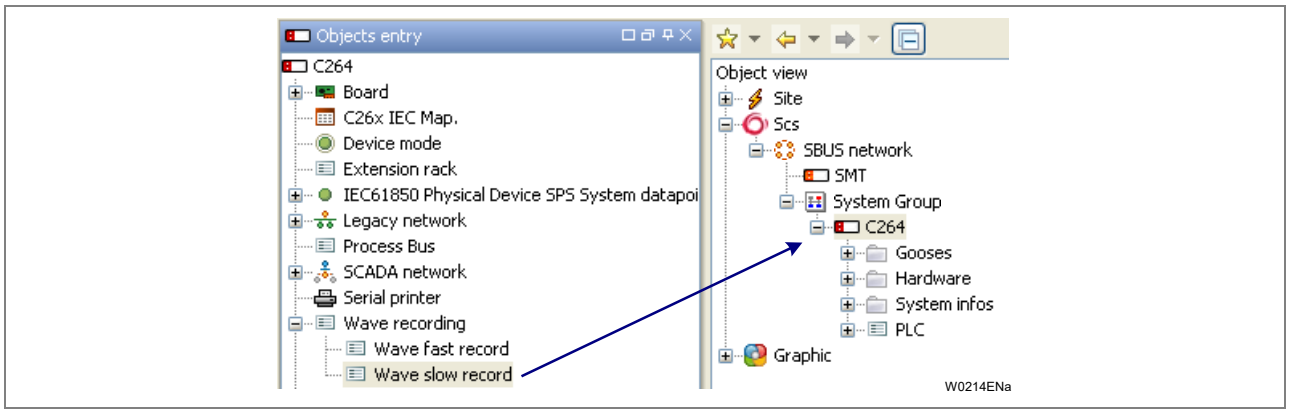


Figure 131: Adding a slow waveform recording

Once added, slow waveform recording attributes must be set at SCE level:

(1) **short name** and **long name** of the recording used for internal SCE identification

(2) **pre-trigger cycle** (range [1, 4998], step 1): number of records that are stored before triggering

(3) **total records** (range [20 , 5000], step 1): see previous description

(4) **number of files** (1 / 2 / 5 / 10 / 20 / 50): see previous description

(5) **arbitration period** (range [10, 100], step 1): percentage of time during which the logical data must be set to 1 to consider the integrated data set to 1

(6) **integration time** (range [1, 216000], step 1): number of cycles (see before)
- [1, 180000] for a power system frequency of 50 Hz
- [1, 216000] for a power system frequency of 60 Hz
(for power system frequency configuration, see section *3.2.3*)

(7) **activation period** (Non periodic/Daily trigger/weekly trigger/Daily & weekly trigger; daily: time 0 to 23:00 when the record starts, weekly: day and time

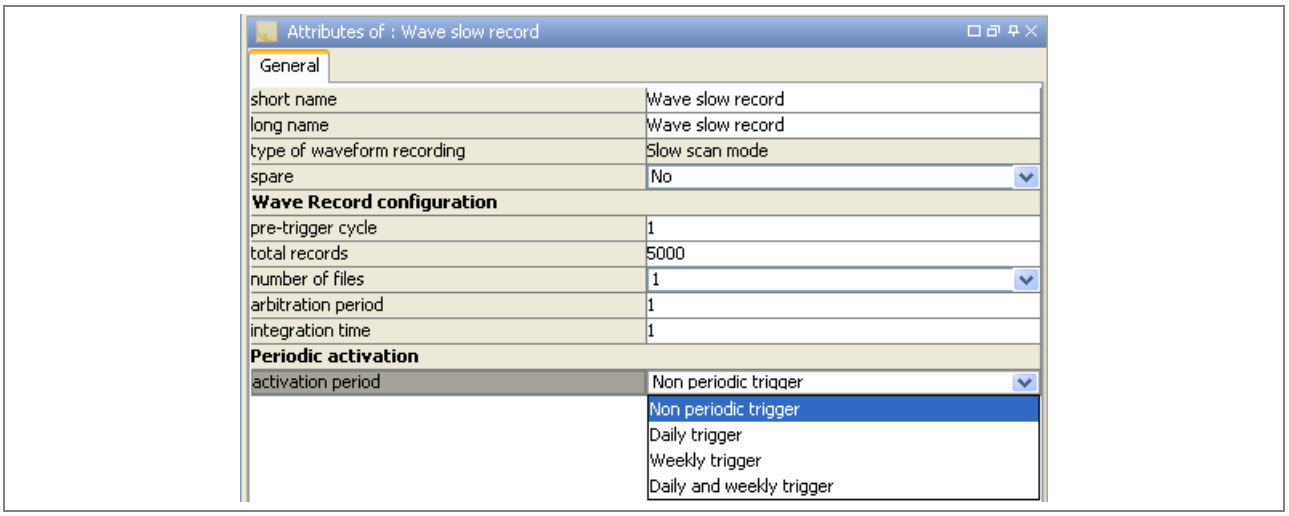


Figure 132: Setting a slow waveform recording

To define the inputs of a slow waveform recording, select the recording level, add the relevant relation (1) and fill in the relation with proper datapoint. Be careful, only datapoints acquired on the C26x can be defined as inputs of its slow waveform recording.

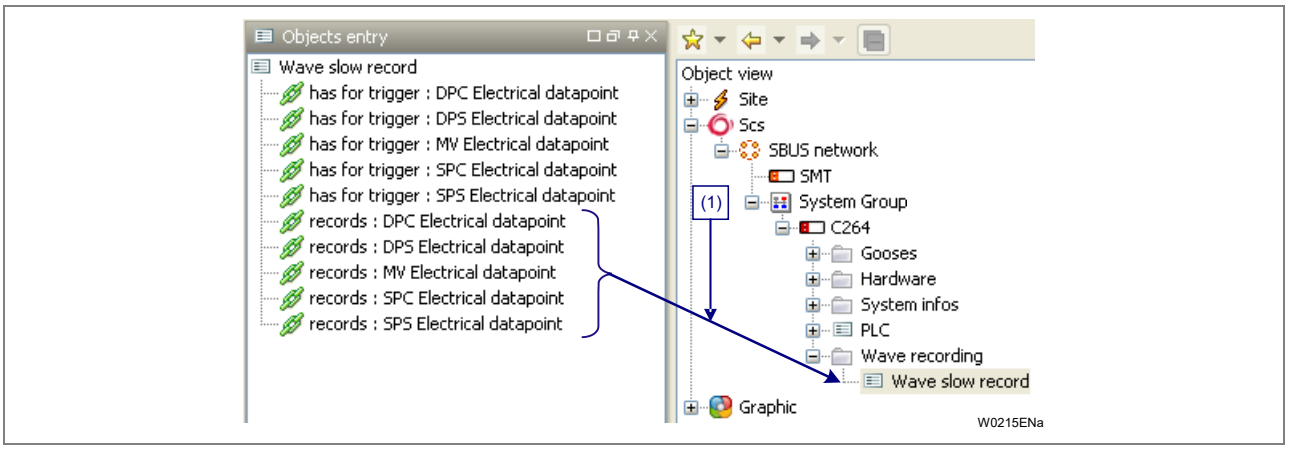


Figure 133: Defining inputs for slow waveform recording

To define the datapoint-triggers of a slow waveform recording, select the recording level, add the relevant relation (2) and fill in the relation with proper datapoint. Be careful, only datapoints acquired on the C26x can be defined as inputs of its slow waveform recording. A slow waveform can be configured without any datapoint-trigger, if a daily or weekly activation period has been defined for it.

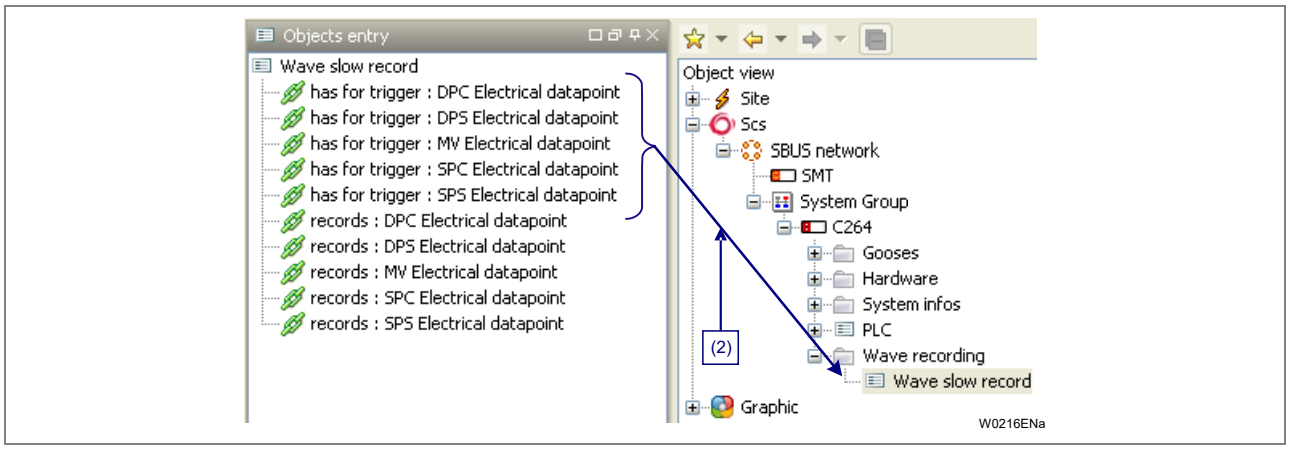


Figure 134: Defining triggers for slow waveform recording

Depending on the datapoint type, extra attributes must be set to a **has for trigger** relation. These attributes give the datapoint states (or thresholds for MV) that trigger recording (see following figure). The Link attribute is automatically filled.

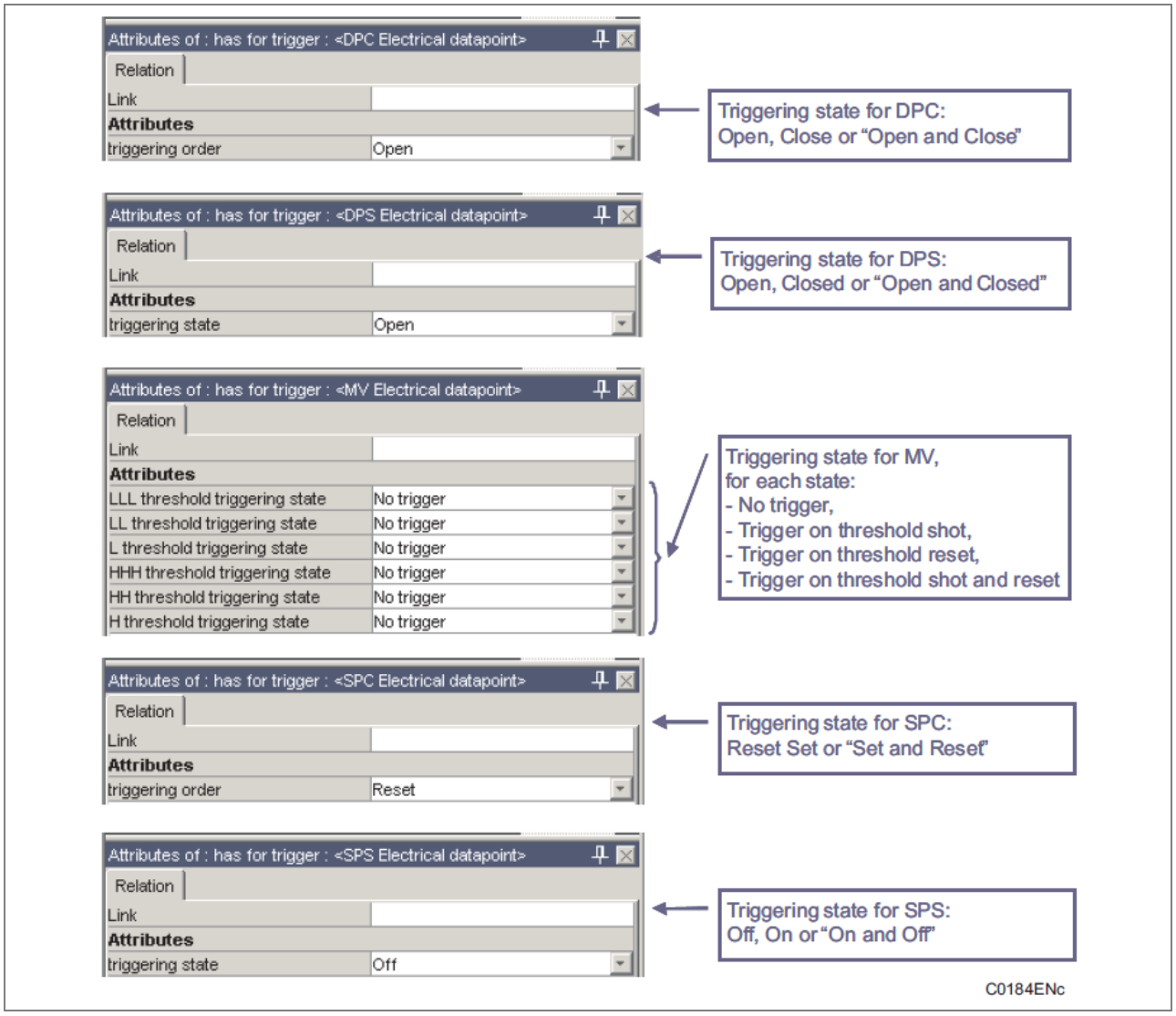


Figure 135: Defining triggers conditions for slow waveform recording

Configuration rules and checks

- The following constraints between the attributes must be respected:
  - "pre-trigger cycle" < "total records"
  - "number of files" ∗ "total records" ≤ 5000 records
- If "electrical frequency" ≡ 50 Hz:
  - The "integration time" value must be in the range [1..180000].
  - If the "integration time" value is > 5, then NO DPC, SPC, DPS, SPS recording is allowed.
- If "electrical frequency" ≡ 60 Hz:
  - The "integration time" value must be in the range [1..216000].
  - If the "integration time" value is > 6, then NO DPC, SPC, DPS, SPS recording is allowed.

3.9 DEFINING A C26X KLAXON

A C26x can manage up to one external klaxon, that is started as soon as an audible local alarm is raised on C26x (to define audible alarm see section *4 Defining a datapoint*). The external klaxon is managed by a specific SPC datapoint wired on the C26x ('ON' command starts the klaxon, 'OFF' command stops it).

To define an external klaxon at C26x level, just add the relation **has its klaxon managed by** at C26x level and fill it with the relevant SPC.

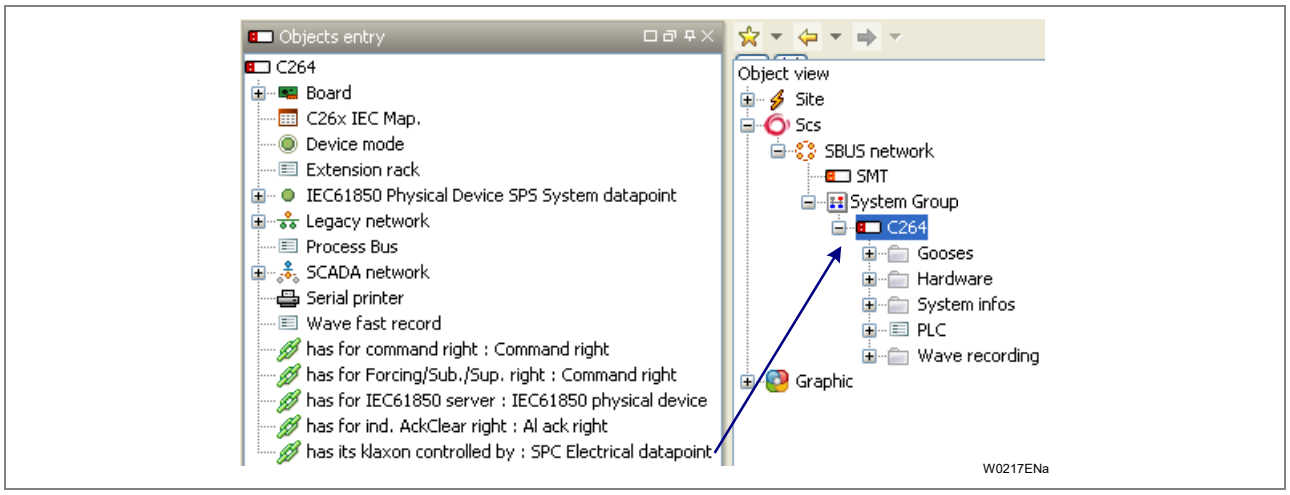


Figure 136: Defining a C26x klaxon

Configuration rules and checks

- The "SPC" link of the relation **has its klaxon controlled by** must be wired on a DO channel of the C26x.

3.10 SETTING SYSTEM INFORMATION FOR C26X COMPONENTS

When creating a C26x, specific datapoints are automatically added in 'system infos' folder (1) at C26x level or PLC sub-component.

So it is when adding a board (2), an IED on legacy network (3), a serial printer (4), or a SCADA network (5) attached to a C26x. In that case, the 'system infos' folder is located under the relevant added object.

For extra C26x functionalities (wave recording, redundancy) some optional datapoints can be required.

SCE calls such 'system infos' datapoints, system datapoints.

System datapoints provide real-time statuses and controls on system software or hardware components, and generally can not be wired on board channels except for redundancy function.

As datapoint, system datapoints must be linked to a profile. For details about datapoint and datapoint profile configuration, see section *4 Defining a datapoint*). Depending on its type, the system datapoint and its relevant profile have specific attributes to be set correctly to ensure a healthy behaviour from the C26x. Below are listed the datapoint and profile requirements for each type of system datapoint.

Generally system datapoints are automatically addressed in IEC 61850 mapping of the relevant C26x at their creation. If manual addressing is necessary, it is indicated in following sections by giving the associated available data object for a given C26x brick in LD0 (⇔<brick name>.<data object name>). For details about SBUS addressing, see section *3.5 Networking a C26x on the station-bus network*.

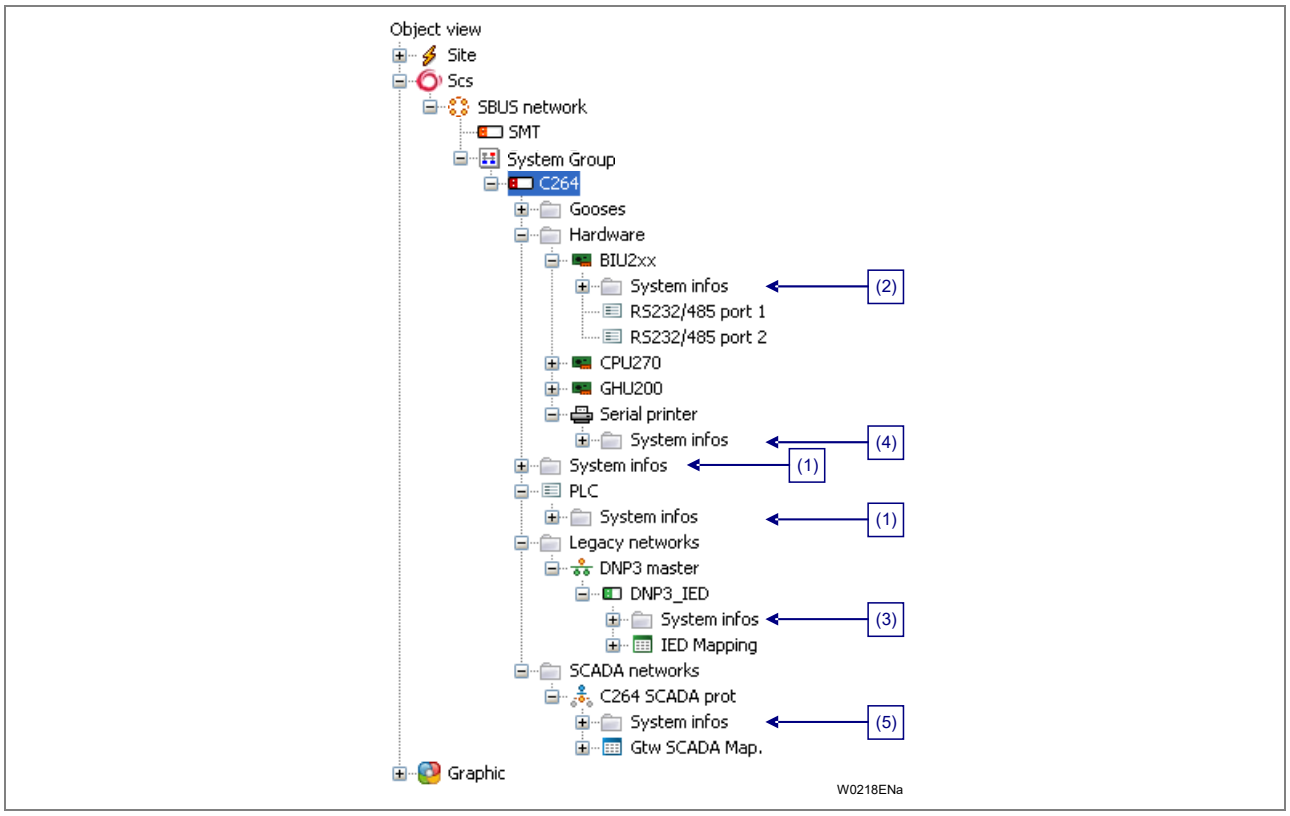


Figure 137: System infos folders for a C26x

3.10.1 SETTING GENERAL SYSTEM INFORMATION OF A C26X

At C26x creation, the mandatory datapoints are implicitly added. They are shown below:

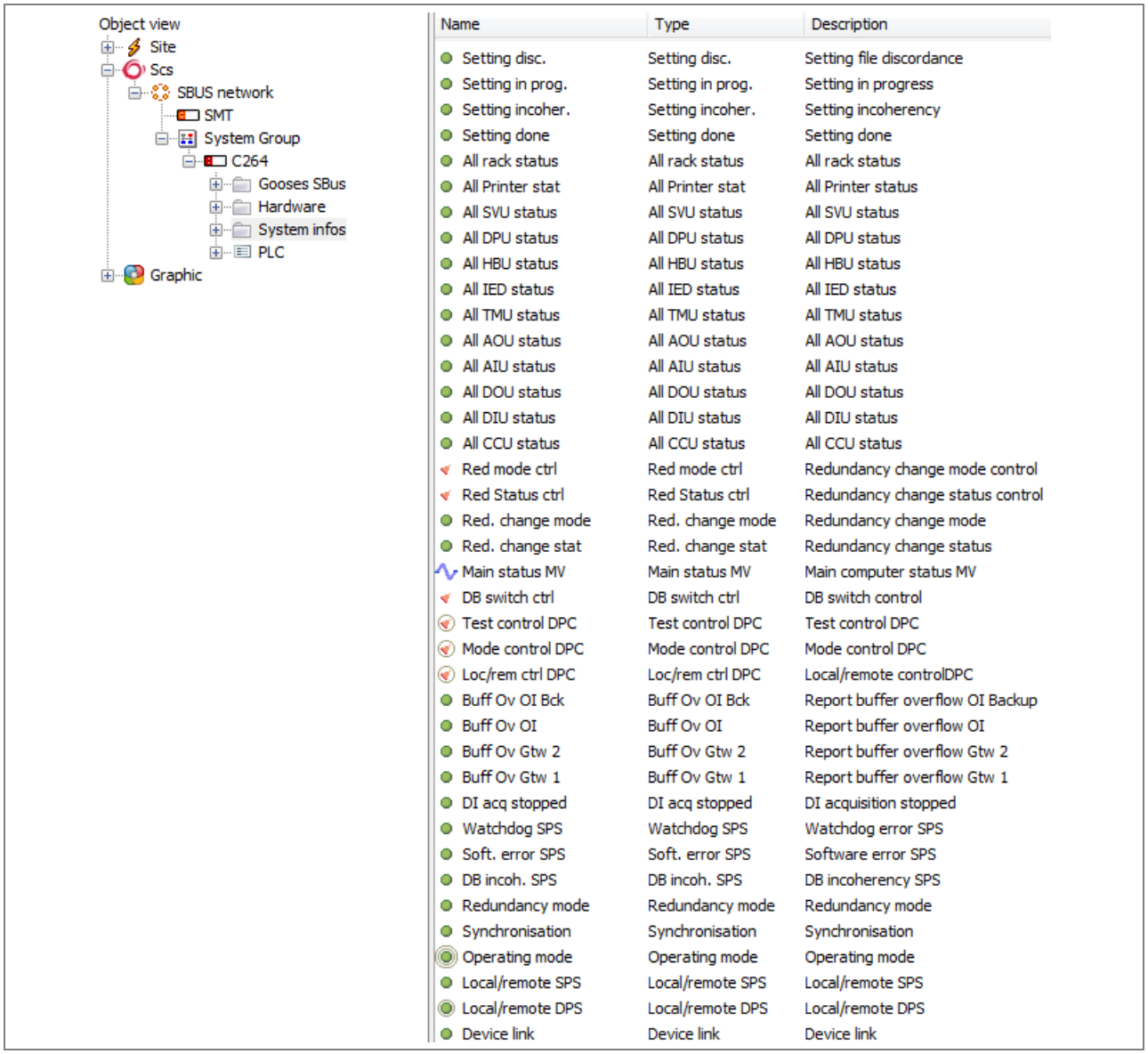


Figure 138: Mandatory System infos datapoints for a C26x

These datapoints must be configured (see section *4*) according to their described features; the manager is mentioned whenever it is different from the C26x itself.

Type	Manager	Datapoint	States	IEC address
Health		All ABC status	RESET: Board type not OK (for multirack)	SBUS auto
		All Printer status	RESET: Printer not OK	no
		DI acq stopped	RESET: Acquisition running SET: Acquisition stopped due to saturation	SBUS automatic
		Soft error SPS	RESET: Software running SET: Software error **	no
		Watchdog SPS	RESET: Watchdog OK SET: Expired time-out **	no

Type	Manager	Datapoint	States	IEC address
		ISaGRAF status	STATE 0: ISaGRAF is running normally STATE 1: Not activated STATE 2: Cycle too long STATE 3: Queue overflow STATE 4: Program Organization Unit faulty	SBUS automatic
	IEC clients	Device link	RESET:IEC real time link with C26x not OK	no
		Main status MV	VALID: Main C26x between min-max high-low	SBUS automatic
		Synchronisation	RESET: Device out of synchronisation SET: Synchronised device	SBUS automatic
Gateway buffer report O/F		Buff Ov Gtw	RESET: No Gateway buffer report overflow SET: GTW buffer report overflow	SBUS automatic
		Buff Ov GtwBck	RESET: No b-up Gateway buffer report overflow SET: Back-up Gateway buffer report overflow	
OI buffer report O/F		Buffer overflow	RESET: No OI buffer report overflow SET: OI buffer report overflow	no
		Buff Ov OI	RESET: No OI buffer report overflow SET: OI buffer report overflow	SBUS automatic
		Buff Ov OIBck	RESET: No b-up OI buffer report overflow SET: Back-up OI buffer report overflow	
Database management		DB incoh. SPS	RESET: Coherent database SET: Incoherent database *	no
	SMT	DB switch ctrl	ON: Switchover to standby database ***	no
Local/ Remote		Loc/rem ctrl DPC	OPEN: Remote mode CLOSE: Local mode	no
		Local/remote ctrl DPS	OPEN: Remote mode CLOSED: Local mode	SBUS automatic
		Local/remote ctrl SPS	RESET: Remote mode (all DPSs are open) SET: Local mode (at least one DPS closed)	SBUS automatic
Operating mode	SMT	Mode control DPC	OPEN: Maintenance mode CLOSE: Operational/Run mode	SBUS automatic
		Operating mode	STATE 0: Faulty mode STATE 1: Operational mode STATE 3: Test/blocked mode (single C26x)/Test mode (redundant C26x) STATE 5: Maintenance mode	SBUS automatic
	SMT	Test control DPC	OPEN: Test mode CLOSE: Normal mode	no
Redundancy		Red mode ctrl	ON: Active mode indication (DO1)	no
		Red status ctrl	ON: Network connection indication (DO2)	no
		Red. change mode	RESET: Active mode indication (DI1)	no
		Red. change stat	RESET: Network connection indication (DI2)	no
		Redundancy mode	RESET: Active mode indication to SCADA	SBUS automatic
Settings (DS Agile S1)		Setting disc.	SET: Discordance of value, format …	
		Setting done	SET: Transfer with DS Agile S1 completed	SBUS automatic
		Setting in prog.	SET: Transfer C26x-DS Agile S1 in progress	
		Setting incoher.	SET: Incoherency in setting file version	

the C26x switches to mode * Maintenance, ** Faulty, *** Maintenance or Operational/Run

At C26x level, the following optional datapoint can be added.

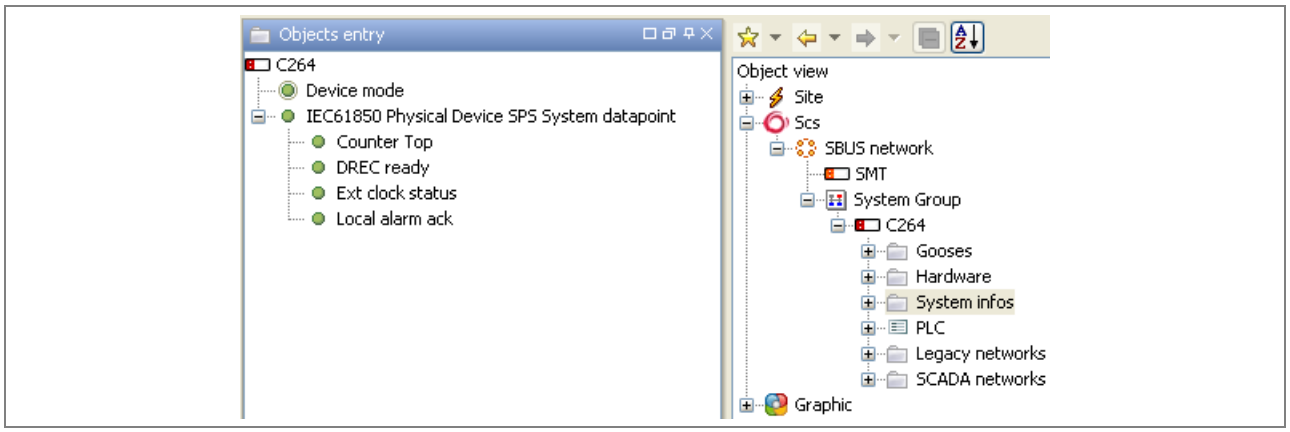


Figure 139: Optional System infos' datapoints for a C26x

These datapoints must be configured (see section *4 Defining a datapoint*) according to their described features:

Device mode DPS	OPEN: Maintenance mode CLOSED: Operational mode JAMMED: Test/blocked mode (single C26x)/Test mode (redundant C26x) UNDEFINED: Operational mode	SBUS automatic
Counter Top (generally wired)	RESET: no transmission SET: launch transmission of counter value on IEC & SCADA networks	SBUS automatic
DREC ready	RESET: no waveform record available SET: waveform record file available, see section 3.8	SBUS automatic
External clock status for IRIG-B	RESET: IRIG-B signal (see section 3.2.1) is present SET: lack of IRIG-B signal	SBUS automatic
Local alarm ack	RESET: no immediate acknowledgement of all the C26x alarms SET: immediate acknowledgement of all the C26x alarms *	no

* in addition to the Global Alarm Acknowledgement SPS, you can define a Local Alarm Acknowledgment SPS, one for each C26x; it can be wired, managed by an automation or associated with a control. It cannot be transmitted over the Station Bus network, but only used locally. When the Local alarm ack is configured in a C26x, the Global alarm Ack is no more taken into account by this C26x.

3.10.2 SETTING SYSTEM INFORMATION OF BOARD

When creating a board (except CPU board) the following mandatory datapoint is implicitly added.

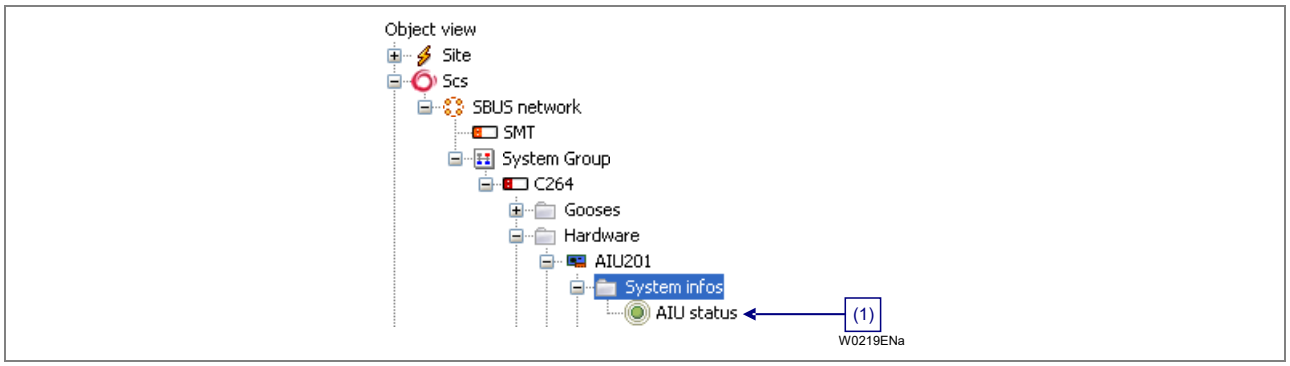


Figure 140: Mandatory System infos datapoint for a board (example for an AIU board)

- **Board status MPS** (1): this datapoint indicates the status of the board. Addressing this datapoint can be done:
  - using SBUS automatic addressing.

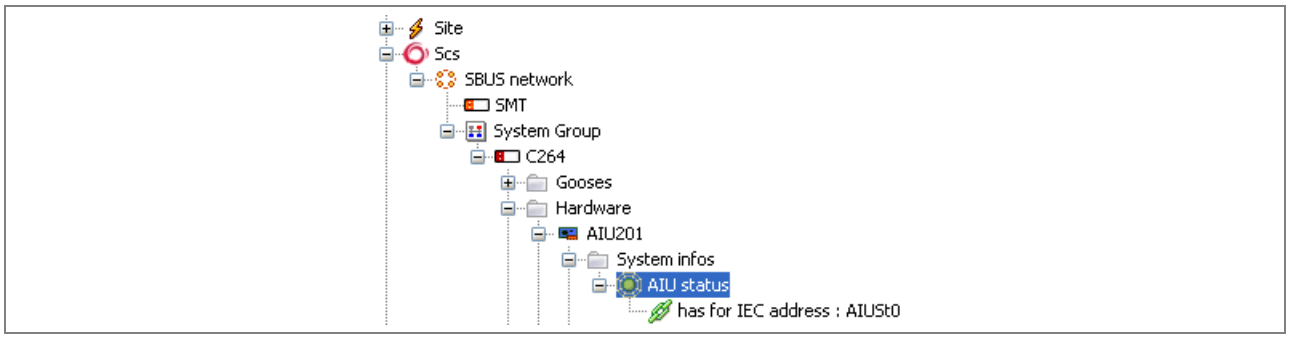


Figure 141: Automatic IEC addressing of a board status datapoint

  - Manually. In that case, the relevant data object given the IEC address of the status, must be coherent with the board number (e.g. if AIU board number is 3, corresponding data object is AIUSt).
    The available states of this datapoint are:
  - "STATE 0" for board OK
  - "STATE 1" for self-check failure
  - "STATE 2" for configured but missing
  - "STATE 3" for not configured but present
  - "STATE 4" for board not present

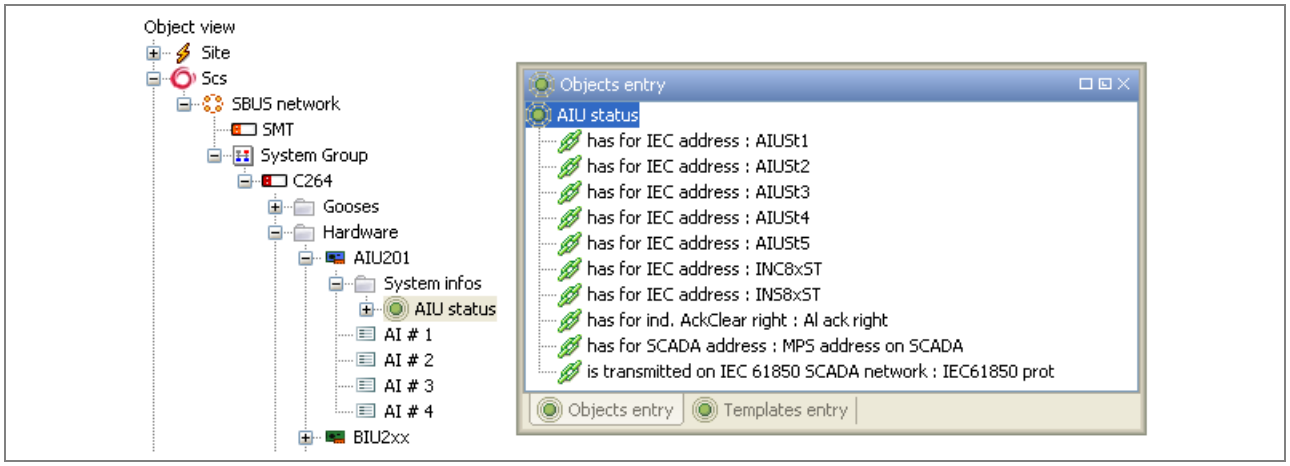


Figure 142: Manual IEC addressing of a board status datapoint

3.10.3 SETTING SYSTEM INFORMATION OF LEGACY IED

When creating a legacy IED, the following mandatory datapoints are implicitly added.

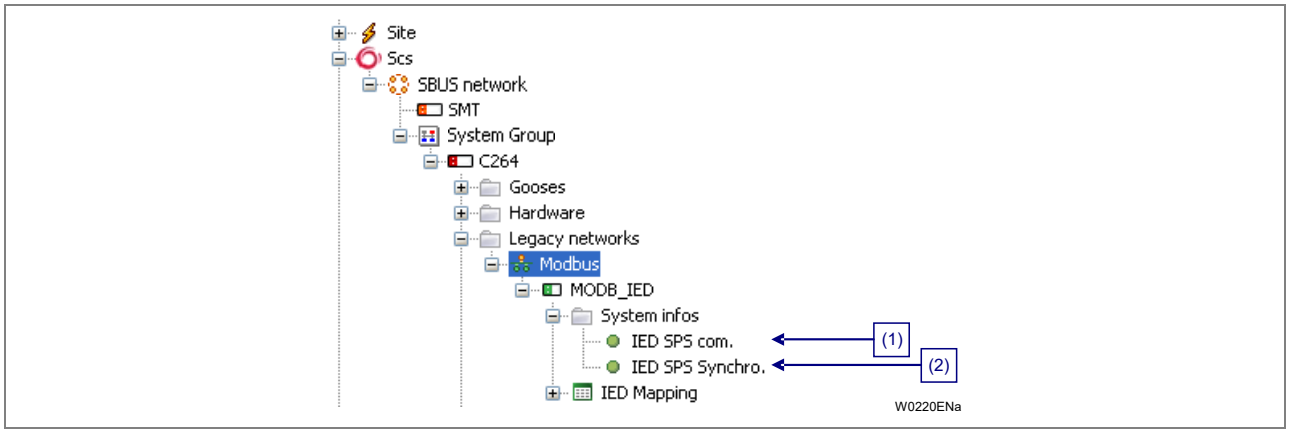


Figure 143: Mandatory System infos datapoints for a legacy IED

These datapoints must be configured (see section *4 Defining a datapoint*) according to their described features:

- **IED communication status SPS** (1): is put in 'SET' state if communication with the IED is operational.
  The available states of this datapoint are:
  - "RESET" for communication not OK
  - "SET" for communication OK
  - An IEC address for this datapoint is defined using SBUS automatic addressing.
- **IED synchronization status SPS** (2): is put in 'SET' state if IED is synchronized.
  The available states of this datapoint are:
  - "RESET" for IED not synchronized
  - "SET" for IED synchronized
  - An IEC address for this datapoint is defined using SBUS automatic addressing.

At IED level, the following optional datapoint can be added:

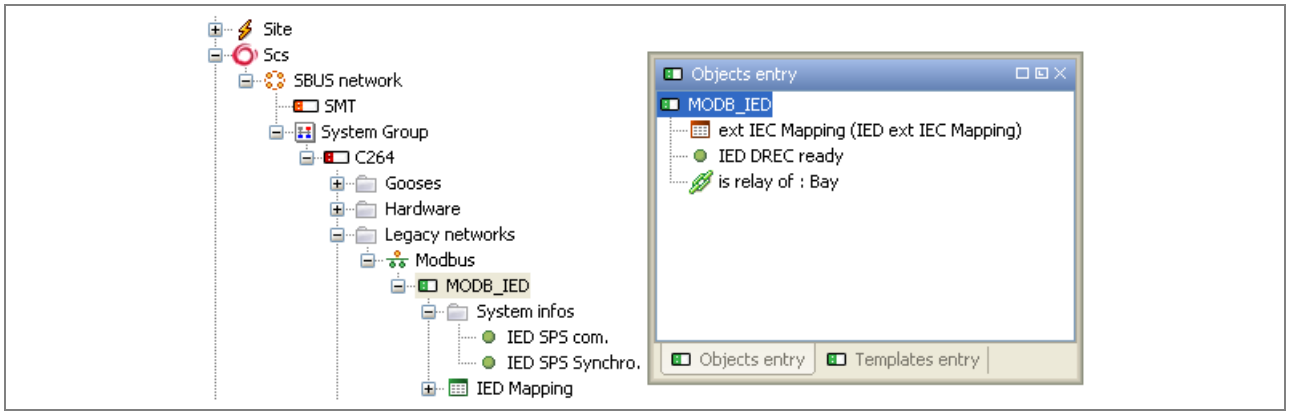


Figure 144: Optional System infos datapoint for a legacy IED

- **IED disturbance status SPS** (2): this datapoint indicates the availability of a disturbance file for the IED (for details, see section *3.8.1 Defining the management of IED disturbance records*). This

datapoint is put in 'SET' state if a disturbance file is available.
The available states of this datapoint are:

- "RESET" for no disturbance file available
- "SET" for disturbance file available
- An IEC address for this datapoint is defined using SBUS automatic addressing.

3.10.4 SETTING SYSTEM INFORMATION OF SERIAL PRINTER

When creating a serial printer, the following mandatory datapoint is implicitly added.

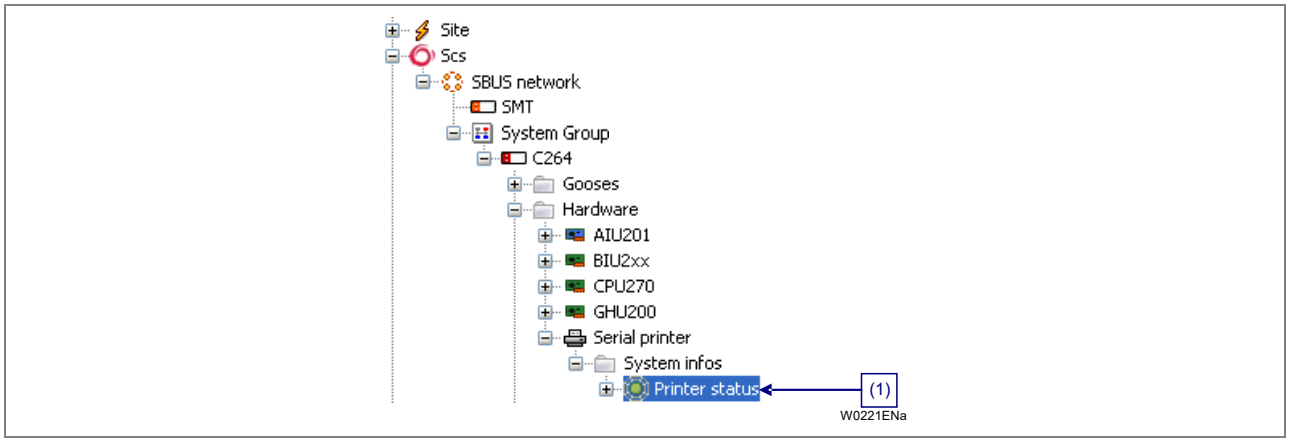


Figure 145: Mandatory System infos datapoint for a serial PRINTER

- **Printer status MPS** (1): this datapoint indicates the status of the printer.
  The available states of this datapoint are:
  - STATE 0 for printer OK
  - STATE 1 for self-check failure
  - STATE 4 for printer not present
  - An IEC address for this datapoint is defined using SBUS automatic addressing.

3.10.5 SETTING SYSTEM INFORMATION OF A SCADA NETWORK

When creating a SCADA network, the following mandatory datapoints are implicitly added.

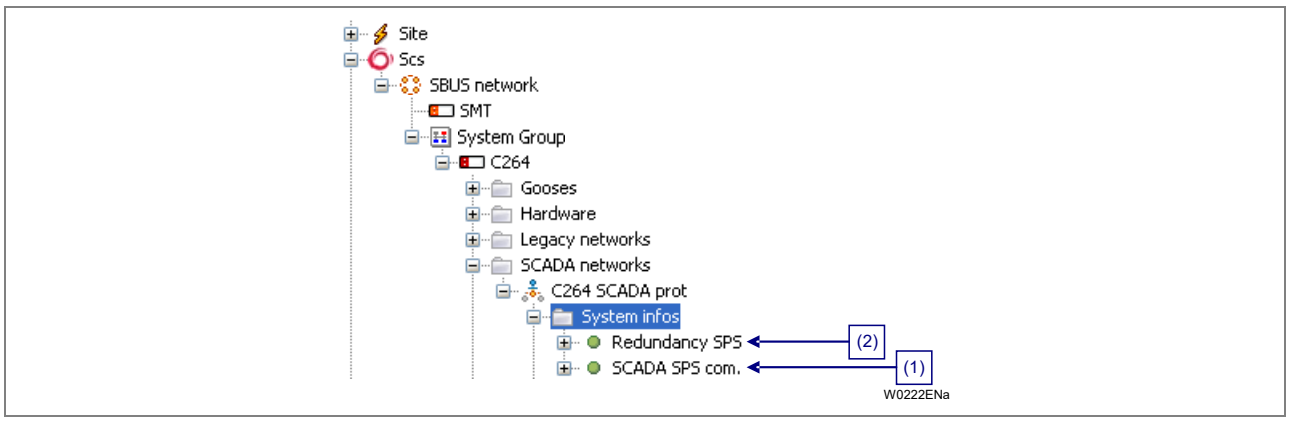


Figure 146: Mandatory System infos datapoint for a SCADA network

- **SCADA communication status SPS** (1): this datapoint is in “SET” state if communication with the SCADA is operational.
  The available states of this datapoint are:
  - RESET for communication with the SCADA not OK
  - SET for communication with the SCADA OK
  - An IEC address for this datapoint is defined using SBUS automatic addressing.
- **SCADA redundancy status SPS** (2): this datapoint is in “SET” state if redundancy with the SCADA is active.
  The available states of this datapoint are:
  - RESET for standby
  - SET for active
  - An IEC address for this datapoint is defined using SBUS automatic addressing.

4 DEFINING A DATAPOINT

4.1 TOPOLOGY

4.1.1 ELECTRICAL AND SYSTEM DATAPOINTS

Electrical and system topologies share entities called datapoints:

- those of the electrical topology are called electrical datapoints
- those belonging to the system topology are called system datapoints

A datapoint corresponds to an atomic object with real-time value, status or control. Moreover, datapoints support extra system functions like forcing, suppression, filtering, and alarms, logging.

Generally, system datapoint creation is automatic when adding system units or sub-components to system units. They are never wired, except for system datapoint used by redundancy and more often correspond to system diagnostics (device, printer board status, control of device mode, …).

Electrical datapoint creation is rarely automatic except when they are required for correct DS Agile system behaviour (for instance, ‘Order running SPS’ at bay level, ‘Computed switchgear position’ at circuit-break level), or relevant to an electrical built-in function that imposes their existence.

4.1.2 INPUT AND OUTPUT DATAPOINTS

Several types of datapoint exist:

- Input datapoints used for supervision:
  - SPS (Single Point Status), DPS (Double Point Status), MPS (Multiple Point Status)
  - MV (Measurement Value), Counter
- Output datapoints used for control:
  - SPC (Single Point Control), DPC (Double Point Control)
  - Setpoint

Input datapoints can be acquired through sensors (input channels) addressed on IED at IED legacy network level or substation network level. They can also be calculated or deduced by the system units. They can be sent to SCADA by addressing them on SCADA networks.

Output datapoints can be controlled through relays (output channels), addressed on IED at IED legacy network level or substation network level or on SCADA networks. They can also be managed by built-in functions or user functions.

There are four types of Binary outputs:

- Single Point Status (SPC): derived from one Digital Output
- Double Point Status (DPC): derived from two Digital Outputs
- System output: control information related to the system, meant for configurable and built-in automations or electrical process deprived of acquisition possibilities
- Setpoint (SetPoint): derived from n Digital Outputs

SPC, DPC and SetPoints are mainly controlled via digital output boards (DOU board) or via IEDs connected by a serial link (for details see section *4.6*).

By extension, at SCE level, system outputs are seen as particular SPC or DPC depending on the number of elementary information they represent (for details about system outputs, see section *3.10 Setting system information for C26x components*). Control sequences are described in chapter C26x/EN FT (Functional Description).

4.2 CREATING A DATAPOINT PROFILE

4.2.1 OVERVIEW

A set of datapoints share often many common characteristics. For instance, all feeder breaker positions have got the same state labels, alarm and logging behaviour. To group these common characteristics, profiles are included in the data modeling. For each type of datapoints (SPS, DPS,…) there exists a relevant profile (SPS profile, DPS profile, …). Several datapoints of the same type are linkable to the same profile.

The profile attributes can be seen as the datapoint attributes **as soon as** this datapoint is assigned a profile.

For input datapoints, the following characteristics are set in the profile:

- state labels and eventual unit label for MV and counter
- definition of the archived and logged states
- definition of the alarmed states (gravity, delay, audibility)
- definition of state interlocking values
- definition of forcing/substitution/suppression (FSS) and SBMC facilities

For output datapoints, the following characteristics are set in the profile:

- order labels and eventual unit label for setpoints
- definition of the significant orders for SPC and DPC
- definition of the alarmed order failure (gravity, delay, audibility)
- definition of the archived and logged transitions
- SBO mode facility

Be careful: (See section *3.5.1 Connecting a C26x to other station-bus sub-systems*, for Client / Server definition). In the set of all the C26x units of an Scs:

- the following profile functional characteristics logging, alarm, archiving and FSS, are only useful and given to the C26x that serves the linked DPs because these functions are always done by the server C26x. So, a C26x A using a DP acquired on a C26x B never logs, signals or archives events relevant to this DP
- the profile functional characteristics ‘interlock values’ are given to server and client C26xs using a datapoint, because interlock evaluation is a distributed function done on every C26x that needs it before controlling its own electrical modules
- the profile functional characteristic ‘SBMC’ is given to server or client C26x units using a datapoint exchanged on a SCADA network they manage, because SBMC filtering is a distributed function done on C26x units managing SCADA networks
- the profile characteristics ‘state/order labels’ are given to server or client C26x units using a datapoint but are only used by the server: C26x bay mimics, logging, alarm definitions are reduced to datapoints that the C26x is server of

4.2.2 USING THE PROFILES TABLE

If the Profiles Table is not displayed, click the icon Reset perspective in the toolbar and the button Profiles Table in the lower part (in Auto Hide mode, move the cursor over the bottom toolbar). To adjust a column width, pass the cursor over the border in the header till the cursor turns to ↔; then drag and drop.

To fill the table:

- Click in a cell to fill out
- Type one character or click two more times; click the button [v] overlaying in the cell and select one value in the drop-down list (it contains all the created datapoint values); ∅ refers to a void value; the type can be changed this way

Note:
For the field 'value', the field SMBC must have been set to Yes *previously*

- To exchange data with a spreadsheet editor like Excel: select **Copy**/**Paste**

Note:
To paste the headers (including the tab labels) into the editor, select any row, right click, select Copy columns header.Null = value in editor of empty cell

- To speed up entry: select a row, copy it and select **Paste and add profile(s)**; this adds a row(s) at the end (regardless of the selected row) with the values in the clipboard
- To delete a profile, which is not linked to any datapoint (brown relation icon), right click and select **Delete**
- To delete the duplication of a profile, select the menu Data/**Indiced profiles merge** (all attributes are taken into account in the comparison, excluding short name and long name)
- After a database migration, to compute the new profile reference of each datapoint (object and template) to the profile table, select the menu Data/**Upgrade to indiced profile**

If you import a library template (.mpl), the source profiles that are referenced by the template are imported into the target profile table.

Assignation can be done in the datapoint attribute table OR in a row, after the datapoints have been defined, in the Profiles table (click the second column link icon). The editor shows these template and object datapoints:

- In Object mode: only object DPs and all instances of template DP (ONLY if 'Profile reference' attribute is set to DOF)
- In Template mode: only template DPs (no instances of template DP). Only the selected template is used to parse the available template DP

Refer to the *Application chapter, OI/EN AP* for OI-specific attributes.

4.2.3 DEFINING AN XPS PROFILE

4.2.3.1 OVERVIEW

The binary inputs are defined in section 5.1 of the chapter C26x/EN FT.

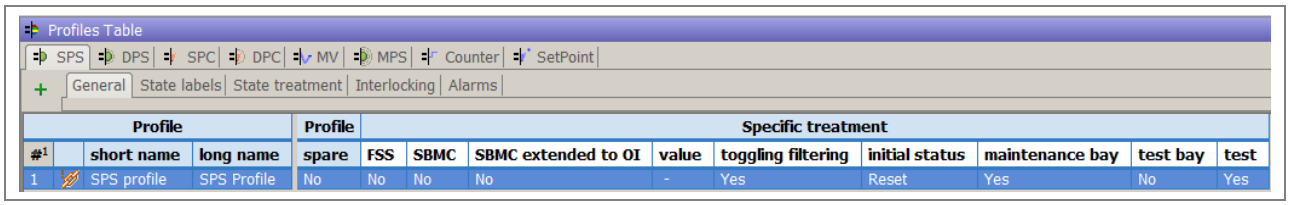
By extension, in SCE:

- System Inputs (SI) are seen as particular SPS, DPS or MPS depending on the number of elementary information they represent (for details about SI, see section *3.10 Setting system information for C26x components*).
- Group binary input is seen as particular SPS.

4.2.3.2 ADDING AN XPS PROFILE

To create an xPS profile, at any level:

- Select the type tab SPS/DPS/MPS
- Click the icon +
- Set the profile attributes (see following sections). The relation with the datapoints (icon in the second column) will be established, when the datapoints are created



Profile				Profile	Specific treatment								
#1		short name	long name	spare	FSS	SBMC	SBMC extended to OI	value	toggling filtering	initial status	maintenance bay	test bay	test
1		SPS profile	SPS Profile	No	No	No	No	-	Yes	Reset	Yes	No	Yes

Figure 147: Adding an SPS profile (example given at C26x level)

4.2.3.3 SETTING GENERAL ATTRIBUTES

(1) **short name** and **long name** of the profile only used for profile identification in SCE

And for linked SPS datapoints:

(2) enable **F**orce/**S**ubst/**S**up (*No* / *Yes*)

(3) **SBMC**-dependent (*No* / *Yes*)

(4) SBMC state substitution **value** (*Suppressed* /…): significant and visible if SBMC-dependent is set to Yes

(5) **test**-mode dependent (*No* / *Yes*)

and, for SPS and DPS:

(6) **toggling filtering** (*No* / *Yes*): useful for a datapoint acquired on a DI board to filter toggling.

(7) **initial status**: used for C26x software initialization especially for system datapoints.

(8) **maintenance bay**: not used in system version v6.x

(9) **test bay**:not used in system version v6.x

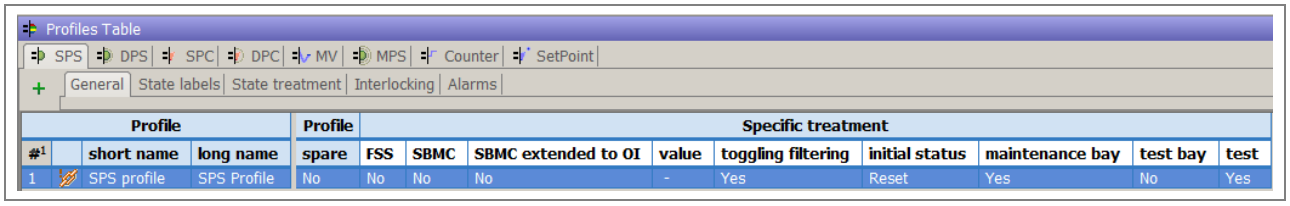


Figure 148: Setting the general attributes of an SPS profile

Configuration rules and checks

- The profile of a datapoint of the System topology must have its **F**orce/**S**ubst/**S**up attribute set to *No*.

4.2.3.4 SETTING STATE LABELS ATTRIBUTES

These attributes are used for events/alarm management at C26x level (logging, display).

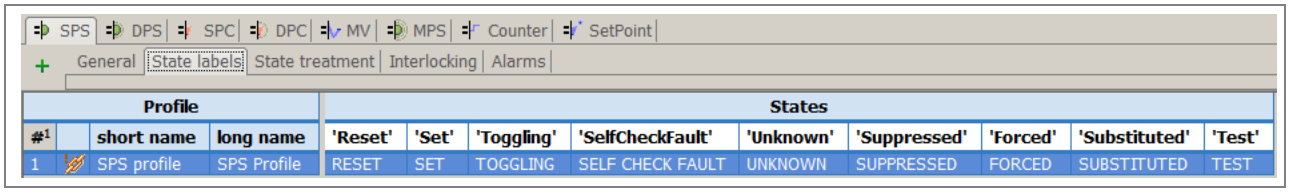


Figure 149: Setting the State labels attributes of an SPS profile

4.2.3.5 SETTING STATE TREATMENT/C26X TREATMENT ON ATTRIBUTES

Available attribute values are:

- no archive, no logging
- no archive, no logging
- archive, logging
- archive, no logging

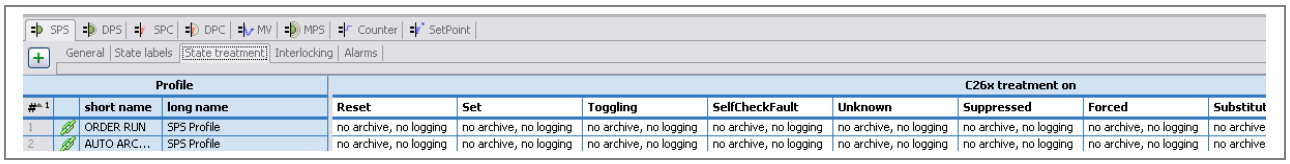


Figure 150: Setting the State treatments attributes of an SPS profile

4.2.3.6 SETTING INTERLOCKING ATTRIBUTES

For each possible state linked to this profile and belonging to an interlocking equation, select among values Invalid, False, True the one used for evaluation of the interlocking equation.

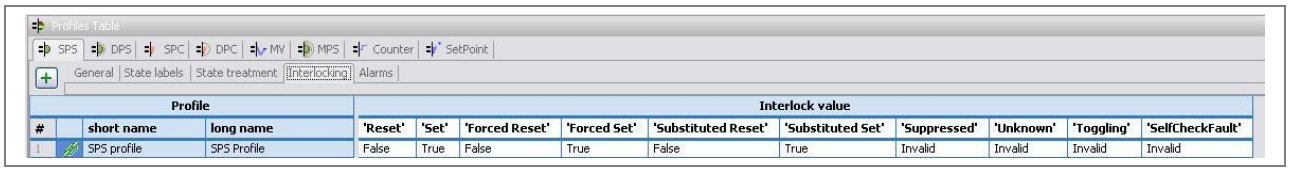


Figure 151: Setting the Interlocking attributes of an SPS profile

4.2.3.7 SETTING ALARMS ATTRIBUTES

(1) **condition** (Appearance/Appearance & disappearance): this attribute is common to all states of each xPS linked to this profile. It defines when alarm are generated

For each state the following attributes are settable:

(2) **defined** (*No* / *Yes*)

(3) **masking** due to control (*No* / *Yes*): this attribute must be set to Yes to manage correctly discrepancy (alarm appears only in case of spontaneous change of state without previous control)

(4) **delay (s)** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(5) **gravity** (range [1, 5], step 1)

(6) **audible** (*No* / *Yes*): to activate a klaxon

(7) **clearing**: to precise the way alarm is cleared when alarm condition disappears:

- Manual: users must explicitly clear the alarm
- Automatic: no user intervention is needed to clear the alarm
- Cf. Scs – Clearing mode for gravities: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

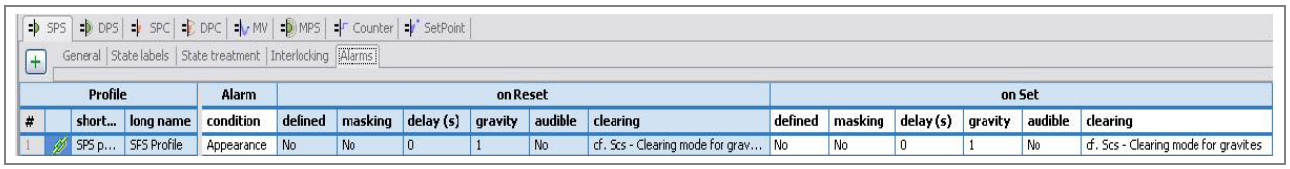


Figure 152: Setting the Alarm attributes of an SPS profile

4.2.4 DEFINING AN MV PROFILE

4.2.4.1 ADDING AN MV PROFILE

To create an MV profile:

- Select the type tab MV
- Click the icon + at any level
- Update the profile attributes (see following sections).

The alarm logging printer is defined is the same time as Event Logging.

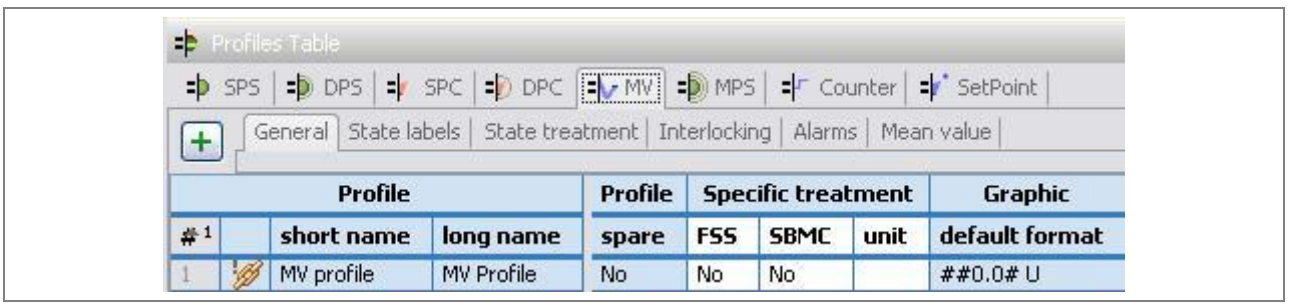


Figure 153: Setting the Interlocking attributes of an MPS profile

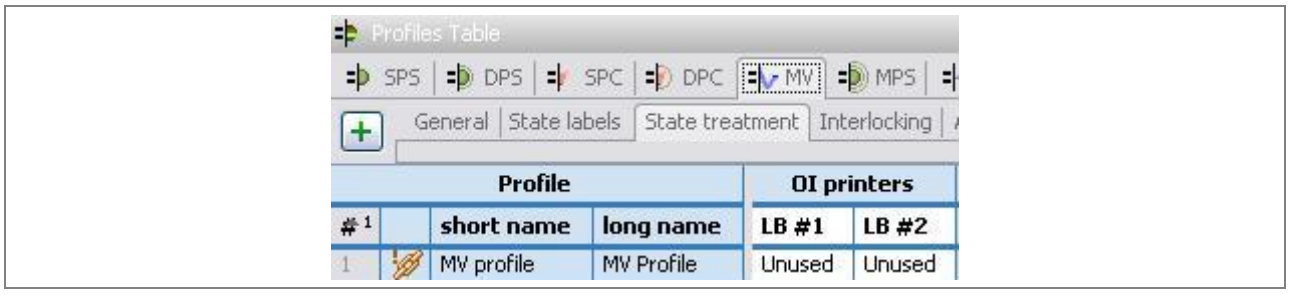


Figure 154: Defining the event log printer for an MV profile

4.2.4.2 SETTING GENERAL ATTRIBUTES

When adding an MV profile, some general attributes must be updated:

(1) **short name** and **long name**: only used for profile identification in SCE

and for linked MV datapoints:

(2) enable **F**orce/**S**ubst/**S**up (*No* / *Yes*)

(3) **SBMC**-dependent (*No* / *Yes*)

(4) **unit**: used for display, logging and alarm at C26x, Gateway and system HMI levels. Maximum length: 5 characters.

(5) **default format**: Reserved for Substation control point usage

Default format attribute is a string composed of the following characters:

#	display only significant figures
0	display non-significant zeros
~	suppress sign
%	display in percentage mode
‘’ ‘’	display strings with reserved characters
\	display reserved characters
U	display unit
.	display decimal delimiter

Configuration rules and checks

- The profile of a datapoint of the System topology must have its enable **F**orce/**S**ubst/**S**up set to *No*

4.2.4.3 SETTING STATE LABELS ATTRIBUTES

The **State labels** attributes are used for events and alarm management at C26x level (logging, display).

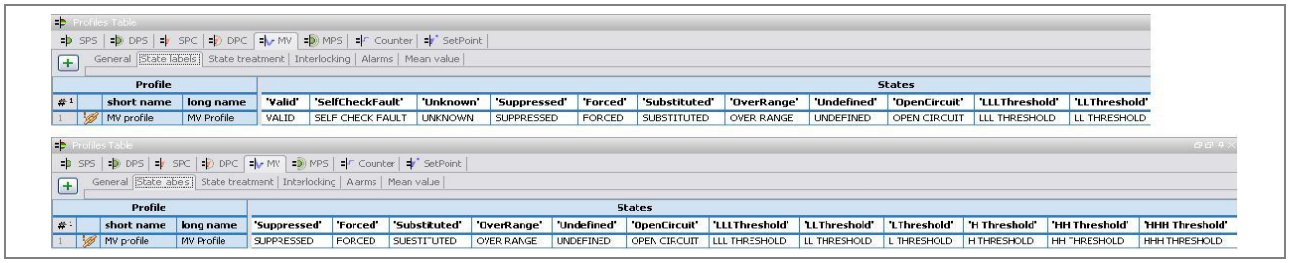


Figure 155: Setting the State labels attributes of an MV profile

4.2.4.4 SETTING STATE TREATMENT ATTRIBUTES

Available attribute values are:

- C26x: no archive, logging
- C26x: archive, logging
- C26x: archive, no logging
- C26x: archive, logging

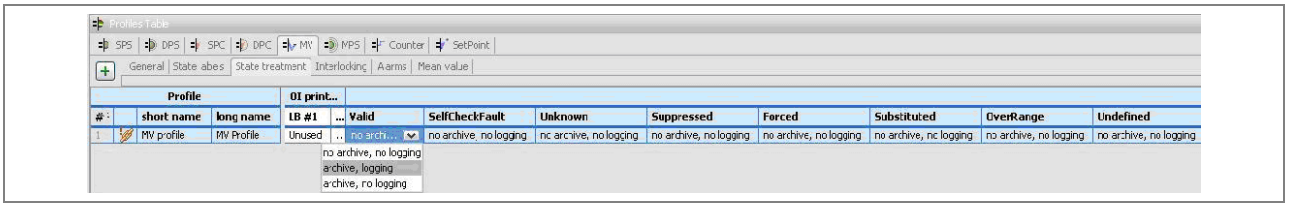


Figure 156: Setting the 'State treatment' attributes of an MV profile

4.2.4.5 SETTING INTERLOCKING ATTRIBUTES

For each possible state of an MV linked to this profile and belonging to an interlocking equation the user chooses among three values (Invalid, False, True) which one will be used for evaluation of the interlocking equation.

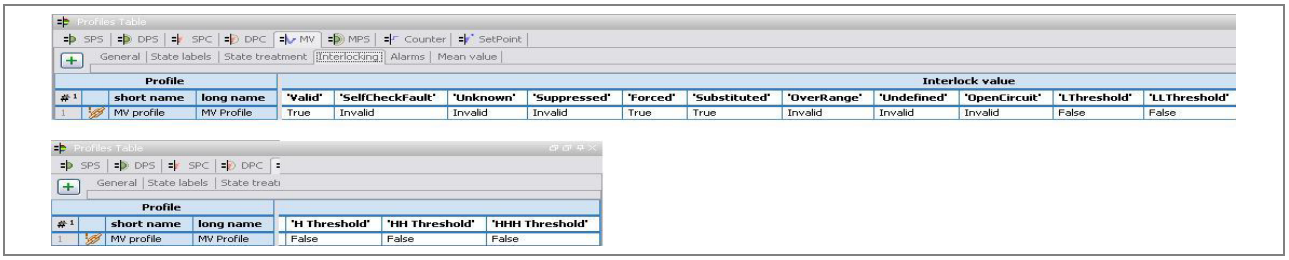


Figure 157: Setting the Interlocking attributes of an MV profile

4.2.4.6 SETTING ALARMS ATTRIBUTES

When adding an MV profile some **Alarms** attributes must be updated, for each available state of the linked datapoints.

For each state, following alarm information are settable:

(1) **generation condition** (*Appearance* / *Appearance and disappearance*): this attribute is common for all the states of each MV linked to this profile. It defines when alarm are generated

(2) For each state the following attributes are settable

(3) **defined** (*No* / *Yes*)

(4) **delay** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(5) **gravity** (range [1, 5], step 1).

(6) **audible** (*No* / *Yes*): to activate a klaxon

(7) **clearing mode**: to precise the way alarm is cleared when alarm condition disappears:

- Manual: users must explicitly clear the alarm
- Automatic: no user intervention is needed to clear the alarm
- Cf. Scs – Clearing mode for gravities: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

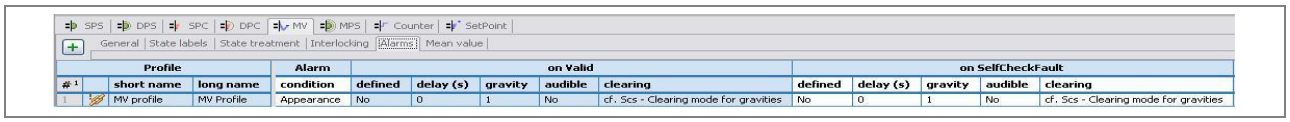


Figure 158: Setting the Alarm attributes of an MV profile

4.2.4.7 SETTING MEAN VALUE ATTRIBUTES

The 'Mean value' attributes are reserved for substation control point usage.

(1) **computation** (*No* / *Yes*)

(2) **reference hour** (range [0, 23], step 1)

(3) **reference day** (range [0, 31], step 1)

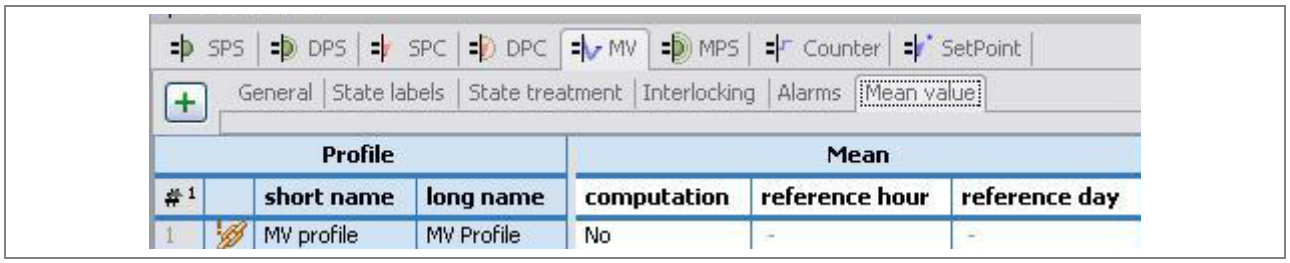


Figure 159: Setting the Mean value attributes of an MV profile

4.2.5 DEFINING A COUNTER PROFILE

4.2.5.1 ADDING A COUNTER PROFILE

To create a Counter profile:

- Select the type tab Counter
- Click the icon + at any level
- Update the profile attributes (see following sections).

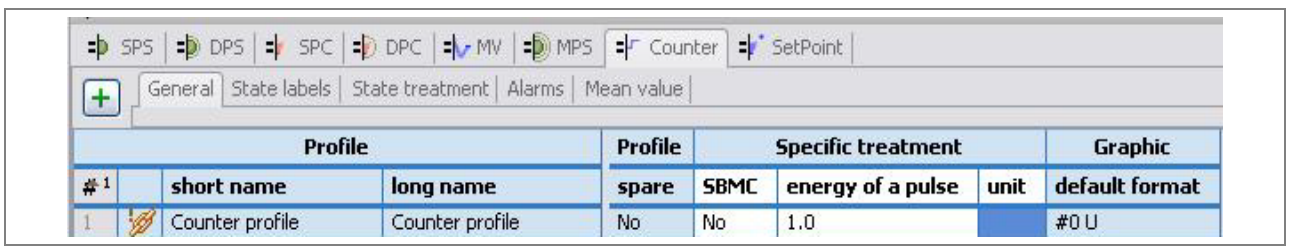


Figure 160: Adding a counter profile

4.2.5.2 SETTING THE GENERAL ATTRIBUTES OF A COUNTER PROFILE

When adding a Counter profile, some general attributes must be updated:

(1) **short name** and **long name**: only used for profile identification in SCE

and for linked Counter datapoints:

(2) **SBMC**-dependent (Yes to suppressed / No)

(3) **energy of a pulse** (range [-3.4E38, +3.4E38]: multiplicative coefficient

(4) **unit** used for display, logging and alarm at C26x level

(5) **default format**: reserved for Substation control point usage

Default format attribute is a string composed of the following characters:

display only significant figures

display non-significant zeros

~ suppress sign

% display in percentage mode

‘’ ‘’ display strings with reserved characters

\ display reserved characters

U display unit

. display decimal delimiter

4.2.5.3 SETTING STATE LABELS ATTRIBUTES

The state of a counter can be:

VALID	Not in one of the states below
SELFCHECK FAULT	Due to the SELFCHECK FAULTY of the DI
UNKNOWN	If the counter is acquired via a transmission link, the information is unknown when the link is disconnected
UNDEFINED	Due to a counting failure of DCT (non-complementarity of the 2 contacts)
OVER RANGE	When the maximum value is reached

The ‘State labels’ attributes are used for C26x events and alarm management (logging, display).

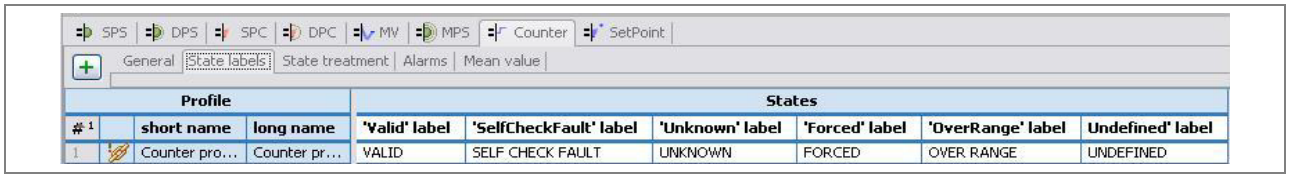


Figure 161: Setting the State labels attributes of a counter profile

4.2.5.4 SETTING STATE TREATMENT ATTRIBUTES

Available attribute values for each available state of the linked datapoints:

- C26x: no archive, logging
- C26x: archive, logging
- C26x: archive, no logging
- C26x: archive, logging

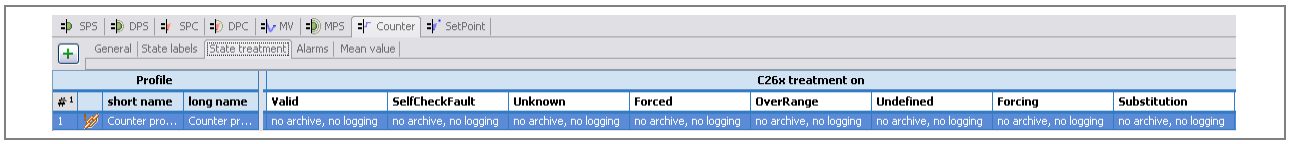


Figure 162: Setting the State treatment attributes of a counter profile

4.2.5.5 SETTING ALARMS ATTRIBUTES

For all Counter states, the attribute General/condition defines when alarms are generated for the datapoint: ‘appearance of the event’ / ‘appearance and disappearance of the event’.

For each state, set the following alarm attributes:

(1) **defined** (*No* / *Yes*)

(2) **delay** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(3) **gravity** (range [1, 5], step 1)

(4) **audible** (*No* / *Yes*), to activate a klaxon

(5) **clearing mode** (*Manual* / *Automatic* / *Gravity basis*): to precise the way alarm is cleared when alarm condition disappears:

- Manual: users must explicitly clear the alarm
- Automatic: no user intervention is needed to clear the alarm
- Cf. Scs – Clearing mode for gravities: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

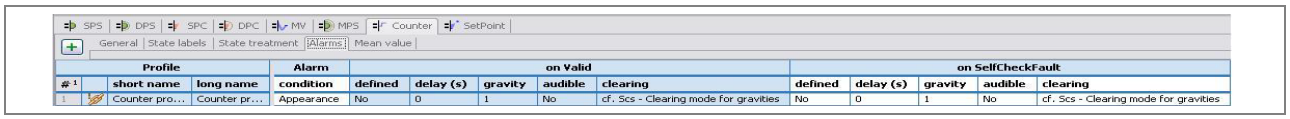


Figure 163: Setting the Alarms attributes of a counter profile

4.2.5.6 SETTING MEAN VALUE ATTRIBUTES

The ‘Mean value’ attributes are reserved for substation control point usage.

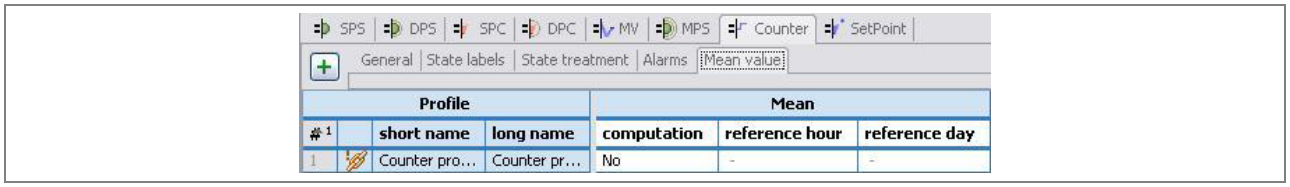


Figure 164: Setting the Mean value attributes of a counter profile

4.2.6 DEFINING AN XPC PROFILE

4.2.6.1 ADDING AN XPC PROFILE

To create an xPC profile:

- Select the type tab SPC/DPC
- Click the icon + at any level
- Set the profile attributes (see following sections)

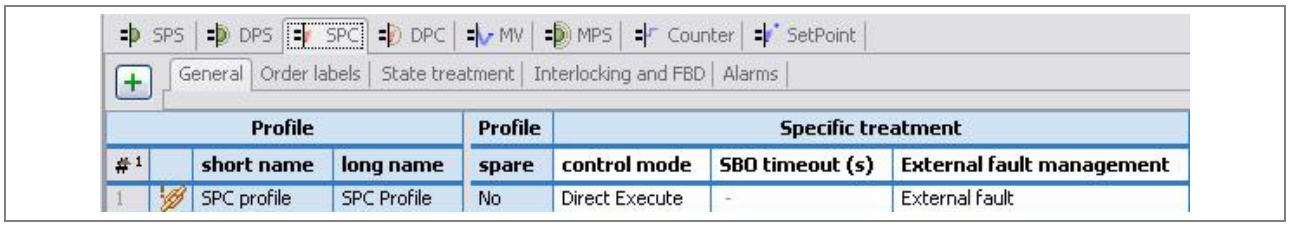


Figure 165: Adding an SPC profile (example given on C26x)

4.2.6.2 SETTING GENERAL ATTRIBUTES

Some general attributes must be set:

(1) **short name** and **long name** of the profile only used for profile identification in SCE

and for linked SPC datapoints:

(2) **control mode** (for details see section 6.1.2 of chapter C26x/EN FT)
Available values are:

- Direct execute
- SBO operate once
- SBO operate many
- Direct execute with SBO popup (reserved to substation control point usage), similar to 'Direct execute' for C26x

(3) **SBO timeout (s)** (range [0, 600 s], step 1s), significant if SBO mode is set to 'SBO operate once' or 'SBO operate many'

(4) **External fault management**

- External fault: the C26x waits for feedback confirming the position change
- OK (special use)

4.2.6.3 SETTING ORDER LABELS ATTRIBUTES

The 'Order labels' attributes are used for C26x events and alarm management (logging, display) and for correct xPC order management. Generic attribute:

(1) **Order.. usage** (*No* / *Yes*): if there is a label (*Yes*), the related wording **Order.. label**

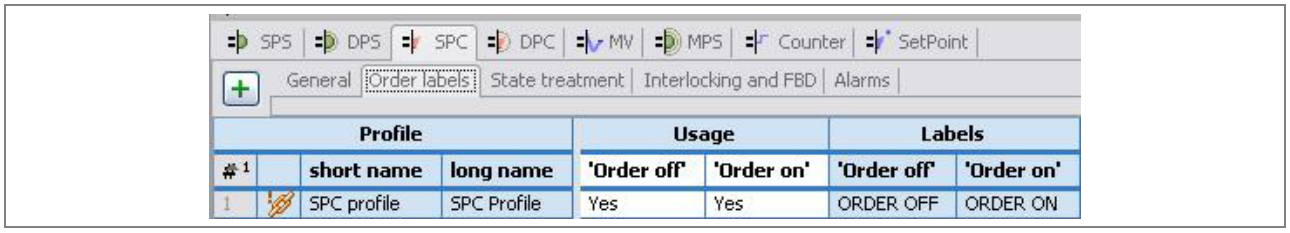


Figure 166: Setting the Order labels attributes of an SPC profile

4.2.6.4 SETTING STATE TREATMENT ATTRIBUTE

The 'State treatment' attribute must be updated globally for all available control and acknowledgement steps of the linked datapoints. The available attribute values are:

- C26x: no archive, logging
- C26x: archive, logging
- C26x: archive, no logging
- C26x: archive, logging

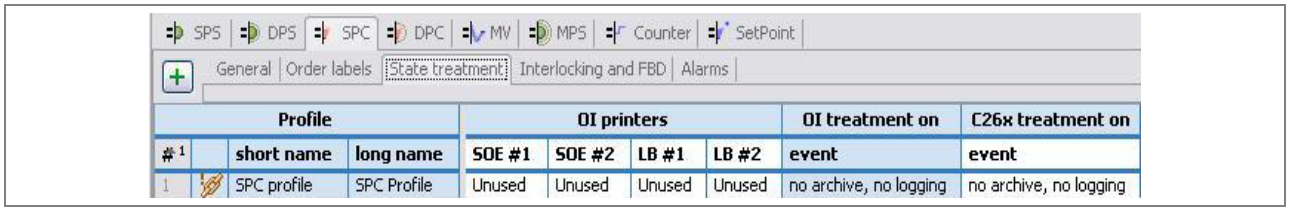


Figure 167: Setting the State treatment attribute of an SPC profile

4.2.6.5 SETTING INTERLOCKING AND FBD ATTRIBUTES

Some 'Interlocking and FBD' attributes can be updated for Boolean evaluation of interlocking equation, if the xPC belongs to an interlock equation or is an input of FBD automation (see sections *5.7.4 Defining an interlock* in this manual and *4.5 Defining an FBD fast automation* in SCE/EN AP).

Generic settable attribute:

(1) **.. order interlock value** (*Invalid* / *False* / *True*): defines the value affected to the y order state of the xPC for evaluation of an interlock equation or a FBD using this xPC

For C26x configuration, all attributes are significant for datapoints it is server of.

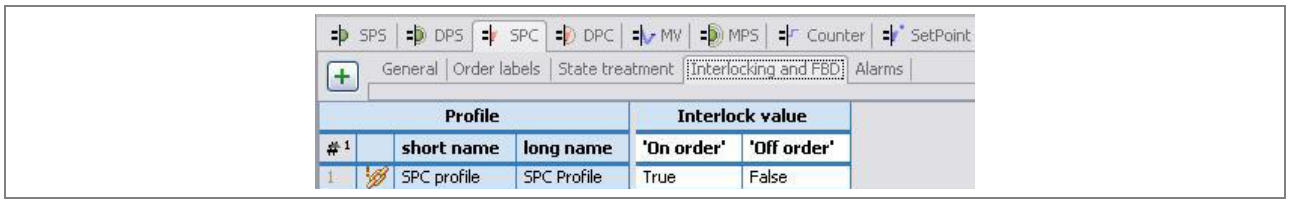


Figure 168: Setting the Interlocking and FBD attributes of an SPC profile

4.2.6.6 SETTING ALARMS ATTRIBUTES

Some 'Alarms' attributes must be set, for the correct alarm management in case of a negative acknowledgement concerning control of the linked datapoints.

The following alarm information is settable:

(1) **defined** (*No* / *Yes*)

(2) **delay (s)** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(3) **gravity** (range [1, 5], step 1)

(4) **audible** (*No* / *Yes*), to activate a klaxon

(5) **clearing** mode: to define the way alarm is cleared when alarm condition disappears:

- Manual: users must explicitly clear the alarm
- Automatic: no user intervention is needed to clear the alarm
- Cf. Scs – Clearing mode for gravities: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

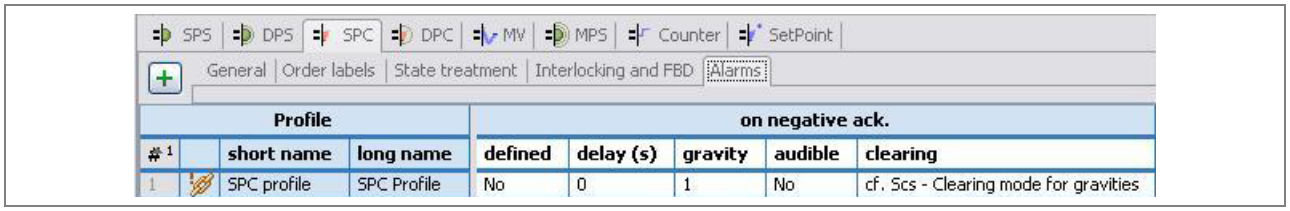


Figure 169: Setting the Alarms attributes of an SPC profile

4.2.7 DEFINING A SETPOINT PROFILE

4.2.7.1 ADDING A SETPOINT PROFILE

To create an SP profile:

- Select the type tab SP
- Click the icon + at any level
- Update the profile attributes (see following sections)

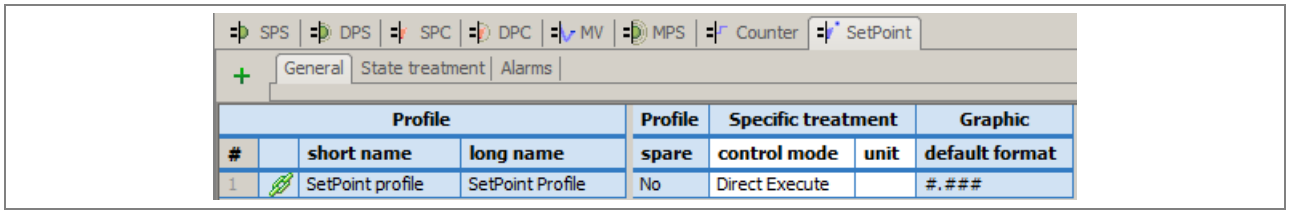


Figure 170: Adding a setpoint profile (example given on C26x)

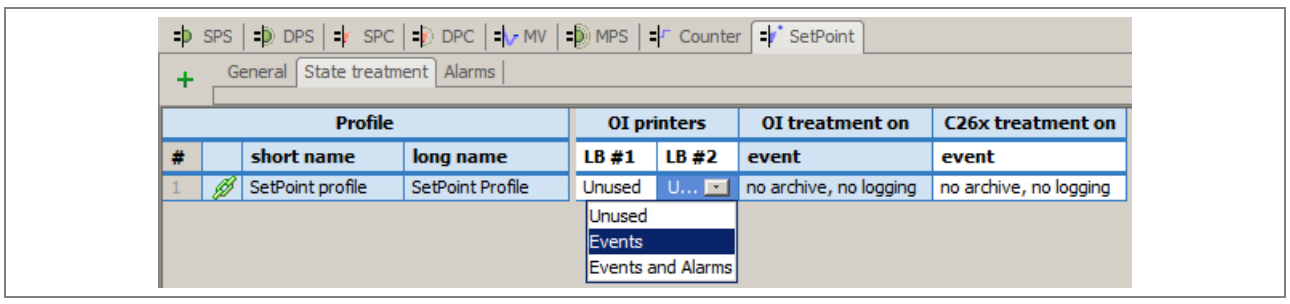


Figure 171: Defining event logging printer for setpoint profile

4.2.7.2 SETTING GENERAL ATTRIBUTES

When adding a SetPoint profile, some general attributes must be updated:

(1) **short name** and **long name** of the profile only used for profile identification in SCE

and, for linked SetPoint datapoints:

(2) **control mode**: The available values are:

- *Direct Execute*
- *Direct Execute* with SBO popup (reserved to substation control point usage), similar to 'Direct execute' for C26x (but it pops up in a window as in SBO mode)

(3) **unit**, electrical unit used for display, logging and alarm on C26x.

(4) **default format**, format of the setpoint value that can be sent from the DS Agile OI:

- decimal separator: only the point (**.**) is allowed,
- force absolute values: enter **~** anywhere in the **default format** field to render negative values invalid,
- **#** to define the number of significant digits:

  - if # represents a decimal digit, i.e. if it is preceded by a decimal point, it define the maximum number of decimal digits: # = 1 digit max., ## = 2 digits max. etc.,

  - if there is no decimal point or if # is placed to the left of the point, # represents at least one digit (no maximum number, except that the maximum number of characters of the whole setpoint value cannot be more than 255).

Examples:

default format	meaning	permitted values	forbidden values
#	any integer value	1, -23, 345, -15000, ...	1.1, 1.15, 25.357...
#.##	any integer or decimal value with not more than 2 decimal digits	1, 1.2, 25, -22.25, 345.45, -15000, ...	1.222, -1.2225, …
~#.###	any positive integer or decimal value with not more than 3 decimal digits	1.2, 22.25, 34.545, 234.2, 15000, ...	-1.2, -22.25, 34.5678, ...

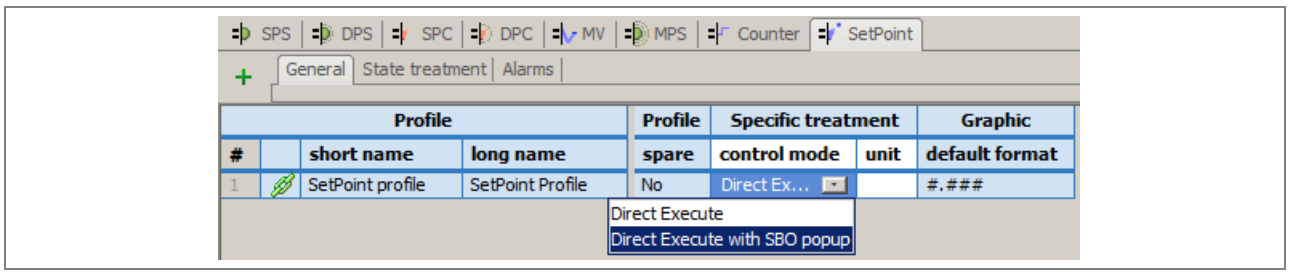


Figure 172: Setting the general attributes of a setpoint profile

4.2.7.3 SETTING TREATMENT ON EVENT ATTRIBUTES

The 'treatment on event' attribute must be set globally for all available control and acknowledgement steps of the linked datapoints.

The available values for the attribute **C26x treatment on** are:

- C26x: no archive, no logging
- C26x: no archive, logging
- C26x: archive, logging
- C26x: archive, no logging

The available values for the attribute **OI treatment on** are:

- C26x: no archive, no logging
- C26x: archive, logging
- C26x: archive, no logging

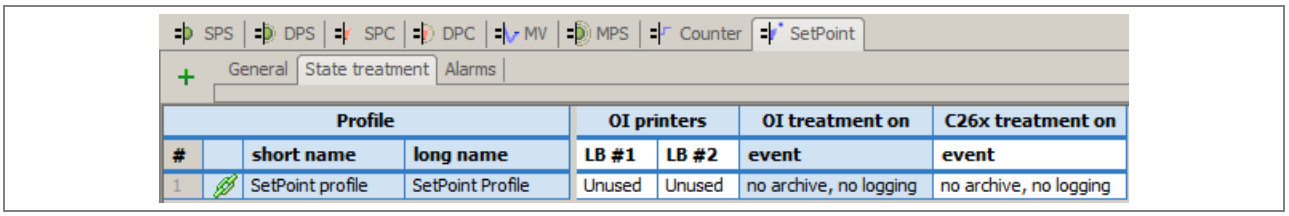


Figure 173: Setting the State treatment attribute of a setpoint profile

DS Agile aView only uses the “archive” setting: The state changes will be taken into account if set to *archive* (logging or no logging makes no difference). Logging is configured in Blend.

Event logging printers managed by DS Agile aView are not configured in SCE and the settings for **OI printers** has no effect.

4.2.7.4 SETTING ALARMS ATTRIBUTES

Some ‘Alarms’ attributes must be set, for the correct alarm management in case of a negative acknowledgement concerning control of the linked datapoints.

The following alarm information is settable:

(1) **defined** (*No* / *Yes*)

(2) **delay** (range [0 s, 120 s], step 1 s): to avoid alarm generation if alarm condition disappears within this delay

(3) **gravity** (range [1, 5], step 1)

(4) **audible** (*No* / *Yes*), to activate a klaxon

(5) **clearing mode**: to define the way alarm is cleared when alarm condition disappears:

- Manual: users must explicitly clear the alarm
- Automatic: no user intervention is needed to clear the alarm
- Cf. Scs – Clearing mode for gravities: the clearing mode is deduced from the one given at Scs object level for the relevant gravity

For C26x configuration, all attributes are significant for datapoints it is server of.

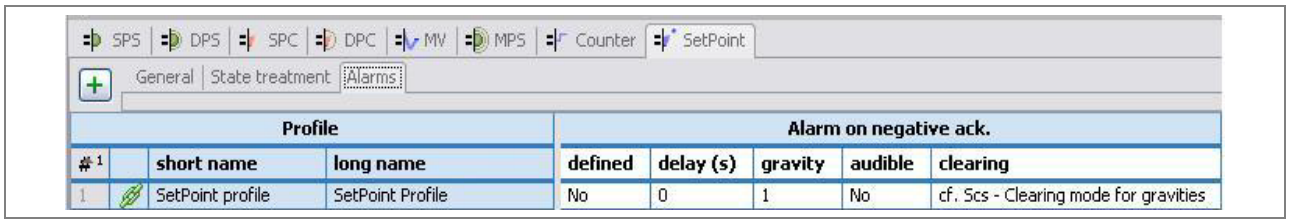


Figure 174: Setting the Alarms attributes of a setpoint profile

4.3 CREATING A DATAPOINT

Be careful

(See section *3.5.1 Connecting a C26x to other station-bus sub-systems*, for Client / Server definition).

In the set of all the C26x units of a Scs, the previous described SPS attributes (except short name and long name) are only useful and given to the C26x that serves the datapoint because the relevant functions are always done at C26x server level.

4.3.1 DEFINING AN SPS DATAPOINT

To create an SPS datapoint:

- Select the required system or electrical object level and add an SPS from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of SPS exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*)
- Update the SPS attributes (see following topic); some attributes can be fixed or masked depending on the pre-defined type of SPS
- Update its relation **has for profile** to point to a specific existing profile (2)

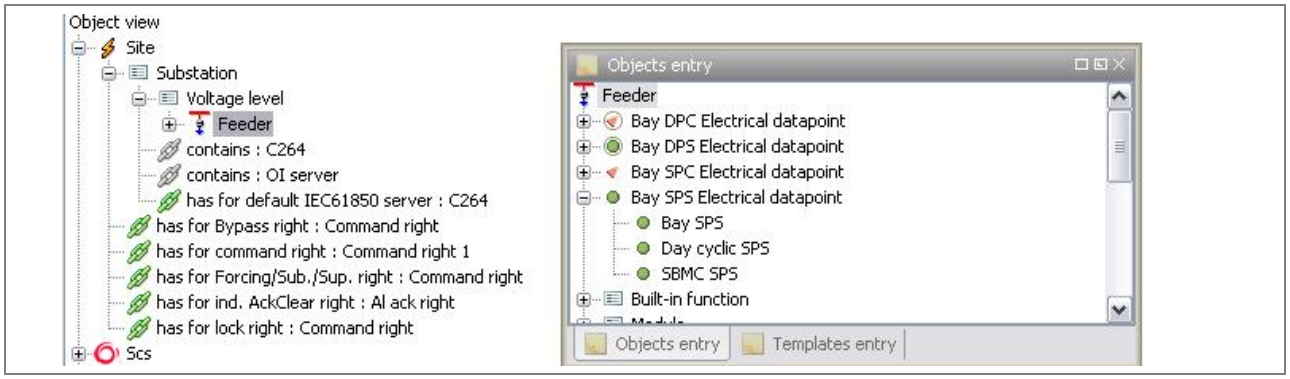
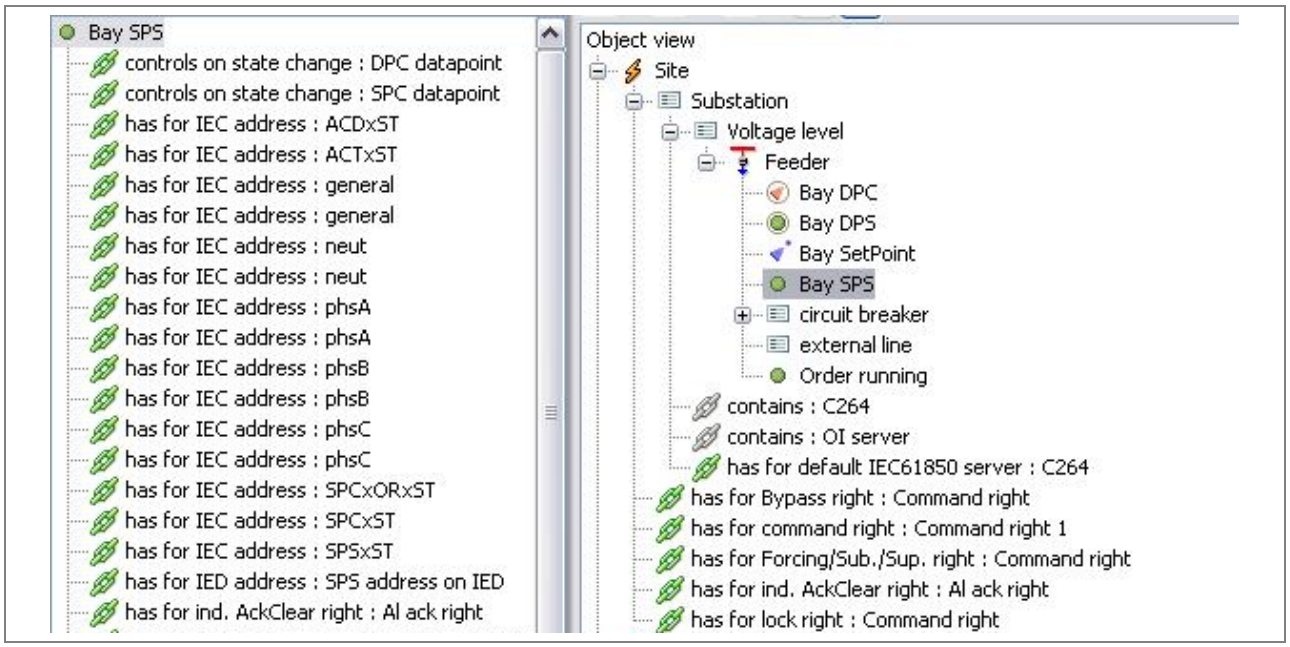


Figure 175: Adding an SPS datapoint (example given at bay level for generic SPS)



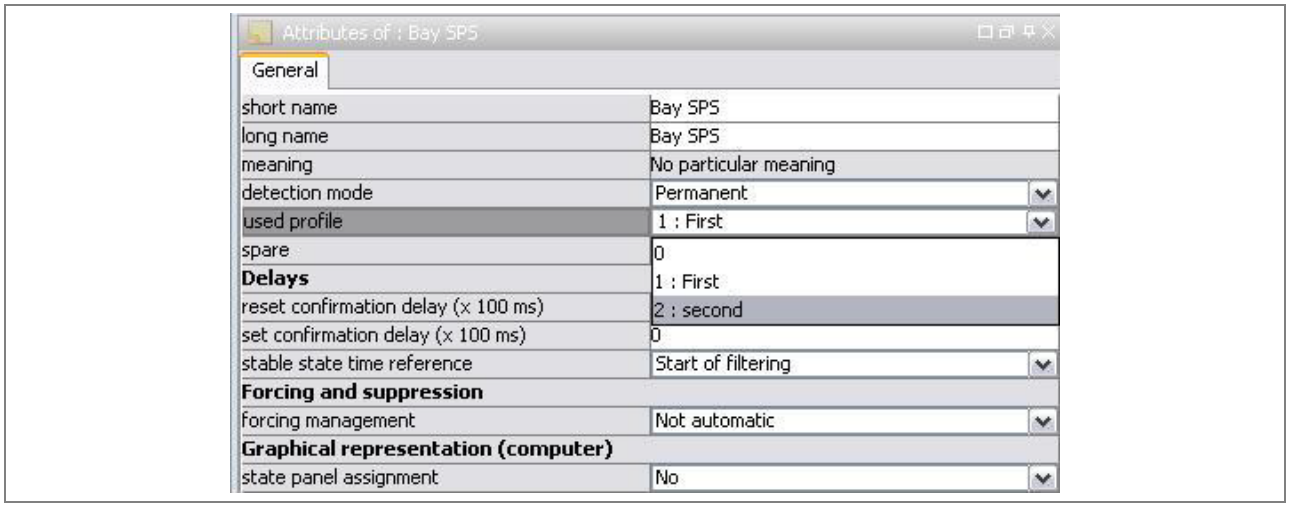


Figure 176: Linking an SPS datapoint to its profile (example for a generic SPS at Bay level)

Updating SPS attributes (description for generic SPS)

When adding a generic SPS datapoint, some general attributes must be updated:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **detection mode** (*Permanent* / *Transient* / *Permanent with computer auto-reset*): when this attribute is set to *Permanent with computer auto-reset* the SPS is reset automatically after 1 ms

(3) **used profile**: the drop-down list refers to the SPS tab of the Profiles table

(4) **reset confirmation delay** (range [0 s, 300 s], step 100 ms]: confirmation delay for stable ‘reset’ state

(5) **set confirmation delay** (range [0 s, 300 s], step 100 ms]: confirmation delay for stable ‘set’ state

(6) **stable state time reference** (Start of filtering / End of filtering)

(7) **forcing management** (*Not automatic* / *Automatic to reset state* / *Automatic to set state*): when an SPS goes to invalid state, C26x can force or not its status to set or reset state automatically. This attribute defines the way this forcing management is done. Automatic forcing management is independent of the FSS enable facility provided in the SPS profile

(8) **state panel assignment** (*No* / *Yes*): set to *Yes* to enable SPS state display at C26x local HMI level

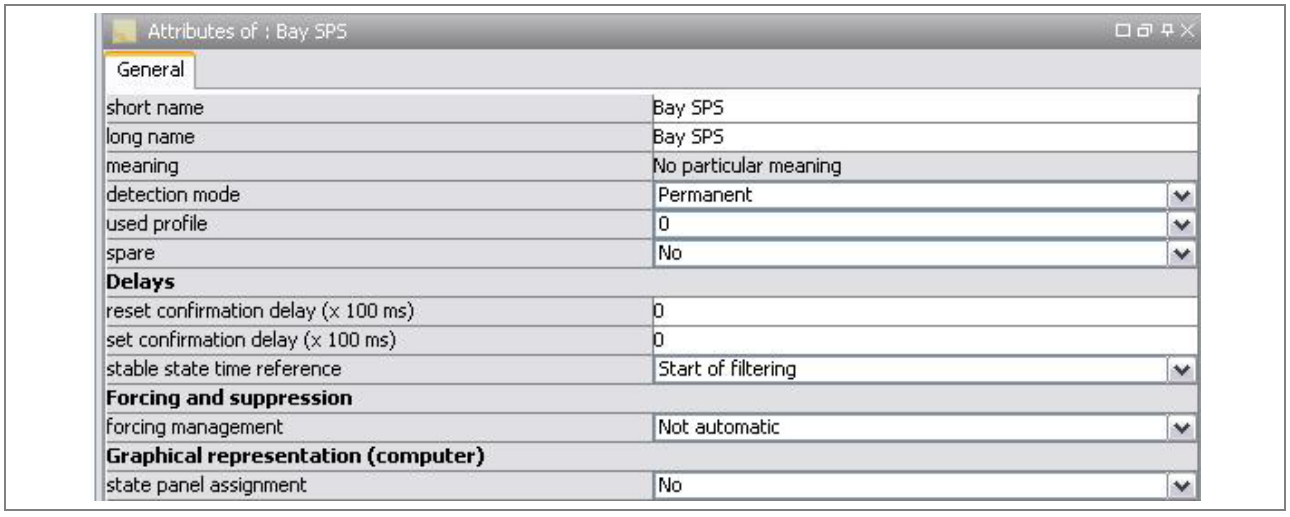


Figure 177: Setting the general attributes of an SPS datapoint (example for a generic SPS at Bay level)

4.3.2 DEFINING A DPS DATAPOINT

To create a DPS datapoint:

- Select the required system or electrical object level (1) and add a DPS from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of DPS exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*)
- Update the DPS attributes (see following topic); some attributes can be fixed or masked depending on the pre-defined type of DPS
- Update its relation **has for profile** to point to a specific existing profile (2)

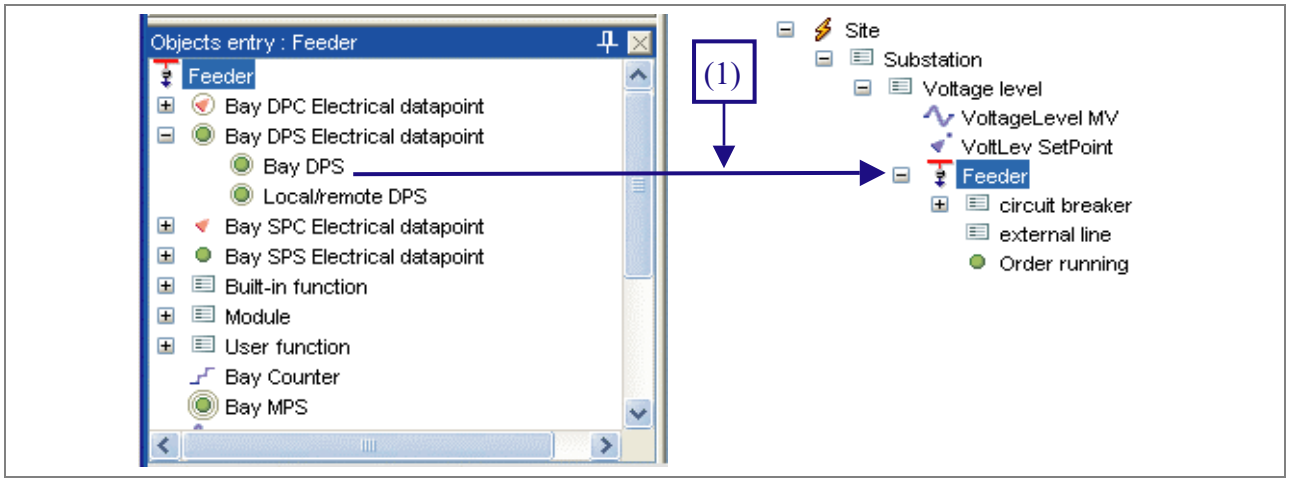


Figure 178: Adding a DPS datapoint (example a generic DPS at Bay level for)

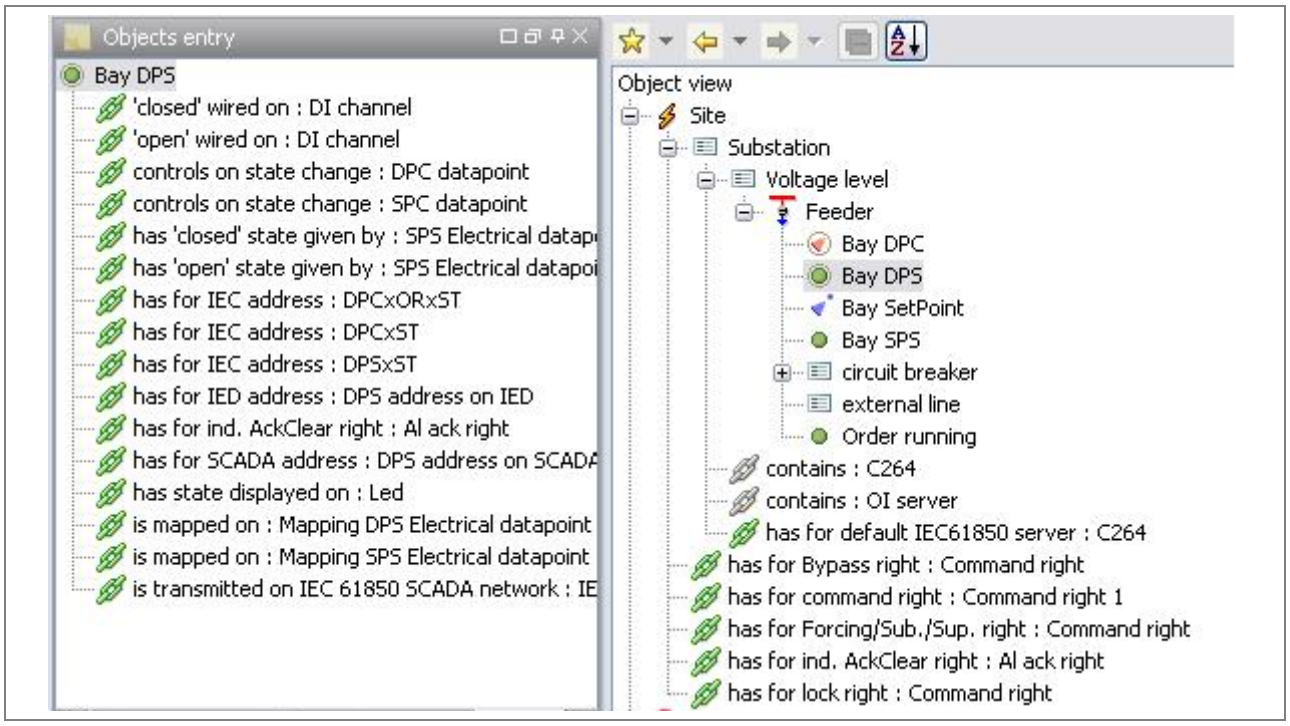


Figure 179: Linking a DPS datapoint to its profile(example for a generic DPS at Bay level)

Updating DPS attributes (description for generic DPS)

When adding a generic DPS datapoint, some general attributes must be set:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **used profile**: the drop-down list refers to the DPS tab of the Profiles table

(3) **complementary delay jammed** (range [0 s, 60 s], step 100 ms): this attribute defines the delay for the MOTION00 (JAMMED) state filtering. It corresponds to parameter T_{00} mentioned in section 5.1.3.1 of chapter C26x/EN FT

(4) **complementary delay undefined** (range [0 s, 60 s], step 100 ms): this attribute defines the delay for the MOTION11 (UNDEFINED) state filtering. It corresponds to parameter T_{11} mentioned in section 5.1.3.1 of chapter C26x/EN FT

(5) **open confirmation delay** (range [0 s, 300 s]), step 100 ms): this attribute defines the confirmation delay for the OPEN state. It corresponds to parameter T_O mentioned in section 5.1.3.2 of chapter C26x/EN FT

(6) **closed confirmation delay** (range [0 s, 300 s]), step 100 ms): this attribute defines the confirmation delay for the CLOSED state. It corresponds to parameter T_C mentioned in section 5.1.3.2 of chapter C26x/EN FT

(7) **stable state time reference** (*Start motion* / *End motion*): this attribute defines the time reference for a stable state: at start of motion filtering or end of motion filtering

(8) **forcing management** (*Not automatic* / *Automatic to reset state* / *Automatic to set state*): when a DPS is in an invalid state, the C26x can force or not its status to set or reset state automatically. This attribute defines the way this forcing management is done. Automatic forcing management is independent of the FSS enable facility provided in the DPS profile

(9) **state panel assignment** (*No* / *Yes*): set to Yes to enable the display of the DPS state at the C26x local HMI level.

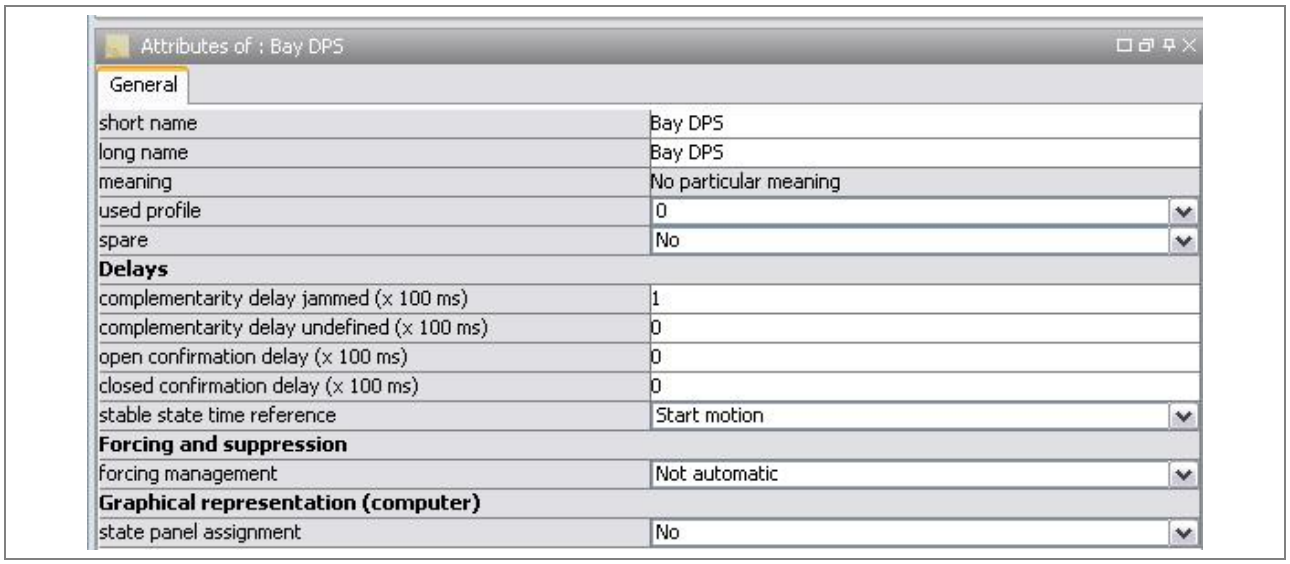


Figure 180: Setting the general attributes of a DPS datapoint (example for a generic DPS at Bay level)

4.3.3 DEFINING AN MPS DATAPOINT

To create an MPS datapoint:

- Select the required system or electrical object level (1) and add an MPS from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of MPS exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*)
- Update the MPS attributes (see following topic); some attributes can be fixed or masked depending on the pre-defined type of MPS
- Update its relation **has for profile** to point to a specific existing profile (2)

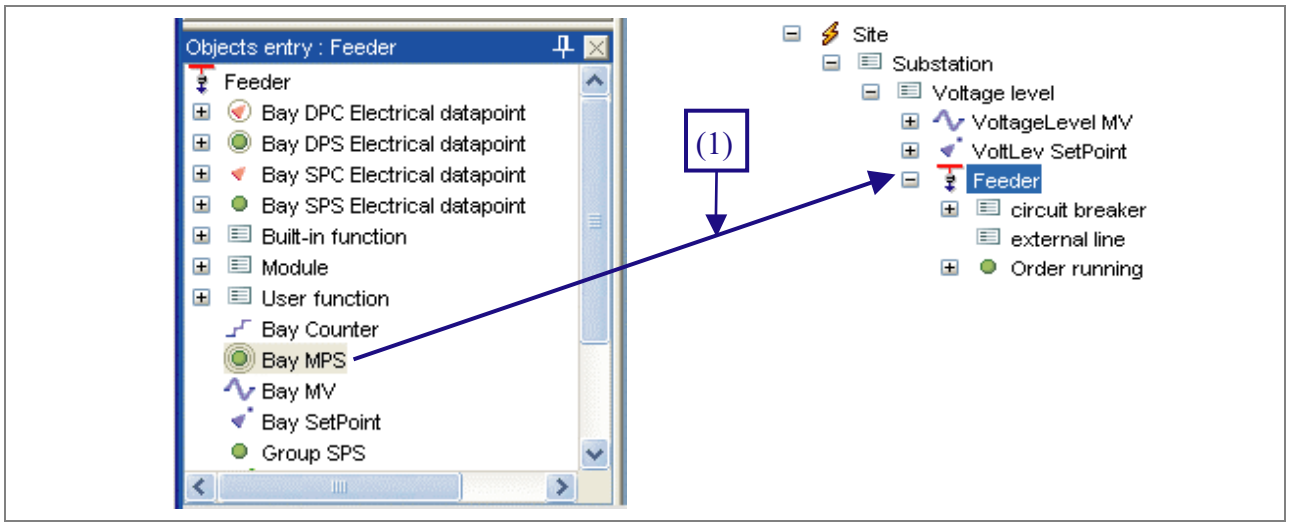


Figure 181: Adding an MPS datapoint (example for a generic MPS at Bay level)

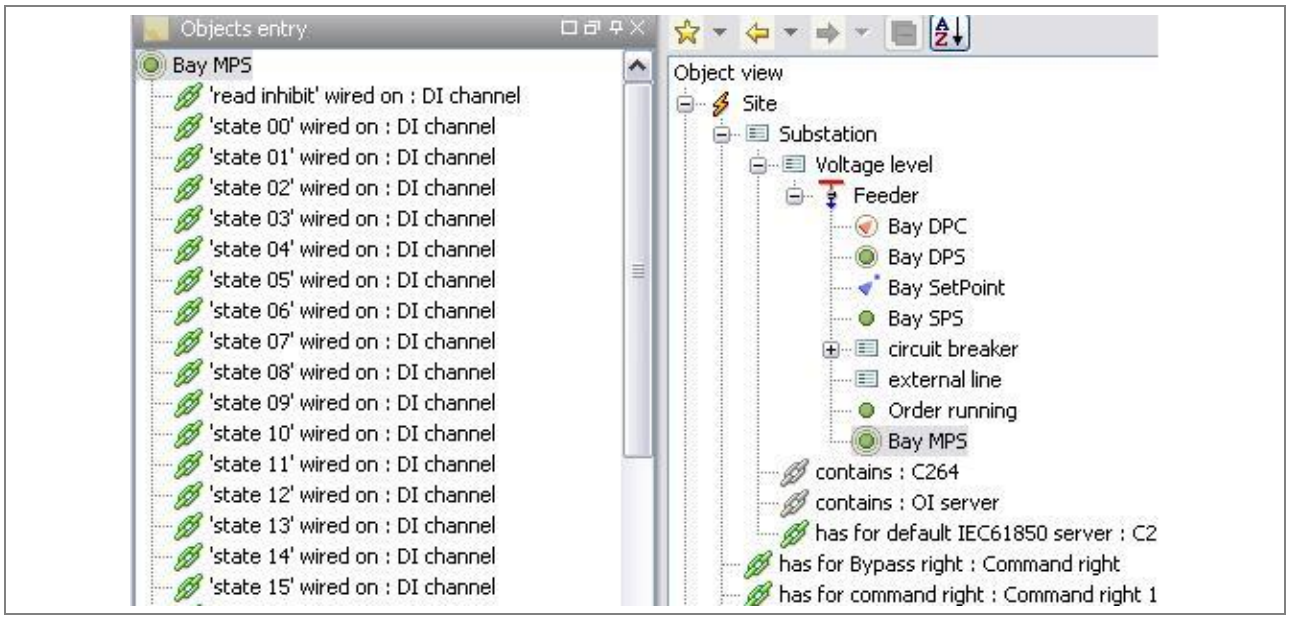


Figure 182: Linking MPS datapoint to its profile (example for a generic MPS at Bay level)

Updating MPS attributes (description for generic MPS)

When adding a generic MPS datapoint, some general attributes must be updated:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **used profile**: the drop-down list refers to the MPS tab of the Profiles table

(3) **filtering delay** (range [0 s, 6553.5 s], step 10 ms)

(4) **inhibition delay** (range [0 s, 6553.5 s], step 10 ms)

(5) **forcing management** (*Not automatic* / *Automatic to state <i> (i ∈ [0, 15])*): when an MPS goes in invalid state, C26x can force or not its status to set or reset state automatically. This attribute defines the way this forcing management is done. Automatic forcing management is independent of the FSS enable facility provided in the MPS profile.

(6) **state panel assignment** (*No* / *Yes*): set to *Yes* to enable MPS state display at C26x local HMI level.

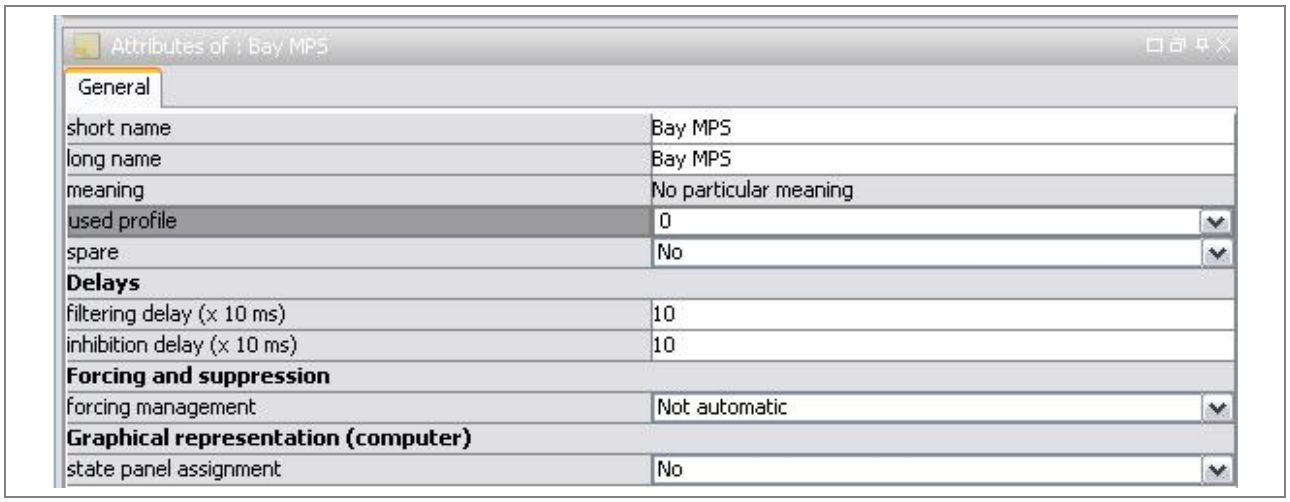


Figure 183: Setting the general attributes of an MPS datapoint (example for a generic MPS at Bay level)

4.3.4 DEFINING AN MV DATAPOINT

4.3.4.1 ADDING AN MV DATAPOINT

To create an MV datapoint:

- Select the required system or electrical object level (1) and add an MV from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of MV exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*)
- Update the MV attributes (see following sections); some attributes can be fixed or masked depending on the pre-defined type of MV
- Update its relation **has for profile** to point to a specific existing profile (2)

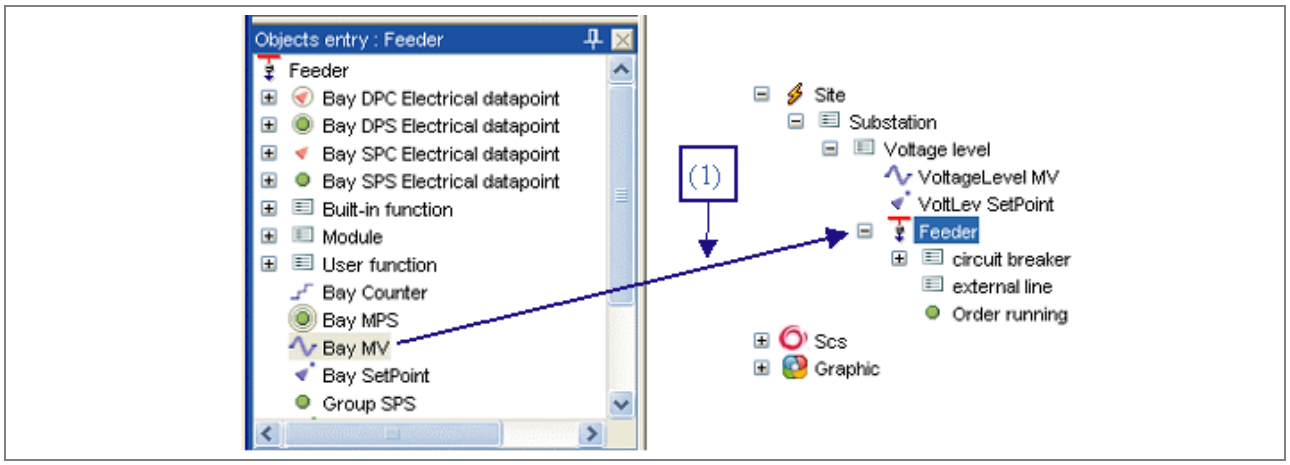


Figure 184: Adding an MV datapoint (example for a generic MV at Bay level)

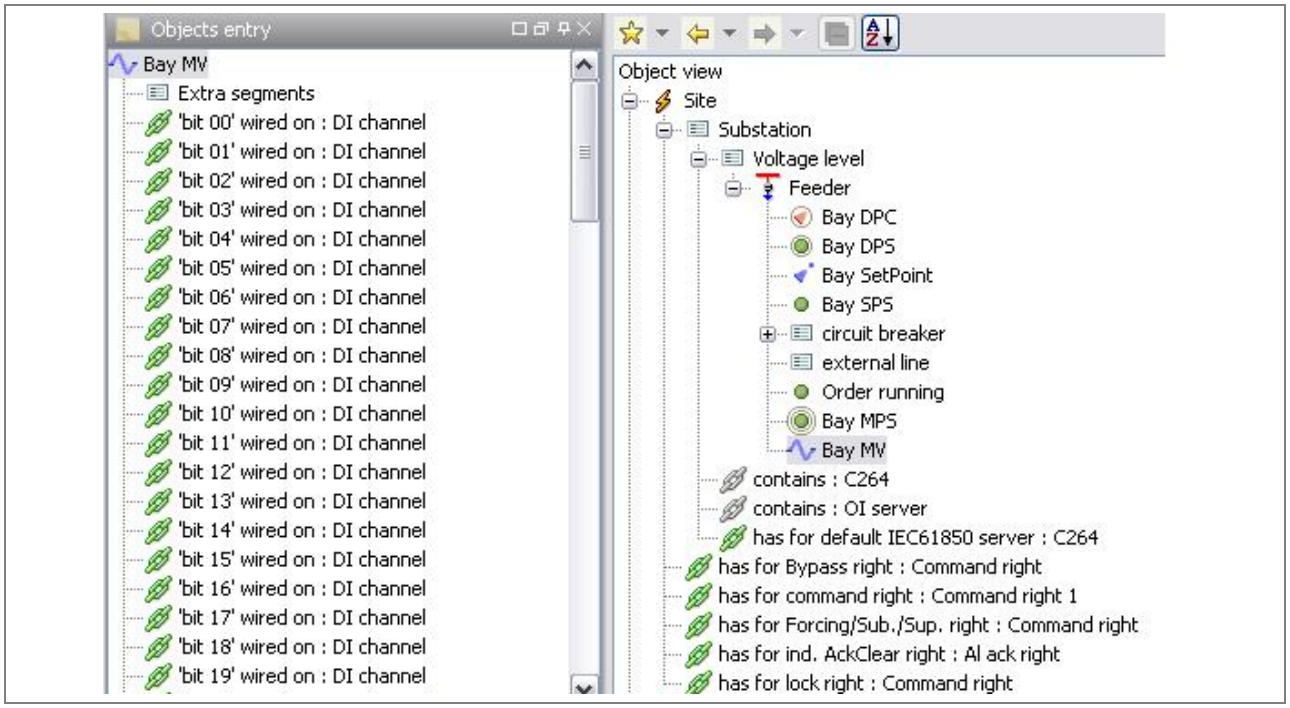


Figure 185: Linking an MV datapoint to its profile (example for a generic MV at Bay level)

Note:
To create a Computed MV, select the window Wiring and the board TMU2xx, then click Insert.

4.3.4.2 SETTING THE GENERAL ATTRIBUTES OF AN MV DATAPOINT

When adding a generic MV datapoint, some general attributes must be updated:

(1) **short name** and **long name**: used for logging, alarms ...

(2) **type**: available values are:

- Analogue (used for analogue acquisition, IED acquisition, CT/VT calculation or system input)
- Digital coded 'BCD' (only used for digital acquisition)
- Digital coded 'pure binary' (only used for digital acquisition)
- Digital coded 'gray' (only used for digital acquisition)
- Digital coded '1 among n' (only used for digital acquisition)
- Digital coded 'decimal' (only used for digital acquisition)
- For details about digital encoding see section 4.6.3 of chapter C26x/EN FT.

(3) **used profile**: the drop-down list refers to the MV tab of the Profiles table

(4) **automatic forcing** (*No* / *Yes*): when an MV goes in invalid state, C26x can force or not its value automatically. Automatic forcing management is independent of the FSS enable facility provided in the MV profile.

(5) **value for automatic forcing**: MV value when automatic forcing

(6) **transmission on event** (*Cyclic long period* / *Cyclic short period* / *According to a ‰ of full scale value* / *According to a ‰ of current value*)

(7) **deadband (‰ variation)** (range [0, 255], step 1): this attribute is significant only if the previous parameter is set to *'According to a ‰ of ...'*: this attribute corresponds to the 'p' parameter described in section *5.2.23 Transmission* of chapter C26x/EN FT.

(8) **MV panel assignment** (*No* / *Yes*): set to *Yes* to enable MV value displayed at C26x local HMI level.

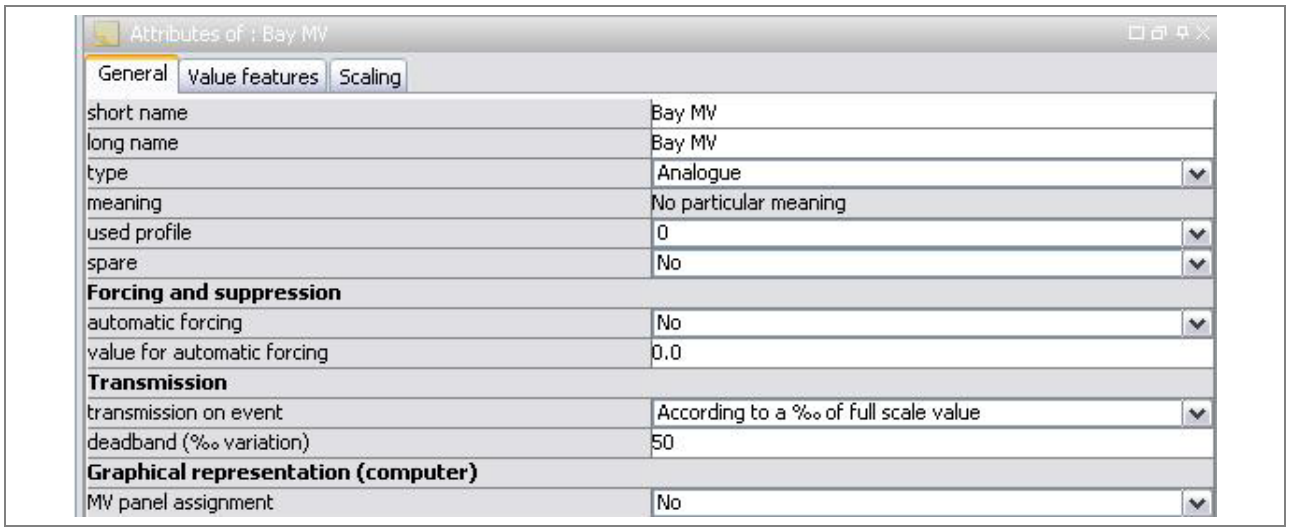


Figure 186: Setting the General attributes of an MV datapoint

4.3.4.3 SETTING THE VALUE FEATURES ATTRIBUTES OF AN MV DATAPOINT

When adding a generic MV datapoint, some 'Value features' attributes must be updated:

(1) **minimum value** (range [-3.4E38, 3.4E38]: used for full scale calculation and scaling

(2) **maximum value** (range [-3.4E38, 3.4E38]: used for full scale calculation and scaling. (Full scale = maximum value - minimum value)

(3) **zero value suppression** (% of full scale value) (range [0,10], step 0.1): this parameter is used to define the zero suppression area (deadband) for zero value suppression processing (see section *5.2.5* of chapter C26x/EN FT for details)

(4) **Hysteresis** used for threshold detection (see section *5.2.18* of chapter C26x/EN FT for details)

(5) **Threshold usage** (*No* / *Yes*)

(6) **Threshold** value

Note:
*MV datapoints that are feedbacks of setpoints (via the relation **is feedback of :**) do not support thresholds.*
If thresholds are nonetheless configured, they will not be transmitted over the IEC 61850 network.

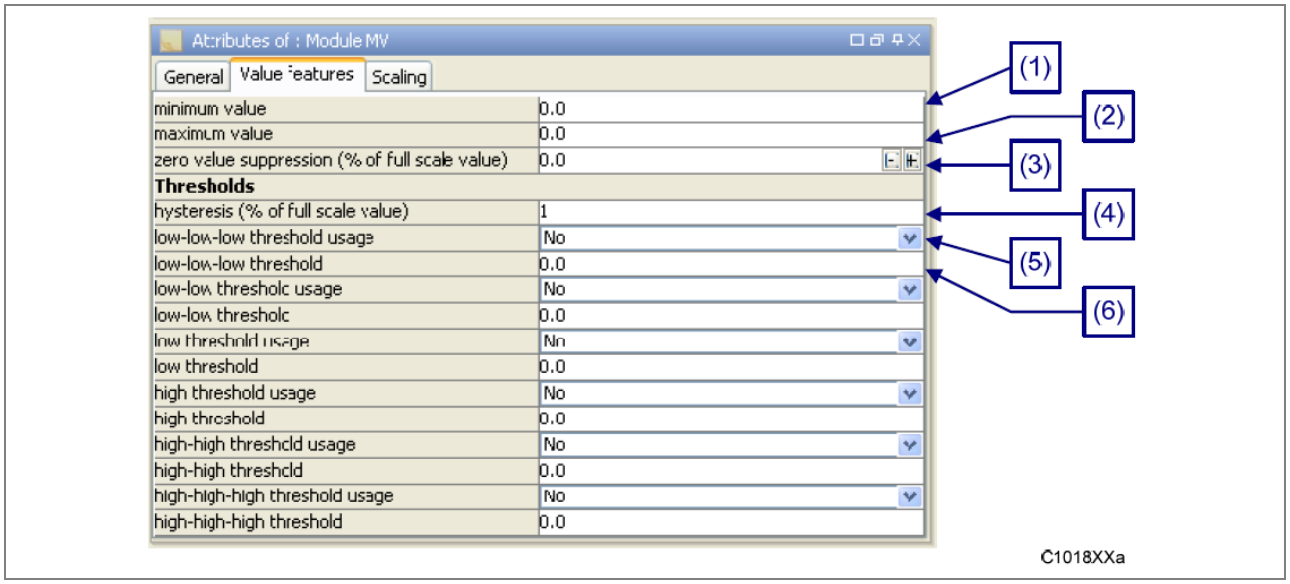


Figure 187: Setting the value features attributes to MV datapoint (example for a generic MV at Bay level)

4.3.4.4 SETTING THE SCALING ATTRIBUTES OF AN MV DATAPOINT

When adding a generic MV datapoint, some 'Scaling' attributes must be updated:

(1) **scaling rule**: available values are (see section *5.2.5* of chapter C26x/EN FT for calculation details): Linear/Quadratic/Quadratic with offset.

Note:
For MVs received from external IEDs, only linear scaling is available. Any other setting will be ignored.

(2) **minimum acq. value** (used for scaling)

(3) **maximum acq. value** (used for scaling)

In case of multi-segment scaling:

(4) **Ai coefficient**

(5) **Bi offset**

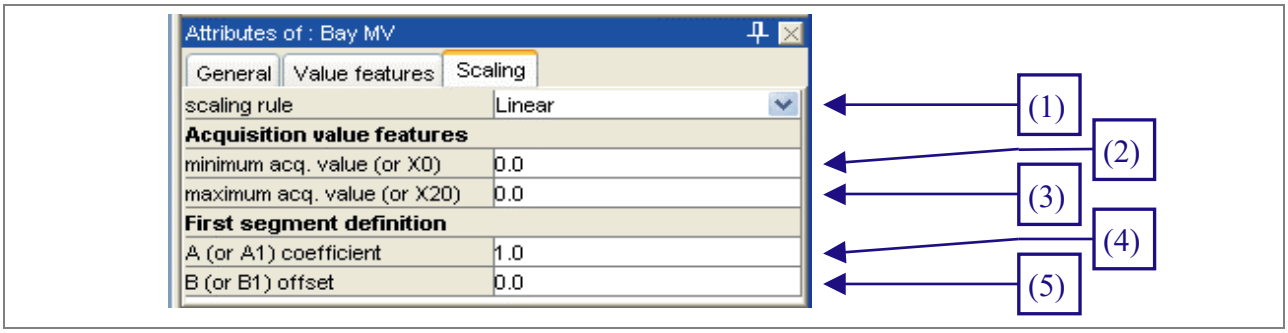


Figure 188: Setting the scaling attributes of an MV datapoint (example for a generic MV at Bay level)

4.3.5 DEFINING A TPI DATAPOINT

Tap Position Indicator (TPI) is an MV with specific features:

- Its value is an integer in the range [1..64]
- Acquisition can be done via AI channel of AIU board
- Acquisition can be done on digital channels of DIU board (up to 64 DI channels). In this case, available digital MV type are: Decimal, Gray, BCD or '1 among n'

4.3.5.1 ADDING A TPI DATAPOINT

TPI datapoint is automatically created when adding a tap changer built-in function under a mandatory transformer module of a transformer bay. For details about transformer bay, module or tap changer function creation see section *5 Defining a C26x configuration in the electrical hierarchy*.

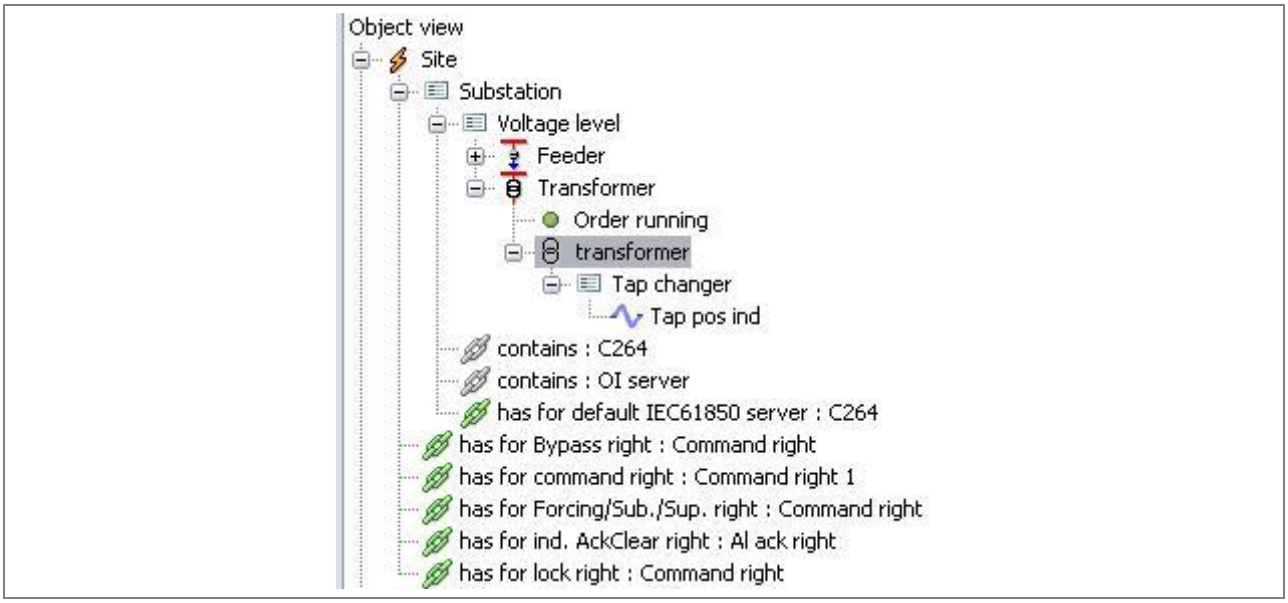


Figure 189: Automatic TPI creation for the tap-changer built-in function

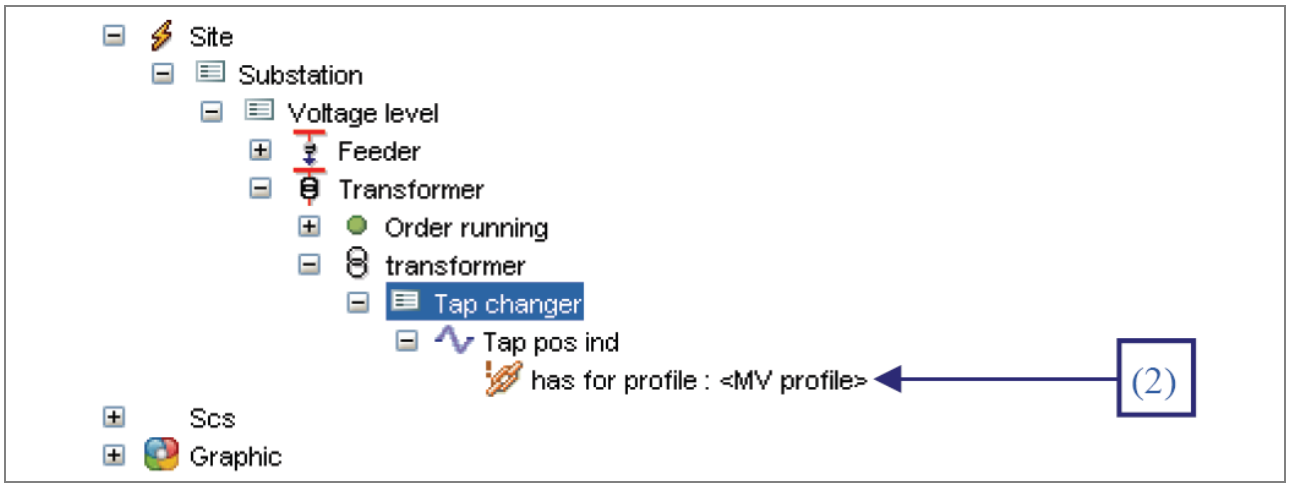


Figure 190: Linking a TPI datapoint to its profile

4.3.5.2 SETTING THE GENERAL ATTRIBUTES OF A TPI DATAPOINT

Some general attributes, similar to MV attributes, must be set:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **type**: available values are:

- *Analogue tap position*
- *Digital tap position coded '1 among N'* (only used for digital acquisition)
- *Digital tap position coded 'decimal'* (only used for digital acquisition)
- *Digital tap position coded 'gray'* (only used for digital acquisition)
- *Digital tap position coded 'BCD'* (only used for digital acquisition)

For details about digital encoding see section 4.6.3 of chapter C26x/EN FT.

(3) **used profile**: the drop-down list refers to the MV tab of the Profiles table

(4) **MV panel assignment** (*No* / *Yes*): set to 'yes' to enable MV value display at C26x local HMI level.

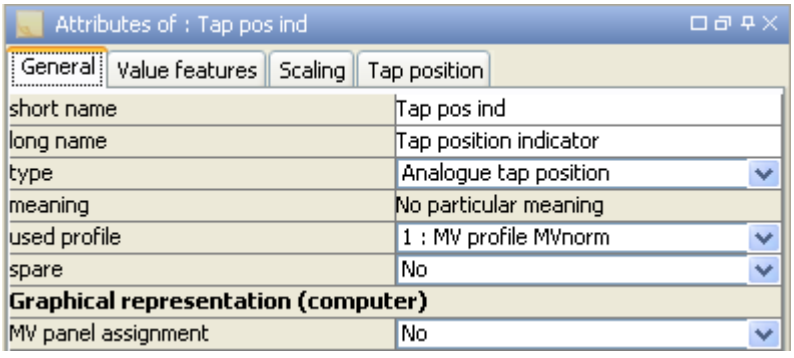


Figure 191: Setting the general attributes of a TPI datapoint

4.3.5.3 SETTING THE VALUE FEATURES ATTRIBUTES OF A TPI DATAPOINT

See section *4.3.4.3 Setting the Value features attributes of an MV datapoint*

Configuration rules and checks

- The following constraint between the two attributes must be respected:
  ("maximum value" – "minimum value" + 1) ∈ [1..64]

4.3.5.4 SETTING THE TAP POSITION ATTRIBUTES OF A TPI DATAPOINT

For a TPI datapoint, some specific attributes must be updated:

(1) **filtering delay** (range [0 , 655,35 s], step 10 ms):

- for digital TPI, corresponds to T_{stab} of digital measurement
  (See section 4.6 of chapter C26x/EN FT for attribute description)
- for analog TPI, corresponds to a delay to filter transient UNDEFINED state (delay to confirm UNDEFINED state)

(2) **current valid range (% maximum value)** (range [0 , 20 %], step 1 %): only used for analogue TPI, corresponds to N parameter described in section 5.3 of chapter C26x/EN FT

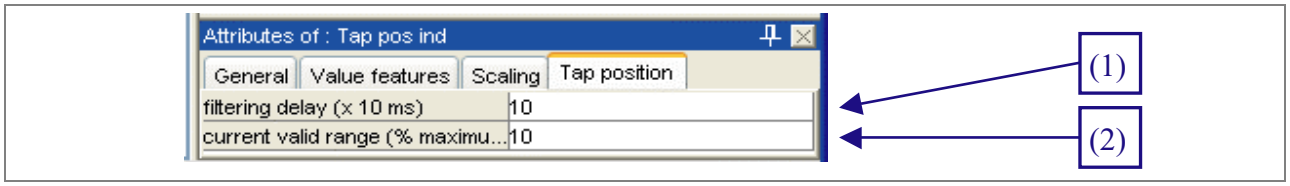


Figure 192: Setting the tap position attributes of a TPI datapoint

4.3.5.5 SETTING THE SCALING ATTRIBUTES OF A TPI DATAPOINT

For an analogue TPI datapoint, some 'Scaling' attributes appears and must be updated:

(1) **minimum acq. value**: corresponds to Imin parameter described in section 5.3.2 of chapter C26x/EN FT.

(2) **maximum acq. value**: corresponds to Imax parameter described in section 5.3 of chapter C26x/EN FT.

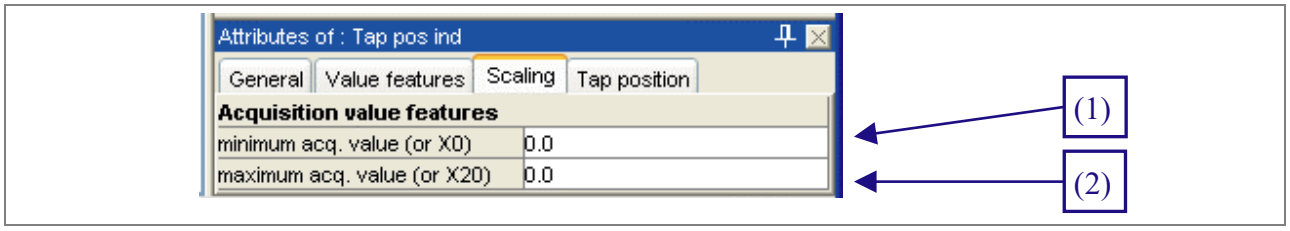


Figure 193: Setting the scaling attributes of a TPI datapoint

4.3.6 DEFINING A COUNTER DATAPOINT

Single counters and double counters are described in section 4.5 of chapter C26x/EN FT.

Scaling is used for printing or displaying a counter. EPI is a parameter giving the amount of energy in kW-h or kVAR-h equivalent to a pulse. The displayed value is:

N x EPI kW-h (N = value of a counter)

4.3.6.1 ADDING A COUNTER DATAPOINT

Select the required system or electrical object level (1) and add a Counter from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of counter exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*).

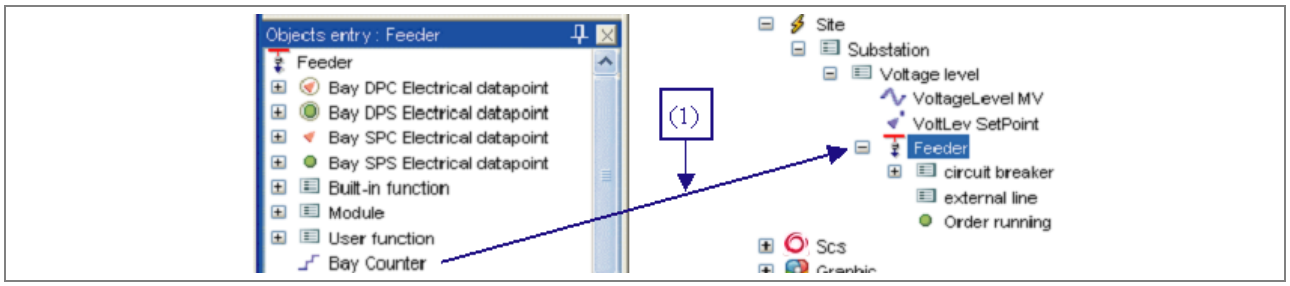


Figure 194: Adding a counter datapoint (example for generic counter at Bay level)

4.3.6.2 SETTING GENERAL ATTRIBUTES OF A COUNTER DATAPOINT

When adding a generic Counter datapoint, some general attributes must be updated:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **used profile:**the drop-down list refers to the Counter tab of the Profiles table

(3) **counter type** (*Standard* / *Energy import* / *Energy export*): when this attribute is set to "Standard" associated attributes are Validation duration (3), Invalidity duration (4), IED value already totaled (5), Cumul period (6) and Reset at cumulative period (7). When this attribute is set to *Energy import* or *Energy export*, the associated attributes are energy type (9), Scale factor (10), Transmission period (11) and reset after transmission (12)

(4) **validation duration** (range [0, 10 s], step 1 ms): corresponds to T_{count} parameter described in section 4.5 of chapter C26x/EN FT

(5) **invalidity duration** (range [5, 10 s], step 1 ms): corresponds to T_{def} parameter described in section 4.5 of chapter C26x/EN FT

(6) **IED value already totalized** (*No* / *Yes*): attribute must be set to Yes if counter value acquired on IED must not be totaled periodically (total done at IED level)

(7) **cumul period** (*10 mn* / *15 mn* / *30 mn* / *N h* ($N \in [1, 24]$)): corresponds to period length of internal clock parameter just described

(8) **reset at cumulative period** (*No* / *Yes*): when set to Yes that the way to transmit the periodic register, if not the cumulative register is transmitted

(9) **MV panel assignment** (*No* / *Yes*): set to Yes to enable Counter value display at C26x local HMI level

(10) **scale factor**

(11) **energy type** (*Active energy* / *Reactive energy*)

(12) **transmission period** (*10 mn* / *15 mn* / *30 mn* / *N h* ($N \in [1, 24]$))

(13) **reset after transmission** (*No* / *Yes*)

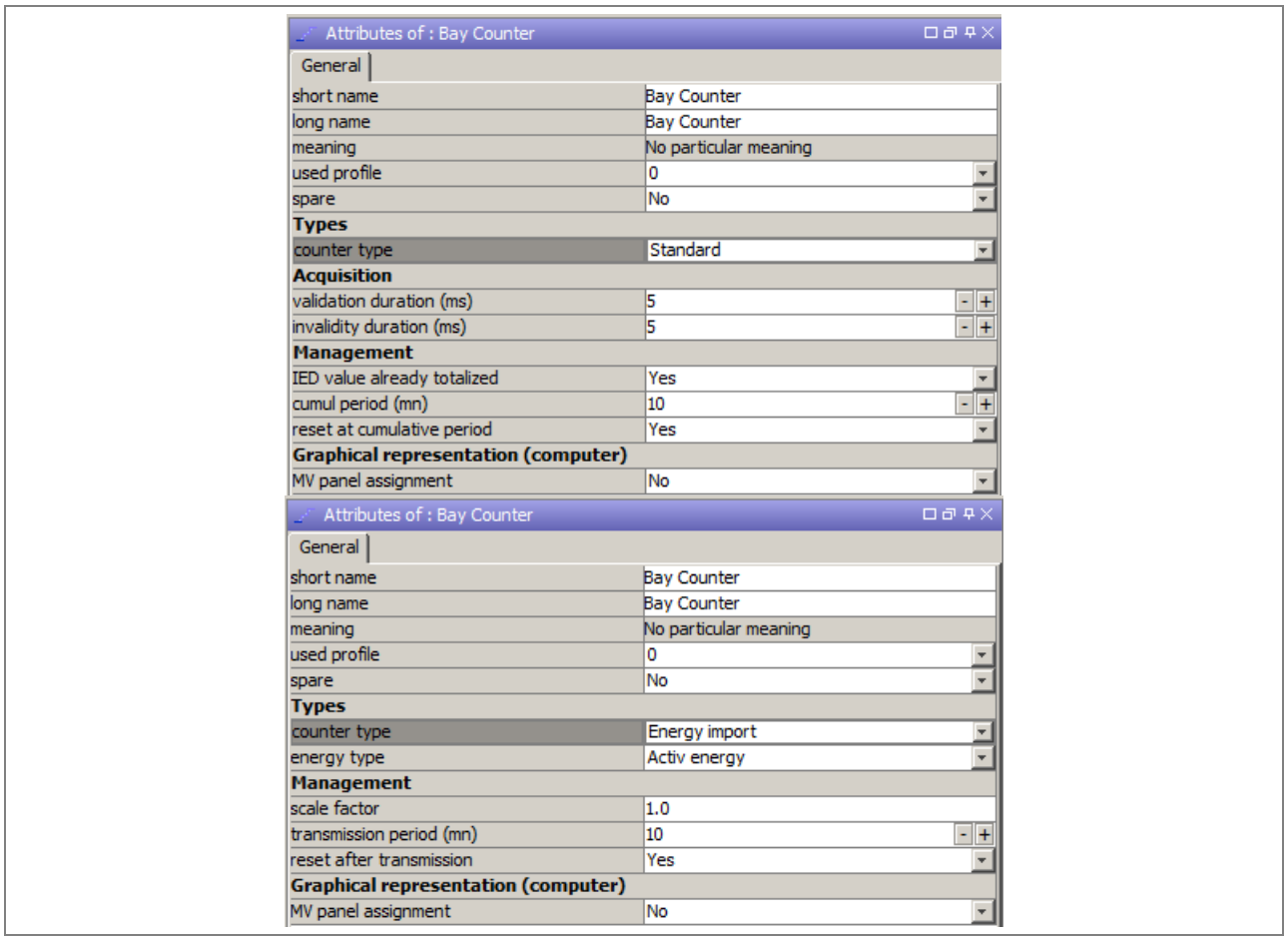


Figure 195: Setting the general attributes of a counter datapoint (example for a generic counter at Bay level)

4.3.7 DEFINING AN SPC DATAPOINT

- Select the required system or electrical object level and add an SPC from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of SPC exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*).

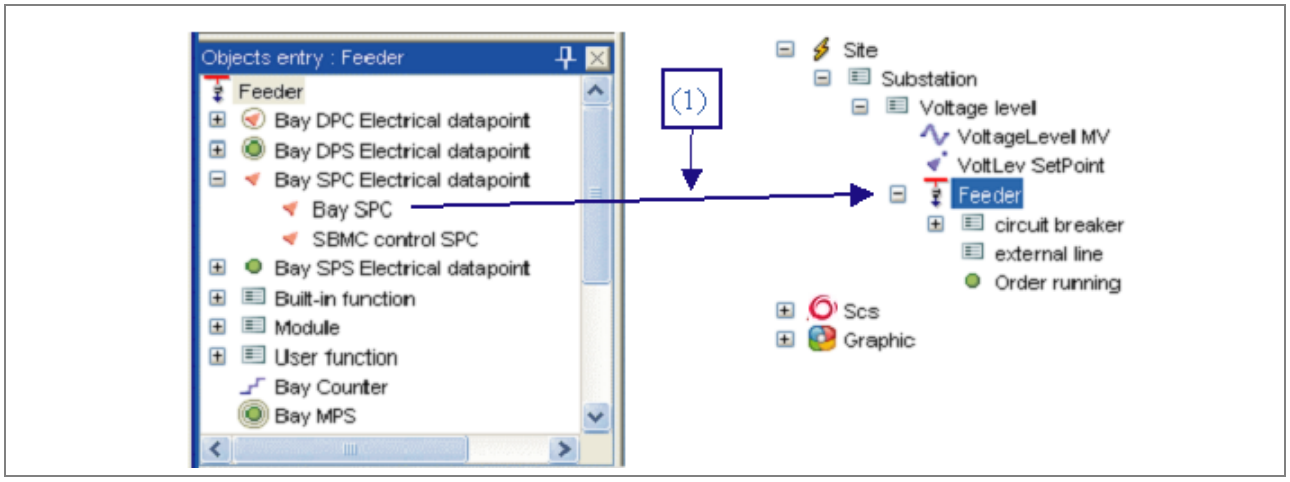


Figure 196: Adding an SPC datapoint (example for a generic SPC at Bay level)

4.3.7.1 SETTING THE GENERAL ATTRIBUTES OF AN SPC DATAPOINT

When adding a generic SPC datapoint, some general attributes must be updated:

(1) **short name** and **long name**: used for logging, alarms ...

(2) **used profile**: the drop-down list refers to the SPC tab of the Profiles table

(3) **activation mode** (*Permanent* / *Transient* / *Permanent until feedback*)

(4) **order on duration** (range [0, 15 s], step 10ms): this attribute is only available if the activation mode is set to *Transient*. It defines the time while the contact is closed before re-opening.

(5) **hold duration** (range [0, 10 s], step 10ms): this attribute is only available if the activation mode is set to *Permanent until feedback*. It defines the time while the contact is held in the requested position after reception of the confirmation of the position of the device.

(6) **time between two orders** (range [0, 10 s], step 100ms): this attribute corresponds to the inter-control delay

(7) **command panel assignment** (*No* / *Yes*): set to *Yes* to enable SPC control at C26x local HMI level

(8) **bay mode dependency:** *Yes* / *No*

(9) **SBMC mode dependency**: *Yes* / *No*

(10) **bay control uniqueness**: (*No* / *Yes*): only significant if control uniqueness is set to bay at substation level

(11) **Local substation dependency**: *Command from SCADA is refused* / *Allowed*

(12) **Remote substation dependency**: *Command from OI* (OI = substation control point, i.e. OI or aView) *is refused* / *Allowed*

(13) **Remote alarm substation dependency:** Customer-specific, not used in system versions V6.1.x. It should be set to its default value: *Command always accepted*.

(14) **Backup alarm substation dependency:** Customer-specific, not used in system versions V6.1.x. It should be set to its default value: *Command always accepted*.

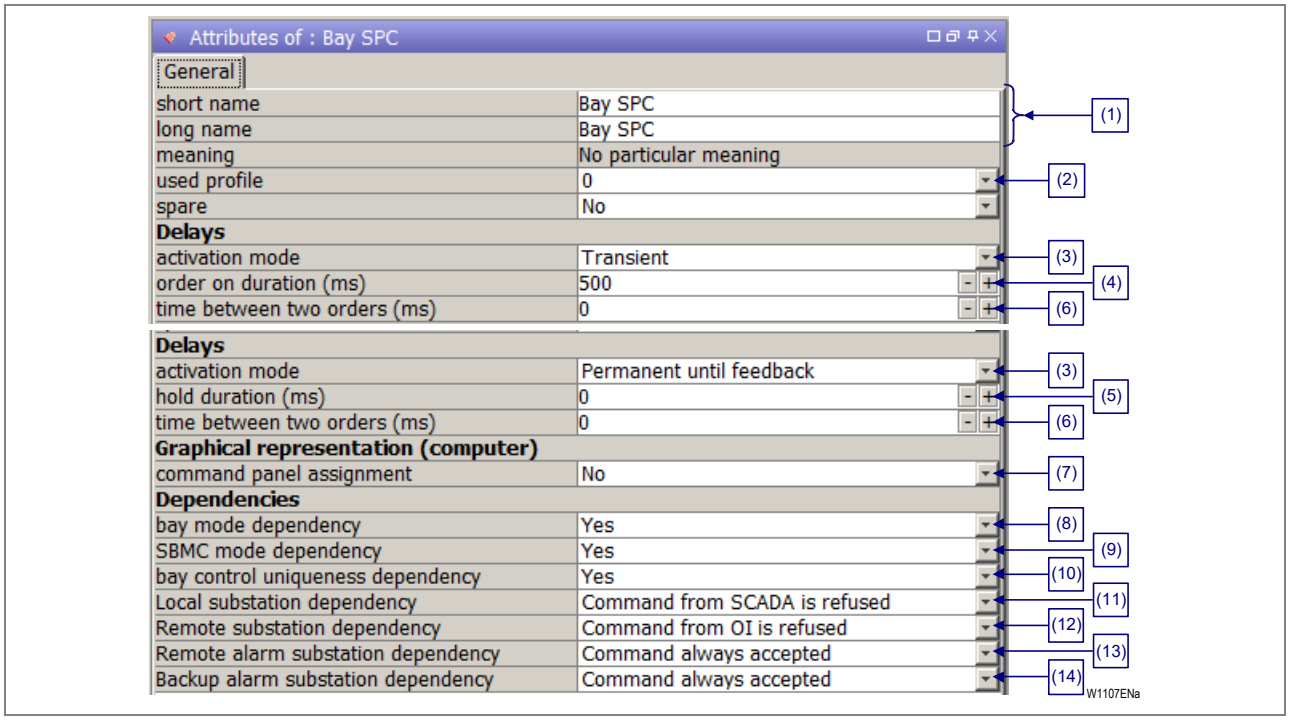


Figure 197: Setting the general attributes of an SPC datapoint (example for a generic SPC at Bay level)

4.3.7.2 DEFINING AN SPC FEEDBACK

For correct execution behaviour and control acknowledgement, an SPC datapoint can be linked to an SPS or DPS datapoint that corresponds to a feedback. For instance a circuit-breaker control SPC is linked to the circuit-breaker status DPS.

To define an SPC feedback:

- Add the relation **has for feedback** at SPC level: choose exclusively one of the two relations **has for feedback: SPS datapoint** (1) or **has for feedback: DPS datapoint** (2) depending on the type of feedback datapoint.
- Fill the relation with the relevant SPS or DPS datapoint.
- If necessary set the relation attributes:

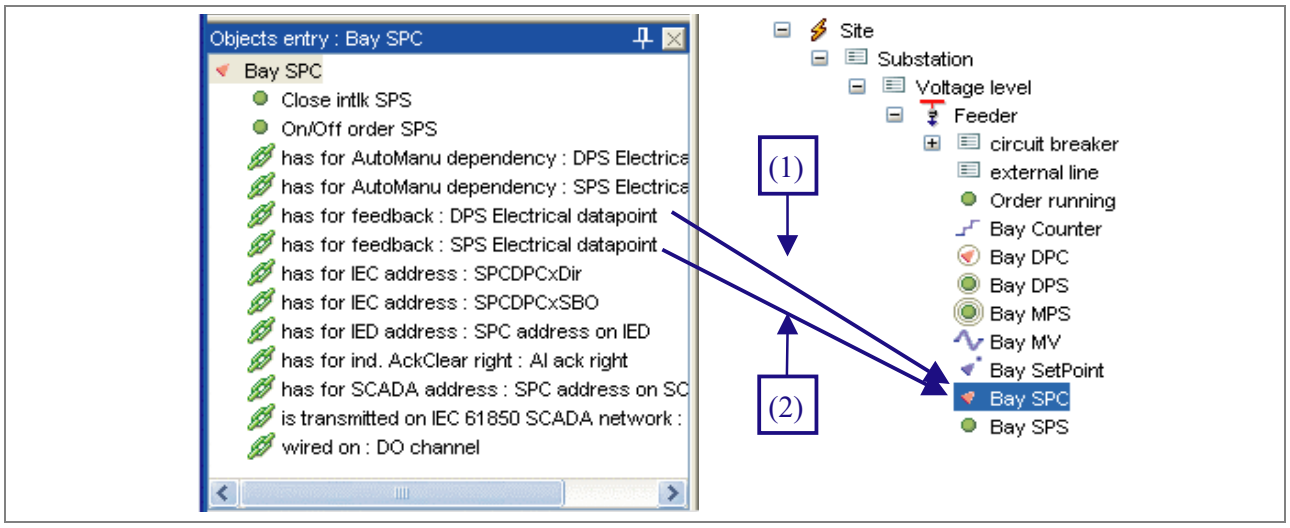


Figure 198: Defining an SPC feedback

(1) **execution time-out** (range [0, 6000 s], step 100 ms): in this given delay, feedback must change relatively to the control. If not, a negative acknowledgement is sent for the control

(2) **status check for command** (*No check* / *Control authorized only if the device is in the opposite state* / *Control authorized only if the device is in the opposite state, jammed or undefined* / *Control refused if the device is in the same state*): this attribute corresponds to the 'current status check for the device' described in section 6.1.6.8 of chapter C26x/EN FT and used also for execution checks (see section 6.1.8 of chapter C26x/EN FT)

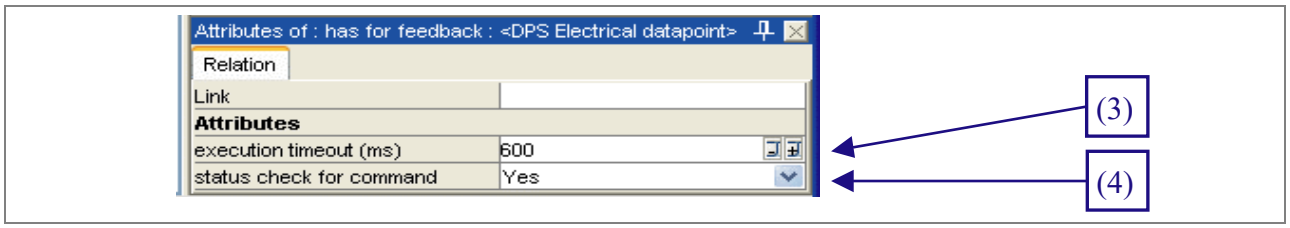


Figure 199: Setting the attributes of an SPC feedback relation

Configuration rules and checks

- For each "SPC", two relations **has for feedback** are available, but they are mutually exclusive
- A datapoint and its feedback datapoint must comply with the following rules:
  - both must have the same Server device
  - if one of them is a "Wired" datapoint, the other one must be "Wired" too (Here, the term "Wired"

means that the datapoint is linked to a digital or analog channel of a C26x, or linked to an IED address, else it's "System")
- if one of them is a "System" datapoint, the other one must be "System" too.
- if one of them is linked to an " IEC61850 gen IED" through the relation **has for IEC61850 address**, this relation must also be defined for the other one

- For an "SPC" datapoint, if its attribute "activation mode" is set to the "Transient" value, respect the rule: "execution timeout" > "order on duration"

4.3.8 DEFINING A DPC DATAPOINT

To create a DPC datapoint:

- Select the required system or electrical object level (1) and add a DPC from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of DPC exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*).
- Update the DPC attributes (see following topic); some attributes can be fixed or hidden depending on the pre-defined type of DPC.

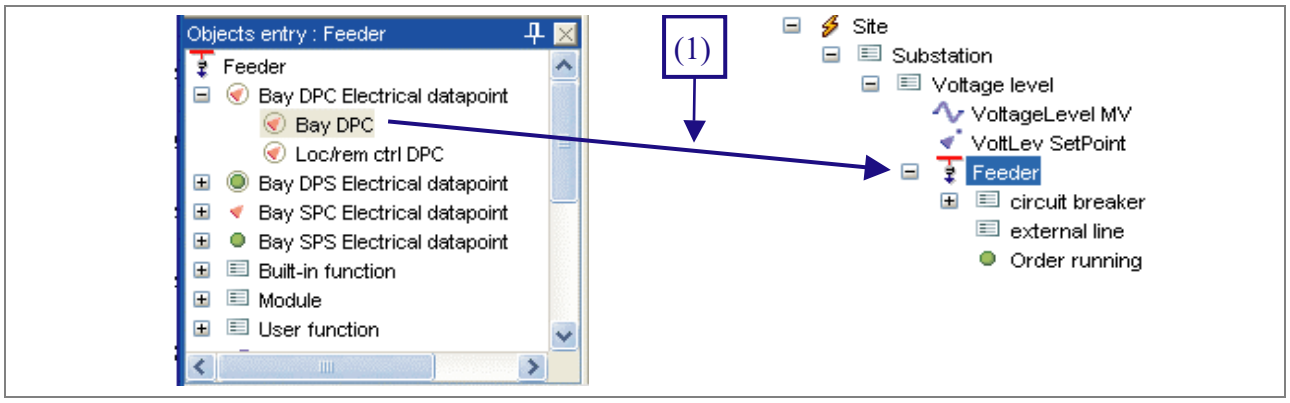


Figure 200: Adding a DPC datapoint

4.3.8.1 SETTING THE GENERAL ATTRIBUTES OF A DPC DATAPOINT

When adding a generic DPC datapoint, some general attributes must be updated:

(1) **short name** and **long name**: used for logging, alarms ...

(2) **used profile**: the drop-down list refers to the DPC tab of the Profiles table

(3) **activation mode** (*Permanent* / *Transient* / *Permanent until feedback*)

(4) **close duration** (range [0, 15 s], step 10ms): this attribute is only available if the activation mode is set to **Transient**. It defines the time while the DPC is held in the "closed" state before returning to the "open" state.

(5) **open duration** (range [0, 15 s], step 10ms): this attribute is only available if the activation mode is set to *Transient*. It defines the time while the DPC is held in the "open" state before returning to the "closed" state.

(6) **hold duration** (range [0, 10 s], step 10ms): this attribute is only available if the activation mode is set to *Permanent until feedback*. It defines the time while the contact is held in the requested state after reception of the confirmation of the position of the device.

(7) **time between two orders** (range [0, 10 s], step 100ms): this attribute corresponds to the inter-control delay defined in section 6.1.6.1 of chapter C26x/EN FT and use also used for execution checks (see section 6.1.8 of chapter C26x/EN FT).

(8) **command panel assignment** (*No* / *Yes*): set to *Yes* to enable SPC control at C26x local HMI level.

(9) **bay mode dependency**: *Yes* / *No*

(10) **SBMC mode dependency**: *Yes* / *No*

(11) **bay control uniqueness dependency**: *Yes* / *No* (only significant if control uniqueness is set to bay at substation level)

(12) **Local substation dependency**: *Command from SCADA is refused* / *Allowed*

(13) **Remote substation dependency**: *Command from OI is refused* (OI = substation control point, i.e. OI or aView) / *Allowed*

(14) **Remote alarm substation dependency:** Customer-specific, not used in system versions V6.1.x. It should be set to its default value: *Command always accepted*.

(15) **Backup alarm substation dependency:** Customer-specific, not used in system versions V6.1.x. It should be set to its default value: *Command always accepted*.

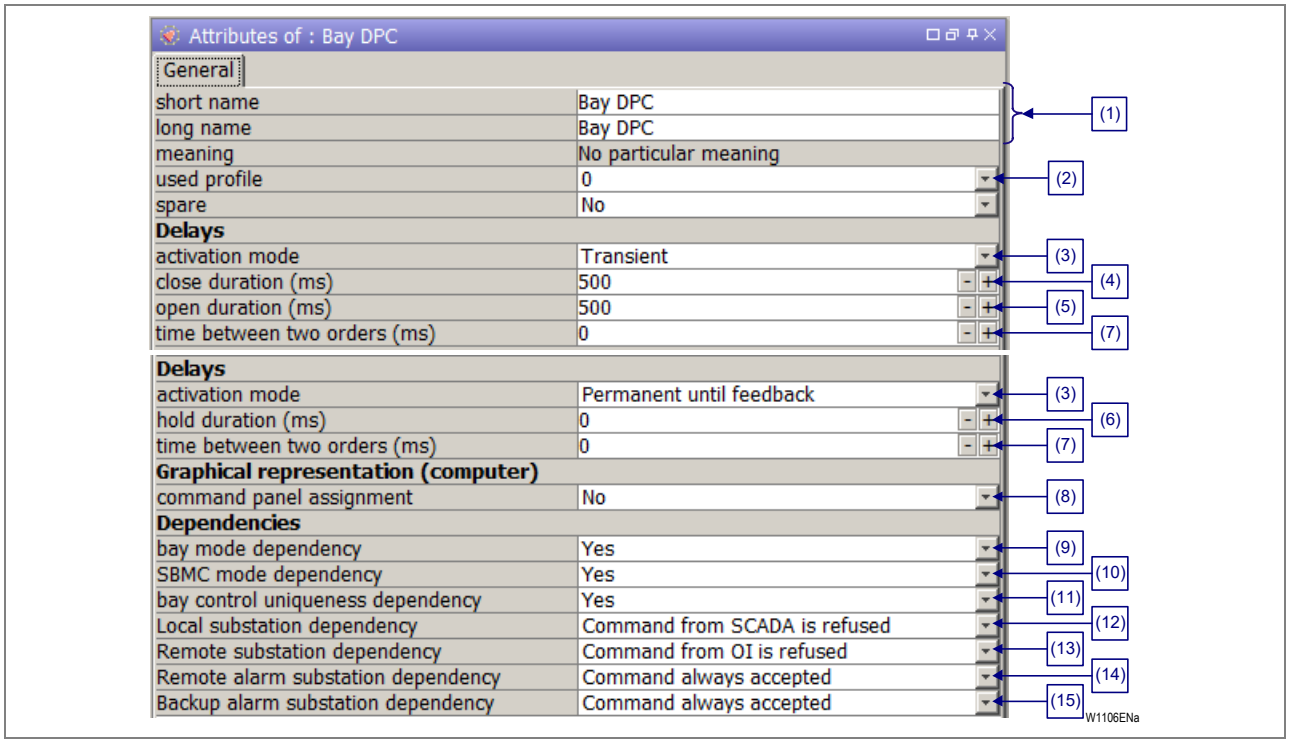


Figure 201: Setting the general attributes of a DPC datapoint (example for a generic DPC at Bay level)

4.3.8.2 DEFINING A DPC FEEDBACK

For correct execution behaviour and control acknowledgement, a DPC datapoint can be linked to an SPS or DPS datapoint that corresponds to a feedback. For instance a circuit-breaker control DPC is linked to the circuit-breaker status DPS.

To define a DPC feedback:

- Add the relation **has for feedback** at DPC level: choose exclusively one of the two relations **has for feedback: SPS datapoint** (1) or **has for feedback: DPS datapoint** (2) depending on the type of feedback datapoint.
- Fill the relation with the relevant SPS or DPS datapoint.
- If necessary update the relation attributes:
  - **execution timeout** (range [0, 6000 s] step 100 ms): in this given delay, feedback must change relatively to the control. If not, a negative acknowledgement is sent for the control
  - **status check for command**: this attribute corresponds to the 'current status check for the device' described in section 6.1.6.8 of chapter C26x/EN FT and also used for execution checks (see section 6.1.8 of chapter C26x/EN FT). Values:
    - No check
    - Control authorized only if the device is in the opposite state
    - Control authorized only if the device is in the opposite state, jammed or undefined
  - Control refused if the device is in the same state

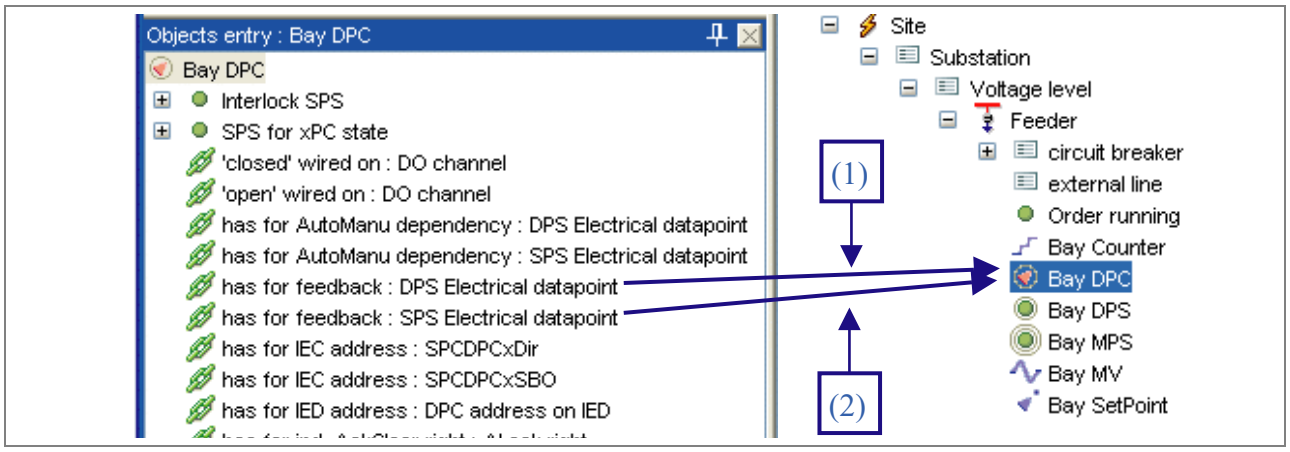


Figure 202: Defining a DPC feedback

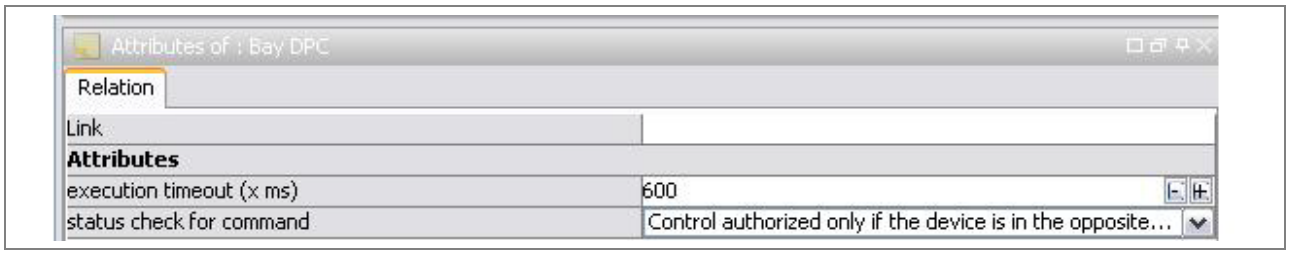


Figure 203: Setting the attributes of a DPC feedback relation

Configuration rules and checks

- For each "DPC", two relations **has for feedback** are available, but they are mutually exclusive
- A datapoint and its feedback datapoint must comply with the following rules:
  - both must have the same Server device
  - if one of them is a "Wired" datapoint, the other one must be "Wired" too (here, Wired" means that the datapoint is linked to a digital or analog channel of a C26x, or linked to an IED address, else it is referred to as "System")
  - if one of them is a "System" datapoint, the other one must be "System" too
  - if one of them is linked to an " IEC61850 gen IED" through the relation **has for IEC61850 address**, this relation must also be defined for the other one
- For a "DPC" datapoint, if its attribute "activation mode" is set to the "Transient" value, then the following rule must be respected: "execution timeout"> max ["open duration" , "close duration"]

4.3.9 DEFINING A SETPOINT DATAPOINT

4.3.9.1 OVERVIEW OF SETPOINT PROCESSING

Digital setpoints are described in section 4.9 of chapter C26x/EN FT.

SetPoints are used to send instruction values to the process or to ancillary units. DS Agile C26x units manage four types of SetPoints:

- Digital SetPoints
- SetPoints to IEDs
- System SetPoints
- Analog Setpoints

Digital SetPoints

Digital SetPoints are executed via DO channels of Digital Output boards. This type of controls is managed in “Direct Execute mode” only.

The checks performed during execution phase for SetPoints are:

- Substation and bay modes: check user selectable.
- Uniqueness: check user selectable.
- Device Locked: check user selectable.
- Automatism running control: check user selectable.

Digital SetPoints may be configured with digital “refresh DO” (see following topic).

The configuration also allows to define two methods of activation of the SetPoint relays:

- Raw activation: all activated relays which must be open are deactivated, all relays which must be closed are activated. If a “read inhibit DO” is configured this one must be deactivated during the relay positioning (see following topic).
- Incremental activation: the restitution of the SetPoint and relays can be done by successive increments from the initial value to the final one. The value of increments and the duration of the activation are user selectable. If a “read inhibit DO” is configured this one must be deactivated during every incremental activation (see following topic).

SetPoints to IEDs

SetPoints controls towards IEDs are managed in “Direct execute mode”. Execution phase is identical to the digital SetPoints. The execution is performed via the communication protocol of the concerned IED.

System SetPoint

SetPoints can be locally managed by C26x as a system control for automation for instance. Execution phase is identical to the digital SetPoints.

Analog Setpoints

Analog setpoints are measurement values sent on the Analog Output board.

These setpoints commands (with analog indication) are received from the Remote Control Point (RCP) or from the local HMI (with LCD).

Analog Setpoints are used to interface auxiliary units requiring analog inputs (ex: measurement viewers, generator).

The AO values are secured with an external power supply which allows keeping the analog output value in case of C26x shutdown or power off. A quality indication is available with the additional Read Inhibit output relays (NO) associated with each AO.

4.3.9.2 ADDING A SETPOINT DATAPOINT

To create a SetPoint datapoint:

- Select the required system or electrical object level (1) and add a SetPoint from the contextual **Objects entry** window. Depending on the object level, different pre-defined types of SetPoint exist. They are used for specific needs at electrical topology level (for details see relevant section in *5 Defining a C26x configuration in the electrical hierarchy*) or system topology level (for details see section *3.10 Setting system information for C26x components*).
- set the SetPoint attributes (see following section); some attributes can be fixed or masked depending on the pre-defined type of SetPoint.

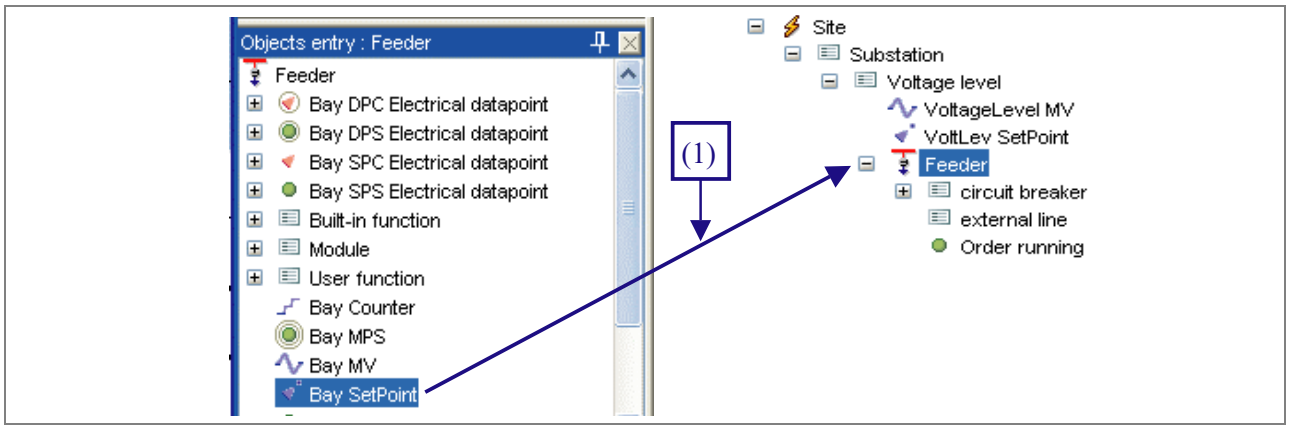


Figure 204: Adding a SetPoint datapoint

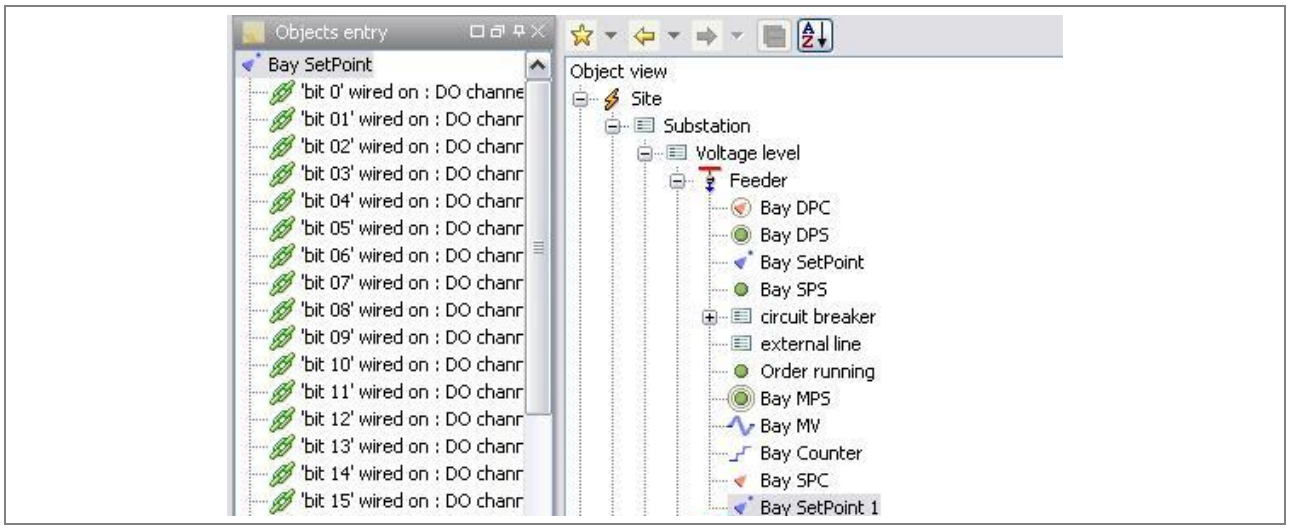


Figure 205: Linking a SetPoint datapoint to its profile

4.3.9.3 SETTING GENERAL ATTRIBUTES OF A SETPOINT DATAPOINT

When adding a generic SetPoint datapoint, some general attributes must be set:

(1) **short name** and **long name** of the datapoint used for logging, alarms ...

(2) **type**:

- *Analogue*: SetPoint is managed by system output or by AOU board output
- *Digital coded BCD*
- *Digital coded 'Pure binary'*
- *Digital coded 'Gray'*
- *Digital coded '1 among N'*
- *Digital coded 'decimal'*

(3) **used profile**: the drop-down list refers to the SetPoint tab of the Profiles table

(4) **progressive step usage**: only used for digital SetPoint. *No* corresponds to **Raw activation**, *Yes* to **Incremental Activation**, as described in section *Defining a SetPoint datapoint*.

(5) **minimum value** (range [-3.4E38, 3.4E38]): used for value control and scaling

(6) **increment value** (range [1, 24], step 1): used for incremental activation only

(7) **maximum value** (range [-3.4E38, 3.4E38]): used for value control and scaling

(8) **increment duration** (range [1 s, 999 s], step 1 s): used for incremental activation only

(9) **command panel assignment** (*Yes* / *No*): set to Yes to enable SetPoint control at C26x local HMI level

(10) **bay mode dependency:** *Yes* / *No*

(11) **SBMC mode dependency**: *Yes* / *No*

(12) **bay control uniqueness dependency**: *Yes* / *No* (only significant if control uniqueness is set to bay at substation level)

(13) **Local substation dependency**: *SetPoint from SCADA is refused* / *Allowed*

(14) **Remote substation dependency**: *SetPoint from OI is refused* (OI = substation control point, i.e. OI or aView) / *Allowed*

(15) **Remote alarm substation dependency:** Customer-specific, not used in system versions V6.1.x. It should be set to its default value: *Command always accepted*.

(16) **Backup alarm substation dependency:** Customer-specific, not used in system versions V6.1.x. It should be set to its default value: *Command always accepted*.

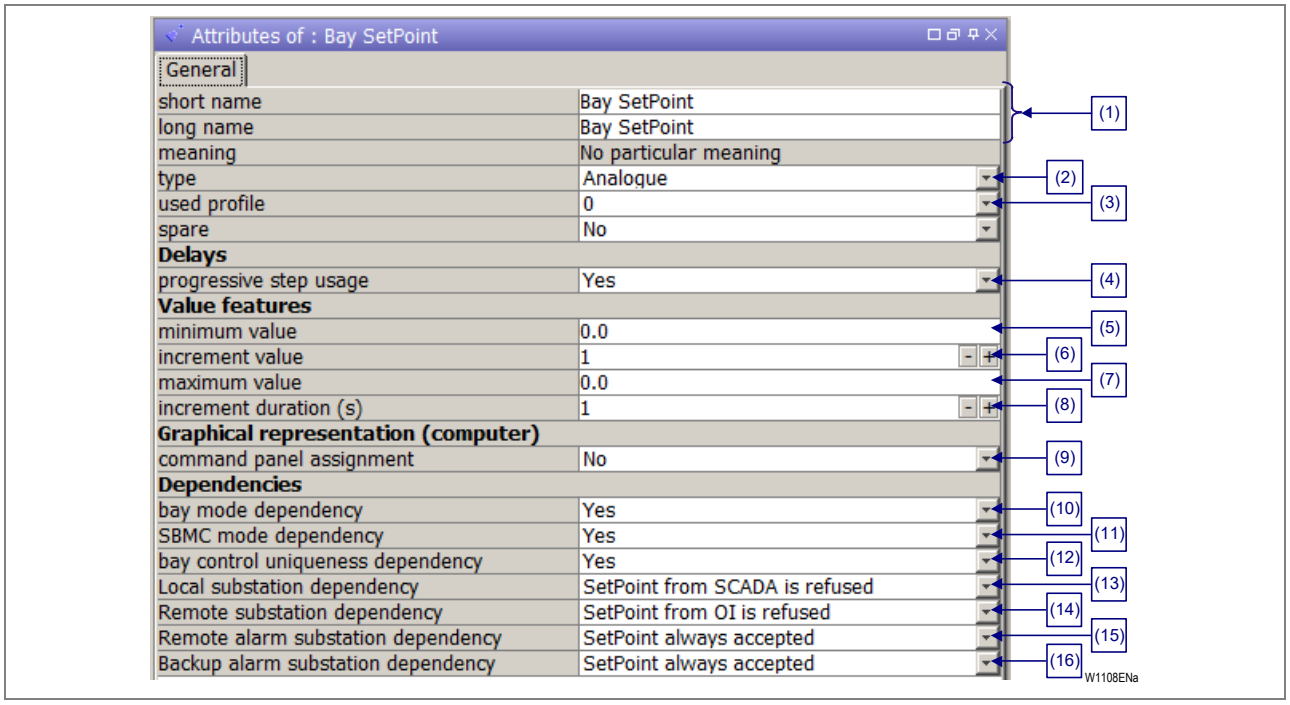


Figure 206: Setting the general attributes of a SetPoint datapoint

Configuration rules and checks

A Setpoint datapoint wired on DO channels of a C26x must be digital and have a profile with attribute “SBO mode” set to "Direct Execute" or “Direct Execute with SBO popup”.

4.3.9.4 DEFINING A SETPOINT FEEDBACK

For correct execution behaviour and control acknowledgement, a SetPoint datapoint can be linked to an MV datapoint that corresponds to a feedback.

To define SetPoint feedback:

- Add the relation **has for feedback** (1) at SetPoint level by tapping into the Object entry window
- Double click the relation in the browser and select the relevant MV datapoint in the Relation link editor
- If necessary set the relation attribute:

(1) **execution timeout** (range [0, 999 s], step 1 s): within this delay, the feedback must change relatively to the control. Otherwise, a negative acknowledgement is sent for the control

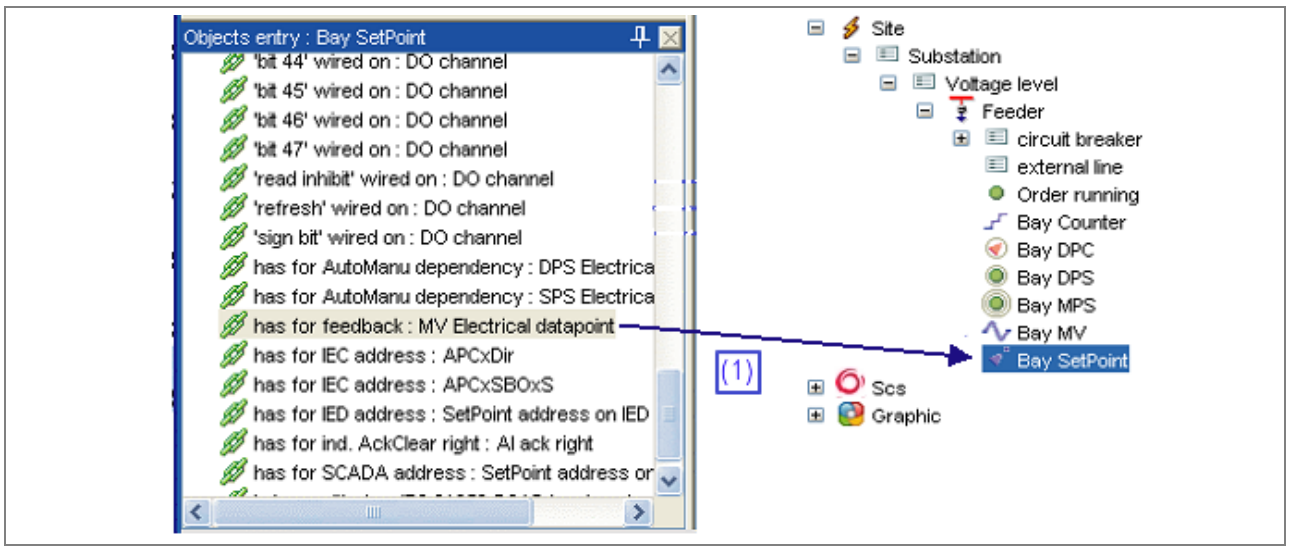


Figure 207: Defining SetPoint feedback

Configuration rules and checks

- A datapoint and its feedback datapoint must comply with the following rules:
- both must have the same Server device
- if one of them is a "Wired" datapoint, the other one must be "Wired" too (here "Wired" means that the datapoint is linked to a digital or analog channel of a C26x, or linked to an IED address, otherwise it is referred to as "System")
- if one of them is a "System" datapoint, the other one must be "System" too
- if one of them is linked to an "IEC61850 gen IED" through the relation has for IEC61850 address, this relation must also be defined for the other one

4.4 DEFINING LOCAL ARCHIVING OF DATAPOINT EVENTS AND ALARMS BY THE C26X

A C26x manages only archiving of the datapoints it is server of (see section *3.5.1 Connecting a C26x to other station-bus sub-systems*, for Client/Server definition).

For C26x, archiving is available or not for all the EVENTS appearing on a given datapoint. Archiving is activated as soon as one ‘state treatment’ attribute is set to ‘Archive and logging’ or ‘archive only’ at datapoint profile level

ALARM archiving at C26x level is defined globally for all the C26x units at Scs object level (see section *3.1 Setting the general system's parameters relevant to C26x units* - item (8)).

4.5 DEFINING LOCAL LOGGING OF DATAPOINT EVENTS AND ALARMS BY THE C26X

A C26x manages only logging of the datapoints it is server of (see section *3.5.1 Connecting a C26x to other station-bus sub-systems*, for Client/Server definition).

For C26x, event logging is available or not for all the events appearing on a given datapoint.

Event and alarm logging is activated as soon as the datapoint profile is linked to the local printer of the C26x.

To create a C26x printer, see section *3.3.6 Adding a printer*.

4.6 DEFINING THE ACQUISITION SOURCE FOR INPUT DATAPOINTS

4.6.1 OVERVIEW

Input datapoints have real-time values, fed by several ways excluding each other:

- acquisition via input channel(s)
- acquisition via IED legacy network
- acquisition via non-DS Agile IEC61850-communicating IED

(Virtual) acquisition via software production:

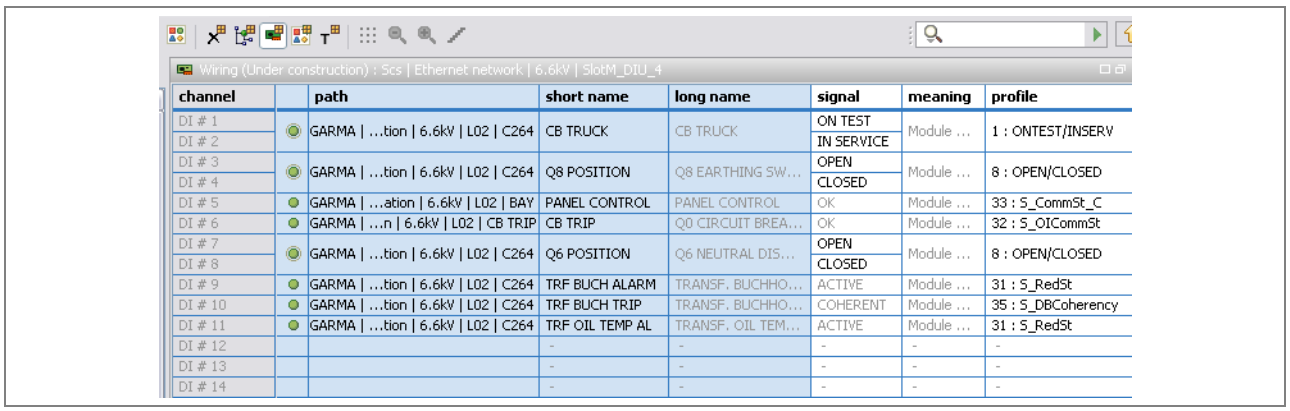
- diagnostic and control of system components
- datapoints relevant to built-in function and user’s function
- MV or counter datapoint relevant to CT/VT board computation

The wiring is based on some best practices:

- first channel of DPS wired in an ODD channel
- two channels of a DPS contiguous
- channels of an MPS contiguous
- digital MV wired into 4 channels at least

4.6.2 SMART TABLES

Select in the browser a board (different than BIU or CPU) as in this screenshot:



Select, in the menu Window, Wiring editor. If it is grayed out, click the Wiring button in the lower part. If there is no button, click the icon Reset perspective in the toolbar (like in the screenshot). The window Wiring features a table:

- the channel number
- the variants (pictograms) and the attributes (path of DP parent, short name, profile, long name); copy/paste is enabled; the long name is editable
- the read-only attributes (meaning, signal); copy is enabled
- the profiles; copy/paste is enabled

To adjust a column width, pass the cursor over the border in the header till the cursor turns to ↔; then drag and drop.

Procedure to fill the table (this must be done from left to right)

- Click in a cell to fill out
- Type one character or click two more times; click the button [v] overlaying in the cell and select one value in the drop-down list (it contains all the created datapoint values); ∅ refers to a void value; the type can be changed this way
- The ‘short name’ prompted in the list depend on the DP available at the path level; to create a new DP, enter its short name (see sketch in section 2).
- The ‘meaning’ prompted in the list depends on the level reflected in the path and is the one found in the Objects entry pane; it includes among others:
  - at substation level, Substation <DP type>
  - at voltage level, VoltageLevel <DP type>
  - at bay level, Bay <DP type>
  - at module level, Module <DP type>

  The same value is repeated for the long name, but it can be fixed manually. The relation **wired on** gets created under the DP with the short name.

- To export the table to a spreadsheet editor like Excel, select the rows and copy/paste them; the empty cells are filled with the word ‘null’ (for the headers, use the menu item **Copy columns header**)
- To break the relation **wired on**, select ∅ as short name; only path is retained
- To clear a row information, select the row(s), right-click and select **Unwire**. Unwiring channels linked to DPs inside the unity of templates is ineffective.

Notes:
*For the datapoints without automatic addressing it is possible to add the relation **has for IEC address** and define it.*
A channel cannot be edited if it is already wired in a used template.
In template mode, the available objects (as paths) are:
- unified template if DPs are defined directly as root
- all the electric elements with DP, if board not defined under C26x
- objects in local templates (inside same unified template)

Multi-channel DP: when the meaning is selected, the SCE allocates automatically the required number of channels. For example, A TPI acquired by a DIU board on 4 bits (a fifth bit, a sign bit, a refresh bit, or a read inhibit can be added via the attribute ‘signal’):



Copying / pasting to another board’s table works if both boards are of the same type.

4.6.3 SMART TABLES FOR TMU BOARDS

For TMU boards, the channel column is replaced by a **measure type** column and a button Insert allows to create a DP. The table is similar to the table used for mapping legacy networks (see *3.6.2.1*).

When a row is selected, the insertion results in computing the next measure type (e.g. ‘IA value of the current phase A’ is followed by ‘IB value of the current phase B’); if the type is already used, the new row has no type.

When no row is selected, a row is inserted at the table beginning and the list for measure type is limited to the items not yet used.

Note:
Vr and Ir are the residual values, ADC stands for Analog/Digital Conversion.

There are two ways to delete the DP relation **is computed by: <board name>**; right click and select:

- **Suppress measure type**: the whole row is erased
- **Clear datapoint**: short name, meaning, profile, long name are erased

To export the table to a spreadsheet editor, select any cell, right click and select

- **Copy all measure types** and paste them in editor’s first column; the empty cells are filled with the word ‘null’
- **Copy columns header** and paste them in editor’s heading row
- **Copy** the cells by row or group of rows and paste them in editor’s rows (an empty cell produces the value Null; in a path, the objects are separated with |)

To import a sheet from a spreadsheet editor like Excel, copy the rows in the editor; in SCE, select a row, right click and select **Insert & paste**; the pasted row takes precedence over the older ones:

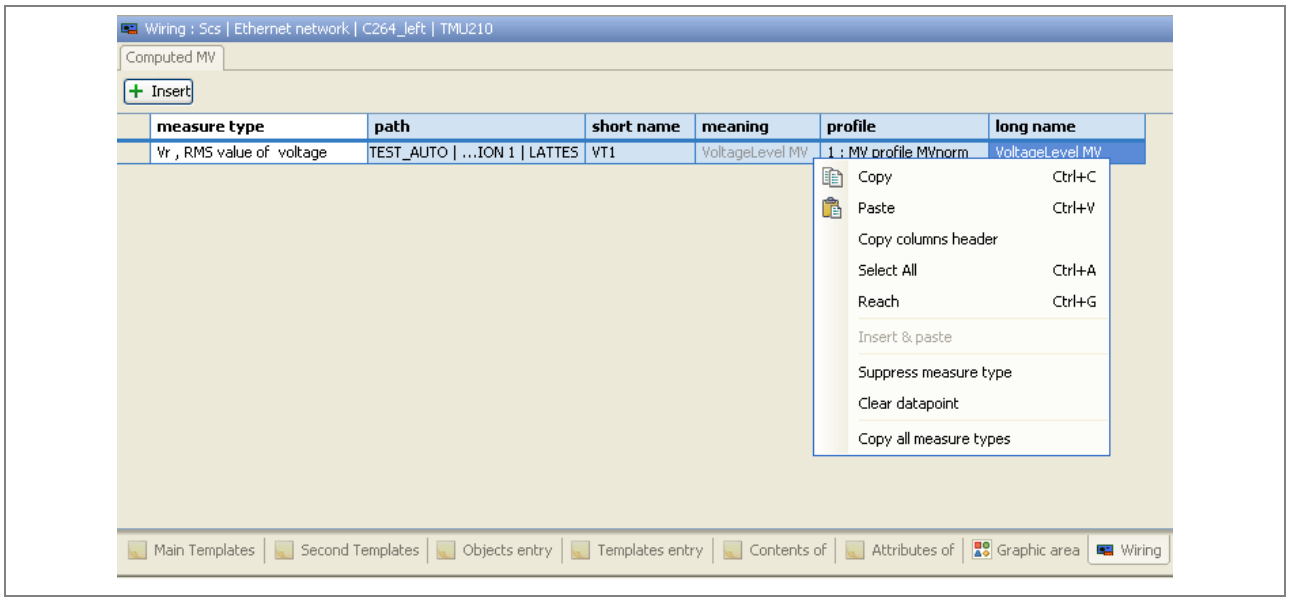
- If a measure type was all ready used, the new data point used this measure type and the old DP remains in the table but the measure type is deleted
- if the copied path and short name are already used in one row, the path and short name are stripped away from this row

On a paste action if the clipboard content inconsistent data a message box is displayed with error message and the error details:



List of possible errors

- Invalid path
- MV Type of datapoint not compatible to compute on the current board, not analog.
- Invalid MV type for current TMU
- Profile attribute is read-only
- Datapoint creation impossible under specified path
- Datapoint has many acquisition sources
- Datapoint meaning is invalid for datapoint creation
- Relation for wiring are not compatible with current datapoint
- Relation attribute measure type is read-only



Note:
With the TMU210, another tab shows (DPS I/O). DO NOT USE IT.

A red row denotes a wrong input; this can result from these situations:

- the same measure type is used for more than one computed MV on the TMU
- the MV is computed by more than one TMU board
- the MV is computed AND issued from an IED
- the MV is computed AND physically wired on a board
- the MV is not analog

To erase the row, select it, right click and select Reach, then delete the relation at the DP level.

4.6.4 ACQUIRING INPUT DATAPOINTS VIA INPUT CHANNELS

At SCE level, linking datapoint to specific channels (DI or AI channels) belonging to the DIU200-210-211, CCU200, AIU2xx boards of the C26x is called input datapoint wiring.

4.6.4.1 WIRING AN SPS DATAPOINT VIA ONE DI CHANNEL

A wired SPS is in the SET or in the RESET state, depending on the state of the associated Digital Input and of the mode, normal or inverted (defined in configuration), of the SPS.

DI state	Mode	SPS state
ON	Normal	SET
OFF	Normal	RESET
ON	Inverted	RESET
OFF	Inverted	SET
Faulty	*	SELFCHECK FAULTY

To wire an SPS datapoint on a DI channel:

- Add the relation **wired on** (1) at SPS datapoint level
- Fill the relation with the relevant DI channel:
  When datapoint level is lower than or equal to bay level, only DI channels from DIU boards belonging to the C26x BCU that manages the bay are available. To define the control unit that manages a bay, see section *5.1.4 Defining a Bay*
- If necessary update the relation attribute **inverted value** (2): If you select *Yes*, the corresponding SPS will be *RESET* when the DI is energised and *SET* when it is not (see above table).

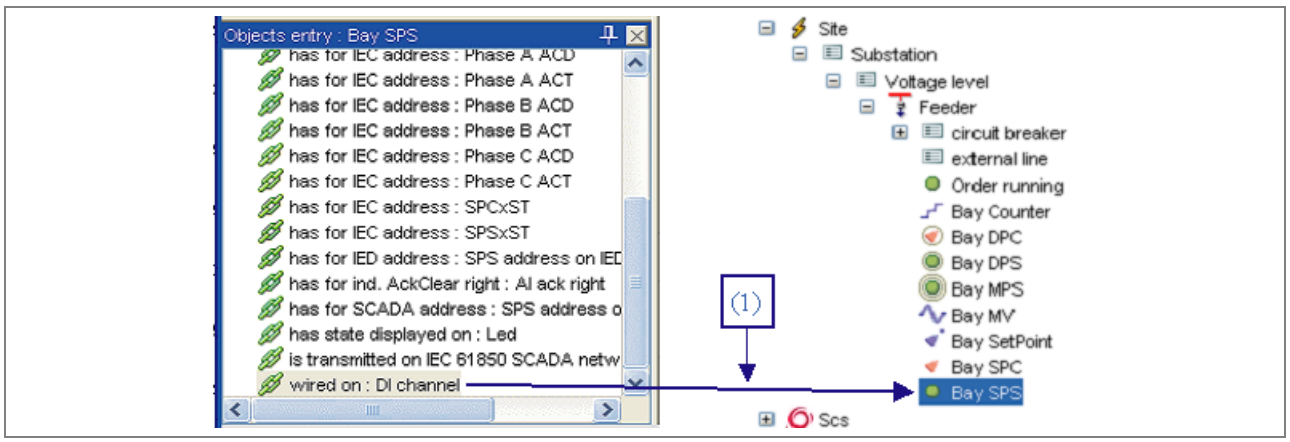


Figure 208: Wiring an SPS datapoint via one DI channel

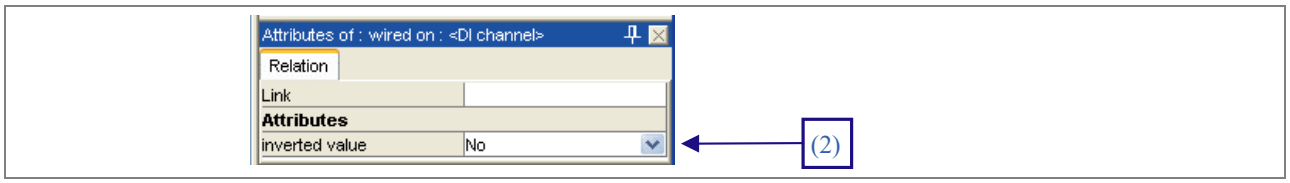


Figure 209: Updating the wiring of an SPS datapoint

4.6.4.2 WIRING A DPS DATAPOINT VIA TWO DI CHANNELS

To wire a DPS datapoint on two DI channels:

- Add the relations **closed' wired on** (1) and **'open' wired on** (2) at DPS level.
- Fill the relations with the relevant DI channels:
  When datapoint level is lower than or equal to bay level, only DI channels from local or remote DIU boards belonging to the C26x that manages the bay are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.

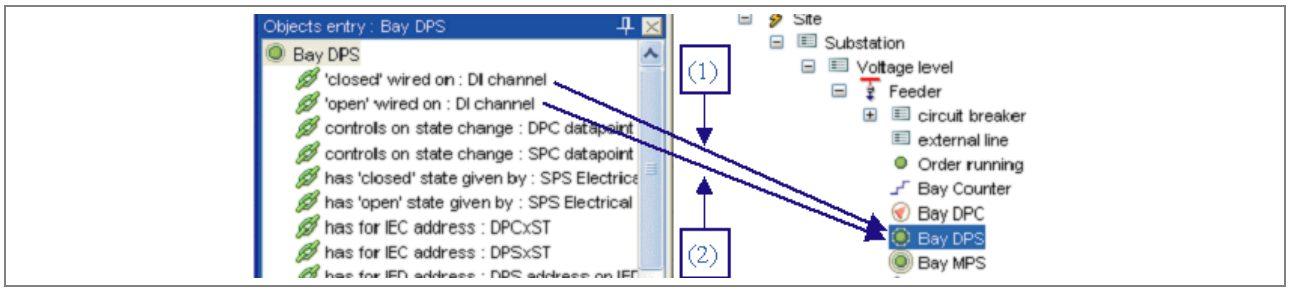


Figure 210: Wiring a DPS datapoint via two DI channels

4.6.4.3 WIRING AN MPS DATAPOINT VIA N DI CHANNELS

MPS datapoint wiring is done via 3 or more DI channels (up to 16) for each state, and an optional DI channel for ‘read inhibit’ indication.

To wire an MPS datapoint on n DI channels (n <=16):

- Add the relations **state <i> wired on** (1) at MPS datapoint level, for each available state of the MPS (i begins from 0).
- Fill the relations with the relevant DI channels: when datapoint level is lower than or equal to bay level, only DI channels from local DIU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- If a read inhibit signal exists for the MPS, add the relations **read inhibit wired on** (2) at MPS datapoint level.

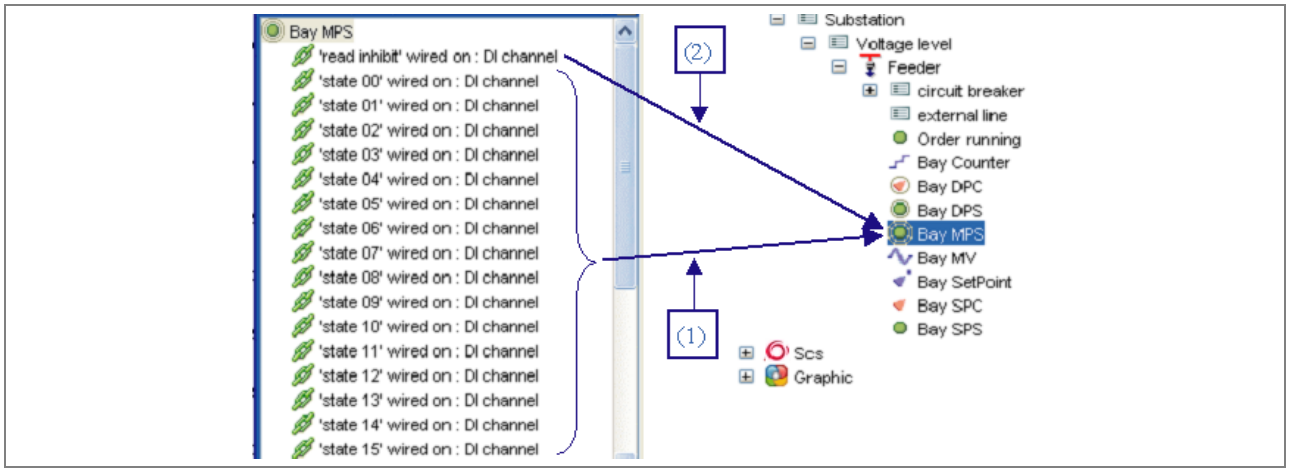


Figure 211: Wiring an MPS datapoint via n DI channels

4.6.4.4 WIRING MV AND TPI DATAPOINTS

MV and TPI datapoint wiring is done via 1 AI channel (analogue measurement) or via up to 64 DI channels (for digital measurements) and two optional DI channels for ‘read inhibit’ indication and sign bit.

To wire an MV or TPI datapoint on AI channel:

- Add the relation **wired on** (1) at MV or TPI datapoint level.
- Fill the relation with the relevant AI channel: when datapoint level is lower than or equal to bay level, only AI channels from AIU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- To define sensor range of the AI channel, see section *3.3.5 Configuring an AI channel*.

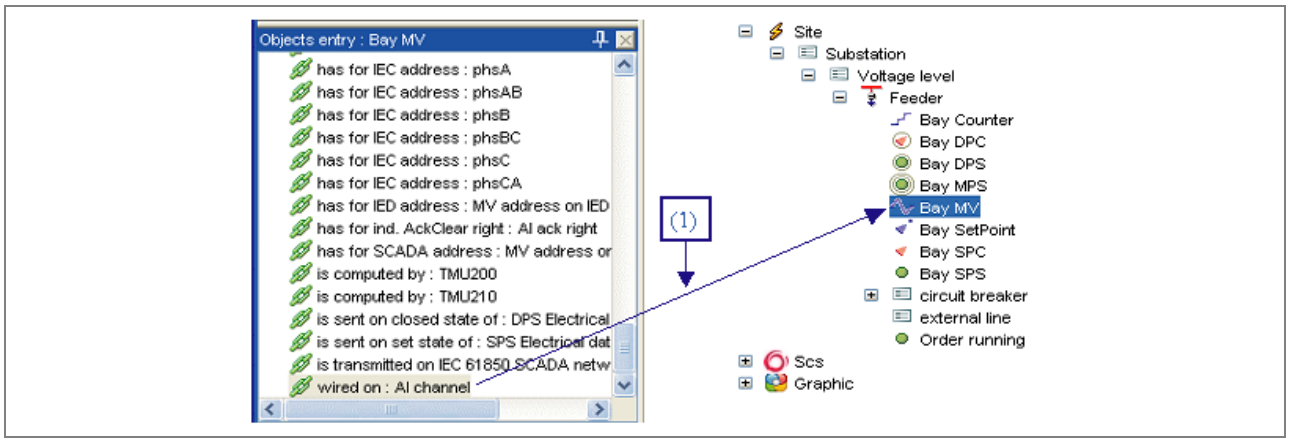


Figure 212: Wiring an MV datapoint or a TPI datapoint via one AI channel

To wire an MV or TPI datapoint on n DI channels (n <=64):

- Add the relations **bit <i> wired on** (1) at MV or TPI datapoint level, for each available bit channel of the MV or TPI (i begins from 0).
- Fill the relations with the relevant DI channels: when datapoint level is lower than or equal to bay level, only DI channels from local DIU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- If a read inhibit signal exists for the MV or TPI, add the relations **read inhibit wired on** (2) at MV or TPI datapoint level.
- If a sign bit exists for the MV, add the relations **sign bit wired on** (3) at MV datapoint level.

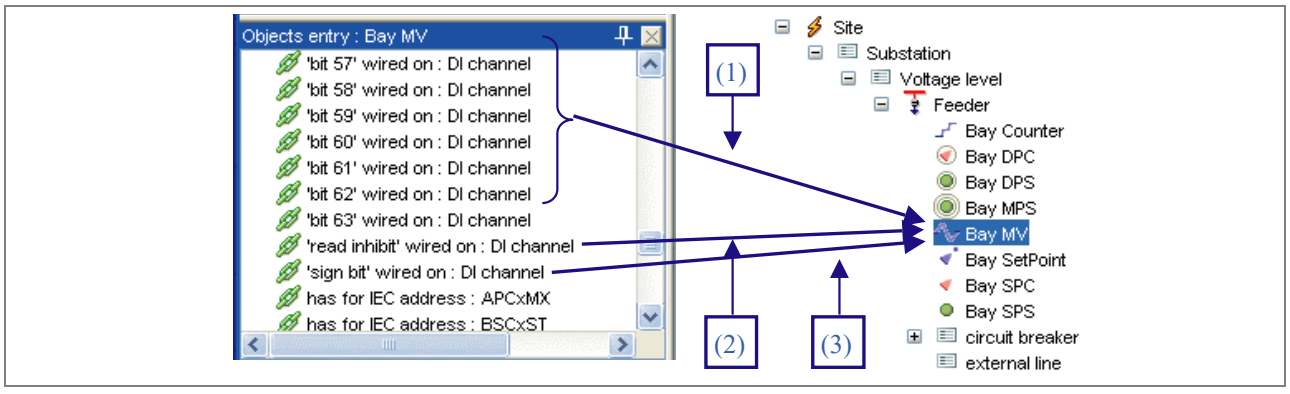


Figure 213: Wiring an MV or TPI datapoint via n DI channels

4.6.4.5 WIRING A COUNTER DATAPOINT

A "standard" Counter datapoint ("counter type" attribute set to "standard") wiring is done via one DI channel (simple standard counter) or two DI channels (double standard counter).

To wire a Counter datapoint on DI channel:

- Add the relation **primary input wired on** (1) at Counter datapoint level.
- If it is a double counter, add the extra relation **secondary input wired on** (2) at Counter datapoint level.
- Fill the relations with the relevant DI channel: when datapoint level is lower than or equal to bay level, only DI channels from local DIU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- When the counter is used as an energy counter ("counter type" attribute set to "Energy import" or "Energy Export") no wiring is needed but the relation **integrate: MV electrical datapoint** (3) must be added to define the input of the counter. This relation must be filled with the relevant MV datapoint.

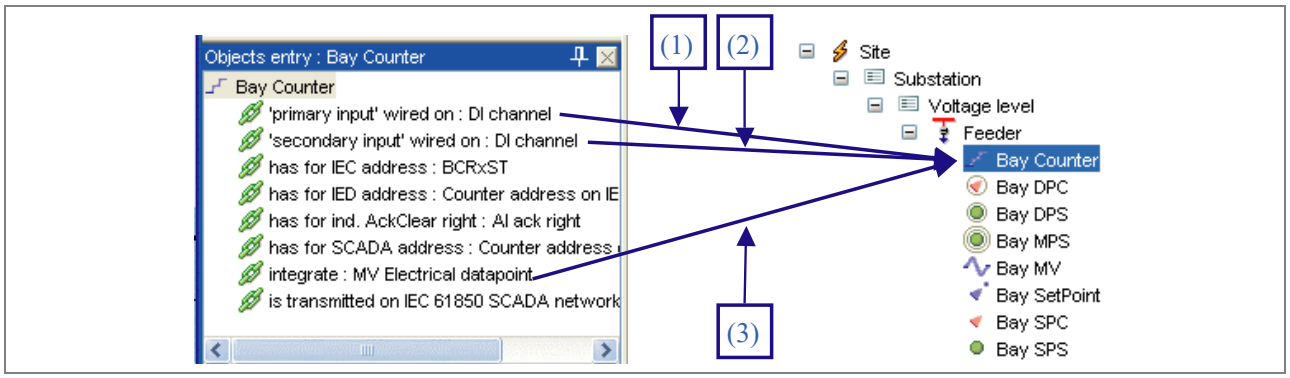


Figure 214: Wiring a Counter datapoint via a DI channel

4.6.5 ACQUIRING AN INPUT DATAPOINT VIA AN IED LEGACY NETWORK

At SCE level, IED wiring is not described. Acquiring input datapoint issued from IED is done by giving it a communication address in the relay's legacy network mapping. This addressing can be seen as a virtual wiring regardless to channel wiring.

Addressing an MPS datapoint on an IED legacy network is not possible.

Depending on legacy network type, addressing information can be different.

See section *3 Defining a C26x configuration in the system hierarchy* for further details about IED legacy network creation and address mapping definition.

To link an input datapoint to an existing IED address in an IED mapping:

- Add the relation **has for IED address** (1) at datapoint level. Generally, only one relation adding is available per datapoint, except for DPS datapoint where up to 2 relations can be added, corresponding to each elementary bit of the DPS if the legacy protocol does not support the DPS feature. In that case, the DPS is split in two SPS regarding to the legacy protocol.
- Fill the relation with the relevant IED address: when datapoint level is lower than or equal to bay level, only IED addresses from IEDs belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.

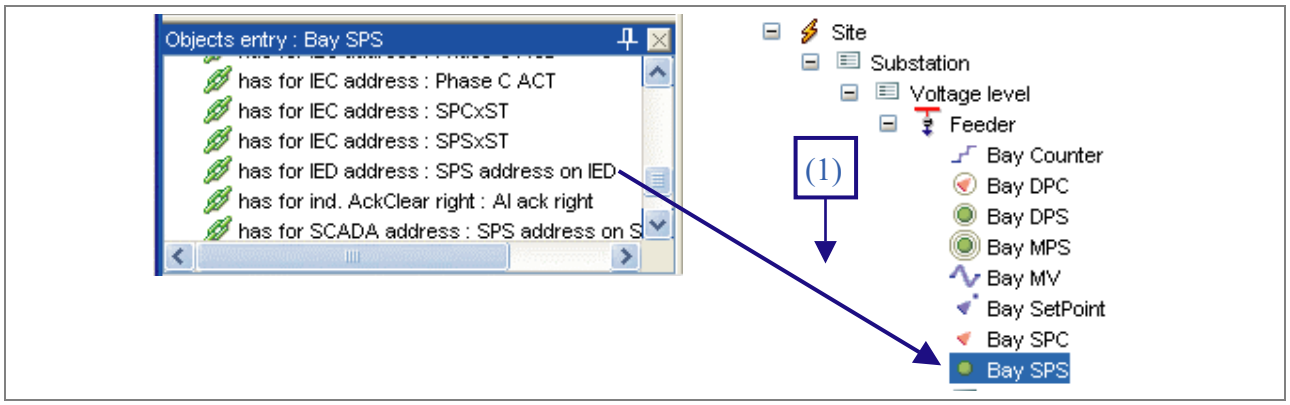


Figure 215: Acquiring an input datapoint via an IED legacy network (example for an SPS datapoint)

Configuration rules and checks

A DPS datapoint can have one or two relation(s) **has for IED address**:

- In the case of one IED address, the attribute "contact type" of the IED address must be set to the "Unused" value
- In the case of two IED addresses, the attribute "contact type" of one of the IED addresses must be set to the "open" value, and the attribute "contact type" of the other IED address must be set to the "close" value.

4.6.6 ACQUIRING AN INPUT DATAPOINT VIA A NON-DS AGILE IEC61850-COMMUNICATING IED

At SCE level, IED wiring is not described. Acquiring input datapoint issued from IEC 61850 IED is done by giving it a communication address in the relay's IEC 61850 mapping. This addressing can be seen as a virtual wiring regardless to channel wiring (implicit association is done at IED level).

See relevant application guide for further details about IED creation and corresponding IEC 61850 address mapping definition (nevertheless, a similar IEC 61850 address mapping is described in section *3.5.2 Defining the address map of a station-bus network* of the present guide).

To link an input datapoint to an existing IEC 61850 IED address in the IED mapping:

- Add the relation **has for IED address** (1) at datapoint level
- Fill the relation with the relevant IEC61850 address

Do not confuse:

- Give an IEC 61850 address to a datapoint, still wired on a C26x, via **has for IEC address** relation adding.
- Give an IEC address to a datapoint on an IEC IED. In that case the datapoint can not be wired, because it is seen as produced or managed by the IEC IED.

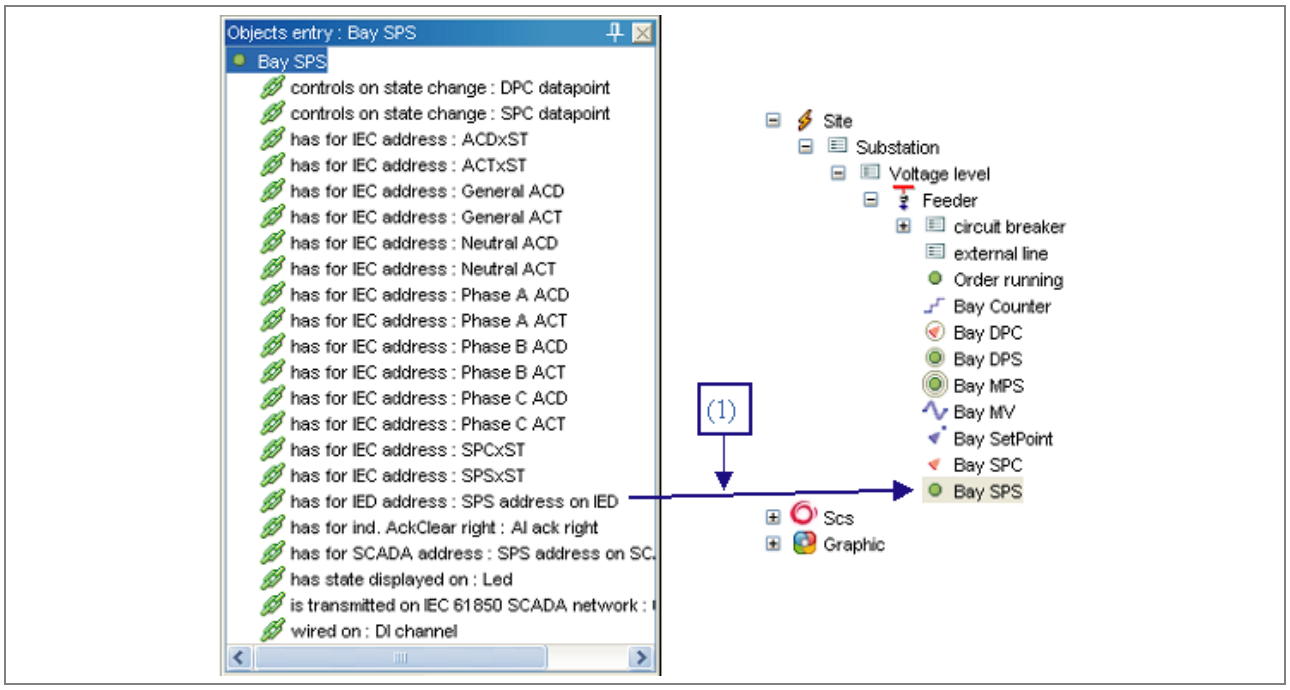


Figure 216: Acquiring an input datapoint via a non-DS Agile IED (example for an SPS datapoint)

4.6.7 PRODUCING AN INPUT DATAPOINT

Another way to produce input datapoint real-time values is to allow software functions to generate them.

This is done at several software levels:

- Supervision of an IEC 61850 DS Agile system device, where system datapoints are produced to indicate the device mode, synchronisation device, database status,…
- Supervision of IEC61850 DS Agile system device board (board status diagnostics).
- Supervision of legacy network and IED managed by DS Agile C26x units (communication status diagnostics).
- Supervision of redundancy between two DS Agile C26x units (redundancy status diagnostics).
- Supervision of logging printers managed by the OI/aView server or DS Agile C26x (printer status diagnostics).
- Supervision of archiving managed the by OI/aView server (archiving status diagnostics).
- Facilities given by built-in electrical and grouping functions or user's function, in DS Agile C26x units.

4.6.7.1 IMPLICIT SYSTEM INPUT DATAPOINT VIA SYSTEM DECOMPOSITION

In data modeling many components of the system topology own input datapoints. Their creation is generally implicit when creating the component: they belong to its hierarchy.

Most of system input datapoints when transmitted on station bus network are addressed in IEC 61850 diagnostics bricks.

The list of such system datapoints are given in section *3.10 Setting system information for C26x components*.

4.6.7.2 IMPLICIT ELECTRICAL INPUT DATAPOINT VIA A BUILT-IN FUNCTION

Implicit input datapoints can be embedded in built-in function creation. For details refer to the following sections:

- *5.2 Defining a Synchrocheck function*,
- *5.3 Defining an Auto-recloser built-in function*,
- *5.4 Defining a Tap changer built-in function.*

4.6.7.3 DEFINING AN ISAGRAF SLOW AUTOMATION

By setting output plug, fast automation can produce real-time value for electrical input datapoint (see section *4.5 Defining an FBD fast automation* of SCE/EN AP).

So can slow automation when it manages electrical datapoints or owns management input datapoints (see section *5.5 Defining an ISaGRAF slow automation* of SCE/EN AP).

For group needs, an electrical SPS containing the group result must be created (see section *5.7.1 Defining a group*).

For SPS-DPS association, the resulting DPS is the product of the two SPS associations (see section *5.7.3 Producing a DPS*).

To define (open or close) interlocking equation on SPC or DPC datapoint, an extra (open or close) SPS should be produced, whose result is interlocking equation computation (see section *5.7.4 Defining an interlock*).

4.6.7.4 EXPLICIT ELECTRICAL INPUT DATAPOINT VIA CT/VT COMPUTATION

Another way to produce an MV electrical datapoint is to link it to a CT/VT C26x board. Then, a specific link attribute must be filled to precise which MV computation is concerned (power, harmonic ...).

Data produced by CT/VT board computation concern:

- RMS Values of phase voltage
- RMS values of busbar voltage
- RMS values of phase current
- RMS values of residual voltage and current
- Fundamental sequence components
- Active Power
- Reactive Power
- Apparent Power
- Frequency
- Harmonics levels (expressed as a ratio of the magnitude of the fundamental voltage or fundamental current)

To link an MV datapoint to a CT/VT computation:

- Add the relation **is computed by** (1) at datapoint level.
- Fill the relation with the relevant CT/VT board. When datapoint level is lower than or equal to bay level, only the CT/VT board belonging to the C26x that manages the bay, is available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.
- Select in the relation attribute **measure type** (2) the computation type and the harmonics/fundamental taken in account.

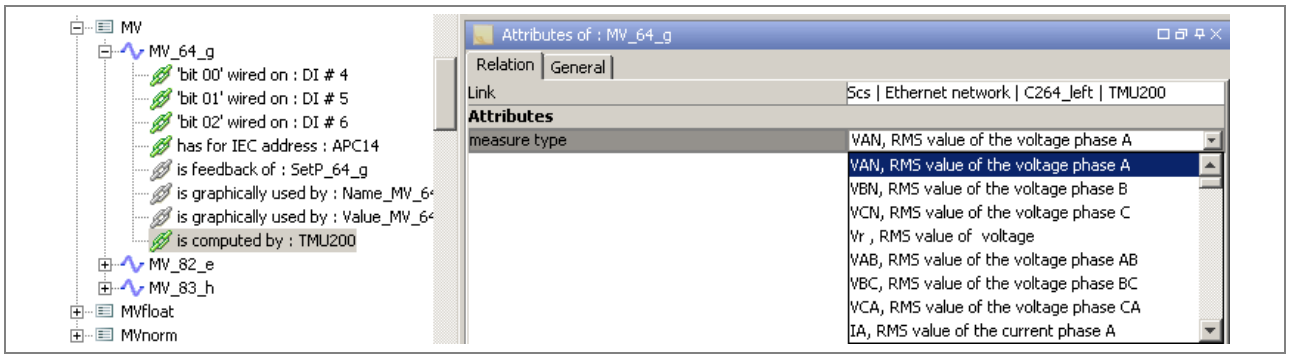


Figure 217: Defining CT/VT computation for an MV datapoint

4.7 DEFINING THE CONTROL SOURCE FOR OUTPUT DATAPOINTS

4.7.1 OVERVIEW

Output datapoints have real-time control values, managed by several ways excluding each other:

- control via output channel(s)
- control via IED legacy network
- control via non-DS Agile IEC 61850-communicating IED
- (virtual) control via software production:
  - control of system components
  - datapoints relevant to built-in function and user's function

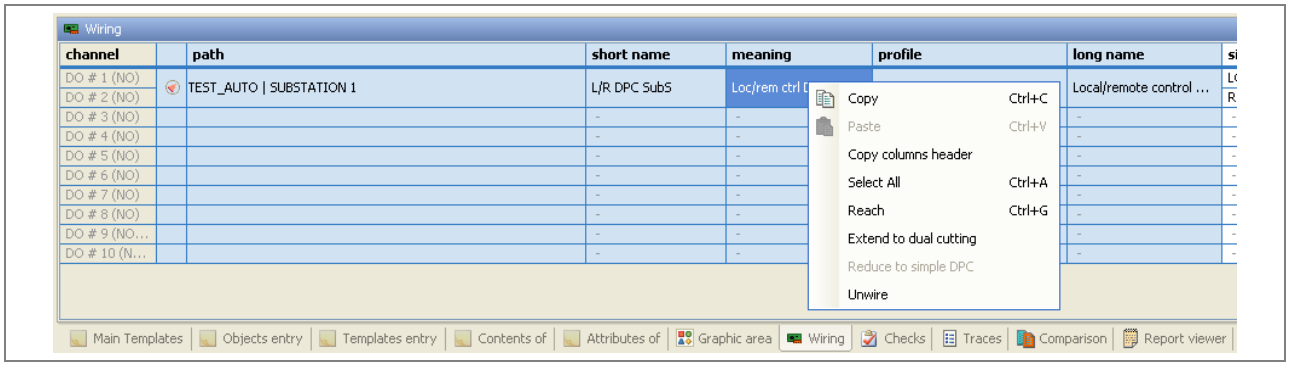
The wiring is based on some best practices:

- first channel of DPC wired in an ODD channel
- two channels of a DPC contiguous

4.7.2 SMART TABLES

See section *4.6.2 Smart tables*.

For double DP, creating a channel results in automatic creation of the associated channel with the same attributes:



To extend to 4 channels, select **Extend to dual cutting**.

To undo this, select **Reduce to simple DPC**.

4.7.3 CONTROLLING AN OUTPUT DATAPOINT VIA OUTPUT CHANNELS

At SCE level, linking datapoint to specific channels (DO channels) belonging to DS Agile C26x's DOU200, DOU201, HBU200 or CCU2xx boards is called output datapoint wiring.

4.7.3.1 WIRING AN SPC DATAPOINT VIA ONE OR TWO DO CHANNEL(S)

To wire an SPC datapoint on one or two DO channel(s):

- Add the relation **wired on** (1) at SPC datapoint level (this relation is added twice if 2 DO channels are used).
- Fill the relation with the relevant DO channel(s): when the datapoint level is lower than or equal to bay level, only DO channels from output boards belonging to the C26x that manages the bay are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.

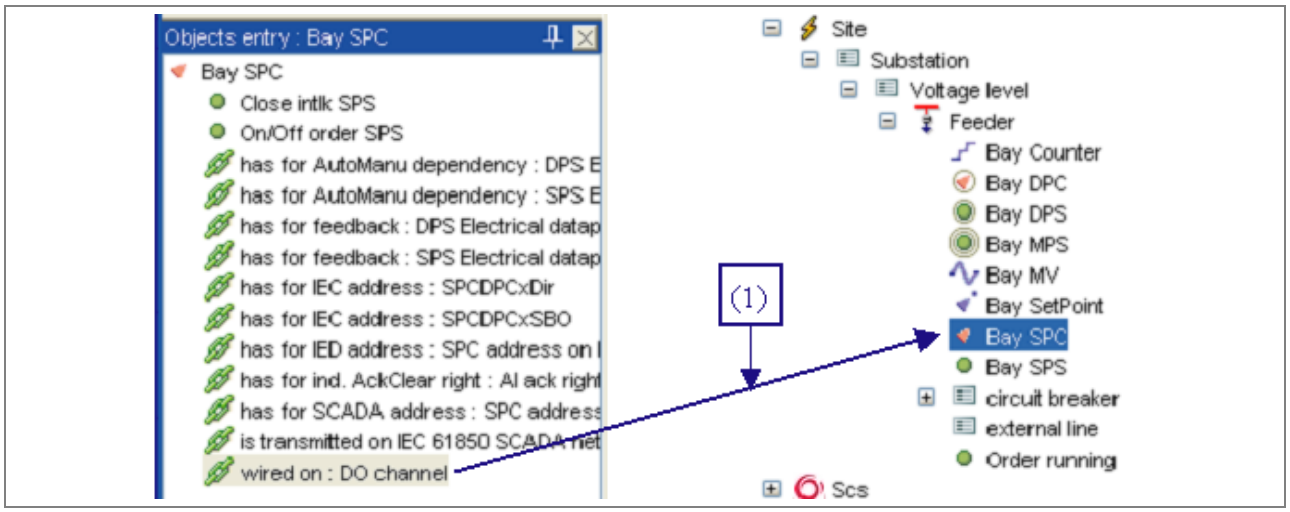


Figure 218: Wiring an SPC datapoint via one DO channel

4.7.3.2 WIRING A DPC DATAPOINT VIA TWO OR FOUR DO CHANNELS

To wire a DPC datapoint on two or four DO channels:

- Add the relations **closed wired on** (1) and **open wired on** (2) at DPC datapoint level (these relations are added twice if 4 DO channels are used)
- Fill the relations with the relevant DO channels: when the datapoint level is lower than or equal to bay level, only DO channels from output boards belonging to the C26x that manages the bay are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*

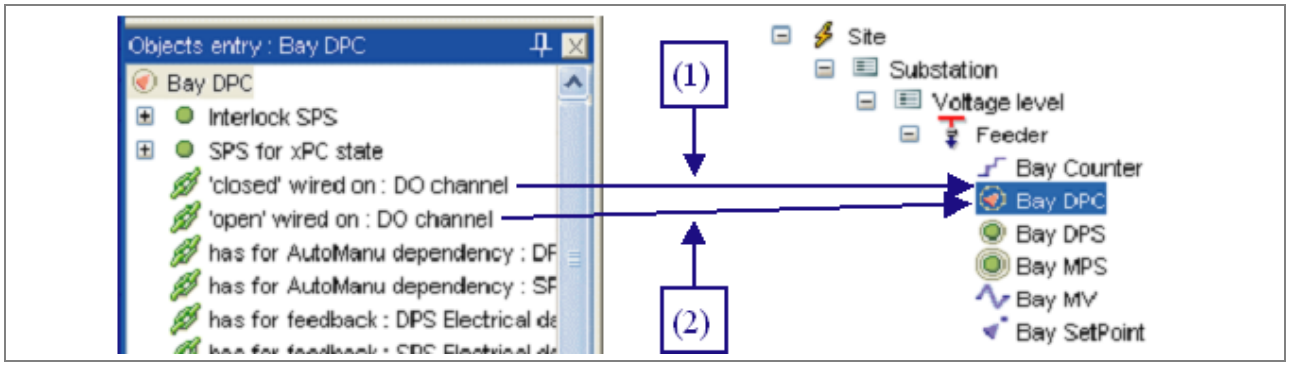


Figure 219: Wiring a DPC datapoint via two DO channels

4.7.3.3 WIRING A SETPOINT DATAPOINT

SetPoint datapoints can only be wired on digital channels (up to 48 DO channels) and two optional DO channel for 'read inhibit' indication and sign bit and can also be wired on 1 Analogue channel.

To wire a SetPoint datapoint on n DO channels (n <=48):

- Add the relations **bit <i> wired on** (1) at SetPoint datapoint level, for each available bit channel of the SetPoint (i begins from 0)
- Fill the relations with the relevant DO channels: when datapoint level is lower than or equal to bay level, only DO channels from DOU boards belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*

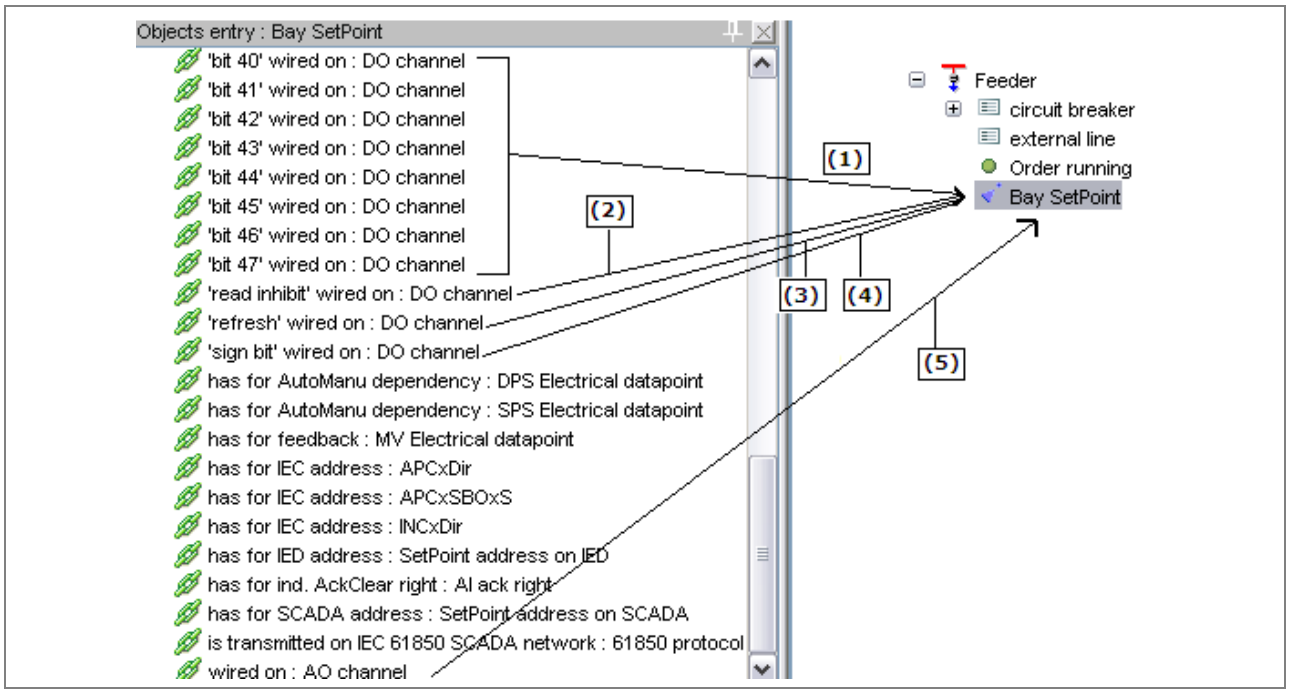


Figure 220: Wiring a setpoint datapoint via a DO channel and an AO channel

Configuration rules and checks

A Setpoint datapoint wired on DO channels of C26x must be digital and have a profile with attribute “SBO mode” set to "Direct Execute" or “Direct Execute with SBO popup”.

To define the optional relations 2 to 4:

- Add the relation at SetPoint level by tapping into the Object entry window
- Double click the relation in the browser and select the target in the Relation link editor
- If necessary set the relation attribute

Mark	Relation	Attribute 0..999 s	At expiry
2	‘read inhibit’ wired on: DO channel	inhibition duration	setpoint is allowed
3	‘refresh’ wired on: DO channel	Refresh duration	alarm not refreshed, but last received SetPoint is maintained
4	‘sign bit’ wired on: DO channel	–	–

For explanation, see section *4.9* of Functional *Description chapter, C26x/EN FT*.

4.7.3.4 WIRING FROM A CCU DATAPOINT

SPC, DPC datapoint can also use digital outputs of CCU boards.

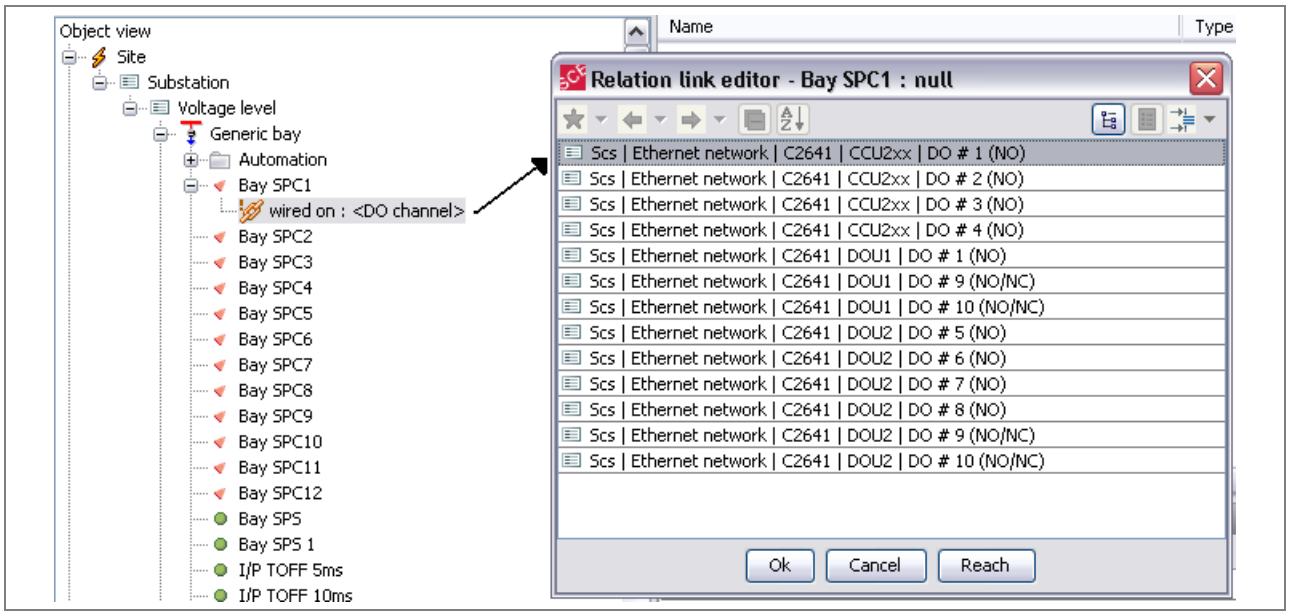


Figure 221: Acquiring an output datapoint using the CCU Card

4.7.4 CONTROLLING OUTPUT DATAPOINT VIA AN IED LEGACY NETWORK

At SCE level IED wiring is not described. Controlling output datapoint issued from IED is done by giving it a communication address in the relay's legacy network mapping. This addressing can be seen as a virtual wiring regardless to channel wiring (implicit association is done at IED level).

Depending on legacy network type, addressing information can be different.

See section *3 Defining a C26x configuration in the system hierarchy* for further details about IED legacy network creation and address mapping definition.

To link an output datapoint to an existing IED address in an IED mapping:

- Add the relation **has for IED address** (1) at datapoint level. Generally, only one relation adding is available for a datapoint, except for a DPC datapoint where up to two relations can be added, corresponding to each elementary bit of the DPC if the legacy protocol does not support the DPC feature. In that case, the DPC is split in two SPC regarding to the legacy protocol.
- Fill the relation with the relevant IED address: when datapoint level is lower than or equal to bay level, only IED addresses from IEDs belonging to the C26x that manages the bay, are available. To define the C26x that manages a bay, see section *5.1.4 Defining a Bay*.

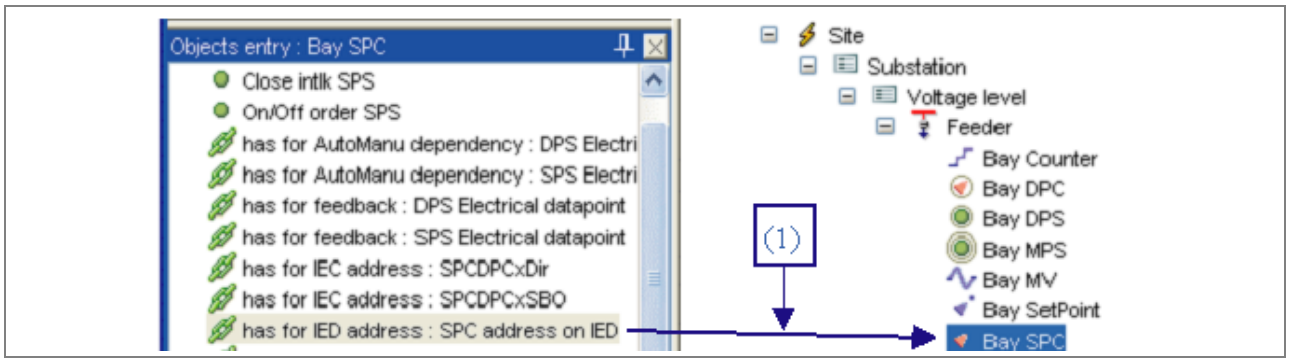


Figure 222: Acquiring an output datapoint via an IED legacy network (example for an SPC datapoint)

Configuration rules and checks

- A "DPC" datapoint can have one or two relation(s) **has for IED address**:
  - In the case of one IED address, the attribute "contact type" of the IED address must be set to the "Unused" value.
  - In the case of two IED addresses, the attribute "contact type" of one of the IED addresses must be set to the "open" value, and the attribute "contact type" of the other IED address must be set to the "close" value.

4.7.5 CONTROLLING AN OUTPUT DATAPOINT VIA A NON-DS AGILE IEC 61850-COMMUNICATING IED

At SCE level, IED wiring is not described. Controlling output datapoint issued from IED is done by giving it a communication address in the relay's IEC 61850 mapping. This addressing can be seen as a virtual wiring regardless to channel wiring.

See relevant application guide for further details about the creation of IEC 61850 IEDs and corresponding address mapping definition (nevertheless, similar IEC address mapping is described in section *3.5.2 Defining the address map of a station-bus network* of the present guide).

To link an output datapoint to an existing IED address in the IED IEC mapping:

- Add the relation **has for IED address** (1) at datapoint level
- Fill the relation with the relevant IED address

Do not confuse:

- Give an IEC address to a datapoint, still wired on a C26x, via **has for IEC address** relation adding.
- Give an IEC address to a datapoint on an IEC IED. In that case the datapoint can not be wired, because it is seen as produced or managed by the IEC IED.

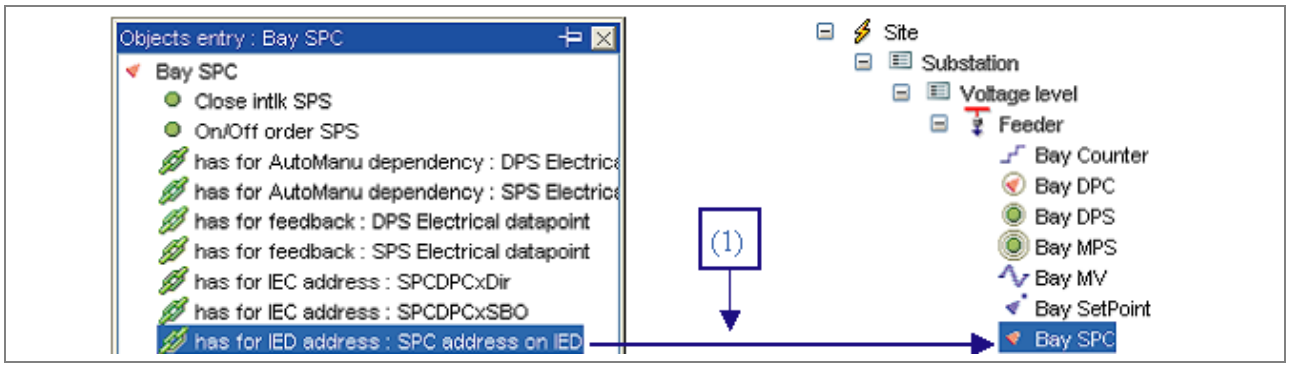


Figure 223: Acquiring output datapoint via non-DS Agile IEC IED

4.7.6 PRODUCING AN OUTPUT DATAPOINT

Another way to produce output datapoint real-time control values is to allow software functions to generate them.

This is done at several software levels:

- Supervision of IEC 61850 DS Agile system device, where system datapoints are produced to control mode device, database switch. These output system datapoints are only used by System Management Tool.
- Supervision of redundancy between two DS Agile C26x units (redundancy controls).
- Facilities given by built-in electrical and grouping functions or user's function, in DS Agile C26x units.

4.7.6.1 IMPLICIT SYSTEM OUTPUT DATAPOINT VIA SYSTEM DECOMPOSITION

In data modeling, only DS Agile units of the system topology own output datapoints for device mode management and database switch. Their creation is implicit when creating the device: they belong to its hierarchy.

C26x redundancy needs specific output typed datapoints that must be manually added in C26x's hierarchy.

Most of system output datapoints when transmitted on station bus network are addressed in IEC 61850 diagnostics bricks.

The list of such system datapoints are given in section *3.10 Setting system information for C26x components*.

4.7.6.2 IMPLICIT ELECTRICAL OUTPUT DATAPOINT VIA A BUILT-IN FUNCTION

Implicit output datapoints can be embedded in built-in function creation. For details see the following sections:

- *5.2 Defining a Synchrocheck function*
- *5.3 Defining an Auto-recloser built-in function*
- *5.4 Defining a Tap changer built-in function*

4.7.6.3 DEFINING AN ISAGRAF SLOW AUTOMATION

By setting output plug, fast automation can produce real-time order value for electrical output datapoint. So can slow automation when it manages electrical output datapoints or owns management output datapoints (see section *5.5 Defining an ISaGRAF slow automation* in SCE/AP EN).

For xPS-xPC association, an electrical output SPC or DPC linked to the SPS or DPS must exist and sometimes be created (see section *5.7.2 Controlling an xPC*).

4.7.7 ACKNOWLEDGEMENT DEFINITION IN CASE OF SIMULTANEOUS ORDERS

When two opposite orders (Open/Close or Close/Open) are simultaneous and from different origins, the acknowledgment management is described on the following table:

Cmd1	Cmd2	Action	Ack
PSL	PSL	Cmd 1 cancelled	NA
PSL	Operator	Cmd 1 cancelled	NA
Operator	PSL	Cmd 1 cancelled	CO_ACK_FAILED_ORDER (ACK 19)
Operator	Operator	Cmd 2 ignored	CO_REQUEST_IN_PROGRESS (ACK 6)

When two identical orders (Open/Open or Close/Close) are simultaneous and from different origins, the acknowledgment management is described on the following table:

Cmd1	Cmd2	Action	Ack
PSL	PSL	Cmd 2 Ignored	NA
PSL	Operator	Cmd 2 Ignored	CO_REQUEST_IN_PROGRESS (ACK 6)
Operator	PSL	Cmd 2 Ignored	NA
Operator	Operator	Cmd 2 ignored	CO_REQUEST_IN_PROGRESS (ACK 6)

4.8 DEFINING A DATAPOINT ASSOCIATION

This functionality is used to create a link between two datapoints so that the state of one datapoint (called the target datapoint) is defined by the state of the other datapoint (called the original datapoint).

Target datapoints can be one of the following types: SPS or DPS. They are available with default name **Mapping SPS** and **Mapping DPS** at each level of the Electrical topology. In the example given here after these two "target" datapoints are shown at the Substation level (1).

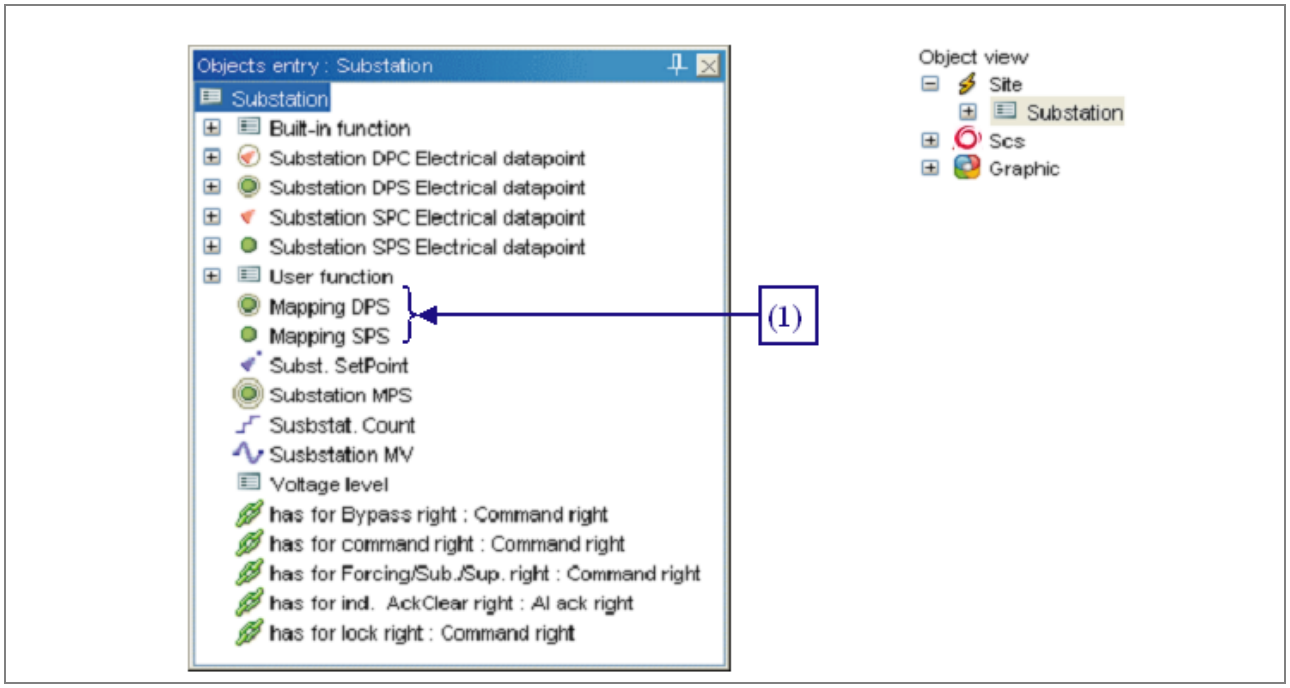


Figure 224: The two target datapoints of the substation level

Original datapoints can be one of the following types: SPS, DPS, MPS, and MV.

4.8.1 ADDING A TARGET DATAPOINT

To add a target datapoint, select the required electrical level (Substation in our example) and add the Mapping xPS from the contextual **Objects entry** window.

4.8.2 LINKING THE TARGET DATAPOINT TO THE ORIGINAL DATAPOINT

To link the target datapoint to the original datapoint a relation **'is mapped on'** (1) must be added to the selected "original" datapoint (**order running** at generic bay level in our example). Once added, the undefined relation is present in the "**Contents of**" window associated with the order running datapoint (2).

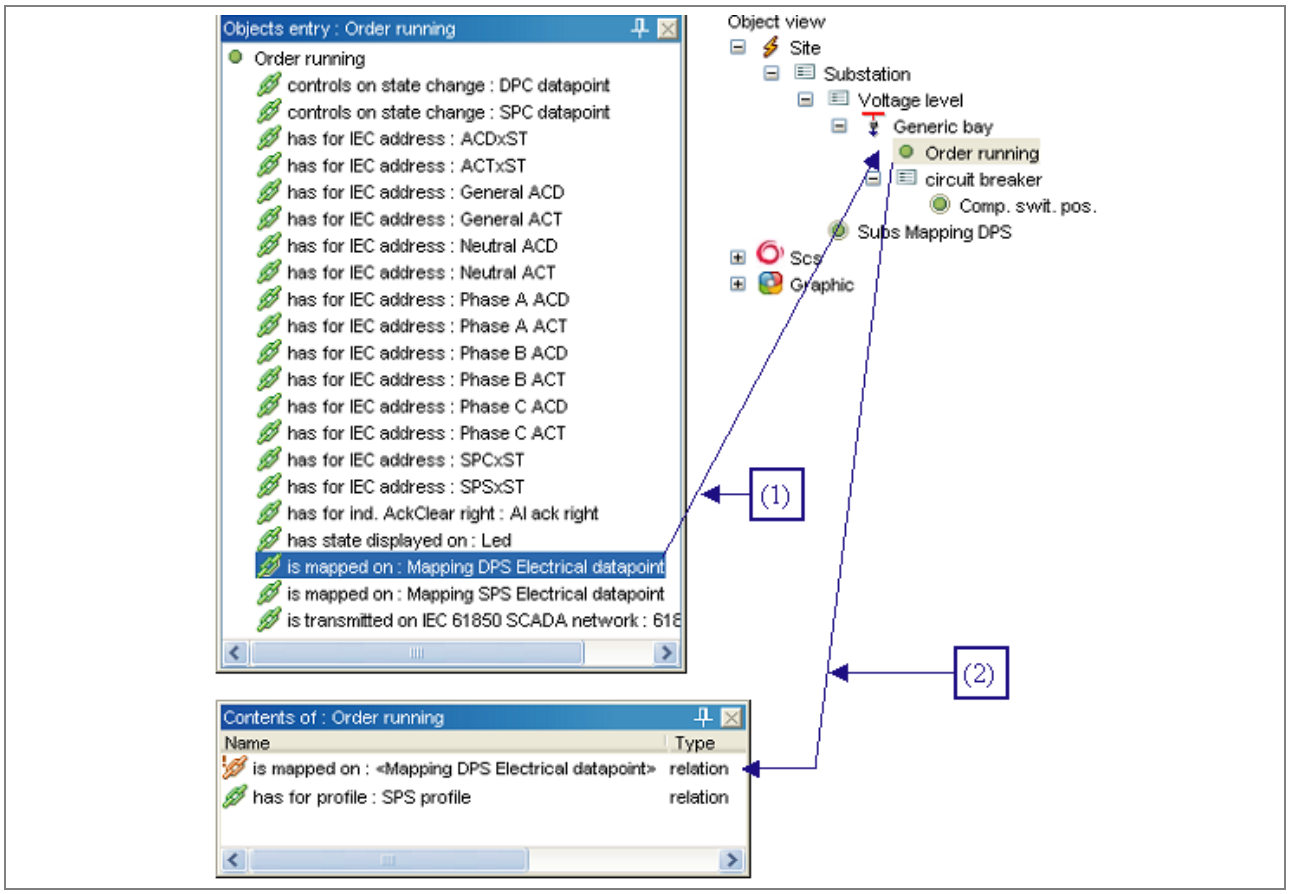


Figure 225: Linking the target datapoint to the original datapoint

To select the target datapoint double-click the undefined relation **is mapped on:** (3). In the **Relation link editor** dialog box are displayed all the available Mapping DPS datapoints (4). Click the Mapping DPS datapoint you want to be associated with the **order running** datapoint (**Subs Mapping DPS** in our example) then click the **OK** button.

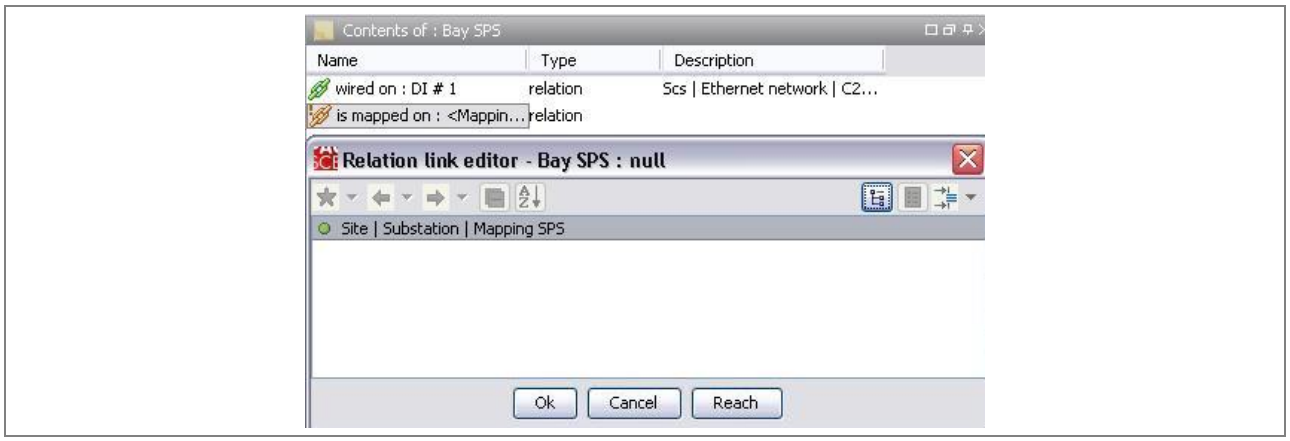


Figure 226: Selecting the target datapoint

4.8.3 DEFINING THE STATES ASSOCIATIONS

For every possible state of the original datapoint the user can define the corresponding state of the target datapoint. To perform this association click the now defined relation **is mapped on:** (5) in the **"Contents of:"** window associated with the "**order running**" datapoint. In the **"Attributes of:"** window associated with this relation are listed all the possible states of the original datapoint (6) and for each one the user has to select the corresponding state of the target datapoint (7).

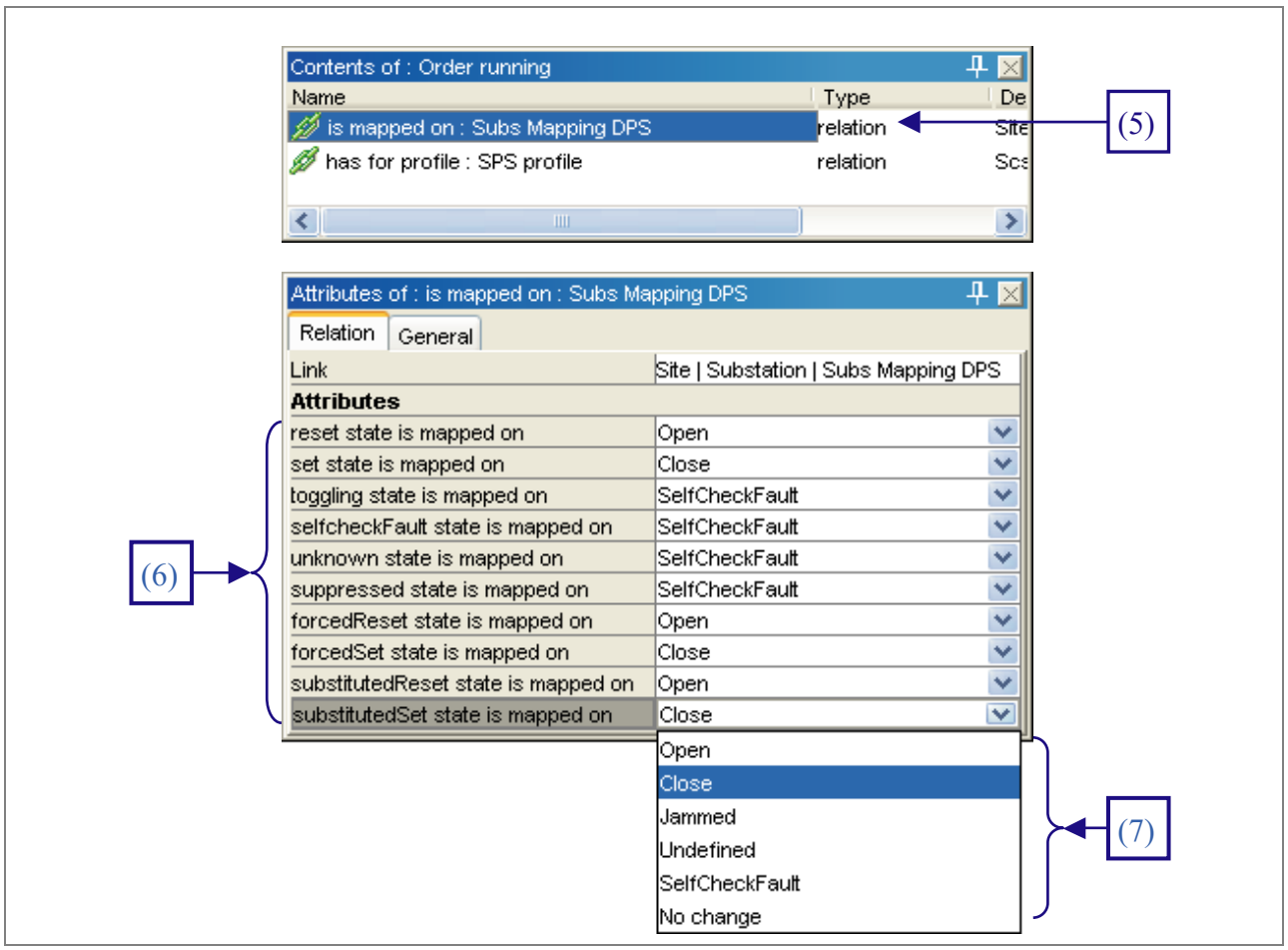


Figure 227: Defining the states associations

Configuration rules and checks

- Up to 10 target datapoints can be associated with an original datapoint
- Up to 100 datapoints can be defined as original datapoints
- The original datapoint and the target datapoint can belong to different C26x units. In this case the states of the original datapoints are transmitted through GOOSE messages
- A target datapoint is managed as any other datapoint: transmission, used in automation, alarms, …
- An SPS original datapoint can be associated with an SPS or a DPS
- A DPS original datapoint can be associated with an SPS or a DPS
- An MPS original datapoint can only be associated with an SPS (the relation **is mapped on: Mapping DPS Electrical datapoint** is not available in the **"Objects entry"** window associated with an MPS)
- An MV original datapoint can only be associated with an SPS (the relation **is mapped on: Mapping DPS Electrical datapoint** is not available in the **"Objects entry"** window associated with an MV)

5 DEFINING A C26X CONFIGURATION IN THE ELECTRICAL HIERARCHY

5.1 DEFINING AN ELECTRICAL TOPOLOGY

At SCE data modeling level, the entry point of electrical topology is the ‘Site’ object. At the moment, a ‘Site object’ (1) can be composed of only one ‘Substation’ object.

A substation (2) is constituted of ‘Voltage level’ objects, each of them corresponding to an electrical partitioning of the substation by voltage level value (in kV).

A voltage level (3) is an aggregation of ‘Bay’ object (4), grouping of electrical units, called module (5). Generally this grouping is electrically self-safety, i.e. can be isolated from others bays by switchgears for maintenance and managed by only one DS Agil C26x. There are different types of bays: feeder, transformer, busbar, bus coupler, bus section, capacitor bank and generic bay.

Coupling two voltage levels is commonly done via transformer. To respect SCE data modeling electrical partitioning, this transformer must belong to a transformer bay (6) arbitrary put in one of both voltage levels (generally its primary). An extra relation on transformer defines to which voltage level its secondary (or primary) belongs.

Final electrical components are modules composing bays. There are different types of modules: circuit breaker, switchgear, transformer, motor, generator, battery, capacitor, inductor, converter and generic module. An extra module exists to describe substation external connection (external line).

Every level of the electrical topology, except Site level, can own datapoints whose features and configuration are described in section *4 Defining a datapoint*.

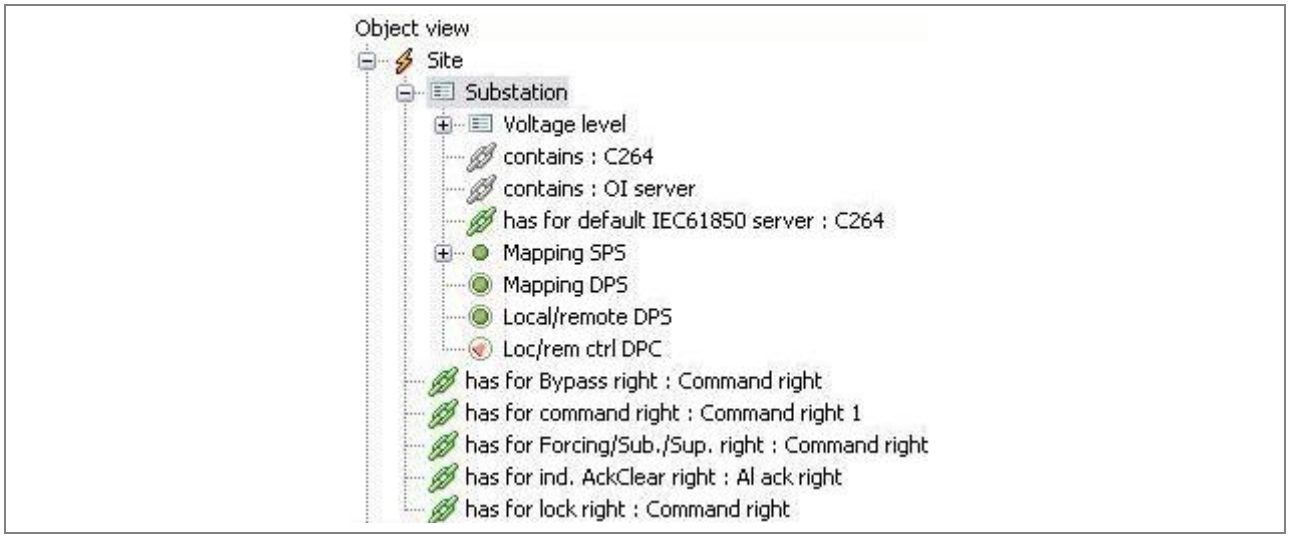


Figure 228: Electrical topology definition (example)

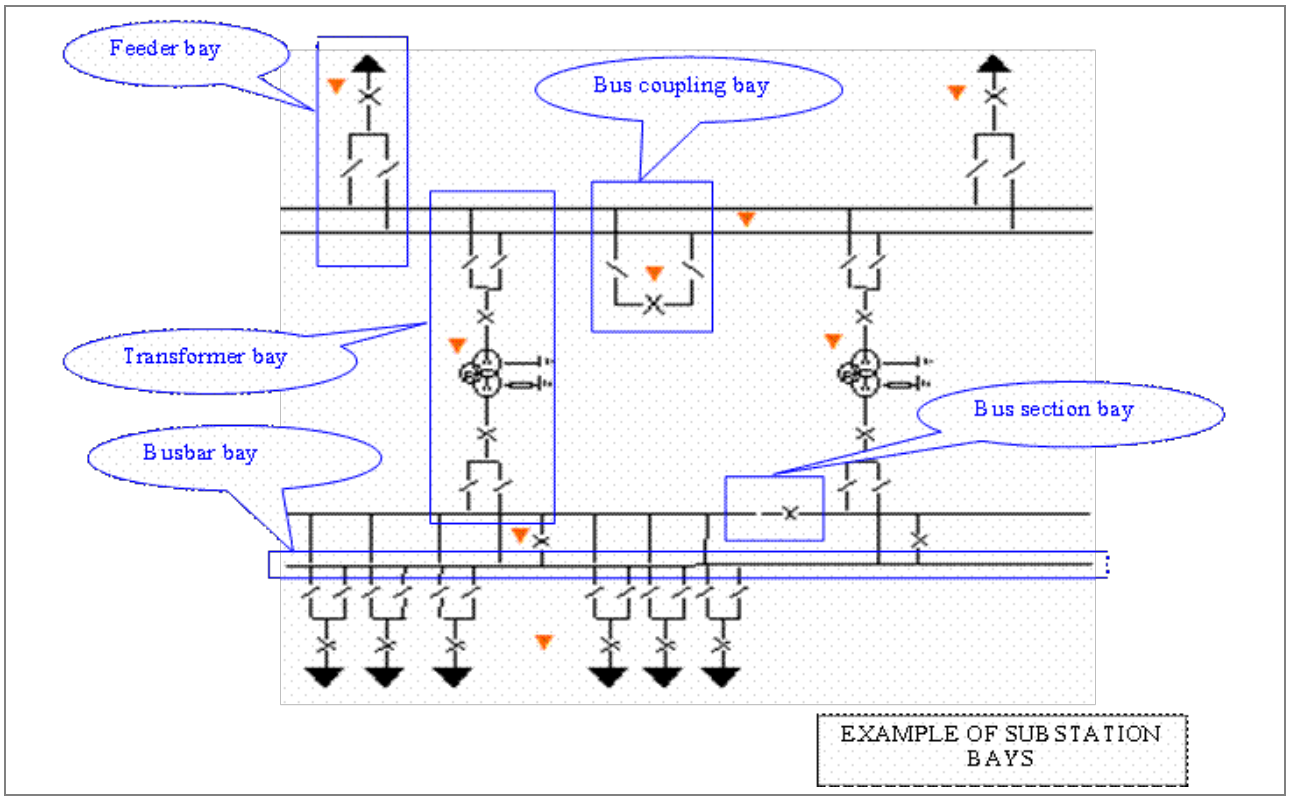


Figure 229: Bay examples

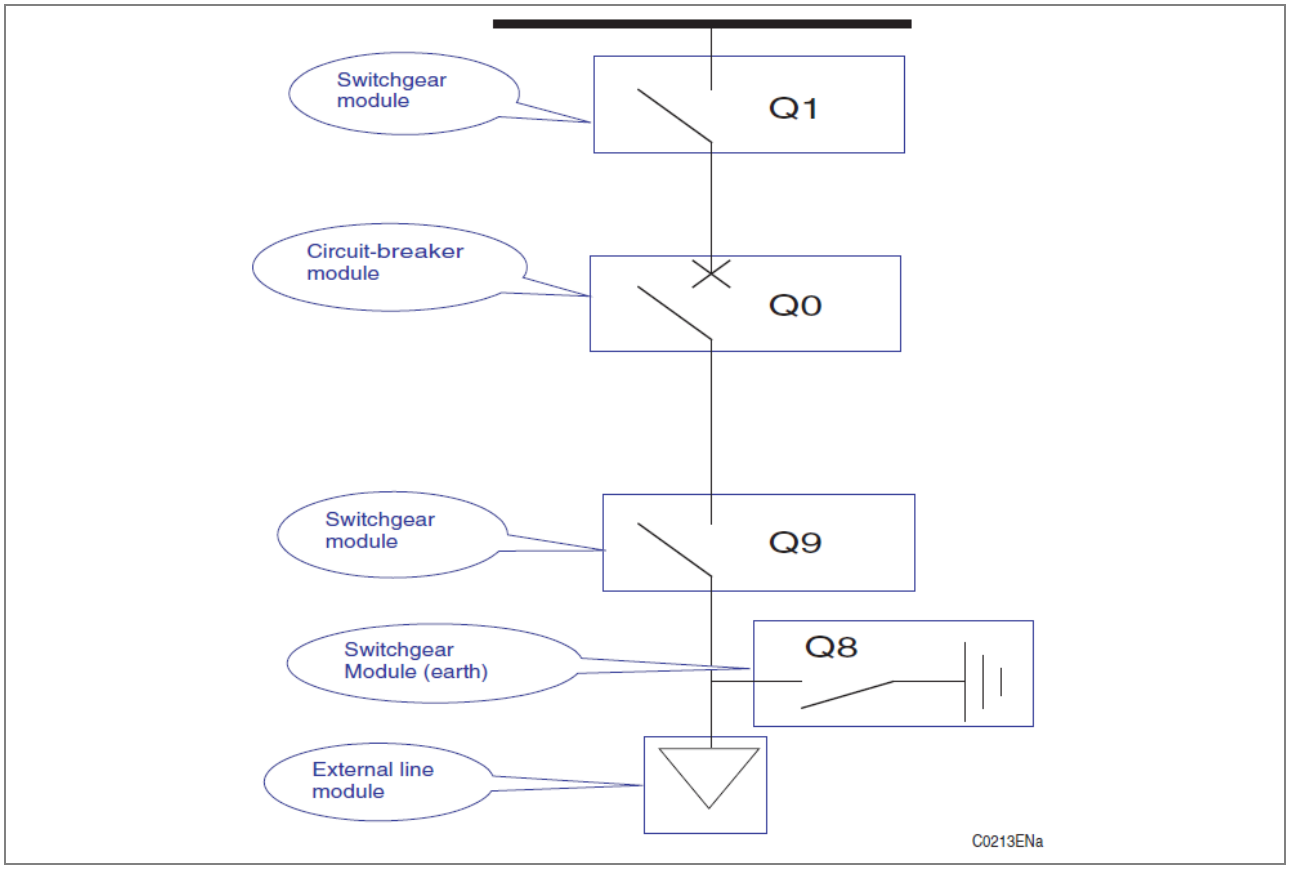


Figure 230: Module examples

5.1.1 DEFINING A SITE

When creating a new configuration with the SCE, the electrical topology is automatically instantiated via a 'Site' root object, containing a mandatory 'Substation' object.

A **Site** object corresponds to customer project identification: its attributes **short name** and **long name** (1) can be entered at SCE level. At the moment, these attributes are not used.

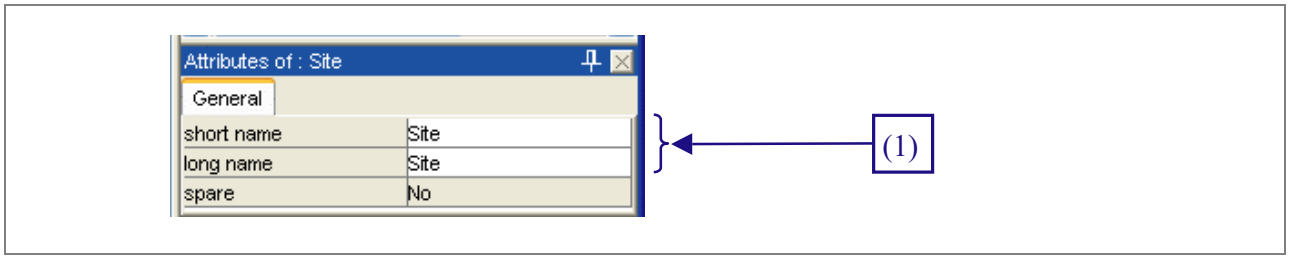


Figure 231: Setting the attributes of a site

5.1.2 DEFINING A SUBSTATION

When creating a new configuration using SCE, the electrical topology is automatically instantiated via 'Site' root object, containing a mandatory 'Substation' object.

A **Substation** object corresponds to customer substation identification: its attributes **short name** and **long name** (1) must be entered at SCE level, for proper logging formatting and datapoint identification, at C26x and system HMI evels.

At substation level, the attribute 'default uniqueness' (2) defines the way control uniqueness of physically wired controls is managed for the whole substation. The available values are:

- None: no control uniqueness is provided by the DS Agile system for the substation.
- Substation level: control uniqueness is provided by the DS Agile system for the whole substation, i.e. 2 simultaneous controls are refused within the substation, except for control datapoints configured as independent of substation uniqueness (see sections *4.3.7.1, 4.3.8.1* and *4.3.9.3*),
- Bay level: control uniqueness is provided by the DS Agile system for an entire bay, i.e. 2 simultaneous controls are refused within the same bay, except for control datapoints configured as independent of bay uniqueness (see sections *4.3.7.1, 4.3.8.1* and *4.3.9.3*).

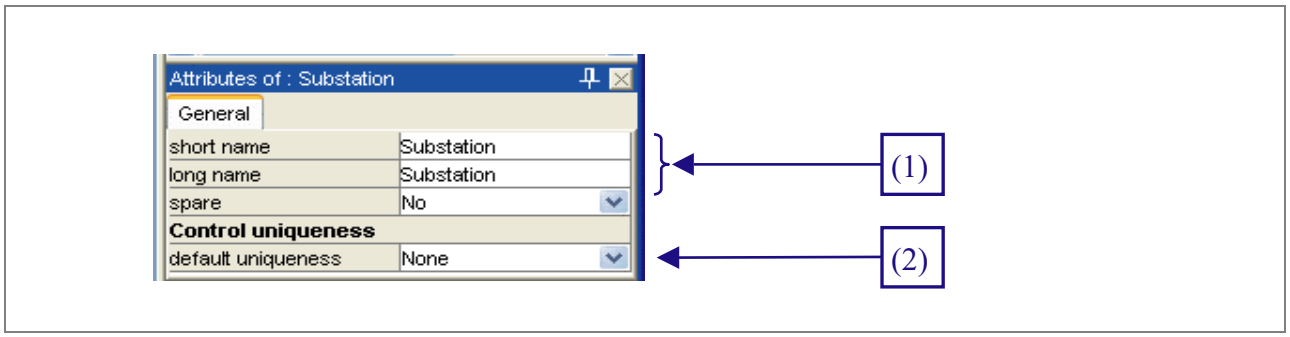


Figure 232: Setting the attributes of a substation

Bay and substation uniqueness are managed by C26x by synthesis of mandatory SPS datapoints 'Order running', automatically added under a bay at its creation (see section *5.1.4 Defining a Bay*).

Configuration rules and checks

- When control uniqueness is set for a substation, all the C26x units in the substation must be IEC 61850 clients of all 'order running' SPS datapoints defined for all the bays. So, a correct

IEC 61850 configuration must be done for all C26x units to support that feature. For details about IEC 61850 configuration, see section *3.5 Networking a C26x on the station-bus network*.

5.1.2.1 ADDING A SUBSTATION GENERIC DATAPOINT

To add a typed datapoint to a substation, select the substation level and add the typed datapoint from the contextual **Objects entry** window. The following generic datapoints (standard usage) are out of the specific substation functions scope:

- Local/remote for substation (see section *5.1.2.2 Defining a Local/Remote datapoint)*
- Taking Control for substation and SCADA links (see section *5.1.2.3 Defining a Taking Control datapoint for substation and SCADA links*)

For more details about datapoints and their configuration, see section *4 Defining a datapoint*.

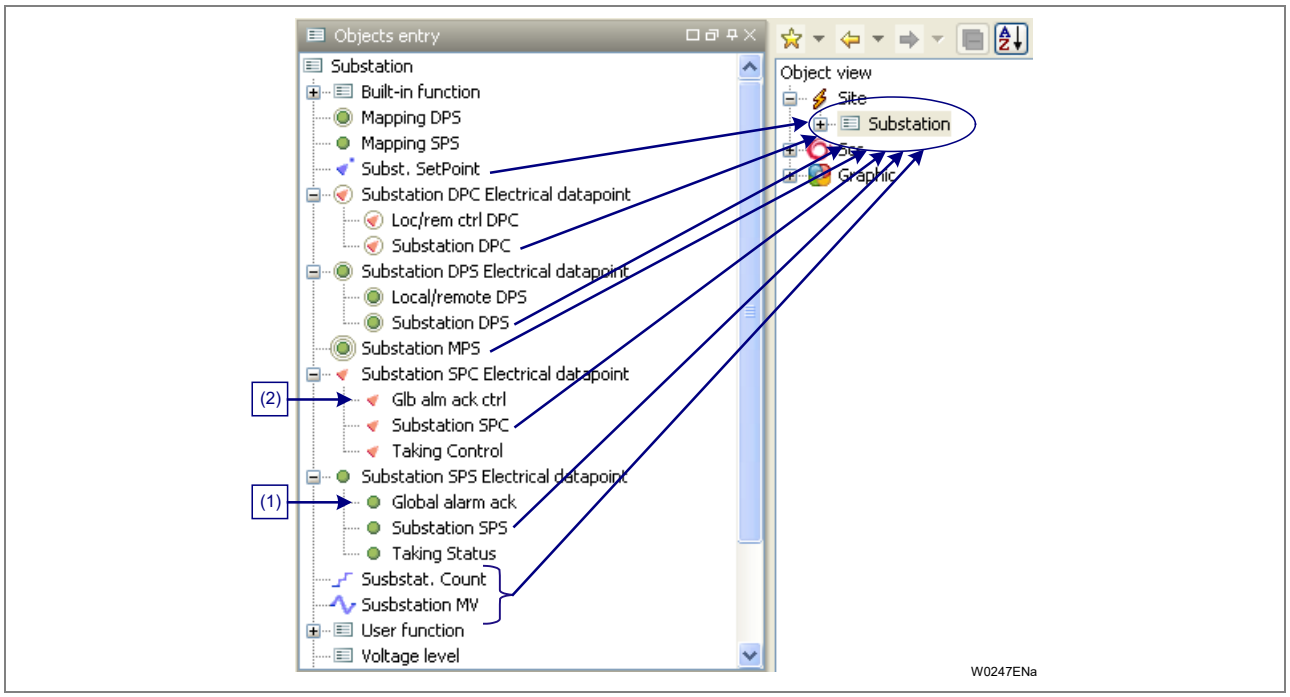


Figure 233: Adding a substation generic datapoint

Note:
A Global alarm ack SPS (1) can be added to the substation level in order to automatically acknowledge the new alarms from the C26x and the system HMI. The detection mode attribute of this SPS must be set to "Permanent" or "Permanent with C26x auto-reset". This SPS may be any wired SPS or SPS activated by a control (using the Glb alm ack ctrl SPC(2)) from the SCADA or generated by any PSL. It is also possible to launch a global alarm acknowledgment at a fixed time using a cyclic SPS (described in section 5.1.4.1 Adding a bay generic datapoint)

5.1.2.2 DEFINING A LOCAL/REMOTE DATAPOINT AT STATION BUS LEVEL

A substation can be in remote or local control mode, either globally for the whole substation, or independently per bay.

Remote mode means that the substation/bay is controlled from the Remote Control Point (RCP) through the gateway. No controls can be sent from the Substation Control Point level (except if the concerned bay is in SBMC mode, see section *5.1.4.3 Defining the SBMC mode for a bay*).

Local mode means that the substation/bay is controlled from the DS Agile system HMI (OI or aView at the Substation Control Point). The controls issued from the RCP (SCADA or upper level DS Agile OI/aView) are not taken into account by the system and rejected.

Some control commands, defined during the configuration stage, can be independent of the local/remote control mode: it means that they can be issued from the SCP or RCP whatever the current control mode. Control commands from a configurable automation (see section *5.7 Defining an electrical regulation by user function*) are accepted in both modes. For details about the configuration of this dependency attribute, refer to sections:

- SPC: see section *4.3.7.1*,
- DPC: see section *4.3.8.1*,
- SetPoint: see section *4.3.9.3*.

In Local or Remote mode the information acquired by C26x units and IEDs is always sent to the RCP and the SCP.

The automatic “Forcing of Invalid BI” function is used to avoid processing invalid states of the substation mode (the local or remote substitution state is defined in configuration). The “Forced Local” state is processed as “Local” state. The “Forced Remote” state is processed as “Remote” state.

Moreover, any IEC 61850 client (i.e. system HMI, gateway, C26x units) will automatically force the substation mode to “Forced Local” or “Forced Remote” if it takes the UNKNOWN state (due for example to the loss of communication between the C26x that manages the substation mode and the IEC 61850-8-1 clients).

5.1.2.2.1 Global substation L/R datapoint

To enable the Substation Local/Remote feature for the whole substation:

- add the optional datapoints Local/remote DPS’ (1) and/or Loc/rem ctrl DPC’ (2) from the contextual **Objects entry** window at substation level,
- configure them (see section *4 Defining a datapoint*),
- if necessary, do not forget to link Loc/rem ctrl DPC’ to Local/remote DPS’ via the **has for feedback** relation.

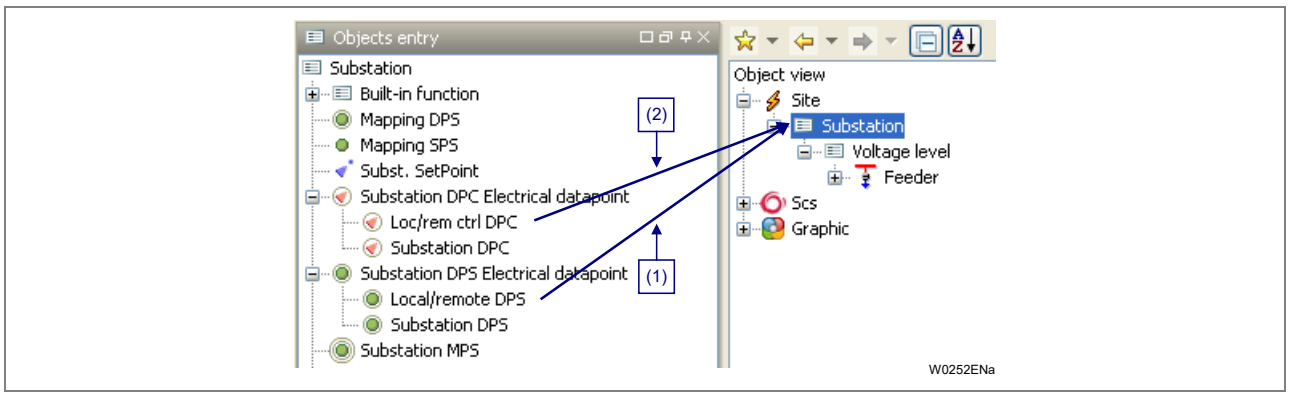


Figure 234: Defining a Local/Remote datapoint for a substation

Configuration rules and checks

Note:
Here the term "wired" means that the datapoint must be wired to (a) digital channel(s) of a C26x.

- If *Loc/rem ctrl DPC* is present, then *Local/remote DPS* must be present (it is its feedback).
- If *Local/remote DPS* is not wired, then *Loc/rem ctrl DPC* is mandatory.
- If *Local/remote DPS* is wired, then *Loc/rem ctrl DPC* is optional but, if it is present, it must be wired.
- If, under a Substation, a "DPC" or "SPC" datapoint is configured to be dependent on the L/R mode, then the Substation's *Local/remote DPS* datapoint must be present.
- If the two datapoints *Local/remote DPS* and *Loc/rem ctrl DPC* are present, they must have the same Server device.
- The *Loc/rem ctrl DPC* datapoint must have its profile attribute **SBO mode** set to *Direct Execute* or *Direct Execute with SBO popup*.

Initial state configuration

The initial state of the Local/remote DPS is selected in its profile, in the **General** tab-pane.
Setting for **Specific treatment|Inital status**: *Closed* = *Remote* and *Open* = *Local*.

5.1.2.2.2 Substation L/R datapoint per Bay

Note:
This feature can only be used in single ring Station Bus networks; it cannot be used in an IEC 61850/IEC 61850 architecture.



Caution:
In order to use the Substation L/R mode per bay, the initial state of the global substation L/R mode must be set to Remote in the Local/remote DPS's profile (i.e. Specific treatment|Inital status = *Closed*).
It must remain in that state: Do not give users any means of changing that setting (buttons, etc...).

To enable the Substation Local/Remote feature independently for each bay:

- add the optional datapoints *SS LR/bay DPS* (1) and/or *SS LR/bay DPC* (2) from the contextual **Objects entry** window at bay level,
- configure them (see section *4 Defining a datapoint*),
- if necessary, do not forget to link *SS LR/bay DPC* to *SS LR/bay DPS* via the **has for feedback** relation.

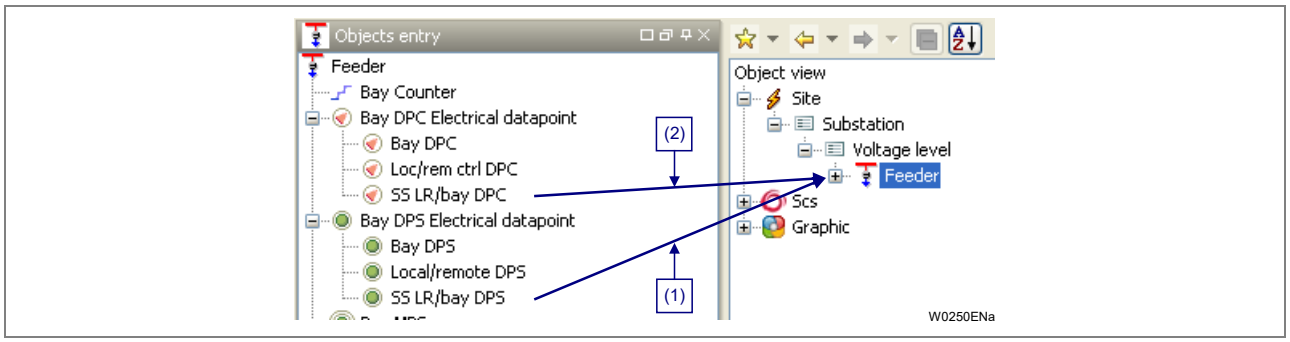


Figure 235: Defining a substation Local/Remote datapoint for a bay

Caution:
If the Substation L/R mode per bay is used, it must be defined for ALL the bays in the database that are managed by a C26x.

Configuration rules and checks

Note:
The term "wired" means that the datapoint must be wired to (a) digital channel(s) of a C26x.

- If *SS LR/bay DPC* is present, then *SS LR/bay DPS* must be present (it is its feedback).
- If *SS LR/bay DPS* is not wired, then *SS LR/bay DPC* is mandatory.
- If *SS LR/bay DPS* is wired, then *SS LR/bay DPC* is optional but, if it is present, it must be wired.
- If, under a bay, a "DPC" or "SPC" datapoint has its attribute **Substation mode dependency** set to *Yes*, then the bay's *SS LR/bay DPS* datapoint must be present.
- If the two datapoints *SS LR/bay DPS* and *SS LR/bay DPC* are present, they must have the same Server device.
- The *SS LR/bay DPC* datapoint must have its profile attribute **SBO mode** set to *Direct Execute* or *Direct Execute with SBO popup*.

Initial state configuration

The initial state of the *SS LR/bay DPS* is selected in its profile, in the **General** tab-pane.
Setting for **Specific treatment|Inital status**: *Closed* = *Remote* and *Open* = *Local*.

5.1.2.3 DEFINING A TAKING CONTROL DATAPOINT FOR SUBSTATION AND SCADA LINKS

This facility allows a Remote Control Point (RCP) to force the mode of the substation from LOCAL to REMOTE and to define on which link the SCADA controls must be accepted.

To activate Taking control facilities for a given SCADA network:

- add the optional datapoints ‘Taking Control’ (2) and ‘Taking status’ (1), via the **Objects entry** window at substation level by clicking on mouse’s right button.
- configure them (see section *4 Defining a datapoint*).
- add the relation **is taken control of** at ‘Taking status’ datapoint level (3), and fill it with the relevant given SCADA network.
- do not forget to link via **has for feedback** relation, the control with the status datapoint.

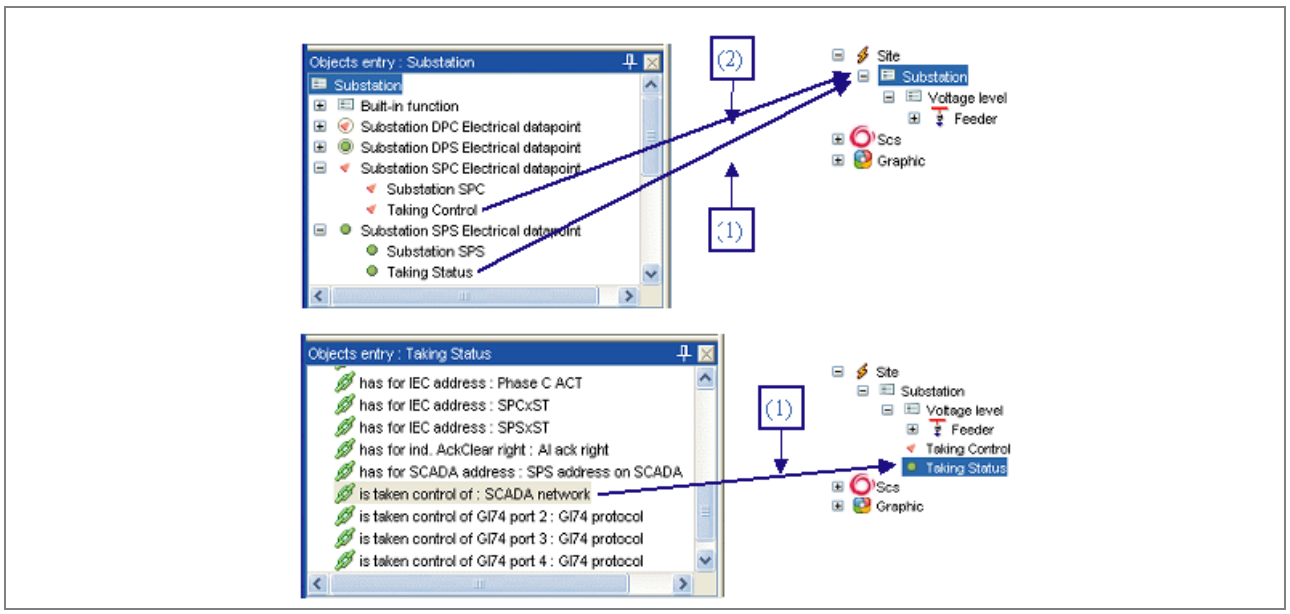


Figure 236: Defining a Taking Control datapoint for a substation and SCADA link

Configuration rules and checks

- If, at least, one SCADA network is linked to a Taking Control function, all the SCADA Networks of the system must be linked to a Taking Control function.
- If a "Taking Status" datapoint is linked to a SCADA Network, it must also be linked to a "Taking Control" datapoint through the relation **has for feedback**.
- A "Taking Control" datapoint must be linked to a "Taking Status" datapoint through the relation **has for feedback**.
- The "Taking Control" datapoint must have its **activation mode** attribute set to a "Permanent…" value. The "Taking Status" datapoint must have its **detection mode** attribute set to the "Permanent" value.
- Both "Taking Control" and "Taking Status" datapoints must be linked to a SCADA address in the mapping of their SCADA network.
- If a Taking-Control function is defined then, the "Loc/rem ctrl DPC" for substation must be present and not wired.
- The Server of the Local/Remote datapoints is the **Server** of each datapoint pair "Taking Status" / "Taking Control".
- All the units having a SCADA network linked to a Taking-Control function are:
  - **Clients** of each datapoint pair "Taking Status" / "Taking Control".
  - **Clients** of the datapoint pair "Local/remote DPS" / "Loc/rem ctrl DPC".

5.1.2.4 ADDING A USER FUNCTION TO A SUBSTATION

To add a user function to a substation, select the substation level and add the user function from the contextual **Objects entry** window.

For more details about user functions usage and configuration, see section *5.7 Defining an electrical regulation by user function*.

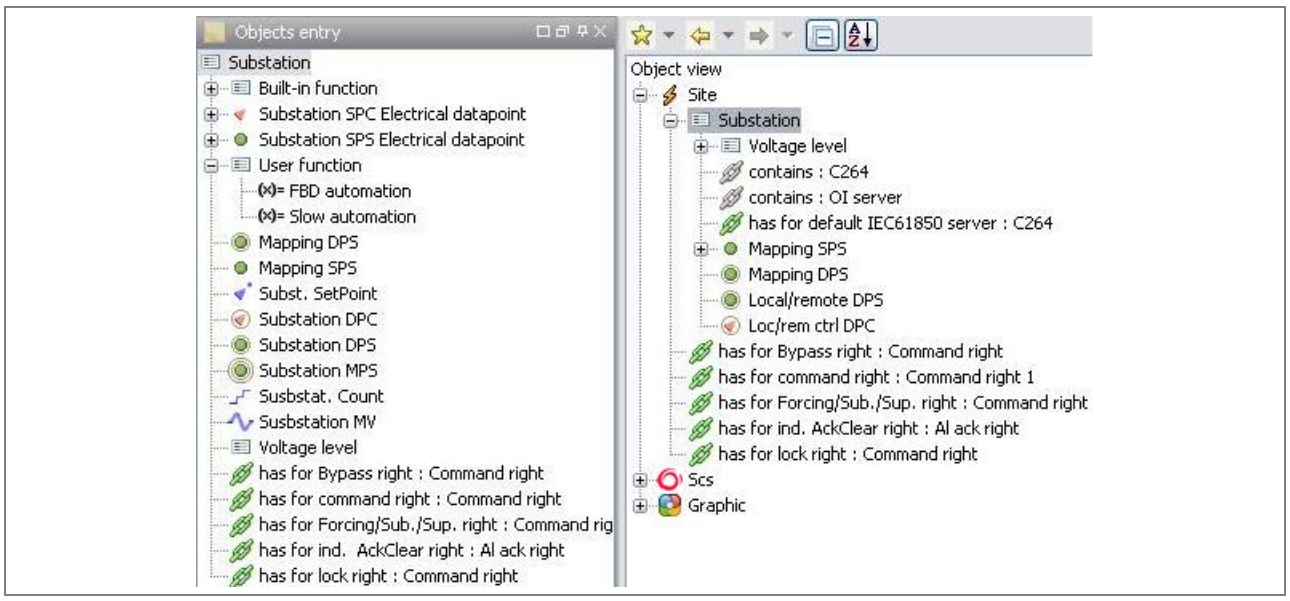


Figure 237: Adding a user function to a substation

5.1.3 DEFINING A VOLTAGE LEVEL

At substation level, several 'voltage level' objects can be added. A voltage level corresponds to a substation area whose electrical bays and sub-modules refer to the same nominal voltage. There is an exception for transformer bay, coupling 2 different voltage levels, that must be arbitrary located on one of the both.

To create a voltage level, select the substation level and add the voltage level from the contextual **Objects entry** window, as follows:

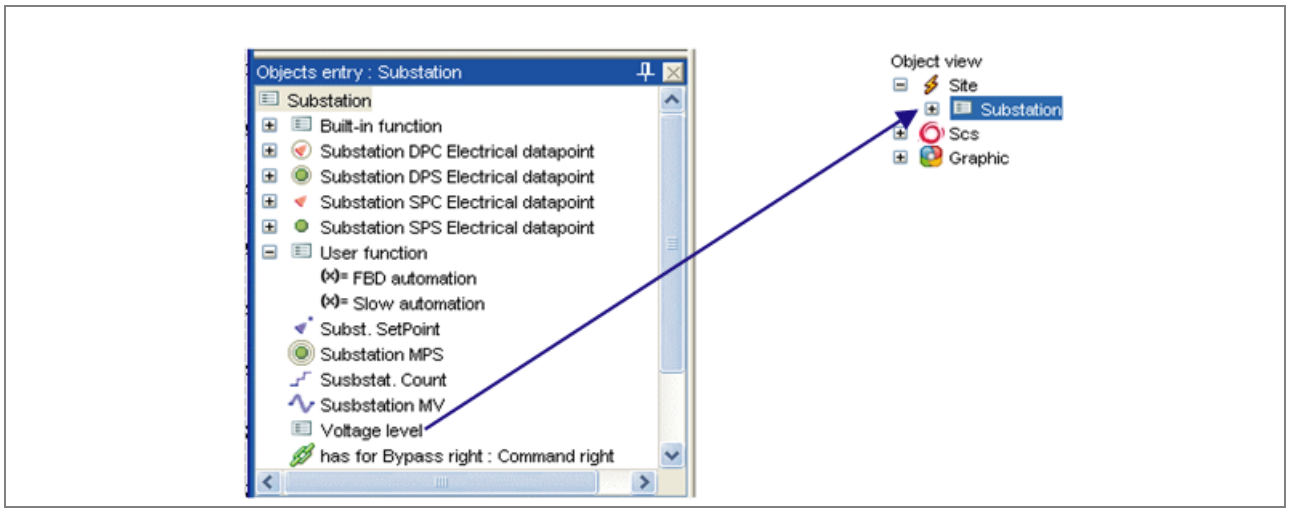


Figure 238: Adding a Voltage Level

When adding a voltage level, some general attributes must be updated:

- **short name** and **long name**: used for logging, alarms ...
- **nominal value** in kV
- **ATCC existence** (*No* / *Yes*): when set to 'yes', an extra tab-pane appears for the voltage level, to enter specific ATCC regulation feature for the voltage level. For details about ATCC configuration and this attribute, see section *0*
- *Defining an automatic voltage regulation – ATCC – built-in* function)

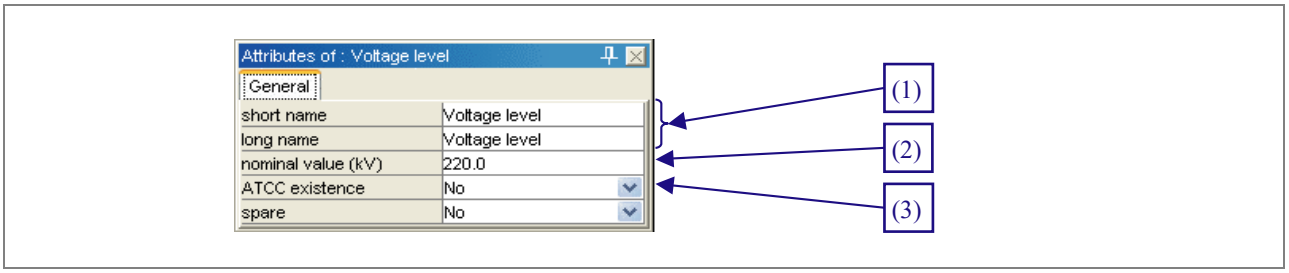


Figure 239: Setting the general attributes of an MV datapoint (example for a generic MV at Bay level)

5.1.3.1 ADDING A VOLTAGE LEVEL GENERIC DATAPOINT

To add a typed datapoint to a voltage level, select the voltage level and add the typed datapoint from the contextual **Objects entry** window. The available generic datapoints (standard usage) are listed in the figure below.

For more details about datapoints and their configuration, see section *4 Defining a datapoint*.

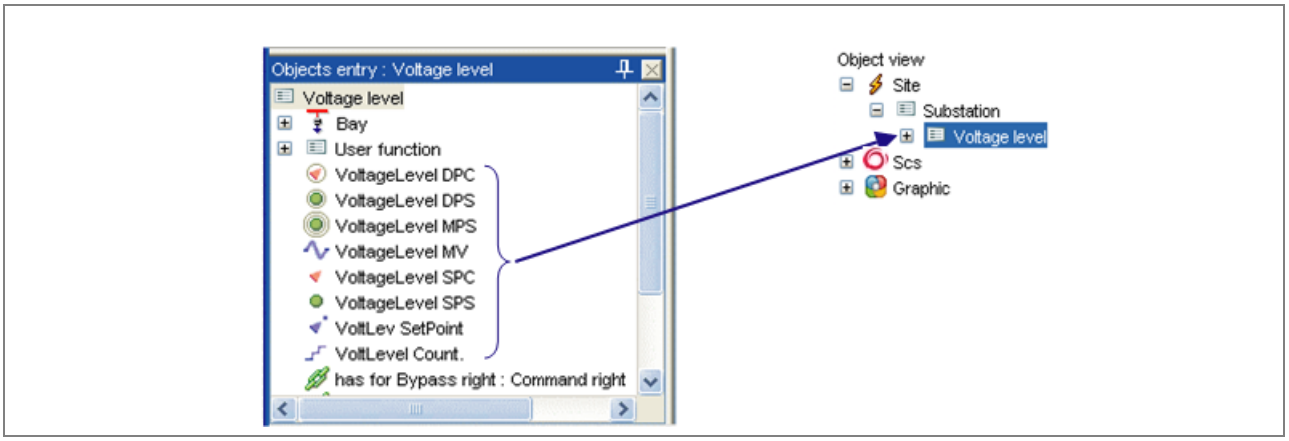


Figure 240: Adding a Voltage Level generic datapoint

5.1.3.2 ADDING A USER FUNCTION TO A VOLTAGE LEVEL

To add a user function to a voltage level, select the voltage level and add the user function from the contextual **Objects entry** window.

For more details about user functions' usage and configuration, see section *5.7 Defining an electrical regulation by user function*.

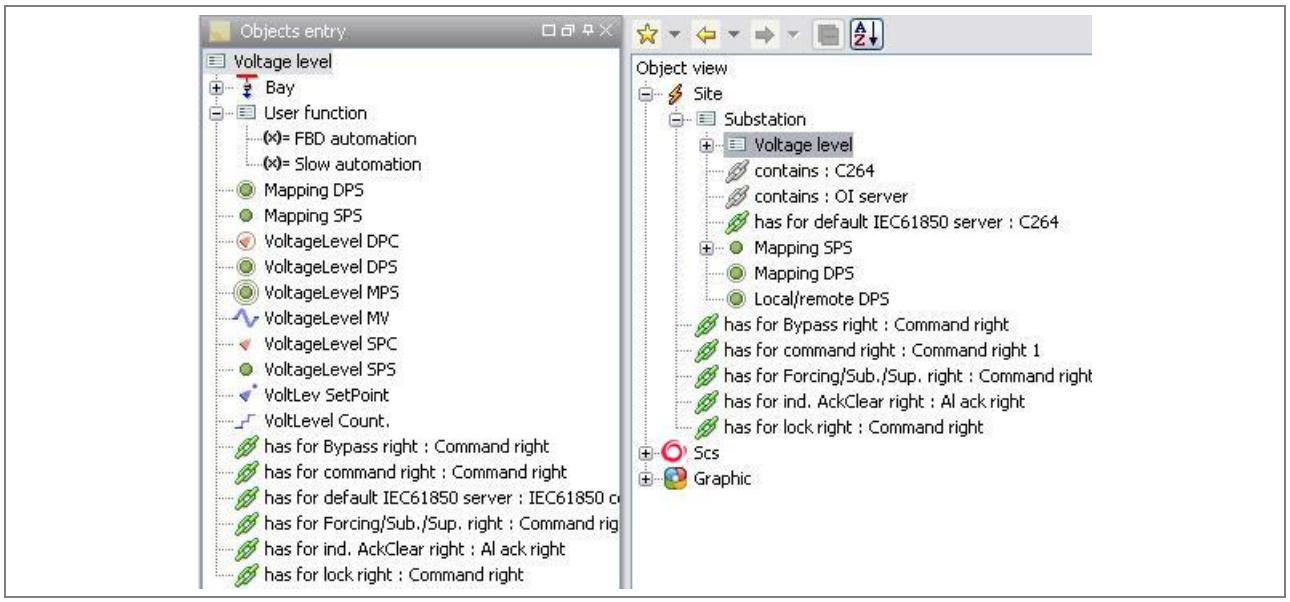


Figure 241: Adding a user function to a Voltage Level

5.1.4 DEFINING A BAY

At 'voltage level' level, several 'bay' objects can be added. A voltage level corresponds to a substation area whose electrical bays and sub-modules refer to the same nominal voltage. There is an exception for transformer bay, coupling two different voltage levels that must be arbitrary located on one of the both.

To create a bay:

- Select the voltage level (1) and add a typed bay from the contextual **Objects entry** window.
- Update the bay attributes.
- Update its **is managed by** relation, to define which C26x manages the bay (2).

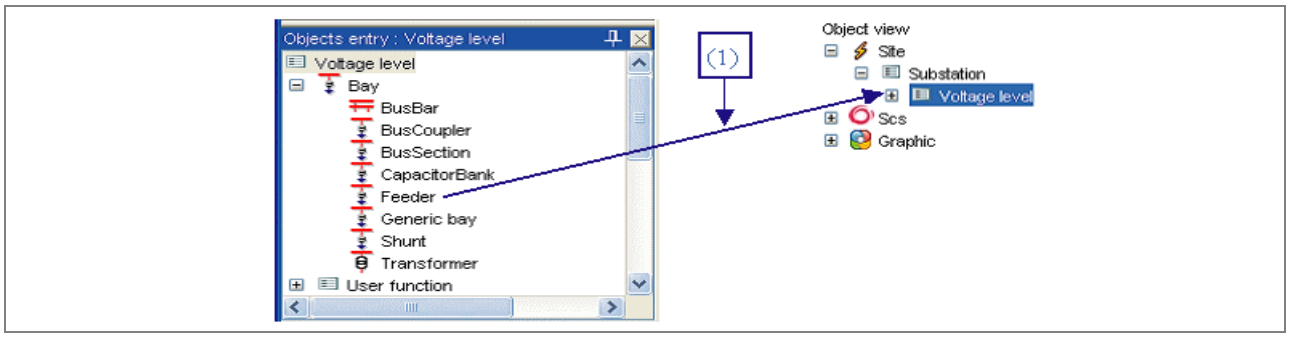


Figure 242: Adding a typed bay

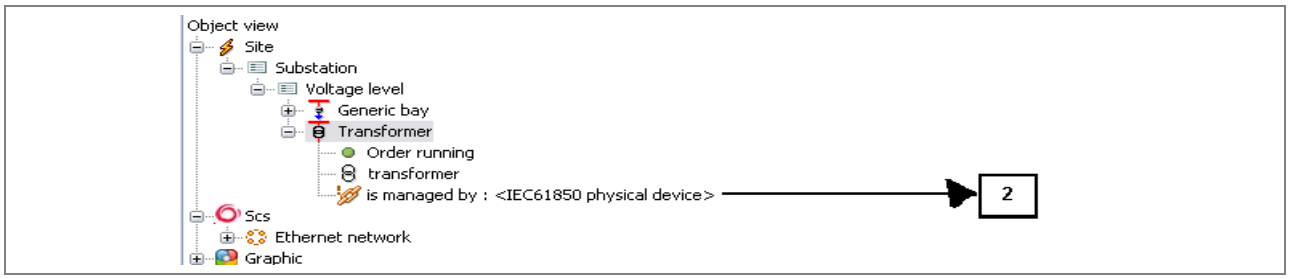


Figure 243: Defining the C26x that manages a bay

When adding a bay, some general attributes must be updated:

(1) **short name** and **long name** of the bay used for logging, alarms ...

(2) **control uniqueness** used for output datapoints under the bay.
The available values are:

- *None*: no control uniqueness is provided by the DS Agile system for output datapoints under the bay.
- *See substation definition*: control uniqueness is inherited from the attribute 'default uniqueness' at substation level (see section *5.1.2 Defining a Substation*).

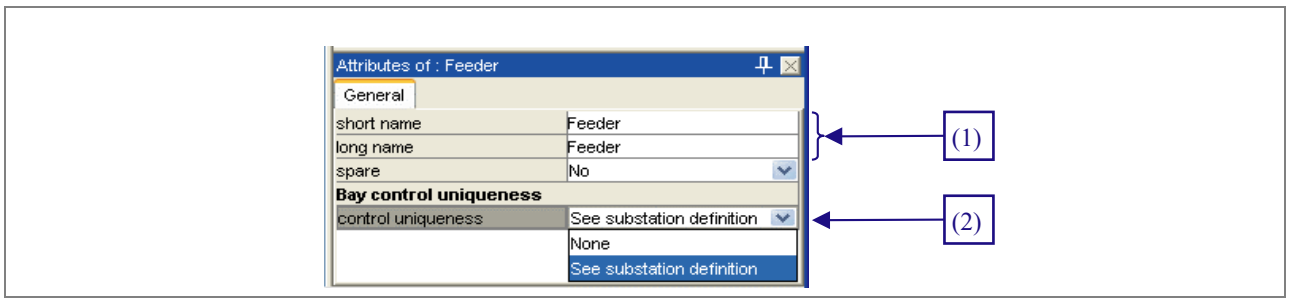


Figure 244: Setting the general attributes of a bay (example for a Feeder Bay type)

When adding a bay, a mandatory SPS datapoint 'order running' is automatically created at bay level. This datapoint allows DS Agile system to manage control uniqueness at substation and bay level: it is set when a control is in progress on a bay.

Configuration rules and checks

- When control uniqueness is set to substation, all the C26x units of a substation must be IEC 61850 clients of all 'order running' SPS datapoints defined for all the bays. So, proper IEC 61850 configuration must be done for all C26x units to support that feature. For details about IEC 61850 configuration, see section *3.5 Networking a C26x on the station-bus network*.

Typed bay features

Using typed bay allows implicit sub-component creation. All the typed bays are listed below, with their sub-component features:

- Feeder: a circuit-breaker and external line modules are mandatory and implicitly created,
- Transformer: a transformer module is mandatory and implicitly created,
- Bus coupler: a circuit-breaker module is mandatory and implicitly created,
- Bus section: a circuit-breaker module is mandatory and implicitly created,
- Capacitor bank: a capacitor module is mandatory and implicitly created,
- Shunt: a circuit-breaker module is mandatory and implicitly created,
- Busbar: no module is available. This typed bay must be seen as a single electrical node. A specific attribute 'node reference' used for electrical topology definition for ATCC function can be entered for a busbar. For details about ATCC configuration and this attribute, see section *0*
- *Defining an automatic voltage regulation – ATCC – built-in function*)**.**
- Generic bay: no sub-component constraint. Used for general usage outside the scope of other previous typed bays.

5.1.4.1 ADDING A BAY GENERIC DATAPOINT

To add a typed datapoint to a bay, select the bay level and add the typed datapoint from the contextual **Objects entry** window. The generic datapoints (standard usage) out of the specific bay functions' scope are listed below:

- Local/remote for bay (see section *5.1.4.2 Defining a bay Local/Remote datapoint*)
- SBMC for bay (see section *5.1.4.3 Defining the SBMC mode for a bay*)
- Group computation (see section *5.7.1 Defining a group*)

For more details about datapoints and their configuration, see section *4 Defining a datapoint*.

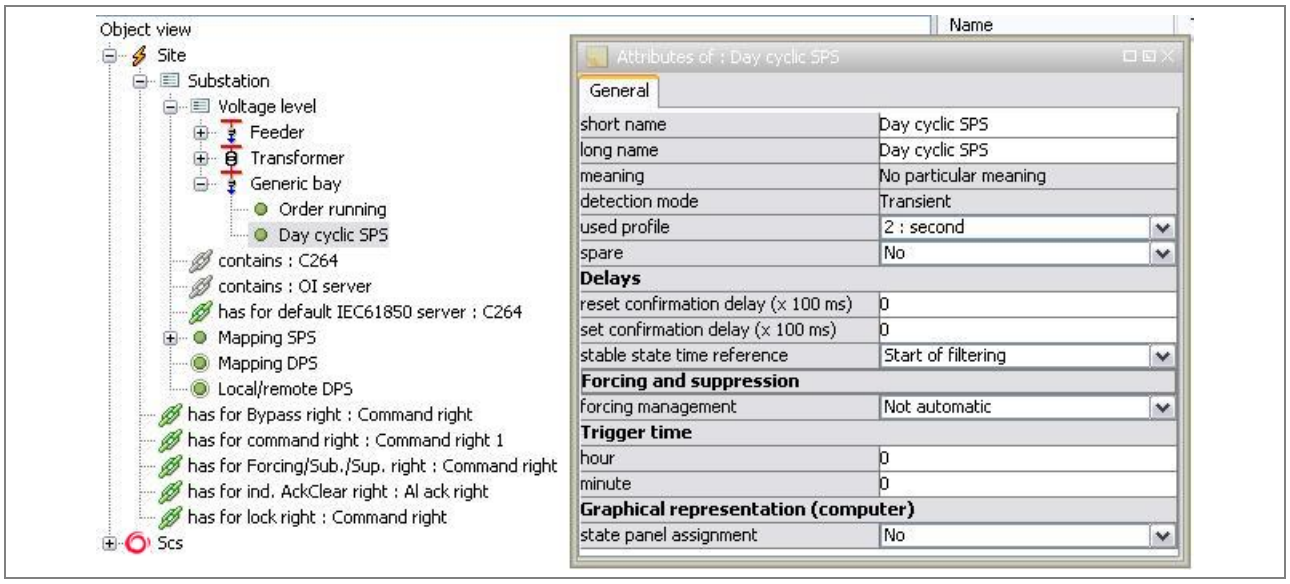


Figure 245: Adding a generic datapoint to a bay

Note:
In the C26x, up to 8 transient SPS datapoints (1) can be defined as cyclic (day cycle). They can be used to activate a periodic treatment. In addition to the usual attributes of SPS datapoints, these require the configuration of an extra two specific attributes (2) that define their time of activation.

5.1.4.2 DEFINING A BAY LOCAL/REMOTE DATAPOINT

Each bay can be independently switched to Remote or Local mode.

Remote mode means that the bay is controlled from the upper level, i.e. the Remote Control Point (RCP) or the Substation Control Point (SCP), depending on the current substation control mode. No control commands can be sent from the Bay Control Point (BCP) level, i.e. the front panel LHMI of the C26x unit that manages the bay.

Local mode means that the bay is controlled from the BCP. Control commands issued from the upper level are ignored.

Some control commands, defined during the configuration stage, can be independent of the bay control mode: it means that they can be issued from any control points whatever was the current control mode. Controls from configurable automation (ISaGRAF) are accepted in remote mode. For details about the configuration of this dependency attribute, refer to sections:

- SPC: see section *4.3.7.1*
- DPC: see section *4.3.8.1*
- SetPoint: see section *4.3.9.3*

Note:
*- A control command sent from an ISaGRAF automation that uses only datapoints coming from the **C26x unit on which the Isagraf automation is running** has an* orCat value = 4 (AUTOMATIC_BAY_CONTROL).
*It means that all the datapoints (command and status) are managed by the C26x unit that manages the automation. In this case, **the check is done at bay level**.*
*- A control command sent from an ISaGRAF automation that uses datapoints coming from **several C26x units in the substation** has an* orCat value = 5 (AUTOMATIC_STATION_CONTROL).
*It means that the datapoints (command and status) belong to several C26x units. In this case, **the check is done at the substation level**.*



Caution:
A control command linked to an ISaGRAF automation with an *orCat value = 4 (AUTOMATIC_BAY_CONTROL)* is always sent with that *orCat value = 4*, even when it is activated by another automation that needs an *orCat value = 5 (AUTOMATIC_STATION_CONTROL*).
This means that a system's set of ISaGRAF automations can only provide one *orCat value.*

Whether in Local or Remote mode, the indications transmitted by the bay are always sent to both the SCP and the RCP.

The function automatic "Forcing of Invalid BI" is used to avoid processing the invalid states of the bay mode (the local or remote substituted state is defined in configuration). The "Forced Local" state is processed as the "Local" state. The "Forced Remote" state is processed as the "Remote" state.

To enable Local/Remote bay facilities:

- add the optional datapoints **Local/remote DPS** (1) and/or **Loc/rem ctrl DPC** (2), at bay level from the contextual **Objects entry** window
- configure them (see section *4 Defining a datapoint*),
- if necessary, do not forget to link the control of the Local/remote with the Local/remote status datapoint using the **has for feedback** relation.

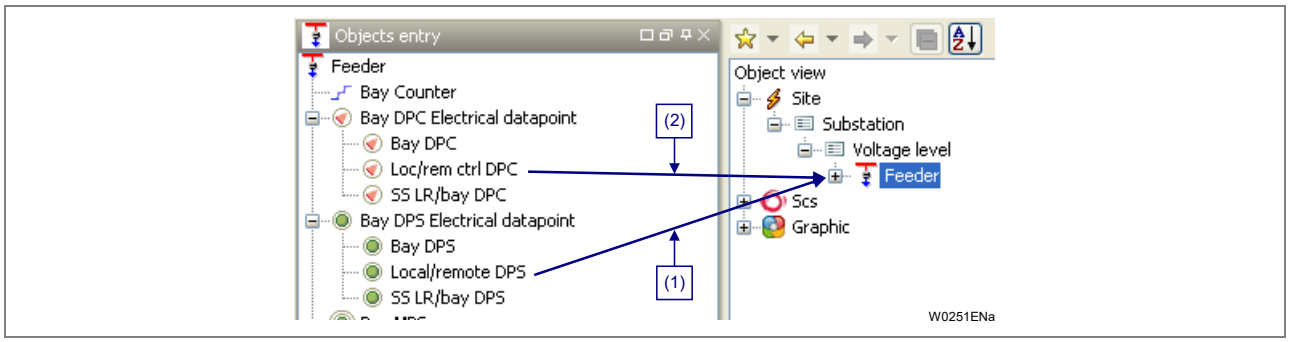


Figure 246: Defining a Local/Remote datapoint for bay

Configuration rules and checks

Note:
Here, the term "wired" means that the datapoint must be linked to a C26x's digital input(s).

- If **Loc/rem ctrl DPC** is present, then **Local/remote DPS** must be present (it is its feedback).
- If **Local/remote DPS** is not wired, then **Loc/rem ctrl DPC** is not required but, if it is nevertheless present, it must NOT be wired.
- If **Local/remote DPS** is wired, then **Loc/rem ctrl DPC** is not required but, if it is nevertheless present, it MUST be wired.
- If, under a Bay, a "DPC" or "SPC" datapoint has its attribute **bay mode dependency** set to *Yes*, then the Bay **Local/remote DPS** datapoint must be present.
- The **Loc/rem ctrl DPC** datapoint must have its profile attribute **SBO mode** set to *Direct Execute* or *Direct Execute with SBO popup*.

If a C26x's "GHU200" board has its attribute **HMI type** set to *Simple*, then the **Local/remote DPS** datapoints of the bays managed by the same C26x must be all be "Wired" or all "System".

5.1.4.3 DEFINING THE SBMC MODE FOR A BAY

Any electrical bay can be separately switched to SBMC mode (Site Based Maintenance Control mode) using a dedicated control datapoint (*SBMC control SPC*). While the bay is in SBMC mode, its datapoints that have been defined as SBMC-dependent are processed according to different rules:

- While in SBMC mode, an electrical bay does not receive, and therefore does not execute, SBMC-dependent xPC commands received from the Remote Control Point (RCP), even if the substation is in remote mode and whatever device manages them.
  It is possible, however, to configure some xPC datapoints to be independent of the SBMC mode.
- Whatever the device that manages it, if an indication datapoint belonging to a bay that is in SBMC mode is configured as SBMC-dependent (in its profile), the Gateway sends the SBMC state defined in

its profile to the RCP. It is, however, still processed normally at the substation control system level (i.e. none of the processes inside the system are impacted by the state alteration of an indication at the RCP interface).

For details about the configuration of the dependency attribute, refer to sections:

- SPC: see section *4.3.7.1*
- DPC: see section *4.3.8.1*
- SetPoint: see section *4.3.9.3*

Note:
The SBMC Control SPC/SBMC SPS *datapoints only affect SBMC-dependent datapoints attached to the same electrical bay.*

The states of indication datapoints sent to the RCP in SBMC mode are configured in their profile. The available SBMC states vary depending on the type of datapoint:

SPS	SUPPRESSED, SET, RESET
DPS	SUPPRESSED, OPEN, CLOSE, JAMMED
MPS	SUPPRESSED, UNDEFINED
MV, TPI and Counter	SUPPRESSED

To enable the SBMC function at bay level:

- add the optional datapoints ‘SBMC SPS’ (1) and ‘SBMC control SPC’ (2), from the contextual **Objects entry** window at bay level,
- configure them (see section *4 Defining a datapoint*),
- do not forget to link the control of the SBMC with the SBMC status datapoint using a **has for feedback** relation,

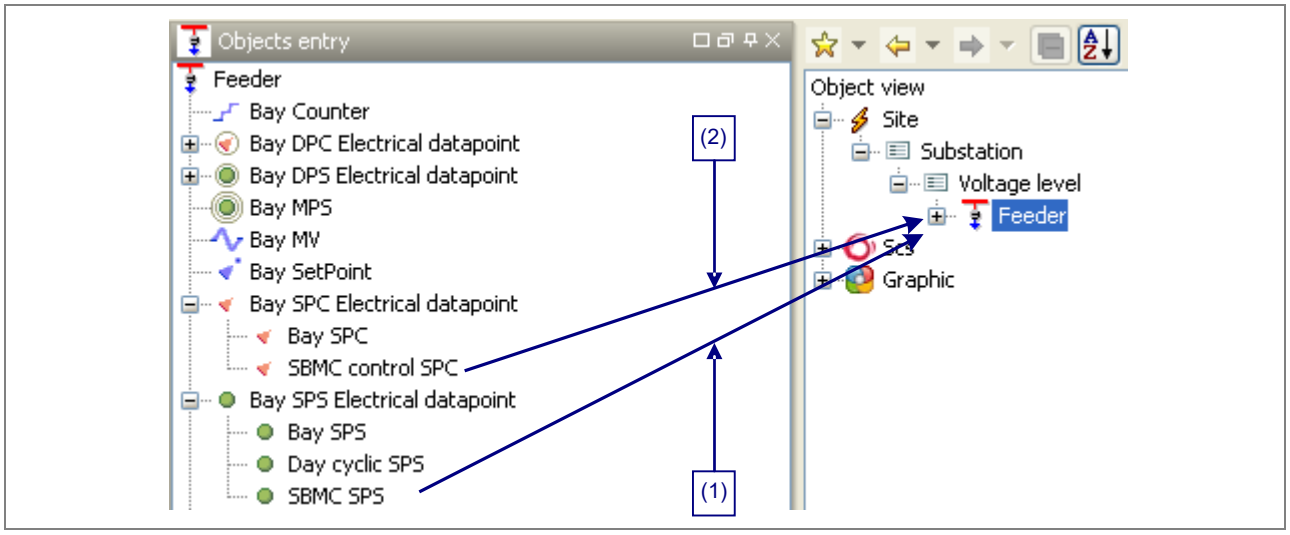


Figure 247: Defining the SBMC mode for a bay

Configuration rules and checks

- If **SBMC SPS** is present, then **SBMC control SPC** must be present
- If **SBMC control SPC** is present, then **SBMC SPS** must be present
- If **SBMC control SPC** is present, then its attribute **bay mode dependency** must be set to "No"
- If a "DPC" or "SPC" datapoint has its attribute **SBMC mode dependency** set to *Yes*, then the **SBMC SPS** datapoint must be present
- If a "DPS" or "SPS" datapoint has the attribute **SBMC dependent** of its profile set to *Yes*, then the "SBMC SPS" datapoint must be present

5.1.4.4 ADDING A USER FUNCTION TO A BAY

To add a user function to a bay, select the bay level and add the user function from the contextual **Objects entry** window.

For more details about user functions usage and configuration, see section *5.7 Defining an electrical regulation by user function*.

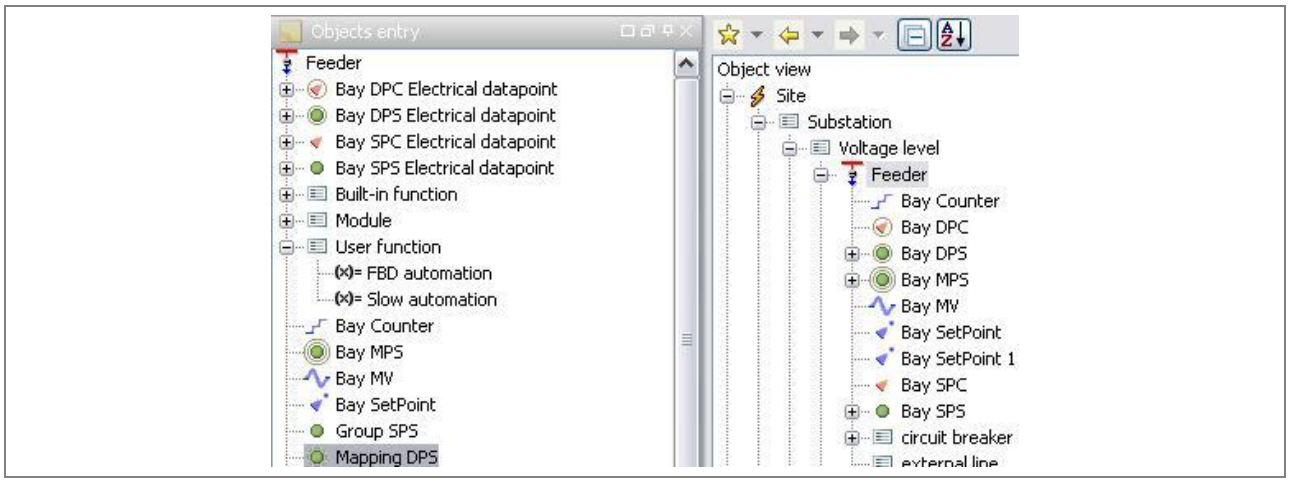


Figure 248: Adding a user function to bay

5.1.5 DEFINING A MODULE

This section covers general module configuration. The configuration of specific module types is described in the relevant sections further down.

At 'bay' level, several 'module' objects can be implicitly or explicitly added. A module generally corresponds to a substation electrical plant: transformer, circuit-breaker, etc.. It can have its own **Order running SPS**.

To explicitly create a module:

- Select the bay level (1) and add a typed module from the contextual **Objects entry** window

For an implicit or explicit module:

- Update the module attributes (see the following sections)

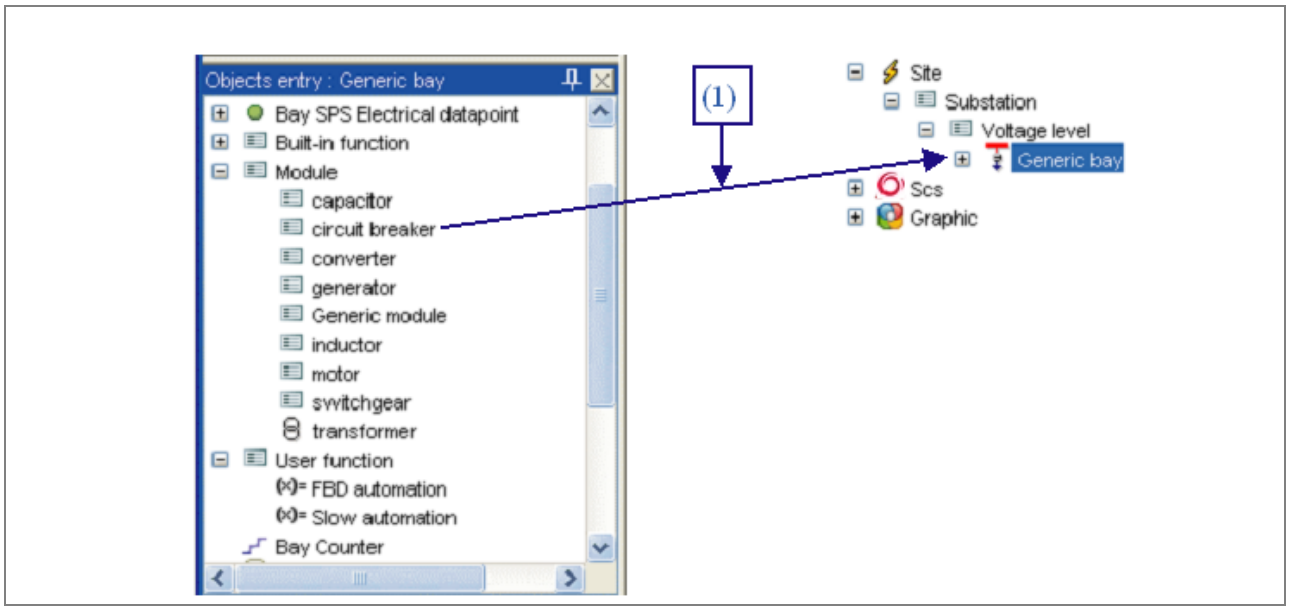


Figure 249: Explicitly adding a typed module

When adding a module, some general attributes must be updated:

(1) **short name** and **long name** of the module used for logging, alarms ...

(2) **node reference**, used for electrical topology definition. For details about this attribute, see section *4.3.8.1 Defining the electrical topology for an ATCC function*.

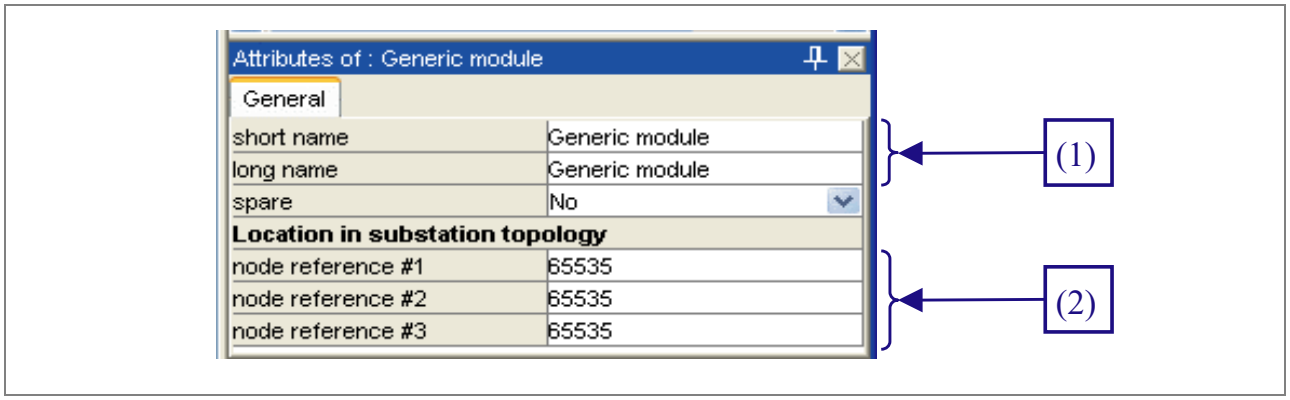


Figure 250: Setting the general attributes of a generic module

Typed module features

Using a typed module narrows down the configuration of the module. All the available typed modules with their main configuration features are listed below:

- Capacitor, Inductor:
  - Specific attribute ‘reactive power value’ (in MVA).
  - Non-lockable module
- Converter, generator, motor:
  - Non-lockable module
- Transformer:
  - Lockable module
  - Supports the Tap changer built-in function
  - Supports the ATCC built-in function
- Circuit-breaker module:
  - Lockable module
  - Supports synchrocheck and auto-recloser built-in functions
  - Supports withdrawing if the circuit-breaker is withdrawable
- Switchgear module
  - Lockable module
  - Supports withdrawing if the switchgear is withdrawable
- External line:
  - Only support SPS and DPS assignment
- Generic module:
  - Lockable module
  - Used for plant items other than the above typed modules

Some modules (three-pole circuit-breaker, switchgear, converter) support the Operating MV datapoint in addition to the Module MV datapoint. This is used in particular to represent a state (operation) counter from a third-party IED.

5.1.5.1 ADDING A MODULE GENERIC DATAPOINT

To add a typed datapoint to a module, select the module level and add the typed datapoint from the contextual **Objects entry** window. The generic datapoints (standard use) out of the specific module functions' scope are listed below:

- Group computation (see section *5.7.1 Defining a group)*.
- Locking module (see section *5.1.5.3 Defining a lockable module)*.
- Specific features and configuration of typed modules (see following sections).

For more details about datapoints and their configuration, see section *4 Defining a datapoint.*

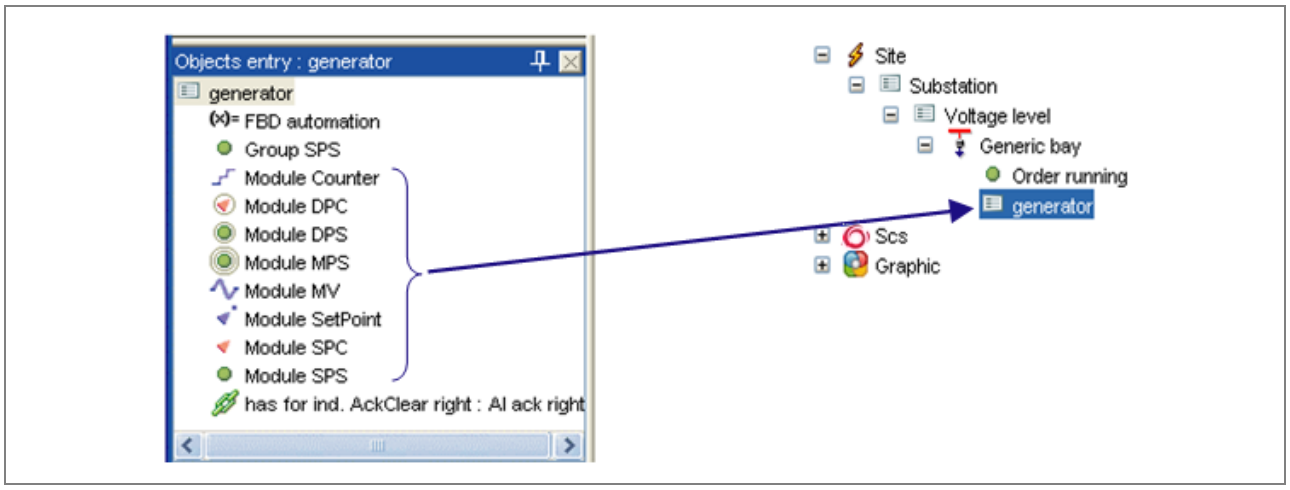


Figure 251: Adding a module generic datapoint (example for a generator module)

5.1.5.2 ADDING A USER FUNCTION TO A MODULE

To add a user function to a module, select the module level and add the user function from the contextual **Objects entry** window.

For more details about user function use and configuration, see section *5.7 Defining an electrical regulation by user function.*

Modules do not support the ISaGRAF function.

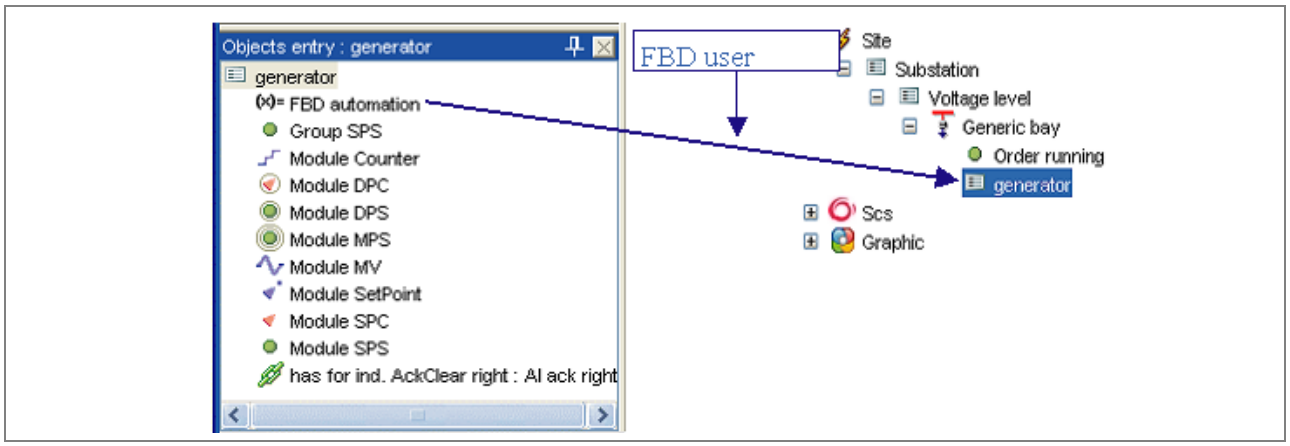


Figure 252: Assigning a user function to a module (example for generator module)

5.1.5.3 DEFINING A LOCKABLE MODULE

In the DS Agile system, module locking is a system function running on the C26x that manages the bay containing the module.

After a module has been locked, any subsequent control command it receives is denied. Locking is checked during control sequence processing at C26x level.

Only the following module types are lockable:

- Circuit-breaker,
- Switchgear,
- Transformer,
- Generic module.

To set such a module as lockable:

- Add the pre-defined SPS datapoint **Lock SPS** at module level (1) and configure it (see section *4 Defining a datapoint*),
- Add the pre-defined SPC datapoint **Lock control SPC** at module level (2) and configure it (see section *4 Defining a datapoint*),
- Define **Lock SPS** as feedback for **Lock control SPC** by adding and filling in the **has for feedback** relation at the SPC level (see section *4.3.7.2 Defining an SPC feedback*).

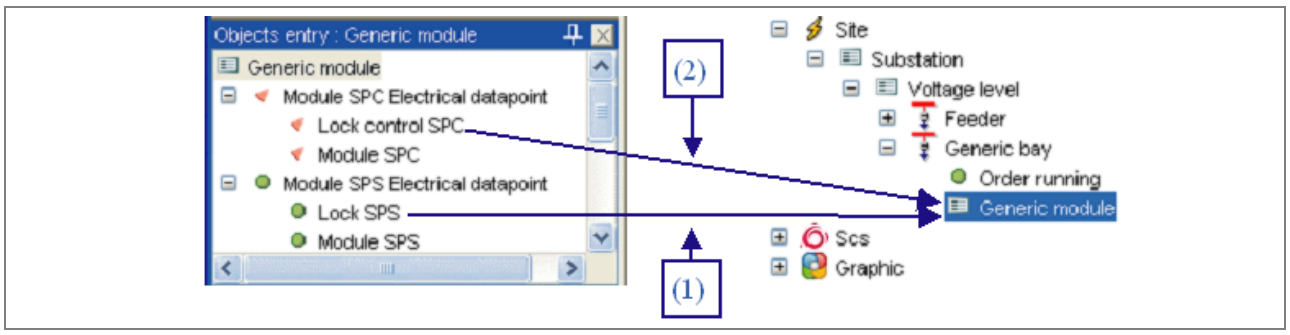


Figure 253: Defining a lockable module

Lock SPS and **Lock control SPC** are datapoints fed and controlled directly by the C26x that manages the module. They cannot be wired.

Configuration rules and checks

- **Lock control SPC** must have **Lock SPS** for feedback.

5.1.5.4 DEFINING A WITHDRAWABLE CIRCUIT-BREAKER OR SWITCHGEAR

To define a withdrawable circuit-breaker or switchgear:

- add the pre-defined SPS 'Withdrawn' at module level
- configure it (see section *4 Defining a datapoint*)

The Withdrawn state information is useful for bay mimic animation on the C26x front panel LCD. For more details, see section *6.2.3 Defining a C26x Bay mimic*.

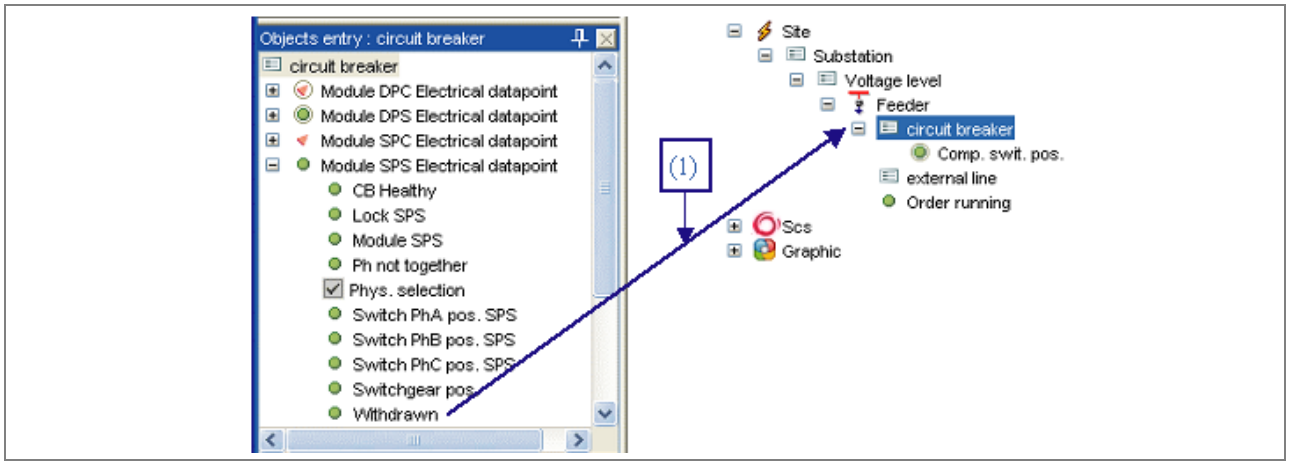


Figure 254: Defining a withdrawable module (example for a circuit-breaker)

5.1.5.5 DEFINING A CIRCUIT-BREAKER

This section covers the general features of circuit-breakers and their associated input and output datapoints at the C26x level.

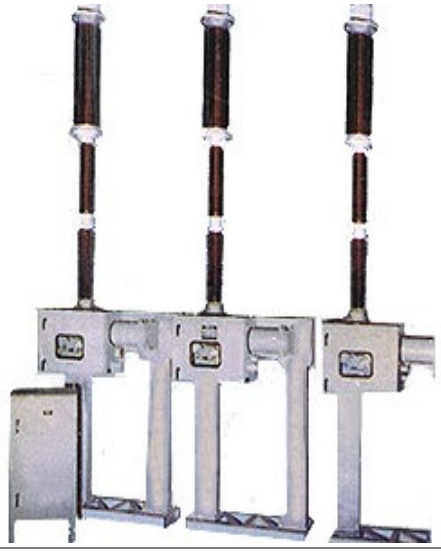
If the circuit-breaker is synchronized by an internal or external synchrocheck, there are extra datapoints. For more details see section *5.2 Defining a Synchrocheck function*.

The general features of modules are described in section *5.1.5 Defining a Module.* They are applicable to the circuit-breaker module and not discussed here.

After having created a circuit-breaker module (or automatically added it as part of a bay), either one of the following objects must be added from the contextual **Objects entry** window:

- *Single-pole*: this will create the datapoints compulsory for a **single pole circuit-breader** according to IEC 60870-7-4
- *Three-pole*: this will create the datapoints compulsory for a **three-pole circuit-breader** according to IEC 60870-7-4

Circuit-breaker type

Single-pole CB	Three-pole CB
The 3 poles can be operated independently. 	The 3 poles can only be operated together. 

If the circuit-breaker is to be synchronised in a breaker-and-a-half arrangement (diameter topology "type 3" internal synchrocheck function), its rank attribute must be set:

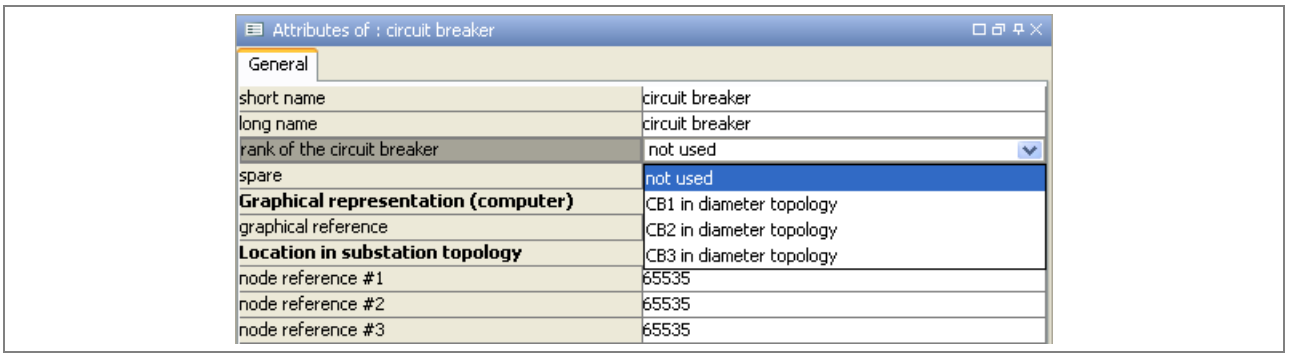


Figure 255: Circuit-breaker rank definition in diameter topology

The tables further down give the inputs and outputs of the circuit breaker functions controlled by the C26x for three-pole and single pole circuit-breakers. The SCE label of each datapoint is assigned a number for reference in the figure below.

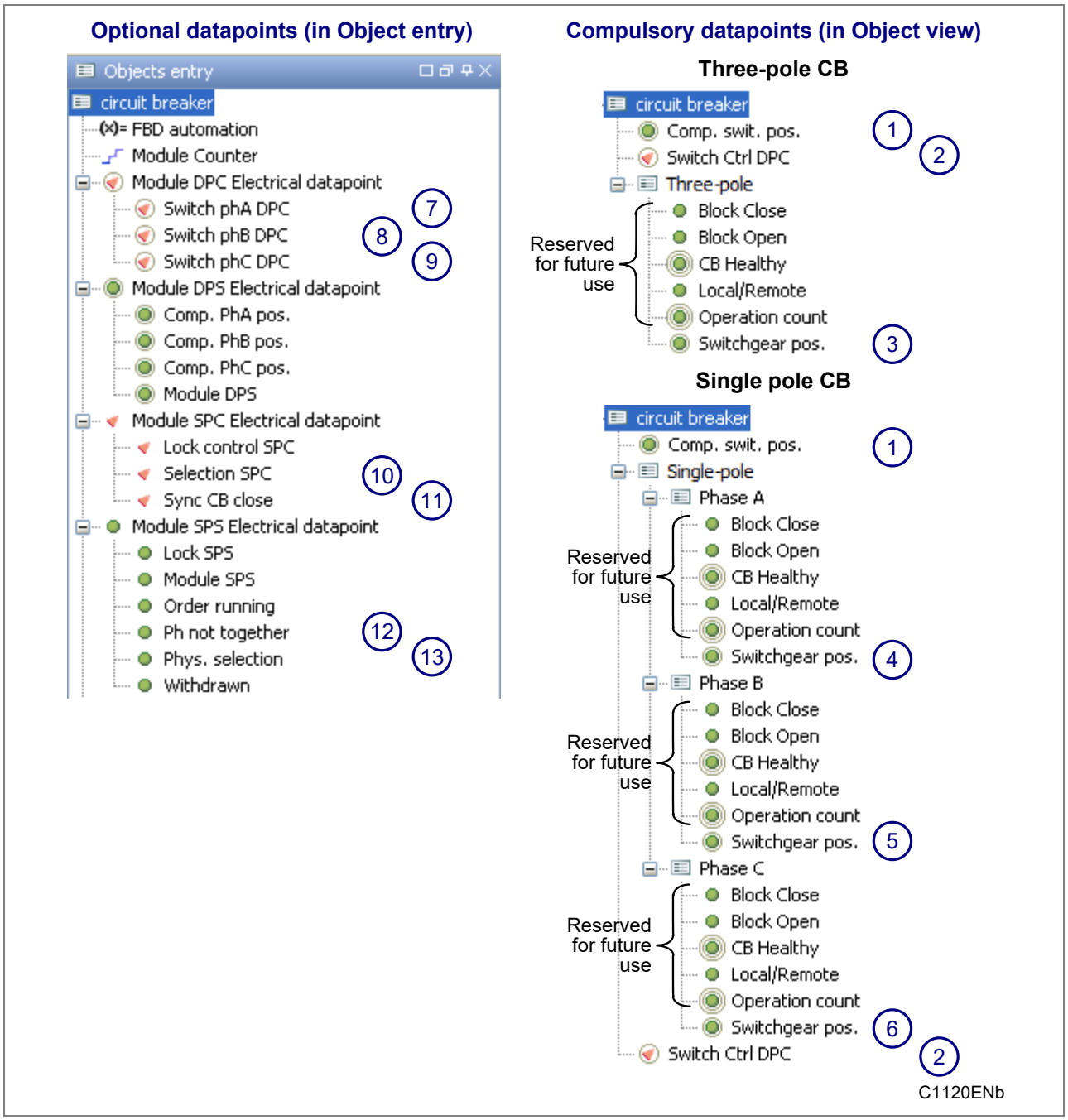


Figure 256: Pre-defined datapoints available for a circuit-breaker module

When creating a circuit breaker module, either implicitly or explicitly (section *5.1.4 Defining a Bay*), the mandatory pre-defined DPS **computed switch position** (1) is automatically created.

To correctly configure a circuit-breaker module:

- add the relevant datapoints according to the tables below,
- configure them (see section *4 Defining a datapoint*),
- do not forget to link the control (2) of the circuit breaker to the **computed switch position** (1) datapoint with the **has for feedback** relation,.

Three-pole circuit-breaker		
	Outputs to CB	**Inputs from CB**
Device control	(2) DPC, device open/close control	(3) DPS, physical position of the device (1 pole) (12) SPS (optional), pole discrepancy (ph not together) indication (1) System DPS, feedback of the control (i)
Device selection (hardware)	(10) SPC (optional), device selection control	(13) SPS (optional), device selection position indication

Single pole circuit-breaker			
	Outputs to CB 3-p operations	**Outputs to CB 1-p operations**	**Inputs from CB**
Device control	(2) DPC, device open/close control	(7) DPC, control to open phase A (8) DPC, control to open phase B (9) DPC, control to open phase C (2) DPC, control to close the device	(4) DPS, physical position of pole A (5) DPS, physical position of pole B (6) DPS, physical position of pole C (12) System SPS, "ph not together" indication (ii) (1) System DPS, control feedback (iii)
Device selection (hardware)	(10) SPC (optional), device selection control	(10) SPC (optional), device selection control	(13) SPS (optional), device selection position indication

(i) The computed value matches the state of the CB's auxiliary contacts when there is no pole discrepancy, i.e. if the value of **ph not together** is *false*, otherwise the computed value is *jammed*.

(ii) The computed **ph not together** value is *false* if all the CB poles are in the same open or closed position. It is *true* when a pole discrepancy is detected.

(iii) The computed value matches the state of phase A if the state of **ph not together** is equal to *false* (i.e. no pole discrepancy is detected), otherwise the computed value is *jammed*.

Configuration rules and checks

- If the circuit-breaker sub-group "Single-pole" is selected, and that the datapoint(s) *Switch phx DPC* (7/8/9) and/or *Switchgear pos.* (6/7/8) have been added to a "Phase x", they must also be added to the other two.
- The **Selection SPC** datapoint must have its profile attribute **SBO mode** set to *Direct Execute* or *Direct execute with SBO popup*

Control sequence for non-synchronized circuit breakers

Circuit breakers units are managed in “direct execute mode” and in “SBO once mode”. Refer to the generic description.

Control sequence for synchronized circuit breakers

See section *5.2 Defining a Synchrocheck function*.

5.1.5.6 DEFINING A SWITCHING DEVICE

This section covers the general features of switchgear and their associated input and output datapoints at the C26x level.

The general features of modules are described in section *5.1.5 Defining a Module.* They are applicable to switchgear modules and not discussed here.

When adding a switchgear module, the following specific general attribute must be updated:

- **Switchgear type**:

  The available values are:

  - Busbar disconnector (e.g. S3, S4, S7, S8)
  - Disconnector (e.g. S11)
  - Bypass disconnector (e.g. S18 to S20)
  - Transfer busbar disconnector (e.g. S13)
  - Earth switch (e.g. S5, S6, S9, S10, S12, S14, S17)

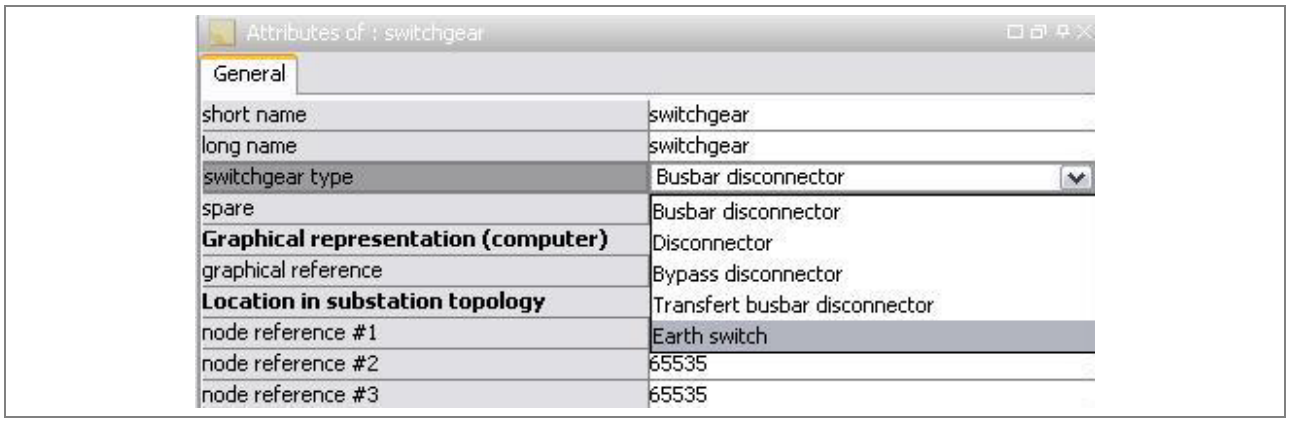


Figure 257: Setting the type of switchgear

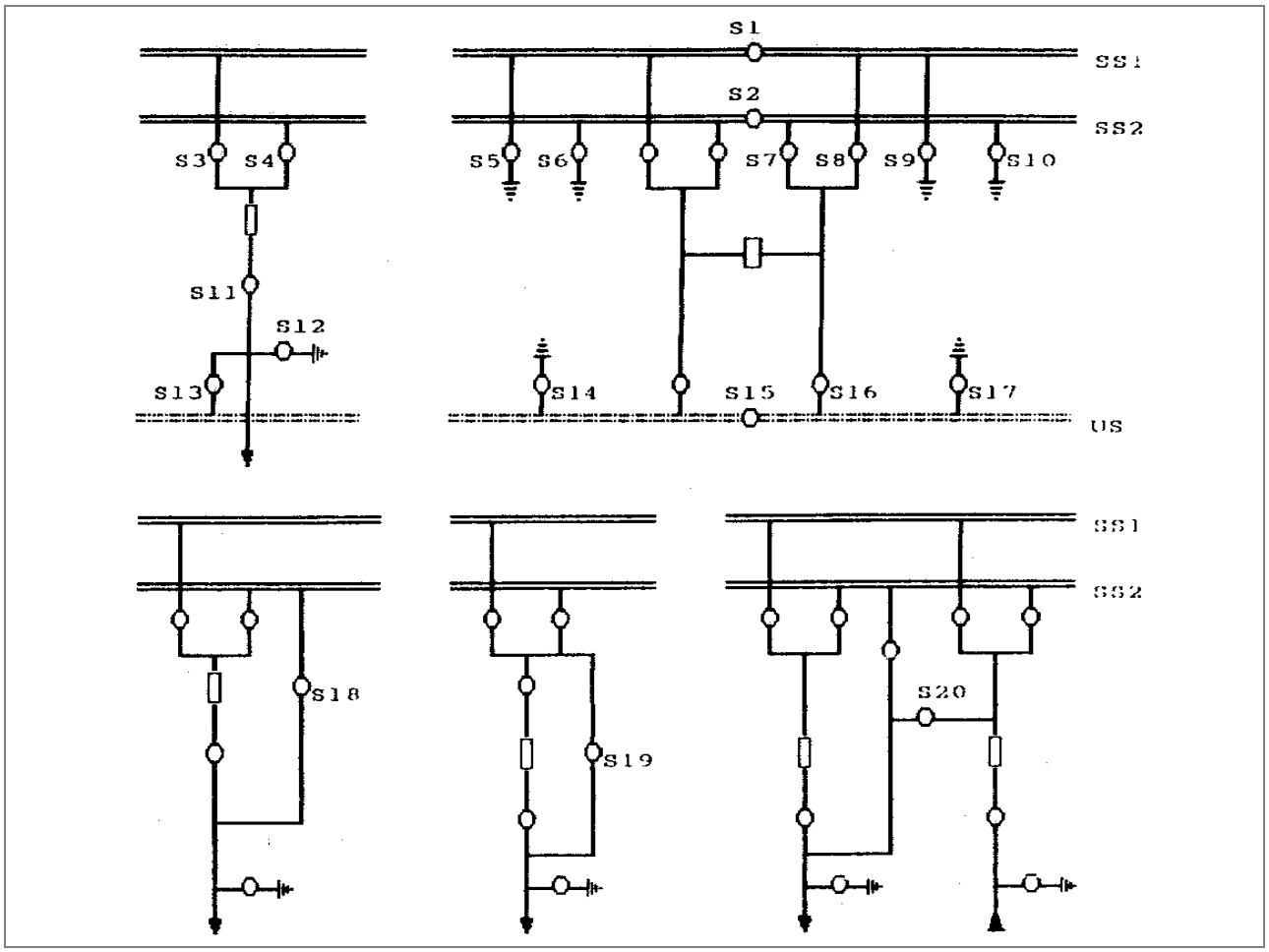


Figure 258: Types of switchgear in various substation architectures

The table below gives the inputs and outputs of the switchgear functions controlled by the C26x. The SCE label of each datapoint is assigned a number for reference in the figure below.

To correctly configure a switchgear module:

- add the relevant datapoints, according to the table below,
- configure them (see section *4 Defining a datapoint*),
- do not forget to link the control (3) of the switchgear (if it exists) to the switch position datapoint (1) or (5) with the **has for feedback** relation.

Switchgear		
	Outputs to switchgear	**Inputs from switchgear**
Device control	(3) DPC, control for open/close of device	(1) DPS, physical position of the device (1 phase)
Device selection (hardware)	(2) SPC, (optional) control of device selection	(4) SPS (optional), device selection position information

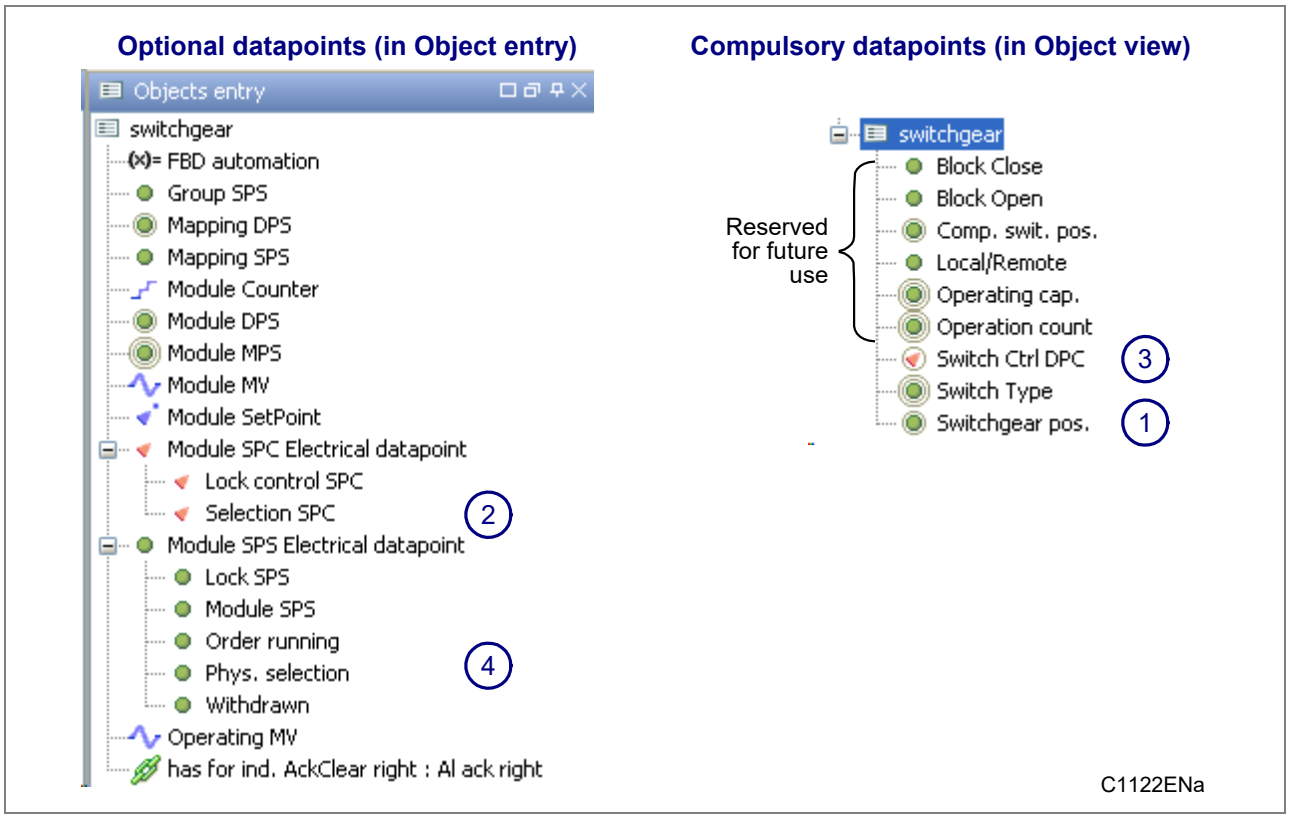


Figure 259: Pre-defined datapoints available for a switching device

Control sequence for switchgear

Switchgear units are managed in “direct execute mode” and in “SBO once mode”. Refer to the relevant generic description.

5.1.5.7 DEFINING A TRANSFORMER

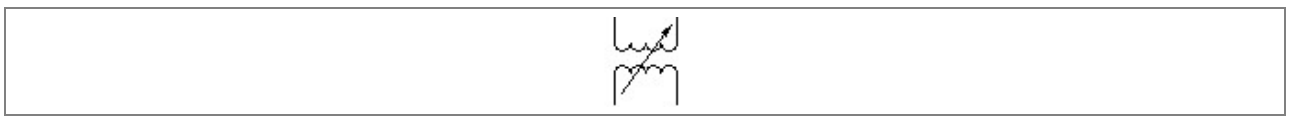
This section covers the general features of transformers and their associated input and output datapoints at the C26x level.

The general features of modules are described in section *5.1.5 Defining a Module*. They are applicable to transformer modules and not discussed here.

When a transformer bay is created (see section *5.1.4 Defining a Bay*), a a transformer module is implicitly added and the following general attribute must be updated:

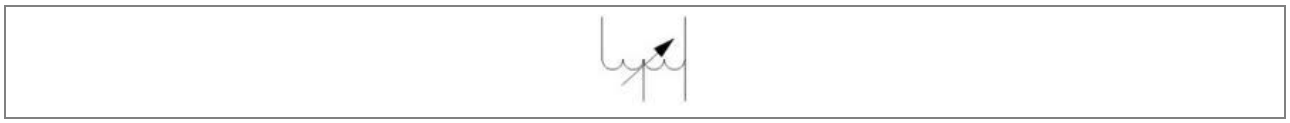
(1) **transformer type**:

- *Double wound*: a double wound (or two-winding) transformer is a transformer with galvanic isolation between its primary and secondary coils. The Tap Changer (with additional winding) is usually located at the HV-neutral side for economic reasons. Tapping-up (raise command) reduces the width of the primary winding and increases the LV voltage.



- *Auto transformer*: an auto transformer (or auto-wound, or single wound) is a transformer without galvanic isolation between its primary and secondary windings. The secondary winding follows the primary winding (windings are linked in series). The Tap Changer (with the tap on a separate winding) is mounted in series. Increasing the tap position (raise command) acts simultaneously on

the primary and secondary windings, it reduces the transformer ratio and therefore the voltage on the LV side. Thus the raise order must be inverted (considered as a lower command) for this type of transformers.



(2) **power value** (range [1 to 300 MVA), used for ATCC regulation

(3) **impedance**, whose unit is a percentage of the value for S=100 MVA (range [0.01 to 24.99 in steps of 0.01) , used for ATCC regulation

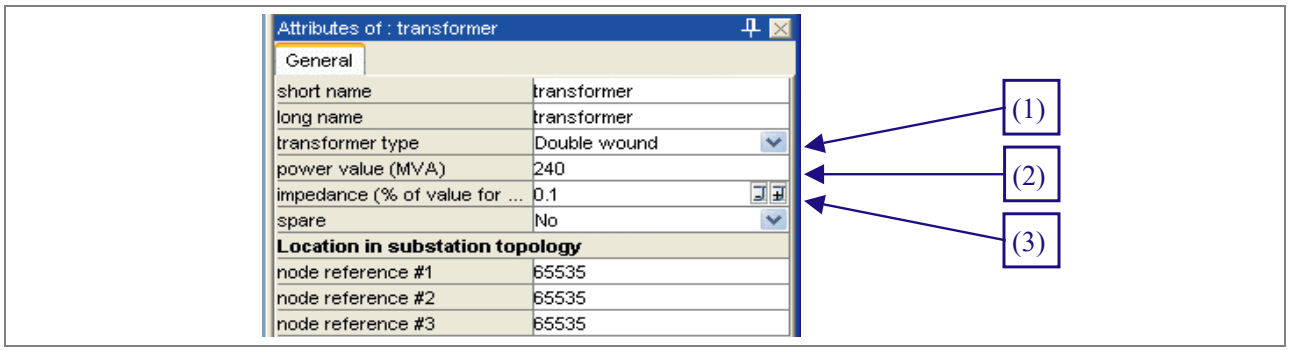


Figure 260: Setting the type of transformer

The transformer is used for coupling two voltage levels. Because the SCE's data modeling is based on electrical partitioning, this transformer must belong to a transformer bay arbitrarily placed in either voltage level (usually the primary voltage level). An extra relation must be defined on the transformer to indicate which voltage level its other side (secondary or primary) belongs to.

To create such a relation:

- Add the correct relation at transformer level
- Fill in the relation with the relevant voltage level

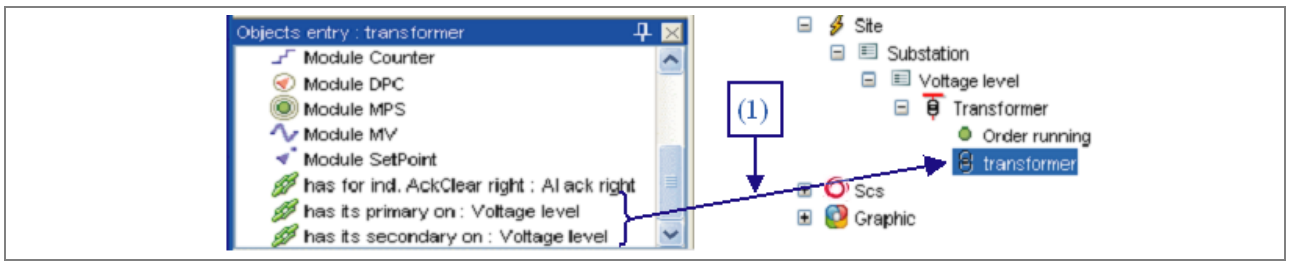


Figure 261: Linking the primary/secondary sides of a transformer

When adding a transformer, some optional datapoints can be created at module level and they must be configured (see section *4 Defining a datapoint*):

(1) **MCB position DPS**: used for the ATCC function (see section *5.5*) to give the position of the Mini Circuit-Breaker associated with the tap-changer, using a DPS datapoint

(2) **MCB position SPS**: used for the ATCC function (see section *5.5*)

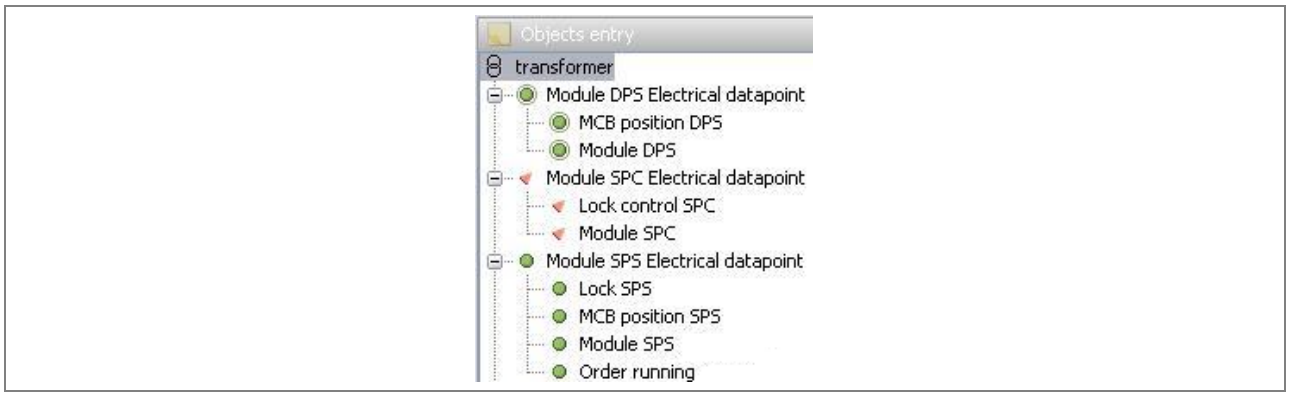


Figure 262: Optional datapoints for a transformer

When it exists, the tap position of a transformer is controlled by a specific built-in **Tap changer** function available at transformer module level. For details about transformer control using the tap changer function, see section *5.4 Defining a Tap changer built-in function*.

5.2 DEFINING A SYNCHROCHECK FUNCTION

5.2.1 CIRCUIT-BREAKER DEFINITION FOR SYNCHROCHECK

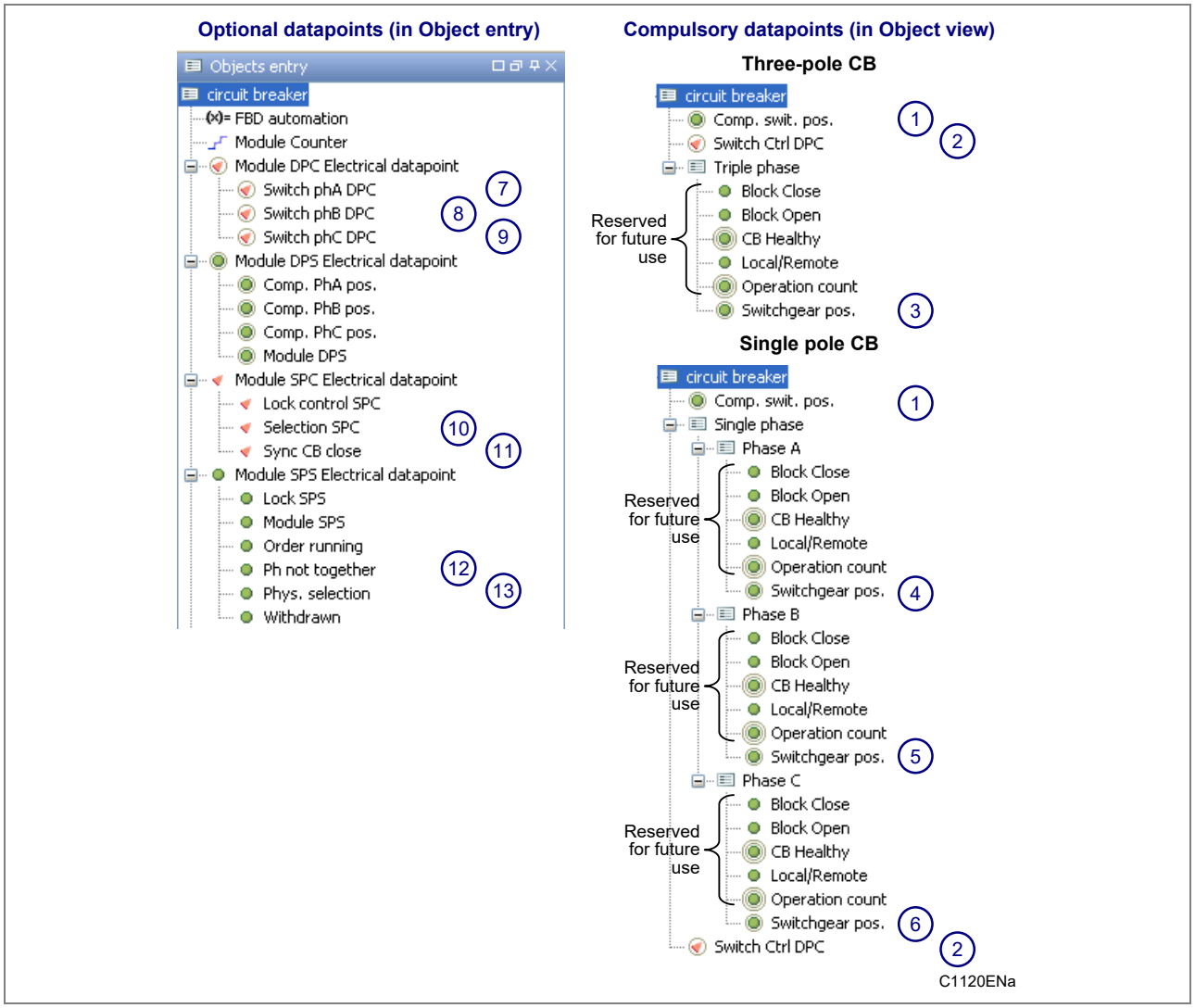


Figure 263: Available pre-defined datapoints for a circuit-breaker with synchrocheck

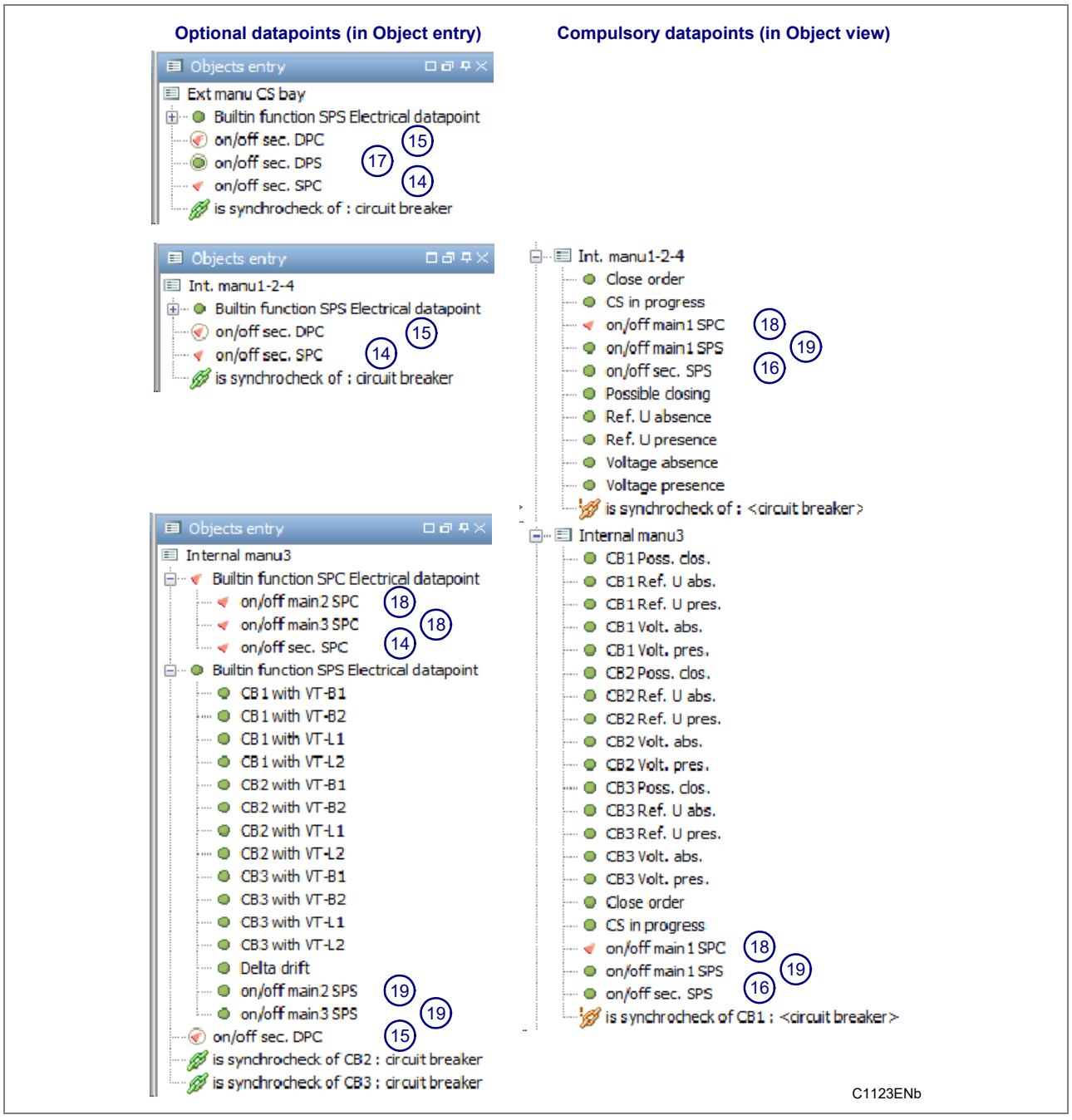


Figure 264: Common pre-defined datapoints for synchrocheck

The tables below give the inputs and outputs of the circuit breaker functions controlled by the C26x for three-pole and single-pole circuit-breakers, with regards to the synchrocheck function. The SCE label of each datapoint is assigned a number for reference in the above figures.

These tables complement those described in section *5.1.5.5 Defining a circuit-breaker*. To correctly configure a circuit-breaker module with synchrocheck:

- add the relevant datapoints according to the tables below.
- configure them (see section *4 Defining a datapoint*).
- do not forget to link the control (2) of the circuit-breaker to the computed switch position (1) datapoint with the **has for feedback** relation.
- link the circuit-breaker to an existing synchrocheck function created at bay or substation level. This link is placed at synchrocheck level (for details see *5.2.2 Creating a synchrocheck function*). Only 1 circuit breaker can be linked to the same standard (type 1, 2 or 4) internal synchrocheck and 3 for "breaker-and-a-half" (type 3) arrangements.
- correctly configure the function itself (see *5.2.2 Creating a synchrocheck function*).

Three-pole circuit-breaker with synchrocheck		
	Outputs to CB	**Inputs from CB**
Device control	(2) DPC: device open/close control (11) SPC: close with synchrocheck control	(3) DPS: physical position of the device (1 pole) (12) SPS (optional): pole discrepancy (ph not together) indication (1) system DPS: feedback of the control (i)
Device selection (hardware)	(10) SPC (optional): device selection control	(13) SPS (optional): device selection position indication
Enable/disable close with synchrocheck schemes	(14) SPC or (15) DPC (optional): synchrocheck scheme on/off control	(16) SPS or (17) DPS (optional for external S/C): synchrocheck scheme on/off indication
Enable/disable synchrocheck function (for a specific CB in CB-1/2 topology) (internal S/C only) (vi)	(18) SPC: synchrocheck function on/off control for specific CB (1 or 3)	(19) SPS: synchrocheck function on/off control for specific CB (1 or 3)

Single pole circuit-breaker with synchrocheck			
	Outputs to CB 3-p operations	**Outputs to CB 1-p operations**	**Inputs from CB**
Device control	(2) DPC: Device open/close control (11) SPC: Close control with synchrocheck	(7) DPC: open phase A control (8) DPC: open phase B control (9) DPC: open phase C control (2) DPC: close of device control (11) SPC: Close control with synchrocheck	(4) DPS: physical position of phase A (5) DPS: physical position of phase B (6) DPS: physical position of phase C (12) System SPS: ph not together indication (ii) (1) System DPS: control feedback (iii)
Device selection (hardware)	(10) SPC: (optional) device selection control	(10) SPC (optional): device selection control	(13) SPS (optional): device selection position indication
Enable/disable close with synchrocheck schemes (iv)	(14) SPC or (15) DPC: (optional) synchrocheck scheme on/off control	(14) SPC/(15) DPC: (optional) synchrocheck scheme on/off control	(16) SPS or (17) DPS: (optional for external S/C) synchrocheck scheme on/off indication

Single pole circuit-breaker with synchrocheck			
Enable/disable synchrocheck function (for a specific CB in CB-1/2 topology) (internal S/C only) (v)	(18) SPC: synchrocheck function on/off control for specific CB (1 or 3)	(18) SPC: synchrocheck function on/off control for specific CB (1 or 3)	(19) SPS: synchrocheck function on/off control for specific CB (1 or 3)

(i) The computed double signal is equal to the state of the CB auxiliary contacts when there is no pole discrepancy, i.e. if the value of **ph not together** is *false*, otherwise the computed signal is equal to *jammed*.

(ii) The computed **ph not together** signal is equal to *false* if all the poles are in the same open or closed position. It is equal to *true* when a pole discrepancy is detected.

(iii) The computed signal is equal to the state of phase A if the state of **ph not together** is equal to “false” (i.e. no pole discrepancy is detected), otherwise the computed signal is equal to “jammed”.

(iv) Wired SPC and SPS for external synchrocheck and system SPC and SPS for internal synchrocheck. If not configured, the external synchrocheck module or the internal synchrocheck function is considered as permanently disabled. DPC & DPS are used only for manual synchrocheck.

(v) **on/off main2 SPx** and **on/off main3 SPx** are only available for Synchrocheck type 3 function (breaker-and-a-half topology).

The mandatory **Comp. swit. pos.** DPS is implicitly created at circuit-breaker level. It cannot be deleted.

Configuration rules and checks

- If the physical position of the device is given by an SPS (21), the **ph not together** indication (15) must be configured.
- A Circuit Breaker may only be linked once to a Synchrocheck function (relation **is synchrocheck of**).
- If a Circuit Breaker is linked to an automatic Synchrocheck function (relation **is synchrocheck of**), then its **Sync CB close** SPC datapoint must be present.
- The **Sync CB close** datapoint of a **Circuit breaker** linked to an **Ext manual CS** or **Int synchrocheck** synchrocheck must have its profile attribute **Control mode** set to *Direct Execute* or *Direct Execute with SBO popup*.
- The **Sync CB close** datapoint of a **Circuit breaker** linked to an **Ext auto CS** synchrocheck must have its profile attribute **Control mode** set to *SBO Operate Once*.
- The **Sync CB close** datapoint of a **Circuit breaker** linked to an internal automatic synchrocheck must have its profile attribute **Order off** set to *No*. (Setting it to *Yes* would be nonsensical and as a result the control popup would freeze.)
- All commands (except the **Sync CB close** SPC) under a circuit breaker associated with an automatic synchrocheck or an internal manual synchrocheck must have their **control mode** set to *SBO Operate Once* in their profile. See *Functional Description* chapter (*C26x/EN FT*), *Control Sequences* section for details on circuit-breaker control.

“Open” control sequence for synchronized circuit breakers

This sequence is identical to the sequence for non-synchronized circuit-breakers (see section *5.1.5.5 Defining a circuit-breaker*).

“Close” control sequence for synchronized circuit breakers

This sequence varies depending on the type of synchrocheck configured:

- External synchrocheck: the CB is closed by an external synchrocheck module.
- Internal synchrocheck: the CB is closed by a C26x internal synchrocheck function

The close control sequence can be defined with:

- Manual activation of the external synchrocheck module or internal synchrocheck function.
- Automatic activation of the external synchrocheck module or internal synchrocheck function.

Furthermore, while waiting for the external module to close the CB, the initiator of the request can:

- Cancel the request.
- Force the closing of the device.

5.2.2 CREATING A SYNCHROCHECK FUNCTION

The synchrocheck function can be created at several levels of the electrical topology:

- Substation level:
  - if the synchrocheck function is shared by several breakers (external manual only)
- Bay level:
  - if the synchrocheck function is dedicated to a particular breaker of the bay,
  - if the synchrocheck function manages a "breaker-and-a-half" arrangement.

To add a synchrocheck function, select the substation or bay level. At substation level, select Built-in function un the contextual **Objects entry** window, expand it and double-click on **Ext manual CS** (external manual synchrocheck, only available synchrocheck option at this level). At bay level, scroll down to Built-in function, expand it, select Synchrocheck Built-in function and expand it. Double-click on the appropriate function:

- **Ext auto CS**: External automatic synchrocheck
- **Ext manu CS bay**: External manual synchrocheck
- **Internal auto CS**: Internal automatic synchrocheck
- **Int. manu1-2-4**: Internal manual synchrocheck for standard topology
- **Internal manu3**: Internal manual synchrocheck for breaker-and-a-half topology

Synchrocheck functions can only be added to the following typed bays:

- Busbar,
- Bus coupler,
- Bus section,
- Feeder,
- Transformer,
- Generic bay.

5.2.3 INTERNAL SYNCHROCHECK AUTOMATION

There are several types of internal synchrocheck:

(1) Internal automatic synchrocheck

(2) Internal manual synchrocheck for standard topology

(3) Internal manual synchrocheck for breaker-and-a-half topology

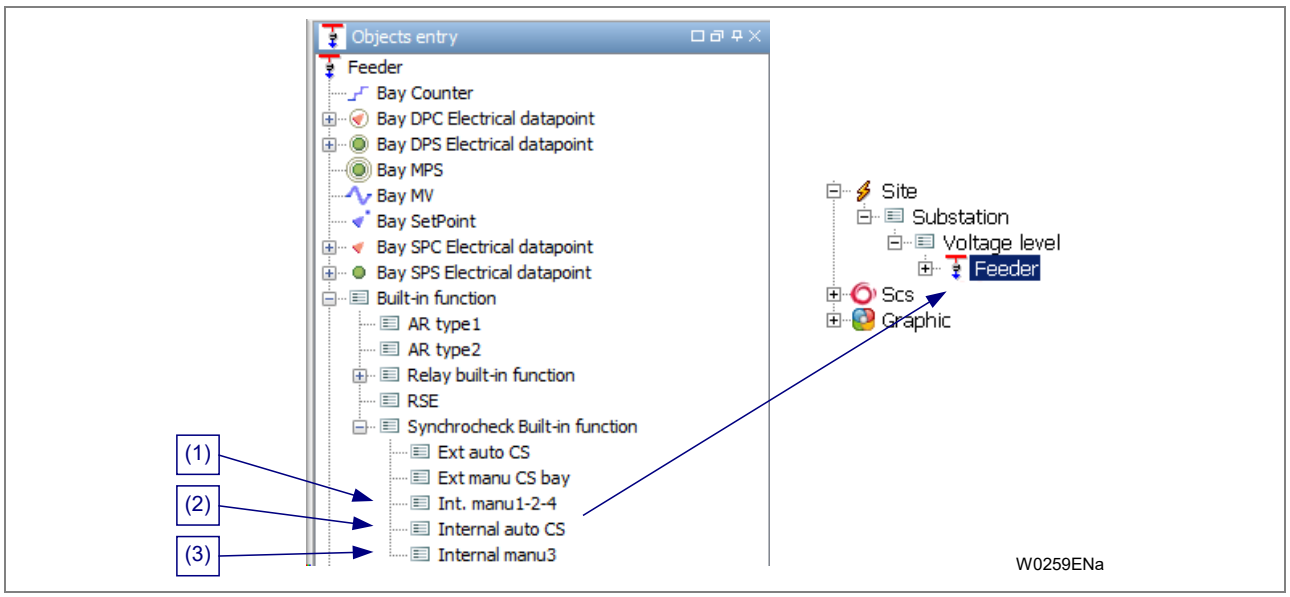


Figure 265: Adding a synchrocheck function at bay level (example for a feeder)

Principle

The above three types of internal synchrocheck can be used in conjunction with the following schemes:

	Close scheme	Close with synchro scheme	Autorecloser (types 1, 2 & 4)
Power system locking for live line - live bus + delta checks	X	X	X
Power system coupling for live line - live bus + delta checks		X	
Live line - dead bus	X	X	X
Dead line - live bus	X	X	X
Dead line - dead bus	X	X	X

The authorized schemes are defined during the configuration process. The behaviour of manual close with synchrocheck is described in the following sections.

5.2.3.1 INTERNAL SYNCHROCHECK FUNCTION FOR STANDARD CB TOPOLOGY (TYPES 1, 2 AND 4)

5.2.3.1.1 Datapoints

When adding an internal synchrocheck, a number of mandatory system datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*). They give information about internal synchrocheck context (both voltage presences and absences) and statuses. They are managed by the C26x that runs the internal synchrocheck.

- **Close order**: Transient SPS, *SET* when a coupling close command is issued
- **CS in progress**: Transient SPS, *SET* when a synchronized closure is in progress
- **on/off main1 SPC**: Enable/disable command for synchrocheck function
- **on/off main1 SPS**: Permanent SPS, synchrocheck function on/off information

Note:
*Do not forget to define **on/off main1 SPS** as feedback of **on/off main1 SPC** if they exist, or as the result of an FBD logic.*

- **on/off sec. SPS** (implicitly created): Permanent SPS, selection of the closing scheme: when the datapoint is *SET*, the enabled **Close with synchro** schemes will be used, when it is *RESET*, the **Close schemes** will be used.

The remaining available datapoints depend on the type of selected synchrocheck (type 1, type 2 or type 4).

The following datapoints are mandatory for synchrocheck types 1, 2 and 4. They are automatically created when an **Int. manu1-2-4** synchrocheck function is added to a bay:

- **Possible closing** SPS: Permanent SPS, in locking mode, *SET* when all the conditions after delay are met to authorize synchronized closing
- **Ref. U absence** SPS: Permanent SPS, *SET* when the reference (usually busbar) voltage is absent, i.e. the measured voltage is lower than the set threshold **bus voltage under threshold (%)**
- **Ref. U presence** SPS: Permanent SPS, *SET* when the reference (usually busbar) voltage is present, i.e. the measured voltage is higher than the set threshold **bus voltage over threshold (%)**
- **Voltage absence** SPS: Permanent SPS, *SET* when the main (usually line) voltage is absent, i.e. the measured voltage is lower than the set threshold **line voltage under threshold (%)**
- **Voltage presence** SPS: Permanent SPS, *SET* when the main (usually line) voltage is present, i.e. the measured voltage is higher than the set threshold **line voltage over threshold (%)**

More datapoints can be added from the contextual **Objects entry** window:

Datapoint		S/C Type 1	S/C Type 2	S/C Type 4
busbar V choice:	Permanent SPS, indicates which busbar input voltage is used, either 0 (*RESET*) = busbar 1 or 1 (SET) = busbar 2.	✓		✓
Split sync mode:	Permanent SPS, *SET* when Split and Coupling conditions are met.	✓		
Delta drift:	Information on frequency delta drift from Coupling range to Locking range, Evolutive mode only (see Synchrocheck functional description in chapter C26x/EN FT).	✓		✓
Locking mode:	Permanent SPS, *SET* when the Locking conditions are met.	✓		✓

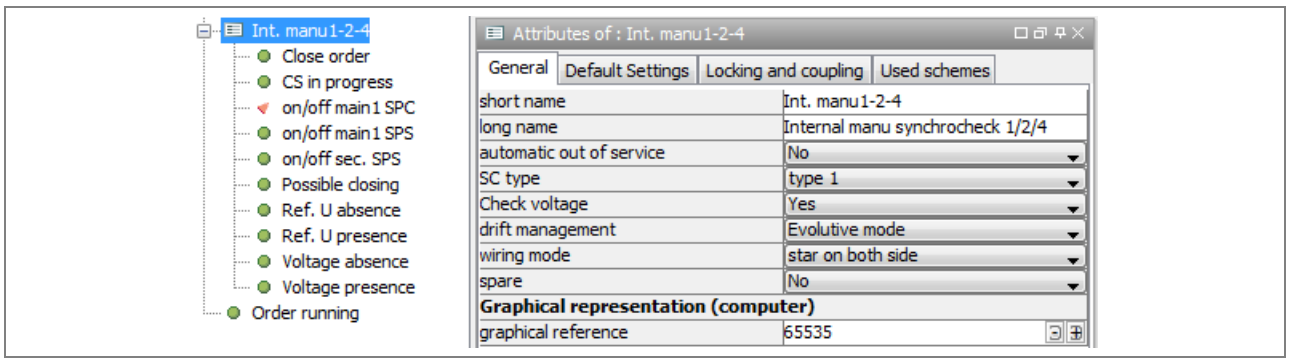
Datapoint		S/C Type 1	S/C Type 2	S/C Type 4
on/off sec. SPC:	Selection of the closing scheme: when the datapoint is *SET*, the enabled **Close with synchro** schemes will be used, when it is *RESET*, the **Close schemes** will be used.	✓	✓	✓
on/off sec. DPC:	Selection of the closing scheme: when the datapoint is CLOSED, the enabled **Close with synchro** schemes will be used, when it is OPEN, the **Close schemes** will be used.	✓	✓	✓
Accept forcing SPS:	Permanent SPS, used in conjunction with Synchrocheck bypass via the **Accept forcing** DI.	✓	✓	✓
CS locked:	Permanent SPS, *SET* when the Synchrocheck function is blocked. When SET, it prevents the synchrocheck algorithms from starting, and thus prohibits CB closing.	✓	✓	
CS locked:	Same datapoint as above, but it has a different behaviour with S/C type 4: In addition to preventing the synchrocheck function from starting, if it becomes *SET* while a synchronism check is in progress, the check is terminated with a negative acknowledge, and no close command is sent to the CB.			✓
Fusion first U:	Permanent SPS, fuse failure information for main (usually line) voltage transformer.	✓	✓	✓
Fusion ref U:	Permanent SPS, fuse failure information for reference (usually busbar) voltage transformer.	✓	✓	✓
Bypass:	Permanent SPS, when this datapoint is *SET*, the voltage check is bypassed, i.e. ignored, so as to allow CB closure.		✓	
Scheme Coupling:	State of the closing scheme during coupling conditions.		✓	
Scheme LD/BD:	State of the closing scheme during dead line/dead bus conditions.		✓	
Scheme LD/BL:	State of the closing scheme during dead line/ live bus conditions.		✓	
Scheme LL/BD:	State of the closing scheme during live line/dead bus conditions.		✓	
Scheme Locking:	State of the closing scheme during locking conditions.		✓	

5.2.3.1.2 Attribute parameters

The default settings for the internal synchrocheck function are dependent on the parameters for the corresponding automation.

When adding an internal synchrocheck, the following specific attributes must be updated:

General attributes



- **automatic out of service** (*No* / *Yes*)
- **SC type**: there are two types of internal manual synchrocheck features for standard breaker topology:
  - *type 1* (standard)
  - *type 2* (frequency shift-based)
  - *type 4* (type 1 variant with overvoltage threshold, “retry” timeout and binary input to terminate S/C processing)
- **Check voltage** (*No* / *Yes*)

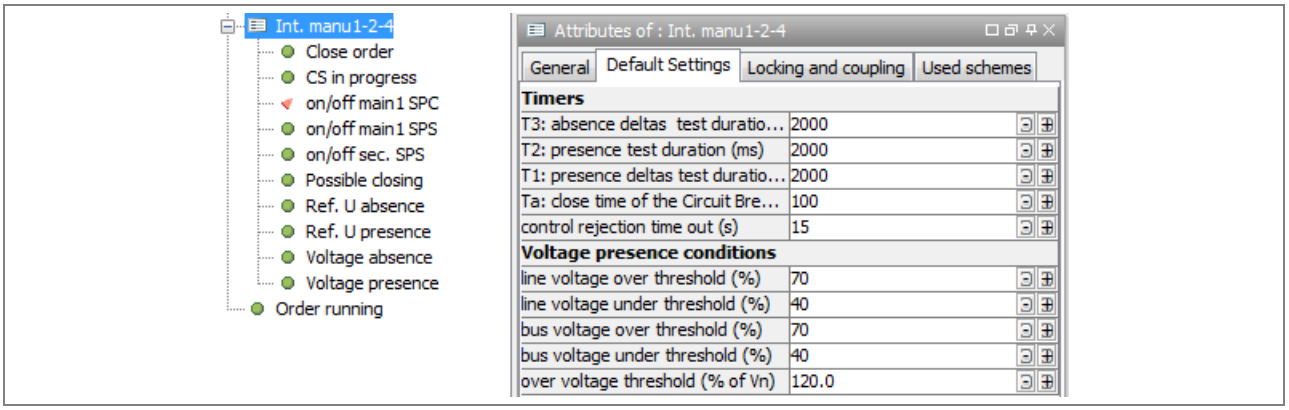
Types 1 and 4 only:

- **drift management**: mode used for management of drift between locking and coupling ranges:
  - *Exclusive mode*
  - *Evolutive mode*
  - *Split mode* (type 1 only)
- **wiring mode**: VT connection arrangements on line and busbar sides:
  - *star on both side*
  - *delta on both side*
  - *star on line – delta on busbar* (type 1: with TMU220 only; type 4: with TMU210 and TMU220)
  - *delta on line – star on busbar* (type 1: with TMU220 only; type 4: with TMU210 and TMU220)

Type 2 only:

- **S filtering value (Hz)** (range [0.8 Hz, 1.6 Hz], step 0.1 Hz)
- **dS/dt filtering enable** (*No* or *Yes*)
- **dS/dt filtering value (Hz)** (range [0.5 Hz, 2 Hz], step 0.1 Hz)
- **dS/dt max value (mHz)** (range [10 mHz, 50 mHz], step 5 mHz)

Default Settings



Timers

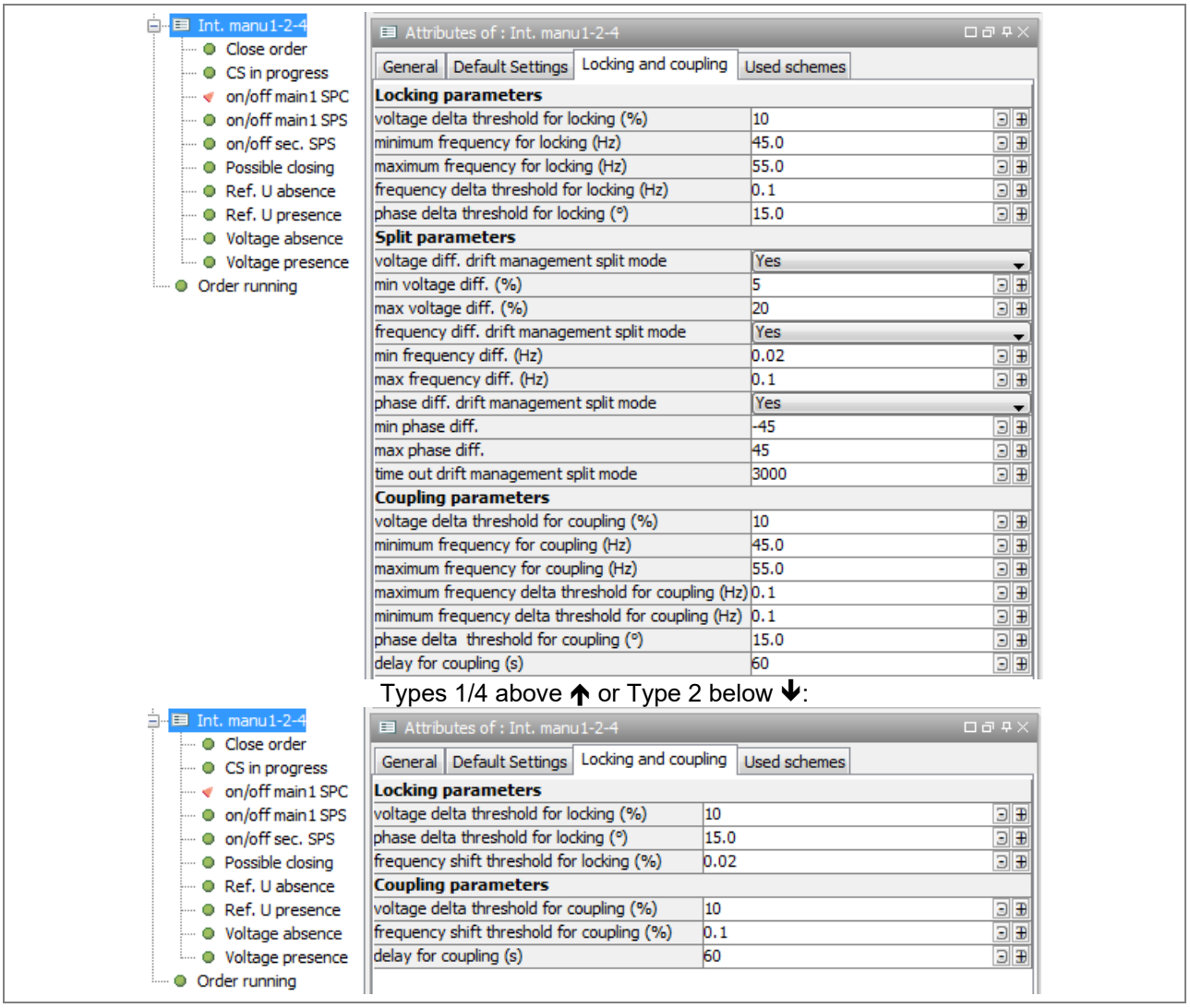
	Type 1	Type 2	Type 4
• **T3: absence deltas test duration (ms)** (range [200 ms, 10 s], step 20 ms)	✓	✓	✓
• **T2: presence test duration (ms)** (range [200 ms, 10 s], step 20 ms)	✓	✓	✓
• **T1: presence deltas test duration (locking) (ms)** (range [20 ms, 10 s], step 10 ms)	✓	✓	✓
• **Ta: close time of the Circuit Breaker (ms)** (range [0, 1 s], step 10 ms)	✓	✓	✓
• **control rejection time out (s)** (range [0, 60 s], step 1 s)			✓

Note:
The control rejection time out (s) must be set to a higher value than the three confirmation timers, T1, T2 and T3, otherwise it may expire before a closing condition can be confirmed and thus systematically prevent CB closing.

Voltage presence conditions

	Type 1	Type 2	Type 4
• **line voltage over threshold (%)** (range [0, 100% Vn], step 1% Vn)	✓	✓	✓
• **line voltage under threshold (%)** (range [0, 100% Vn], step 1% Vn)	✓	✓	✓
• **bus voltage over threshold (%)** (range [0, 100% Vn], step 1% Vn)	✓	✓	✓
• **bus voltage under threshold (%)** (range [0, 100% Vn], step 1% Vn)	✓	✓	✓
• **over voltage threshold (% of Vn)** (range [100, 150% Vn], step 1% Vn)			✓

Coupling and locking



Locking parameters

	Type 1	Type 2	Type 4
• **voltage delta threshold for locking (%)** (range [0, 100% Vn], step 1% Vn)	✓	✓	✓
• **minimum frequency for locking (Hz)** (range [45, 59.5 Hz], step 0.1 Hz)	✓		✓
• **maximum frequency for locking (Hz)** (range [50.5, 66 Hz], step 0.1 Hz)	✓		✓
• **frequency delta threshold for locking (Hz)** (range [0, 1 Hz], step 0.01 Hz)	✓		✓
• **phase delta threshold for locking (°)** (range [0, 90°], step 1°)	✓	✓	✓
• **frequency shift threshold for locking (%)** (range [0.02, 0.1%], step 0.01%)		✓	

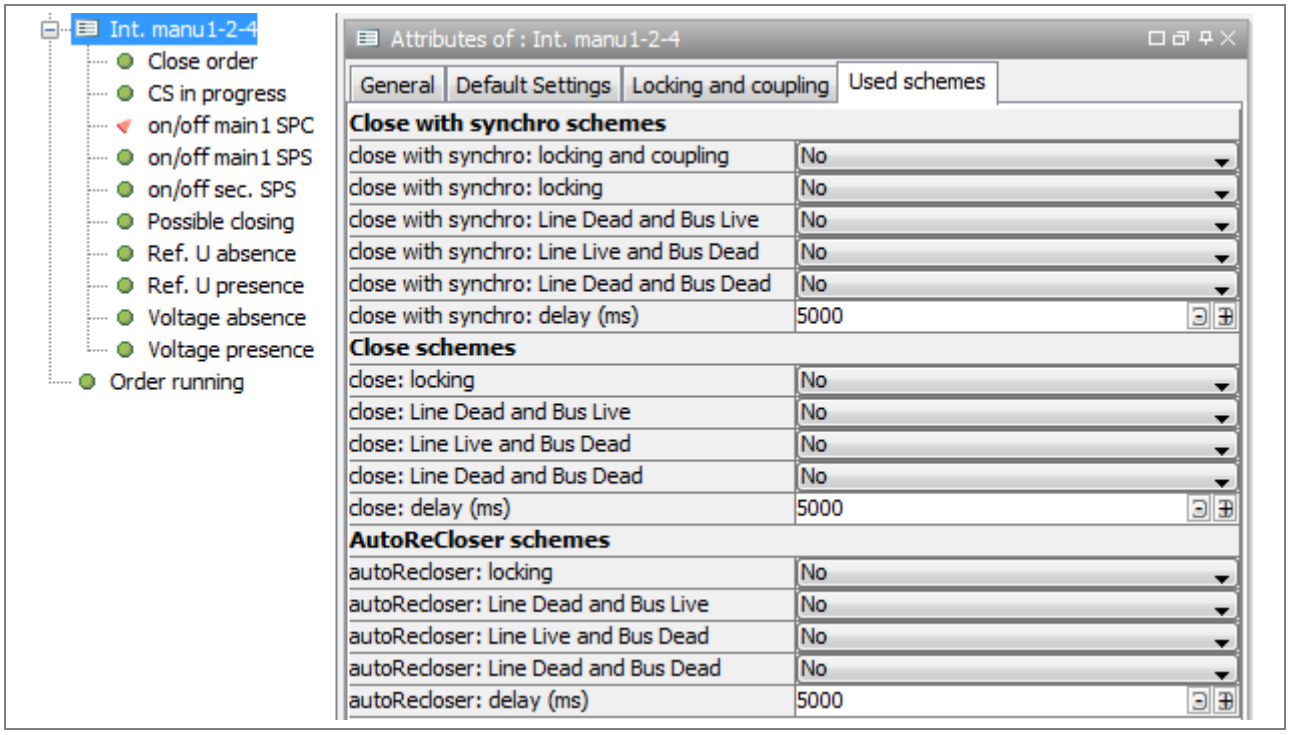
Split parameters (type 1 only)

- **voltage diff. drift management split mode** (*No* or *Yes*)
- **min voltage diff. (%)** (range [0, 100% Vn], step 1% Vn)
- **max voltage diff. (%)** (range [0, 100% Vn], step 1% Vn)
- **frequency diff. drift management split mode** (*No* or *Yes*)
- **min frequency diff. (Hz)** (range [0, 1 Hz], step 0.01 Hz)
- **max frequency diff. (Hz)** (range [0, 1 Hz], step 0.01 Hz)
- **phase diff. drift management split mode** (*No* or *Yes*): This attribute must be set to *Yes* if split mode is used.
- **min phase diff.** (range [0, -180°], step 1°)
- **max phase diff.** (range [0, 180°], step 1°)
- **time out drift management split mode** (range [0, 10000 ms], step 100 ms)

Coupling parameters

	Type 1	Type 2	Type 4
• **voltage delta threshold for coupling (%)** (range [0, 100% Vn], step 1% Vn)	✓	✓	✓
• **minimum frequency for coupling (Hz)** (range [45, 59.5 Hz], step 0.1 Hz)	✓		✓
• **maximum frequency for coupling (Hz)** (range [50.5, 66 Hz], step 0.1 Hz)	✓		✓
• **maximum frequency delta threshold for coupling (Hz)** (range [0, 1 Hz], step 0.01 Hz)	✓		✓
• **minimum frequency delta threshold for coupling (Hz)** (range [0, 1 Hz], step 0.01 Hz)	✓		✓
• **phase delta threshold for coupling (°)** (range [0, 90°], step 1°)	✓		
• **frequency shift threshold for locking (%)** (range [0.02, 0.1%], step 0.01%)		✓	
• **delay for coupling (s)** (range [1 s, 3600 s], step 1 s)	✓	✓	✓

Used schemes



Close with synchro schemes (types 1, 2 and 4)

- **close with synchro: locking and coupling** (*No* or *Yes*)
- **close with synchro: locking** (*No* or *Yes*)
  (only visible if **close with synchro: locking and coupling** is set to *No*)
- **close with synchro: Line Dead and Bus Live** (*No* or *Yes*)
- **close with synchro: Line Live and Bus Dead** (*No* or *Yes*)
- **close with synchro: Line Dead and Bus Dead** (*No* or *Yes*)
- **close with synchro: delay (ms)** (range [200 ms, 10 s], step 10 ms)

Close schemes (types 1, 2 and 4)

- **close: locking** (*No* or *Yes*)
- **close: Line Dead and Bus Live** (*No* or *Yes*)
- **close: Line Live and Bus Dead** (*No* or *Yes*)
- **close: Line Dead and Bus Dead** (*No* or *Yes*)
- **close: delay (ms)** (range [200 ms, 10 s], step 10 ms)

AutoRecloser schemes (types 1, 2 and 4)

- **autoRecloser: locking** (*No* or *Yes*)
- **autoRecloser: Line Dead and Bus Live** (*No* or *Yes*)
- **autoRecloser: Line Live and Bus Dead** (*No* or *Yes*)
- **autoRecloser: Line Dead and Bus Dead** (*No* or *Yes*)
- **autoRecloser: delay (ms)** (range [200 ms, 10 s], step 10 ms)

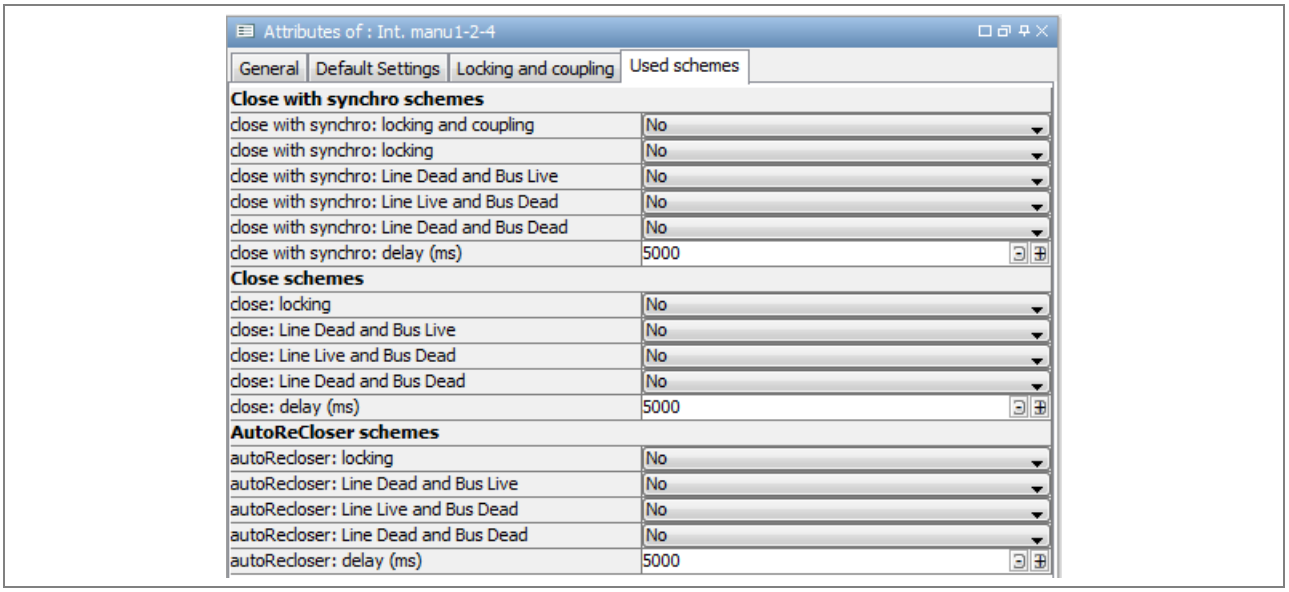


Figure 266: Setting the used schemes attributes of an internal synchrocheck function (types 1, 2 and 4)

5.2.3.2 INTERNAL SYNCHROCHECK FUNCTION FOR BREAKER-AND-A-HALF TOPOLOGY (TYPE 3)



Caution:
Make sure that the rank of each circuit-breaker managed by the type 3 synchrocheck function is defined in its attributes (see section *5.1.5.5* Defining a circuit-breaker).

5.2.3.2.1 Datapoints

When adding a type 3 internal synchrocheck, a number of mandatory system datapoints are automatically created at function level and must be configured. They give information about internal synchrocheck context (both voltage presences and absences) and statuses. They are managed by the C26x that runs the internal synchrocheck.

- **CBx Poss. clos.** SPS: Permanent SPS, in locking mode, *SET* when all the conditions after delay are met to authorize synchronized closing
- **CBx Ref. U abs.** SPS: Permanent SPS, *SET* when the reference (usually busbar) voltage is absent, i.e. the measured voltage is lower than the set threshold **bus voltage under threshold (%)**
- **CBx Ref. U pres.** SPS: Permanent SPS, *SET* when the reference (usually busbar) voltage is present, i.e. the measured voltage is higher than the set threshold **bus voltage over threshold (%)**
- **CBx Voltage abs.** SPS: Permanent SPS, *SET* when the main (usually line) voltage is absent, i.e. the measured voltage is lower than the set threshold **line voltage under threshold (%)**
- **CBx Voltage pres.** SPS: Permanent SPS, *SET* when the main (usually line) voltage is present, i.e. the measured voltage is higher than the set threshold **line voltage over threshold (%)**
- **Close order**: Transient SPS, set when a close command is issued
- **CS in progress**: Permanent SPS, *SET* when a synchronized closure is in progress
- **on/off main1 SPC**: Enable/disable synchrocheck function for CB1
- **on/off main1 SPS**: Permanent SPS, synchrocheck function on/off information for CB1
- **on/off sec. SPS**: Permanent SPS, selection of the closing scheme: when the datapoint is *SET*, the enabled **Close with synchro** schemes will be used, when it is *RESET*, the **Close schemes** will be used.

More datapoints can be added from the contextual **Objects entry** window:

- **on/off main2 SPC**: Enable/disable synchrocheck function for CB2
- **on/off main3 SPC**: Enable/disable synchrocheck function for CB3

Note:
*Do not forget to define **on/off mainx SPS** as feedback of **on/off mainx SPC** if they exist, or as the result of an FBD logic.*

- **on/off sec. SPC**: Selection of the closing scheme: when the datapoint is *SET*, the enabled **Close with synchro** schemes will be used, when it is *RESET*, the **Close schemes** will be used.
- **on/off sec. DPC**: Selection of the closing scheme: when the datapoint is *CLOSED*, the enabled **Close with synchro** schemes will be used, when it is *OPEN*, the **Close schemes** will be used.
- **Delta drift**: Information on frequency delta drift from Coupling range to Locking range, Evolutive mode only (see Synchrocheck functional description in chapter C26x/EN FT)
- **on/off main2 SPS**: Permanent SPS, synchrocheck function on/off information for CB2
- **on/off main3 SPS**: Permanent SPS, synchrocheck function on/off information for CB3

For each of the three circuit-breakers, 4 SPS datapoints are available, each indicating a possible VT connection:

- **CBx with VT-B1**: Voltage transformer selection SPS
- **CBx with VT-B2**: Voltage transformer selection SPS
- **CBx with VT-L1**: Voltage transformer selection SPS
- **CBx with VT-L2**: Voltage transformer selection SPS

All 4 datapoints must be defined for each circuit-breaker.

The VT and SPS combinations are described in chapter C26x/EN FT.

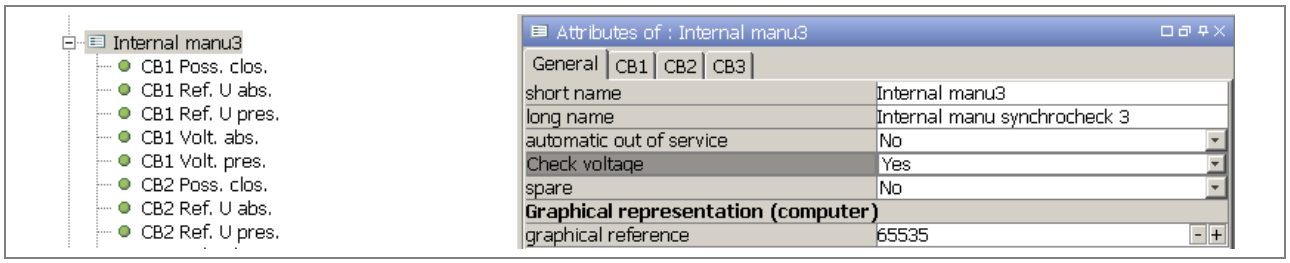
5.2.3.2.2 Attribute parameters

The default settings for the internal synchrocheck function are dependent on the parameters for the corresponding automation.

When adding an internal synchrocheck, the following specific attributes must be updated:

General attributes

- **automatic out of service** (*No* / *Yes*)
- **Check voltage** (*No* / *Yes*)



Settings

The parameters of each CB are set separately in 3 dedicated tab-panes.

Timers

- **T3: absence deltas test duration (ms)** (range [200 ms, 10 s], step 20 ms)
- **T2: presence test duration (ms)** (range [200 ms, 10 s], step 20 ms)
- **T1: presence deltas test duration (locking) (ms)** (range [20 ms, 10 s], step 10 ms)
- **Ta: close time of the Circuit Breaker (ms)** (range [0, 1 s], step 10 ms)

Voltage presence conditions

- **line voltage over threshold (%)** (range [0, 100% Vn], step 1% Vn)
- **line voltage under threshold (%)** (range [0, 100% Vn], step 1% Vn)
- **bus voltage over threshold (%)** (range [0, 100% Vn], step 1% Vn)
- **bus voltage under threshold (%)** (range [0, 100% Vn], step 1% Vn)

Locking parameters

- **voltage delta threshold for locking (%)** (range [0, 100% Vn], step 1% Vn)
- **minimum frequency for locking (Hz)** (range [45, 59.5 Hz], step 0.1 Hz)
- **maximum frequency for locking (Hz)** (range [50.5, 66 Hz], step 0.1 Hz)
- **frequency delta threshold for locking (Hz)** (range [0, 1 Hz], step 0.01 Hz)
- **phase delta threshold for locking (°)** (range [0, 90°], step 1°)

Coupling parameters

- **voltage delta threshold for coupling (%)** (range [0, 100% Vn], step 1% Vn)
- **minimum frequency for coupling (Hz)** (range [45, 59.5 Hz], step 0.1 Hz)
- **maximum frequency for coupling (Hz)** (range [50.5, 66 Hz], step 0.1 Hz)
- **maximum frequency delta threshold for coupling (Hz)**
  (range [0, 1 Hz], step 0.01 Hz)
- **minimum frequency delta threshold for coupling (Hz)**
  (range [0, 1 Hz], step 0.01 Hz)
- **delay for coupling (s)** (range [1 s, 3600 s], step 1 s)

Close with synchro schemes

- **close with synchro: locking and coupling** (*No* or *Yes*)
- **close with synchro: locking** (*No* or *Yes*)
  (only visible if **close with synchro: locking and coupling** is set to *No*)
- **close with synchro: Line Dead and Bus Live** (*No* or *Yes*)
- **close with synchro: Line Live and Bus Dead** (*No* or *Yes*)
- **close with synchro: Line Dead and Bus Dead** (*No* or *Yes*)
- **close with synchro: delay (ms)** (range [200 ms, 10 s], step 10 ms)

Close schemes

- **close: locking** (*No* or *Yes*)
- **close: Line Dead and Bus Live** (*No* or *Yes*)
- **close: Line Live and Bus Dead** (*No* or *Yes*)
- **close: Line Dead and Bus Dead** (*No* or *Yes*)
- **close: delay (ms)** (range [200 ms, 10 s], step 10 ms)

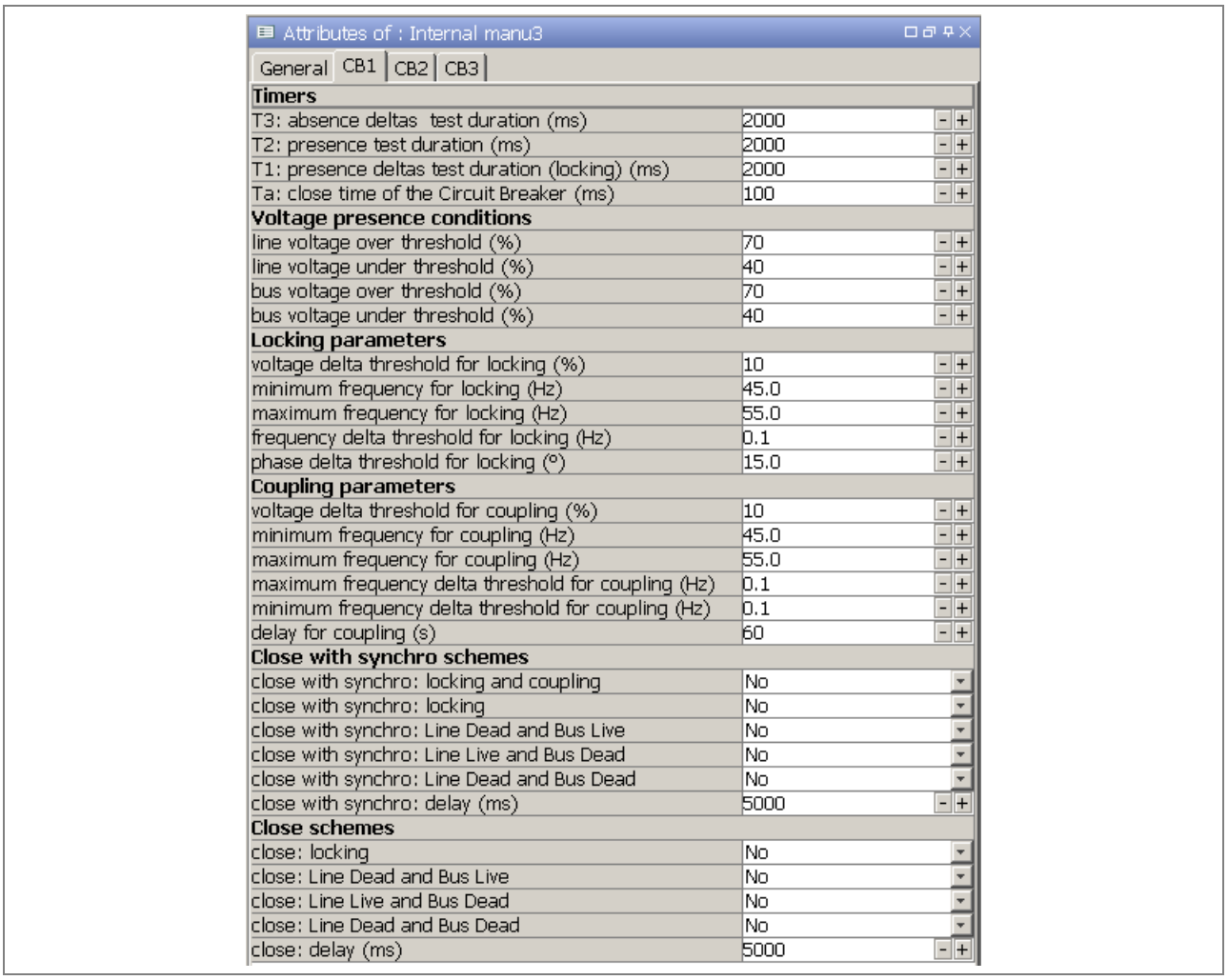


Figure 267: Setting the attributes of an internal synchrocheck function (type 3)

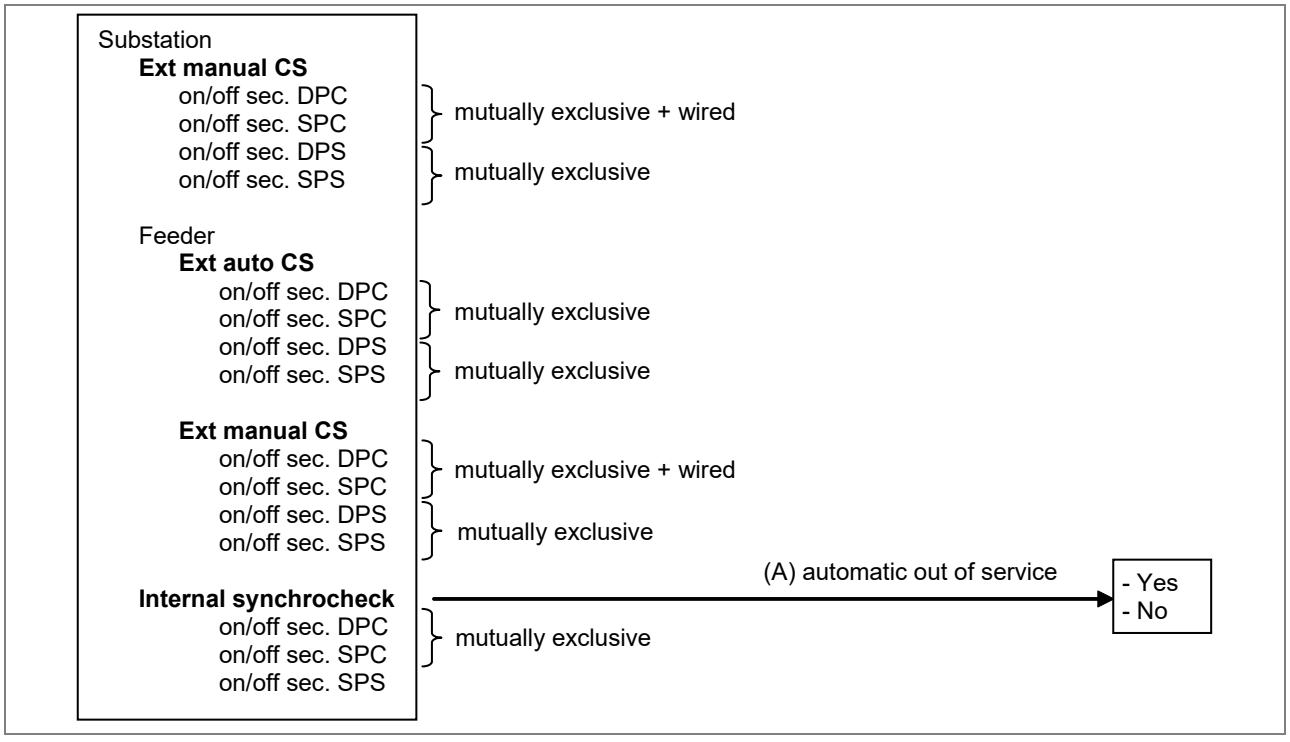
5.2.3.3 GENERAL RULES FOR CB DATAPOINT CONFIGURATION

The difference between the automatic synchrocheck and the manual synchrocheck is in the way it is set up: The Internal Manual S/C function uses the datapoint **on/off sec. SPC/DPC** to enable (if SET) or disable (if RESET) the use of the set synchronizing schemes to authorise closing whereas the Internal Automatic S/C function automatically sets **on/off sec. SPC/DPC** to SET and uses the **Sync CB Close** SPC to issue the close command.

	Automatic Synchrocheck	Manual Synchrocheck
Synchrocheck	The 4 SPS datapoints that give the dead/live status for busbar/line must have a profile with initial status = RESET	
	on/off sec. SPS: profile with initial status = SET	on/off sec. SPC/DPC with on/off sec. SPS/DPS for feedback (no need to have initial status = SET; it depends on the customer's requirements)
Circuit-Breaker	The Sync CB Close SPC has no IEC 61850 address. It is used to set the synchrocheck bits in the IEC 61850 command message. The profile for the Sync CB Close SPC must be the same as for Switch Ctrl DPC with regards to DE/SBO. They must also be controlled by the same pop-up. The SCADA address of the "close with synchrocheck" command is an SPC SCADA address.	There is no Sync CB Close SPC. - When on/off sec. SPS/DPS is SET, Switch Ctrl DPC is considered to be "close with synchrocheck" - When on/off sec. SPS is RESET, Switch Ctrl DPC is considered to be "close without synchrocheck" This does not mean "synchrocheck bypass" in live line, live bus conditions: Locking conditions are evaluated according to the configured permissions. The SCADA address of the "close with synchrocheck" command is a DPC SCADA address.

Configuration rules and checks

- As shown in the diagram below, under a Synchrocheck function, some datapoints are mutually exclusive and some must be wired. Here, "wired" means that the datapoint must be linked to a digital/analogue channel of a C26x, or linked to an IED address



- For an internal synchrocheck function, having its **automatic out of service** attribute set to the *Yes*, the **on/off sec. DPC** or **on/off sec. SPC** datapoint must be present.
- The **on/off sec. DPC** or **on/off sec. SPC** datapoint for internal synchrocheck must have its profile attribute **SBO mode** set to *Direct Execute* or *Direct Execute with SBO popup*

5.2.4 EXTERNAL SYNCHROCHECK

5.2.4.1 DATAPOINTS

External synchrocheck has equivalent datapoints and settings for the three available functions:

(1) **Ext manual CS**: manual external synchrocheck at substation level

(2) **Ext auto CS**: automatic synchrocheck at bay level

(3) **Ext manu CS Bay**: manual synchrocheck at bay level

At substation level, only 'external manual synchrocheck' is available:

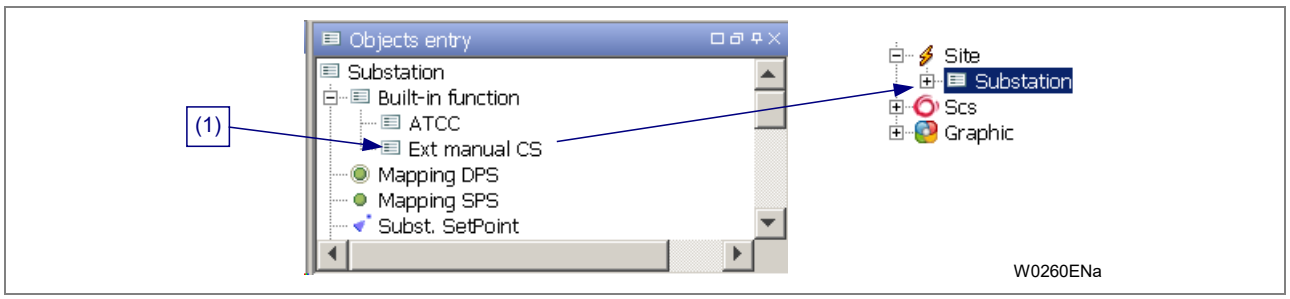


Figure 268: Adding an external synchrocheck function at substation level

At bay level, two types of external synchrocheck functions are available: manual and automatic.

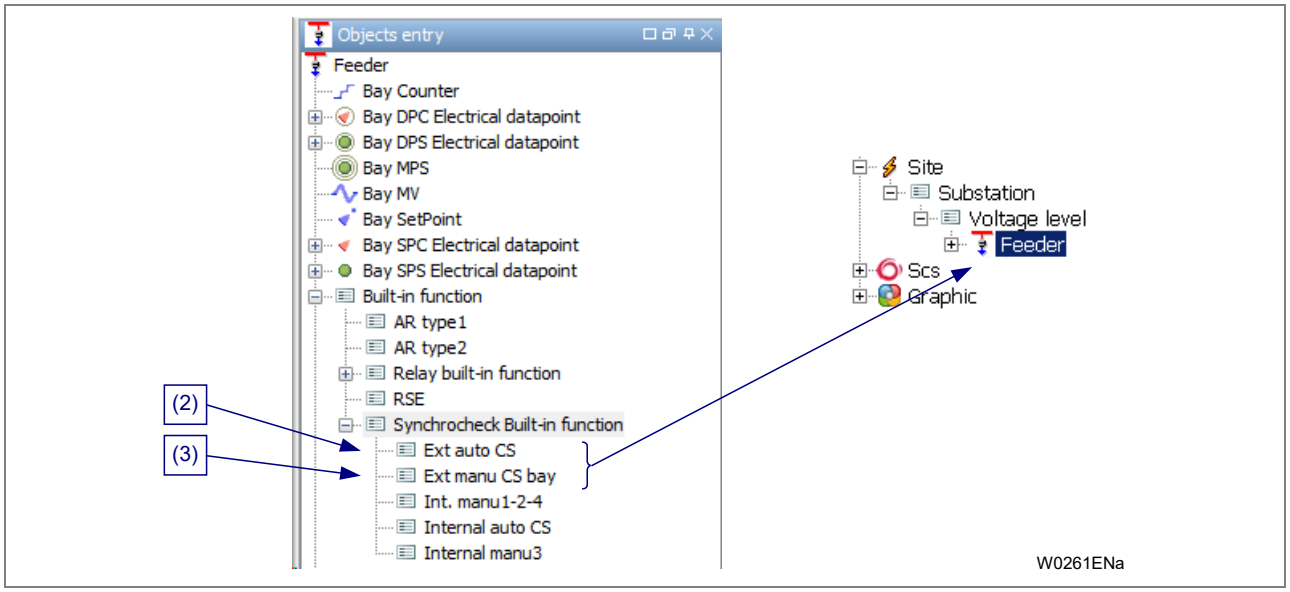


Figure 269: Adding an external synchrocheck function at bay level

Select the substation or bay and insert the relevant external manual synchrocheck field from the contextual **Objects entry** window, under **Synchrocheck Built-in function**. When adding an external synchrocheck function, no compulsory datapoint is implicitly created. Five functional datapoints are available that can be added from the contextual Objects entry window:

(1) **Accept forcing** SPS: Permanent SPS, used in conjuction with Synchrocheck bypass via the **Accept forcing** DI.

(2) **on/off sec. SPS**: global in/out of service status of the synchrocheck function via an SPS

(3) **on/off sec. DPC**: globally enable/disable the synchrocheck function via a DPC

(4) **on/off sec. DPS** (external synchrocheck only): global in/out of service status of the synchrocheck function via a DPS

(5) **on/off sec. SPC**: globally enable/disable the synchrocheck function via an SPC

Do not forget to define **on/off sec. SPS**/**DPS** as feedback of **on/off sec. SPC**/**DPC** if they exist.

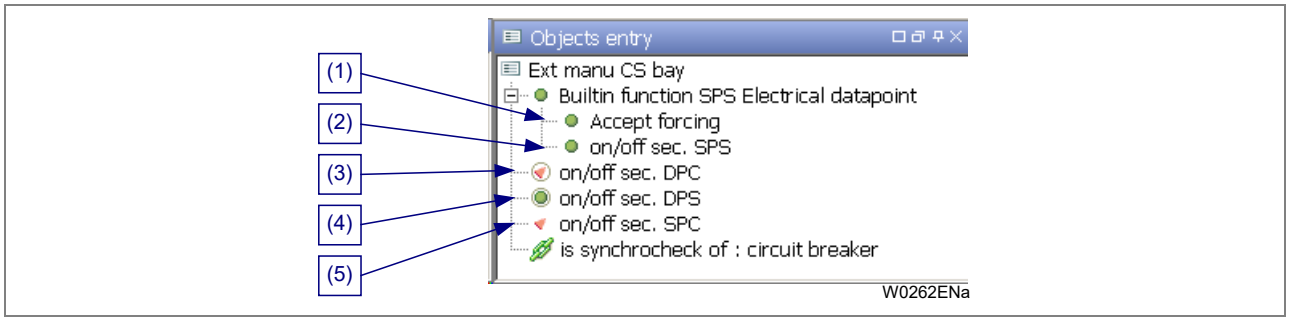


Figure 270: Synchrocheck optional datapoints

Note:
Automatic synchrocheck offers the possibility to automatically select the default closing schemes. It has no relation to automatic reclosing of circuit-breakers upon electrical faults.

5.2.4.2 ATTRIBUTE PARAMETERS

Once added, external synchrocheck general features must be set at SCE level:

(1) Fill in the relation **is synchrocheck of**, indicating which circuit-breaker module is concerned by the function. For substation synchrocheck, several relations **is synchrocheck of** can be added and filled in for all the circuit-breakers managed by the same synchrocheck. For bay synchrocheck, one or two relations **is synchrocheck of** can be filled in for the circuit-breakers of two different bays. Nevertheless, these bays must be managed by the same C26x, and the same synchrocheck parameters will be used to close both circuit-breakers.

(2) **short name** and **long name** of the synchrocheck used for logging, alarms ...

(3) **automatic out of service** (*No* / *Yes*): defines whether the synchrocheck is disabled manually (*No*) or automatically (*Yes*). When it is manually disabled, an extra sequence is performed by the C26x (see above sections). For automatic synchrocheck, it is fixed to *Yes*.

(4) **running time** (range [0, 60s], step 1 s): it is visible when **automatic out of service** is set to *Yes*. It corresponds to a time-delay before disabling the synchrocheck after a successful or unsuccessful close command of the synchronized breaker.

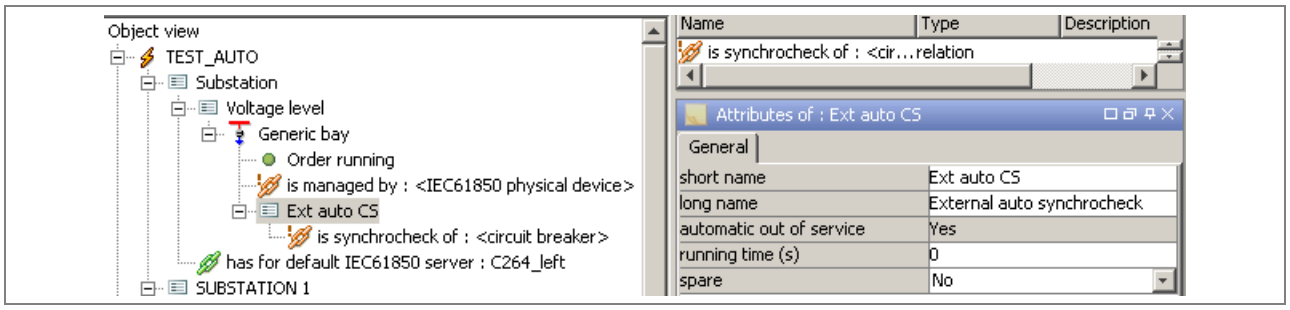


Figure 271: Setting synchrocheck general features (example for an external automatic synchrocheck at bay level)

5.2.5 SYNCHROCHECK POP-UP IN AVIEW

In order to display the synchrocheck measurements in the form of a “synchroscope” on aView, the synchrocheck function (**Int. manu1-2-4**) must be linked to the 3 measurements:

- *frequency_difference (Standard Synchrocheck)* (or *signed dV*)
- *voltage difference (Standard Synchrocheck)* (or *signed dF*)
- *phase difference (Standard Synchrocheck)* (or *signed dPhi*)

by the relation **has for HMI Measurement : MV Electrical datapoint**.

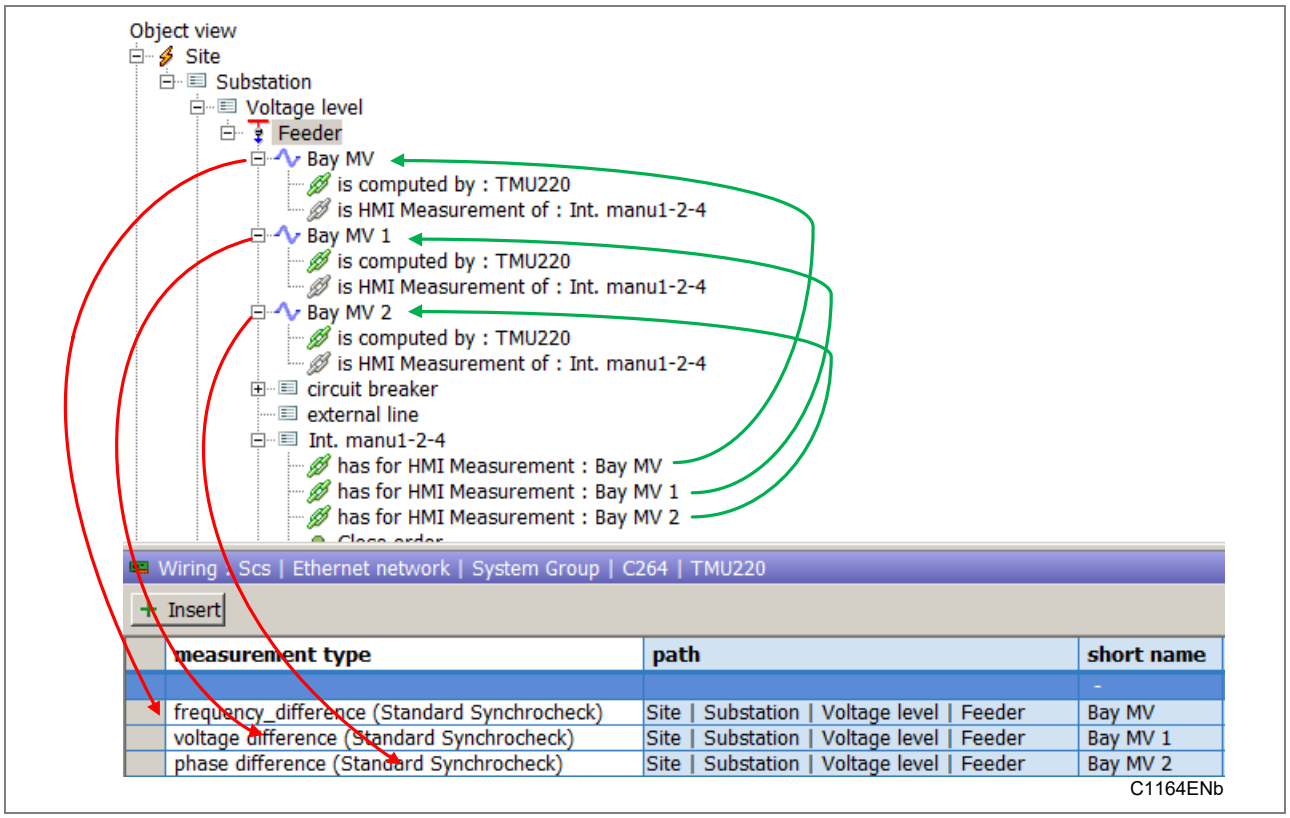


Figure 272: Linking the synchrocheck function to aView

Note:
At this time, this option is not available for Type 3 synchrocheck (breaker-and-a-half configuration).

5.3 DEFINING AN AUTO-RECLOSER BUILT-IN FUNCTION

5.3.1 AUTO-RECLOSER BEHAVIOUR

The Auto–Recloser built-in function is described in section 7.1.1 of chapter C26x/EN FT.

5.3.2 CREATING AN AUTO-RECLOSER FUNCTION

To add an auto-recloser function, select the bay level and add the auto-recloser function from the contextual **Objects entry** window.

Only the following typed bays allow the creation of an auto-recloser function:

- Busbar,
- Bus coupler,
- Bus section,
- Feeder,
- Transformer,
- Generic bay.

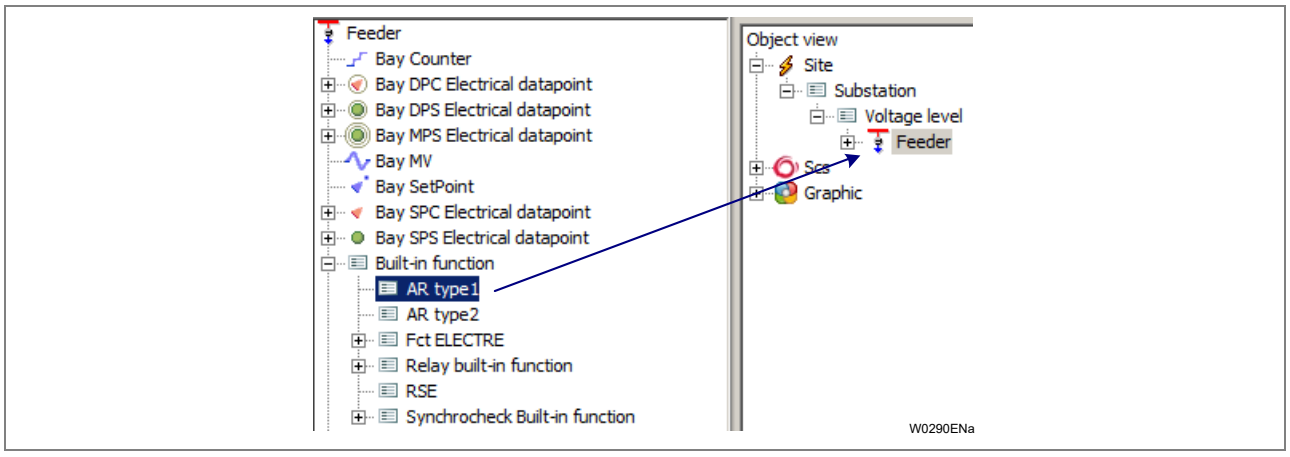


Figure 273: Adding an auto-recloser (type 1) at bay level

Once added, auto-recloser general features must be set at SCE level:

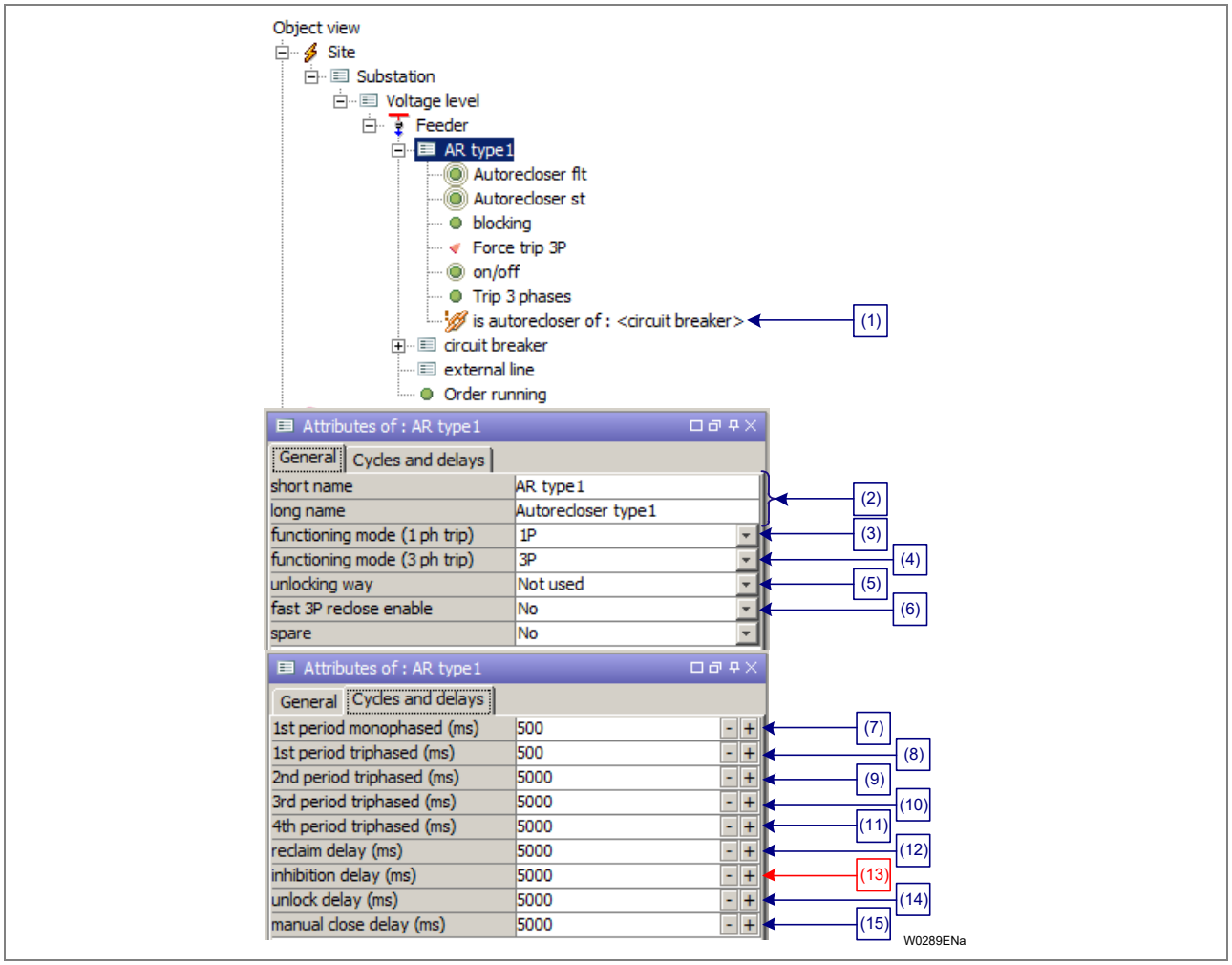


Figure 274: Setting auto-recloser (type 1) features

(1) Fill in the relation **is auto-recloser of**, indicating with which circuit-breaker module the function is associated.

(2) **short name** and **long name** of the auto-recloser used for logging, alarms ...

(3) **functioning mode (1 ph trip)** (*Not used* / *1P* / *1P-3P* / *1P-3P-3P* / *1P-3P-3P-3P*): useable only for single-pole circuit-breaker. Up to 4 cycles where the first one is single-pole (“monophased”) and the others three-pole (“triphased”).

(4) **functioning mode (3 ph trip)** (*Not used* / *3P* / *3P-3P* / *3P-3P-3P* / *3P-3P-3P-3P*): useable for single-pole and three-pole circuit-breakers. Up to 4 cycles where all are three phase.

(5) **unlocking way** (*Not used* / *Reinitialisation* / *Manual close* / *Both ways*). For details refer to the functional description of ‘lock of auto-recloser’ in section 7.1.1 of chapter C26x/EN FT.

(6) **Fast 3 P reclose enable** (*No* / *Yes*): if a synchrocheck exists for the breaker, auto-recloser can bypass it during the 3-phases first cycle if the attribute is set to ‘Yes’.

(7) **1st period monophased** (range [100 ms, 5 s], step 10 ms): time-delay for the first single-pole shot.

(8) **1st period triphased** (range [1 s, 60 s], step 10 ms): time-delay for the first 3-pole shot.

(9) **2nd period triphased** (range [1 s, 3600 s], step 1 s): time-delay for the second 3-pole shot.

(10) **3rd period triphased** (range [1 s, 3600 s], step 1 s): time-delay for the third 3-pole shot.

(11) **4th period triphased** (range [1 s, 3600 s] step 1 s): time-delay for the fourth 3-pole shot.

(12) **reclaim delay** (range [1 s, 600 s], step 1 s): corresponds to ‘reclaimc recovering timer’ described in ‘launch recovering timer’ of section *7.1.1* of chapter C26x/EN FT.

(13) **inhibition delay (ms)**: This attribute is not used by the C26x. Its setting has no effect.

(14) **unlock delay** (range [1 s, 600 s], step 1 s): corresponds to ‘reclaimml recovering timer’ described in ‘lock of auto-recloser’ of section *7.1.1* of chapter C26x/EN FT.

(15) **manual close delay** (range [1 s, 600 s], step 1 s): corresponds to ‘reclaimmc recovering timer’ described in ‘lock of auto-recloser’ of section *7.1.1* of chapter C26x/EN FT.

Configuration rules and checks

- The two attributes "functioning mode (1 ph trip)" and "functioning mode (3 ph trip)" must not be both set to "Not used" value
- If "functioning mode (1 ph trip)" value is set to "1P-3P-3P-3P", then the following rules must be respected:
  - "1st period monophased" < "2nd period triphased"
  - "1st period monophased" < "3rd period triphased"
  - "1st period monophased " < "4th period triphased"
- If "functioning mode (1 ph trip)" value is set to "1P-3P-3P", then the following rules must be respected:
  - "1st period monophased" < "2nd period triphased"
  - "1st period monophased" < "3rd period triphased"
- If "functioning mode (1 ph trip)" value is set to "1P-3P", then the following rule must be respected:
  - "1st period monophased" < "2nd period triphased"
- If "functioning mode (3 ph trip)" value is set to "3P-3P-3P-3P", then the following rules must be respected:
  - "1st period triphased" < "2nd period triphased"
  - "1st period triphased" < "3rd period triphased"
  - "1st period triphased" < "4th period triphased"
- If "functioning mode (3 ph trip)" value is set to "3P-3P-3P", then the following rules must be respected:
  - "1st period triphased" < "2nd period triphased"
  - "1st period triphased" < "3rd period triphased"
- If "functioning mode (3 ph trip)" value is set to "3P-3P", then the following rule must be respected:
  - "1st period triphased" < "2nd period triphased"
- If "functioning mode (1 ph trip)" value is different from "Not used", then the "circuit-breaker type" must be set to "Single phase CircuitBreaker"
- If "functioning mode (3 ph trip)" value is set to "Not used", then the "circuit-breaker type" must be set to "Single phase CircuitBreaker"

To obtain the behaviour described above, when adding an auto-recloser, a number of mandatory datapoints are automatically created at function level and must be configured (see section *4 Defining a datapoint*):

(1) **Autorecloser flt**: is an MPS datapoint, given the failure reason of auto-recloser function. This a system datapoint whose available states are:

- State0: failure due to the synchrocheck
- State1: failure to hardware, lock of device or another running automation linked to the device
- State2: failure due to interlocking function
- State3: no failure

(2) **Auto-recloser st**: is an MPS datapoint which gives the status of the auto-recloser function. This is a system datapoint whose available states are:

- State0: auto-recloser is in service, unlocked and no cycle is in progress
- State1: auto-recloser is waiting CB opening
- State2: the first single-phase cycle is in progress
- State3: the first 3-phases cycle is in progress
- State4: the second 3-phases cycle is in progress
- State5: the third 3-phases cycle is in progress
- State6: the fourth 3-phases cycle is in progress
- State7: the auto-recloser is waiting CB closing
- State8: the Reclaimc timer is launched
- State9: auto-recloser locking due to a max number of reclosing cycles
- State10: an auto-recloser locking
- State11: the reclaimml timer is launched
- State12: the reclaimmc timer is launched

(3) **Force trip 3 P**: is an SPC, used during a 3 phase cycle as mentioned in 'Waiting CB opening' in section 7.1.1 of chapter C26x/EN FT

(4) **on/off**: is a status DPS, corresponding to in / out of service status of the auto-recloser

(5) **Trip 3 phases:** is an SPS, giving information 3-phase trip provided by a relay

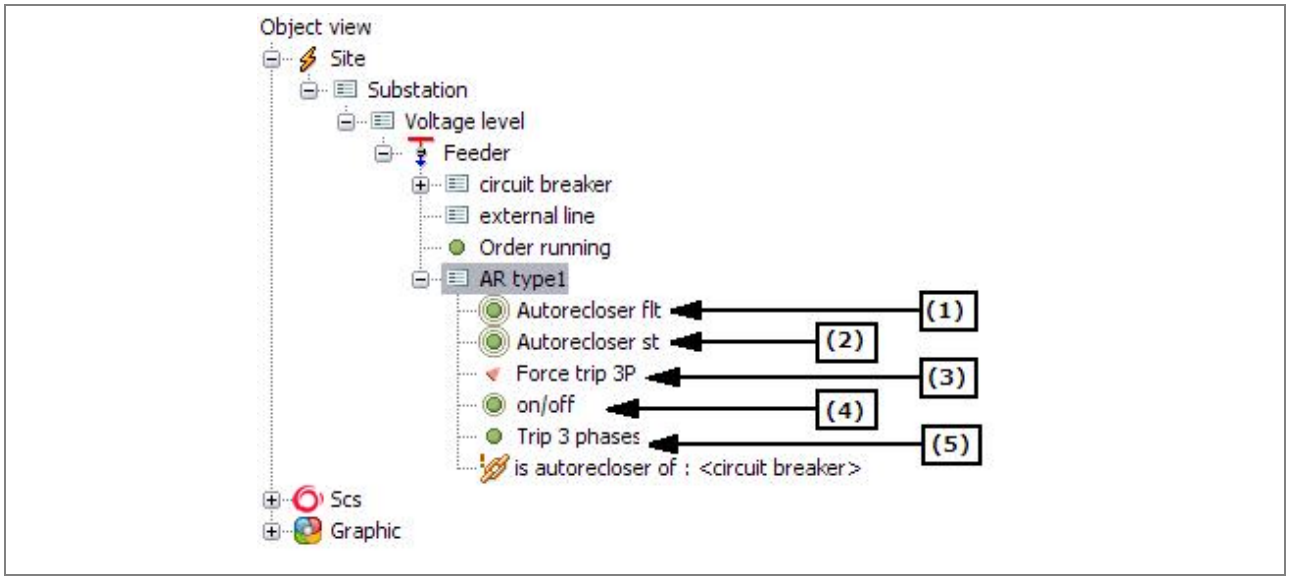


Figure 275: Auto-recloser (type 1) mandatory datapoints

To obtain the behaviour described above, when adding an auto-recloser, some optional datapoints can be created at function level and must be configured (see section *4 Defining a datapoint*):

(1) **Trip PhA**: is an SPS corresponding to trip status for pole A

(2) **Trip PhB**: is an SPS corresponding to trip status for pole B

(3) **Trip PhC**: is an SPS corresponding to trip status for pole C

(4) **blocking** SPS: corresponds to the 'AR_BLOCKING' BI described in section 7.1.1 of chapter C26x/EN FT

(5) **lock/reinit**: is an SPS used to lock / unlock the auto-recloser via SPS. Corresponds to the 'AR_LOCK' signal described in section 7.1.1 of chapter C26x/EN FT

(6) **lock/reinit SPC**: Signal to lock/unlock the auto-recloser via SPC. Corresponds to the 'AR_LOCK' signal described in section 7.1.1 of chapter C26x/EN FT

(7) **on/off ctrl DPC**: to control in/out of service of the auto-recloser via DPC

(8) **on/off ctrl DPS**: to control in/out of service of the auto-recloser via DPS

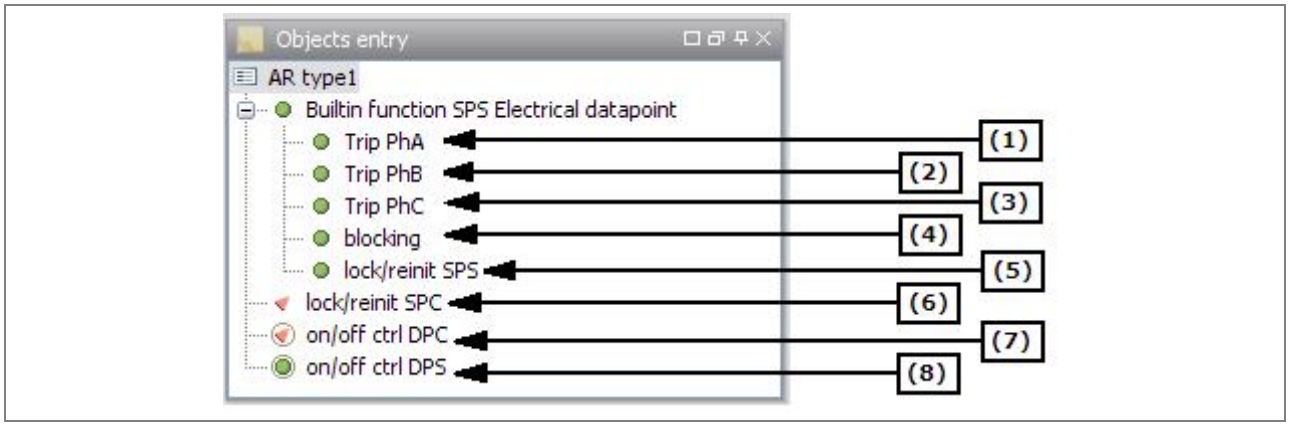


Figure 276: Auto-recloser (type 1) optional datapoints

Configuration rules and checks

- If "functioning mode (1 ph trip)" value is different from "Not used", then at least one of the three SPS datapoints { "Trip PhA", "Trip PhB", "Trip PhC" } is mandatory
- If "functioning mode (1 ph trip)" value is set to "Not used", then none of the three SPS datapoints { "Trip PhA", "Trip PhB", "Trip PhC" } is allowed
- The two datapoints { "on/off ctrl DPC", "on/off ctrl DPS" } are mutually exclusive and, at least one of them is mandatory
- The two datapoints { "lock/reinit SPC", "lock/reinit SPS" } are mutually exclusive. If the "unlocking way" attribute value is set to "Reinitialization" or "Both ways" then, at least one of the two datapoints is mandatory

5.3.3 CREATING AN AUTO-RECLOSE FUNCTION (AR TYPE 2)

The addition of an **AR type 2** function is done at bay level using the contextual **Objects entry** window.

Only the following typed bays allow the creation of an AR function:

- Feeder,
- Generic bay.

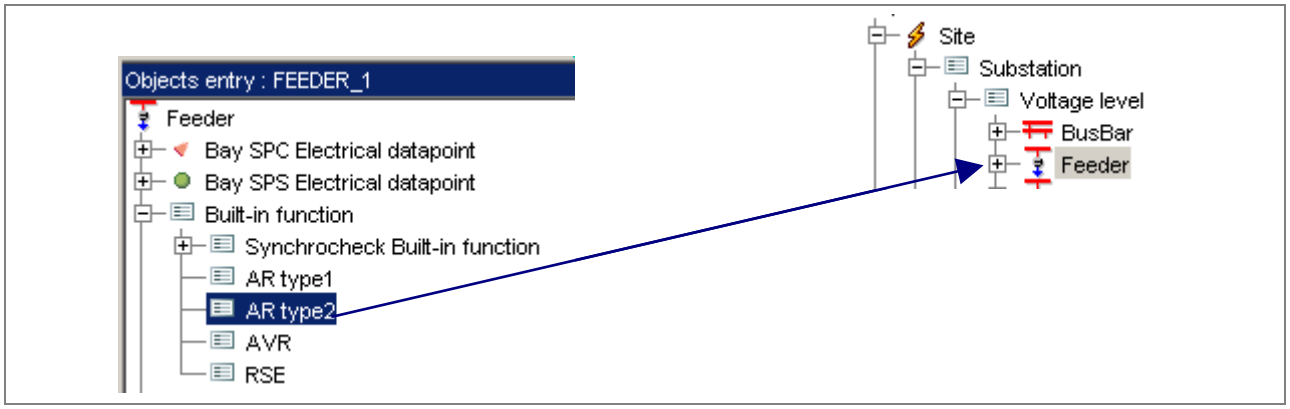


Figure 278: Adding an AR function (type 2) at bay level

Once added, the AR function's general features must be set at SCE level:

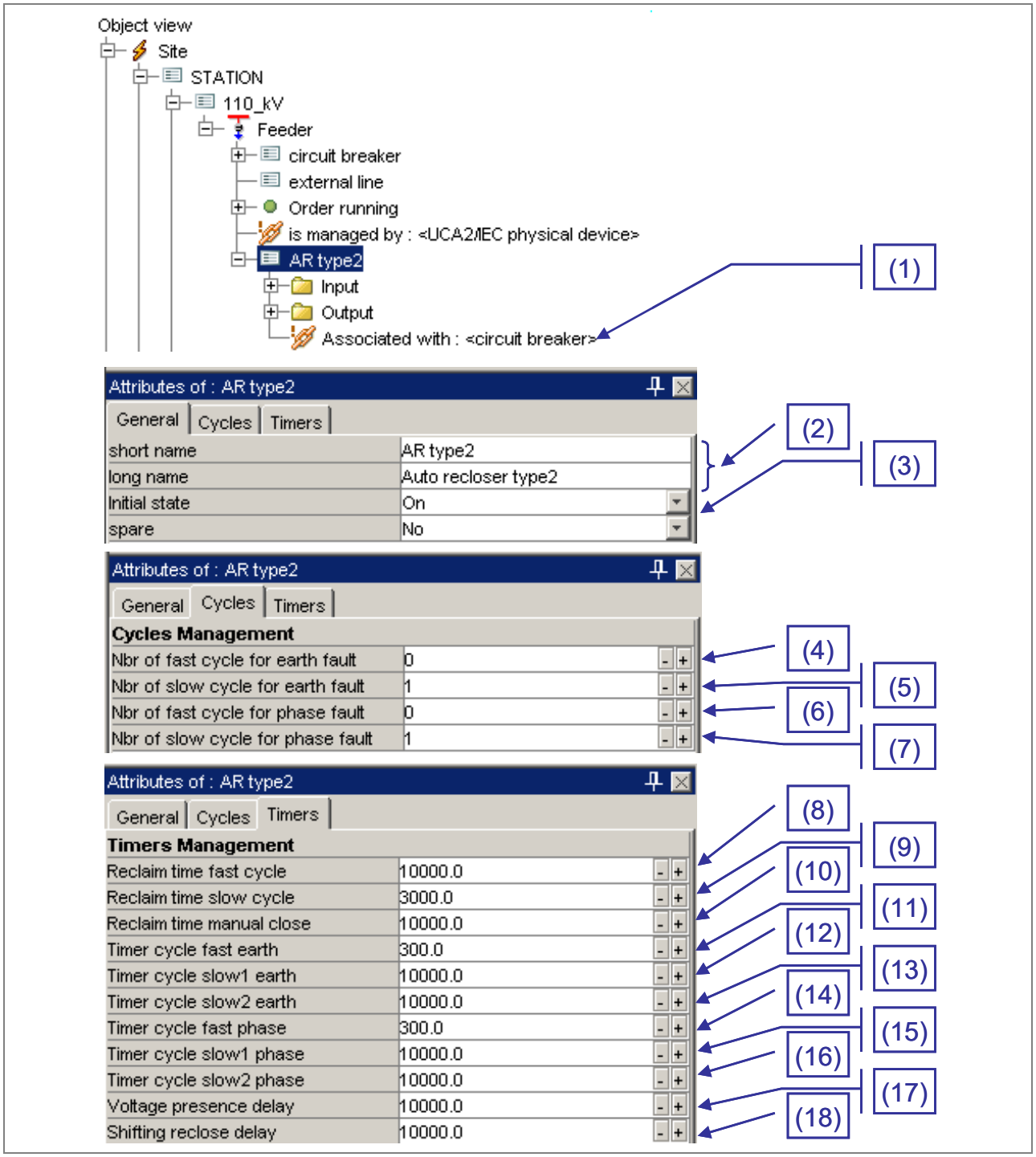


Figure 279: Setting the AR function (type 2) parameters

(1) Fill in the relation **Associated with**, indicating with which circuit-breaker module the function is associated.

(2) **short name** and **long name** of the AR function, used for logging and alarms.

(3) **Initial state** (*On* / *Off*): initial state of the AR function (active = *On*).

(4) **Nbr of fast cycle for earth fault** (0 / 1): Number of "fast" (i.e. high-speed) reclosing cycles (i.e. reclose shots and their associated timers) for single-phase faults.

(5) **Nbr of slow cycle for earth fault** (0 / 1 / 2): Number of "slow" (i.e. time-delayed) reclosing cycles for single-phase faults. If this attribute is set to *2* and that the fault is still present after the first shot , a second "slow" reclosing cycle can be initiated.

(6) **Nbr of fast cycle for phase fault** (0 / 1): Number of "fast" reclosing cycles for double faults and multi-phase faults.

(7) **Nbr of slow cycle for phase fault** (0 / 1 / 2): Number of "slow" reclosing cycles for double faults and multi-phase faults. If this attribute is set to *2* and that the fault is still present after the first shot, a second "slow" reclosing cycle can be initiated.

(8) **Reclaim time fast cycle** (range [10 s, 15 s], step 1 s):
Reclaim time for the "fast" cycle. This timer is launched after any reclose command is issued, in both "fast" and "slow" cycles. It starts when the circuit-breaker closure is confirmed. If it does not trip again before the reclaim time elapses, the reclosing sequence is terminated and the AR function resets to its standby state. If the circuit-breaker trips again during the reclaim time, there are 2 possible cases:

- If at least one "slow" cycle is defined, the first "slow" cycle is launched.
- If no "slow" cycle is defined, then the trip is considered final and the current reclosing sequence is terminated; the AR function resets to its "line permanently open" state.

(9) **Reclaim time slow cycle** (range [3 s, 10 s], step 1 s):
Reclaim time for the "slow" cycle(s). This timer is launched after a "slow" cycle reclose command is issued, concurrently with the **Reclaim time fast cycle** timer. It starts when the circuit-breaker closure is confirmed. If it does not trip again before both reclaim timers elapse, the reclosing sequence is terminated and the AR function resets to its standby state. If the circuit-breaker trips again during the **Reclaim time slow cycle** timer, there are 2 possible cases:

- If this was the first "slow" cycle of the reclosing sequence and that a second "slow" cycle is defined, the second "slow" cycle is launched.
- If this was the second "slow" cycle of the reclosing sequence or if only one "slow" cycle is defined, then the trip is considered final and the current reclosing sequence is terminated; the AR function resets to its "line permanently open" state.

Note:
*The setting for **Reclaim time fast cycle** must be higher than the setting for **Reclaim time slow cycle**.*

(10) **Reclaim time manual close** (range [10 s, 20 s], step 1 s):
Reclaim time following a manual closure of the circuit-breaker (**CTRL.CB.CLOSE** SPS *SET*). The reclaim time starts when the circuit-breaker closure is confirmed.

- If the circuit-breaker does not trip before the manual close reclaim time elapses, the AR function resets to its standby state.
- If the circuit-breaker trips before the manual close reclaim time elapses, the manual closure is considered a switch-on-to-fault. The trip is considered final and the current reclosing sequence is terminated; the AR function resets to its "line permanently open" state.

(11) **Timer cycle fast earth** (range [100 ms, 500 ms], step 1 ms):
"Fast" cycle dead time for single-phase faults. This timer starts when the circuit-breaker trip is confirmed.

- If no blocking condition (**LINE.LIVE** and **RECLOSE.SHIFT** SPS both *RESET*) is present when it elapses, the AR function issues a CB close command.
- If a blocking condition (**LINE.LIVE** or **RECLOSE.SHIFT** SPS *SET*) is present when it elapses, reclosing is suspended and the relevant timer (**Voltage presence delay** or **Shifting reclose delay**) is started.

(12) **Timer cycle slow1 earth** (range [10 s, 30 s], step 1 s):
First "slow" cycle dead time for single-phase faults. This timer starts when the circuit-breaker trip is confirmed.

- If no blocking condition (**LINE.LIVE** and **RECLOSE.SHIFT** SPS both *RESET*) is present when it elapses, the AR function issues a CB close command.
- If a blocking condition (**LINE.LIVE** or **RECLOSE.SHIFT** SPS *SET*) is present when it elapses, reclosing is suspended and the relevant timer (**Voltage presence delay** or **Shifting reclose delay**) is started.

(13) **Timer cycle slow2 earth** (range [10 s, 30s], step 1 s)
Second "slow" cycle dead time for single-phase faults. This timer starts when the circuit-breaker trip is confirmed.

- If no blocking condition (**LINE.LIVE** and **RECLOSE.SHIFT** SPS both *RESET*) is present when it elapses, the AR function issues a CB close command.
- If a blocking condition (**LINE.LIVE** or **RECLOSE.SHIFT** SPS *SET*) is present when it elapses, reclosing is suspended and the relevant timer (**Voltage presence delay** or **Shifting reclose delay**) is started.

(14) **Timer cycle fast phase** (range 100 ms, 500 ms], step 1 ms)
"Fast" cycle dead time for double faults and multi-phase faults. This timer starts when the circuit-breaker trip is confirmed.

- If no blocking condition (**LINE.LIVE** and **RECLOSE.SHIFT** SPS both *RESET*) is present when it elapses, the AR function issues a CB close command.
- If a blocking condition (**LINE.LIVE** or **RECLOSE.SHIFT** SPS *SET*) is present when it elapses, reclosing is suspended and the relevant timer (**Voltage presence delay** or **Shifting reclose delay**) is started.

(15) **Timer cycle slow1 phase** (range [10 s, 30 s], step 1 s)
First "slow" cycle dead time for double faults and multi-phase faults. This timer starts when the circuit-breaker trip is confirmed.

- If no blocking condition (**LINE.LIVE** and **RECLOSE.SHIFT** SPS both *RESET*) is present when it elapses, the AR function issues a CB close command.
- If a blocking condition (**LINE.LIVE** or **RECLOSE.SHIFT** SPS *SET*) is present when it elapses, reclosing is suspended and the relevant timer (**Voltage presence delay** or **Shifting reclose delay**) is started.

(16) **Timer cycle slow2 phase**(range [10 s, 30 s], step 1 s)
Second "slow" cycle dead time for double faults and multi-phase faults. This timer starts when the circuit-breaker trip is confirmed.

- If no blocking condition (**LINE.LIVE** and **RECLOSE.SHIFT** SPS both *RESET*) is present when it elapses, the AR function issues a CB close command.
- If a blocking condition (**LINE.LIVE** or **RECLOSE.SHIFT** SPS *SET*) is present when it elapses, reclosing is suspended and the relevant timer (**Voltage presence delay** or **Shifting reclose delay**) is started.

(17) **Voltage presence delay** (range [1 s, 20 s], step 1 s). Customer-specific. The voltage presence feature is used not to risk damage to a smaller utility if one is connected to the power system. If the **LINE.LIVE** input is *SET* when a cycle dead time elapses, the **Voltage presence delay** timer is triggered and the reclose command is delayed until it elapses. If the **LINE.LIVE** input is still *SET*

when it does, the trip is considered final and the current reclosing sequence is terminated; the AR function resets to its "line permanently open" state.

(18) **Shifting reclose delay** (range [1 s, 30 s], step 1 s). Customer-specific. The shifting delay is used to avoid causing a double fault in the event of a concurrent reclosing sequence or fault clearance in an adjacent bay or any other electrically connected circuit. If the **RECLOSE.SHIFT** input is *SET* when a cycle dead time elapses, the **Shifting reclose delay** timer is triggered and the reclose command is delayed until it elapses. If the **RECLOSE.SHIFT** input is still *SET* when it does, the trip is considered final and the current reclosing sequence is terminated; the AR function resets to its "line permanently open" state.

When adding an AR function, some mandatory datapoints are automatically created at input or output level and must be configured.

Inputs (received datapoints):

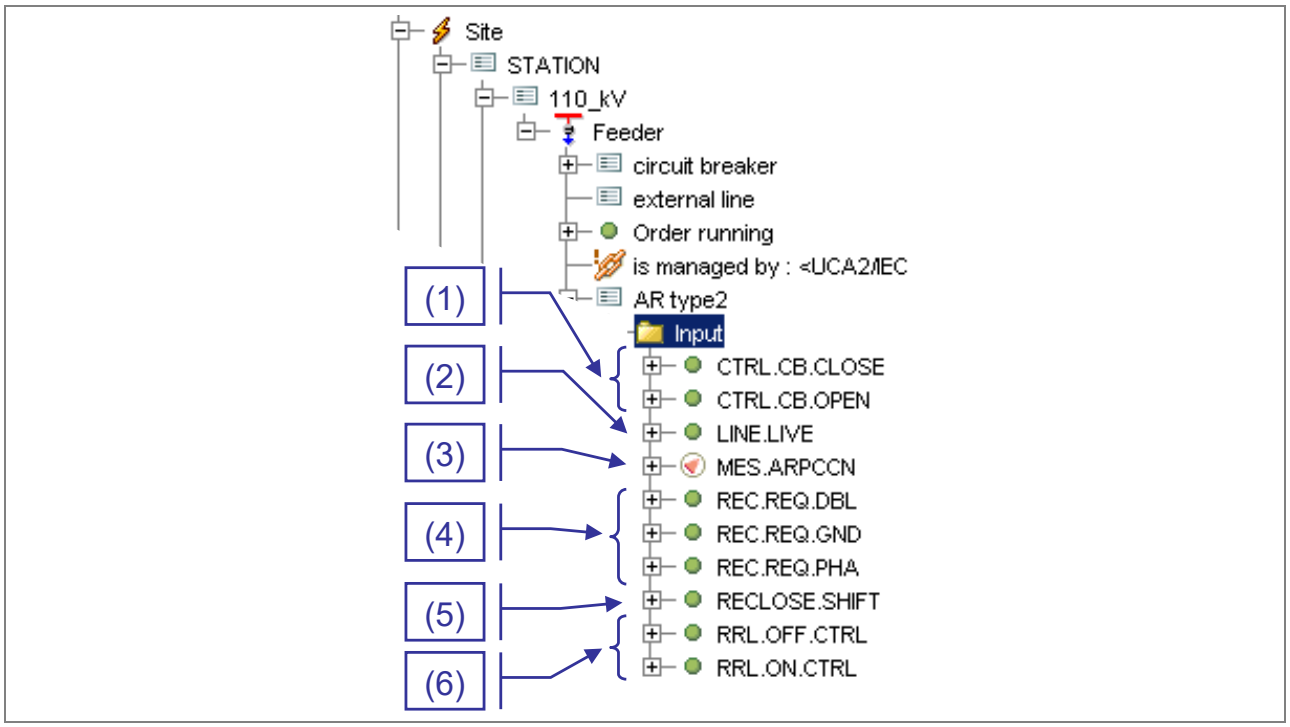


Figure 280: AR function (type 2) mandatory datapoints (1/2)

(1) **CTRL.CB.CLOSE** SPS and **CTRL.CB.OPEN** SPS: Manual close and manual open commands to the circuit-breaker. The **CTRL.CB.CLOSE** SPS is used to start the **Reclaim time manual close** timer and declare a switch-on-to-fault if it is followed by a protection trip before that timer elapses. The **CTRL.CB.OPEN** SPS terminates any reclosing sequence in progress when it becomes *SET*.

(2) **LINE.LIVE** SPS: Live state of the line end connecting a utility to the power system. If this datapoint is *SET* when a cycle dead time elapses, the **Voltage presence delay** timer is triggered and the reclose command is delayed until it elapses.

(3) **MES.ARPCCN** SPC: Switches between the Disable/Enable states of the AR function.

(4) **REC.REQ.DBL**, **REC.REQ.GND** and **REC.REQ.PHA** SPS: Request to start a reclosing sequence (respectively following a double fault, single-phase fault and multi-phase fault).

(5) **RECLOSE.SHIFT** SPS: Indicates whether a reclosing sequence or fault clearance is in progress in an other electrically connected circuit. If this datapoint is *SET* when a cycle dead time elapses, the **Shifting reclose delay** timer is triggered and the reclose command is delayed until it elapses.

(6) **RRL.OFF.CTRL** and **RRL.ON.CTRL** SPS: Disables/enables the AR function.

The source of each input's state must be defined, either by "wiring" it to a DI channel on the BCU or "producing" it from an FBD automation output.

Outputs (transmitted datapoints):

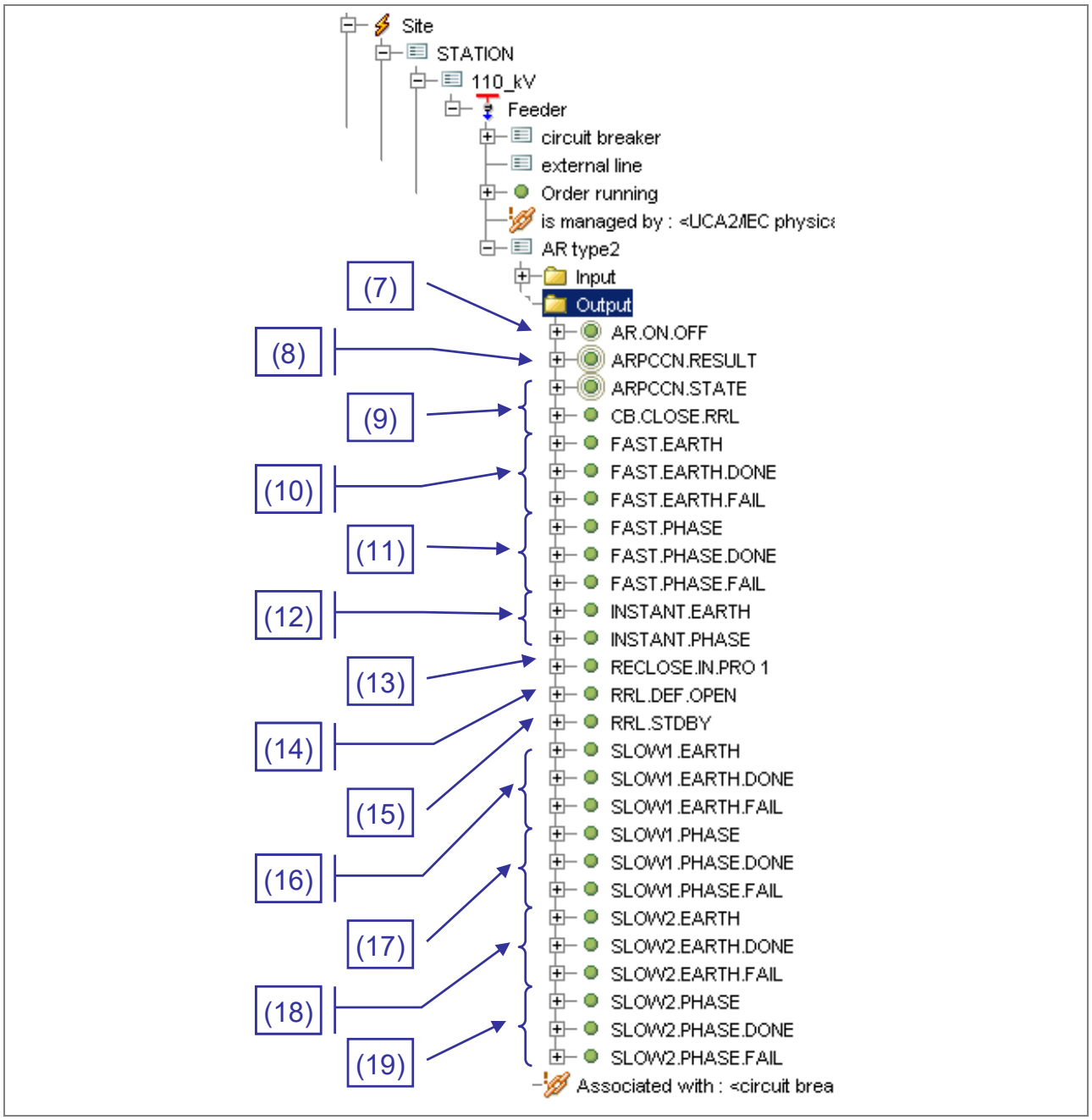


Figure 281: AR function (type 2) mandatory datapoints (2/2)

(7) **AR.ON.OFF** DPS: State of the AR function (enabled/disabled).

(8) **ARPCCN.RESUL** and **ARPCCN.STATE** MPS: Customer-specific multi-state signals providing information on the result of a reclose command and the current state of the AR function.

(9) **CB.CLOSE.RRL** SPS: Circuit-breaker reclose command issued by the local AR function.

(10) **FAST.EARTH** SPS, **FAST.EARTH.DONE** SPS and **FAST.EARTH.FAIL** SPS: States of the high speed ("fast") cycle for single-phase faults (respectively 'reclosing cycle in progress', 'reclosure successful' and 'reclosure failed').

(11) **FAST.PHASE** SPS, **FAST.PHASE.DONE** SPS and **FAST.PHASE.FAIL** SPS: States of high speed "fast" cycle for double faults and multi-phase faults (respectively ‘reclosing cycle in progress’, ‘reclosure successful’ and ‘reclosure failed’).

(12) **INSTANT.EARTH** SPS and **INSTANT.PHASE** SPS: Instantaneous trip permitted. These outputs are *SET* when the AR function is in standby mode and a "fast" reclosing cycle is defined respectively for single-phase faults and for double/multi-phase faults.

(13) **RECLOSE.IN.PRGS** SPS: Auto-reclosing cycle in progress (signal sent just before the reclose command).

(14) **RRL.DEF.OPEN** SPS: Final trip signal, i.e. reclosing sequence terminated.

(15) **RRL.STDBY** SPS: AR function in standby mode.

(16) **SLOW1.EARTH** SPS, **SLOW1.EARTH.DONE** SPS and **SLOW1.EARTH.FAIL** SPS: States of the first time-delayed ("slow") cycle for single-phase faults (respectively ‘reclosing cycle in progress’, ‘reclosure successful’ and ‘reclosure failed').

(17) **SLOW1.PHASE** SPS, **SLOW1.PHASE.DONE** SPS and **SLOW1.PHASE.FAIL** SPS: States of the first "slow" cycle for double faults and multi-phase faults (respectively ‘reclosing cycle in progress’, ‘reclosure successful’ and ‘reclosure failed').

(18) **SLOW2.EARTH** SPS, **SLOW2.EARTH.DONE** SPS and **SLOW2.EARTH.FAIL** SPS: States of the second "slow" cycle for single-phase faults (respectively ‘reclosing cycle in progress’, ‘reclosure successful’ and ‘reclosure failed').

(19) **SLOW2.PHASE** SPS, **SLOW2.PHASE.DONE** SPS and **SLOW2.PHASE.FAIL** SPS: States of the second "slow" cycle for double faults and multi-phase faults (respectively ‘reclosing cycle in progress’, ‘reclosure successful’ and ‘reclosure failed').

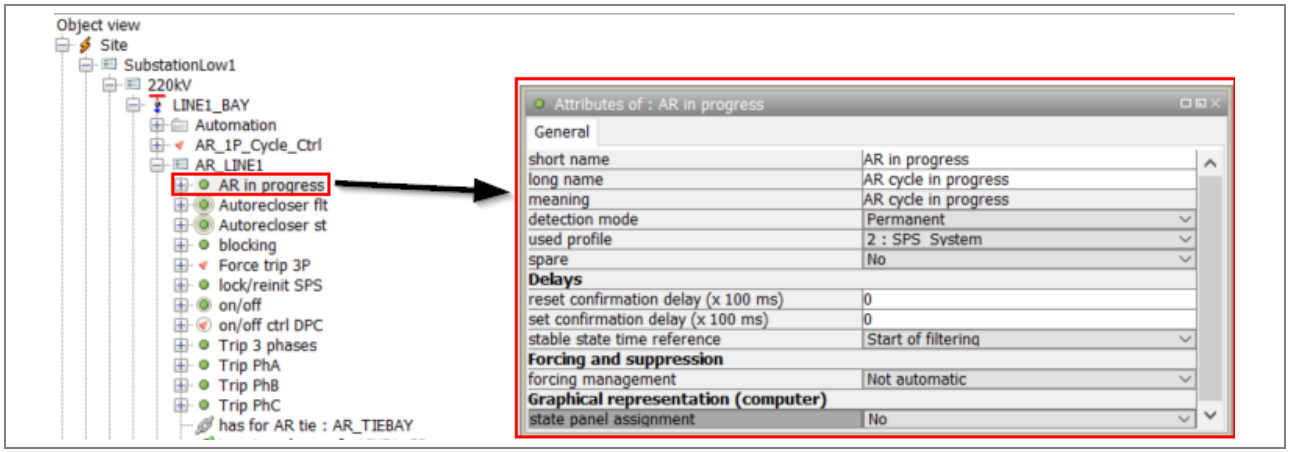
Update the relations and the links of the input and output datapoints to point to relevant existing profile(s).

5.3.4 DEFINING AN AUTO-RECLOSER WITH PRIORITY HOLD

The priority hold for auto-recloser is described in section 7.1.1.4 of chapter C26x/EN FT.

5.3.4.1 MANDATORY DATAPOINTS

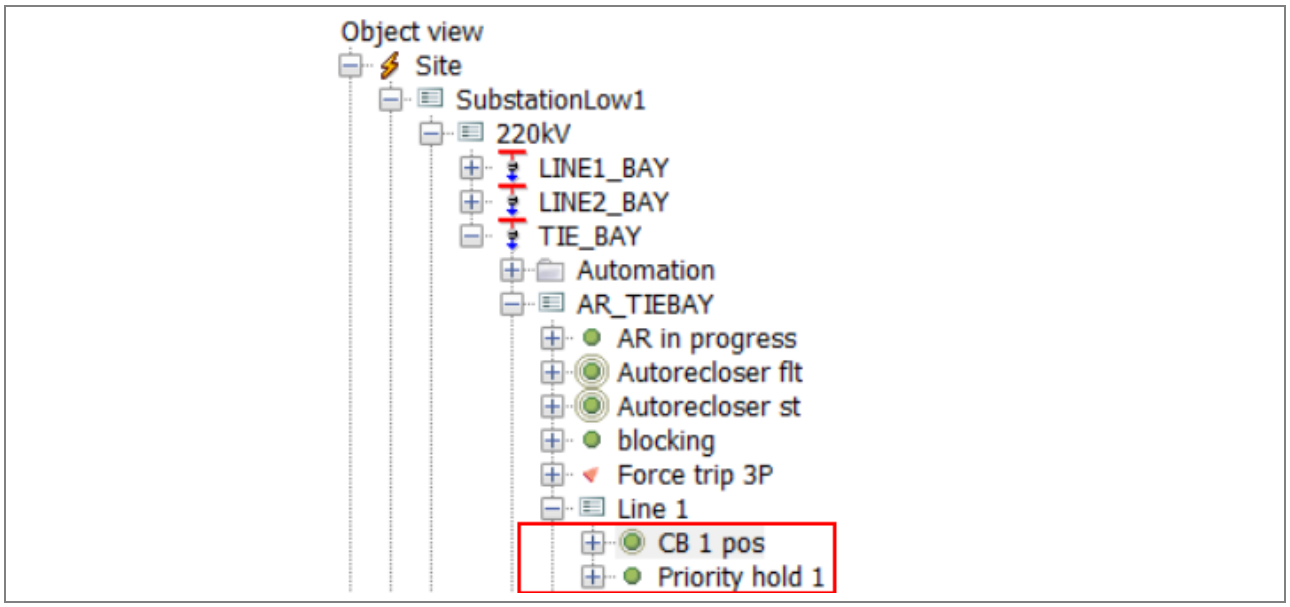
For any configuration of the priority hold (Standalone, Line+Tie or Line + Tie + Line mode) the SPS datapoint AR in progress is mandatory for any Autorecloser of any bay:



The AR in progress status will be SET when Auto-recloser st MPS is in State1, State0, State2, State3, State4, State5 and State6. In other case the AR in progress value is RESET.

5.3.4.1.1 Datapoints in Line + Tie mode

In this configuration, the two following datapoints are mandatory and must be created in the Tie bay:



1 **CB 1 pos**: This DPS is required to get the feedback of the circuit breaker position for the associated line bay. This datapoint is used once the trip initiation is received for the Tie bay auto-recloser and when the Priority_hold_1 is SET**.**

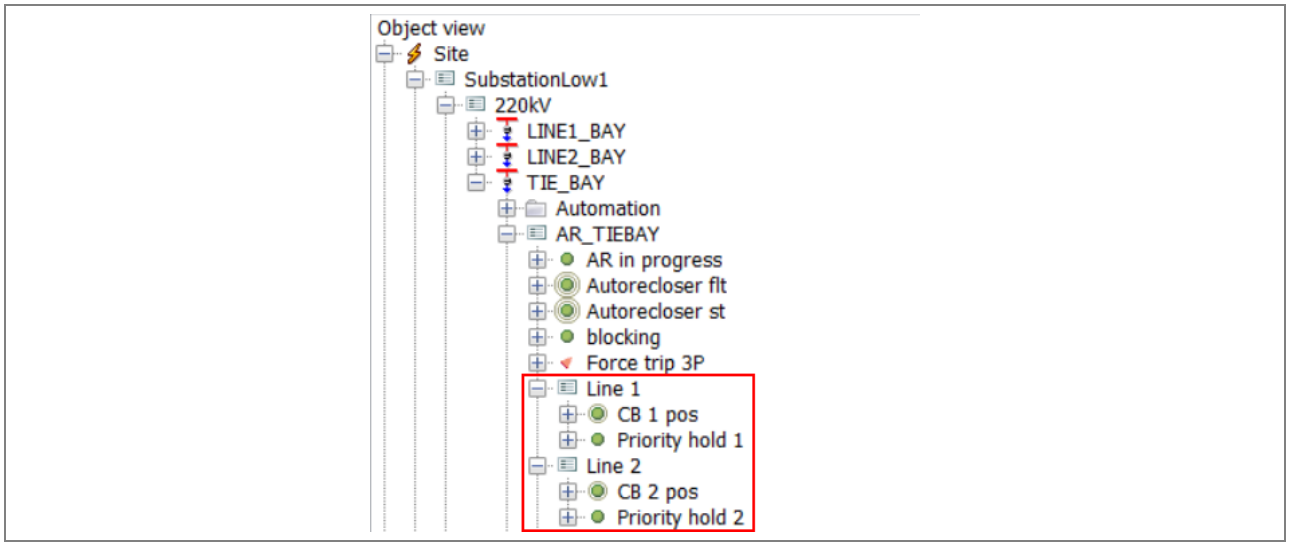
- If the DPS datapoint indicating the feedback of the CB Position for the Line Bay goes to Closed state indicating the successful Autorecloser of the Line bay, it will resume its own Autorecloser cycle.
- Otherwise, if the datapoint indicating the feedback of the CB Position for Line Bay does not go to Closed state till the Lockout Timer for the Autorecloser is elapsed, it will indicate the unsuccessful Autorecloser of the Line bay, and the Tie bay Autorecloser will go to AR_Lock State.

2 **Priority hold 1:** This SPS indicates if the autorecloser of the Line bay has started. It is internnaly linked through GOOSE to the AR_in_progress datapoint in the Line bay.

- Once the trip initiation is received for Autorecloser in the Tie bay. if this Datapoint is SET, it will indicate to the Tie bay that the Line bay Autorecloser is in progress and it has to hold its own autorecloser cycle.
- Once the trip initiation is received for Autorecloser in the Tie bay. if this Datapoint is RESET, it will indicate to the Tie bay that the Line bay autorecloser has not started and it should perform its autorecoser cycle in standalone mode without dependency on the Line bay Autorecloser.

5.3.4.1.2 Datapoints in Line + Tie + Line mode

In this configuration both the CB 1 pos and Priority hold 1 datapoints are mandatory for each line bay associated to the ties bay as follows:



1 **CB 1 pos**: This DPS is required to get the feedback of the circuit breaker position for the associated line bay. This datapoint is used once the trip initiation is received for the Tie bay auto-recloser and when the Priority_hold_1 is SET**.**

- If the DPS datapoint indicating the feedback of the CB Position for the Line Bay goes to Closed state indicating the successful Autorecloser of the Line bay, it will resume its own Autorecloser cycle.
- Otherwise, if the datapoint indicating the feedback of the CB Position for Line Bay does not go to Closed state till the AR Lockout Timer for the autorecloser is elapsed, it will indicate the unsuccessful Autorecloser of the Line bay, and the Tie bay autorecloser will go to AR_Lock State.

2 **Priority hold 1:** This SPS indicates if the autorecloser of the Line bay has started.

- Once the trip initiation is received for Autorecloser in the **Tie Bay**. if this Datapoint is **SET**, it will indicate to the Tie bay that the Line bay Autorecloser is in progress and it must hold its own autorecloser cycle.
- Once the trip initiation is received for Autorecloser in the Tie bay. if this datapoint is RESET, it will indicate to the Tie bay that the Line bay autorecloser has not started and it should perform its autorecoser cycle in standalone mode without dependency on the Line bay Autorecloser.

The two datapoints must be created for each line bay.

- In the case of a multiple autorecloser cycle is configured and fault occurs on First line and Subsequently on the Second Line, if the trip initiation is received by the tie bay for the Line-1 bay, both bays will work regarding the priority hold scenario but, if during the autorecloser cycle, the line-2 bay SPS is SET, then the tie bay autorecloser will go to AR_Lock state. Otherwise, if the Line-2 bay is SET when the tie bay autorecloser cycle has finished, the Tie bay will start a new cycle.

5.4 DEFINING A TAP CHANGER BUILT-IN FUNCTION

5.4.1 TAP CHANGER BEHAVIOUR

The control sequence of a transformer is described in section 6.5 of chapter C26x/EN FT.

Control of a transformer is done via tap changer built-in function and can be performed in the three modes “Direct Execute”, ”SBO once” and “SBO many mode”.

TCIP feature:

The TCIP input information is used to confirm the correct execution of the low/raise control. When adding a TCIP at tap changer level, the two configurable delays must be set at TCIP datapoint level for the correct TCIP management:

(1) **reset confirmation delay** (range [0 s, 120 s], step 100 ms): this delay corresponds to time-out T_R given in section 5.1.2.1 Persistence filtering of chapter C26x/EN FT.

(2) **set confirmation delay** (range [0 s, 120 s], step 100 ms): this delay corresponds to time-out T_S given in section 5.1.2.1 Persistence filtering of chapter C26x/EN FT.

(3) **start confirmation delay** (range [1 s, 60 s], step 100 ms): the TCIP information must appear before the time-out of this delay

(4) **stop confirmation delay** (range [1 s, 60 s], step 100 ms): the TCIP information must disappear before the time-out of this delay

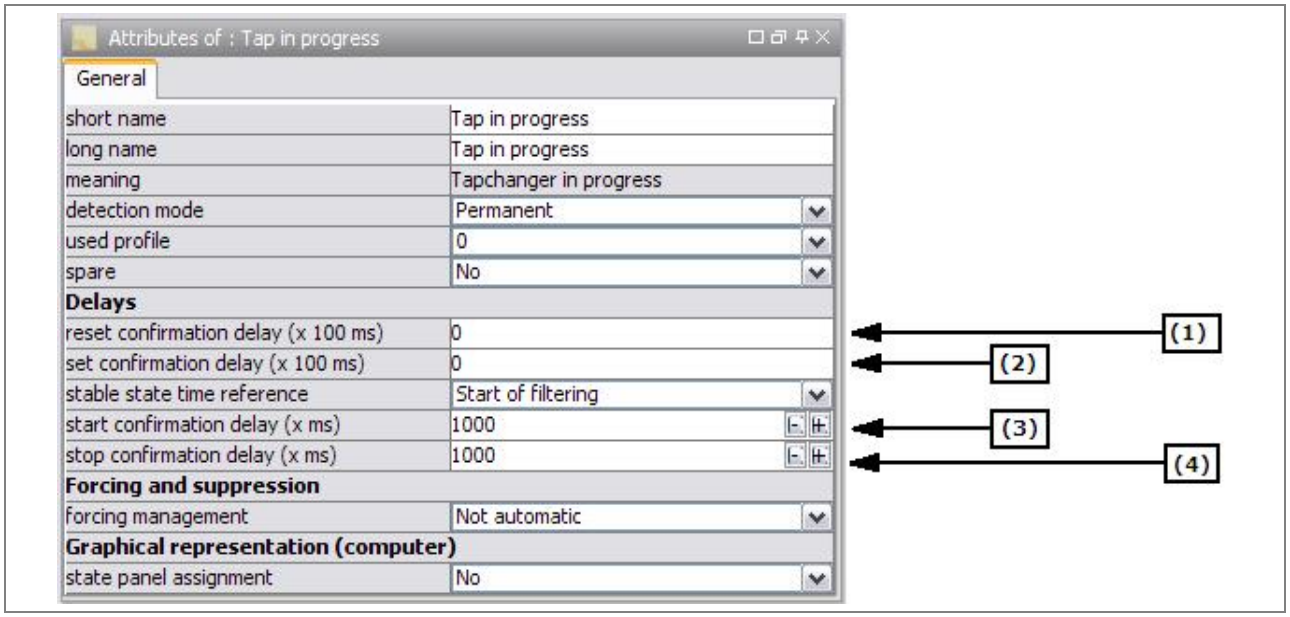


Figure 282: Setting the TCIP general attributes of a TCIP

TPI feature:

Because the TCIP input information is not always configured, the tap control is performed using only the Tap Position Indication (TPI) value to verify the right execution of the request. The TPI value must change in the given delay.

Control of a transformer with TCIP

This feature is described in chapter C26x/EN FT.

Control of a transformer without TCIP

This feature is described in chapter C26x/EN FT.

Suppression, Forcing or Substitution of the TPI

This feature is described in chapter C26x/EN FT.

5.4.2 CREATING A TAP CHANGER BUILT-IN FUNCTION

Tap changer is considered as a function because it verifies maximal and minimal useable positions of tap position indicator. It is like a sub-module of transformer module and owns the tap position indicator and optional controls (Raise/Lower, Goto Min/Max).

To create a tap-changer function, add it from object entry at transformer module level (1).

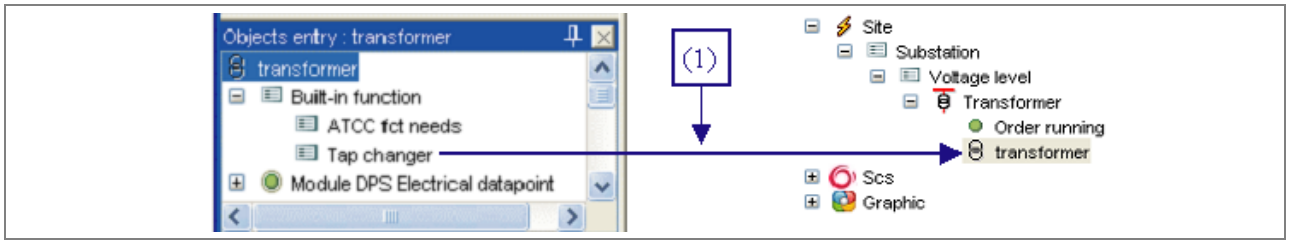


Figure 283: Adding a tap changer built-in function to a transformer

When adding a tap changer function, the following general attributes must be updated:

(1) **short name** and **long name** of the tap changer used for logging, alarms ...

(2) **minimal usable position** (range [1, 64], step 1).

(3) **maximal usable position** (range [1, 64], step 1): must be greater than attribute (2).

(4) **execution timeout** (range [0, 60 s], step 100 ms): It is the maximum delay in which tap position must have changed relatively to the current tap control in progress. If delay expired bad acknowledgement is sent for tap control.

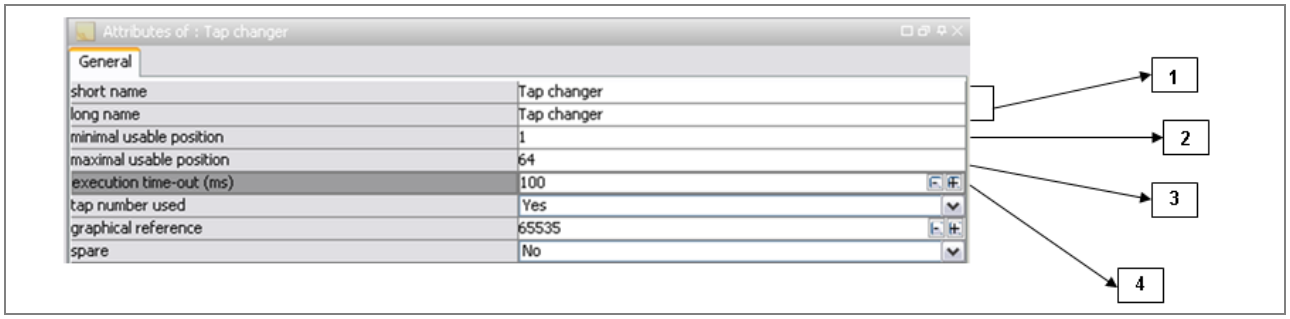


Figure 284: Setting the attributes of a tap changer

When adding a tap changer function, the mandatory datapoint ‘Tap position indicator’ (TPI) is automatically created at function level (8).

The following table gives inputs and outputs tap changer’s features controlled by the C26x. For each datapoint its SCE identification is given by a number, referenced in the following figure.

To configure correctly the tap changer of a transformer module:

- add the relevant datapoints, relatively to the following tables,
- configure them (see section *4 Defining a datapoint*).

Tap changer for transformer		
	OUTPUTS	**INPUTS**
DEVICE CONTROL	(2) DPC raise/lower (1) DPC (optional) goto min/max	(8) TPI value (7) SPS (optional) tap change in progress
DEVICE SELECTION (HARDWARE)	(4) SPC (optional) transformer selection	(i) SPS (optional) selection position information

(i) This SPS is a generic one added at transformer module level and configured as feedback of SPC transformer selection (4).

Datapoints list

(1) **Goto min/max DPC**: if it is not wired to a board DO, this datapoint is managed by an ISaGRAF automation from a Gateway or aView/OI command:

- If the expected position is Min position, the automation must send one or several commands to the transformer to decrease the current position until the transformer reaches the Min position,
- If the expected position is Max position, the automation must send one or several command to the transformer to increase the current position until the transformer reaches the Max position.

(2) **Raise/lower DPC**: this datapoint is managed by the tap changer built-in function.

(3) **MCB open SPC**: this datapoint is managed by the tap changer built-in function.

(4) **TAP Select SPC**: this datapoint is managed by the tap changer built-in function

(5) **Higher position**: if it is not wired to a board DI, this SPS is managed by an ISaGRAF automation:

- set it to 1 if the Tap pos indicator is greater than the max position
- reset it otherwise

(6) **Lower position**: if it is not wired to a board DI, this SPS is managed by an ISaGRAF automation.

- set it to 1 if the Tap pos indicator is lower than the min position
- reset it otherwise

(7) **Tap in progress**: this SPS is taken into account by the tap changer built-in function.

(8) **Tap pos ind**: tap position indication (TPI).

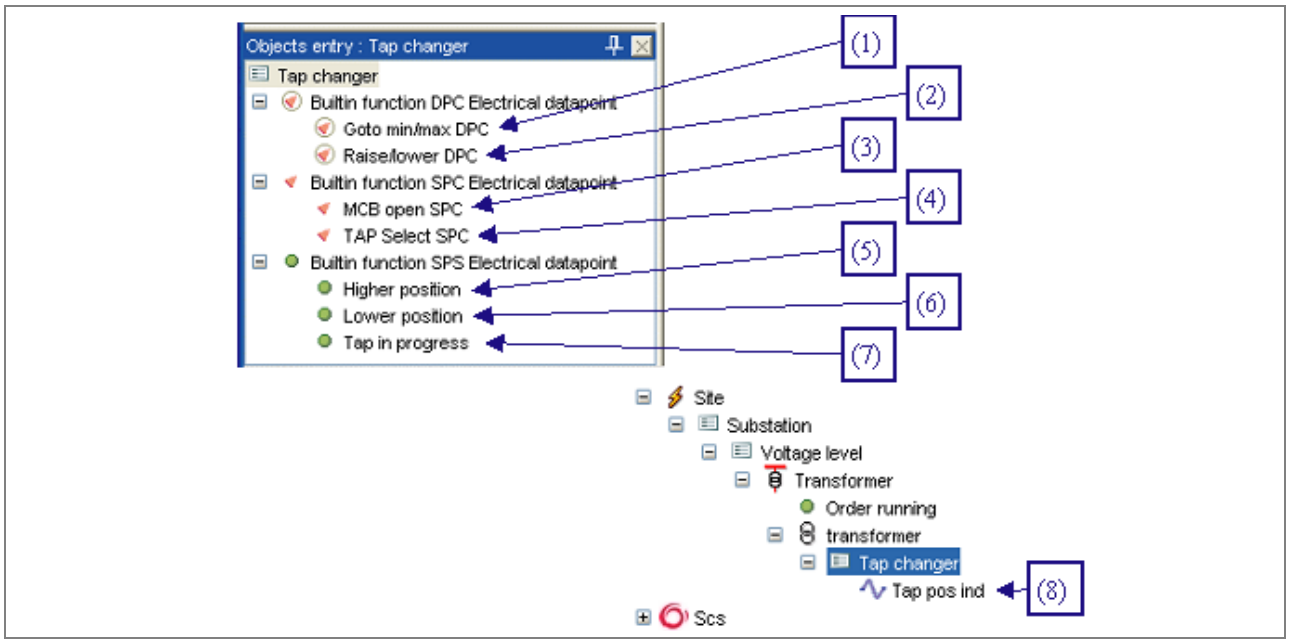


Figure 285: Available pre-defined datapoints for a tap changer

Configuration rules and checks

- The "Raise/lower DPC" datapoint must have its profile attribute “SBO mode” set to "SBO Operate Many"

5.4.3 SETTING THE TPI PARAMETERS

The settings for Tap Position Indications are very similar to those of MV datapoints:

5.4.3.1 SETTING THE GENERAL ATTRIBUTES OF A TPI DATAPOINT

When adding a TPI datapoint, some general attributes must be updated:

(1) **short name** and **long name**: used for logging, alarms ...

(2) **type**: available values are:

- *Analogue tap position* (current input, acquired via an AIU board or an external IED)
- *Digital tap position coded ‘1 among n’* (digital acquisition only)
- *Digital tap position coded ‘decimal’* (digital acquisition only)
- *Digital tap position coded ‘gray’* (digital acquisition only)
- *Digital tap position coded ‘BCD’* (digital acquisition only)
- *Digital tap position coded ‘PCCN code’* (customer-specific)

(3) **used profile**: the drop-down list refers to the MV tab of the Profiles table

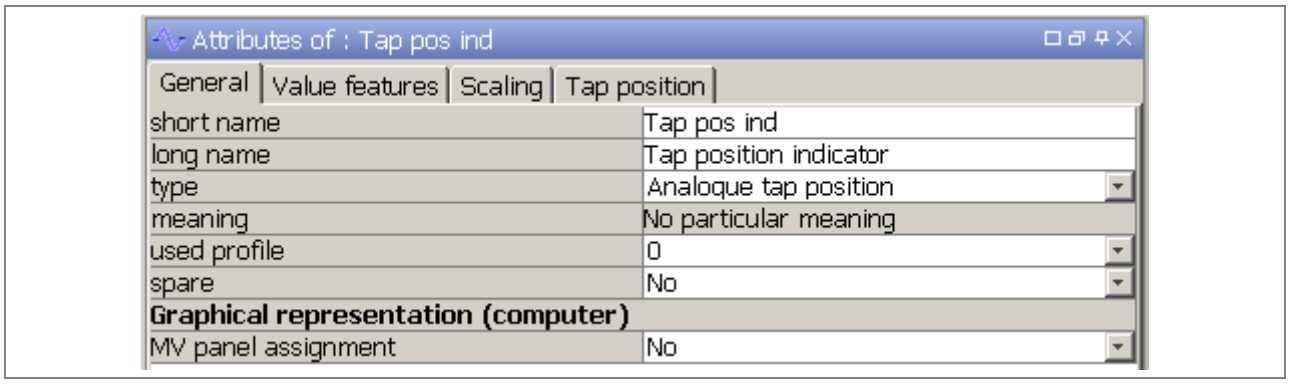


Figure 286: Setting the general attributes of a TPI datapoint

5.4.3.2 SETTING THE VALUE FEATURES ATTRIBUTES OF A TPI DATAPOINT

When adding a generic MV datapoint, some 'Value features' attributes must be updated:

(1) **minimum value** (range [-3.4E38, 3.4E38]: used for full scale calculation and scaling. It must match the **minimal usable position** attribute set for the Tap changer.

(2) **maximum value** (range [-3.4E38, 3.4E38]: used for full scale calculation and scaling. (Full scale = maximum value - minimum value). It must match the **maximal usable position** attribute set for the Tap changer.

(3) **zero value suppression** (% of full scale value) (range [0, 10], step 0.1): this parameter is used to define the zero suppression area (deadband) for zero value suppression processing. This attribute is only visible if the **type** of tap position acquisition is set to Analogue.

(4) **Hysteresis** (% of full scale value) (range [0, 50], step 1): used for threshold detection

(5) **threshold usage** (*No* / *Yes*): for each of the three low thresholds and the three high thresholds, defines whether or not the corresponding threshold is used

(6) **threshold** values (range [-3.4E38, 3.4E38]: value for each threshold, relevant only if the corresponding **threshold usage** attribute is set to *Yes*.

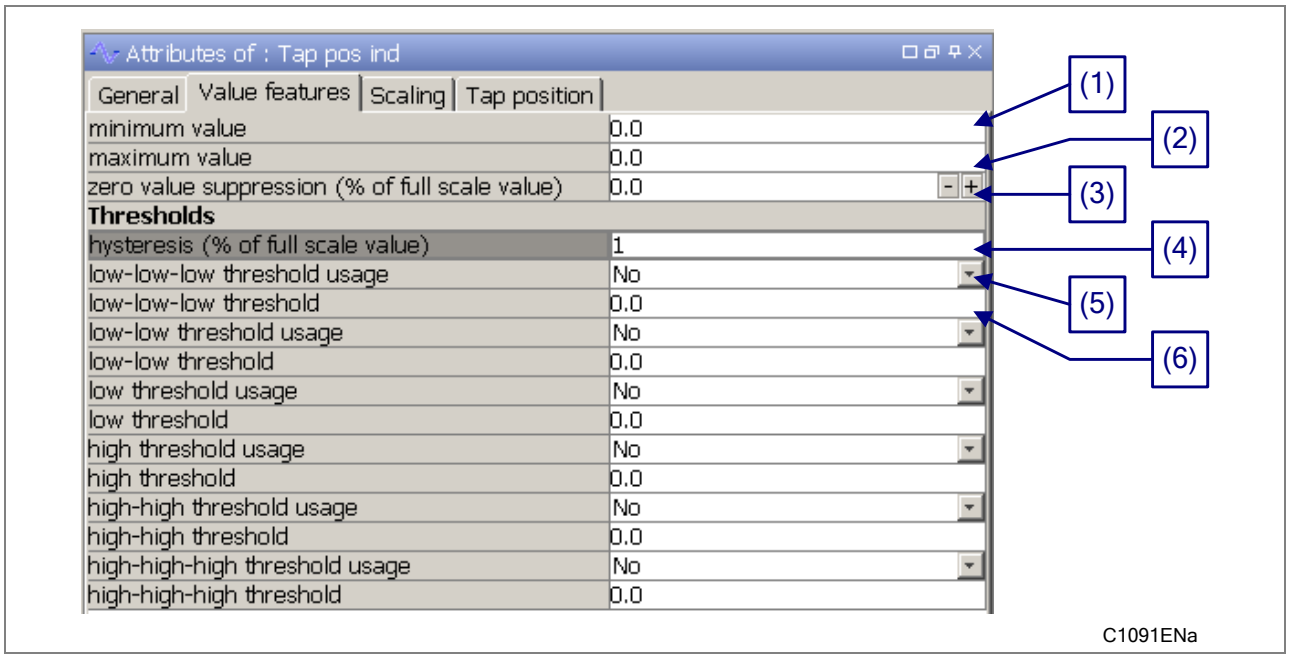


Figure 287: Setting the value features attributes OF A TPI datapoint

5.4.3.3 SETTING THE SCALING ATTRIBUTES OF A TPI DATAPOINT

The **Scaling** attributes are only relevant if the **type** of tap position acquisition is set to Analogue.

Note:
*TPI value scaling is always linear. Therefore there is no **scaling rule** attribute to set.*

(1) **minimum acq. value** (range [-3.4E38, 3.4E38])

(2) **maximum acq. value** (range [-3.4E38, 3.4E38])

(3) **Ai coefficient** (range [-100000, 100000, step 1]): multiplying factor in the scaling equation for the transmitted TPI value

(4) **Bi offset** (range [-100000, 100000, step 1]): added offset in the scaling equation for the transmitted TPI value

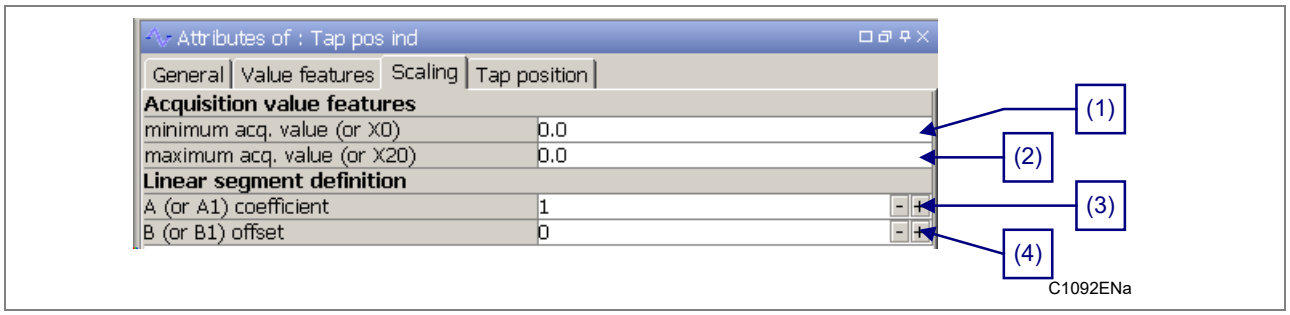


Figure 288: Setting the scaling attributes of a TPI datapoint

5.4.3.4 SETTING THE TAP POSITION ATTRIBUTES OF A TPI DATAPOINT

The Tap position attributes depend on the set **type** of tap position acquisition, analogue or digital.

Analogue tap position acquisition

(1) **filtering delay (x 10 ms)** (range [0 s, 6553.5 s], step 10 ms): confirmation time for tap position change indication

(2) **current valid range (% maximum value)** (range [0, 20%], step 1%): minimum value of the current level required for position change indication

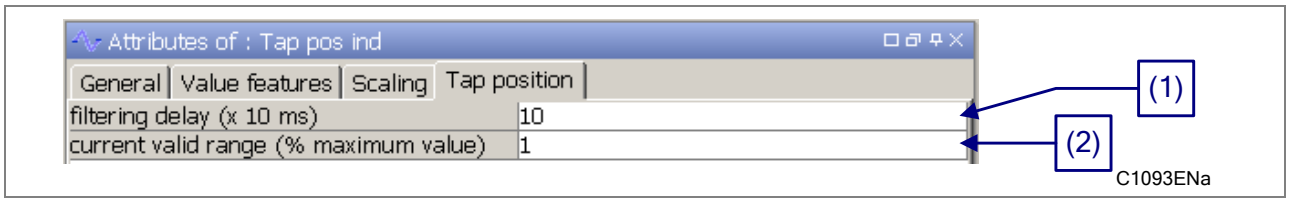


Figure 289: Setting the Tap position attributes of an analogue TPI datapoint

Digital tap position acquisition

(1) **filtering delay (x 10 ms)** (range [0 s, 6553.5 s], step 10 ms): confirmation time for tap position change indication

(2) **inhibition delay (x 10 ms)** (range [0 s, 6553.5 s], step 10 ms): transient intertap filtering time-delay

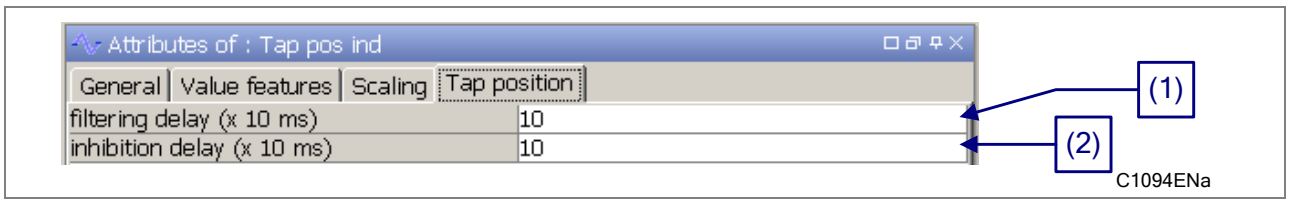


Figure 290: Setting the Tap position attributes of a digital TPI datapoint

5.4.3.5 TAP POSITION WIRING

The permitted tap positions defined in the range [**minimal usable position**, **maximal usable position**] when the Tap change function was created must be wired to digital inputs on the C26x.

To do so, select the **Tap pos ind** measurement under **Tap changer** in the **Object view**. In the contextual **Object entry** window, double-click all the relevant **'bit xx' wired on : DI channel** to place them under **Tap pos ind**. When this is done, double-click each of these relations to display the **Relation link editor** window that contains the list of available DIs and for each, select the corresponding DI.

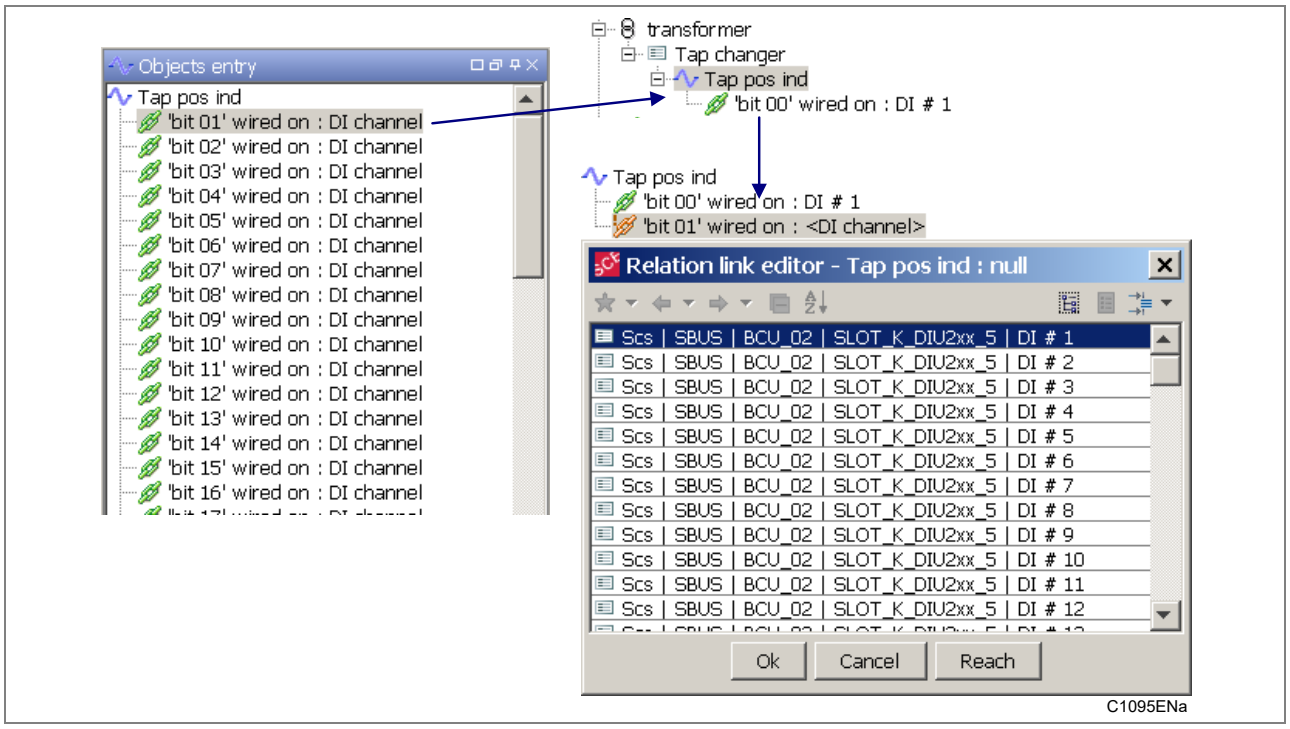


Figure 291: Wiring the Tap position bits to digital inputs

5.5 DEFINING AN AUTOMATIC VOLTAGE REGULATION – AVR – BUILT-IN FUNCTION

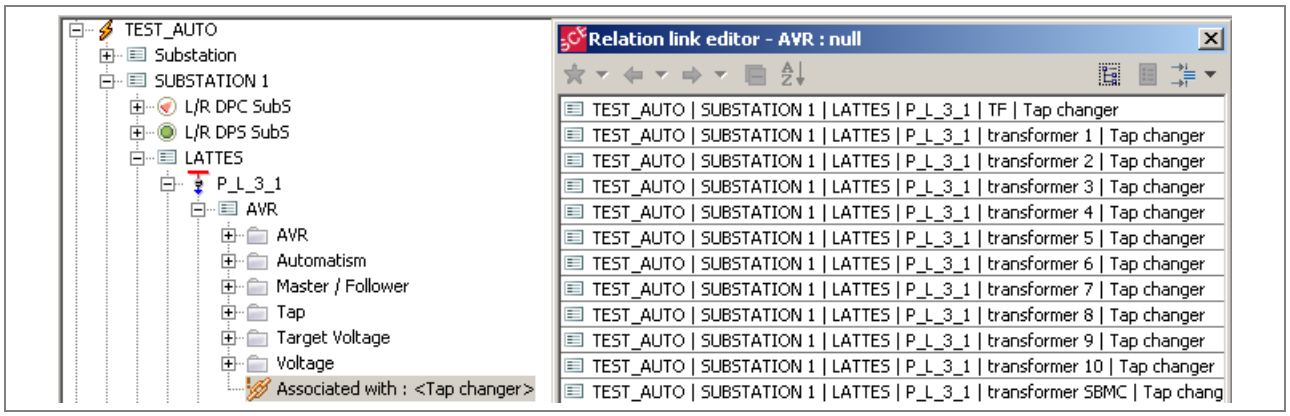
5.5.1 CREATING AN AVR FUNCTION

AVR relates to the transformer bays; hence the configuration is done at this level. The topology is defined by the node references of each individual transformer. Transformers in parallel are located in separate bays; among them, one is master, the others followers. Several independent groups can be configured in the same substation.

In the **Objects entry** window, select the AVR built-in function and right click on *Add*. This permits creation of datapoints related to the AVR real-time information & controls of the transformer bay.

To define the transformer, see section *5.1.5.7 Defining a transformer*. To associate the AVR with a Tap changer:

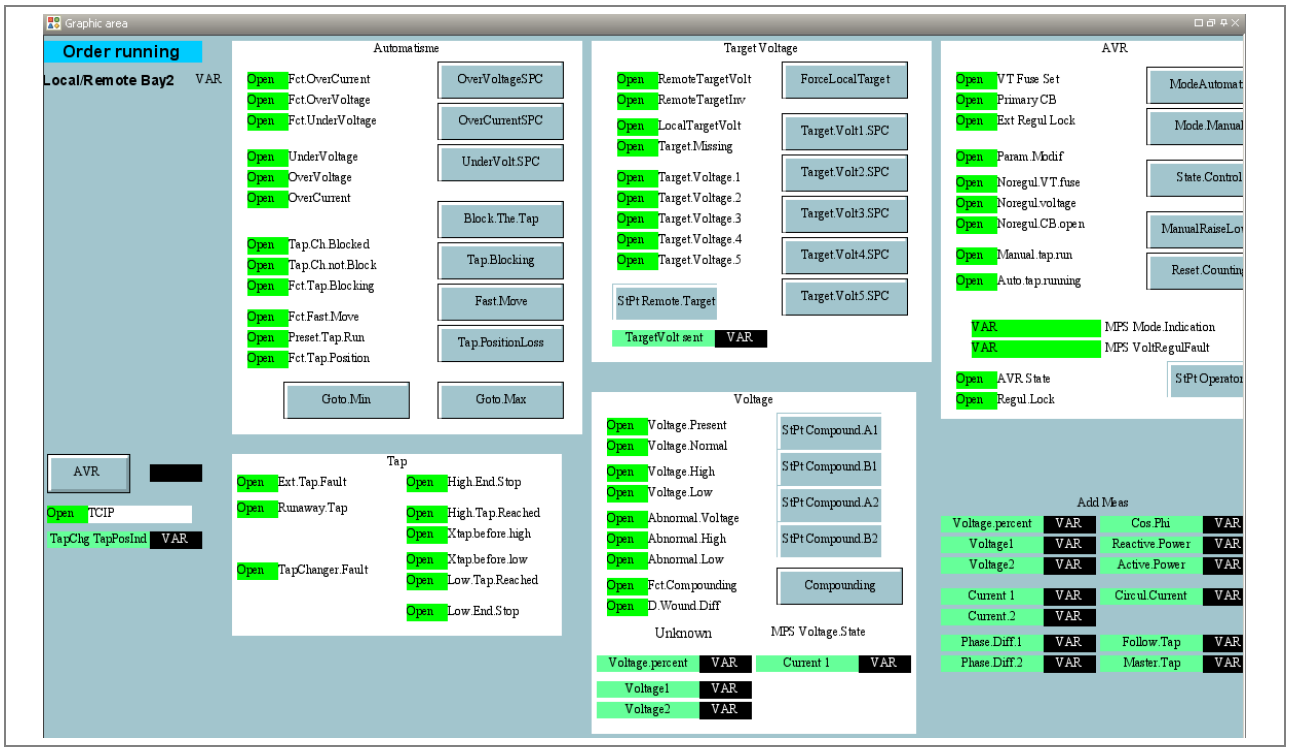
- double click the link 'Associated with'; this opens the Relation link editor
- select the desired path in the list beneath
- click OK



To assign an IEC address to each datapoint:

- select the data point
- tap into the ‘Objects entry’ window to add a link
- double click the link
- select the path in the list
- click **OK**

5.5.2 GRAPHIC SECTION (EXAMPLE OF OPERATOR WORKSTATION LISTING OUT THE DATAPOINTS)



5.5.3 AVR BEHAVIOUR

The AVR built-in function is described in chapter C26x/EN FT. List of attributes:

Tab	Parameter name	Values	Min	Max	Step	Defaults value
AVR	Nominal voltage	Vn	100	120	1	100V
	Nominal current	In	1	5	4	1A
	Regulation type	Phase voltage Van / Compound voltage Ubc	-	-	-	Phase voltage Van
	Manual controls allowed	No / Only on AVR locked / Always				
	Automatic move manual on error	No / Yes (immediately) / Yes only after a delay				
	Manual Mode on Error		1	120	1	
	AVR State	On / Off	-	-	-	On
	AVR Mode	Manual / Automatic	-	-	-	Automatic
	Transformer Nominal voltage		0	1 000 000	500	20000.0V
TAP	Tap changer fault function	Internal and/or external	-	-	-	Internal
	Tap changer fault behaviour	Autom/manual reset/manual mode	-	-	-	Automatic
	Highest tap value		1	64	1	39
	Lowest tap value		1	64	1	1
	Intermediate position	No/yes	-	-	-	no
	Intermediate position active	Off/on				Off
	Intermediate tap delay		0s	60s	1s	10s
	Intermediate tap		1	64	1	1
	First step delay	TA1	10s	70s	5s	60s
	Next tap delay	TA2	2s	30s	2s	10s
	End Tap delay		0s	180s	5s	60s
	First tap delay bypass delay	TA3	20s	120s	10s	30s
	Preset tap		1	39	1	1
	Preset tap delay		0s	10s	1s	1 s
	Tcip delay		5s	180s	5s	10 s
	Tcip end delay		1s	120s	1s	10 s
	Tap changer fault delay		60s	600s	10s	120 s
	Tap Pulse Duration		0.5s	30s	0.1s	0.5 s
	Number of taps before highest tap		1	10	1	4
	Number of taps before lowest tap		1	10	1	4
	Slipping period for counting	Period in days	1	120	1	30
	Intermediate pos active	Off / On				
	Intermediate tap delay		0	60	1	
	Intermediate tap		1	64	1	
	Runaway tap delay		0s	60s	1s	30 s
	Voltage confirmation delay		0	10	0.1	0.5
	Double wound	Yes/no	-	-	-	No
	Double wound voltage	Voltage 1 / voltage 2 / average				Voltage 1
	Double wound voltage difference	% of Vn	0%	10%	1%	5%
	Voltage presence threshold	Displayed in volt but used as % Vn	20%	80%	10%	50%

Tab	Parameter name	Values	Min	Max	Step	Defaults value
VOLTAGE	Regulation deadband	% of target voltage	0%	4%	0.25%	1.25%
	Abnormal voltage (threshold)	□, % of target voltage	2%	11%	1%	5%
	Abnormal voltage present delay		0s	600s	1s	0s
	Abnormal voltage delay present	T4	20s	600s	10s	300s
	Abnormal voltage delay missing		0s	600s	10s	0s
	Voltage present delay	Tp	0s	120s	1s	0s
	Voltage missing delay	Ta	30s	180s	10s	120s
	Compounding activation*	Off / On	-	-	-	Off
	Compounding method	Active / Reactive	-	-	-	Active
	Active compounding method par. A1**	% of Vn/In	0%	20%	0.5%	0%
	Active compounding method par. B1**	% of Vn/In	0%	20%	0.5%	0%
	Reactive compounding method p A2**	% of Vn/In	0%	20%	0.5%	0%
	Reactive compounding method p B2**	% of Vn/In	0%	20%	0.5%	0%
	Double wound Volt diff		0	10	1	
	Compound nominal current		0		0.01	0.1
	Voltage correction		0		0.01	0%
TARGET VOLTAGE	Target voltage management	Controls/Remote-Local	-	-	-	Controls
	Target voltage active	No/1/2/3/4/5				1
	No target voltage active delay		10	300	10	120
	Remote target voltage min value	In % of Vn	90%	105%	0,25%	90%
	Remote target voltage max value	In % of Vn	95%	110%	0,25%	110%
	Remote target maximum difference between 2 target voltages remote or remove????	In Volt (MV range value)	50V	500V	10V	200V
	End of remote target voltage delay		0mn	480mn	10mn	60mn
	End of local target voltage delay		3mn	10mn	1mn	5 mn
	Target voltage 1	Displayed in volt but used as % Vn	88%	112%	0.1%	100%
	Target voltage 2	Displayed in volt but used as % Vn	100%	104%	0.1%	102%
	Target voltage 3	Displayed in volt but used as % Vn	103%	107%	0.1%	105%
	Target voltage 4	Displayed in volt but used as % Vn	106%	110%	0.1%	108%
	Target voltage 5	Displayed in volt but used as % Vn	93%	97%	0.1%	95%
	Local Target Voltage	Displayed in volt but used as % Vn	90%	110%	0.25%	100%
	Tap Changer Set					
	Voltage loss position tap	on defined tap/lock automatic reg				On defined tap
	Tap changer position behaviour	Preset tap/Curren tapt/Lowest tap				preset
	Primary CB state	Open/close				open
	Overcurrent behavior	Signalisation / Signal. & locking				signalisation
	Overvoltage behavior					

Tab	Parameter name	Values	Min	Max	Step	Defaults value
AUTO	Undervoltage behavior					
	Tap changer position active*	Off/on	-	-	-	off
	Tap changer fast move active*	Off/on	-	-	-	off
	Line Overcurrent detection active *	Off/on	-	-	-	off
	Line Overcurrent threshold	% of In	50%	500%	10%	250%
	Line Overcurrent delay		0s	30s	0.1s	2 s
	Overvoltage detection active*	Off/On	-	-	-	Off
	Overvoltage threshold	% of Vn	100%	130%	1%	130%
	Overvoltage delay		0s	30s	0.1s	2 s
	Undervoltage detection active*	Off/on	-	-	-	off
	Undervoltage threshold	% of Vn	50%	100%	1%	70%
	Undervoltage delay		0s	30s	0.1s	2 s
	Tap Changer blocking *	Off/on	-	-	-	off
	Tap Changer blocking delay		0s	300s	10s	60 s
TRANSFO in //	Transformer in parallel	Yes/No	-	-	-	No
	Role	Master/Followe/Foll master backup				
	Master failure management	Follower becomes master /Standalone regulation	-	-	-	Follower becomes master
	Stand alone regulation method	None/Negative reactance compensation/Minimize circulating current	-	-	-	None
	Backup mode delay		0s	120s	1s	60 s

* means that it can be modified through operator controls, ** through setpoints

5.6 DEFINING AN AUTOMATIC VOLTAGE REGULATION – ATCC – BUILT-IN FUNCTION

5.6.1 ATCC BEHAVIOUR

The ATCC built-in function is described in chapter C26x/EN FT.

5.6.2 CREATING AN ATCC FUNCTION

ATCC is a complex built-in function for it concerns specific objects (transformer, busbar, voltage level) constituting the substation. At SCE level, ATCC modeling is split into different objects (ATCC function needs) located under each relevant electrical component. The whole of these objects corresponds to the configuration of the substation's ATCC built-in function.

Adding the 'ATCC function needs' object under an electrical component allows automatic datapoint creation. These datapoints relate to the ATCC real-time information and controls relevant to this electrical component.

Voltage levels managed by ATCC do not need specific datapoints for the ATCC function. So, specific attributes put at voltage level objects are preferred to give extra ATCC function needs for each voltage level.

In the following sub-sections, required datapoints for ATCC function are prefixed with an identifier, referred in chapter C26x/EN FT.

Configuration rules and checks

- If there is NO ATCC under the Substation, then:
- a "Voltage level" must have its "ATCC existence" attribute set to "No".
- the "ATCC fct needs" is allowed neither under a "transformer" nor under a "BusBar".
- If there is an "ATCC fct needs" under a "transformer", then:
- the "Tap changer" with its "Raise/lower DPC" datapoint are mandatory.
- one of the datapoints { "MCB position DPS", "MCB position SPS" } is mandatory. They are mutually exclusive
- the "transformer" must be linked to a Voltage level through one and only one of either relation { "has its primary on", "has its secondary on" }. The Voltage level must be different from the one under which the transformer is located.

5.6.2.1 DEFINING AN ATCC FUNCTION'S REQUIREMENTS AT SUBSTATION LEVEL

The entry point of ATCC configuration is done at substation level.

This is done via the **Objects entry** window at substation level by clicking on mouse's right button.

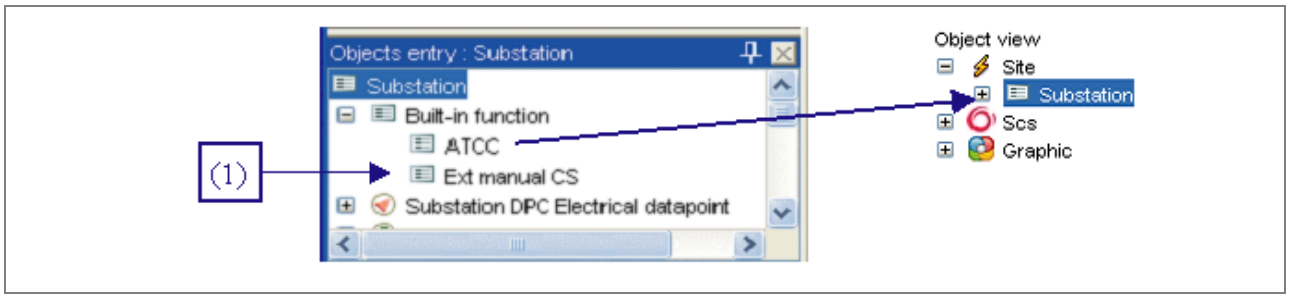


Figure 292: Adding an ATCC function at substation level

Once added, ATCC features must be set at SCE level:

(1) Fill the relation **is managed by**, giving which C26x runs and supervises ATCC function at substation level

(2) **short name** and **long name** of the ATCC used for logging, alarms ...

‘General’ attributes

- ‘calculation’ attributes
  - **calculation period**
  - **calculation mode**
- ‘Homing’ attributes
  - **active homing**
  - **homing deadband**
- ‘ATCC mode changing’ attributes
  - **mode on group interconnection**
- **mode on bay in local**

‘Compounding’ attributes

  - **compounding method**

Delays’ attributes

- ‘Nominal’ attributes
  - **fixed initial tap delay** (*no* means inverse delay).
  - **initial tap delay (in ms)**
  - **inter tap delay (in ms).**
- ‘Homing’ attributes
  - **homing initial tap delay (in ms)**
  - **homing inter tap delay (in ms)**
- ‘Hunting’ attributes
  - **hunting window (in ms)**
  - **opposite max tap changes** (default value: 4)

‘Inhibition’ attributes

- ‘Inhibition conditions’ attributes
  - **max voltage difference (ratio)** (default value: +2%)
  - **tolerable nominal under voltage (ratio)** (default value: 80%)
  - **tolerable nominal over voltage (ratio)** (default value: 120%).

‘Busbar voltage’ attributes

- Coefficients for busbar voltage calculation attributes
  - **voltage coefficient for 1 transfo**
  - **voltage coefficient for 2 transfos**
  - **voltage coefficient for 3 transfos**
  - **voltage coefficient for 4 transfos**

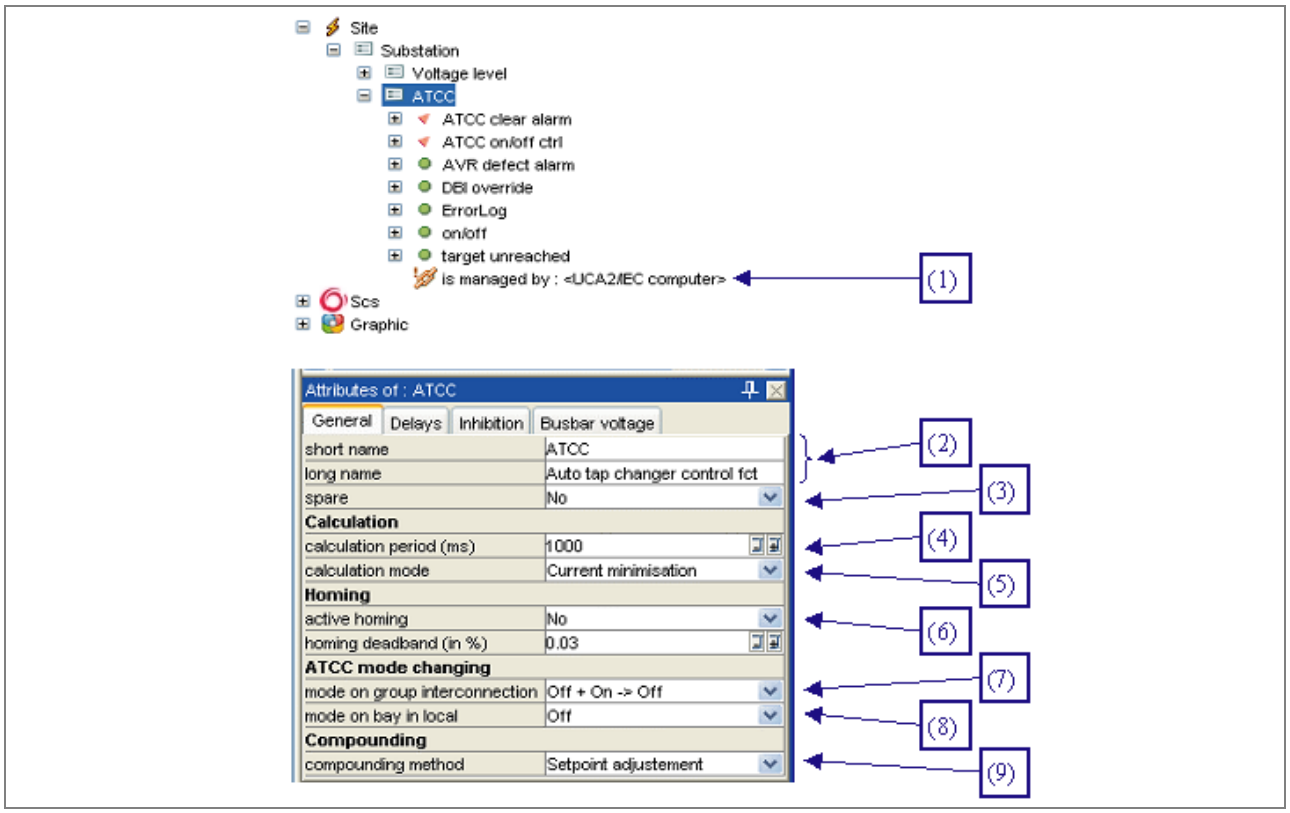


Figure 293: Setting the General features of an ATCC

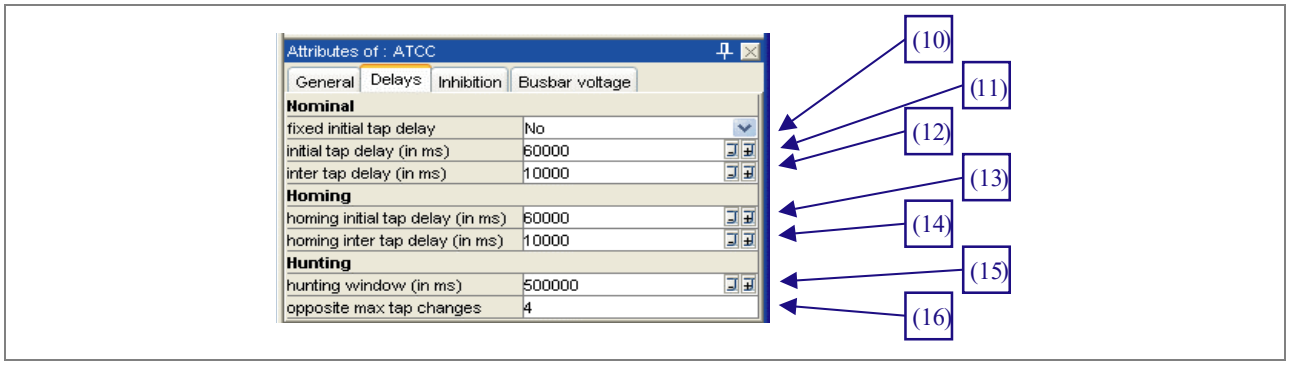


Figure 294: Setting the Delays attributes of an ATCC

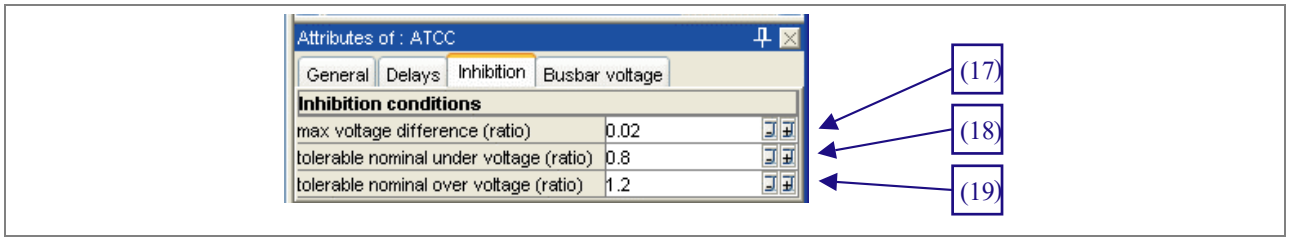


Figure 295: Setting the Inhibition attributes of an ATCC

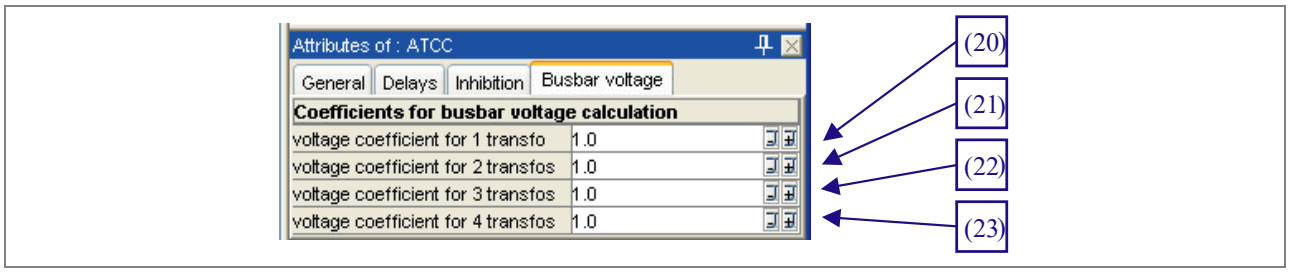


Figure 296: Setting the Busbar voltage attributes of an ATCC

When adding an ATCC to a substation, the following mandatory datapoints are automatically created and must be configured (see section *4 Defining a datapoint*):

(DPT_Sub 1) ATCC clear alarm SPC

(DPT_Sub 2) ATCC on/off control SPC

(DPT_Sub 3) AVR defect alarm SPS

(DPT_Sub 4) DBI override SPS

(DPT_Sub 5) ErrorLog SPS

(DPT_Sub 6) On/off SPS

(DPT_Sub 7) Target unreached SPS

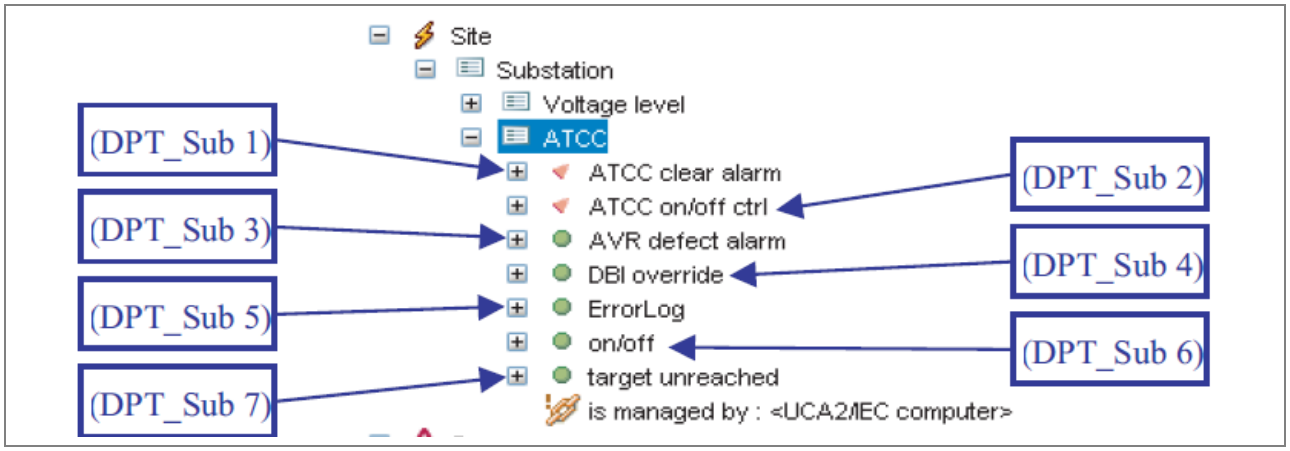


Figure 297: Mandatory datapoints for an ATCC at substation level

5.6.2.2 DEFINING AN ATCC FUNCTION'S REQUIREMENTS AT VOLTAGE LEVEL

For each voltage level containing a transformer concerned by an ATCC function, extra ATCC configuration must be done.

'General' attributes

This is done under SCE at voltage level, by setting the attribute '**ATCC existence**' to 'Yes' (1).

Then an extra 'ATCC' tab appears with the following attributes to update:

voltage targets attributes

(2) **voltage target by default**

(3) **voltage target 1**

(4) **voltage target 2**

(5) **voltage target 3**

(6) **voltage target 4**

(7) **voltage target 5**

'regulation' attributes

(8) **voltage target ramping rate (kV/mn)**

(9) **max tap change rate (kV/min)**

(10) **voltage deadband to end tapping**

(11) **voltage deadband to initiate tapping**

When a voltage level is concerned by an ATCC function, do not forget to set correctly its attribute 'nominal value (kV)' (see section *5.1.3 Defining a Voltage level*). It is used for transformer nominal ratio computation.

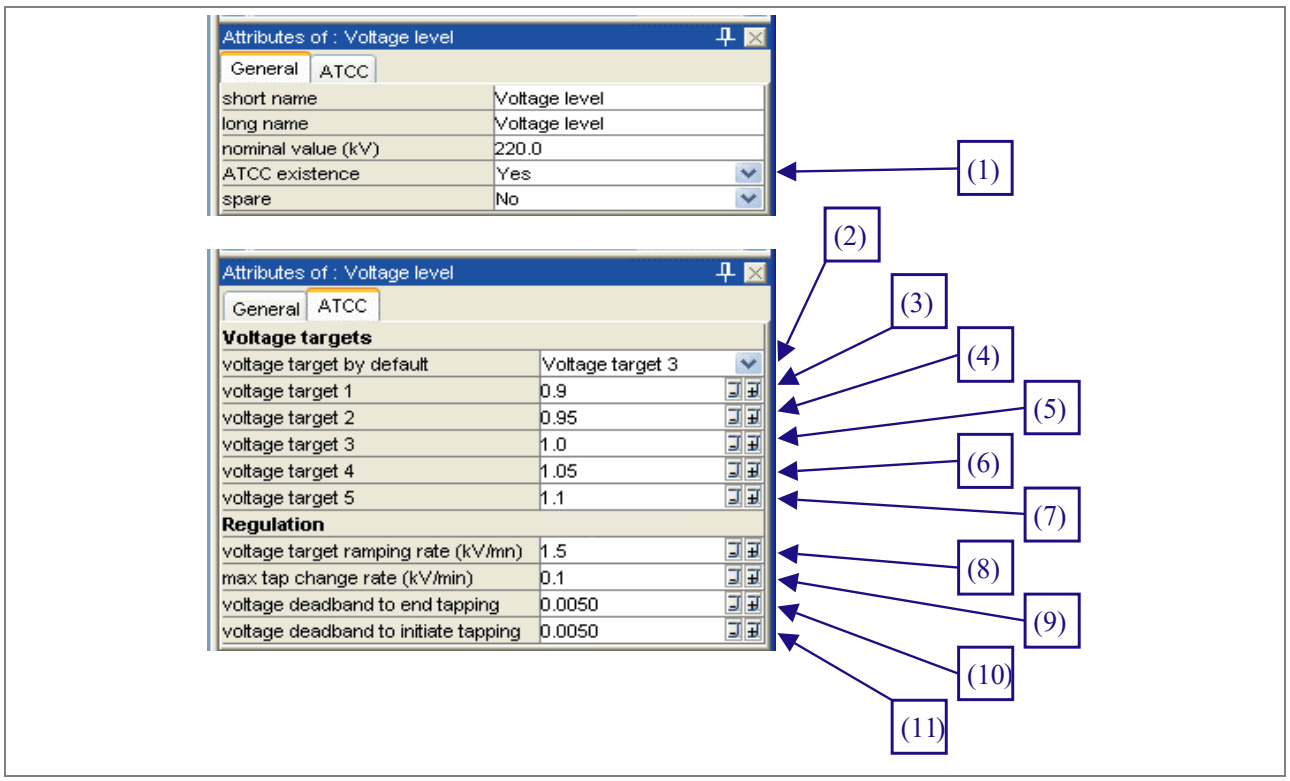


Figure 298: Setting the attributes of an ATCC function at voltage level

5.6.2.3 DEFINING AN ATCC FUNCTION'S REQUIREMENTS AT BUSBAR LEVEL

For each busbar bay concerned by an ATCC function, extra ATCC configuration must be done. For details about busbar bay creation, see section *5.1.4 Defining a Bay*.

This is done via the **Objects entry** window at busbar level by clicking on mouse's right button.

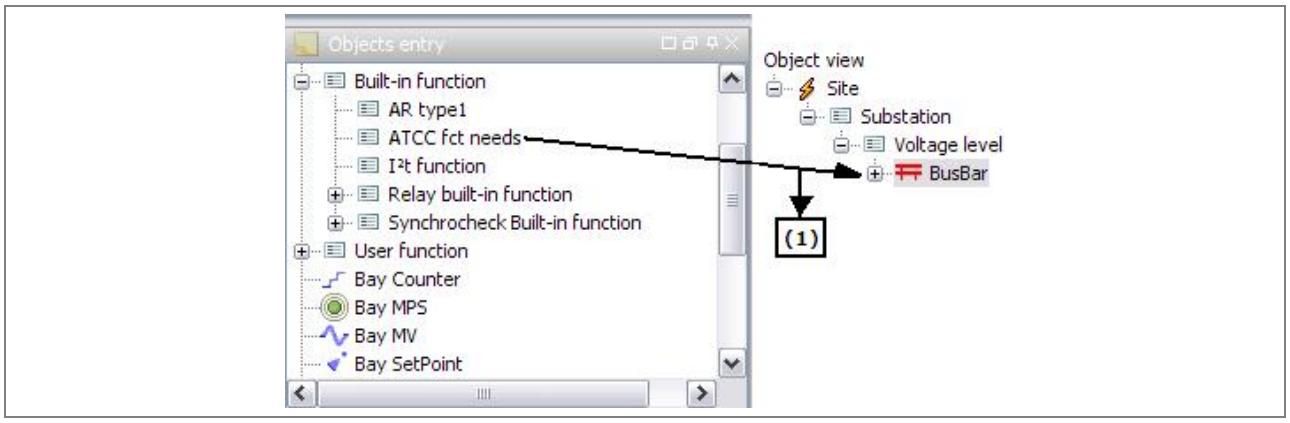


Figure 299: Adding an ATCC function's requirements at busbar level

Once added, ATCC busbar features must be set at SCE level:

'General' attributes

(1) **setpoint ponderation**

(2) **priority**

- 'line drop compensation (if setpoint adjustement)' attributes

(3) **resistive coefficient**

(4) **reactive coefficient**

- 'line drop compensation (if voltage adjustement)' attributes

(5) **transfo-busbar resistive coefficient**

(6) **transfo-busbar reactive coefficient**

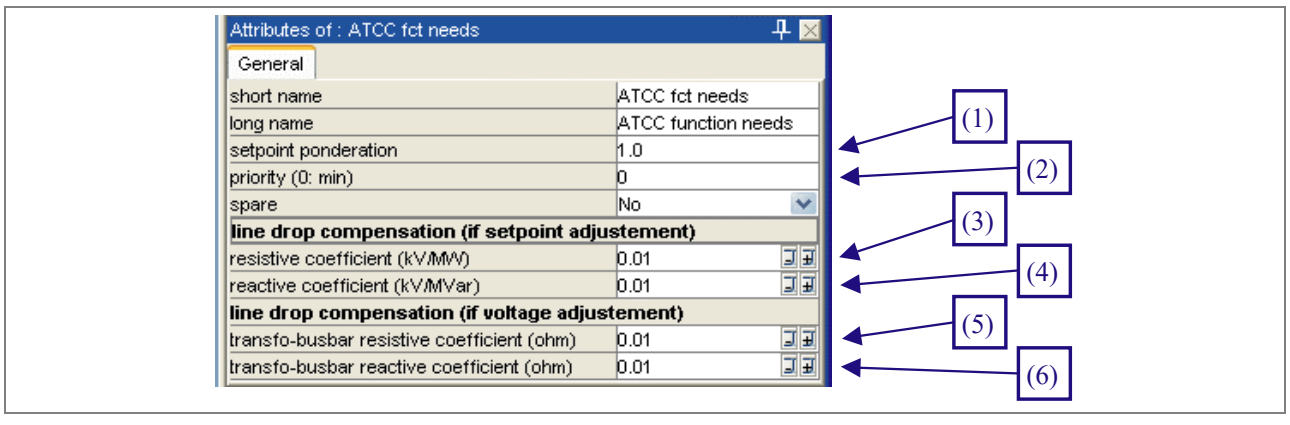


Figure 300: Setting the general busbar features of an ATCC

When adding an ATCC function needs at busbar level, the following mandatory datapoints are automatically created and must be configured (see section *4 Defining a datapoint*):

(DPT_Bb 1) ATCC inhibited

(DPT_Bb 2) ATCC inv module
(DPT_Bb 3) ATCC inv voltage
(DPT_Bb 4) ATCC max transfo
(DPT_Bb 5) ATCC on/off
(DPT_Bb 6) ATCC on/off ctrl
(DPT_Bb 7) ATCC targ 1 ctrl
(DPT_Bb 8) ATCC targ 2 ctrl
(DPT_Bb 9) ATCC targ 3 ctrl
(DPT_Bb 10) ATCC targ 4 ctrl
(DPT_Bb 11) ATCC targ 5 ctrl
(DPT_Bb 12) ATCC target 1
(DPT_Bb 13) ATCC target 2
(DPT_Bb 14) ATCC target 3
(DPT_Bb 15) ATCC target 4
(DPT_Bb 16) ATCC target 5
(DPT_Bb 17) ATCC to target
(DPT_Bb 18) BusBar voltage

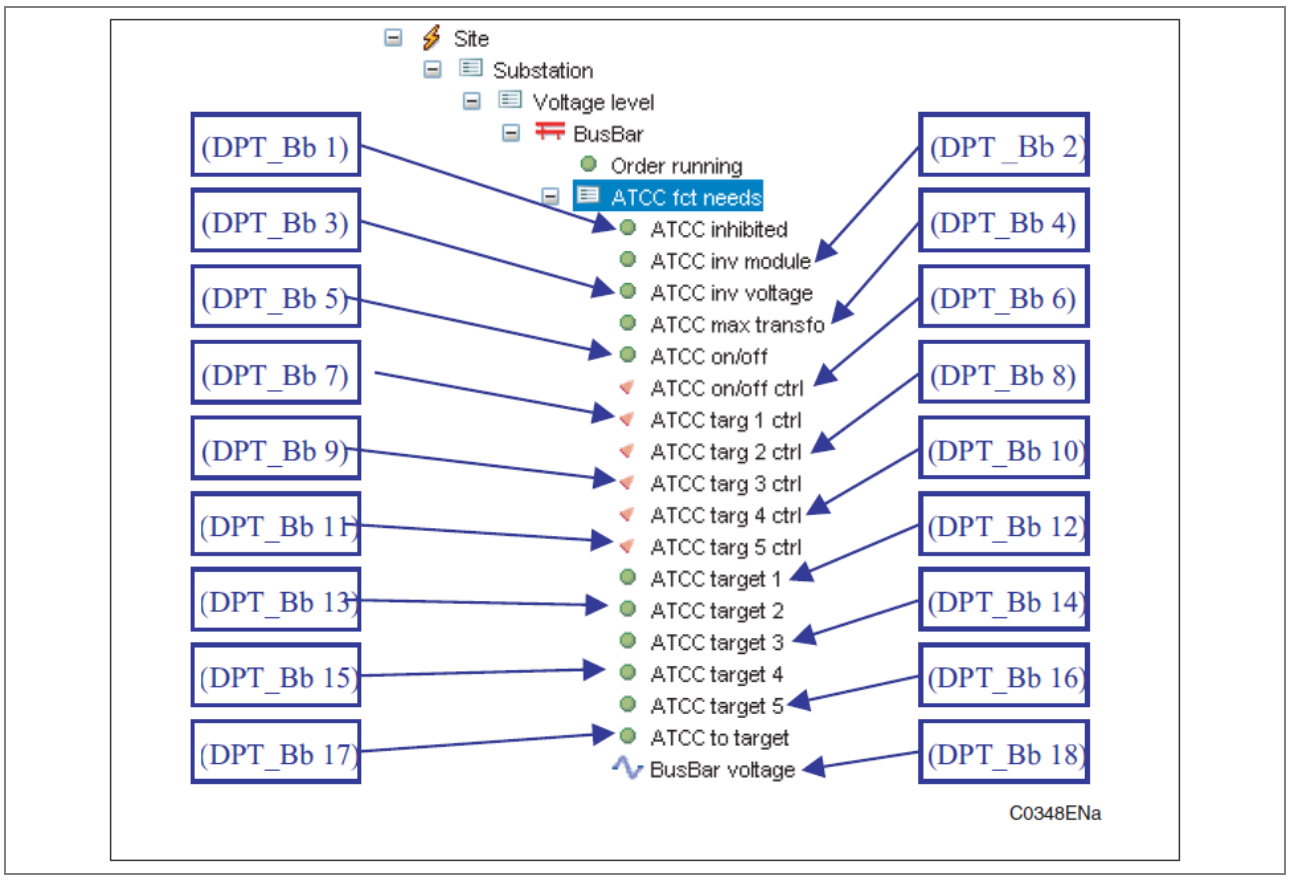


Figure 301: Mandatory datapoints for an ATCC at busbar level

5.6.2.4 DEFINING AN ATCC FUNCTION'S REQUIREMENTS AT TRANSFORMER LEVEL

For details about transformer bay (and subsequent transformer module) creation, see section *5.1.4 Defining a Bay*.

For each transformer concerned by an ATCC function, extra ATCC configuration must be done at several levels:

- Set properly the following features for transformer module:
- 'Transformer type' attribute
- 'Power value' attribute: (range [1, 300 MVA]).
- 'Impedance' attribute, whose unit is a percent of value for S=100 MVA (range [0,01 to 24,99 by step 0,01):
- MCB position SPS or DPS is mandatory (see section *5.1.5.7 Defining a transformer*).
- Add and configure a Tap-changer built-in function for the transformer module (see section *5.4 Defining a Tap changer built-in function*), with the following features:
- Raise/Lower DPC is mandatory
- Tap in progress SPS is mandatory
- MCB open SPC is mandatory
- Add and configure an 'ATCC fct needs' object for transformer, via the **Objects entry** window at transformer module level by clicking on mouse's right button (1):

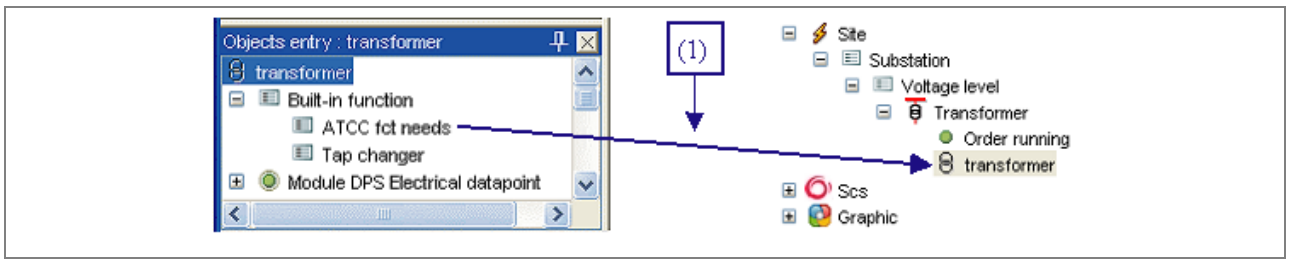


Figure 302: Adding an ATCC function's requirements at transformer level

Once added, the features of 'ATCC function needs for transformer' must be set at SCE level:

'General' attributes

- 'Tpi range' attributes

(1) **up range**

(2) **down range**

'Inhibition conditions' attributes

(3) **Overcurrent ratio**

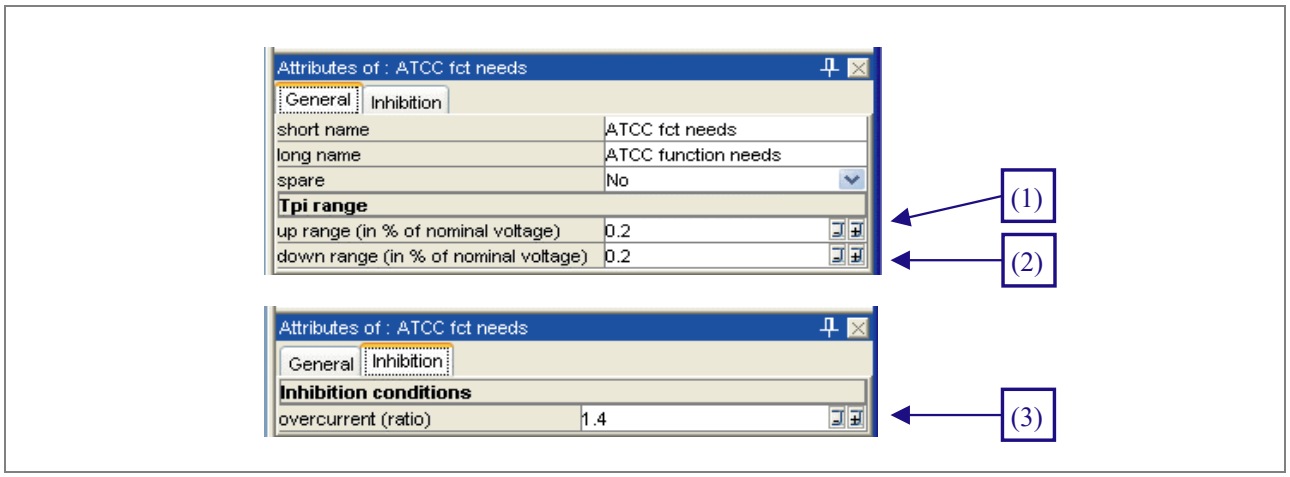


Figure 303: Setting the general transformer features of an ATCC

When adding ATCC function needs at transformer level, the following mandatory datapoints are automatically created and must be configured (see section *4 Defining a datapoint*):

(DPT_Trf 1) ATCC on/off

(DPT_Trf 2) ATCC homing

(DPT_Trf 3) ATCC hunting

(DPT_Trf 4) TAP bad TCIP

(DPT_Trf 5) TAP long TCIP

(DPT_Trf 6) TAP invalid

(DPT_Trf 7) Run away

(DPT_Trf 8) ATCC disc eqpt

(DPT_Trf 9) ATCC local bay

(DPT_Trf 10) MCB trip

(DPT_Trf 11) ATCC overcurrent

(DPT_Trf 12) ATCC overvoltage

(DPT_Trf 13) ATCC low-voltage

(DPT_Trf 14) ATCC inv voltage

(DPT_Trf 15) Second. voltage

(DPT_Trf 16) Second. current

(DPT_Trf 17) Second. active P

(DPT_Trf 18) Second. react. Q

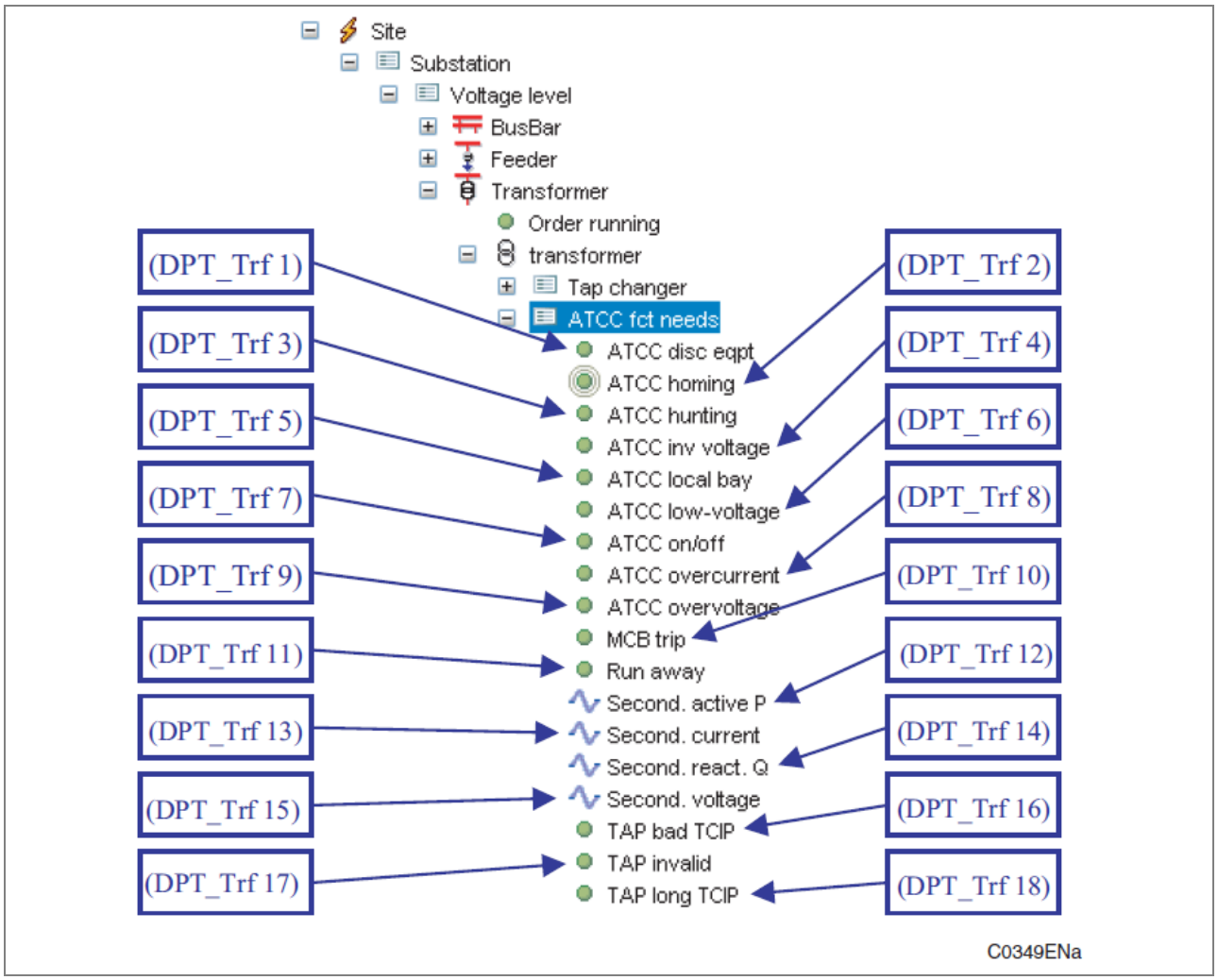


Figure 304: Mandatory datapoints for an ATCC at transformer level

5.6.2.5 DEFINING THE ELECTRICAL TOPOLOGY FOR AN ATCC FUNCTION

For correct behaviour of ATCC function, electrical topology of the LV side, including connection of the transformer to the busbar and coupling of busbars into the LV level must be defined.

Any electrical topology can be defined by modules interconnected by nodes.

A node is in relation with at least on module. The most common “node” is busbars.

Electric modules are mostly dipoles. Switchgears and circuit-breakers are connected to two nodes. Special module cases are:

- motor/generator that are connected to only one node,
- line arrival that is a node,
- special (German) double switch, in fact association of earth switch and disconnector,
- transformer connected to 3 nodes but the third node is reserved to neutral compensation.

At SCE level, nodes are special attributes of module, whose values are given by integers. Each identified node in the electrical topology has a unique arbitrary value. Two interconnected modules share the same node value. The best practice to value nodes is to do it directly from the substation electrical diagram.

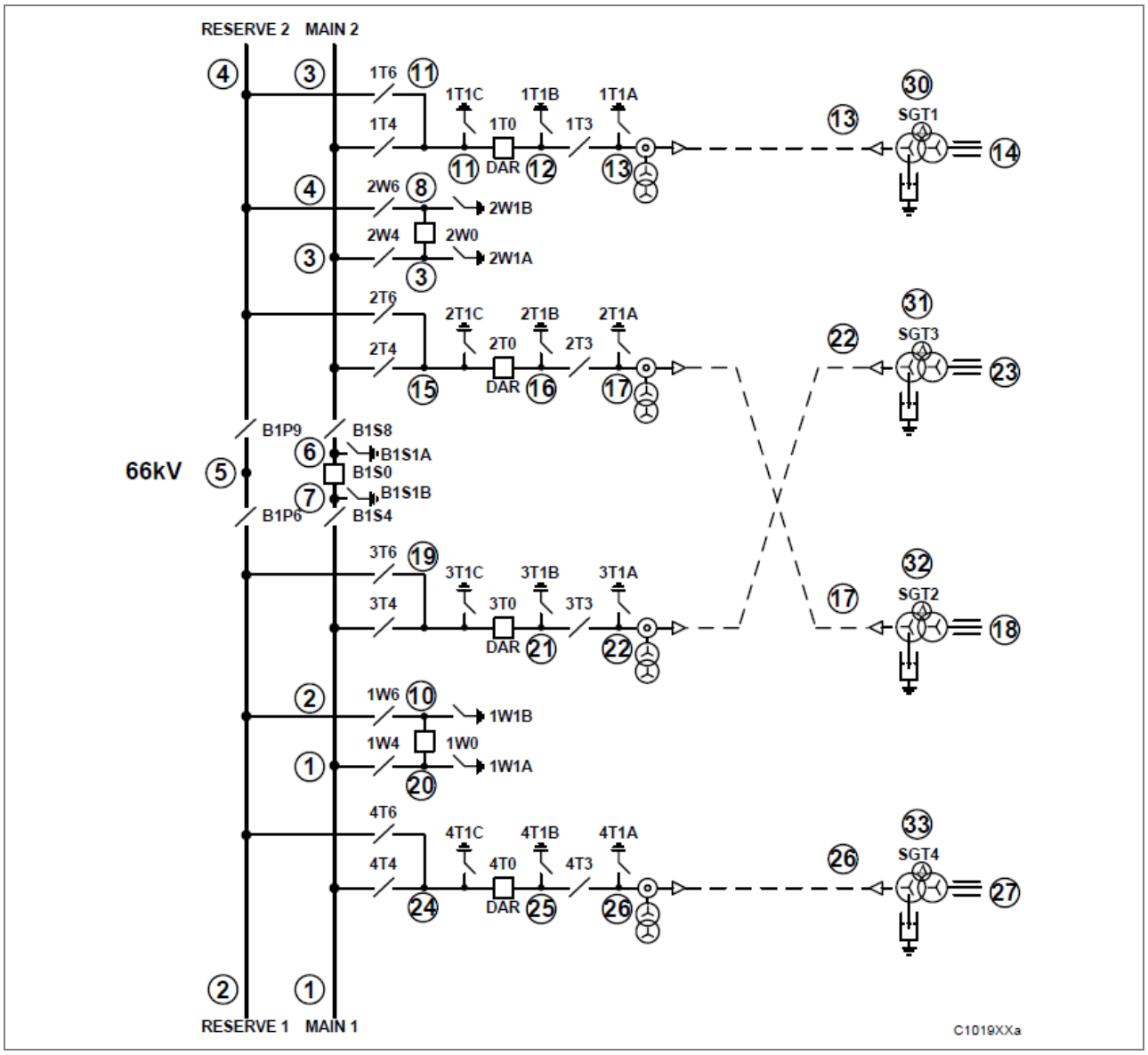


Figure 305: Identifying nodes in an electrical diagram (example)

This manual approach of nodes identification must be projected at SCE electrical object level:

- “Busbar” bay, where one node reference must be filled (1),
- “External line” module of “Feeder” bay, where one node reference must be filled (2),
- “Circuit-breaker” and “Switchgear” module, where two node references must be filled (3),
- “Transformer” module, where at least two node references must be filled, and a extra one in case of neutral compensation (4),
- “Capacitor” & “inductor” module, used for neutral compensation, where one node reference must be filled (5); it corresponds to the neutral node of the associated transformer.

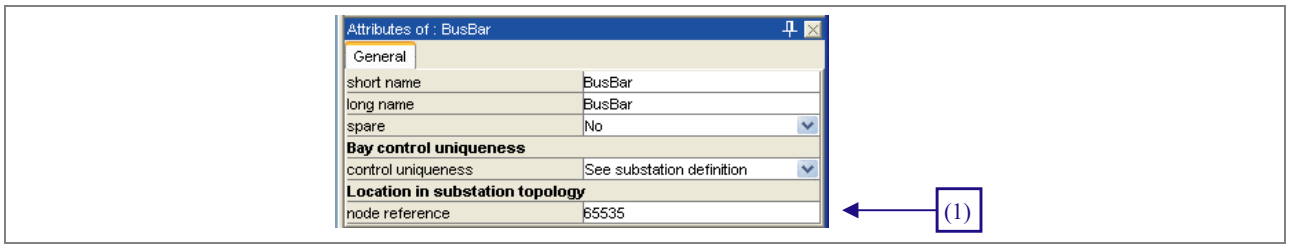


Figure 306: Setting the busbar node reference (ATCC function)

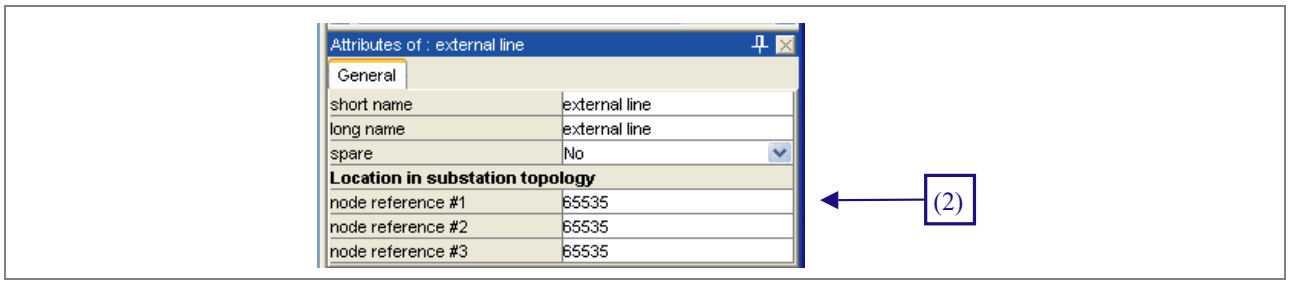


Figure 307: Setting the external line node references (ATCC function)

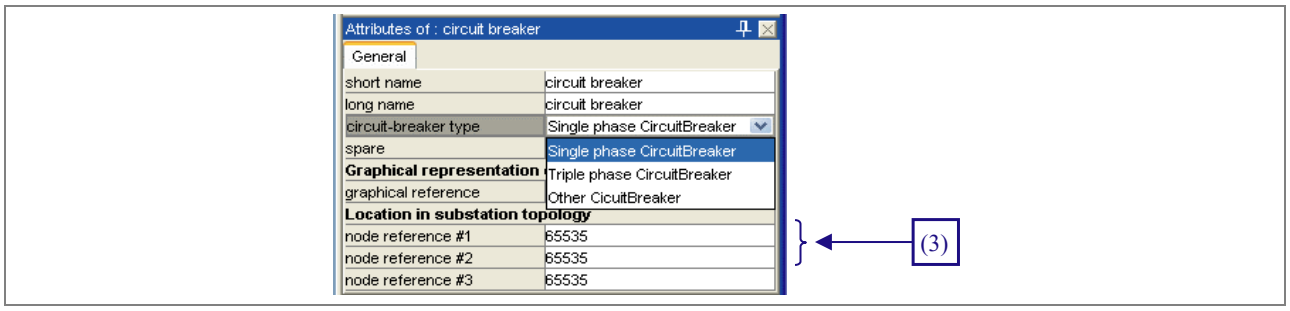


Figure 308: Setting the circuit-breaker node references (ATCC function)

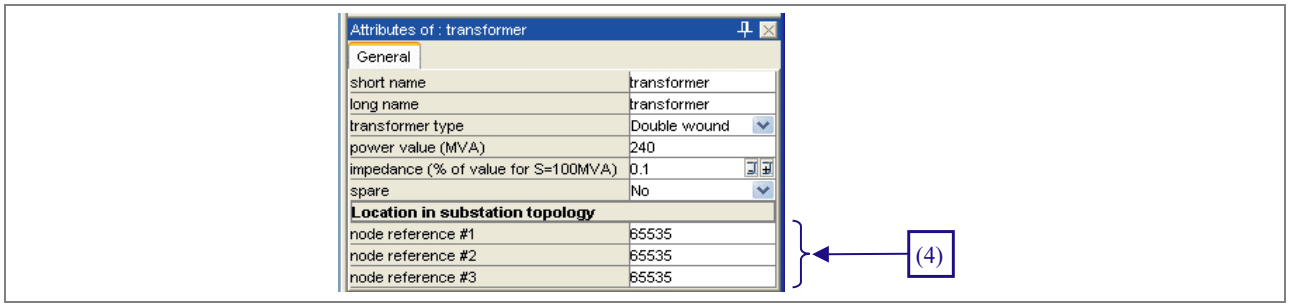


Figure 309: Setting the transformer node references (ATCC function)

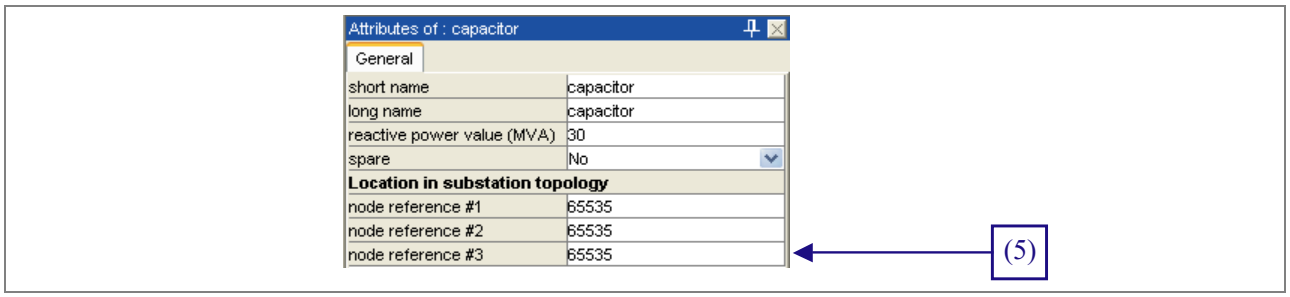


Figure 310: Setting the capacitor node references (ATCC function)

5.7 DEFINING AN ELECTRICAL REGULATION BY USER FUNCTION

DS Agile allows the user to configure specific control sequences or automations (e.g. switching sequences, busbar transfer, load shedding, GIS-pressure supervision, etc …) during the configuration phase.

To do that, there are two main solutions:

- Using ISaGRAF workbench for slow automations, where the execution of the automation is cyclic, based on a cycle that can not be less than 50 ms.
- Using extended logical function modeling (Boolean, timer, bistable functions) via FBD workbench, where the execution is event-driven.

User function can be put at any level of the electrical topology except Site. Moreover, slow automation is unavailable at module level. User function must always specify on which C26x it runs.

or details, refer to the **Application** chapter of the **SCE** user manual.

Extra solutions for simpler needs exist at configuration level (they could be seen as restriction of particular FBD functions):

- Group modeling: SPS production based on a pre-defined Boolean function working on a set of datapoint.
- xPS-xPC association: on a particular state of xPS, ability to control a given xPC.
- SPS-DPS association: DPS production based on the synthesis of 2 SPSs.
- Interlocking definition: production of virtual SPS datapoints used to control opening and/or closure of modules. These virtual datapoints are defined through specific FBD logical diagrams where inputs are generally breaker and switch positions.
- Automatic/manual dependency set at control level (SPC, DPC or SetPoint): when a control is linked to an SPS or DPS via the automatic/manual dependency, control is refused if the SPS (resp. DPS) is in the SET (resp. CLOSED) state.

5.7.1 DEFINING A GROUP

A group is a logical OR, AND, NOR or NAND combination of "inputs" whose type is SPS, DPS, or groups. An input can belong to several groups. Datapoint grouping is configured in the SCE using the specific SPS called '**Group SPS**' in data modelling

A "Group SPS" can be added to any type of bay or module (except circuit-breaker). The C26x that manages the bay (or the bay containing the module) computes it.

A group SPS can be seen as a particular fast automation reduced to one Boolean function (gate) with one implicit output (the group SPS itself) and inputs corresponding to each component of the group.

5.7.1.1 DEFINING A GROUP OF DATAPOINTS

To add a "Group SPS":

1 Click on the bay or module in the electrical topology,

2 In the **Object entry** panel, right-click on the "**Group SPS**" datapoint and then, select **Add** from the context menu.

For details on electrical topology creation, see section *5.1 Defining an electrical topology*.

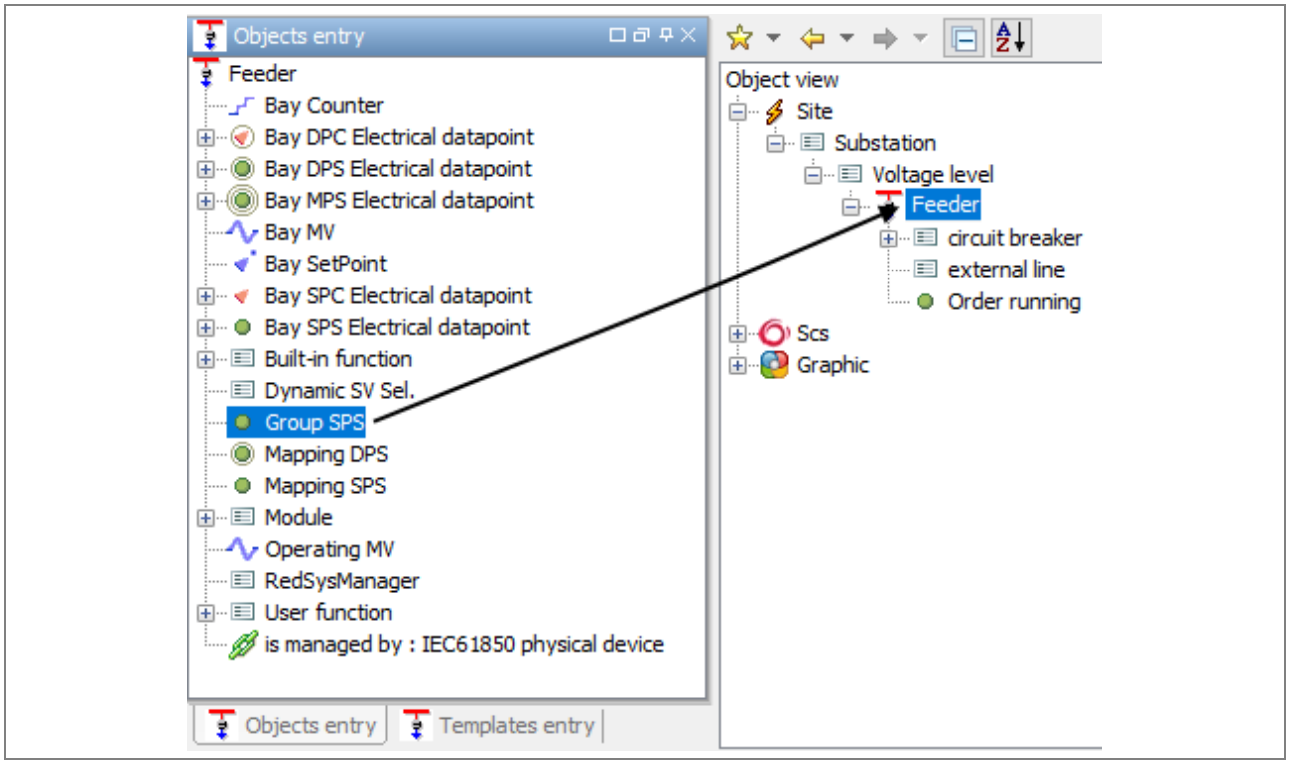


Figure 311: Adding a group SPS (example for a feeder at bay level)

Once added, set the "Group SPS" features at SCE level, as SPS datapoint. For details about SPS datapoint configuration, see section *4.3.1 Defining an SPS datapoint*.

Nevertheless, the specific attribute **operator type** (1) must be set for the group. It corresponds to the logical operator (OR, AND, NOR or NAND) applied on all the inputs (datapoints) of the group.

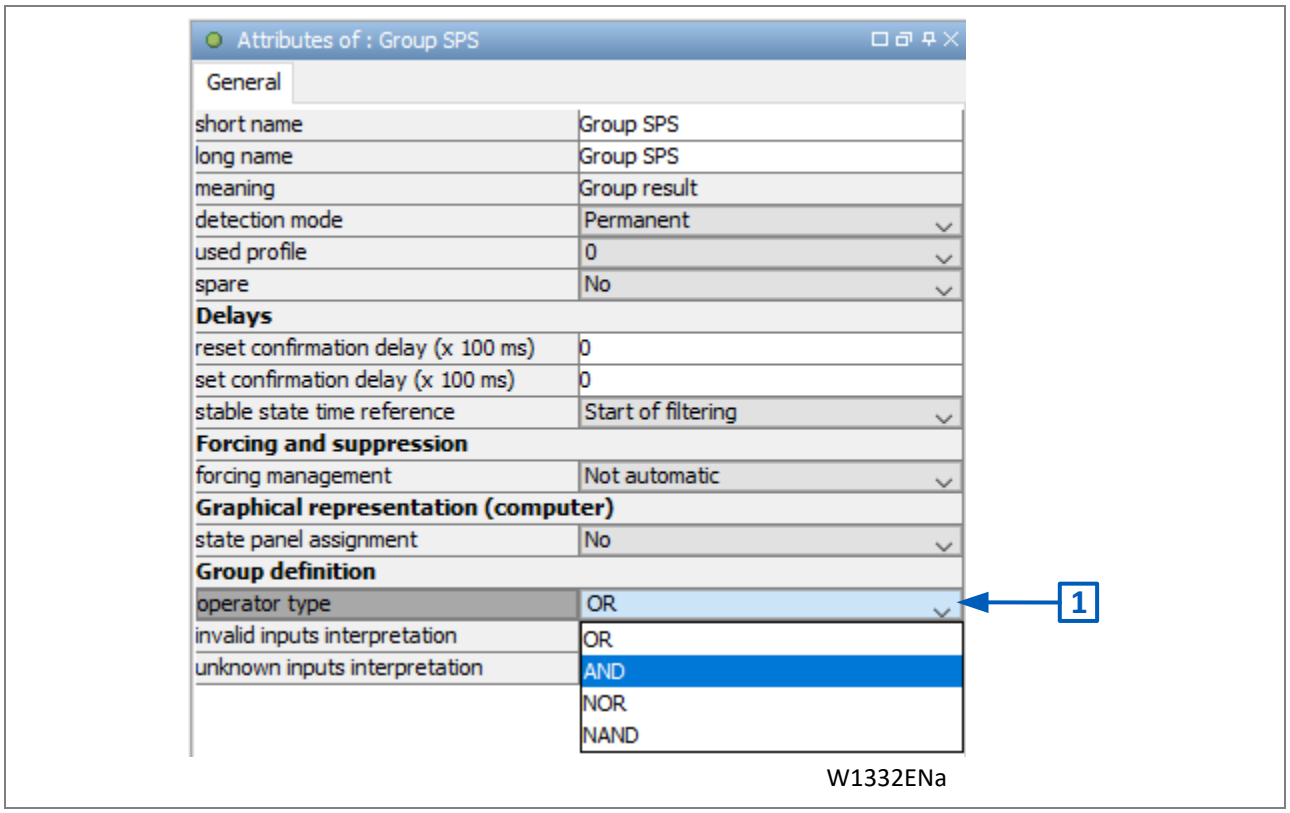


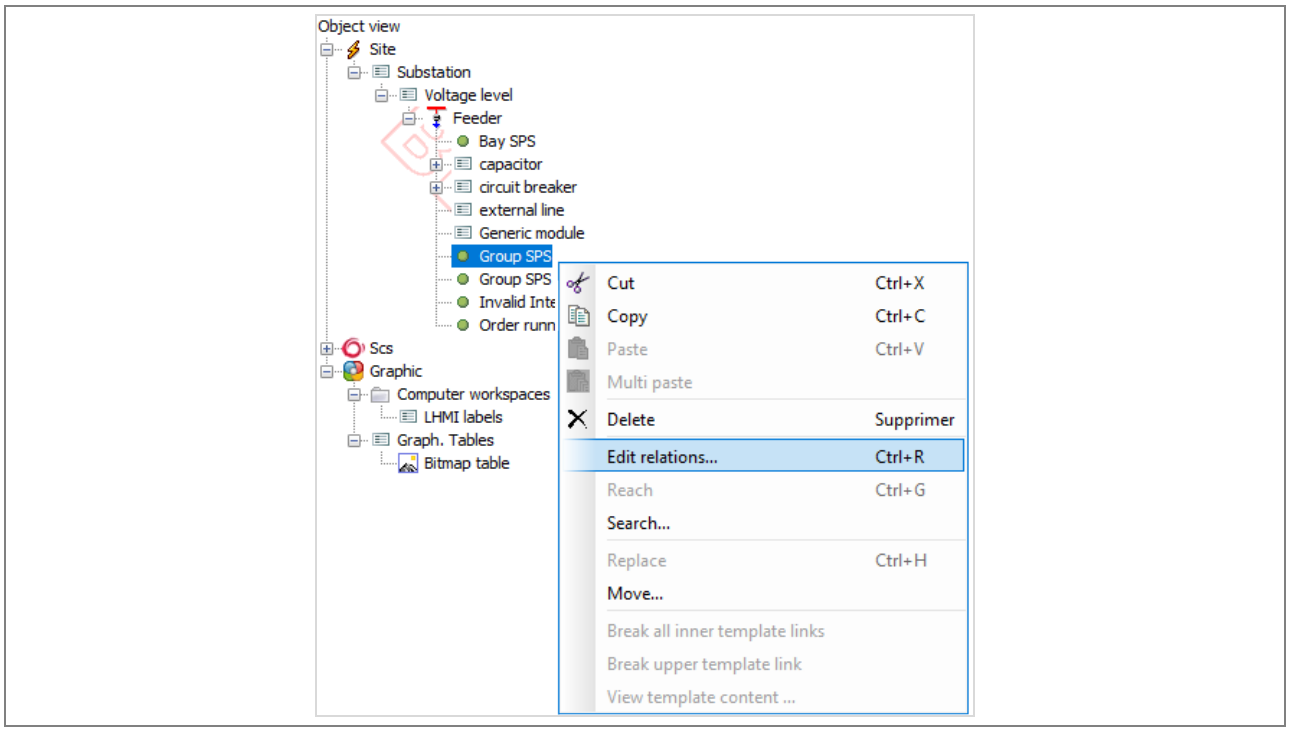
Figure 312: Setting the Group type attribute of a group SPS

Note:
*The attributes **Invalid input interpretation** and **Unknown input Interpretation** are used only when the bay and the Group SPS is managed by a Gateway. They are not taken into account for a Group SPS managed by the C26x.*

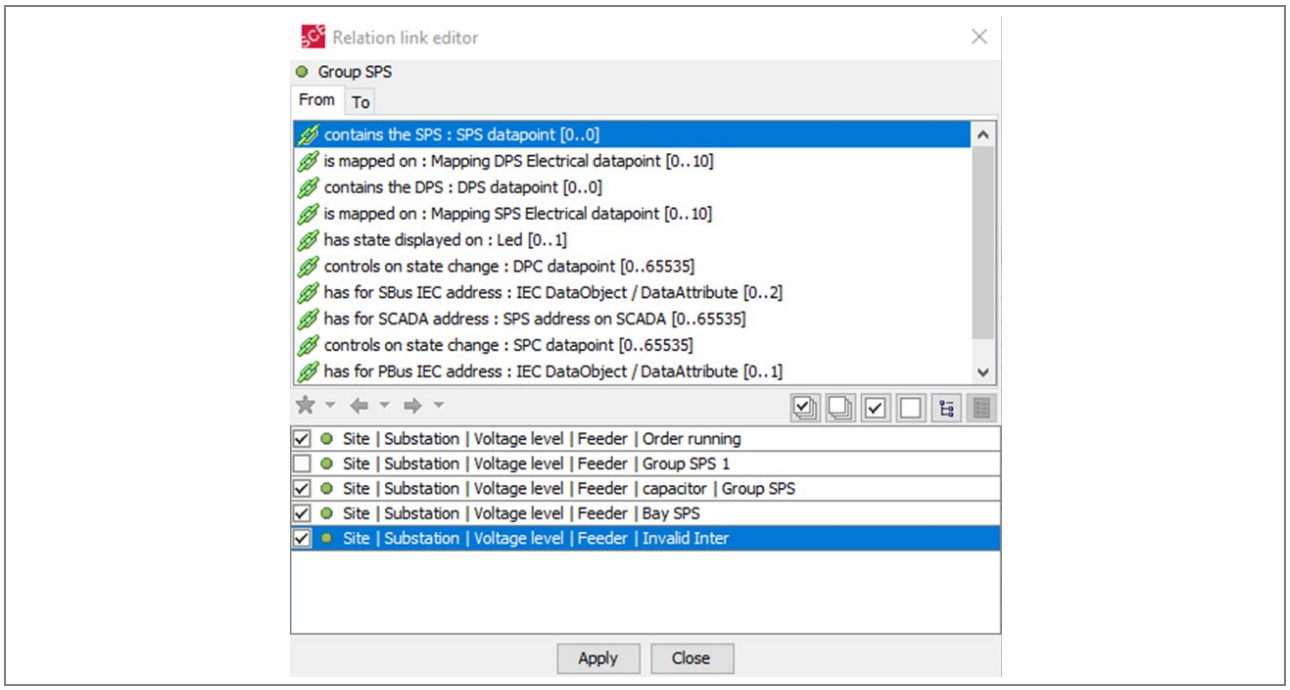
5.7.1.2 ADDING AN INPUT TO A GROUP OF DATAPOINTS

To add several inputs to a group of datapoints (SPS, DPS or group):

- Right-click on the "**Group SPS**" and select **Edit relations…** from the context menu:



- In the **From** tab, select the relation **contains the <XXX>** at "**Group SPS**" level, where XXX corresponds to the datapoint type (SPS, DPS)
- Then, fill in the relation by selecting the relevant datapoints at the bottom of the window and click **Apply** to validate your selection:



If you need to add a single input:

- Click on the “**Group SPS**” in the electrical topology,
- In the **Object entry** panel, right-click and add the relation **contains the <XXX>** at “**Group SPS**” level, where XXX corresponds to the datapoint type (SPS, DPS),

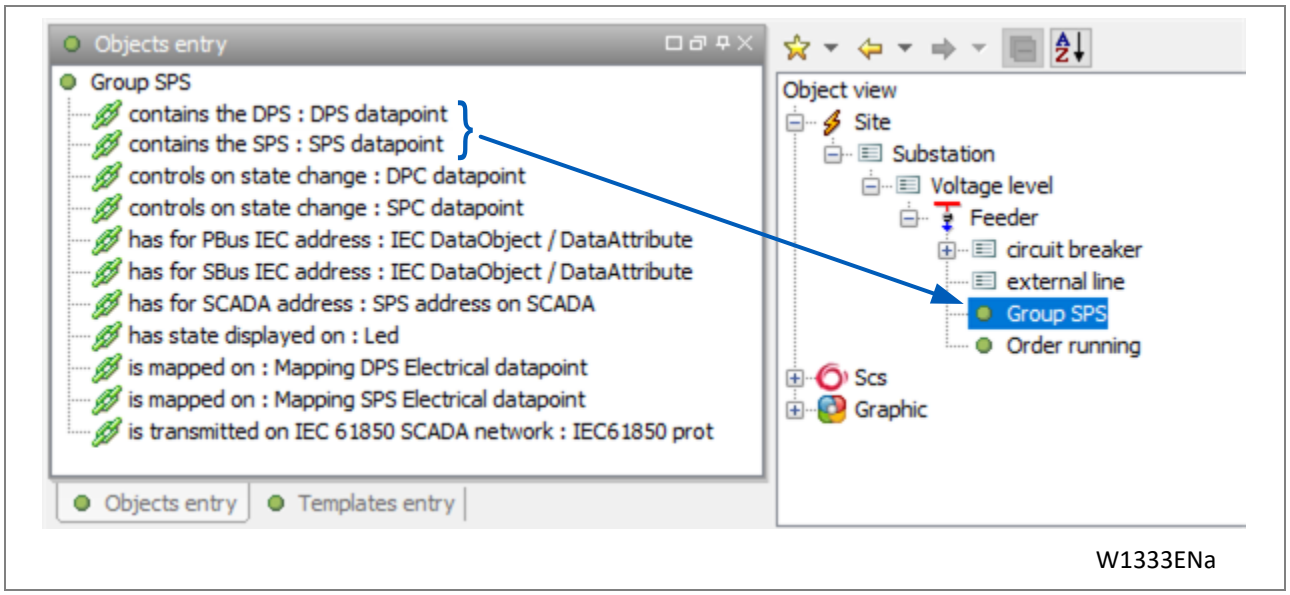


Figure 313: Adding a component (input) to a group

- Then, fill in the relation by selecting the relevant datapoint.

Configuration rules and limits

- The same datapoint whatever it is an SPS, DPS or MPS cannot be used several times in the same Group SPS.
- The maximum number of “Group SPS” managed by a C26x is **512**.
- In a bay managed by a C26x, the “Group SPS” can contain up to **255** datapoints (not spared).
- The 'Group SPS' imbrication level is limited to 8.
- In a "Group SPS", input datapoints from other devices are transmitted through IEC Report Control Block only.
- A datapoint (SPS, DPS or MPS) can not belong to more than **100** groups.

5.7.2 CONTROLLING AN XPC USING AN XPS STATE CHANGE

For specific needs, some SPS or DPS can act on SPC or DPC. This relation is called xPS-xPC association. Such an acted xPC may or may not need a channel for wiring. It can be an xPC used for automation management for instance.

The link defines for each state of the xPS which order must be sent.

To create such a relation:

- Add the relation **controls on state change** (1) at SPS/DPS level; two relations are available depending on control type to act (SPC or DPC). Choose the correct one.
- Fill the relation with the relevant SPC or DPC (2).
- Set the relation attributes (3) giving for each state of the xPS, the order to send: *None*, *Open (resp. Off)* or *Close (resp. On) for DPC (resp. SPC)*.

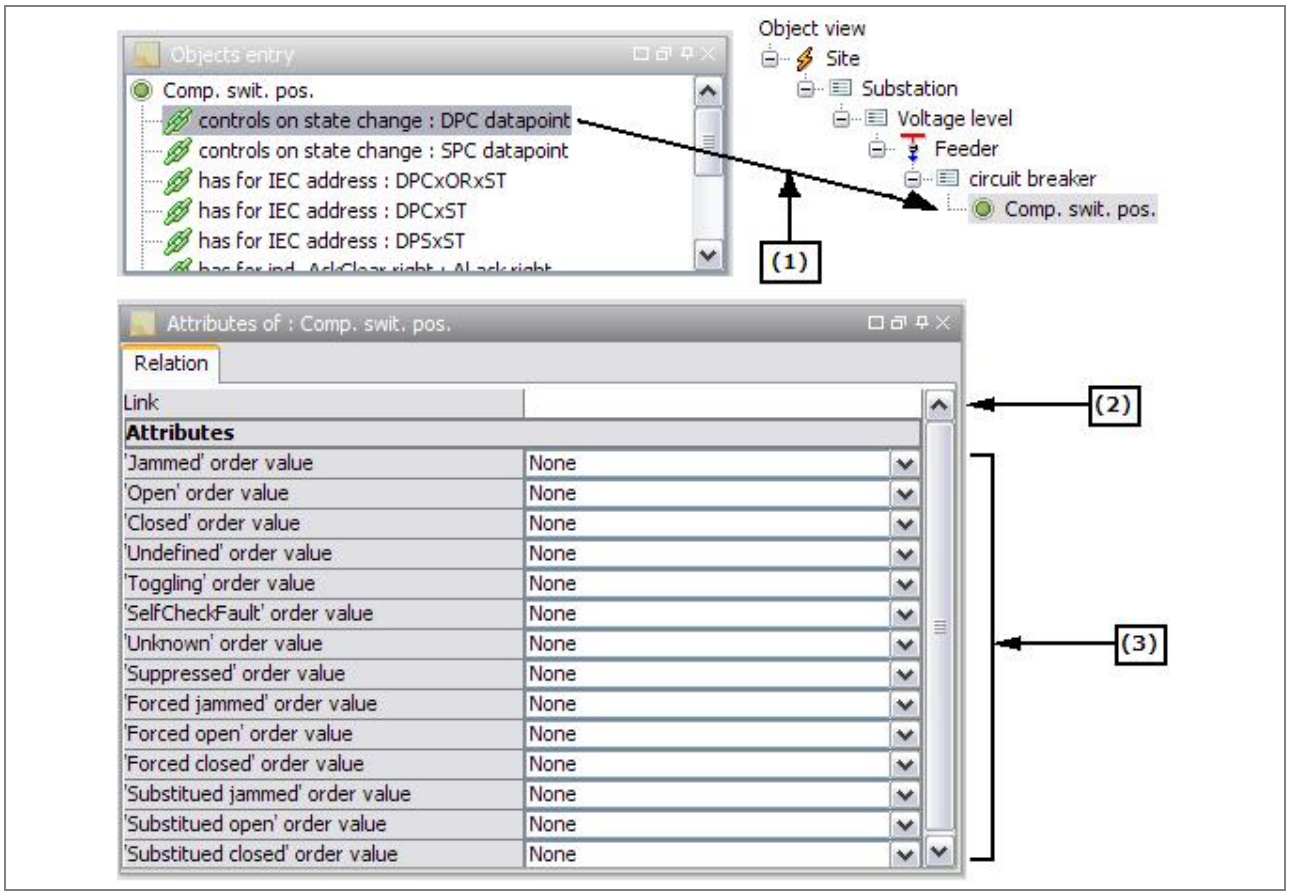


Figure 314: Controlling an xPC using an xPS state change (example)

New attribute: **Control**, whose values can be

- “direct to output relay” i.e. the xPS activates directly the associated xPC
- “through control sequence” i.e. the xPS activates a full control sequence

In case of controls launched by an xPS, the Control Originator fields are:

- orCat = Bay level
- orIdent = xPS label

5.7.3 PRODUCING A DPS FROM 2 SPSS

For specific needs, two SPSs (one for open state, and the other for closed state) can be used to manage a DPS. This relation is called SPS-DPS association.

To produce a DPS from two SPS:

- Create the three datapoints and configure them (see section *4 Defining a datapoint*)
- At the DPS level, add the relations **has open state given by** (1) and **has closed state given by** (2)
- Fill the two relations with the previously created SPS datapoint

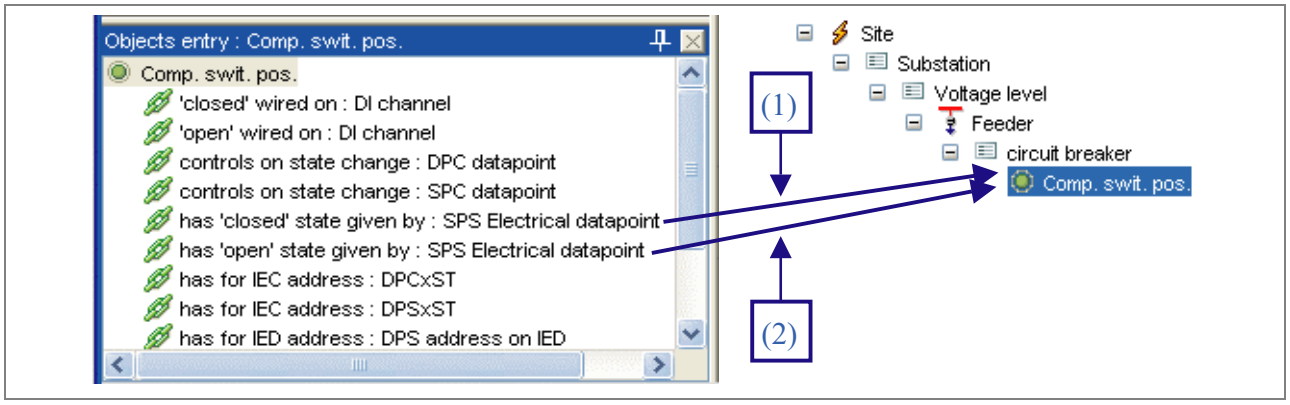


Figure 315: Producing a DPS from 2 SPSs (example)

5.7.4 DEFINING AN INTERLOCK

Any DPC (or SPC) belonging to a bay or module can have interlocking equation for opening order and/or closing order.

Interlocking equation corresponds to a logical function that must be 'true' to send the order.

In data modeling, interlocking equations are under SPC or DPC by adding specific SPS:

- Close/lower interlock
- Open/raise interlock

These SPSs are the result of a function coded with the FBD editor. When the SPS value is true, the control is allowed.

Interlocking equation diagrams are identical to FBD fast automation diagrams, except that:

- timer, bistable function are unusable
- there is no output plug

To add an interlock SPS, select the SPC/DPC datapoint level and add the interlock SPS from the contextual **Objects entry** window (1).

For details about electrical topology creation, refer section *5.1 Defining an electrical topology*

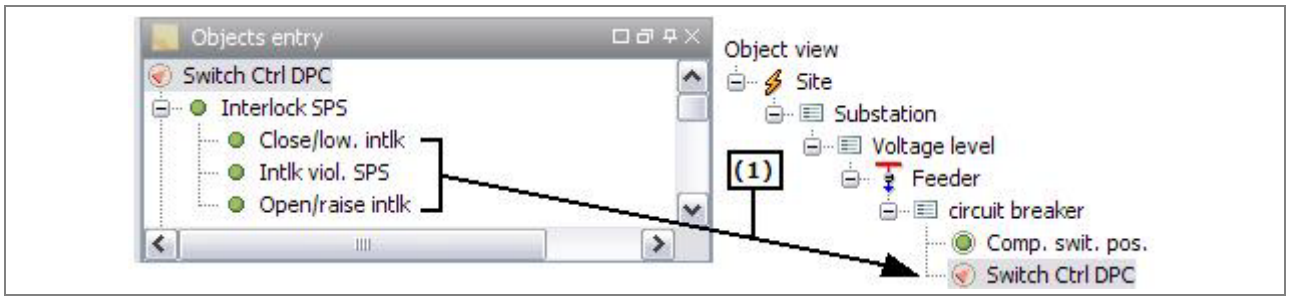


Figure 316: Adding an interlock SPS (example for a DPC)

Once added, interlock SPS features must be set at SCE level, as SPS datapoint. For details about SPS datapoint configuration, see section *4.3.1 Defining an SPS datapoint*.

To define interlocking equation for an interlock SPS:

- Add at interlock SPS level, an FBD interlock object (1):
- Configure this FBD interlock (see section *4.5 Defining an FBD fast automation* in SCE/EN AP), with the existing following restrictions:
  - Only input plugs are available for its interface definition.
  - For its body description via FBD editor, timer and bistable functions do not exist.

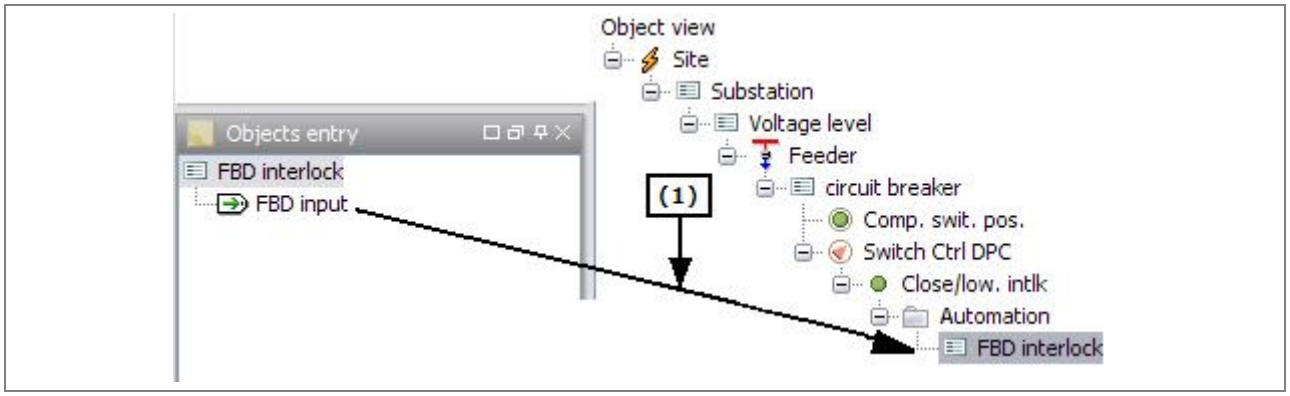
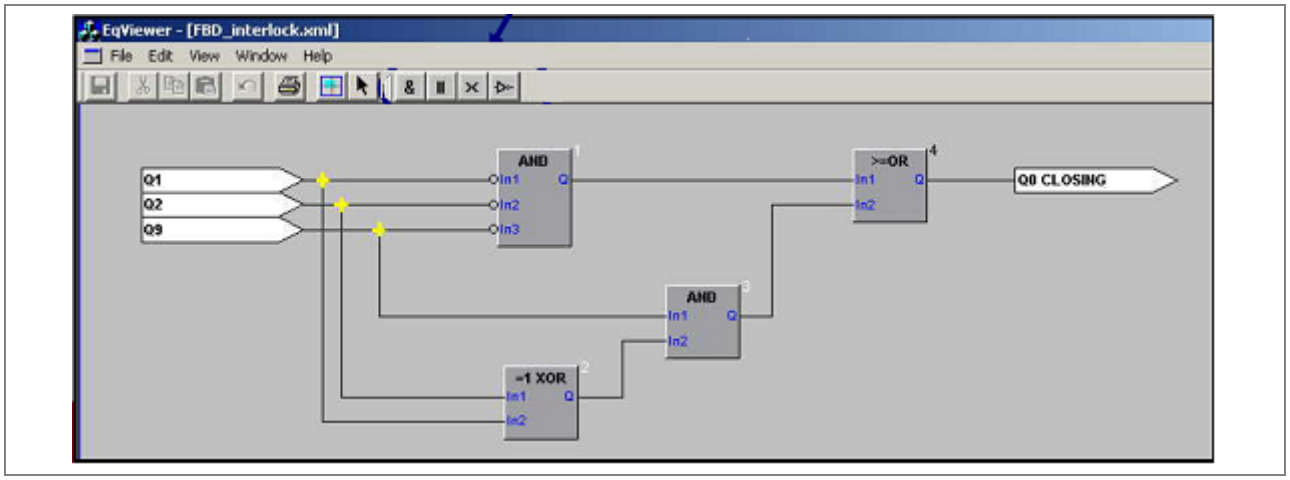


Figure 317: Defining the interlocking equation for an interlock SPS

Example



The optional SPS 'Intlk viol. SPS' is true when the control is rejected. It is used by some SCADAs which cannot know the reason of a NACK (especially with Modbus).

5.7.5 DEFINING AN AUTOMATIC/MANUAL DEPENDENCY

Automatic/manual dependency can be set at control level (SPC, DPC or SetPoint):
When a control is linked to an SPS or DPS via the automatic/manual dependency, control is refused if the SPS (resp. DPS) is in the SET (resp. CLOSED) state. To create an automatic/manual dependency:

- Add the relation **has for AutoManu dependency** (1) at control level; two relations are available depending on the input type setting the dependency (SPS or DPS). Choose the correct one.
- Fill the relation with the relevant SPS or DPS (2).

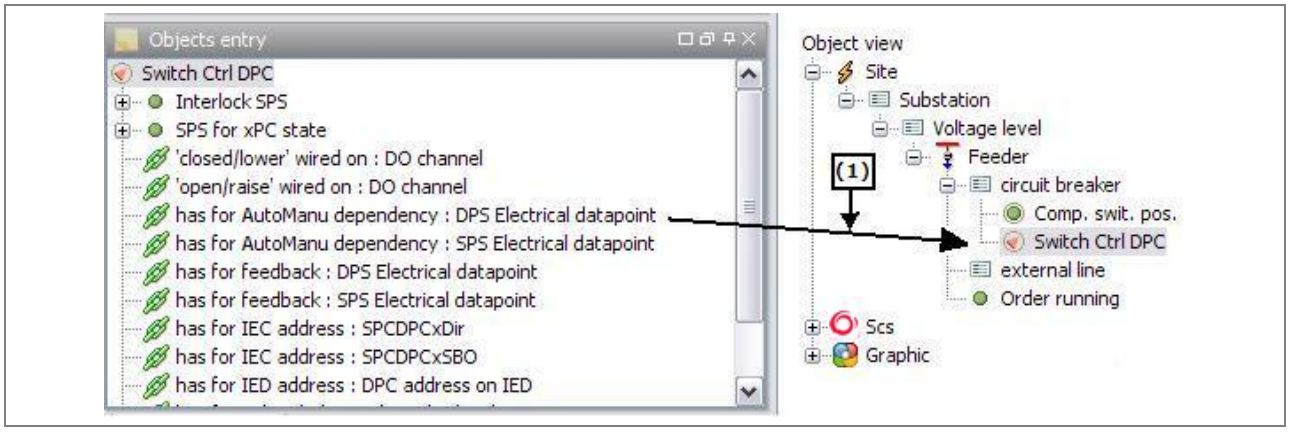


Figure 318: Defining an automatic/manual dependency (example)

Configuration rules and checks

- For each "DPC", "SPC" or "Setpoint" datapoint, 2 relations **has for AutoManu dependency** are available, but they are mutually exclusive.

5.8 DEFINING A LOAD APPLICATION (C26X-STANDALONE)

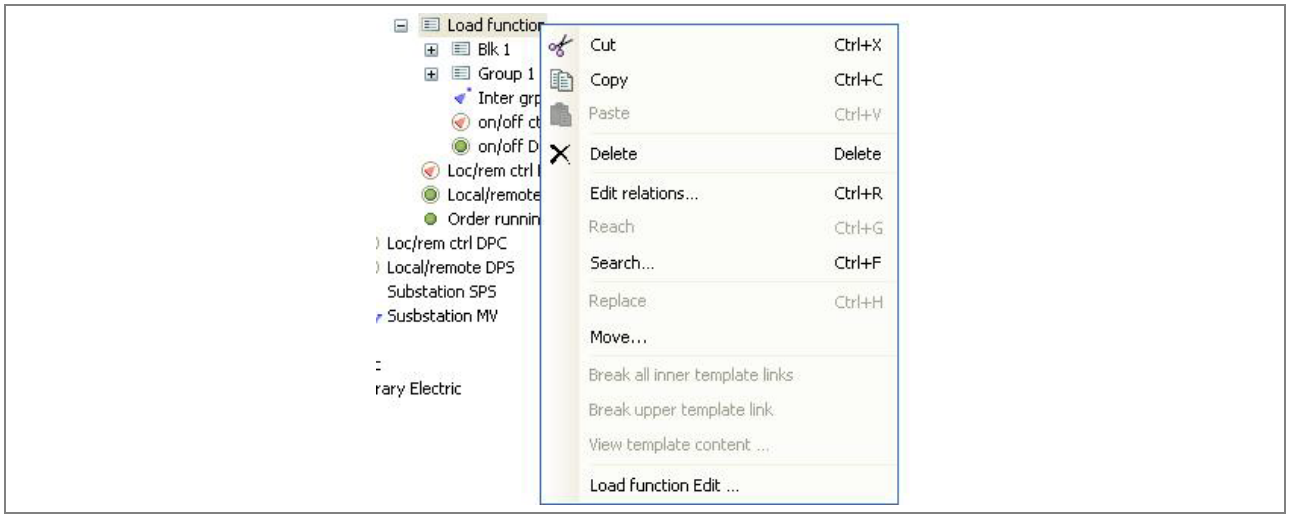
A Load function can be either a Load Shedding function or a Load Curtailment function. The "Type" attribute of "Load function" object allows selecting either. The creation of a Load function template cannot be done; it is only possible in Object mode.

All data points of a "Load function" object have a predefined profile. The user can change it if he/she wishes it.

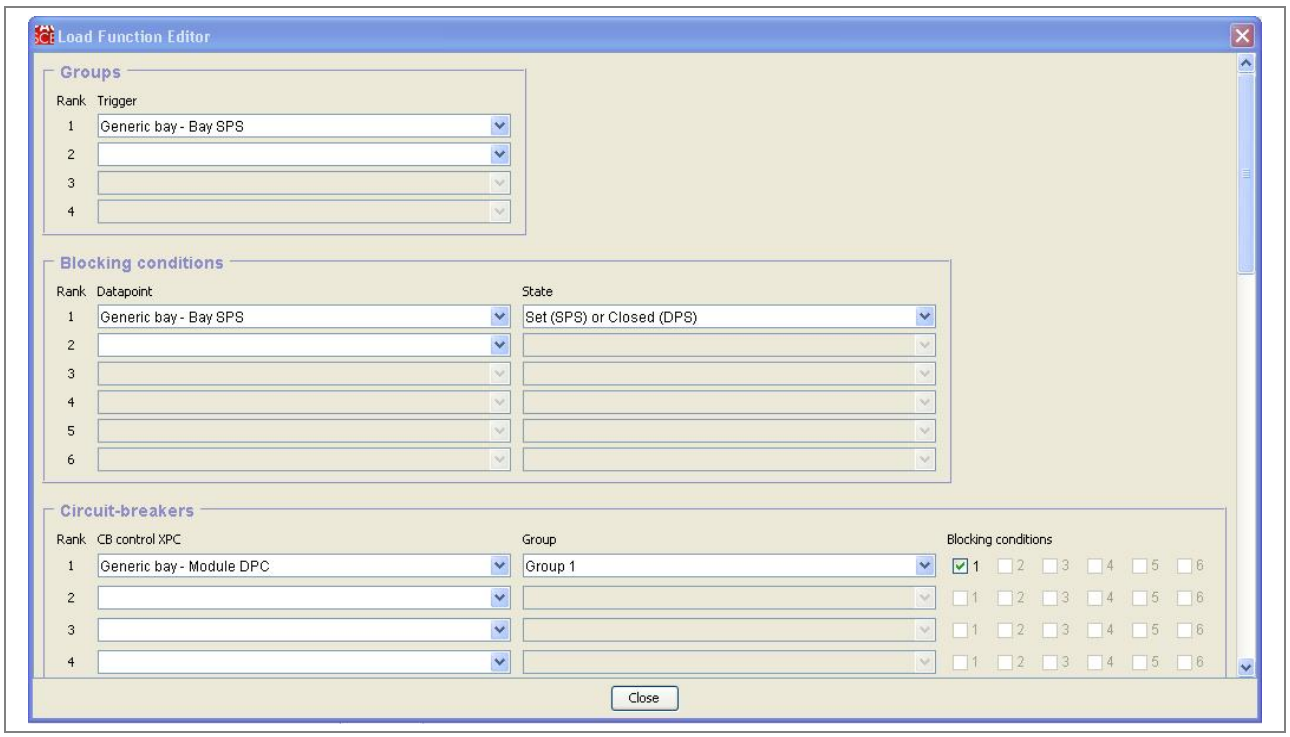
Restrictions on the "Load function" object and its children in the browser:

- Once the "Load function" object is edited, the user cannot change its type,
- No child of the "Load function" object can be added from the **Objects entry** window,
- No child of the "Load function" object can be deleted in the browser,
- The "Load function" object and its components cannot be ''spared'',
- The "number" attribute of a "Load group" is not modifiable,
- The "number" attribute of a "Load blocking" is not modifiable,
- No predefined profile available for data points of a "Load function" object can be deleted

The user can edit a “Load function” by the contextual menu **Load function Edit**:



Fill in the fields:

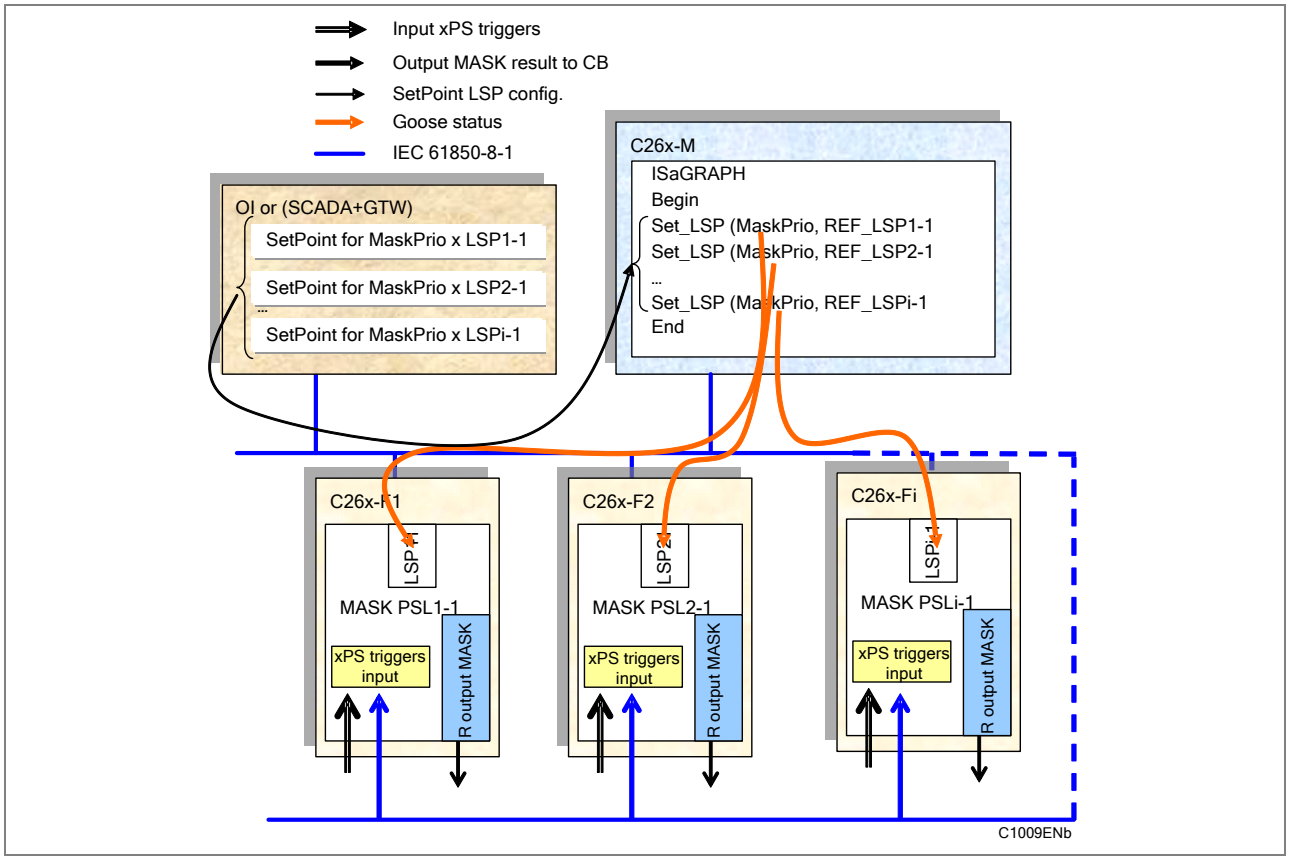


5.9 DEFINING A FAST LOAD SHEDDING APPLICATION

The Fast Load Shedding aims to:

- speed up the Load Shedding process using GOOSE system message exchange
- manage Load Shedding priority process & topology calculation with ISaGRAF functions

5.9.1 DATA FLOW



The C26x-M supports the ISaGRAF automation which allows defining FLS preselections and also automations (ISaGRAF and/or PSL) which allow testing / simulating the FLS.

It is a client of the system HMI and receives the setpoints from it. The FLS preselections are transmitted to C26x-Fi using the LSP (Load Shedding Preselection) datapoints, transmitted by GOOSE.

It is a server of the system HMI and is used to re-transmit the datapoints coming from C26x-Fi to system HMI using datapoint association mechanisms.

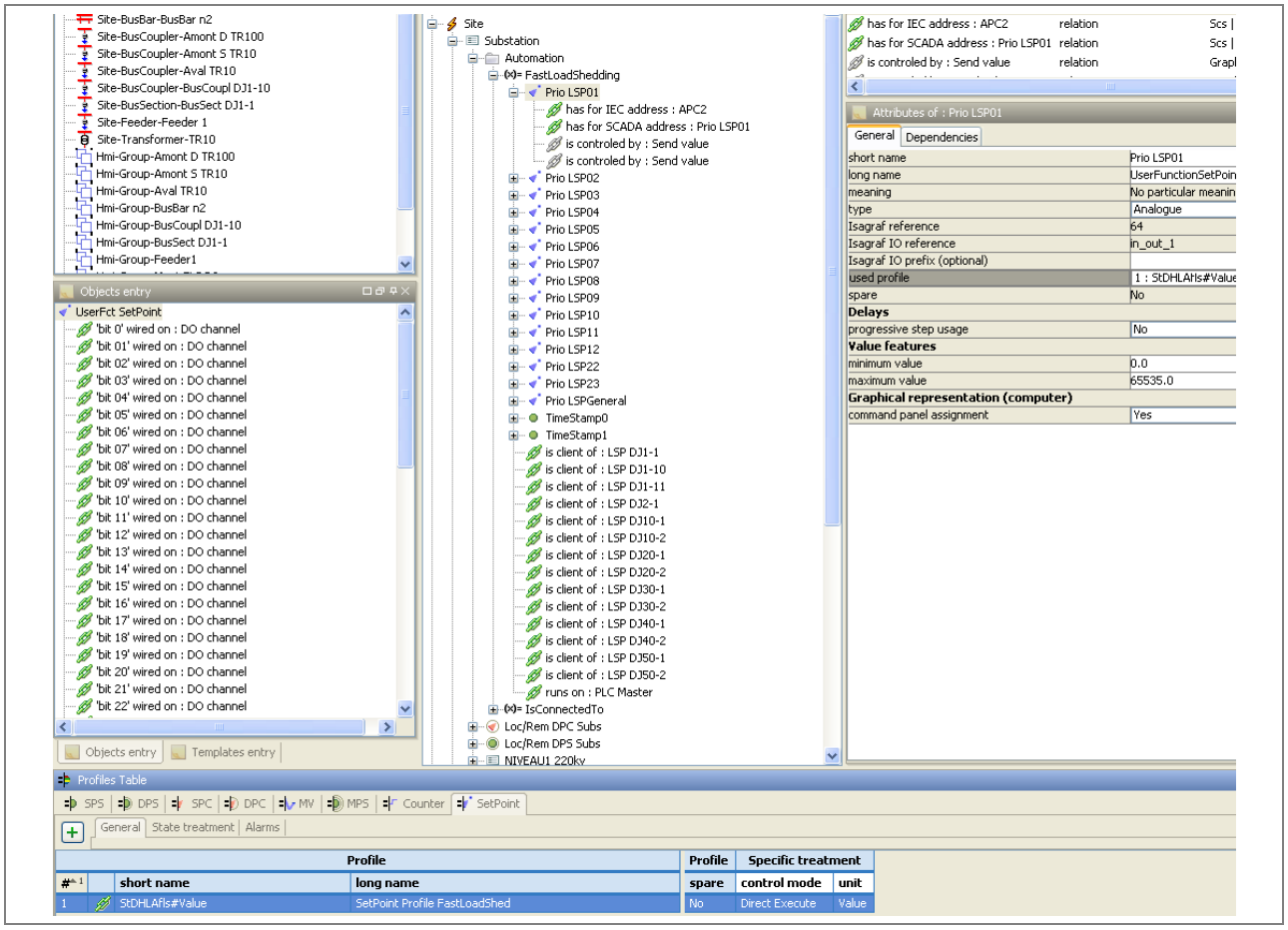
The C26x-Fi controls the feeder and the circuit-breaker trip. In order to secure performance time of breaker trip, C26x-Fi is not servers of the system HMI and C26x-M. They only manage the PSL which allows tripping the feeder regarding the cause and the preselection. They are dedicated to the acquisition of datapoints used for the Fast Load Shedding function (only FLS triggers as input and breaker trip as output).

The C26x-Fi works redundantly. To avoid time performance limitation, the client/server mechanism used in case of C26x redundancy (to exchange the FailSt information) will be replaced by a GOOSE transmission of this information.

5.9.2 PRIORITY SETPOINTS

Priority setpoints are analogue setpoints whose value range from 0 to 65535.

The profile is as follows:



5.9.3 LOAD SHEDDING PRESELECTION (LSP)

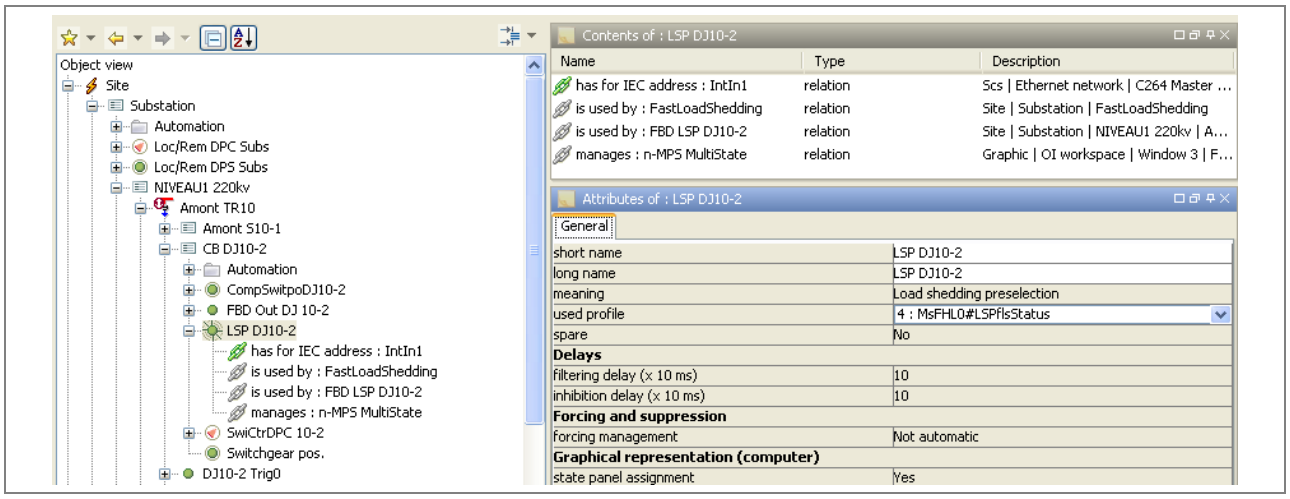
LSP is a 16 bit word in which several bits can be simultaneously set.

The LSP can be created under a module object or a breaker object.

The LSP is a sub-type of the MPS object. The SCE attributes of this object are:

- Short name
- Long name
- Meaning: fixed to “load shedding preselection”
- Used profile – The profile is only used to define:
  - the printing / archiving status at OI level, or
  - the archiving status at aView level

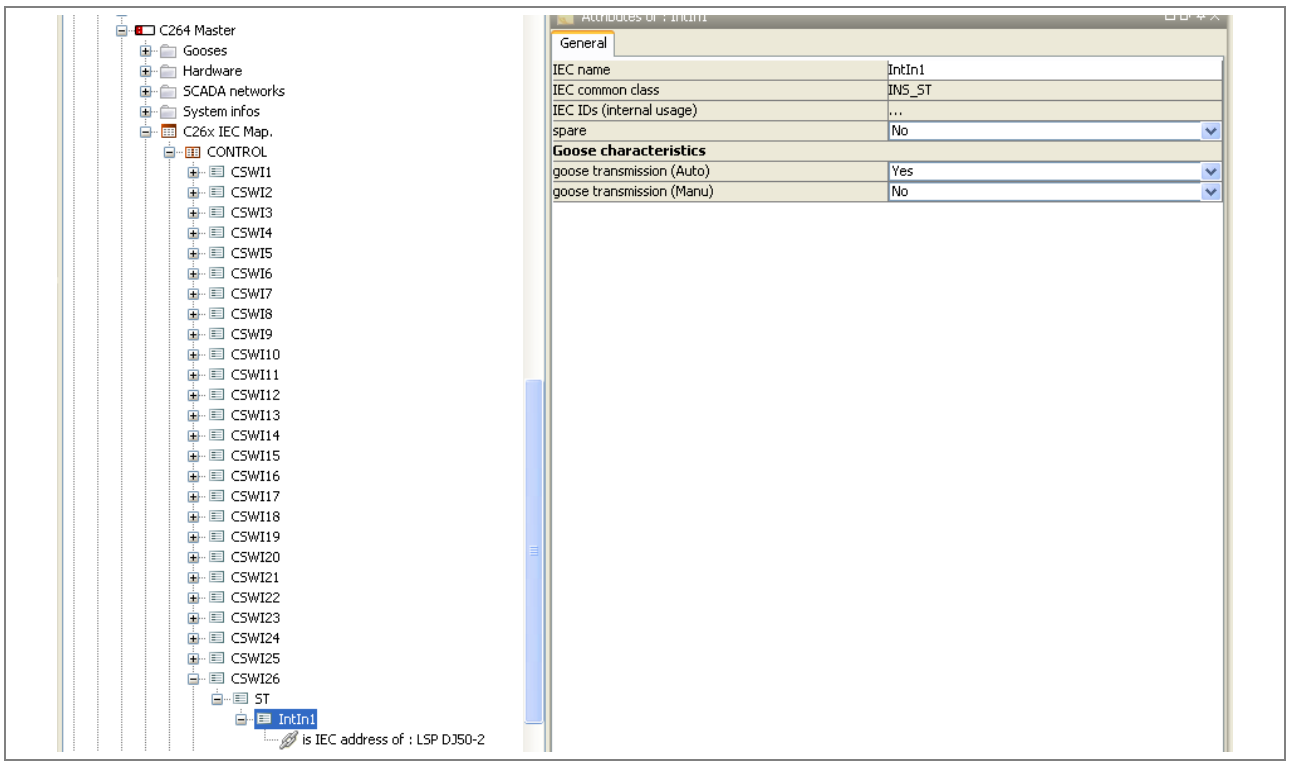
  (alarms, interlocking values are not used).



No wiring nor SCADA address can be associated with this object.

An LSP cannot be forced, suppressed or substituted (FSS).

This dedicated DS Agile object is mapped on an IEC 61850 BSTR16 type:



The Goose transmission can be automated (auto-addressing).

The LSP are not saved in C26x-Mx non-volatile memory.

In case of C26x-Mx reset (or, in case of C26x-M redundancy, when the Standby becomes Active), the LSP are initialized to 0.

The owner of the LSP is the C26x-Mx (and its redundant if it exists): it is the GOOSE publisher and the server of the LSP. So this C26x must be clearly identified in the configuration: a relation **has for LSP manager** is defined at Site level to define this C26x. Dedicated GOOSE message is used to transmit LSP

(i.e. measurement GOOSE / status GOOSE are not used): in this GOOSE, only the LSP status is transmitted: the quality and time-stamp are not transmitted.

5.9.4 GRAPHICAL ANIMATION WITH LSP

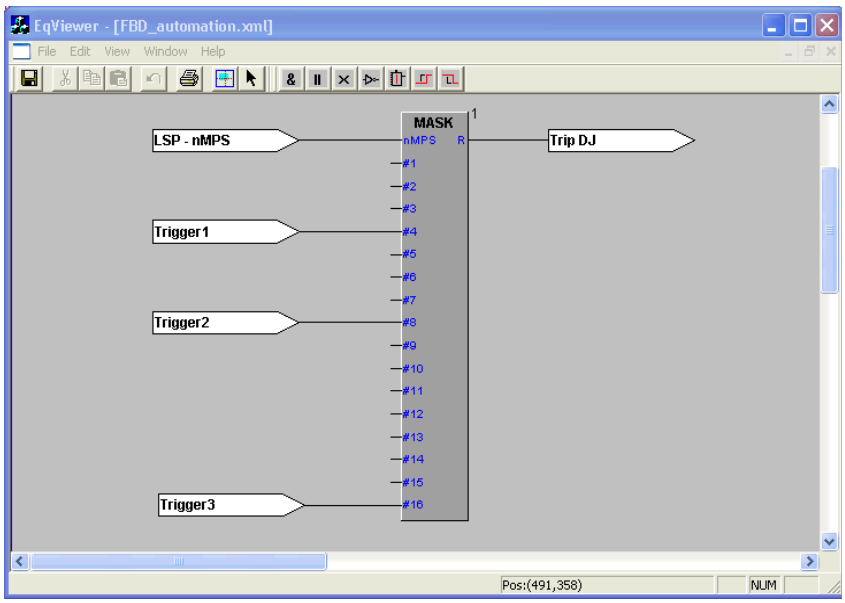
Graphical animation is performed using an LSP Multistate. This object is composed of:

- 3 graphical symbols, associated with the ON, OFF & UNKNOWN states of LSP bits
- Up to 16 components which allow to define the graphical position of the symbol associated with each LSP bit

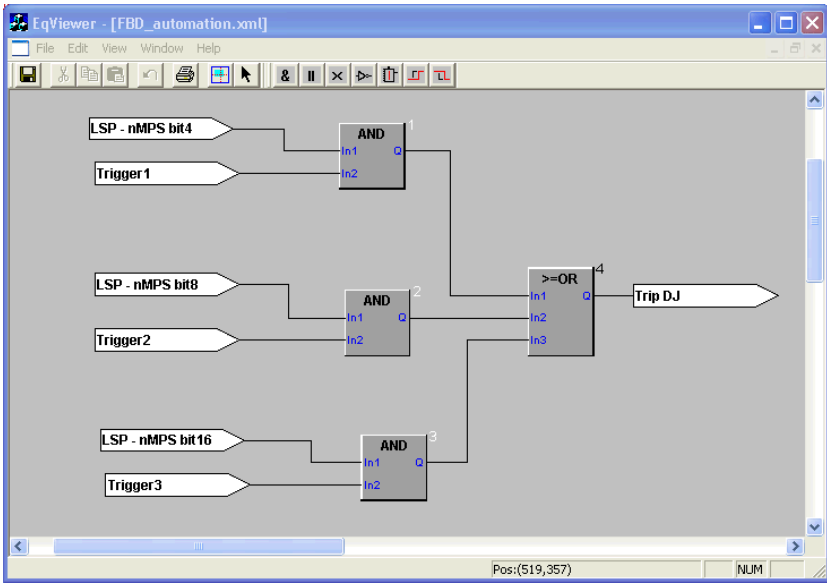
This representation forces to have the same graphic for the 16 bits of the LSP.

5.9.5 USING AN LSP IN A PSL

A dedicated MASK operator allows using the LSP in a PSL:



This operator is equivalent to:



Notes:
The MASK operator is generated as a sum of products in the C26x database. The PSL limitations are applicable on this operator.
In case of redundancy, it is necessary to manage and filter any input from external equipment/automation (ISaGRAF priority issue at switchover).

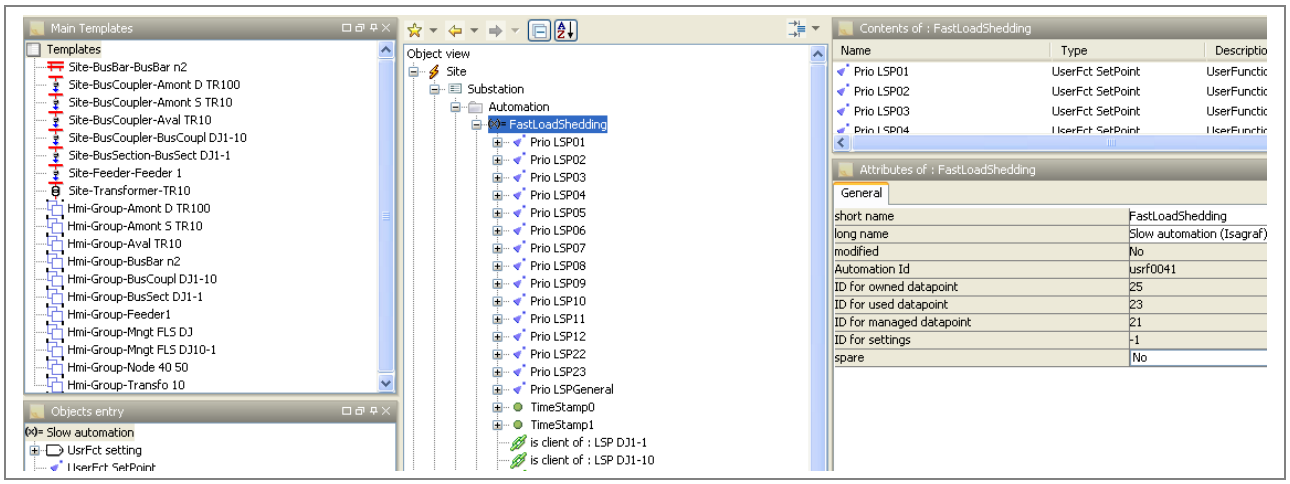
5.9.6 USING AN LSP IN A ISAGRAF DIAGRAM

An ISaGRAF function allows defining LSP values. The prototype of this function is:

Unsigned char Set_LSP (int Value, long Ref_LSP)

The bit representation of the LSP is:

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1



5.9.6.1 SET_LSP() ISAGRAF FUNCTION

ISaGRAF manages the LSP registry through a new function call Set_LSP.(value, reference of nMPS)

An LSP registry is a 16bits value range which defines 16 bits priority mask. The value is in range [0x0000 to 0xFFFF] which represents the 16 bit priority.

- Value 0x0001 activate bit priority 1
- Value 0x0002 activate bit priority 2
- Value 0x0004 activate bit priority 3

…

- Value 0x8000 activate bit priority 16

One LSP registry is allocated to a MASK FBD/PSL object.

This LSP registry is sent from ISaGRAF to C26x Fi FBS/PSL through GOOSE status.

5.9.6.2 IS_CONNECTED_TO() ISAGRAF FUNCTION

This ISaGRAF function is_connected_to (node1,node2,state) may be is used for operation topology process.

The test of this function will be applied to the architecture as described below

The state as described in the specification can be

- Connected: the 2 node equipments are surely connected,
- Unconnected: the 2 node equipments are surely not connected
- Uncertain: if not connected or not unconnected (in the event of a faulty board connection measurement for example)

5.9.7 DATAPOINTS

For SPC datapoints:

- value = 0 for open state
- value = 1 for close state

Datapoints possible states

- LSP: the possible states are SET, RESET, UNKNOWN.
- Input xPS Triggers can be SPS, DPS. Their possible states are described in the Functional Description chapter (C26x/EN FT). The FSS can be applied to the xPS datapoints

Each bit of the LSP datapoint is graphically created at OI level.

5.9.8 MASK OBJECT AND XPS TRIGGERS

5.9.8.1 MASK OBJECT

For each command breaker using into Fast Load Shedding, a PSL/FBD is created.

This PSL included the new MASK object.

One or more MASK object can be created into the FBD/PSL.

This MASK object has:

- One Input LSP value. The LSP value is GOOSE sending from ISaGRAF.
- Up to 16 xPS input triggers.
- One xPS output open/close breaker command.

5.9.8.2 TRIGGER DEFINITION

The triggers are standard xPS. As soon as they are used in a PSL, they are automatically GOOSE-defined using the SBUS automatic addressing.

An xPS input Trigger is mapped on input bit priority MASK Object of PSL/FBD

The combination of the xPS input triggers and the ISaGRAF LSP (transmitted by GOOSE) process the output PSL command datapoint (link to a breaker command).

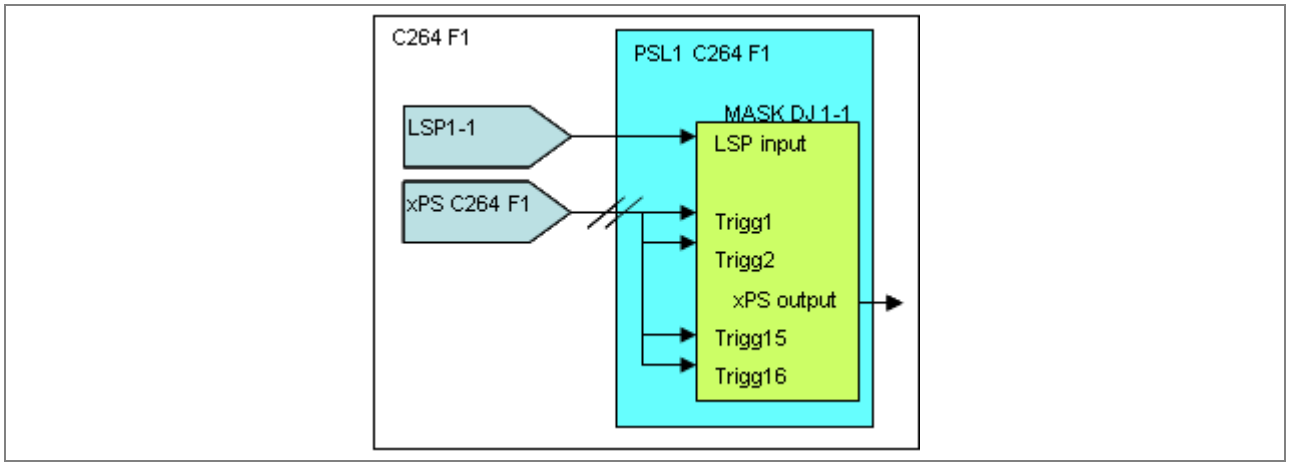
The xPS input triggers state can be changed from:

- C26x front panel Fi input command
- Scada Equipment Simulator through ASE gateway
- System HMI button with SPC command and SPS feedback
- Other IED equipment
- Another C26x Fi

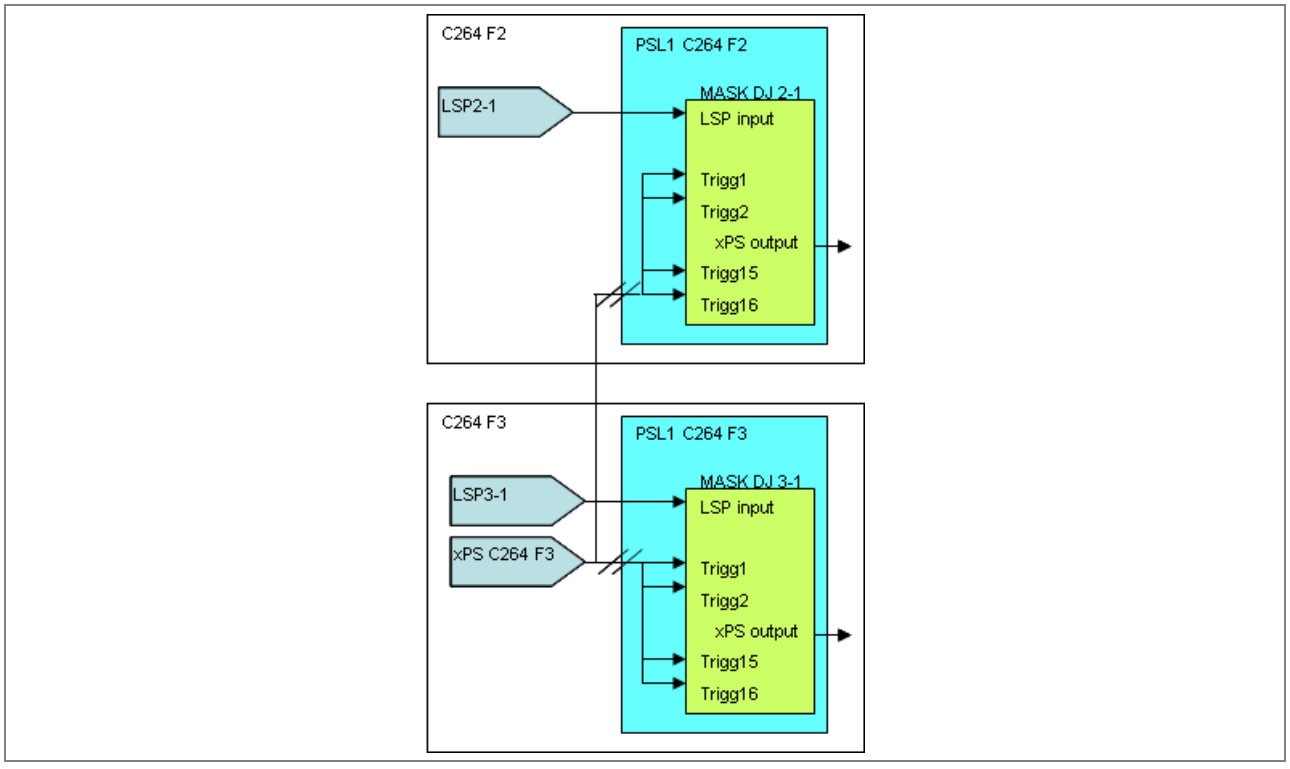
Wired triggers can be connected to extension rack or not.

Options

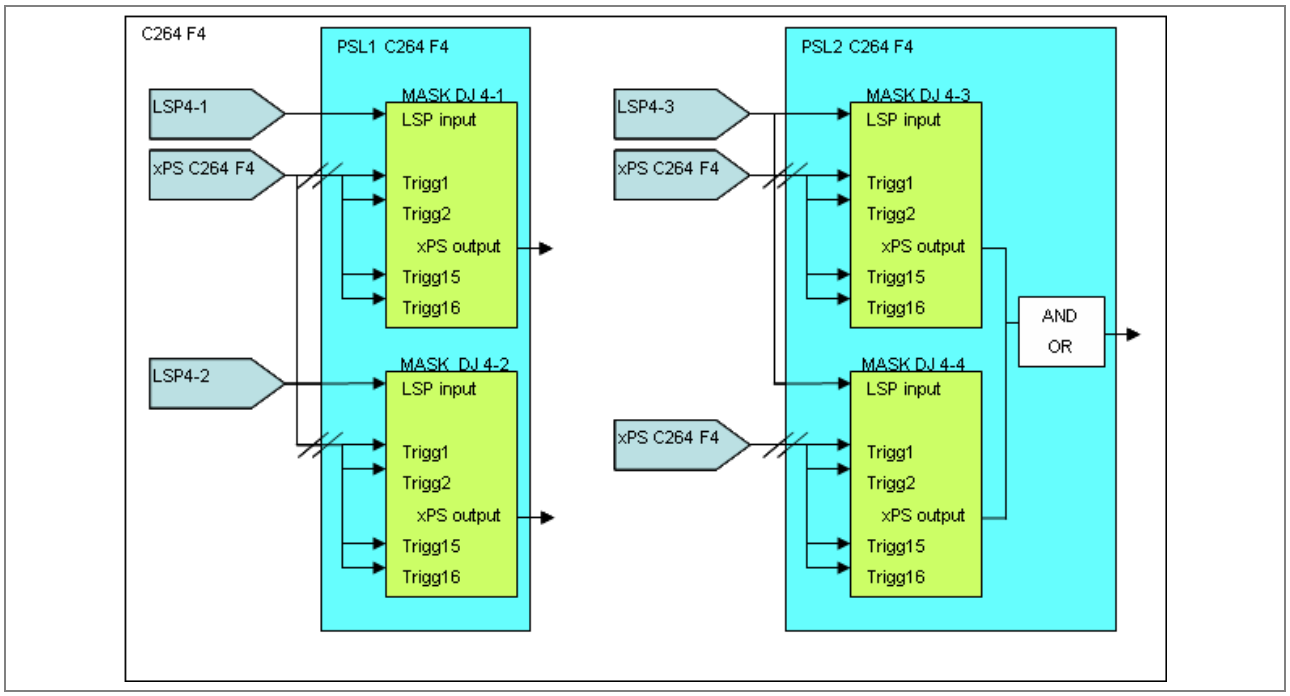
- all xPS triggers are managed by the same C26x:



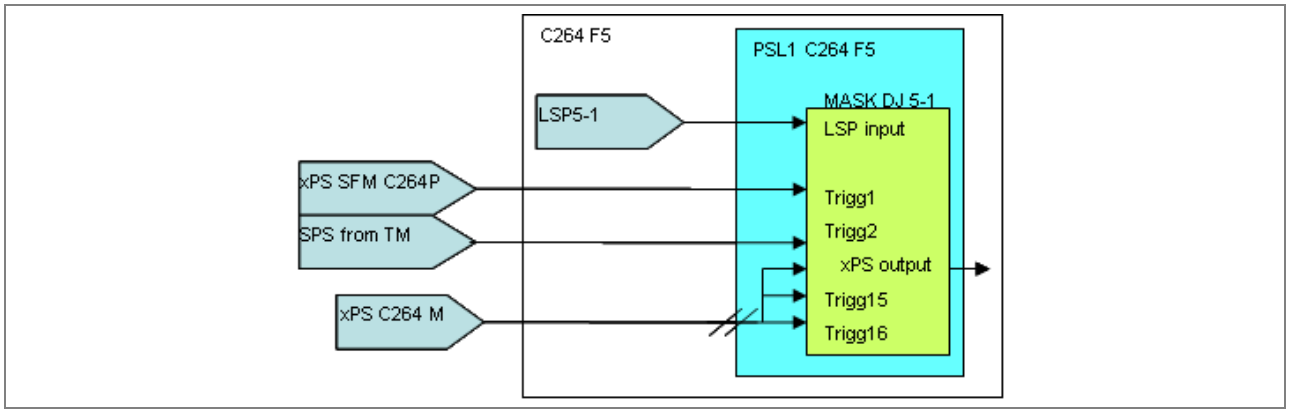
- xPS triggers comes from another C26x Fi:



- multiple MASK objects can be created into a FBD/PSL:



- xPS triggers comes from another C26x M, C26x with protection functions (frequency threshold), SPS from out of range measurement:



5.9.9 TOPOLOGY CALCULATION

An ISaGRAF function allows defining if 2 units are connected:

is_connected_to (node1, node2, state) with state = connected, unconnected, uncertain, and node1 / node2 the reference of the nodes of the 2 units.

The FORCED <state> and SUBSTITUTED <state> status are taken into account as the normal <state> of the datapoint in the topology calculation. The SUPPRESSED status is taken into account as the UNKNOWN status.

Two nodes are *connected* if it exists at least one chain of units between the 2 nodes which are closed, forced closed or substituted closed. Two nodes are *unconnected* if all chains of units between the 2 nodes are open, forced open or substituted open. In all others cases, the status between two nodes is *uncertain*.

6 DEFINING A C26X INTERFACE

6.1 SECURITY DISCLAIMER MESSAGES

For both the DS Agile C26x's front panel LHMI and the DS Agile CMT application, it is possible to enable and define security messages that the user will have to acknowledge before being able to connect to the DS Agile C26x.

These messages are enabled by default. The default English texts are:

LHMI

"Access to this system is limited to users authorized & trained as required by laws

Do not go further if you are not an explicitly authorized user"

CMT

"Access to this system is limited to specifically authorized users having received all trainings required by applicable laws, regulations, and by policies and procedures implemented by the legal entity hosting this system.

Unauthorized users may face criminal or civil liabilities and/or penalties. The use of this system may be recorded and monitored for system operations, security policy and intellectual property compliance related purposes and any information related to the use of this system may further be disclosed to third parties or law enforcement officials as necessary.

Disconnect now if you are not an authorized user or do not agree with the above terms."

6.1.1 DESCRIPTION AND LIMITS

LHMI

Two disclaimer texts can be defined for display on the C26x's front panel LHMI, one for each language managed by the LHMI.

- Maximum length for each line: 21 characters, including blank spaces.
- Maximum number of lines: 14.

CMT

One disclaimer text can be defined for display via the DS Agile CMT application.

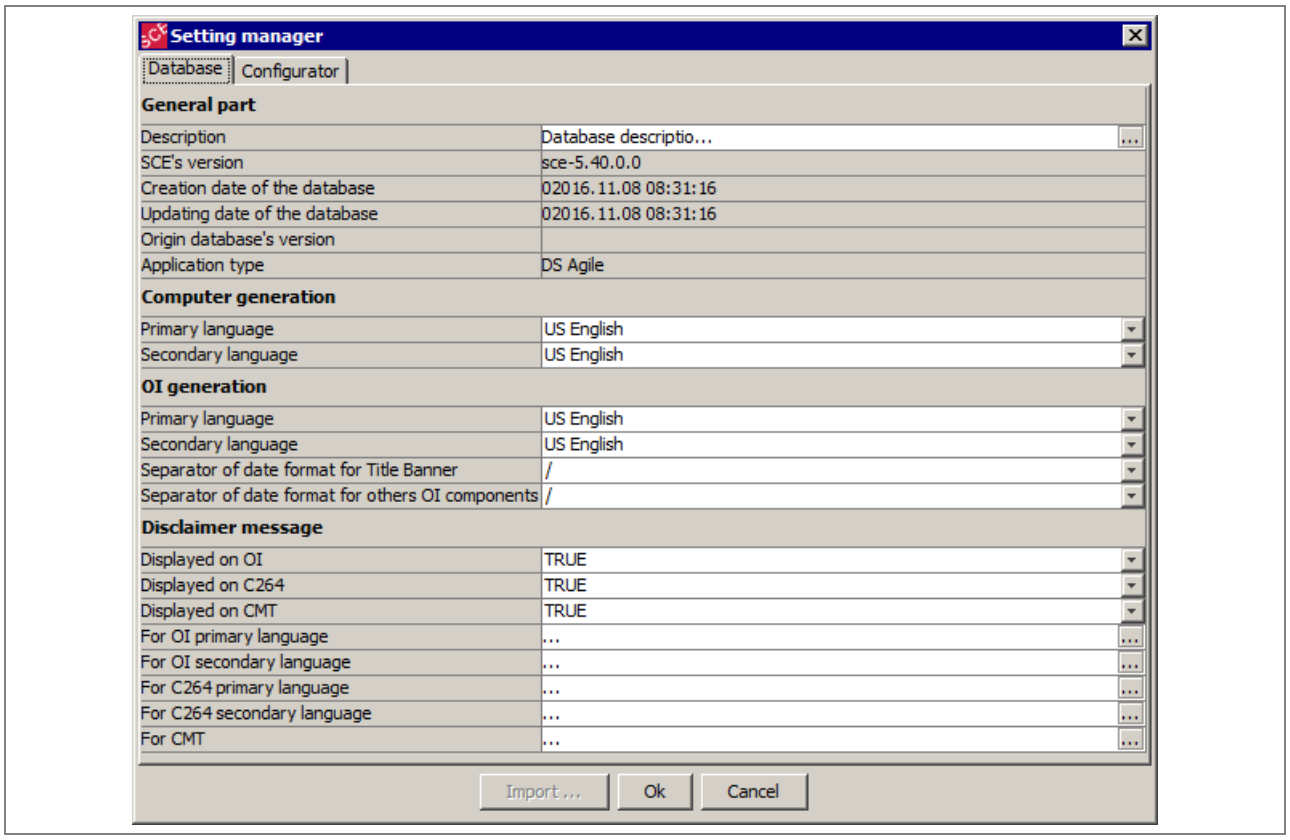
- Maximum length: 1000 characters, including blank spaces.

Note:
When the C26x is in Boot or in Maintenance mode, the CMT always displays the default disclaimer, whatever the database configuration.

6.1.2 CONFIGURATION

- In the **Tools** menu, select **Options...**
- Select the **Database** tab.

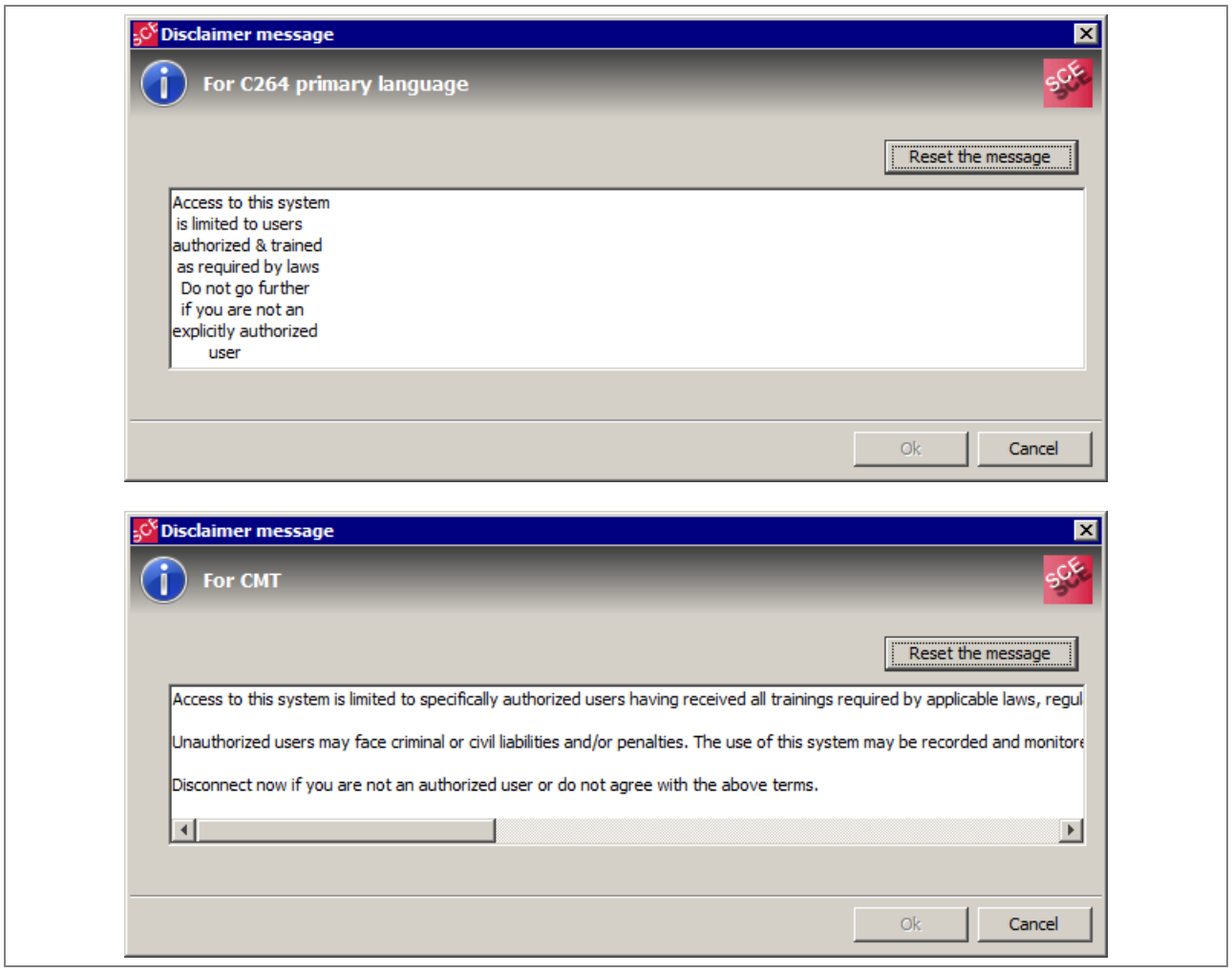
By default both the C264 LHMI and the CMT disclaimers are enabled.



- Disable/enable disclaimers:
  - To disable the disclaimer for front panel LHMI connections, set **Displayed on C264** to *FALSE*. Set **Displayed on C264** back to *TRUE* to enable it again.
  - To disable the disclaimer for connections from the DS Agile CMT application, set **Displayed on CMT** to *FALSE*. Set **Displayed on CMT** back to *TRUE* to enable it again.

Notes:
*The setting for **Displayed on C264** also affects the browsing mode on the front panel LHMI:*
- If it is set to TRUE, the browsing mode is "secure", i.e. no access at all is possible without entering a valid login and password.
- If it is set to FALSE, read only access is allowed without having to log in.
See chapter C26x/EN HI, Human Interface, for more details.

- Change disclaimer texts:
  - To access the edition window of each disclaimer text, click the button **[...]** at the right end of each line.



  - Edit the required texts according to the limits given above and click **Ok** when done.
  - To revert to the default text of any disclaimer, click **Reset the message** then **Ok**.

Although they are configured from the SCE's **Options** menu, these texts are added to the system configuration database, and become available once it is downloaded into the device.

Note:
In this system version, only the Primary language disclaimer is implemented for the C26x's LHMI. Changing the text for the secondary language has no effect.

Maximum disclaimer size

- CMT: 1000 characters
- LHMI: 24 lines, each line under 22 characters

6.2 LOCAL HMI DEFINITION

All types of C26x units can have a GHU200 board for led managing and possible local bay mimic panel animations in case of complete GHU200 board (see section *3.3.3.3 Setting the specific attributes of a GHU2x0 board*).

6.2.1 DEFINING A BITMAP TABLE

To define C26x bay mimics, bitmaps are used. Their definition is located at graphic root of the data modeling.

At C26x bay mimic definition level, objects only reference these bitmaps. So it is an easier way to propagate a bitmap change for instance to all objects that reference it.

At SCE level, bitmap object definition is extended to embed animation: up to 5 elementary static bitmaps can be grouped in a bitmap object:

- one (mandatory) for default representation
- one for ‘open’ (or reset) representation
- one for ‘closed’ (or set) representation
- one for ‘open withdrawn’ representation
- one for ‘closed withdrawn’ representation

Each representation corresponds to a filename containing the static bitmap definition.

To add a bitmap definition, select the Bitmap table level in the graphical topology add the Bitmap from the contextual **Objects entry** window.

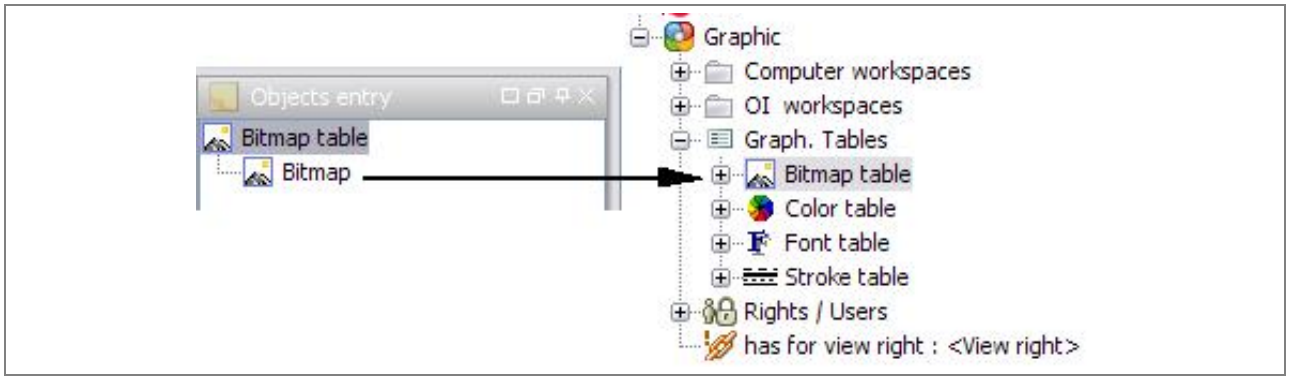


Figure 333: Adding a bitmap

Once added, bitmap attributes must be set at SCE level:

(1) **short name** and **long name**: used for internal SCE identification

(2) **reference index** (range [0, 150]: that must be unique for the set of defined bitmaps. This index will be used in bay mimic definition as described previously

(3) **type** (Single / 5-uple): single is used for static bitmap definition, 5-uple allows dynamic bitmap definition as described previously

(4) **file name by default**: corresponds to the filename containing the bitmap definition used for default representation

(5) **file name for 'open' state**: visible only if type is set to 5-uple: corresponds to the filename containing the bitmap definition used for open state representation

(6) **file name for 'closed' state:** visible if type is set to 5-uple: corresponds to the filename containing the bitmap definition used for closed state representation

(7) **file name for 'withdrawn open' state**: visible if type is set to 5-uple: corresponds to the filename containing the bitmap definition used for withdrawn open state representation

(8) **file name for 'withdrawn closed' state**: (visible if type is set to 5-uple): corresponds to the filename containing the bitmap definition used for withdrawn closed state representation

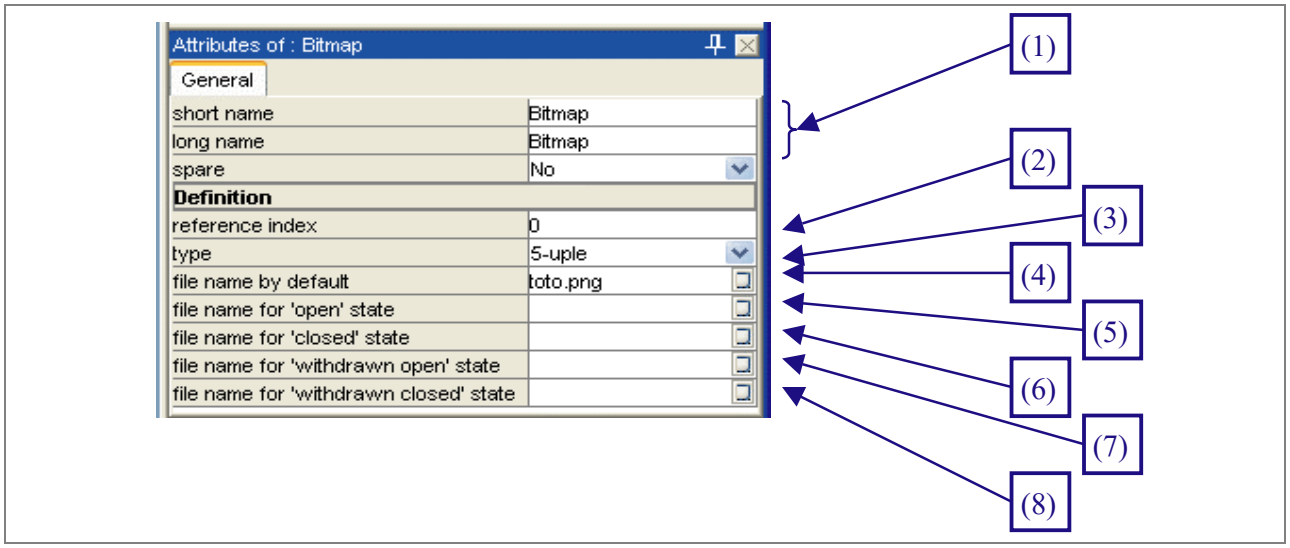


Figure 334: Setting the attributes of a bitmap

Attributes (7) and (8) can be omitted if breakers and switchgears represented in bay mimic are not concerned with withdrawn information.

To set a file name (attributes (4) to (8)) and define graphically a bitmap:

- select the attribute
- edit graphically a bitmap using the bitmap editor at SCE level
- save the graphical definition of the bitmap by giving a file name in bitmap editor

For details about bitmap editor usage refer to SCE/EN HI, Graphic Menu section.

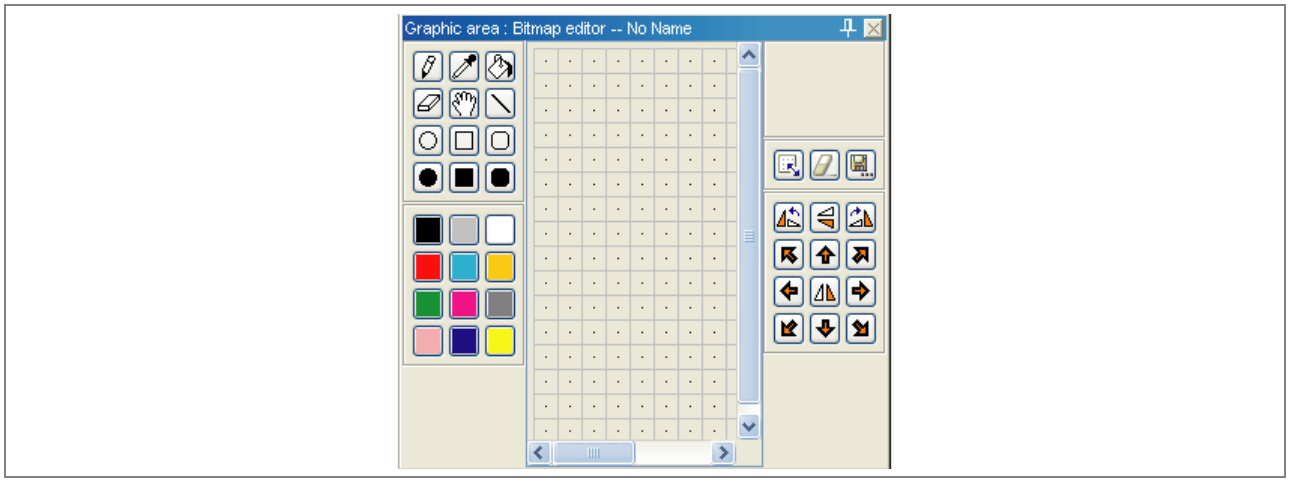


Figure 335: Using the Bitmap Editor

Color usage in bitmap editor is not significant for C26x monochrome LCD.

Configuration rules and checks

- The "reference index" attribute value of each "Bitmap" of the "Bitmap table" must be unique
- Depending on the "type" attribute value, 1 or 5 PNG file(s) can be linked to a Bitmap.
  For each one, the bitmap size must be ≤ 512 bytes

6.2.2 DEFINING A C26X WORKSPACE

Via a complete GHU200 board (see section *3.3.3.3 Setting the specific attributes of a GHU2x0 board*), each C26x with local HMI references a workspace that groups its bay mimic definitions. C26x workspaces cannot be shared by several C26x units because mimics are local to bays managed by a specific C26x.

Up to 24 bay mimics can be put in a C26x workspace, and up to 2 mimics can be linked to the same bay.

Usual labels are used by C26x Local HMI. They are located for all C26x units LHMI in one object grouping all translatable labels, located in “C26x workspaces” folder in Graphic topology.

6.2.2.1 SETTINGS LHMI LABELS

To modify a usual label used at C26x LHMI level, just select and update the corresponding attribute at LHMI labels object.

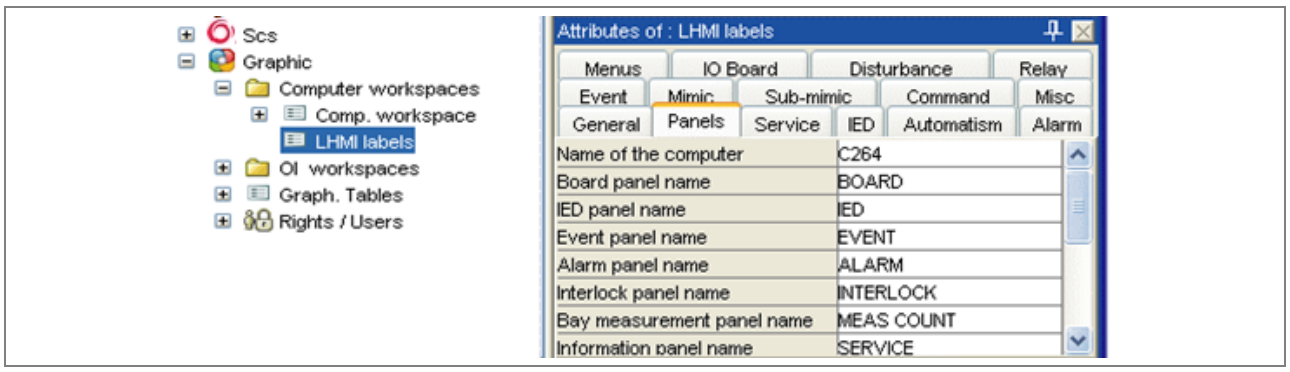


Figure 336: Settings LHMI labels

6.2.2.2 CREATING A WORKSPACE

To add a C26x workspace, select the Graphic level and add the Comp. workspace from the contextual **Objects entry** window.

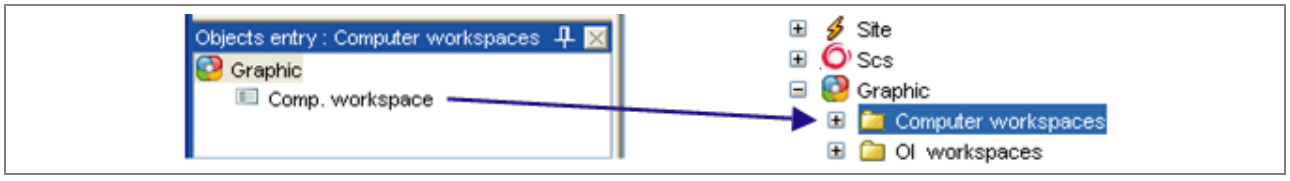


Figure 337: Adding a C26x workspace

Once added, the C26x workspace general features must be set at SCE level:

- Indicate which GHU200 board is concerned by created workspace by filling the relation **has for workspace** at concerned GHU board level (see section *3.3.3.3 Setting the specific attributes of a GHU2x0 board*).
- Setting the **short name** and **long name** (1) attributes of the workspace used for internal SCE identification,
- The attribute **local/remote password usage** (2) is not used.

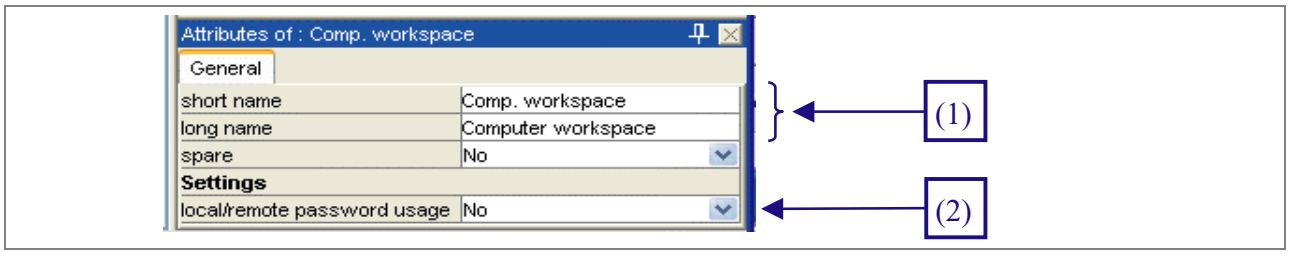


Figure 338: Setting the attributes of a C26x workspace

6.2.3 DEFINING A C26X BAY MIMIC

6.2.3.1 CREATING A C26X BAY MIMIC

To add a Bay mimic to a C26x, select the C26x workspace level and add the Bay mimic from the contextual **Objects entry** window.

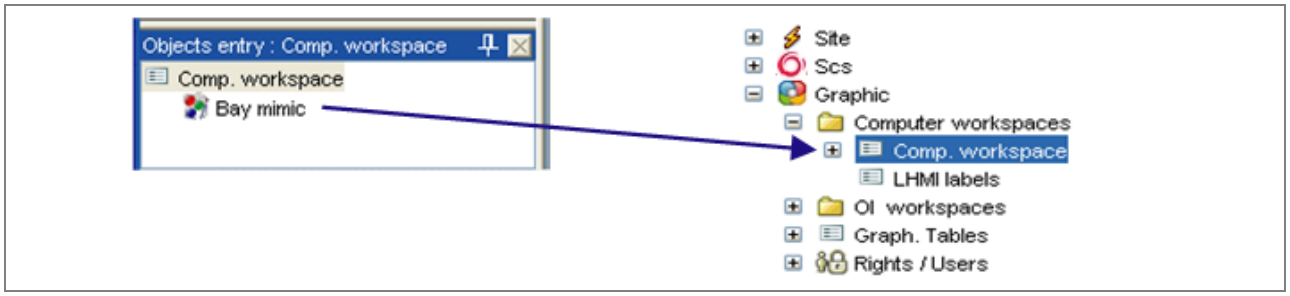


Figure 339: Adding a C26x Bay Mimic

Once added, bay mimic general attributes must be set at SCE level:

(1) **short name** of the bay mimic used for internal SCE identification.

(2) **bargraph representation** (none / Horizontal / Vertical): this attributes defines which type of bar graph is associated with an MV datapoint assigned to a bay mimic (see section *6.2.3.4 Assigning an MV to a bay mimic*).

(3) **module name display** (*No* / *Yes*) this attribute defines if module short names are displayed at mimic level when a module is represented on bay mimic (see section *6.2.3.3 Defining dynamic part: pre-defined dynamic text, generic module representation, transformer representation*).

(4) Fill the relation **represents**, giving which bay is represented by the mimic (for details about bay see section *5.1.4 Defining a Bay*).

(5) If necessary, set the attribute **mimic rank** of the **represents** relation to correct value. This attribute is used when 2 mimics are configured to display an entire bay: as bay is split in 2 representations, the **mimic rank** attribute gives their display rank at C26x LHMI level (1 or 2).

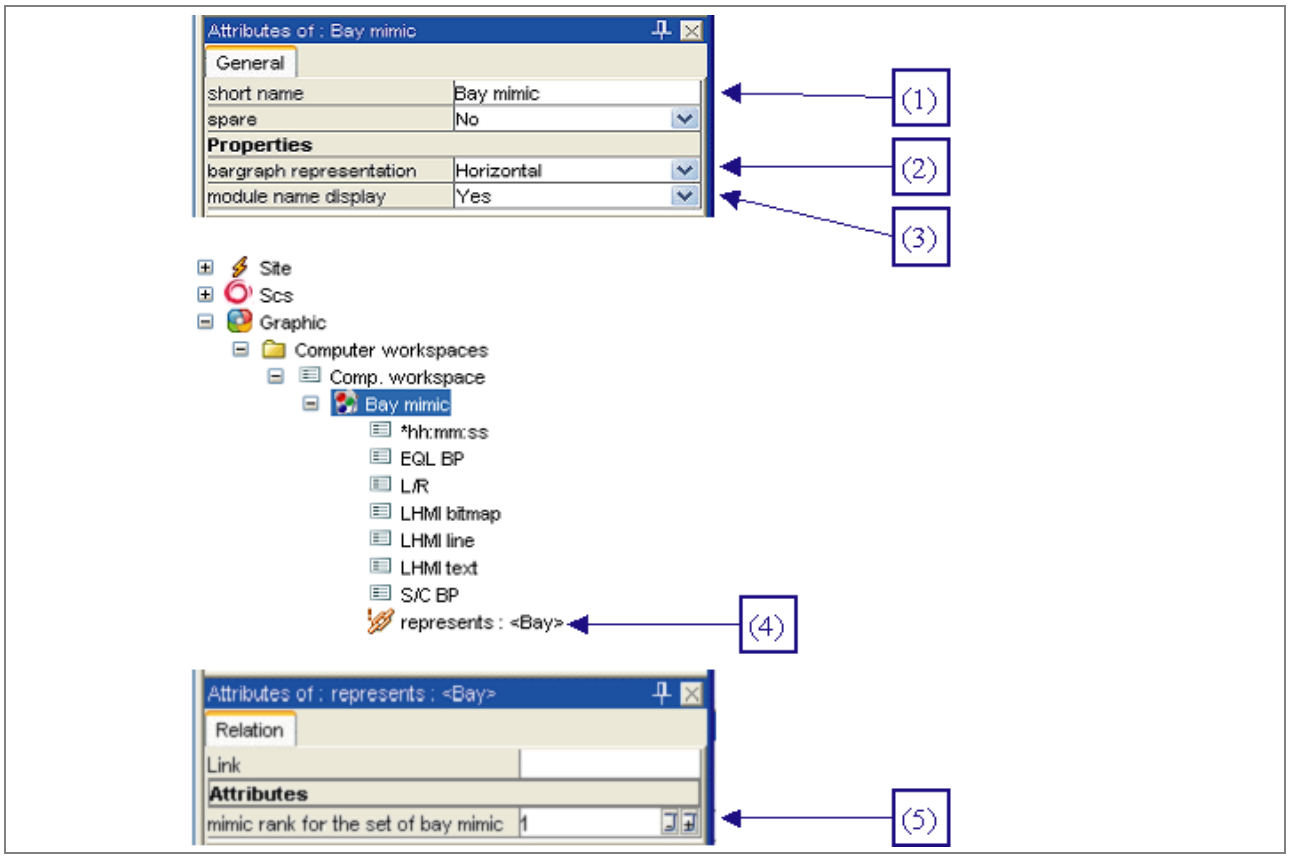


Figure 340: Setting the Bay Mimic features

When adding a bay mimic at workspace level, its core structure (canvas) is automatically created and displayed at SCE level, via bay mimic editor and in SCE tree browser. Its core structure consists of:

(1) Reserved zone for bay name display

(2) Reserved zone for bay local/remote display ((2') in tree browser)

(3) Reserved zone for 'interlocking bypass in progress' information ((3') in tree browser)

(4) Reserved zone for 'synchrocheck bypass in progress' information ((4') in tree browser)

(5) Configurable zone for graphical representation of the bay (static and dynamic parts)

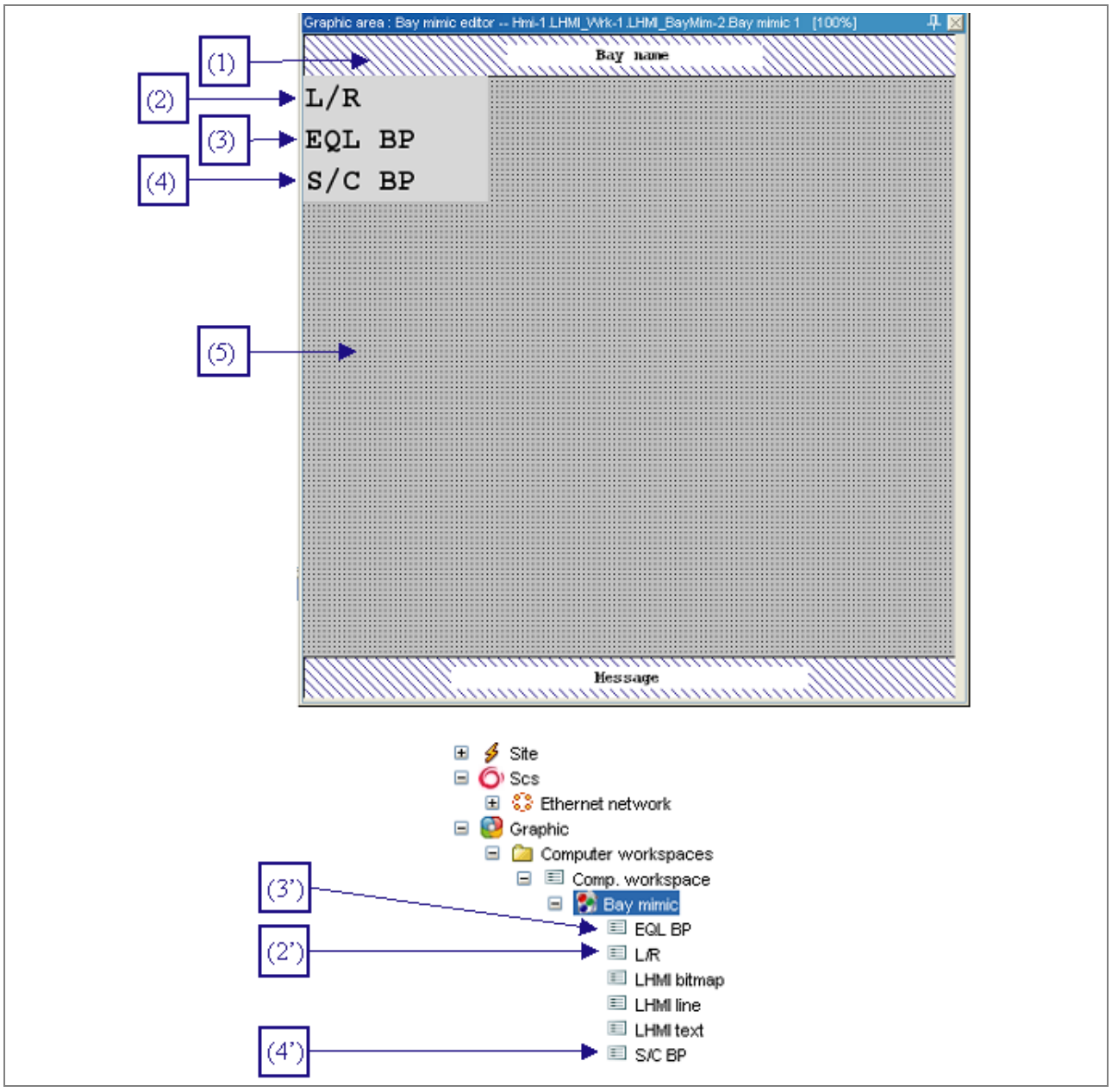


Figure 341: Core structure of a Bay Mimic

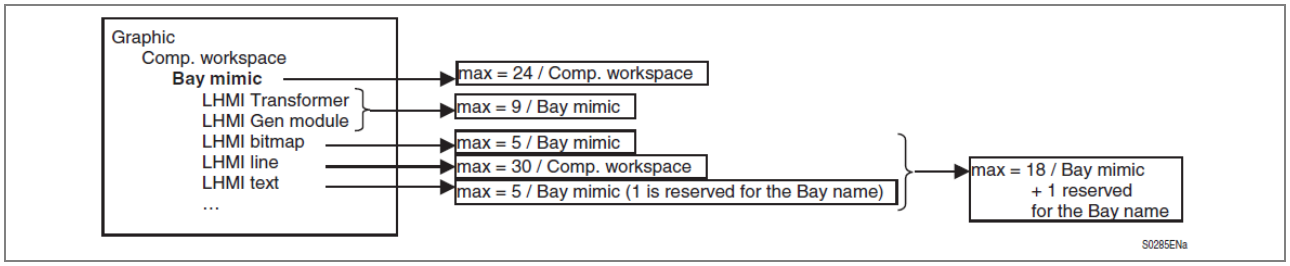
For more details about C26x LCD usage, refer to document User Interface (coded HI for Human Interface) of DS Agile C26x documentation folders.

The configurable zone of a bay mimic can be split in two parts:

- A static part with no real-time animation
- A dynamic part with real-time animated representations.

Configuration rules and checks

- The C26x managing a bay represented by a "Bay mimic" must be the same as the one linked to the "Comp. workspace" (computer workspace) of this "Bay mimic".
- A bay can be represented by 0, 1 or 2 "Bay mimic". Each **represents** relation has an attribute **mimic rank for the set of bay mimic.** In the case of 2 relations, each attribute value must be unique.
- For a Computer, the maximum count of managed bays (relation **is managed by**) which are linked to a "Bay mimic" (relation **represents**), is **12**.
- Limits of the count of symbols:



6.2.3.2 DEFINING THE STATIC PART: LINE, BITMAP, FIXED TEXT

The static part of a C26x bay mimic is described via graphical basic shapes:

- LHMI line: horizontal or vertical line with configurable thickness and length
- LHMI bitmap: bitmap that references a bitmap object in the bitmap table (see *6.2.1 Defining a bitmap*) where default representation is only taken into account
- Fixed text: multi-lingual fixed text

Once added, these elements automatically appear in the window of the bay mimic editor at SCE level.

Configuration rules and checks

- The coordinates (x, y) of a symbol must not be located outside the mimic area.

Adding a line

To add a line in a bay mimic diagram, select the Bay mimic level and add the line from the contextual **Objects entry** window:

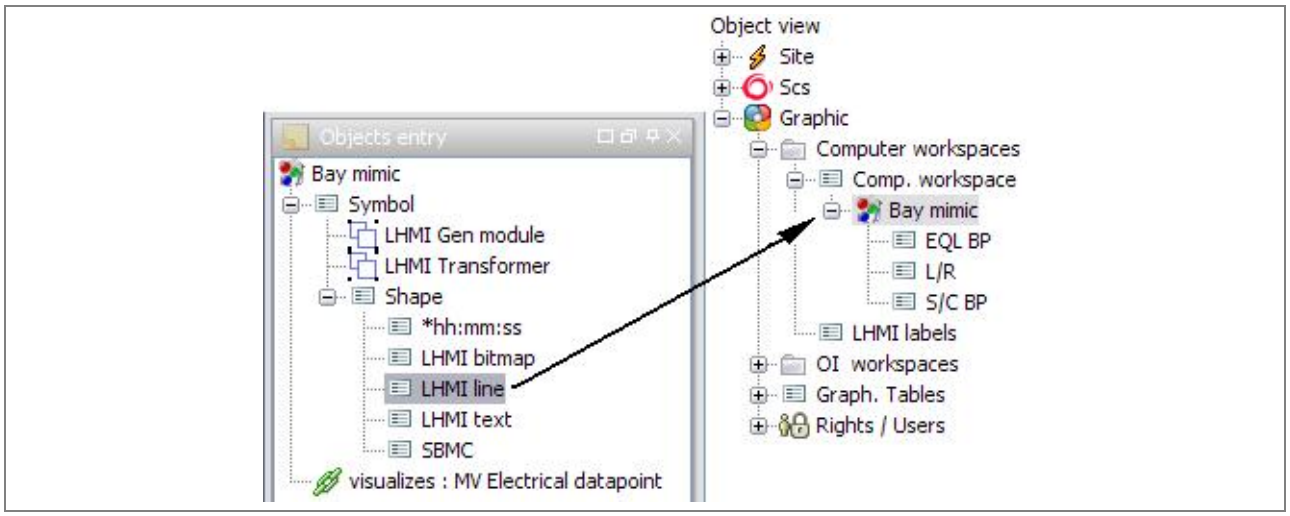


Figure 342: Adding a line to a C26x Bay Mimic

Once added, line attributes must be set:

(1) **short name** of the line used for internal SCE identification

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

(4) **length** (range [1 pixel, 127 pixels], step 1 pixel)

(5) **orientation** (*Horizontal* / *Vertical*)

(6) **thickness** (range [1 pixel, 8 pixels], step 1 pixel)

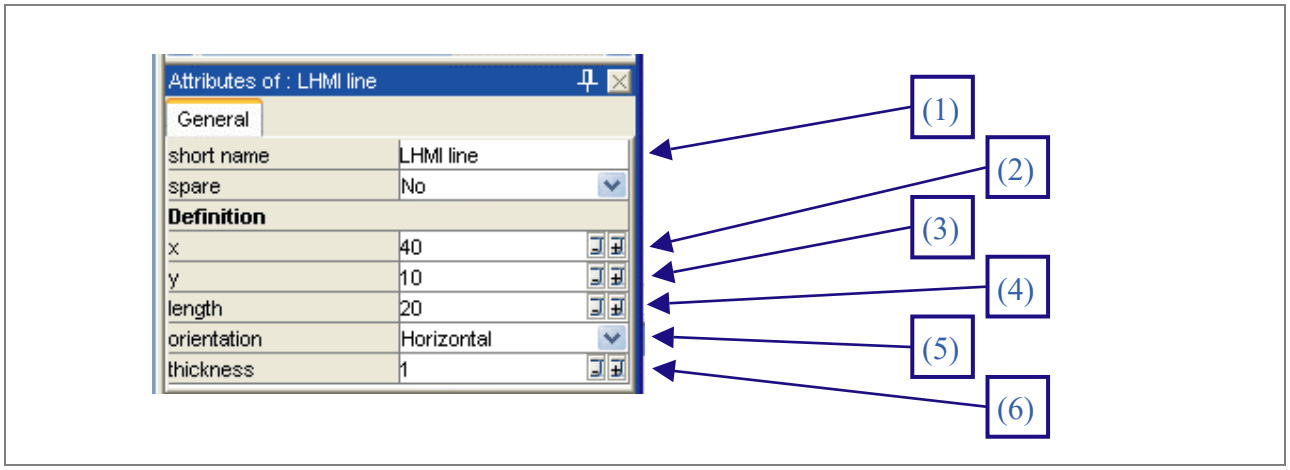


Figure 343: Setting the attributes of a line

Abscissa, ordinate, length and thickness of a LHMI line can be directly adjusted with the mouse in bay mimic editor (for detail, refer to the SCE user's manual)

Adding a bitmap

To add a bitmap image to a bay mimic diagram, select the Bay mimic level and add the bitmap from the contextual **Objects entry** window.

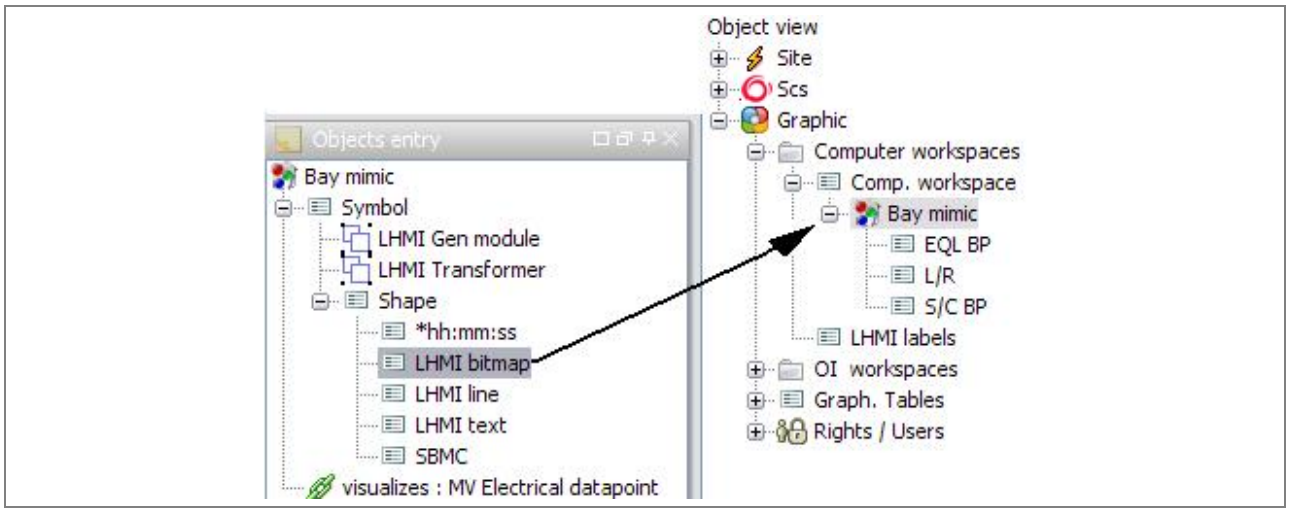


Figure 344: Adding a bitmap to a C26x Bay Mimic

Once added, bitmap attributes must be set:

(1) **short name** of the line used for internal SCE identification

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

(4) **bitmap reference**: corresponds to a link in the bitmap table (see section *6.2.1 Defining a bitmap table)*

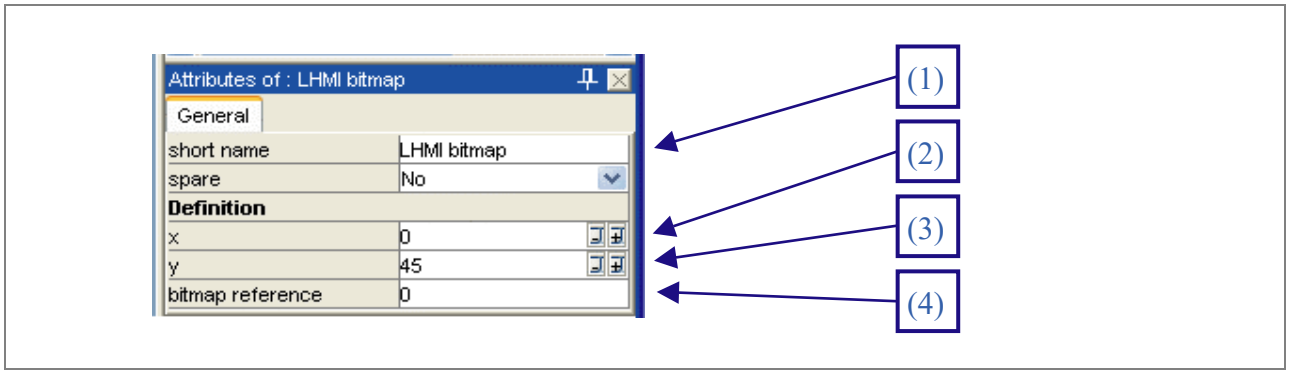


Figure 345: Setting the attributes of a bitmap

Abscissa and ordinate of a bitmap can be directly adjusted with the mouse in bay mimic editor (for detail, refer to SCE user's manual)

Configuration rules and checks

- The link from an element to its bitmap is defined with the attribute "bitmap reference". The value of this attribute must refer to an existing bitmap in the "Bitmap table".

Adding a fixed text (plain text area)

To add a fixed text to a Bay mimic diagram, select the Bay mimic level and add the text from the contextual **Objects entry** window.

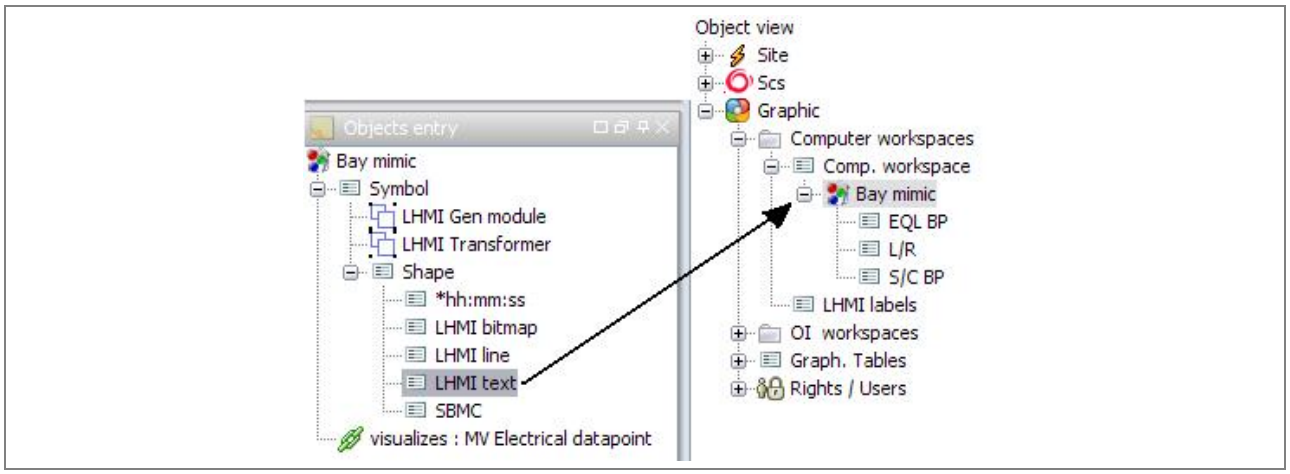


Figure 346: Adding a fixed text to a C26x Bay Mimic

Once added, fixed text attributes must be set at SCE level:

(1) **fixed text value**: text to display at mimic level

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

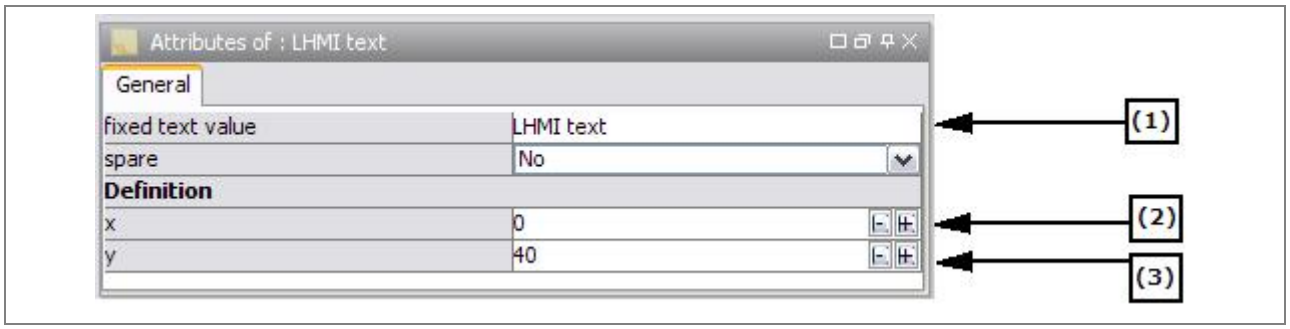


Figure 347: Setting the attributes of a bitmap

Abscissa and ordinate of a fixed text can be directly adjusted with the mouse in bay mimic editor (for detail, refer to SCE user's manual). Text area length at bay mimic is automatically deduced from text value length (attribute (1)).

6.2.3.3 DEFINING DYNAMIC PART: PRE-DEFINED DYNAMIC TEXT, GENERIC MODULE REPRESENTATION, TRANSFORMER REPRESENTATION

To define dynamic part of C26x bay mimics, 3 types of objects are available:

- Pre-defined dynamic text, used:
  - to display local/remote and SBMC status of the bay
  - to manage Synchrocheck and interlock bypass during control sequence on the bay
  - to display time and synchronization status

Generic module representation: used to display module status, linked to a specific SPS or DPS electrical datapoint. Implicit link to possible xPC associated datapoint is given to C26x for command purpose at local HMI level, via the existence of the relation **is feedback of** between the xPS and the xPC.

- A generic module is composed of 2 sub-objects:
  - a name for display (mandatory)
  - a ‘xPS muti-state’ for dynamic module state display (mandatory), referencing a dynamic bitmap object in the bitmap table, and whose relation to a xPS datapoint (SPS or DPS) has to be filled up to precise animation datapoint
- Transformer representation: used to display transformer module; linked to an optional Tap Position Indicator. Transformer is composed of 5 sub-objects:
  - a name for display (mandatory)
  - a ‘TPI muti-state’ for transformer display (mandatory), referencing a dynamic bitmap object in the bitmap table, and whose relation to a TPI datapoint can be filled up to precise the concerned datapoint for the following animation
  - an optional ‘current TPI value’ object to display dynamically the current value of the TPI,
  - an optional ‘max TPI value’ object to display upper available value for the TPI
  - an optional ‘min TPI value’ object to display lower available value for the TPI

Adding time information

To add time information to a Bay mimic diagram, select the Bay mimic level and add the time field from the contextual **Objects entry** window.

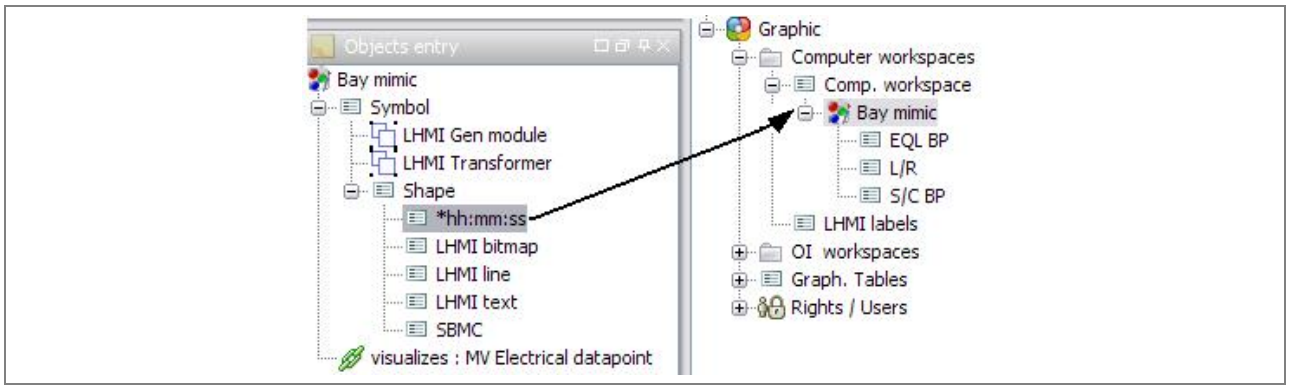


Figure 348: Adding time information to a C26x Bay Mimic

Once added, time information attributes must be set at SCE level:

(1) **short name** of the time information area used for internal SCE identification

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

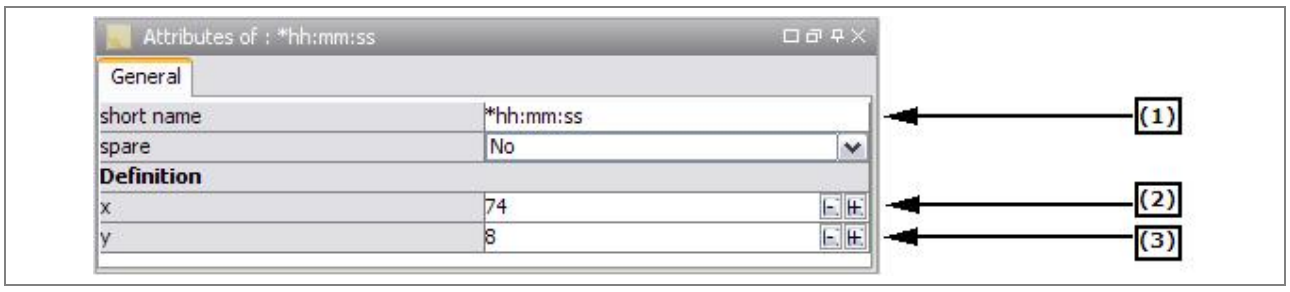


Figure 349: Setting the time information attributes

Abscissa and ordinate of time information can be directly adjusted with the mouse in bay mimic editor (for detail, refer to the chapter SCE/EN HI).

Positioning the Local/Remote state, the Synchrocheck bypass or the Interlock bypass

When creating a bay mimic, the following objects are implicitly created in the mimic at a pre-defined location:

(1) Interlock bypass 'button'

(2) Local/remote status

(3) Synchrocheck bypass 'button'

Depending on customer's need, these data can be positioned at a different location:

- directly using mouse drag and drop in bay mimic editor
- by editing the abscissa and ordinate attributes of the object

Interlock bypass can be inhibited by setting the attribute Spare to Yes.

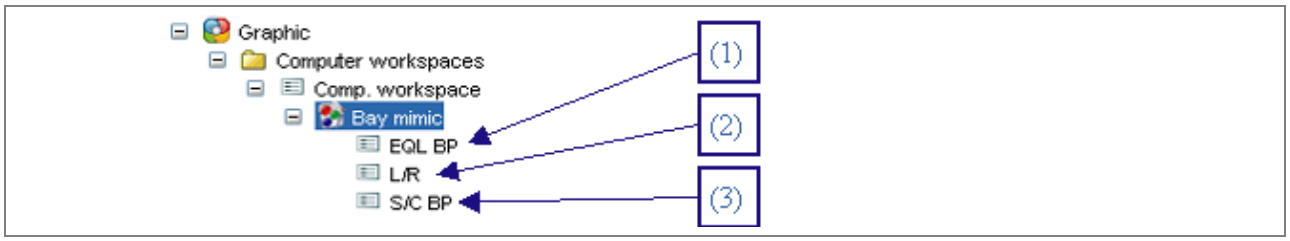


Figure 350: Positioning pre-defined text information in a Bay Mimic

Adding an SBMC indication

To add an SBMC indication to a Bay mimic diagram, select the Bay mimic level and add SMBC from the contextual **Objects entry** window.

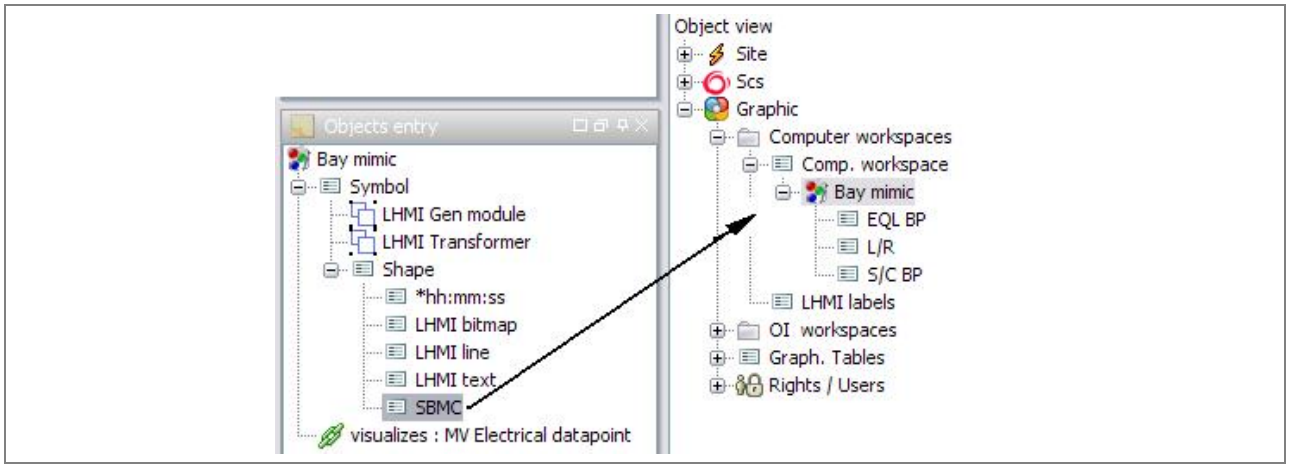


Figure 351: Adding an SBMC indication into a C26x Bay Mimic

Depending on customer's need, the SBMC indication can be positioned at any location in bay mimic:

- directly using mouse drag and drop in bay mimic editor
- by editing the coordinates of the object

Adding a generic module representation

In bay mimic, 'LHMI Gen module' is used for module dynamic representation. A 'LHMI Gen module' is a graphical group constituted of:

- the dynamic representation itself (LHMI Gen module), that is linked to SPS or DPS datapoint and to a dynamic bitmap in bitmap table
- the graphical name of the module (Name), always located on the right of the module representation

To add a generic module representation to a bay mimic diagram, select the Bay mimic level and add the generic module from the contextual **Objects entry** window.

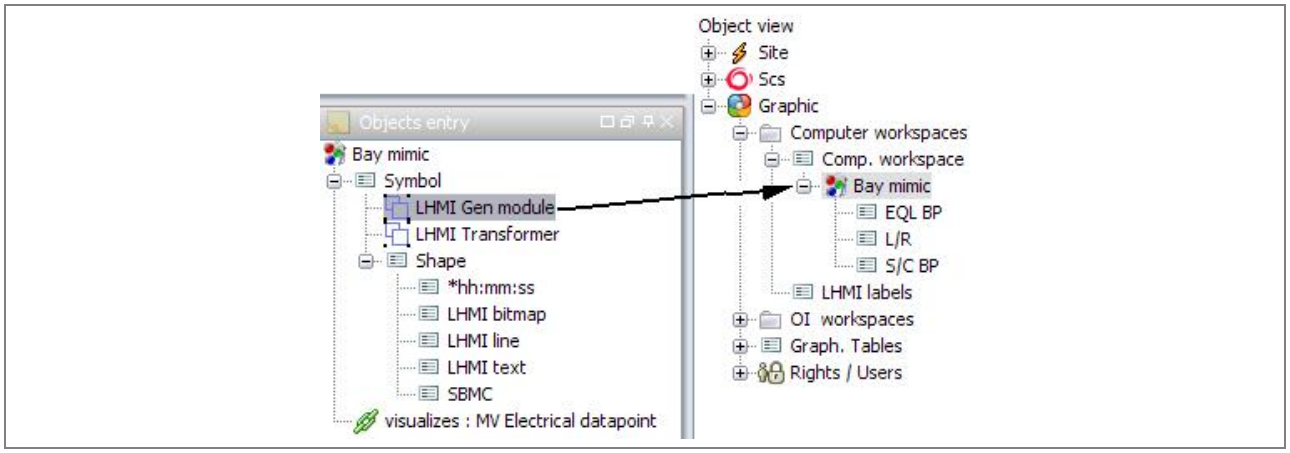


Figure 352: Adding a generic module to a C26x Bay Mimic

Once added, the representation features must be set at SCE level:

(1) **short name** of the representation used for internal SCE identification

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

(4) **control availability** (*No* / *Yes*): attribute to precise if control of the module can be directly done via bay mimic. This attribute is significant if SPS/DPS linked to the generic module representation (via (5) relation) is feedback of a control SPC or DPC. If so, control availability concerns this SPC/DPC

(5) Relation **is managed by** that must be filled to precise which SPS or DPS is used for bitmap animation

(6) **multi-bitmap reference**: corresponds to a link in the bitmap table (see section *6.2.1 Defining a bitmap table*)

(7) **module name value**: text displayed on LCD (up to 4 characters)

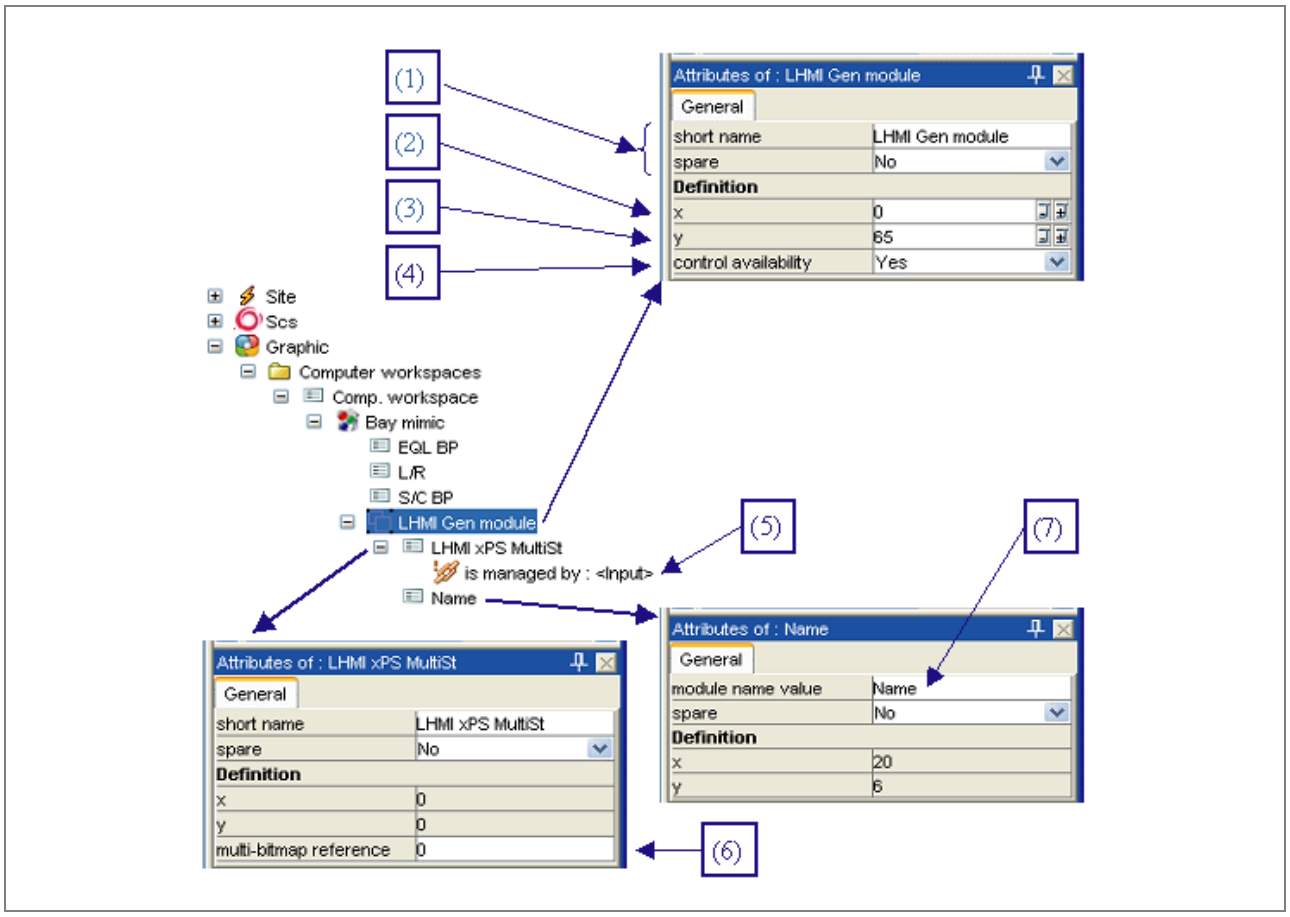


Figure 353: Setting the features of a generic module's representation

Coordinates (x and y) of a generic module can be directly managed using mouse in bay mimic editor (for detail, refer to SCE user's manual).

Configuration rules and checks

- The link from an element to its bitmap is defined with the attribute: "bitmap reference". The value of this attribute must refer to an existing bitmap in the "Bitmap table".
- The "Bitmap" linked to a "LHMI xPS MultiSt" MultiState must be defined as follows:
  - its "type" attribute must be set to "5-uple" value
  - its first 3 file names { "file name by default", "file name for 'open' state", "file name for 'closed' state" } are mandatory and each one must be unique.
  Furthermore, if the MultiState is linked to an SPS or DPS datapoint of a module containing a "Withdrawn" SPS datapoint, through the **is managed by** relation, then the following constraints are added to the "Bitmap" definition:
  - its 2 file names { "file name for 'withdrawn open' state", "file name for 'withdrawn closed' state" } are both mandatory and each one must be unique.

Adding a transformer representation

In bay mimic, 'LHMI Transformer' is used for dynamic transformer representation. A 'LHMI transformer' is a graphical group constituted of:

- the dynamic representation itself (LHMI Gen module), that is linked to SPS or DPS datapoint and to a dynamic bitmap in bitmap table
- the graphical name of the module (Name), always located on the right of the module representation

To add a transformer representation to a bay mimic diagram, select the Bay mimic level and add the transformer from the contextual **Objects entry** window:

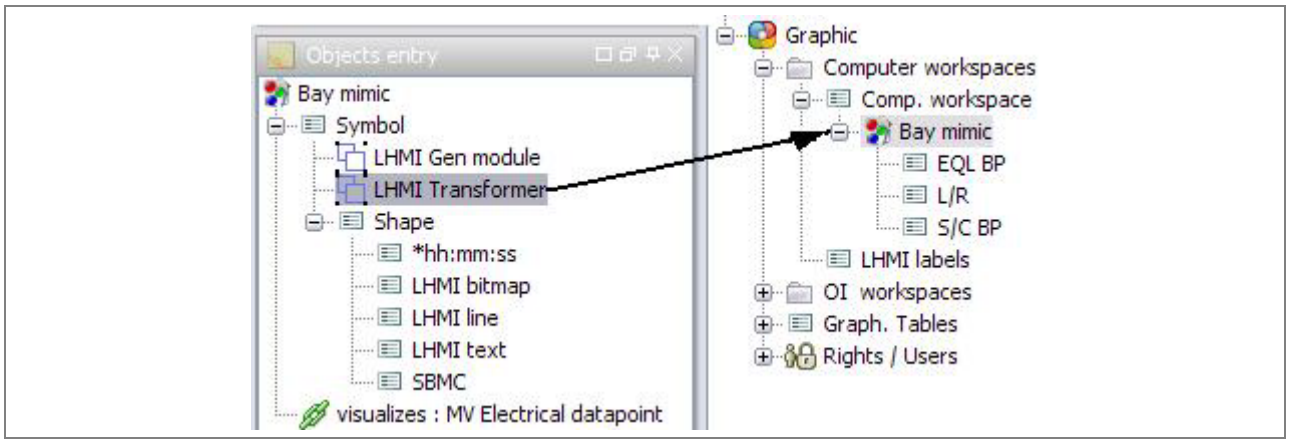


Figure 354: Adding a generic module to a C26x Bay Mimic

Once added, the representation features must be set:

(1) **short name** of the representation used for internal SCE identification.

(2) **x** (range [0, 127 pixels], step 1 pixel): abscissa

(3) **y** (range [0, 127 pixels], step 1 pixel): ordinate

(4) **control availability** (*No* / *Yes*): attribute to precise if control of the transformer can be directly done via bay mimic. This attribute is significant if Raise/Lower DPC control exists for Tap changer built-in function containing the TPI datapoint used for transformer animation (via (5) relation). If so, control availability concerns this DPC.

(5) Relation **is managed by** that must be filled to precise which TPI is used for transformer animation.

(6) **bitmap reference**: corresponds to a link in the bitmap table (see section *6.2.1 Defining a bitmap table*).

(7) **module name value**: name of the transformer: text displayed on LCD (up to 4 characters).

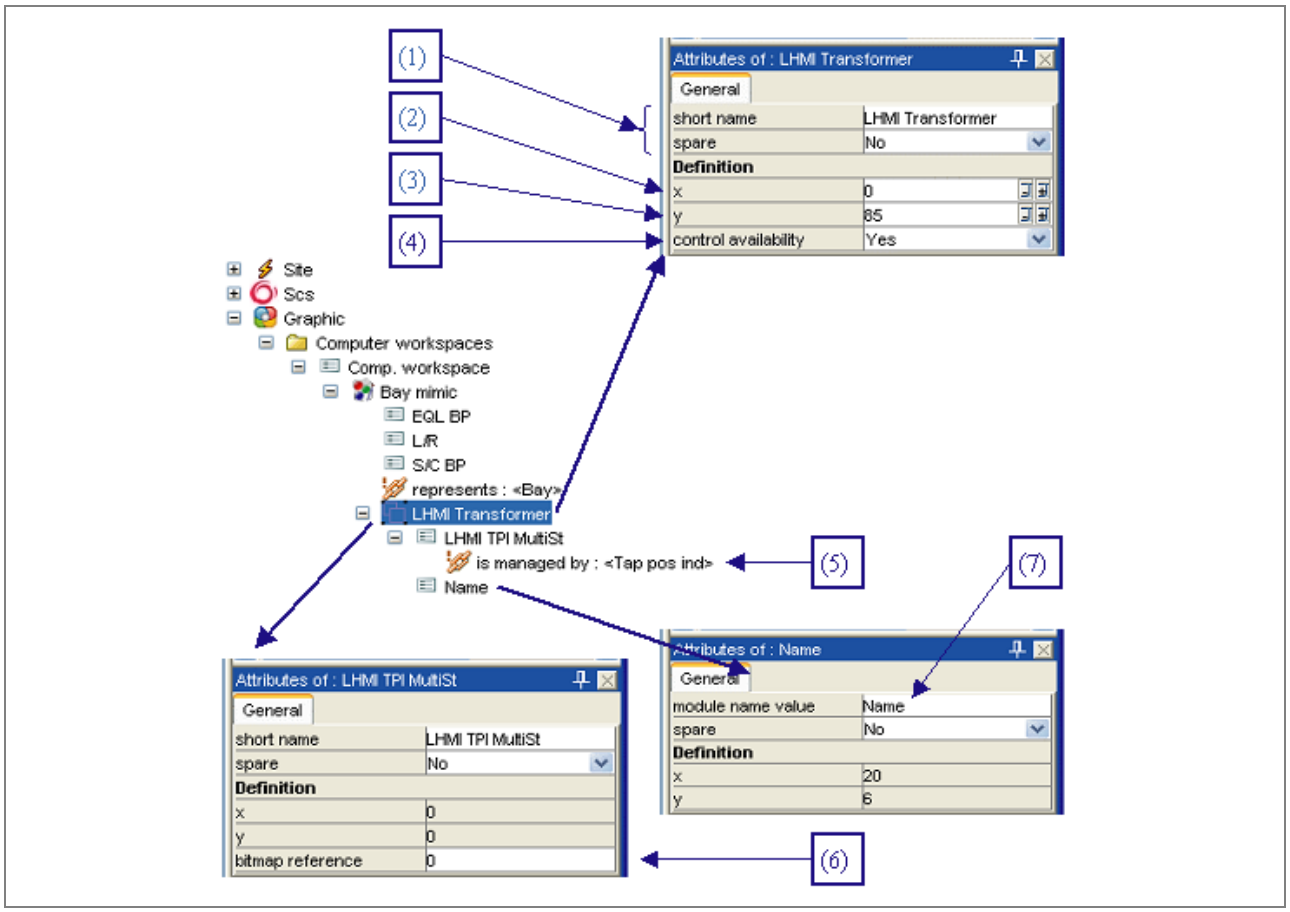


Figure 355: Setting the features of a transformer representation

Abscissa and ordinate of a transformer can be directly adjusted with the mouse in bay mimic editor (for detail, refer to SCE user's manual)

When adding a transformer representation, extra values about associated TPI datapoint can be placed in the bay mimic:

- Current TPI value (dynamic)
- Maximum TPI value
- Minimum TPI value

To add a such TPI information to a bay mimic diagram, select the Bay mimic level and add the TPI field(s) from the contextual **Objects entry** window:

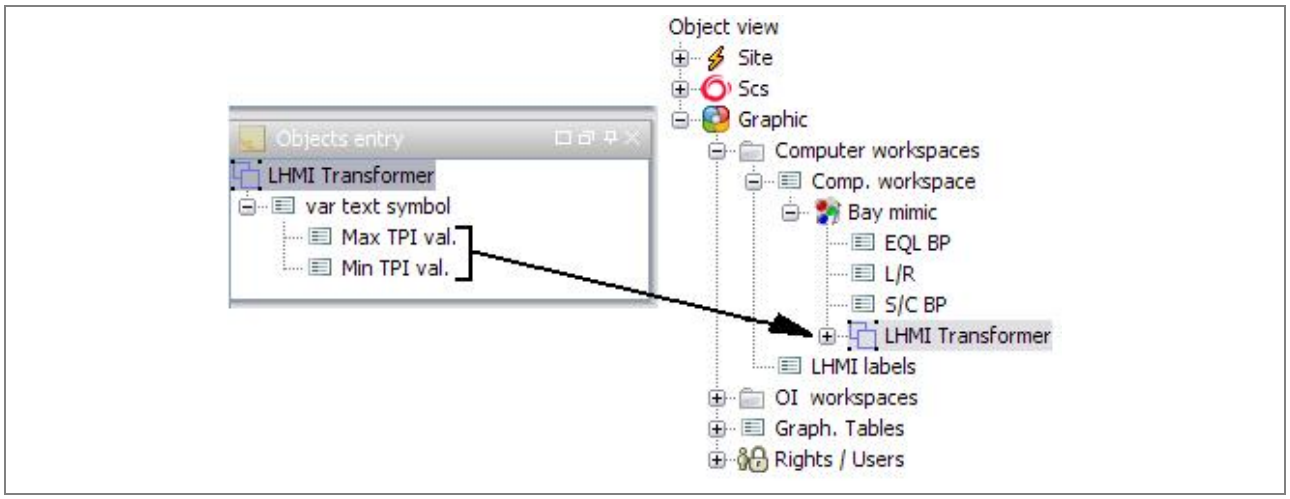


Figure 356: Adding a TPI indication to a C26x Bay Mimic

Once added, TPI information can be positioned at a different location:

- directly using mouse drag and drop in bay mimic editor
- by editing the X-coordinate and Y-coordinate attributes of the object

Configuration rules and checks

- The link from an element to its bitmap is defined with the attribute: "bitmap reference". The value of this attribute must refer to an existing bitmap in the "Bitmap table".

6.2.3.4 ASSIGNING AN MV TO A BAY MIMIC

An MV datapoint is assigned to a specific bay mimic by adding the relation **visualizes** at bay mimic level and filling it with the MV.

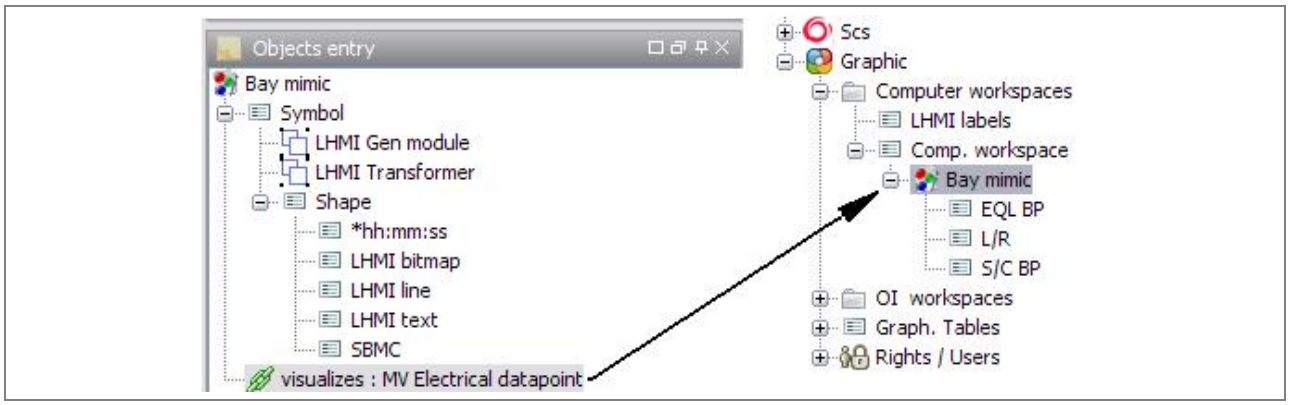


Figure 357: Assigning an MV datapoint to a Bay Mimic

Once the relation added and filled, its attributes **scale** must be set at SCE level:

- **scale** (120% / 200% / No bargraph), to precise which representation is used for the MV in the bay mimic

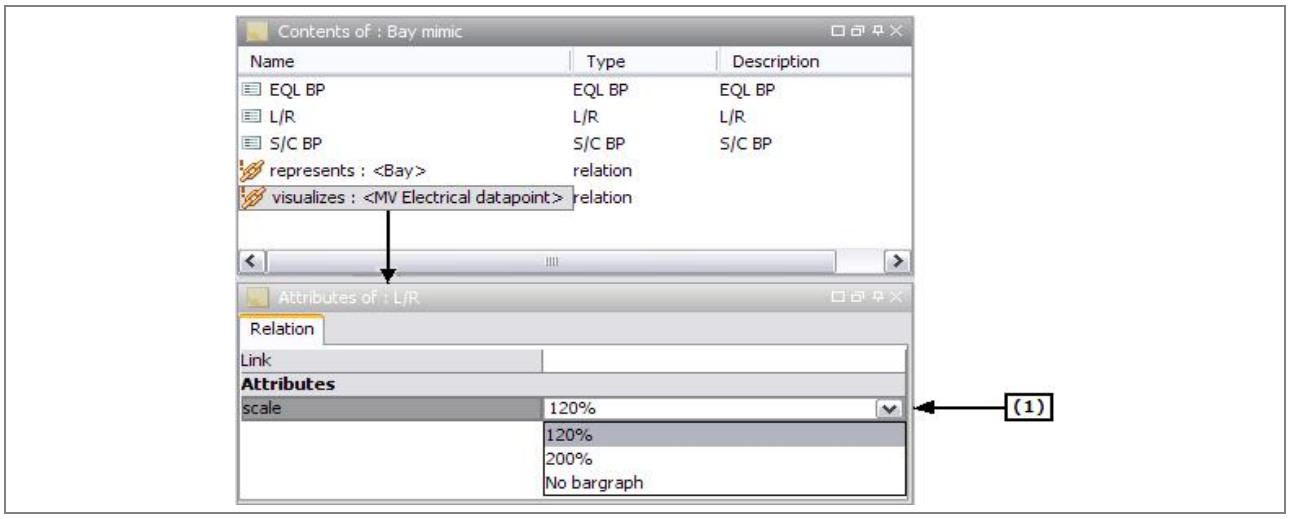


Figure 358: Setting an MV representation in a Bay Mimic

Configuration rules and checks

- An MV datapoint visualized in a "Bay mimic" (relation **visualizes**) must belong to the bay represented by the "Bay mimic" (relation "represents").
- For each visualized MV datapoint, the **transmission on event** attribute must be set neither to "Cyclic short period" value nor to "Cyclic long period" value to avoid overflow of the Bay mimic input buffer.

6.2.4 DISPLAYING A DATAPOINT STATE THROUGH AN LED

SPS and DPS datapoint status can be displayed via the LEDs of the GHU200 board by adding the relation **has state displayed on** at datapoint level (1). Only datapoints managed by the C26x can be displayed via the LEDs of its GHU200 board.

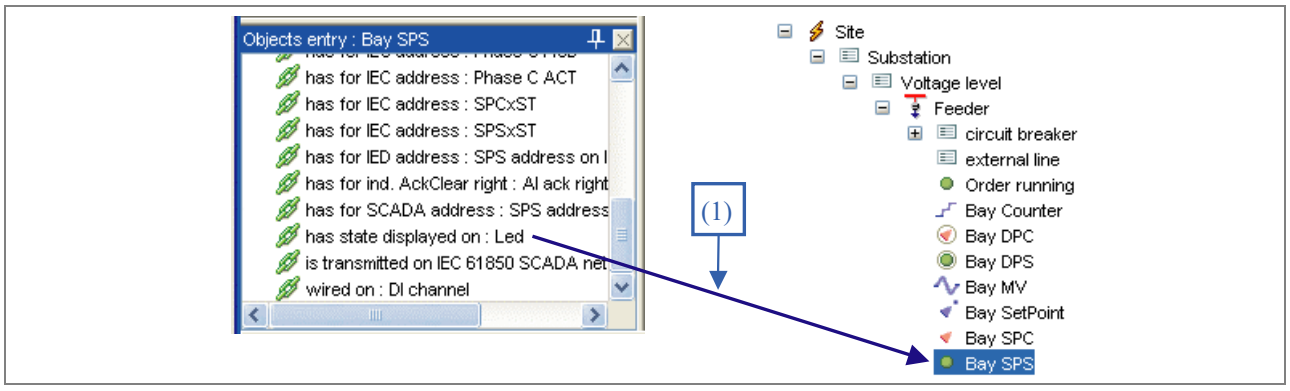


Figure 359: Displaying a datapoint state through an LED (example for a Bay SPS datapoint)

Once added at SPS (resp. DPS) level, select the associated led (link) and the attributes:

- **LED behaviour**: used for alarm/ used for state
- **Status for Set (resp 'Closed')**: *Off* / *On* / *Blinking slow* / *Blinking fast*
- **Status for Reset (resp 'Open')**: *Off* / *On* / *Blinking slow* / *Blinking fast*
- **Status for Invalid**: *Off* / *On* / *Blinking slow* / *Blinking fast*
- **Status for Transient (SPS only)**: *On* / *Blinking slow*

The values are relevant only for the attributes that follow:

Led used Data point	For state	For alarm
SPS	Status for ‘Set’ Status for ‘Reset’ Status for ‘Invalid’	Status for ‘Transient’
DPS	Status for ‘Closed’ Status for ‘'Open' Status for ‘Invalid’	–

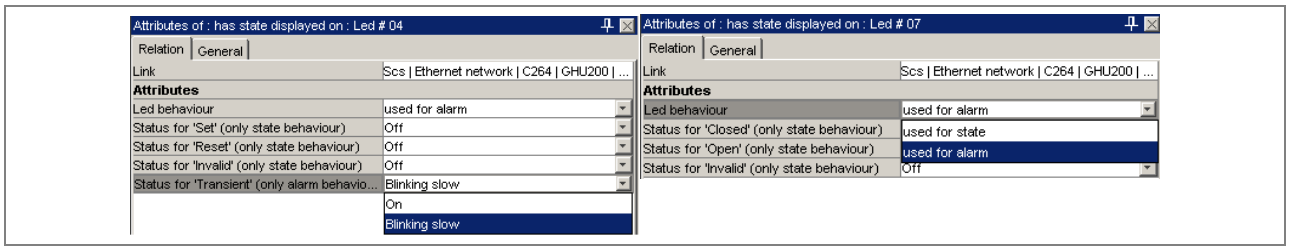


Figure 360: Setting the LED state for a datapoint (SPS on the left/DPS on the right)

Configuration and checks

- If the **HMI type** attribute is set to *Simple*, then **Led#5** must not be assigned (no relation link from **Led#5** to any datapoint) as it is reserved for the Local/Remote indication on that front panel.

7 DEFINING PROTECTION FUNCTIONS

Note:
Protection and Automatism functions are only available if the DS Agile C26x is fitted with TMU210 CT/VT board.

7.1 GENERAL

Protection and automatism functions are respectively described in sections 10 and 11 of the Functional Description chapter (C26x/EN FT).

In the object view tree, the protection functions are associated with a relay (bay level). When the first protection or protection-related function is added to a bay, a “relay” node is automatically added under the bay, and the function is placed under it. Functions subsequently added are placed under the same “relay” node.

The following protections are available with DS Agile C26x units:

- Undervoltage protection ([27] function),
- Wattmetric Earth Fault protection ([32N] function),
- Undercurrent protection ([37] function),
- Negative Sequence Overcurrent protection ([46] function),
- Thermal Overload protection ([49] function),
- Overvoltage protection ([59] function)
- Residual Overvoltage protection ([59N] function),
- Directional overcurrent protection ([67] function),
- Directional Earth Fault protection ([67N] function),
- Overfrequency protection ([81O] function),
- Range Frequency protection ([81R] function),
- Underfrequency protection ([81U] function).

Ancillary functions are available to complement protection:

- Voltage transformer supervision (fuse failure)

7.1.1 GENERAL ARCHITECTURE

In the object view tree, the following tree structure is used to present the protection functions:

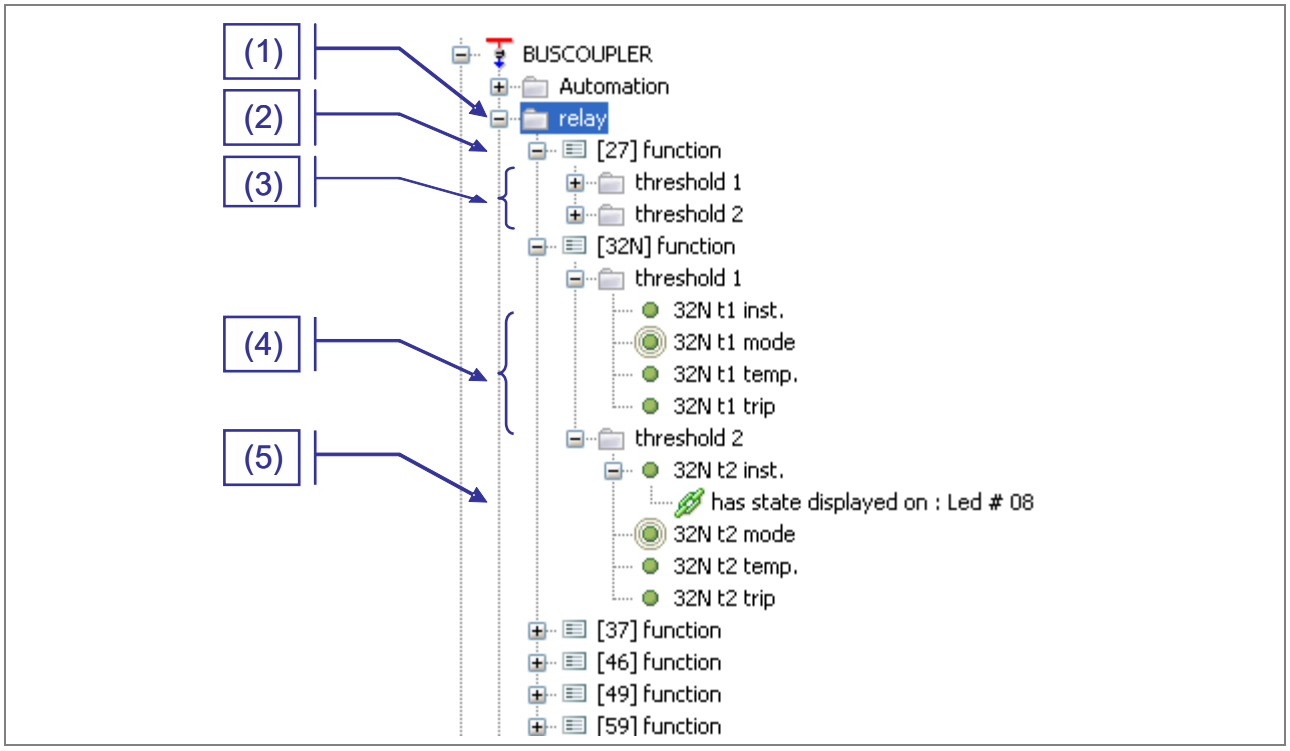


Figure 361: Tree structure for protection functions

Relay (1) object is automatically created when a protection function is added to the bay. Relay does not contain attribute and cannot be edited.

Each Protection function sub-tree (2) contains a folder representing the associated thresholds (3). The characteristics (4) (as instantaneous, time-delay, trip signal, and operation mode) and the links (5) of each characteristic are settable.

7.1.2 DEFINING A PROTECTION FUNCTION

Adding a a protection function is done under SCE using the contextual **Object entry** window at bay level.

To add a protection function:

- Add the protection function from Objects entry (Built-in function, Relay built-in function sub-tree) at bay level (1),
- The protection function (3) is added (Relay (2) is automatically added with the first protection function),
- Select the relay level (2) to display protection and automatic functions in the “Objects entry” area,
- Update the function attributes: **short name** and **long name** (4).

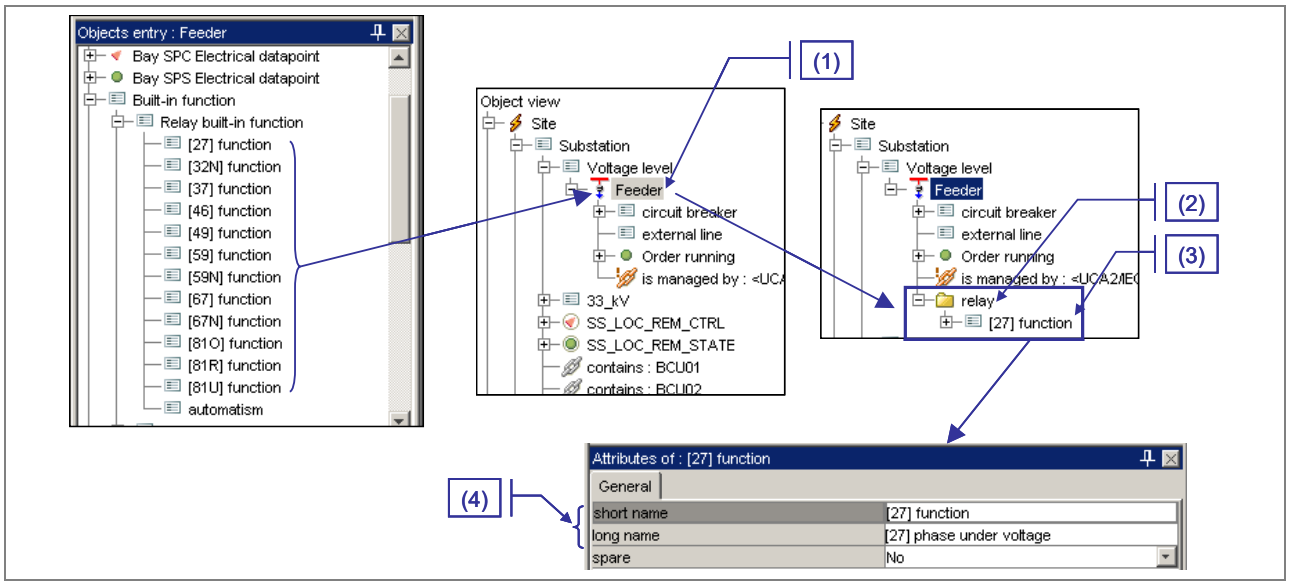


Figure 362: Adding a protection function

7.2 [27] UNDERVOLTAGE PROTECTION

7.2.1 DESCRIPTION OF THE PROTECTION FUNCTION

Undervoltage conditions may occur on a power system for a variety of reasons, for instance increased system loading or complete loss of busbar voltage.

The undervoltage function [27] makes it possible to detect an increase of load. It uses definite time-delay undervoltage protection.

The undervoltage protection element has two programmable stages (**V<**, **V<<**) associated with time-delays: **t V<**, **t V<<**.

The two stages provide both alarm and trip thresholds, where required. Alternatively, different time parameters are settable, depending on the severity of the voltage drop.

7.2.2 DEFINING THE [27] UNDERVOLTAGE PROTECTION FUNCTION

A [27] function is added at bay level from the contextual **Objects entry** window.

The protection function sub-tree contains 2 thresholds (1): **threshold 1, threshold 2**

The first threshold sub-tree contains four nodes:

- **27 t1 inst.** SPS (2): instantaneous undervoltage state for the first threshold, i.e. it is *SET* when the line voltage is below the threshold **V< VALUE**. This SPS is necessarily a permanent signal (**detection mode** attribute not settable).
- **27 t1 mode** MPS (3): operation mode of the protection function for the first threshold, corresponding to **V< ?** = *ON*, *OR* or *AND*. All the attributes are settable. If *OR* is selected, the first undervoltage stage alarm is issued if at least one phase is faulted. If *AND* is selected, this alarm appears when the fault is detected on all three phases.
- **27 t1 temp.** SPS (4) is state for the first time-delay, i.e. it is set when **t V<** is running. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **27 t1 trip** SPS (5): trip signal for the first stage (**Trip V<**). The trip signal is necessarily a transient (pulse) signal (**detection mode** attribute not settable). The time reference, set and reset delays are fixed and cannot be changed.

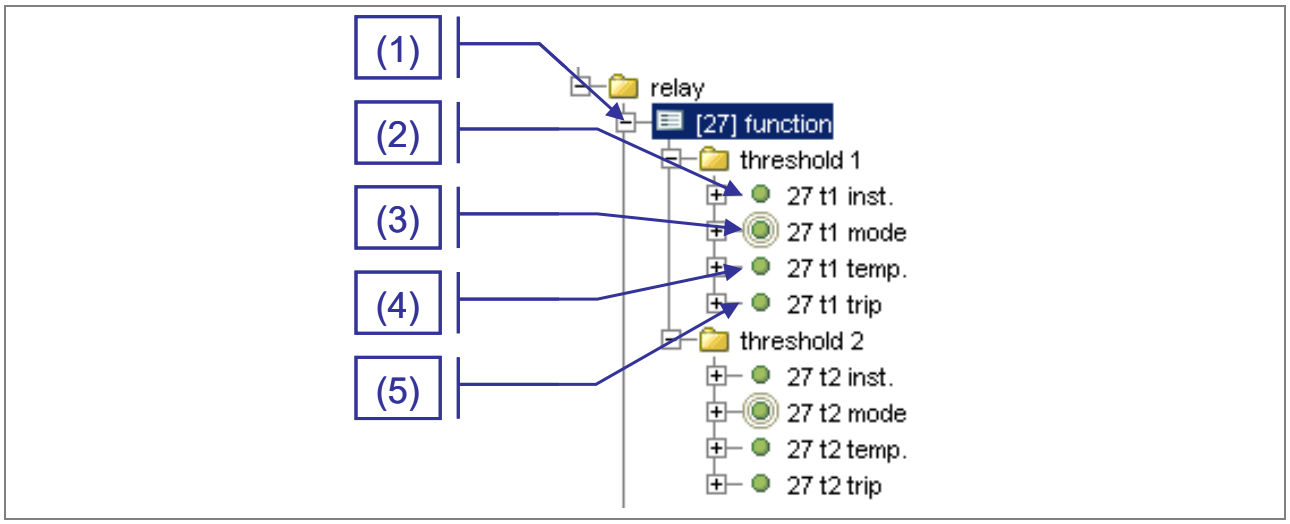


Figure 363: [27] Undercurrent datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

threshold 2 contains the same datapoints as **threshold 2**:

- **27 t2 inst.** is identical to the **27 t1 inst.** SPS for stage 2,
- **27 t2 mode** is identical to the **27 t1 mode** MPS for stage 2,
- **27 t2 temp.** is identical to the **27 t1 temp.** SPS for stage 2,
- **27 t2 trip** is identical to the **27 t1 trip** SPS for stage 2.

7.3 [32N] WATTMETRIC EARTH FAULT PROTECTION

7.3.1 DESCRIPTION OF THE PROTECTION FUNCTION

The directional earth fault protection provides three directional / non directional earth fault stages and two wattmetric and active earth fault current thresholds.

It is possible to choose between Wattmetric (Pe>) protection and IeCos (active component of the earth fault current) protection functionality mode.

The Pe> and Pe>> settings correspond to:

Vres x Ires x Cos (ϕ – ϕc) = 9 x V_0 x I_0 x Cos (ϕ – ϕc)

Where:

ϕ = angle between the polarising voltage (-Vres) and the residual current
ϕc = relay characteristic angle (RCA/torque angle)
Vres = residual voltage
Ires = residual current
V_0 = zero sequence voltage
I_0 = zero sequence current

The measurement of Pe depends on the voltage wiring of the unit. If there is no neutral voltage transformer, Pe will be based on the neutral voltage derived from the vectorial sum of the phase voltages. If a neutral voltage transformer is available, Pe will use the measured neutral voltage.

7.3.2 DEFINING THE WATTMETRIC EARTH FAULT PROTECTION FUNCTION

A [32N] function is added at bay level from the contextual **Objects entry** window.

The protection function sub-tree contains two thresholds (1): **threshold 1** and **threshold 2**,

The first threshold sub-tree contains four nodes:

- **32N t1 inst.** SPS (2): instantaneous earth wattmetric state for the first threshold, i.e it is *SET* when the earth power above the threshold **Pe>**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **32N t1 mode** MPS (3): operation mode of the protection function for the first threshold. corresponding to **Pe> ?** = *ON* or *OFF*. All the attributes are settable.
- **32N t1 temp.** SPS (4): time-delay signal for the first threshold corresponding to the **t Pe >** time-delay. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **32N t1 trip** SPS (5): trip signal for the first threshold (**Trip Pe>**). The trip signal is necessarily a transient (pulse) signal (**detection mode** attribute not settable). The time reference, set and reset delays are fixed.

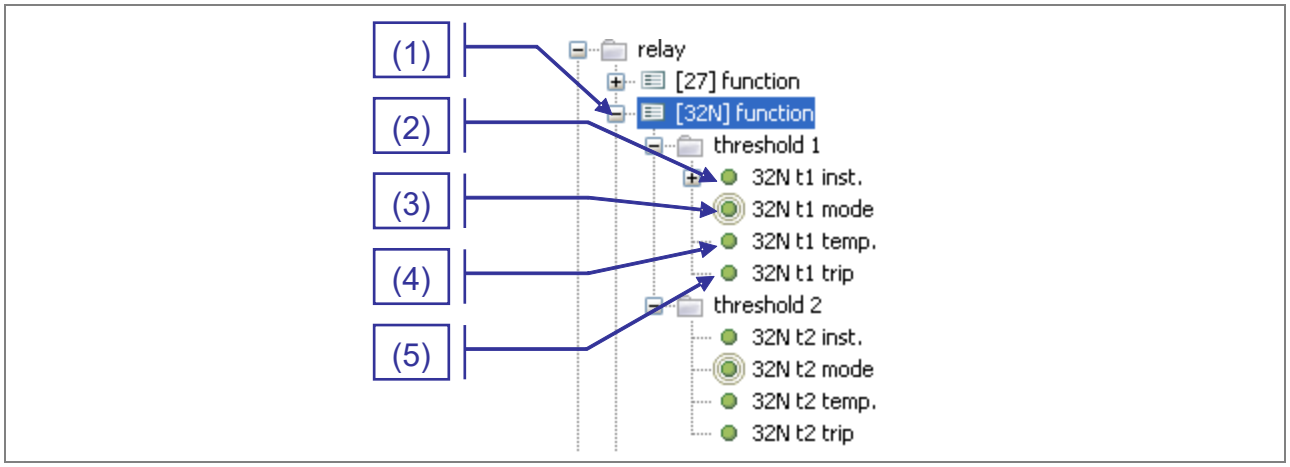


Figure 364: [32N] Wattmetric Earth Fault datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

threshold 2 contains the same datapoints as **threshold 1**:

- **32N t2 inst.** is identical to the **32N t1 inst.** SPS for **threshold 2**,
- **32N t2 mode** is identical to the **32N t1 mode** MPS for **threshold 2**,
- **32N t2 temp.** is identical to the **32N t1 temp.** SPS for **threshold 2**,
- **32N t2 trip** is identical to the **32N t1 trip** SPS for **threshold 2**.

7.4 [37] UNDERCURRENT PROTECTION

7.4.1 DESCRIPTION OF THE PROTECTION FUNCTION

The undercurrent function [37] makes it possible to detect a loss of load (for example the draining of a pump or breakage of a conveyor belt). It uses definite time-delay undercurrent protection.

The undercurrent protection relays consists of one threshold. The user can set the following parameters:

- undercurrent threshold **I<**
- undercurrent time-delay **tI<**

The threshold provides alarm and trip stage, where required. Alternatively, the time setting is settable, depending upon the severity of the current drop.

7.4.2 DEFINING THE [37] UNDERCURRENT PROTECTION FUNCTION

A [37] function is added at bay level from the contextual **Objects entry** window.

The sub-tree contains four nodes:

- **37 t inst.** SPS (2): instantaneous undercurrent status for the first threshold, i.e it is *SET* when the current is below the threshold **I< VALUE** . This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **37 t mode** MPS (3): operation mode of the protection function for the first threshold, corresponding to **I< ?** = *ON* or *OFF*. All the attributes are settable.
- **37 t temp.** SPS (4): time-delay signal for the first threshold, corresponding to the **t I<** time-delay. This datapoint is a necessarily permanent signal (permanent **detection mode** attribute cannot be set).
- **37 t trip** SPS (5): trip signal for the first threshold (**Trip I<**). This datapoint is necessarily a transient (pulse) signal (**detection mode** attribute not settable). The time reference, set and reset delays are fixed.

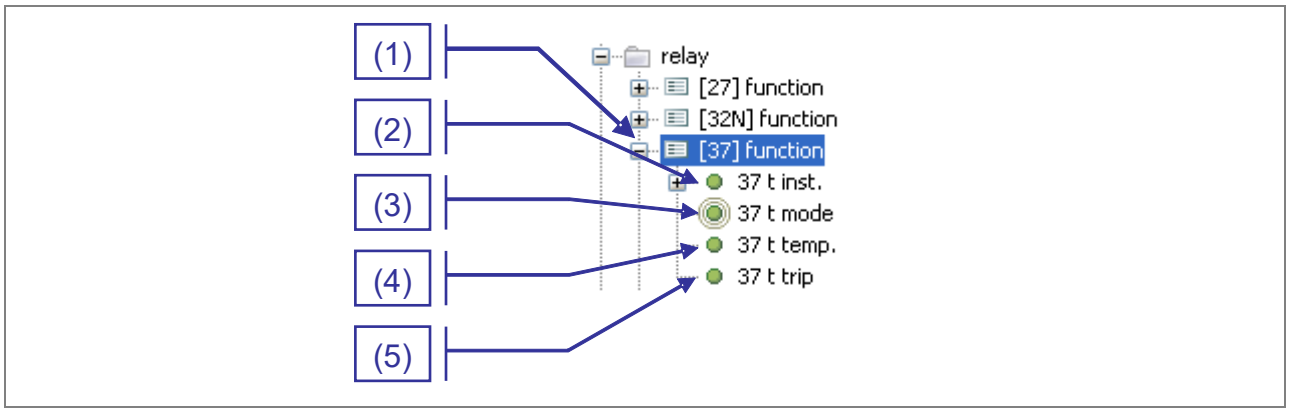


Figure 365: [37] Undercurrent datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

7.5 [46] NEGATIVE SEQUENCE OVERCURRENT PROTECTION

7.5.1 DESCRIPTION OF THE PROTECTION FUNCTION

When applying traditional phase overcurrent protection, the overcurrent elements must be set higher than maximum load current, thereby limiting the sensitivity of the element. Most protection techniques also use an earth fault element operating from residual current, which improves sensitivity for earth faults. However, some faults may arise which can remain undetected by such techniques.

Any unbalanced fault condition will produce negative sequence current. Thus, a negative phase sequence overcurrent element can detect both phase-to-phase and phase to earth faults.

The negative phase sequence overcurrent elements have overcurrent pick-up settings: **I2>**, **I2>>**, **I2>>>**, and their operation is time-delayed by the settable time-delays **tI2>**, **tI2>>**, **tI2>>>**.

The protection element includes three thresholds. The first stage can have a DT or IDMT trip characteristic.

The curves are the same as for the [50/51], [50N/51N] protection function.

The three stages provide both alarm and trip thresholds, where required. Alternatively, different time-delays are settable, depending on the severity of the overcurrent.

7.5.2 DEFINING A [46] NEGATIVE SEQUENCE OVERCURRENT PROTECTION FUNCTION

A [46] function is added at bay level from the contextual **Objects entry** window.

The protection function sub-tree contains three thresholds (1): **threshold 1**, **threshold 2** and **threshold 3**.

The first threshold sub-tree contains four nodes:

- **46 t inst.** SPS (2): instantaneous negative sequence overcurrent status for the first threshold, i.e it is *SET* when the negative-sequence current is above the theshold **I2> VALUE**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **46 t mode** MPS (3): operation mode of the protection function for the first threshold, corresponding to **I2> ?** = ON or OFF. All the attributes are settable.
- **46 t temp.** SPS (4): time-delay signal for the first threshold, corresponding to the **t I2>** time-delay. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **46 t trip** SPS (5): trip signal for the first threshold (**Trip I2>**). This datapoint is necessarily a transient (pulse) signal (**detection mode** attribute not settable). The time reference, set and reset delays are fixed.

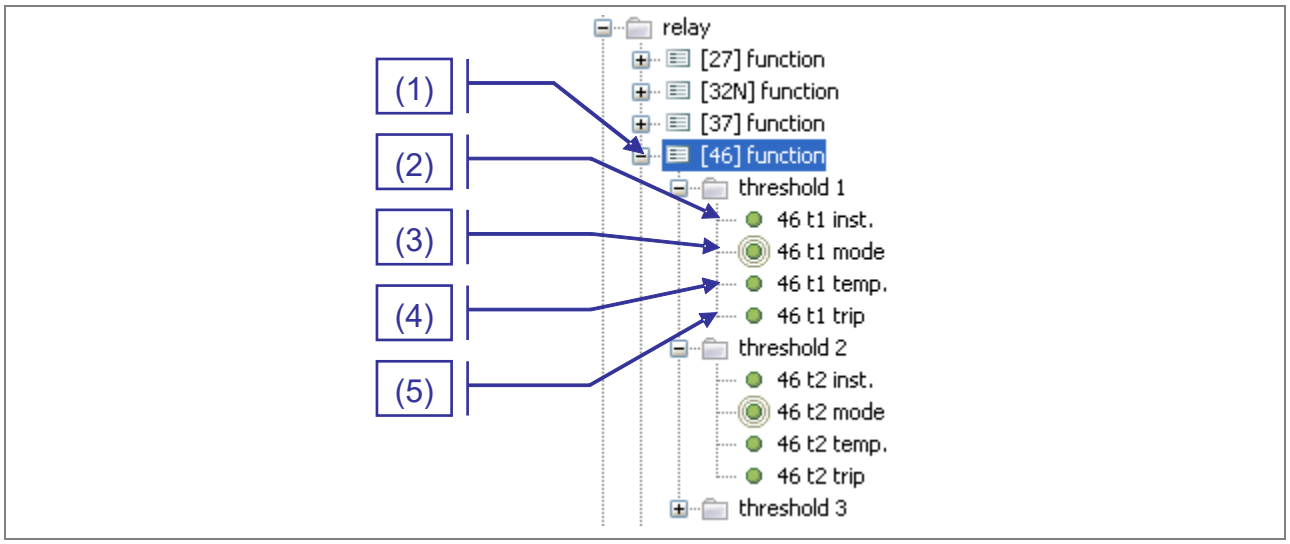


Figure 366: [46] Negative Sequence Overcurrent datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

The contents of **threshold 2** and **threshold 3** are identical to the **threshold 1**.

- **46 t2 inst.** and **46 t3 inst.** are identical to the **46 t1 inst.** SPS for **threshold 2** and **threshold 3**,
- **46 t2 mode** and **46 t3 mode** are identical to the **46 t1 mode** MPS for **threshold 2** and **threshold 3**,
- **46 t2 temp.** and **46 t3 temp** are identical to the **46 t1 temp.** SPS for **threshold 2** and **threshold 3**,
- **46 t2 trip** and **46 t3 mode** are identical to the **46 t1 trip** SPS for **threshold 2** and **threshold 3**.

7.6 [49] THERMAL OVERLOAD PROTECTION

7.6.1 DESCRIPTION OF THE PROTECTION FUNCTION

Thermal overload protection can be used to prevent electrical plant from operating at temperatures in excess of the designed maximum withstand.

Protection relays incorporate a current-based thermal replica, using load current to reproduce the heating and cooling of the protected plant. The thermal overload protection element (**49 th overload**) can be set with both alarm and trip threasholds (**49 th alarm** and **49 trip th over.**).

The time to trip varies depending on the load current carried before application of the overload, i.e. whether the overload was applied from “hot” or “cold”. Curves of the thermal overload time characteristic are given in C26x/EN FT (Functional Description) chapter.

7.6.2 DEFINING THE [49] THERMAL OVERLOAD PROTECTION FUNCTION

A [49] function is added at bay level from the contextual **Objects entry** window.

The protection function sub-tree contains one threshold, with four nodes:

- **49 t mode** MPS (2): operation mode of the protection function, corresponding to **Thermal OL** = *ON* or *OFF*. All the attributes are settable.
- **27 th alarm** SPS (3): instantaneous thermal alarm status, corresponding to thermal alarm value. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **27 th overload** SPS (4): thermal overload status, corresponding to thermal alarm value. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **27 trip th over.** SPS (5): trip signal, corresponding to thermal trip. This datapoint is necessarily a transient (pulse) signal (detection mode attribute not settable). The time reference, set and reset delays are fixed.

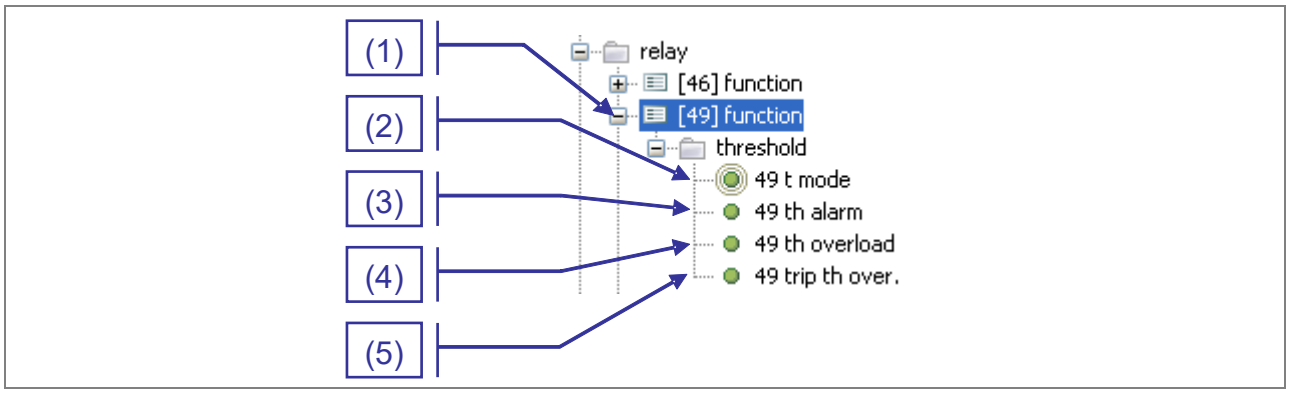


Figure 367: [46] Negative Sequence Overcurrent datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

7.7 [59] OVERVOLTAGE PROTECTION

7.7.1 DESCRIPTION OF THE PROTECTION FUNCTION

Undervoltage conditions are relatively common because they are related to fault conditions etc. However, overvoltage conditions are also a possibility and are generally related to loss of load conditions as described below.

Under conditions of load rejection, the supply voltage will increase in magnitude. This situation would normally be rectified by voltage regulating equipment such as AVR's or on-load tap changers. However, failure of this equipment to bring the system voltage back within prescribed limits leaves the system with an overvoltage condition which must be cleared in order to preserve the life of the system insulation. Hence, overvoltage protection that is suitably time delayed to allow for normal regulator action, may be applied.

During earth fault conditions on a power system there may be an increase in the healthy phase voltages. Ideally, the system should be designed to withstand such overvoltages for a defined period of time. Normally, there will be a primary protection element employed to detect the earth fault condition and to issue a trip command if the fault is uncleared after a nominal time. However, it would be possible to use an overvoltage element as a back-up protection in this instance. A single stage of protection would be sufficient, having a definite time delay.

7.7.2 DEFINING THE [59] OVERVOLTAGE PROTECTION FUNCTION

A [59] function is added at bay level from the contextual **Objects entry** window.

To add a [59] Overvoltage protection function, see section *7.1.2 – Defining a protection function*.

The protection function sub-tree contains 2 thresholds (1): **threshold 1, threshold 2**

The first threshold sub-tree contains four nodes:

- **59 t1 inst.** SPS (2): instantaneous overvoltage state for the first threshold, i.e. it is *SET* when the line voltage is below the **V> VALUE** threshold. This SPS is necessarily a permanent signal (**detection mode** attribute not settable).
- **59 t1 mode** MPS (3): operation mode of the protection function for the first threshold, corresponding to **V> ?** = *ON*, *OR* or *AND*. All the attributes are settable. If *OR* is selected, the first overvoltage stage alarm is issued if at least one phase is faulted. If *AND* is selected, this alarm appears when the fault is detected on all three phases.
- **59 t1 temp.** SPS (4) is state for the first time-delay, i.e. it is set when **t V>** is running. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **59 t1 trip** SPS (5): trip signal for the first stage (**Trip V>** trip). The trip signal is necessarily a transient (pulse) signal (**detection mode** attribute not settable). The time reference, set and reset delays are fixed and cannot be changed.

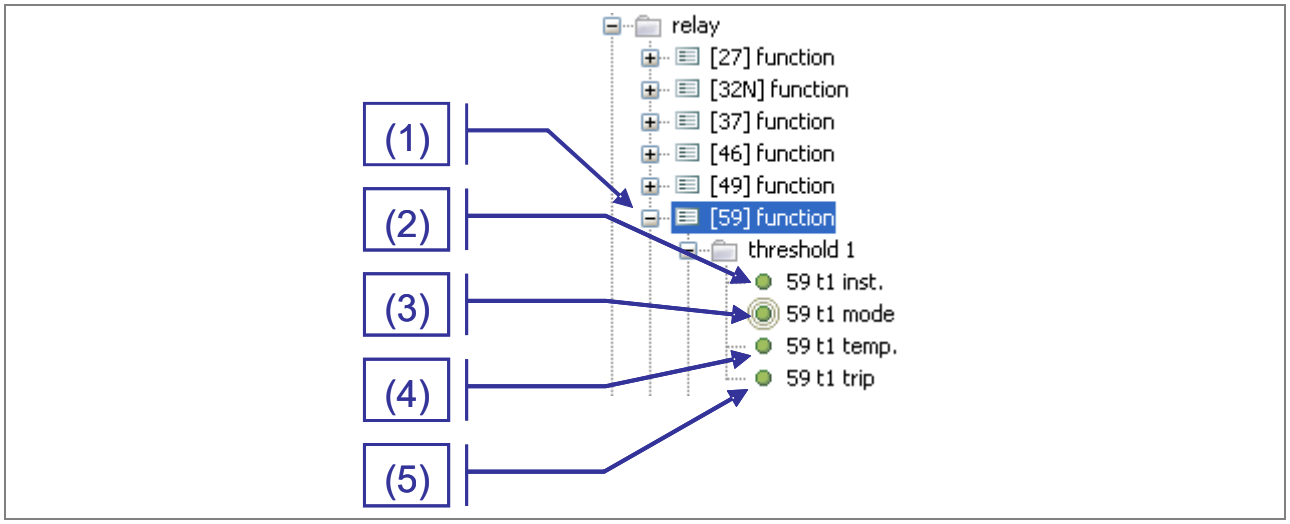


Figure 368: [27] Overcurrent datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

threshold 2 contains the same datapoints as **threshold 2**:

- **27 t2 inst.** is identical to the **27 t1 inst.** SPS for stage 2,
- **27 t2 mode** is identical to the **27 t1 mode** MPS for stage 2,
- **27 t2 temp.** is identical to the **27 t1 temp.** SPS for stage 2,
- **27 t2 trip** is identical to the **27 t1 trip** SPS for stage 2.

7.8 [59N] RESIDUAL OVERVOLTAGE (NEUTRAL DISPLACEMENT) PROTECTION

7.8.1 DESCRIPTION OF THE PROTECTION FUNCTION

On a healthy three-phase power system, the sum of the three phase-to-earth voltages is nominally zero, as it results from the sum of three balanced vectors at 120° to one another. However, when an earth fault occurs on the primary system this balance is upset and a 'residual' voltage is produced. This can be measured, for example, at the secondary terminals of a voltage transformer having a "broken delta" secondary connection. Hence, a residual voltage-measuring relay can be used to offer earth fault protection on such a system. Note that this condition causes a rise in the neutral voltage with respect to earth, which is commonly referred to as "neutral voltage displacement".

The voltage setting applied to the protection elements is dependent upon the magnitude of residual voltage that is expected to occur during an earth fault condition.

This in turn is dependent upon the method of system earthing employed. It must also be ensured that the relay is set above any standing level of residual voltage that is present on the system.

The protection element has one programmable element Uen> with a time-delay tUen>.

7.8.2 DEFINING THE [59N] RESIDUAL OVERVOLTAGE PROTECTION FUNCTION

A [59N] function is added at bay level from the contextual **Objects entry** window.

To add the [59N] Residual Overvoltage protection function, see section *7.1.2 – Defining a protection function*.

The protection function sub-tree contains one threshold with four nodes:

- **59N t inst.** SPS (2): instantaneous zero sequence overvoltage status, i.e. it is *SET* when the residual voltage is above the threshold **Uen> VALUE**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **59N t mode** MPS (3), operation mode of the protection function, corresponding to **Uen> ?** = *ON* or *OFF*. All the attributes are settable.
- **59N t temp.** SPS (4): time-delay signal corresponding to the **tUen>** time-delay. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **59N t trip** SPS (5). trip signal for the first threshold (**Trip Un>**). This trip signal is necessarily a transient (pulse) signal (**detection mode** attribute not settable). The time reference, set and reset delays are fixed.

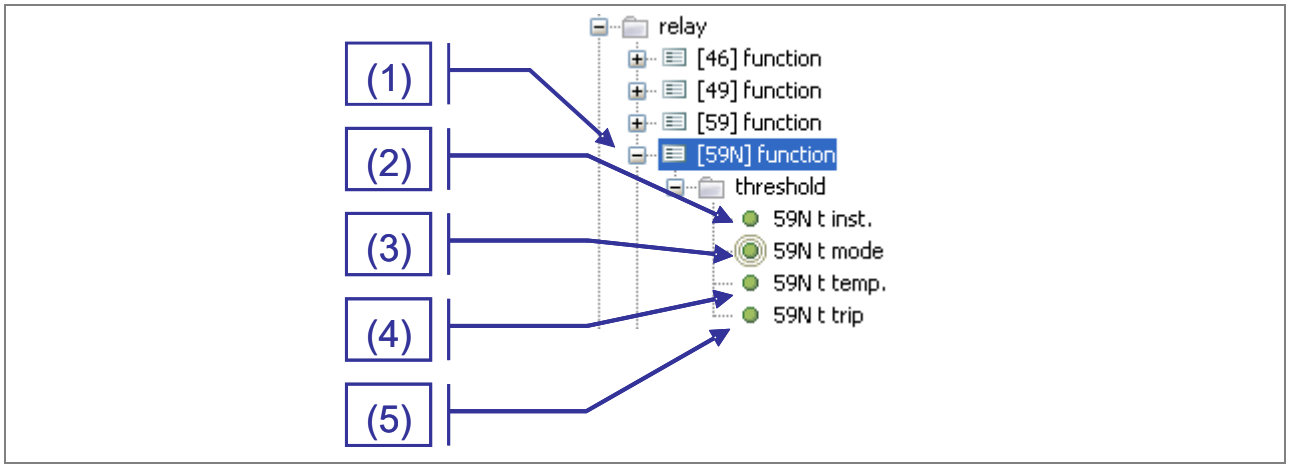


Figure 369: [59N] Residual Overvoltage datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

7.9 [67] DIRECTIONAL OVERCURRENT PROTECTION

7.9.1 DESCRIPTION OF THE PROTECTION FUNCTION

If a fault current can flow in both directions through a relay location, it is necessary to add directionality to the overcurrent relays in order to obtain correct co-ordination. Typical systems that require such protection are parallel feeders and ring main systems.

In order to give directionality to an overcurrent relay, it is necessary to provide it with a suitable reference, or polarising signal. The reference generally used is the system voltage, as its angle remains relatively constant under fault conditions.

Each directional threshold consists of:

- a Current threshold,
- a Relay Characteristic Angle angle (I^U) / Torque angle and Trip boundary zone.

The directional overcurrent protection element compares the directional fault current, residual voltage with the set thresholds **I>**, **U>**, **I>>**, **U>>**, **I>>>**, **U>>>** and the relevant angle between I and U for each threshold.

The first and second thresholds can be set as directional or non-directional and with a definite or inverse time-delay. The third threshold can be set as directional or non-directional with a definite time-delay only, but can be set to operate on the peak of the current measured in non-directional way.

The protection elements trip when the following conditions occur:

- The phase current exceeds the set overcurrent threshold,
- The current vector lies within the trip boundary zone.

The choice of interlock functionality is available when the IDMT delay trip time is chosen on the first threshold: The 2nd and 3rd threshold pickup can suspend 1st threshold output control to save selectivity.

7.9.2 DEFINING THE [67] DIRECTIONAL OVERCURRENT PROTECTION FUNCTION

A [67] function is added at bay level from the contextual **Objects entry** window.

The protection function sub-tree contains three thresholds (1): **threshold 1**, **threshold 2** and **threshold 3**.

The first threshold sub-tree contains six nodes:

- **67 t1 in dir rev** SPS (2): instantaneous non-directional (reverse) overcurrent status for the first threshold, i.e. it is *SET* when the current is above the non directional threshold **I> VALUE**. This datapoint is necessarily a permanent signal (permanent **detection mode** attribute is not settable).
- **67 t1 inst.** SPS (3): instantaneous directional overcurrent status for the first threshold, i.e. it is *SET* when the current is above the directional threshold **I> VALUE**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **67 t1 interlock** SPS (4): interlock status (**I> >> >>> Interlock**). This datapoint is available for the first threshold only. It is necessarily a permanent signal (**detection mode** attribute not settable).
- **67 t1 mode** MPS (5): operation mode of the protection function for the first threshold (**I> ?** = *ON*, *OFF* or *DIR*). All the attributes are settable.
- **67 t1 temp.** SPS (5): time-delay for the first threshold, corresponding to the **t I>** time-delay. The time-delay datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **67 t1 trip** SPS (6): trip signal for the first threshold (**Trip I>**). The trip signal is necessarily a transient (pulse) signal (transient **detection mode** not settable). The time reference, set and reset delays are fixed.

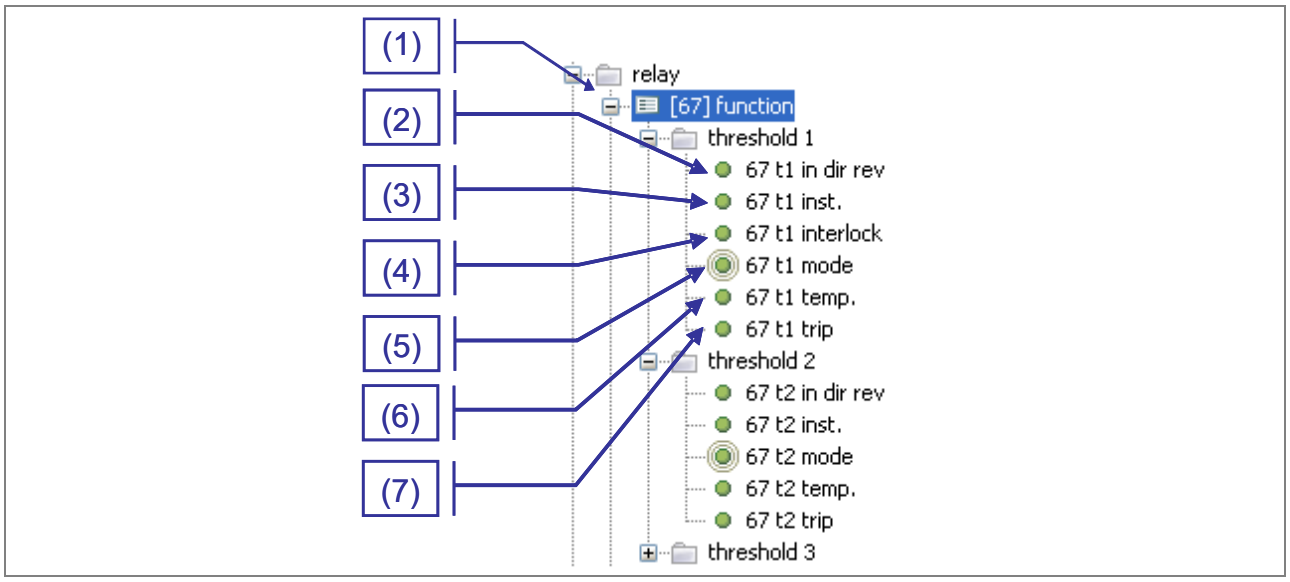


Figure 370: [67] Directional Overcurrent datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

The contents of **threshold 2** and **threshold 3** are similar to **threshold 1**.

- **67 t2 in dir rev** and **67 t3 in dir rev** are identical to the **67 t1 in dir rev** SPS for **thresholds 2** and **3**,
- **67 t2 inst.** and **67 t3 inst.** are identical to the **67 t1 inst.** SPS,
- the **67 t1 interlock** menu does not exist for **thresholds 2** and **3**,
- **67 t2 mode** and **67 t2 mode** are identical to the **67 t1 mode** MPS for **thresholds 2** and **3**,
- **67 t2 temp.** and **67 t2 temp.** are identical to the **67 t1 temp.** SPS for **thresholds 2** and **3**,
- **67 t2 trip** and **67 t2 trip** are identical to the **67 t1 trip** SPS for **thresholds 2** and **3**.

7.10 [67N] DIRECTIONAL EARTH FAULT PROTECTION

7.10.1 DESCRIPTION OF THE PROTECTION FUNCTION

The directional earth fault protection function provides three directional / non directional earth fault thresholds and two wattmetric and active earth fault thresholds (see section *7.3 – [32N] Wattmetric Earth Fault protection* for more details about this protection function).

The directional earth fault protection element compares the earth fault current and the residual voltage with the set thresholds **Ie>**, **Ue>**, **Ie>>**, **Ue>>**, **Ie>>>**, **Ue>>>**, as well as the relevant angle between **Ie** and **Ue** for each threshold.

The first and second thresholds can be associated with definite or inverse time-delays. The third current threshold can be set directional or non-directional but only with a definite time-delay setting.

The protection elements trip when the following conditions occur:

- the thresholds for Ie and Ue are exceeded (earth fault protection element)
- the Ie current vector is in the tripping area (Ie^Ue)
- Ie [mA] + Ue [V] > 18 (Ien=1A) or Ie [mA] + Ue [V] > 90 (Ien=5A)
- the trip time-delay elapses

The peak detection is applied where a CT saturation condition occurs and the measurement is not more trustworthy.

The reset time-delay for each threshold provides protection against intermittent faults.

The choice of interlock functionality is available when the IDMT delay trip time is chosen on the first threshold: The 2nd and 3rd threshold pickup can suspend 1st threshold output control to save selectivity.

7.10.2 DEFINING THE [67N] DIRECTIONAL EARTH FAULT PROTECTION FUNCTION

A [67N] function is added at bay level from the contextual **Objects entry** window.

The protection function sub-tree contains three thresholds (1): **threshold 1**, **threshold 2** and **threshold 3**.

The first threshold sub-tree contains six nodes:

- **67N t1 in dir rev** SPS (2): instantaneous non-directional earth fault status for the first threshold, i.e. it is *SET* when the neutral current is above the non-directional threshold **Ie> VALUE**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **67N t1 inst.** SPS (3): instantaneous directional earth fault status for the first threshold, i.e. it is *SET* when the neutral current is above the directional threshold **Ie> VALUE**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **67N t1 interlock** SPS (4): Interlock status (**Ie> >> >>> Interlock**). This status is available for the first threshold only. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **67N t1 mode** (5): operation mode of the protection function for the first threshold (**Ie> ?** = *ON*, *OFF* or *DIR*). All the attributes can be modified.
- **67N t1 temp.** (5): time-delay signal for the first threshold, corresponding to the **t Ie>** time-delay. The time-delay signal is necessarily a permanent signal (**detection mode** attribute not settable).
- **67N t1 trip** (6). trip signal for the first threshold (**Trip Ie>**). The trip signal is necessarily a transient (pulse) signal (**detection mode** attribute not settable). The time reference, set and reset delays are fixed.

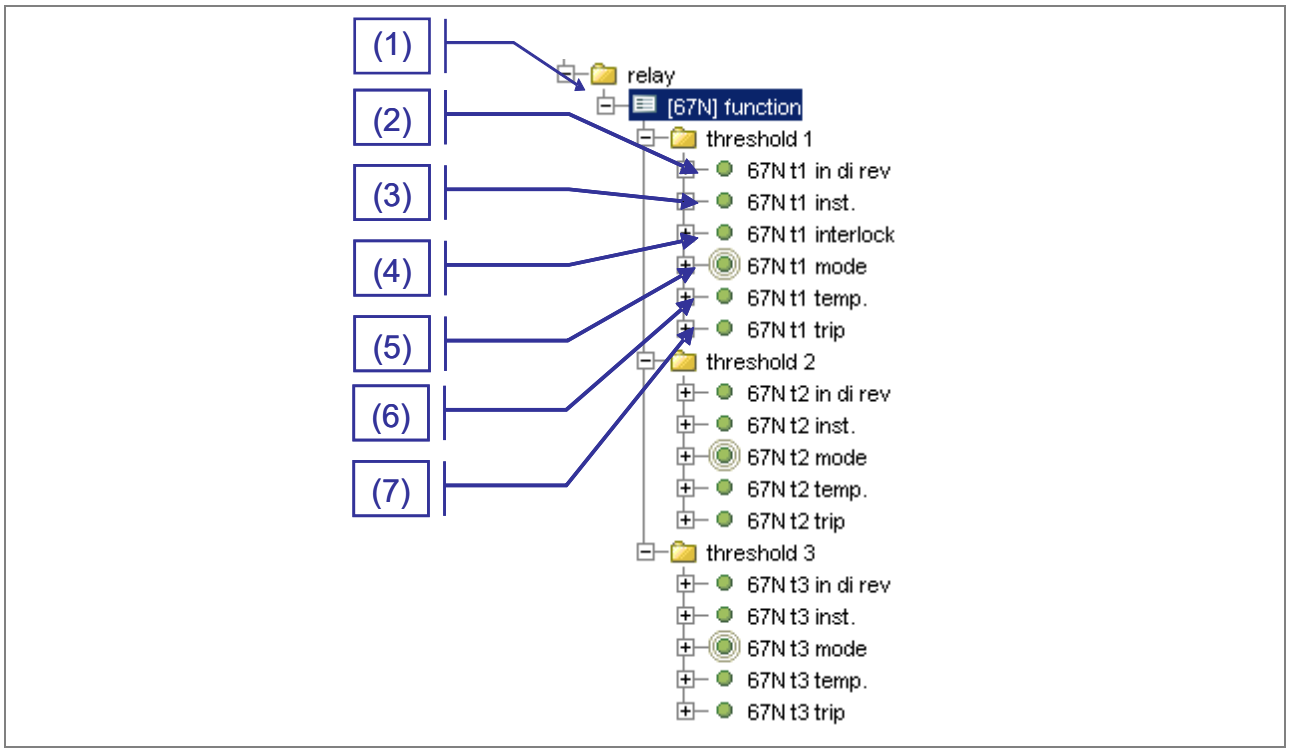


Figure 371: [67N] Directional earth fault sub-tree

Update the relations and the links of the datapoints to point to a specific existing profile.

The contents of **threshold 2** and "**threshold 3**" are similar to **threshold 1**.

- **67N t2 in dir rev and 67N t3 in dir rev** are identical to the **67N t1 in dir rev** SPS for **thresholds 2** and **3**,
- **67N t2 inst.** and **67N t3 inst.** are identical to the **67N t1 inst.** SPS for **thresholds 2** and **3**,
- **67N t1 interlock** menu does not exist for **thresholds 2** and **3**,
- **67N t2 mode** and **67N t2 mode** are identical to the **67N t1 mode** MPS for **thresholds 2** and **3**,
- **67N t2 temp.** and **67N t2 temp.** are identical to the **67N t1 temp.** SPS for **thresholds 2** and **3**,
- **67N t2 trip** and **67N t2 trip** are identical to the **67N t1 trip** SPS for **thresholds 2** and **3**.

7.11 [81O] OVERFREQUENCY PROTECTION

7.11.1 DESCRIPTION OF THE PROTECTION FUNCTION

Overfrequency running of a generator arises when the mechanical power input to the machine exceeds the electrical output. This could happen, for instance, when there is a sudden loss of load due to tripping of an outgoing feeder from the plant to a load center. Under such over speed conditions, the governor should respond quickly so as to obtain a balance between the mechanical input and electrical output, thereby restoring normal frequency. Over frequency protection is required as a back-up to cater for slow response of frequency control equipment.

Following faults on the network, or other operational requirements, it is possible that various subsystems will be formed within the power network and it is likely that each of these subsystems will suffer from a generation to load imbalance. The "islands" where generation exceeds the existing load will be subject to overfrequency conditions, the level of frequency being a function of the percentage of excess generation.

An example of two-stage over frequency protection is shown below using thresholds 5 and 6 of the overfrequency element. However, it should be considered that settings for a real system will depend upon the maximum frequency that equipment can tolerate for a given period of time.

Stage	Overfrequency element	Frequency Setting (Hz)	Time Setting (Sec.)
1	threshold 5	50.5	30
2	threshold 6	51.0	20

The relatively long time-delays are intended to provide time for the system controls to respond and will work well in a situation where the increase of system frequency is slow.

7.11.2 DEFINING THE [81O] OVERFREQUENCY PROTECTION FUNCTION

A [81O] function is added at bay level from the contextual **Objects entry** window.

To add [81O] Overfrequency protection function, see section *7.1.2 – Defining a protection function*.

The protection function sub-tree contains six thresholds (1) from **threshold 1** up to **threshold 6**.

The first threshold sub-tree contains four nodes:

- **81O t1 inst.** SPS (2) is the instantaneous overfrequency status for the first threshold, i.e. it is *SET* when the frequency is above the threshold **f1 VALUE**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **81O t1 mode** MPS (3): operation mode of the protection function for the first threshold, corresponding to **f1 ?** = *MAX*. All the attributes are settable.
- **81O t1 temp.** SPS (4): time-delay signal for the first threshold, corresponding to tf1. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **81O t1 trip** SPS (5): trip signal for the first threshold (**Trip f1**). This datapoint is necessarily a transient (pulse) signal (**detection mode** attribute not settable). The time reference, set and reset delays are fixed.

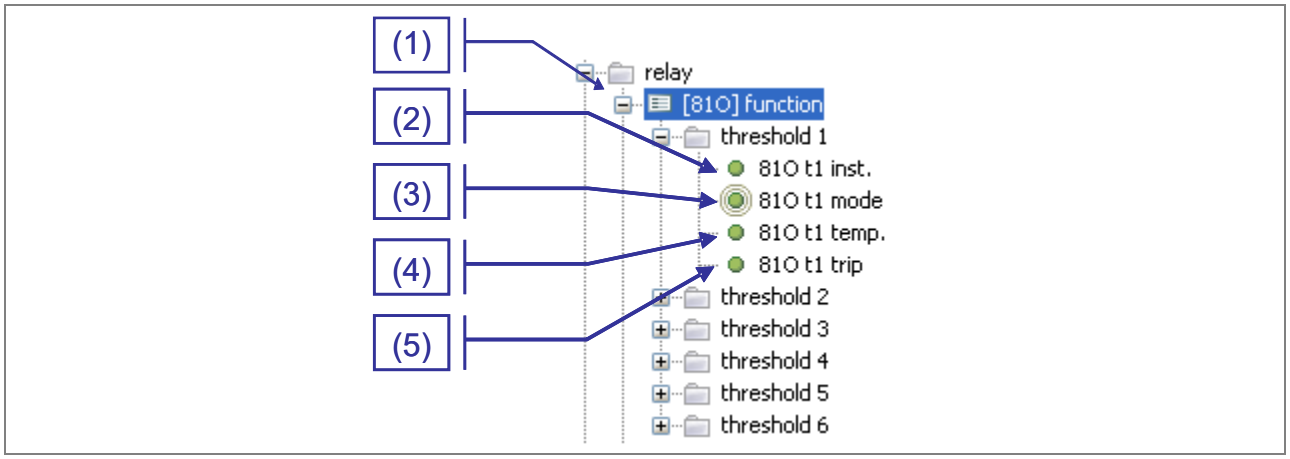


Figure 372: [81O] Overfrequency datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

The contents of **threshold 2** to **6** are identical to the **threshold 1**.

- **81O t2 inst.** to **81O t6 inst.** are identical to the **81O t1 inst.** SPS for **thresholds 2** to **6**
- **81O t2 mode** to **81O t6 mode** are identical to the **81O t1 mode** MPS for **thresholds 2** to **6**
- **81O t2 temp.** to **81O t6 temp.** are identical to the **81O t1 temp.** SPS for **thresholds 2** to **6**
- **81O t2 trip** to **81O t6 trip** are identical to the **81O t1 trip** SPS for **thresholds 2** to **6**

7.12 [81R] RATE OF CHANGE OF FREQUENCY PROTECTION

7.12.1 DESCRIPTION OF THE PROTECTION FUNCTION

The rate of change of frequency protection function allows the user to select the number of cycles to be involved in the calculation of the rate of change of frequency elements, and the number of confirmations of calculation for positioning the protection function.

In fact, the instantaneous element is positioned after exceeding the threshold for a programmable number of df/dt function calculation.

When the input voltage value is insufficient this will lead to irregular behavior and it is possible that the frequency elements could maloperate.

This is important during line energisation, de-energisation or a generator acceleration where significant distortion can be experienced. To prevent the maloperation, all the frequency elements and related thresholds are blocked by means of a settable U/V blocking function.

7.12.2 DEFINING THE [81R] RATE OF CHANGE OF FREQUENCY PROTECTION FUNCTION

A [81R] function is added at bay level from the contextual **Objects entry** window.

The protection function sub-tree contains six thresholds (1) from **threshold 1** up to **threshold 6**.

The first threshold sub-tree contains four nodes:

- **81R t1 inst.** SPS (2) is instantaneous rate of change status for the first threshold, corresponding to the threshold **df/dt1 VALUE**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **81R t1 mode** MPS (3): operation mode of the protection function for the first threshold, corresponding to **df/dt ?** = *ON* or *OFF*. All the attributes are settable.
- **81R t1 temp.** SPS (4): time-delay signal for the first threshold, corresponding to **t df/dt1**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **81R t1 trip** SPS (5): trip signal for the first threshold (**Trip df/dt**). This datapoint is necessarily a transient (pulse) signal (transient **detection mode** not settable). The time reference, set and reset delays are fixed.

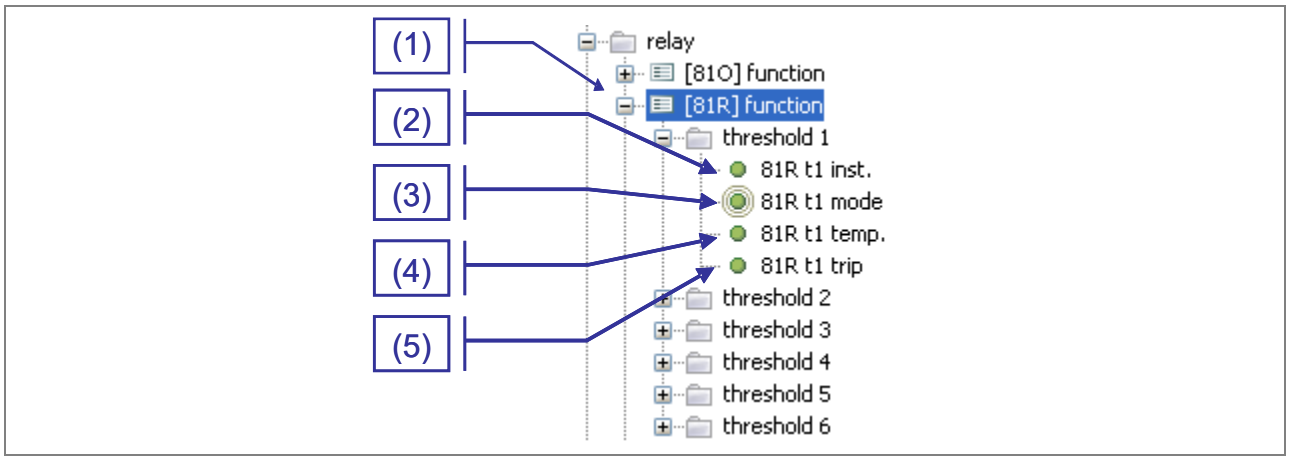


Figure 373: [81R] Rate of change of Frequency datapoints

Update the relations and the links of the datapoints to point to a specific existing profile.

The contents of **threshold 2** to **6** are identical to the **threshold 1**.

- **81R t2 inst.** to **81R t6 inst.** are identical to the **81R t1 inst.** SPS for **thresholds 2** to **6**,
- **81R t2 mode** to **81R t6 mode** are identical to the **81R t1 mode** MPS for **thresholds 2** to **6**,
- **81R t2 temp.** to **81R t6 temp.** are identical to the **81R t1 temp.** SPS for **thresholds 2** to **6**,
- **81R t2 trip** to **81R t6 trip** are identical to the **81R t1 trip** SPS for **thresholds 2** to **6**.

7.13 [81U] UNDERFREQUENCY PROTECTION

7.13.1 DESCRIPTION OF THE PROTECTION FUNCTION

Frequency variations on a power system are an indication that the power balance between generation and load has been lost. In particular, underfrequency implies that the net load is in excess of the available generation. Such a condition can arise when an interconnected system splits, and the load left connected to one of the subsystems is in excess of the capacity of the generators in that particular subsystem. Industrial plants that are dependent on utilities to supply part of their loads will experience underfrequency conditions when the incoming lines are lost.

In order to minimize the effects of underfrequency on a system, a multi stage load shedding scheme may be used with the plant loads prioritized and grouped. During an underfrequency condition, the load groups are disconnected sequentially depending on the level of underfrequency, with the highest priority group being the last one to be disconnected.

Time delays should be sufficient to override any transient dips in frequency, as well as to provide time for the frequency controls in the system to respond.

7.13.2 DEFINING THE [81U] UNDERFREQUENCY PROTECTION FUNCTION

A [81U] function is added at bay level from the contextual **Objects entry** window.

To add [81U] Underfrequency protection function, see section *7.1.2 – Defining a protection function*.

The protection function sub-tree contains six thresholds (1) from **threshold 1** up to **threshold 6**.

The first threshold sub-tree contains four nodes:

- **81U t1 inst.** SPS (2) is instantaneous underfrequency status for the first threshold, i.e. it is *SET* when the frequency is under the threshold **f1 VALUE**. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **81U t1 mode** MPS (3): operation mode of the protection function for the first threshold, corresponding to **f1 ?** = *MIN*. All the attributes are settable.
- **81U t1 temp.** SPS (4): time-delay signal for the first threshold, corresponding to tf1. This datapoint is necessarily a permanent signal (**detection mode** attribute not settable).
- **81U t1 trip** SPS (5): trip signal for the first threshold (**Trip f1**). This datapoint is necessarily a transient (pulse) signal (transient **detection mode** not settable). The time reference, set and reset delays are fixed.

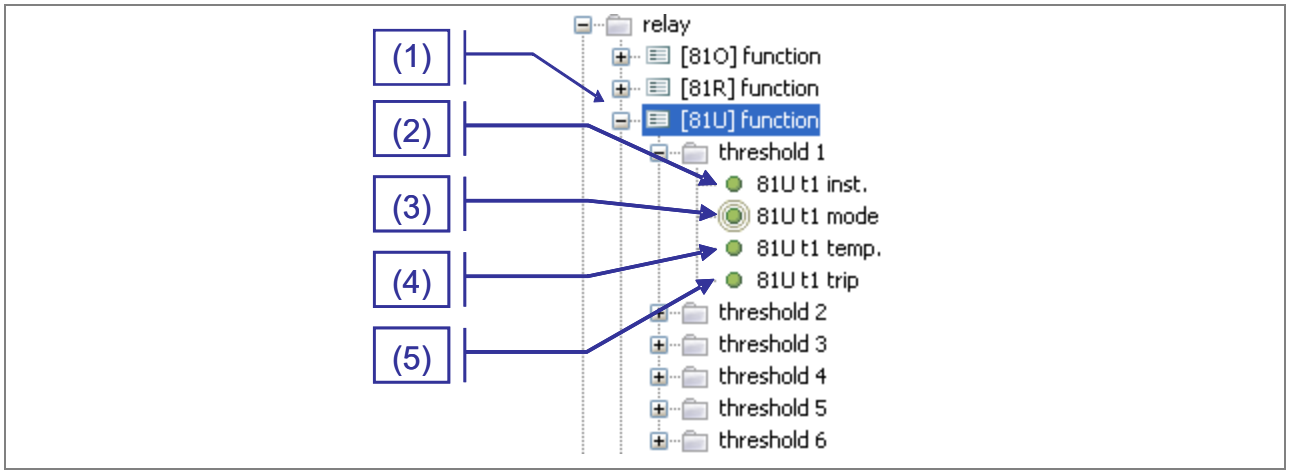


Figure 374: [81R] Rate of change of Frequency sub-tree

Update the relations and the links of the datapoints to point to a specific existing profile.

The contents of **threshold 2** to **6** are identical to **threshold 1**.

- **81U t2 inst.** to **81U t6 inst.** are identical to the **81U t1 inst.** SPS for **thresholds 2** to **6**,
- **81U t2 mode** to **81U t6 mode** are identical to the **81U t1 mode** MPS for **thresholds 2** to **6**,
- **81U t2 temp.** to **81U t6 temp.** are identical to the **81U t1 temp.** SPS for **thresholds 2** to **6**,
- **81U t2 trip** to **81U t6 trip** are identical to the **81U t1 trip** SPS for **thresholds 2** to **6**.

7.14 ANCILLARY FUNCTIONS

7.14.1 VOLTAGE TRANSFORMER SUPERVISION (VTS)

7.14.1.1 DESCRIPTION OF THE VTS FUNCTION

The VTS function implemented in the C26x uses a combination of three detection methods:

- Single- or two-phase fuse failures: Voltage imbalance and no fault currents
- Three-phase fuse failures (optional): No voltages and no superimposed currents
- Miniature circuit-breaker input: Digital input from the voltage transfomer's MCB, indicating that it has tripped

The VTS function is described in detail in chapter FT.

The VTS function is available at Bay level from the contextual Object entry window, in the **Built-in function\Relay built-in function** list with the protection functions.

7.14.1.2 DEFINING THE VTS FUNCTION

Settings

The VTS function is enabled by setting this attribute to *On*.

- **VT Fuse supervision function state** (*On*, *Off*): Enable or disable the VTS function

For single- and two-phase fuse failures, the VTS function has 5 settable analogue thresholds:

- **Residual threshold in Vn** (range [0.1 Vn, Vn], step 0.1 Vn): Residual voltage threshold VN>
- **Reverse threshold in Vn** (range [0.1 Vn, Vn], step 0.1 Vn): Negative-sequence voltage threshold V2>
- **Homopolar current threshold in In** (range [0.1 In, In], step 0.01 In): Zero-sequence current threshold I0>
- **Reverse current threshold in In** (range [0.1 In, In], step 0.01 In): Negative-sequence current threshold I2>
- **Overcurrent threshold in In** (range [0.1 In, In], step 0.01 In): Phase overcurrent threshold I> (setting for IA>, IB> and IC>)

A separate method is used to detect three-phase fuse failures. It is enabled separately and uses 2 settable analogue thresholds:

- **3Phase VT Fuse failre** (*On*, *Off*): Enable or disable three-phase fuse failure detection
- **Current variation threshold in In** (range [0.05 In, 0.5 In], step 0.05 In): Phase superimposed current threshold ΔI> (setting for ΔIA>, ΔIB> and ΔIC>)
- **Undervoltage threshold in Vn** (range [0.1 Vn, Vn], step 0.1 Vn): Phase undervoltage threshold V< (setting for VA<, VB< and VC<)

Confirmation time-delay:

- **VT Fuse delay in seconds** (range [0, 20 s], step 1 s): Time-delay between instantaneous fuse-failure detection and the issuance of the confirmed fuse failure signal.

Inputs and outputs

The VTS function has three logic inputs:

- **NO.AR.PROG**: Internal information: *SET* when no autoreclose cycle is in progress, received from an internal FBD logic scheme
- **ALL.POLE.DEAD**: Internal information: *SET* when all three CB poles are open
- **VT.FUSE.FAIL**: Wired signal received from the VT's miniature circuit-breaker, *SET* when the MCB is open

The VTS function generates two outputs:

- **VT.FUSE.INST**: SPS datapoint, instantaneous, unconfirmed fuse failure indication
- **VT.FUSE.TEMP**: SPS datapoint, time-delayed, confirmed fuse failure signal

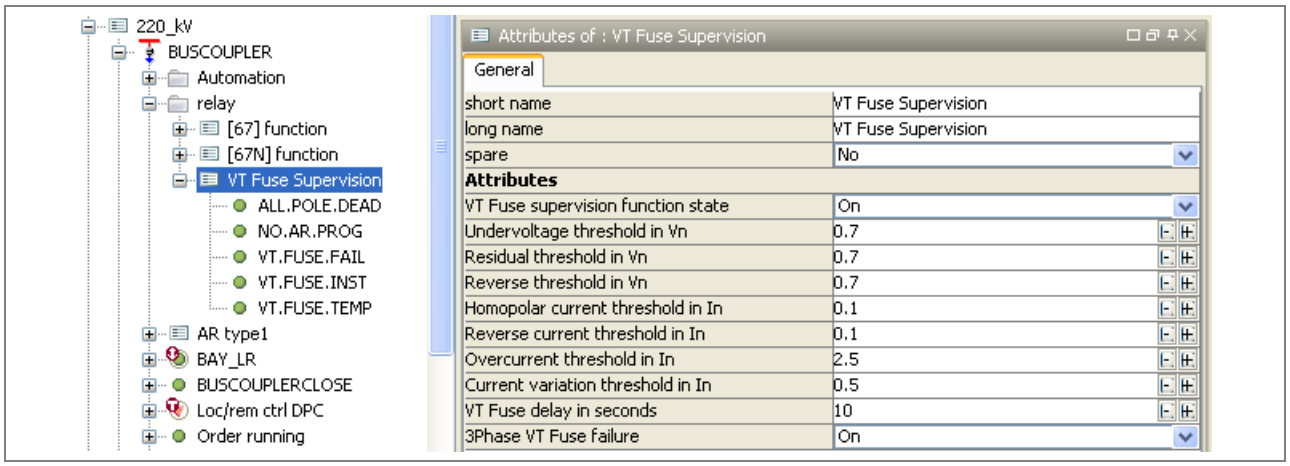


Figure 375: VT Fuse Supervision – Datapoints and attributes

Drop-off thresholds

The drop-off thresholds are fixed at +/- 5% of the nominal value for the set pick-up thresholds, i.e. 95% for 'over' (>) thresholds and 105% for 'under' (<) thresholds.

Accuracy in reference conditions

The accuracy of the detection of voltage and current threshold crossings is 0.5% of the nominal value for the set threshold values.

8 DEFINING AUTOMATISM FUNCTIONS

Note:
Protection and Automatism functions are only available if the DS Agile C26x is fitted with TMU210 CT/VT board.

8.1 GENERAL

Protection and automatism functions are respectively described in sections 10 and 11 of chapter C26x/EN FT. In the object view tree, the automatism functions are associated with a relay (bay level). When automatism is added to a bay, a relay is automatically added as a sub-component.

The automatism function contains the following components:

- 2 protection group,
- [50BF] breaker failure,
- blocking protection,
- cold load start,
- logic selectivity,
- maintenance,
- miscellaneous,
- overcurrent phase segregation
- trip management,
- trip current measurement.

8.2 GENERAL ARCHITECTURE

In the object view tree, the automatism function contains the following architecture:

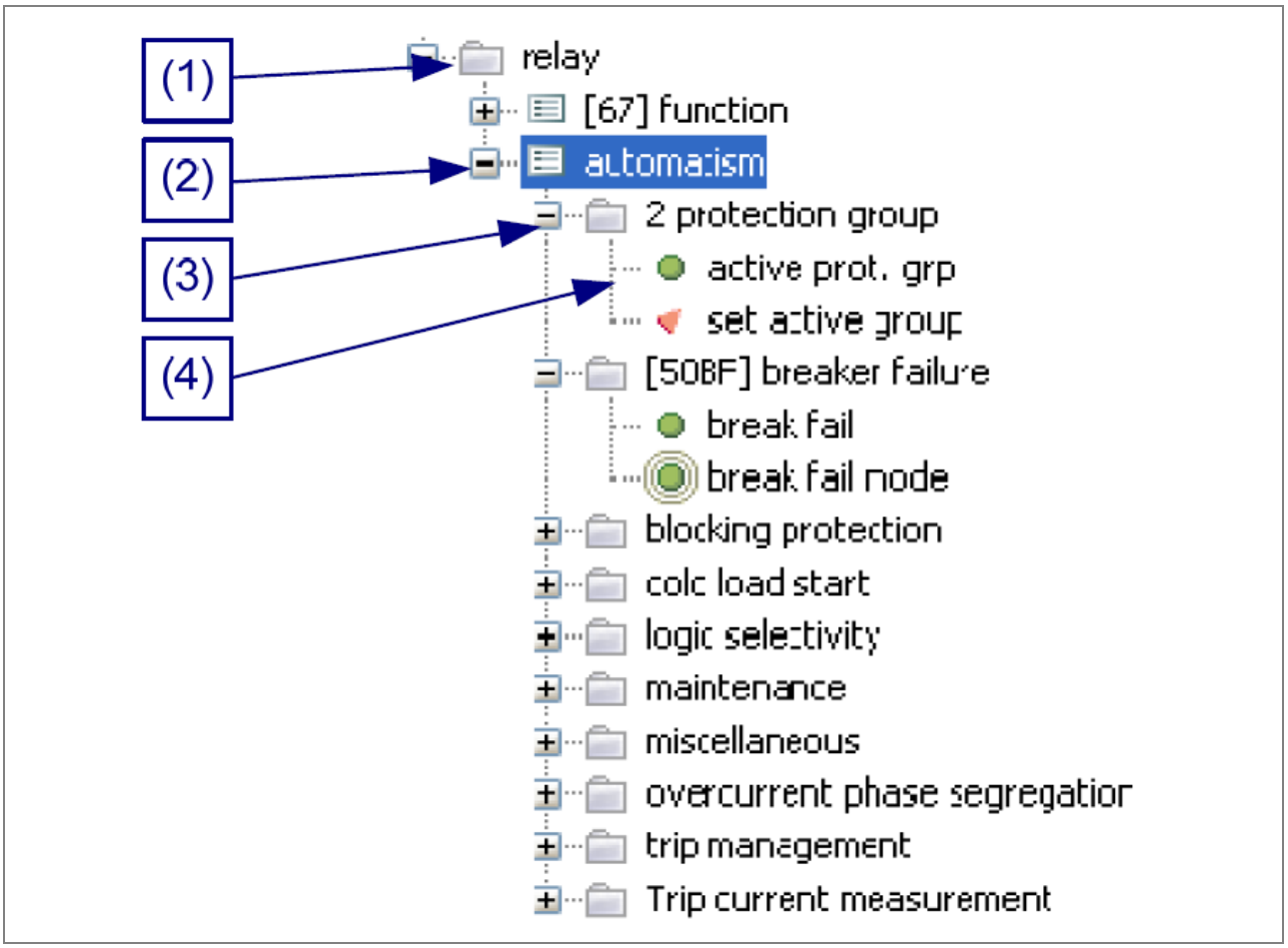


Figure 376: Automatism sub-tree

The **relay** (1) object is automatically created when automatism function is added to the bay. It does not contain any attribute and cannot be edited.

The **automatism** sub-tree (2) contains folders corresponding to the automatic control functions (3). The respective nodes and datapoints associated with these functions (4) are configurable.

8.2.1 ADDING THE AUTOMATISM FUNCTION

The addition of automatism function is done under SCE using the **Object entry** contextual window at bay level.

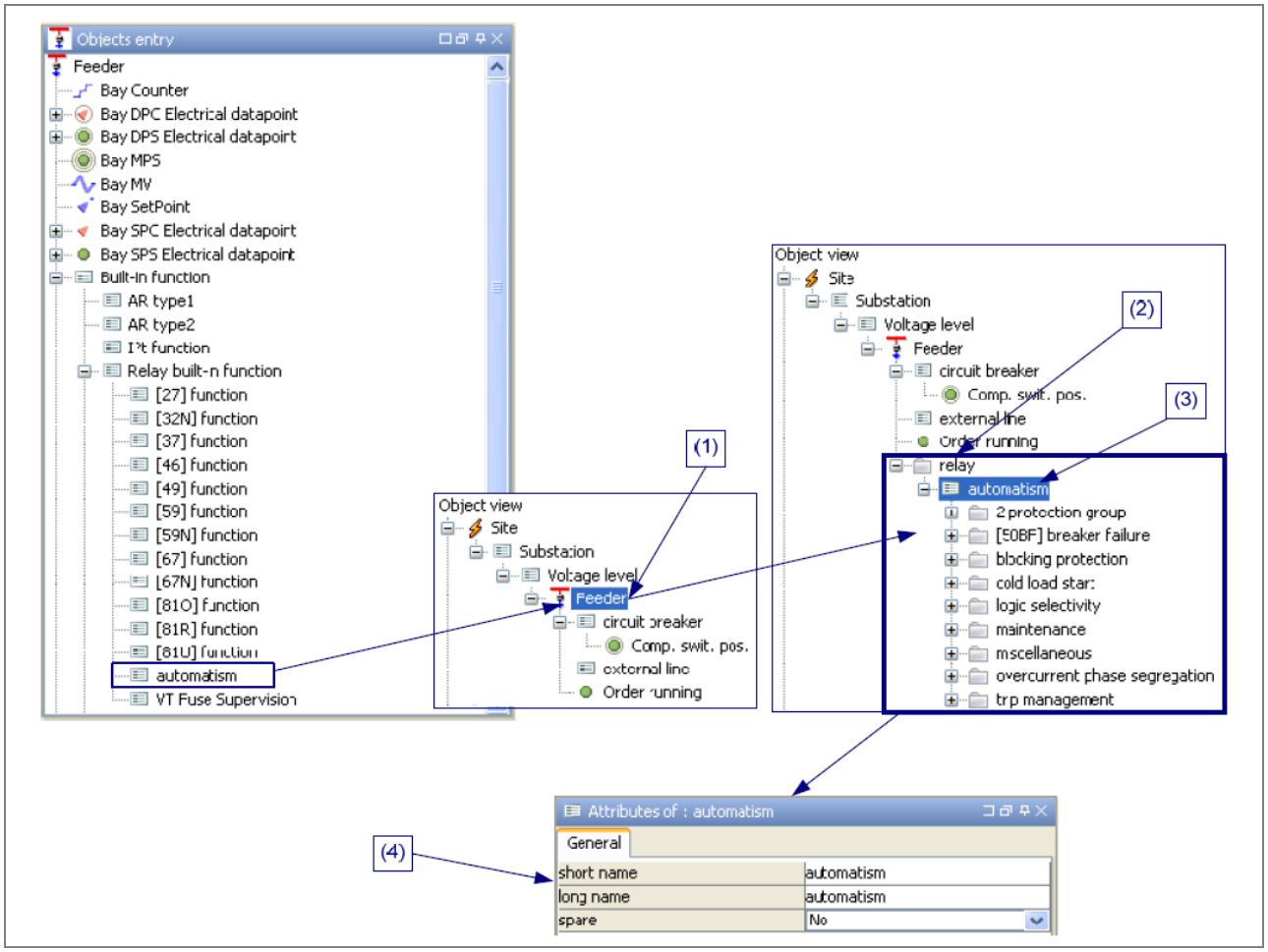


Figure 377: Adding automatism functions

To add the automatism function:

- Add the automatism function using the **Object entry** contextual window (Built-in function, Relay built-in function sub-tree) at bay level (1),
- The automatism function (3) is added (Relay (2) is automatically added with the first protection function),
- Update the function attributes: **short name** and **long name** (4).

8.3 PROTECTION SETTING GROUPS

8.3.1 DESCRIPTION

The DS Agile C26x protection and control units have two protection related setting groups named PROTECTION G1 and PROTECTION G2 when a TMU210 board is fitted. Only one of two setting groups is active at any one time.

Changes between the two groups are executed via a dedicated logic input, or through the Ethernet communication port.

To avoid any undesirable tripping, the setting group change is only executed when no protection function is running excepted than for thermal overload function.

If a setting group change is received during any protection or automation function, it is stored and executed after the last time-delay has elapsed.

8.3.2 SETTING "2 PROTECTION GROUP" AUTOMATISM FUNCTIONS

The "2 protection group" function sub-tree contains two datapoints:

- **active prot. grp** SPS: active protection number (group 1 or group 2). This input is a permanent signal (**detection mode** attribute not settable).
- **set active group** SPC: active setting group control. The activation mode of this control is set to permanent.

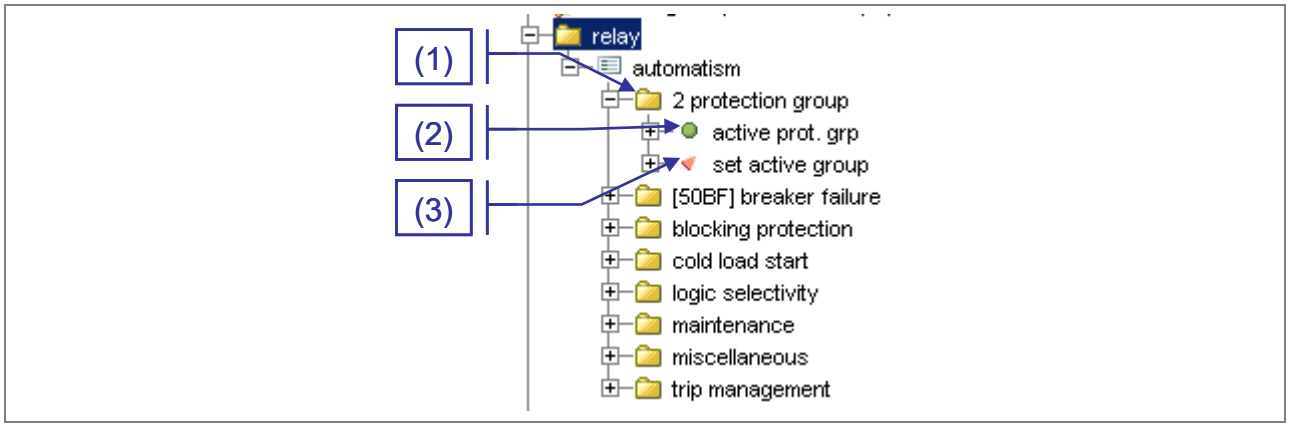


Figure 378: Setting '2 protection group'

Update the relations and the links of the datapoints to point to a specific existing profile.

8.4 [50BF] BREAKER FAILURE PROTECTION

8.4.1 DESCRIPTION

Following the inception of a fault one or more main protection devices will operate and issue a trip output to the circuit-breaker(s) associated with the faulted circuit. Operation of the circuit-breaker is essential to isolate the fault, and prevent damage or further damage to the power system.

For transmission and sub-transmission systems, slow fault clearance can also threaten system stability. It is therefore common practice to install circuit-breaker failure protection [50BF], which monitors that the circuit-breaker has opened within a reasonable time. If the fault current has not been interrupted following a set time-delay from circuit-breaker trip initiation, breaker failure protection will operate.

[50BF] operation can be used to back-trip upstream circuit-breakers to ensure that the fault is isolated correctly. [50BF] can also operate to reset all start output contacts, by external logic, ensuring that any blocks asserted on upstream protection are removed.

8.4.2 SETTING "[50BF] BREAKER FAILURE" AUTOMATISM FUNCTIONS

The "[50BF] breaker failure" function sub-tree contains two datapoints:

- **break fail** SPS (2): breaker failure status. This input is a permanent signal (permanent **detection mode** attribute cannot be modified).
- **break fail mode** MPS (3): breaker failure mode control. All the attributes can be modified.

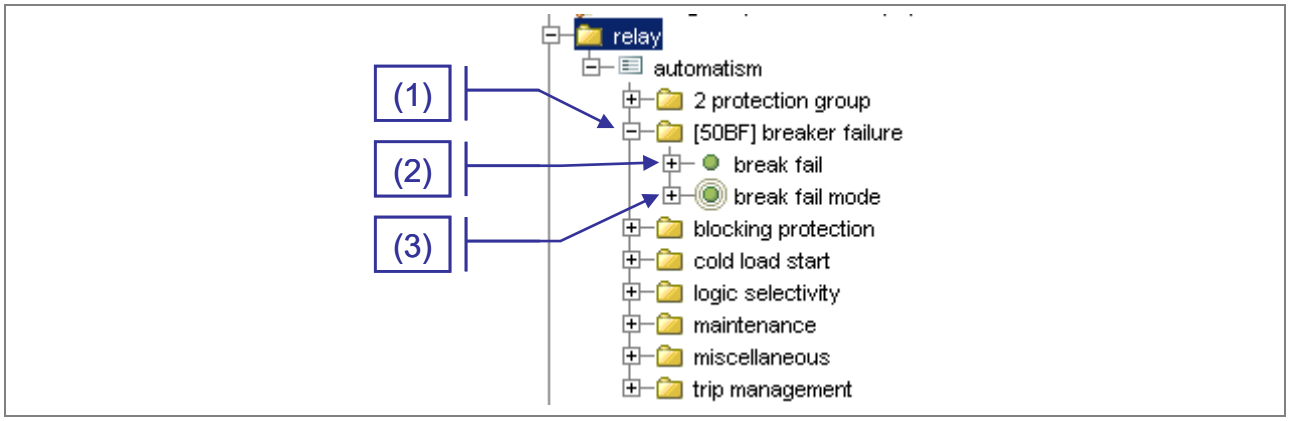


Figure 379: Setting '[50BF] breaker failure'

Update the relations and the links of the datapoints to point to a specific existing profile.

8.5 BLOCKING PROTECTION

8.5.1 DESCRIPTION

The directional, non directional overcurrent and overcurrent protection are applicable for radial feeder circuits where there is small or no back feed.

This application shows that the upstream IDMT relay being blocked by the start output from a downstream relay that has detected the presence of a fault current, which is above its threshold settings. Thus both the upstream and downstream relays can then have the same current and the blocking feature will automatically provide time settings and grading. If the CB failure protection function is active, the blocking order on the upstream relay will be removed if the downstream circuit-breaker fails to trip.

8.5.2 SETTING 'BLOCKING PROTECTION' AUTOMATISM FUNCTIONS

The "Blocking protection" function sub-tree contains four datapoints:

- **bloc CO status** SPS is the blocking protection command status input. This input is necessarily a permanent signal (**detection mode** attribute not settable).
- **bloc DI status** SPS is the blocking protection digital input status. This input is necessarily a permanent signal (**detection mode** attribute not settable).
- **block protection** SPC is the blocking protection control. The activation mode of this control is set to permanent.
- **DI bloc** SPS is the digital input blocking status. This input is necessarily a permanent signal (**detection mode** attribute not settable).

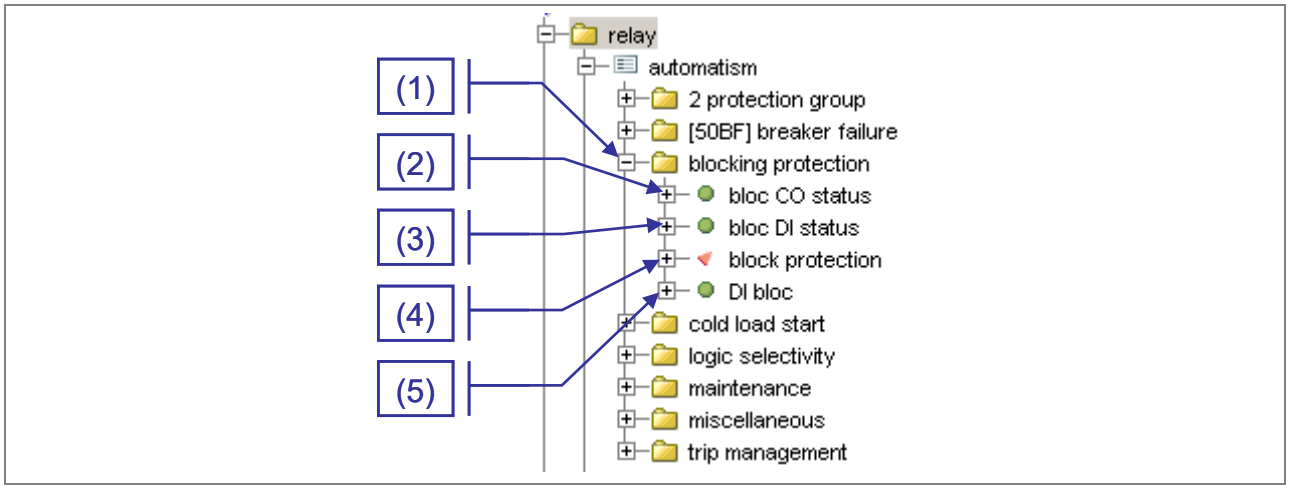


Figure 380: Setting 'Blocking protection'

Update the relations and the links of the datapoints to point to a specific existing profile.

8.6 COLD LOAD START

8.6.1 DESCRIPTION

In a protection relay, the Cold Load Pick-up (or "start") feature enables the selected settings to be changed to react to temporary overload conditions that may occur during cold load starts.

This condition may occur by switching on large heating loads after a sufficient cooling period, or loads that draw high initial starting currents.

When a feeder is energised, the current levels that flow for a period of time following energising may differ greatly from the normal load levels. Consequently, overcurrent settings that have been applied to give short circuit protection may not be suitable during this period.

The Cold Load Pick-up logic raises the settings of selected stages for a set duration. This allows the protection settings to be set closer to the load profile by automatically increasing them after energising.

8.6.2 SETTING 'COLD LOAD START' AUTOMATISM FUNCTION

The "Cold load start" function sub-tree (1) contains two datapoints:

- **cls DI status** SPS (2): status of the cold load start digital input status. This input is a permanent signal (**detection mode** attribute not settable).
- **DI CLS** SPS (3): cold load start digital input status. This input is a permanent signal (**detection mode** attribute not settable).

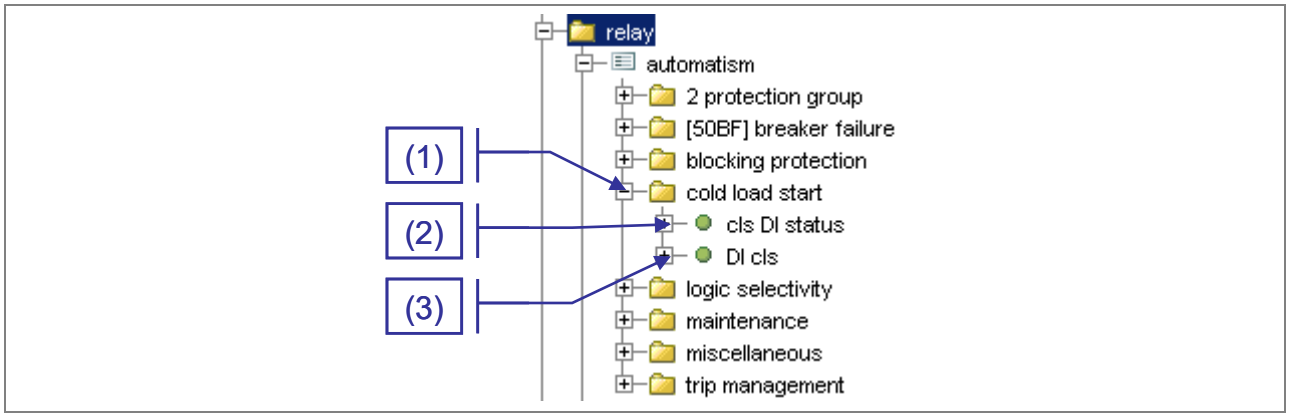


Figure 381: Setting 'cold load start'

Update the relations and the links of the datapoints to point to a specific existing profile.

8.7 LOGIC SELECTIVITY

8.7.1 DESCRIPTION

The Logic selectivity is used in non-cascade protection schemes, using the start contacts from downstream relays to block operation of upstream relays.

In the case of selective overcurrent logic, the start contacts are used to increase the time-delays of upstream relays, instead of blocking them. This provides an alternative approach to achieving a non-cascade type of overcurrent scheme. It may be more familiar to some utilities than the blocked overcurrent arrangement.

The selective overcurrent logic function temporarily increases the time-delay settings of the second and third stages of phase overcurrent.

8.7.2 SETTING 'LOGIC SELECTIVITY' AUTOMATISM FUNCTION

The "logic selectivity" function sub-tree (1) contains four datapoints:

- **DI sel** SPS (2): digital input selectivity status. This input is necessarily a permanent signal (**detection mode** attribute not settable).
- **log. selectivity** SPC (3): logic selectivity control. The activation mode of this control is set to permanent.
- **sel CO status** SPS (4): logic selectivity command status. This input is necessarily a permanent signal (**detection mode** attribute not settable).
- **sel DI status** SPS (5): logic selectivity digital input status. This input is necessarily a permanent signal (**detection mode** attribute not settable).

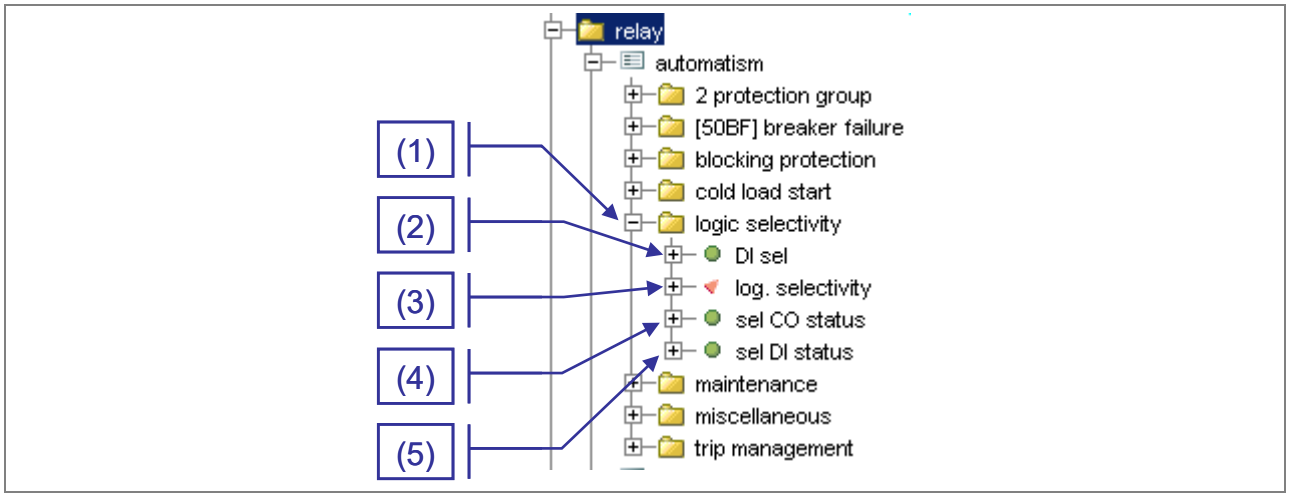


Figure 382: Setting 'logic selectivity'

Update the relations and the links of the datapoints to point to a specific existing profile.

8.8 MAINTENANCE

8.8.1 DESCRIPTION

The maintenance mode allows the user to verify the operation of the protection functions without sending any external order (tripping or signalling).

The maintenance function is used when the selection or the end of the maintenance mode is possible by logic input or control command.

8.8.2 SETTING ‘MAINTENANCE’ AUTOMATISM MENU

The “logic selectivity” function sub-tree (1) contains four datapoints:

- **maintenance** SPS (2): maintenance status. This input is a permanent signal (**detection mode** attribute not settable).
- **maintenance mode** SPC (3): control of the mode of maintenance. The activation mode of this control is set to permanent.

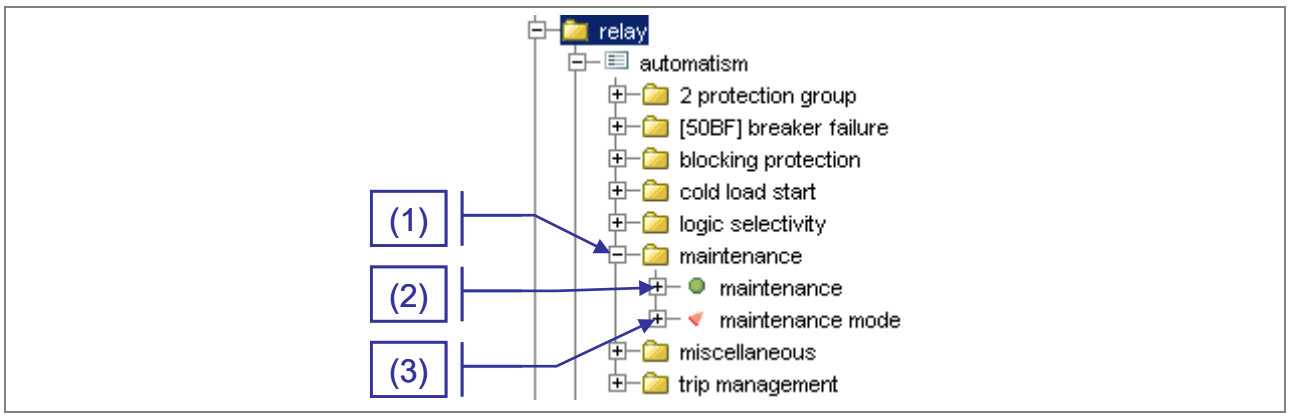


Figure 383: Setting ‘Maintenance’

Update the relations and the links of the datapoints to point to a specific existing profile.

8.9 MISCELLANEOUS

8.9.1 DESCRIPTION

The “Miscellaneous” subtree contains the following automatism functions:

- digital input start disturbance status,
- frequency protection status,
- protection state status,
- Reset thermal status control,
- start disturbance control,
- synthesis of instantaneous fault signals status,
- synthesis of time-delay signals status,
- synthesis of trip signals status.

8.9.2 SETTING 'MISCELLANEOUS' AUTOMATISM MENU

The "Miscellaneous" function sub-tree (1) contains eight datapoints:

- **DI start disturb** SPS (2) (start disturbance digital Input status). This input is a permanent signal (**detection mode** attribute not settable).
- **Feq 81 invalid** SPS (3) corresponds to frequency invalid (overfrequency, underfrequency or out of range frequency) status. This input is a permanent signal (**detection mode** attribute not settable).
- **protection state** MPS (4) (protection state status). All the attributes can be modified.
- **reset thermal st** SPC (5) (thermal reset status). The activation mode of this control is set to permanent.
- **start dist ctrl** SPC (6) (start disturbance control). The activation mode of this control is set to permanent.
- **synthesis inst.** SPS (7) (Synthesis of instantaneous). This input is a permanent signal (**detection mode** attribute not settable).
- **synthesis temp.** SPS (8) (Synthesis of temporisation). This input is a permanent signal (**detection mode** attribute not settable).
- **synthesis trip** SPS (9) (Synthesis of trip). This input is a permanent signal (**detection mode** attribute not settable).

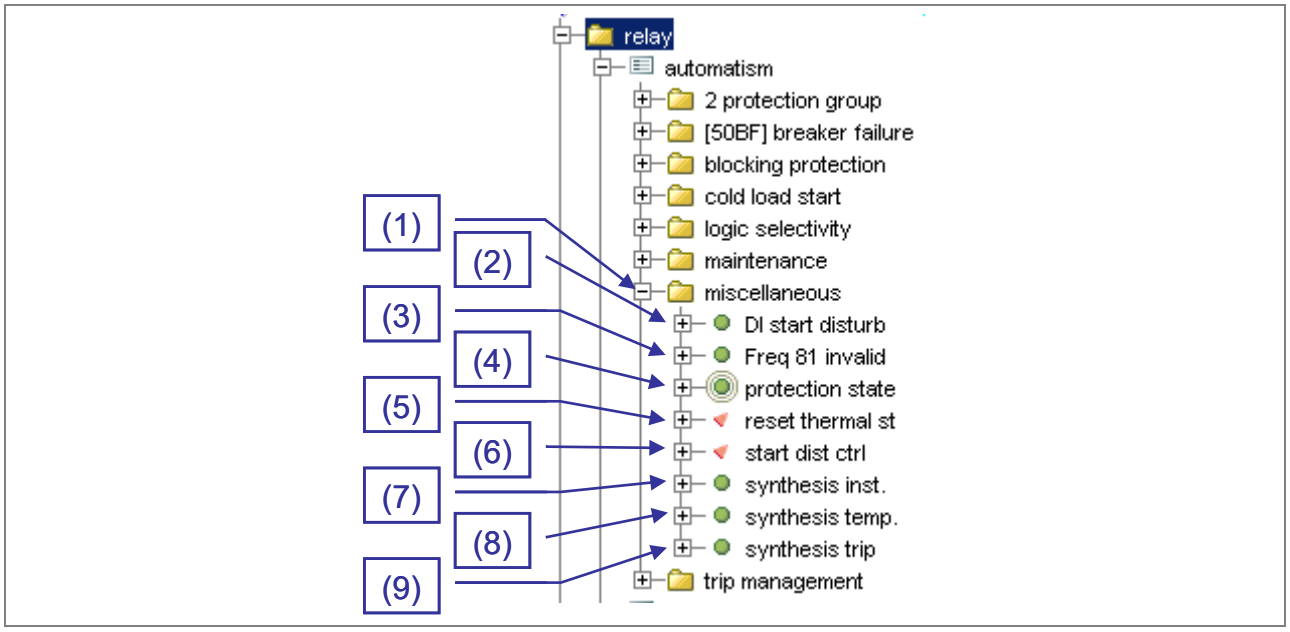


Figure 384: Setting 'Miscellaneous'

Update the relations and the links of the datapoints to point to a specific existing profile.

8.10 TRIP MANAGEMENT

8.10.1 DESCRIPTION

The trip management corresponds to trip relay control and trip status.

8.10.2 SETTING 'MAINTENANCE' AUTOMATISM MENU

The "Maintenance" function sub-tree (1) contains eight datapoints:

- **trip relay ctrl** SPC (2) (trip relay control status). The activation mode of this control is set to permanent.
- **trip status** SPS (3) (trip status datapoint). This input is necessarily a permanent signal (**detection mode** attribute not settable).

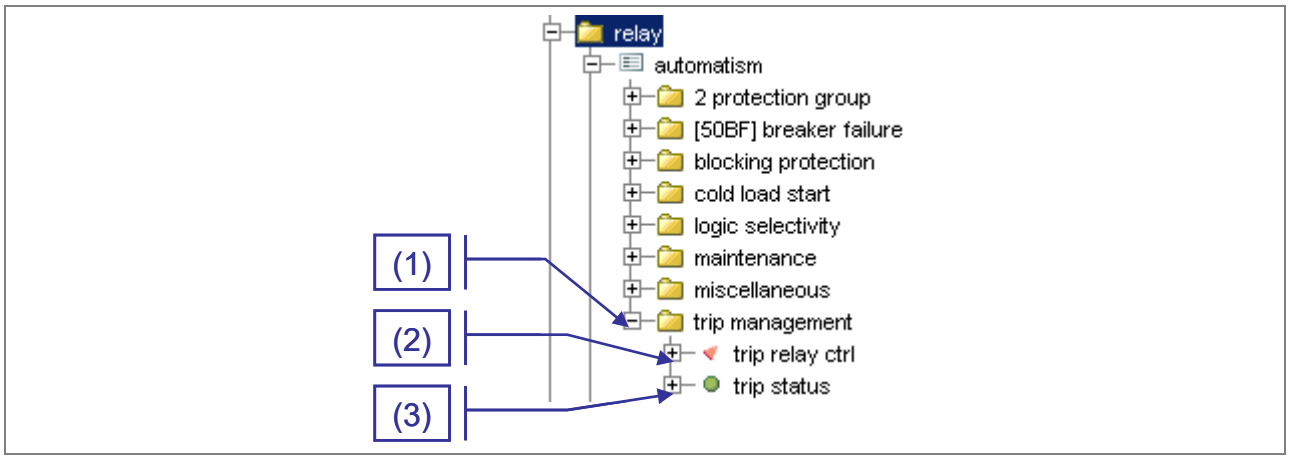


Figure 385: Setting 'trip management'

Update the relations and the links of the datapoints to point to a specific existing profile.

8.11 TRIP CURRENT MEASUREMENT INDICATION

If at least one standard directional/non-directional overcurrent protection function ([67/50/51] or/and [67N/50N/51N]) is defined and the acquisition of the three phase currents is configured (I_N is optional), it is possible to configure a trip current indication built-in function which will record the three phase currents – and optionally the neutral current – at the time of the trip command decision.

These measurements are then processed as standard MVs and can be displayed on the C264P's front panel LCD or/and forwarded to the system HMI or/and the SCADA via the Ethernet network.

4 MVs are available:

- Trip.current.A
- Trip.current.B
- Trip.current.C
- Trip.current.N (optional)

These measurements are individually added under **relay/automatism/Trip current measurement**:

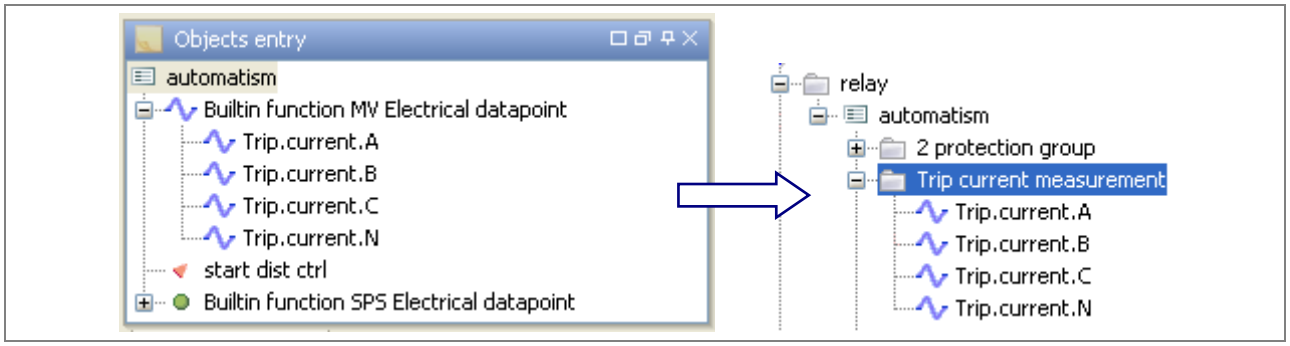


Figure 386: Adding a trip current measurement built-in function

Note:
*If the measurements are configured but no overcurrent protection function is defined, the SCE's **Checks** window will display an error message when it is next refreshed (after pressing F6).*
*If the trip current indication function is defined but any of the 3 phase current measurements is missing, the SCE's **Checks** window will display an error message when it is next refreshed (after pressing F6).*

Defining a Trip current measurement built-in function (relay folder)

The Trip current measurement indication function is described in C264P/EN FT. It is associated with a standard overcurrent protection function.

Set the attributes for the 3 (or 4 if the neutral current is available) measurements: they are the same as those of a standard MV.

8.12 OVERCURRENT/BREAKER FAILURE PHASE SEGREGATION: DEFINING FAULTED CIRCUIT/FAILED CB POLE INDICATION

The **overcurrent phase segregation** function is automatically created when the **automatism** group is added.

If at least one standard directional/non-directional overcurrent protection function ([67/50/51] or/and [67N/50N/51N]) is defined and the acquisition of the three phase currents is configured (I_N is optional), it is possible to add phase fault datapoints to manage faulted circuit indication for the three phases, and optionally the neutral circuit, at the time of the trip command decision.

These indications are then processed as permanent SPS datapoints that will be reset when all the conditions that have initiated the event disappear. The corresponding events (faulted circuit/ failed CB pole and time-stamp) can be displayed in the **Events panel** of the unit's LCD or/and the **Events view** of the system HMI as well as forwarded to the SCADA via the Ethernet network.

7 SPS datapoints are available, one for each circuit and each circuit-breaker pole:

- Phase A overcurrent: **Ia phase fault**
- Phase B overcurrent: **Ib phase fault**
- Phase C overcurrent: **Ic phase fault**
- Neutral for earth fault: **In earth fault**
- CB phase A pole failed to trip: **Ia ph fault 50BF**
- CB phase B pole failed to trip: **Ib ph fault 50BF**
- CB phase C pole failed to trip: **Ic ph fault 50BF**

The three circuit-breaker failure SPS datapoints are automatically added when the **automatism** group is created and the four overcurrent SPS datapoints have to be manually added under **relay/automatism/overcurrent phase segregation**:

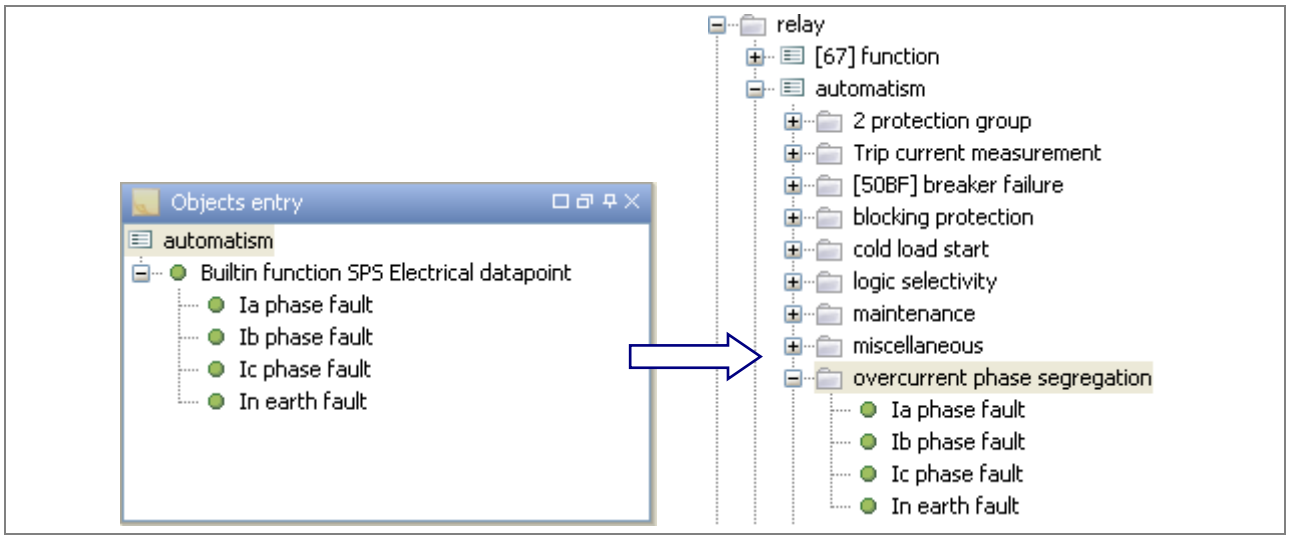


Figure 387: Adding an overcurrent phase segregation built-in function

Notes:
*If the phase segregation function is configured for overcurrent/earth fault indication but neither overcurrent nor earth fault protection function is, the SCE's **Checks** window will display an error message when it is next refreshed (after pressing F6).*
*If the function is used for overcurrent/earth fault indication, the three phase overcurrent SPS datapoints must be configured. Any missing phase overcurrent datapoint will generate an error in the SCE's **Checks** window when it is next refreshed (after pressing F6).*
If circuit-breaker failure indication is used, the 50BF timer should be set to at least 30 ms (using DS Agile S1).

Defining an overcurrent phase segregation built-in function (relay folder)

The overcurrent phase segregation function is described in C26x/EN FT. It is associated with a standard overcurrent/earth fault protection function and/or the circuit-breaker failure function.

Set the attributes for the 6 (or 7, if the neutral current is available) datapoints: they are the same as those of a standard permanent SPS*t*.

SETTINGS

C26X/EN ST/D40

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1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the Settings -or on-line- parameters, which can be modified in runtime on DS Agile C26x units. The setting is done through the LHMI. It is only available with a GHU200 or a GHU201 front panel.

A number of parameters related to user functions can be done on-line from a PC.

2 TREE PANEL

2.1 NAVIGATION

The tree panel is accessible from bay panels by selecting the key [OK].

All data points are grouped into features and folders. To access a given feature the operator should navigate the panels using the arrow keys. Each panel shows the folders hierarchy.

[◄] & [►] switch to neighbouring folder

[▼] selects and expands the folder switching to its first item

[▲] goes up to parent folder

At the bottom of the hierarchy, the folder is the single point of information, control or parameter. Edit mode allows the operator to change values.

[OK] grants access to Edit mode for level 2 password input

[C] cancels edition and the data point modification

The most commonly used settings and controls are selected into a list. To browse the list the operator navigates using the arrow keys. The modification/control sequence is cancelled by [C]. The selection is confirmed by [OK].

2.2 TREE PANEL PARAMETERS

MENU TREE	Available Values Or [min;max] (step)(unit)	Description
COMMAND		
MAIN		
- RESET OP HOURS	RESET	Reset the number of the C26x operating hours
- CHANGE MODE OP	OPERAT, MAINT, TEST	Change the C26x mode into active, maintenance or test mode
- GLB ACK ALARM	ACK	Acknowledge all C26x alarms
- GLB CLR ALARM	CLEAR	Clear all acknowledged and reset alarms
- DATE	DATE	Change the date. Accepted if the C26x is not synchronised
- TIME	TIME	Change the time. Accepted if the C26x is not synchronised. The time format is hh: mn: sec
- DB SWITCH	YES	Switch between active and standby databases
- LANGUAGE	LG1, LG2	Switch between languages 1 & 2
COUNTER		
Counter 1 … Counter N		List of available counters
- COUNTER value	Counter value	Change the value of the counter

MENU TREE	Available Values Or [min;max] (step)(unit)	Description
CONFIG		
COMPUTER		
MAIN		
- IP ADDRESS	xxx.xxx.xxx.xxx	Set the C26x IP address
BAY		
Bay 0 Bay 1 Bay N		
COMM. PORT		
Com 1 … Com 4		
- BAUDRATE	baudrate *	Baudrate of the communication port among: N50,100,200,300,600,1200,2400,4800,9600,19200,38400, 56000.
- NB STOP BIT	1, 2	Number of stop bits
- NB BIT PER CHAR	7, 8	Number of bits per character
- PARITY	odd, even, none	Parity
HMI		
MAIN		
- EXIT MT TIME	[5;300](1)(s)	Time after which the Menu tree is automatically left if there is no pressed button
- BACK LIGHT DELAY	[5;300](1)(s)	Time after which the back light disappears if there is no pressed button
- SELECT EXIT TIME	[5;300](1)(s)	Maximum time between selection and execution orders
- PASSWORD	XXXX	Obsolete. Changing this setting as no effect.
- BYPASS DELAY	[20;120](1)(s)	Time after which a bypass is automatically deselected
BAY		
Bay 0 … Bay N		
- DISPLAY DEV NAME	YES, NO	Flag to validate or inhibit the display of the Name of Devices in the Bay Panel

3 MICOM S1

MiCOM S1 is a setting software that is automatically installed along with CMT. It is used to view and edit the C26x's parameter settings.

3.1 PARAMETER SETTING UPLOAD AND LATER CHANGES

After the databag has been uploaded into the C26x flash memory using either CMT or SMT, the corresponding setting file must be uploaded into the C26x too as the default file already present in the C26x is a standard file that does not relate to the configuration. This should be done using MiCOM S1.

1 Using the DS Agile CMT application, establish a connection with the desired C26x unit, and then launch MiCOM Alstom S1 from the **Security/Administration** panel.

2 Open the file Settings/<C264 Network name>.set (in the databag).

3 Edit the settings if necessary, then save and replace the default file already in the C26x and MiCOM S1.

After editing the values, they can be uploaded back to the C26x unit. The Set function (Build + Send) is allowed only if C26x is in *Operational* or *Test* mode. For details on the modes, refer to chapter C26x/EN FT.

Note:
If the connection with the C26x unit times out before you upload the modified settings, use the CMT to re-establish it.

The same procedure will apply if the C26x's settings need to be updated in the future.

C26x redundancy

Setting files can be only be uploaded to the active C26x: The C26x denies the transfer of the setting file via MiCOM S1 when it is in standby mode.

Workaround: Create a fault on the active C26x in order to cause the standby C26x to become active.

Note:
There is no consistency control between the setting files in redundant C26xs.

3.2 HUMAN-MACHINE INTERFACE

In order for MiCOM S1 to communicate with a C26x unit, the connection must be established in the CMT. To do so:

1 Launch the CMT.

2 Either

a scan for the units in the network by clicking Search computers at the bottom of the window, and then select the C26x unit

or

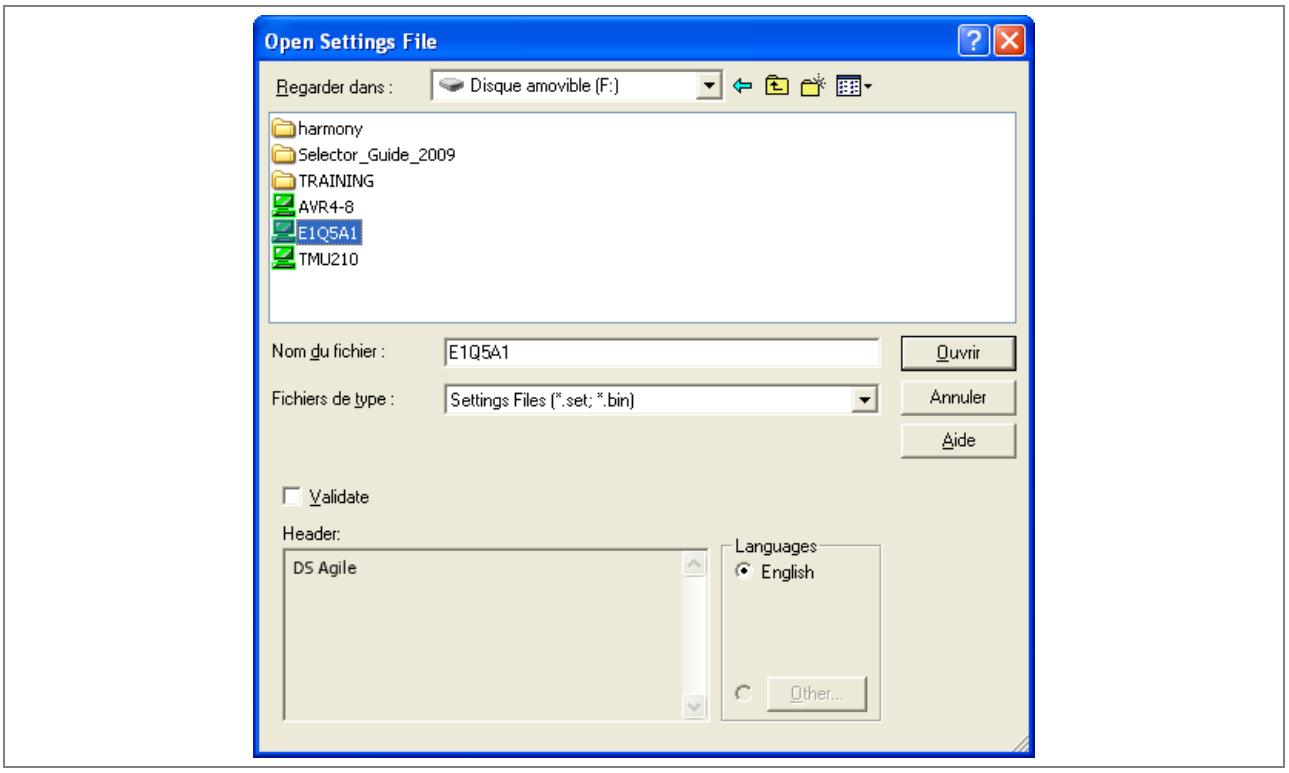
b connect to the C26x unit by entering its IP address in the IP address field at the top right corner of the window.

3 Click the Security menu button on the left hand side.

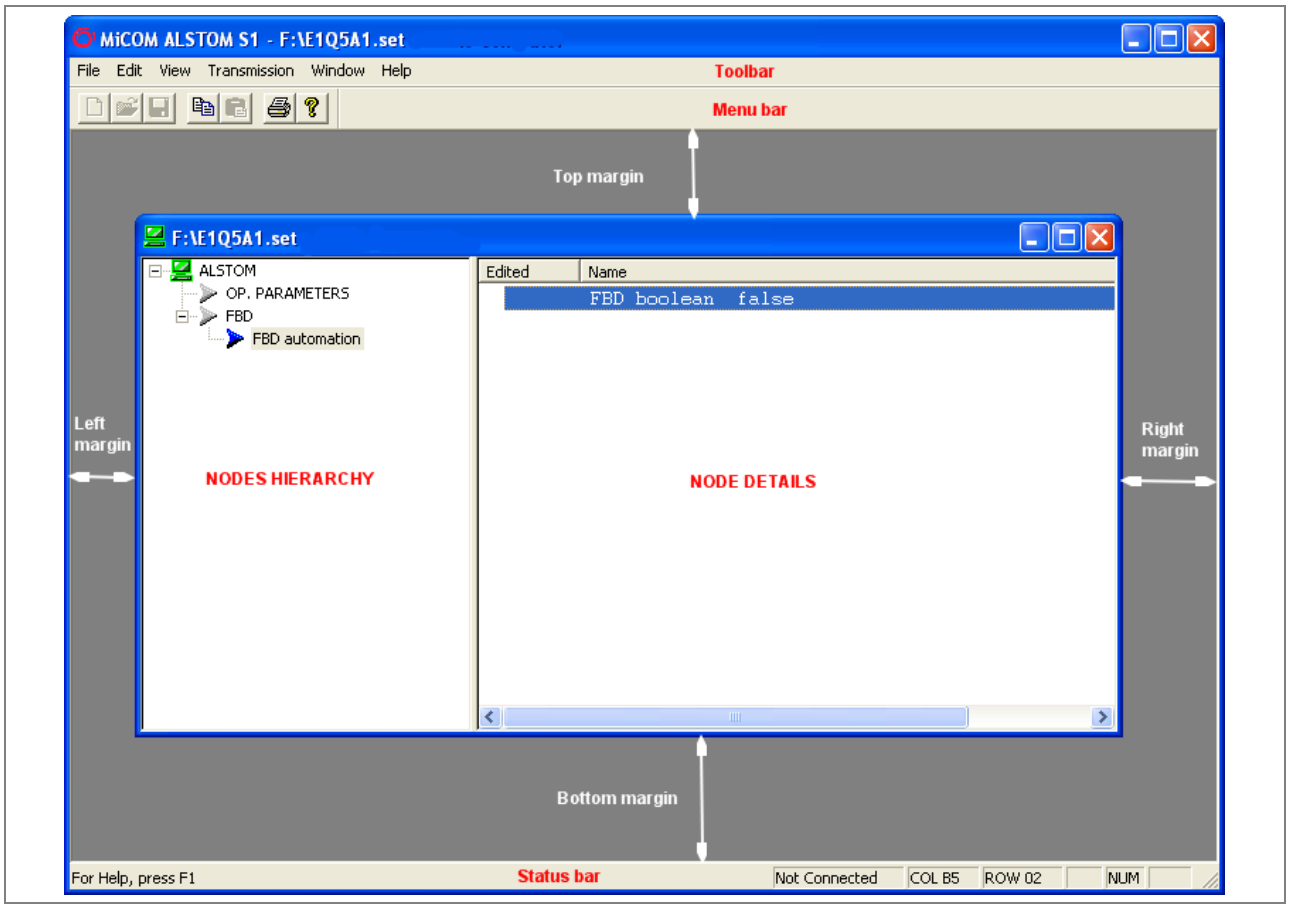
4 In Account Tab > My Account, click the button Connect Micom S1 interface.

Note:
If you launch MiCOM S1 directly from Windows, you will only be able to work with the settings files present on the PC: download and upload will be impossible.

To display settings, select the menu **File>Open settings**, and search for a *.set* file.



Click **Open**; a resizable window embeds in the application windows in accordance with the four margins set in **File>Page Setup**:



The menu includes several items:

- before getting or opening a file: **File**, **View**, **Help**
- in addition, when a file is loaded: **Edit**, **Transmission**, **Window**

The parameters are organised in a tree-like hierarchy; the hierarchy can be expanded to display the parameters.

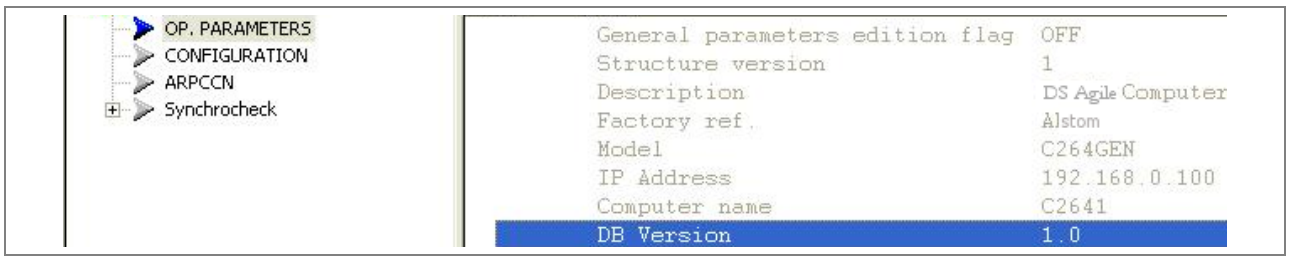
The status bar shows the connection status and the coordinates of the selected parameters.

The **View** menu enables the operator to mask the toolbar and the status bar, and to expand/collapse a selected node.

3.3 OPERATIONS

3.3.1 PRELIMINARY

- Click the FTPD icon (or the executable in the installation folder) to open the ftp server.
- Open the .set file and check the C26x name in the Operational Parameters node to make sure you have opened the right file:



- If needed, create a new register key named “VERSION” and located under:

  `HKEY_LOCAL_MACHINE\Software\Wow6432Node\DCS\MICOM S1\Settings\`

  The value of this key can be 0 or 1. The default value is 1.

3.3.2 TRANSFERRING A FILE FROM THE C26X

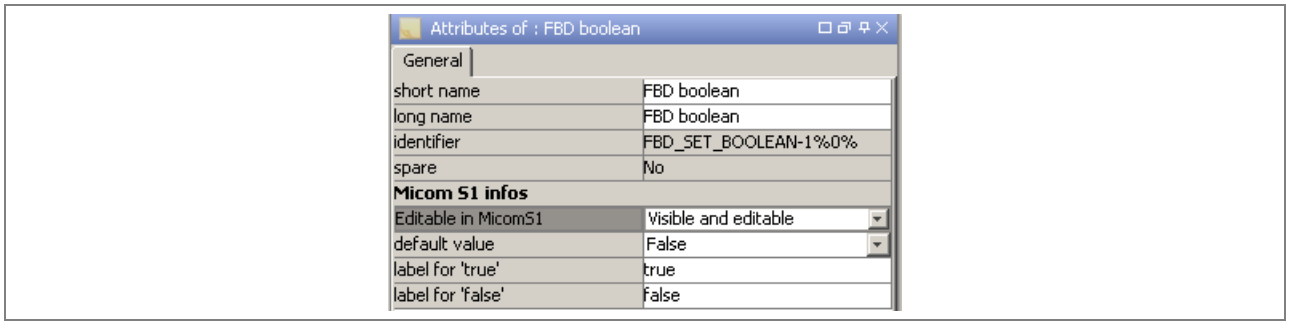
The .val file is transferred via ftp. When data transmission is finished, the C26x sends an acknowledgement message. This message allows to read the .val received. The .val file is converted to .set and the current *.set is updated.

- Use the menu Transmission>Get Settings and wait for the acknowledgment:

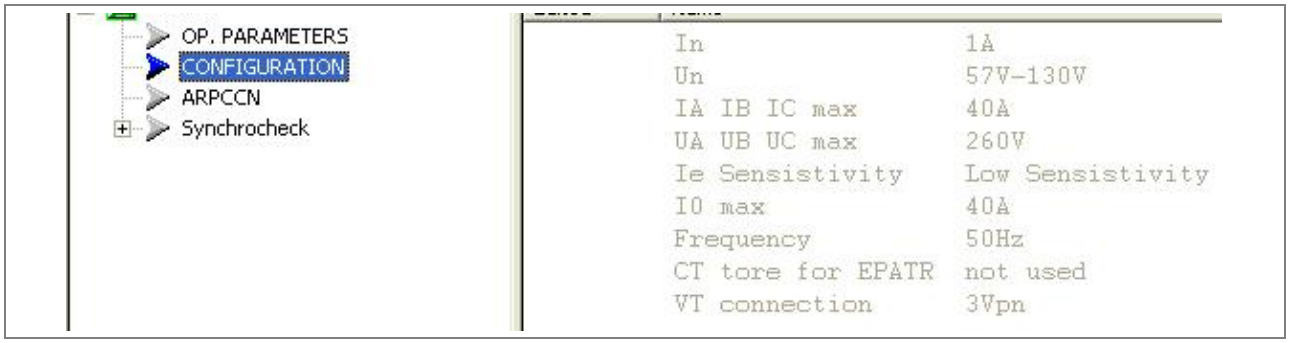


3.3.3 EDITING ONLINE PARAMETERS

The on-line visibility and possibility of setting are attributes configured in SCE:

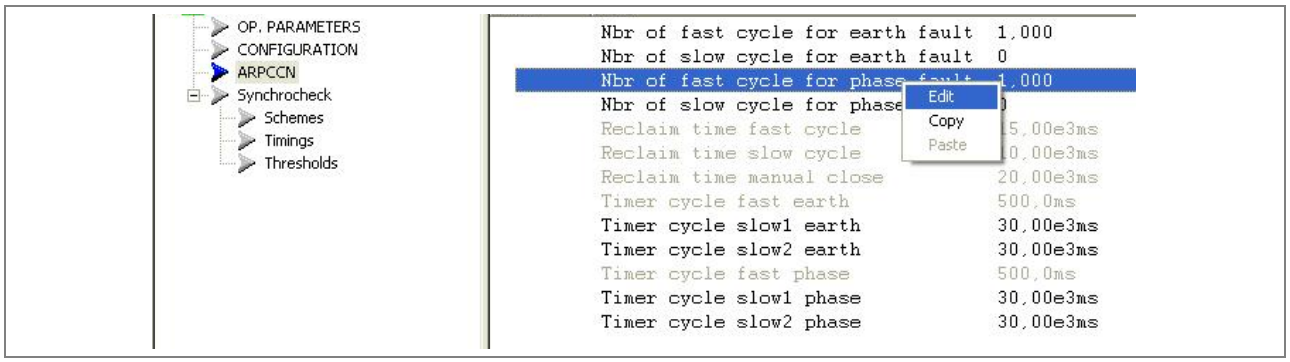


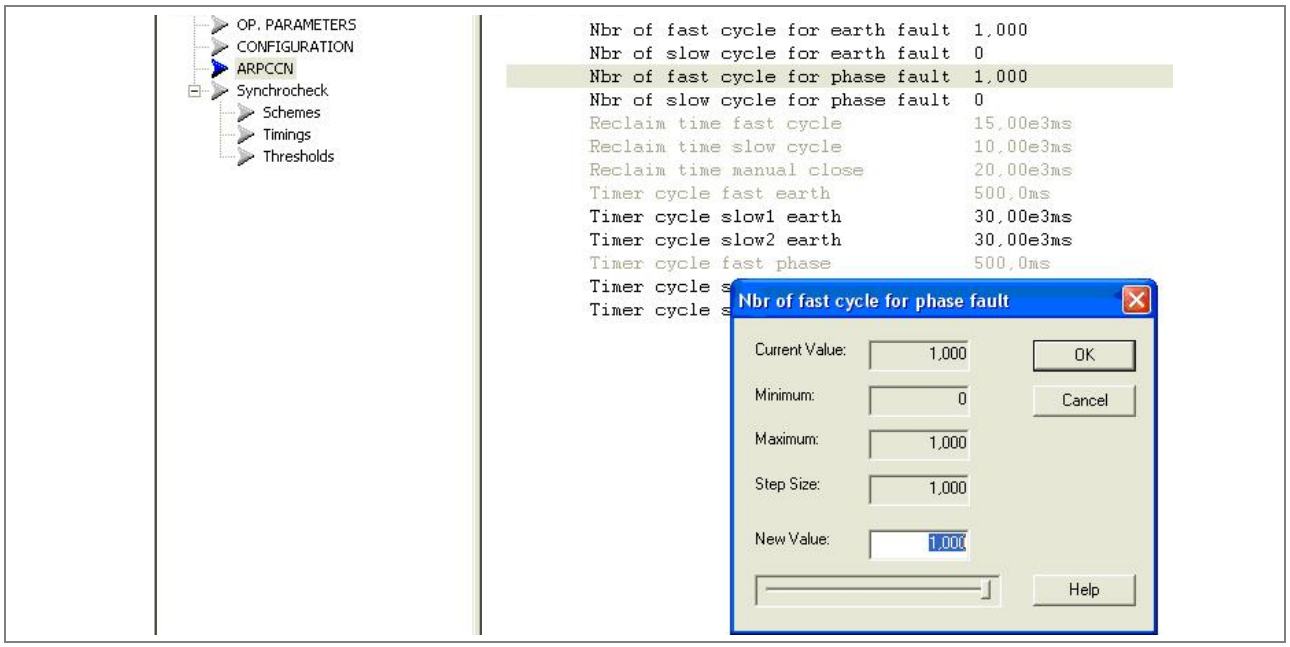
The read-only parameters show greyed out in MiCOM S1:



Editable parameters show in black.

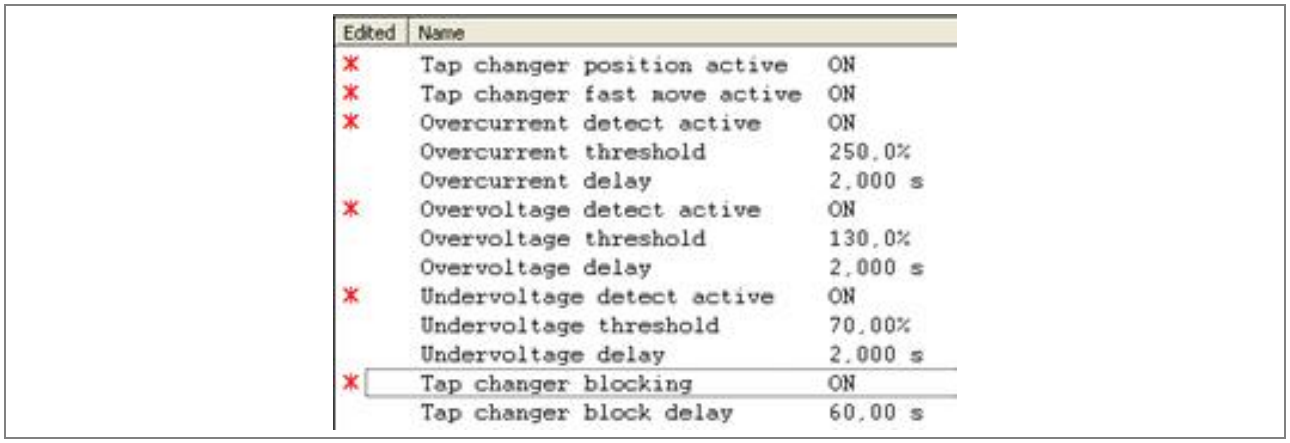
- Clicking edit on the parameters, as shown in below figures:





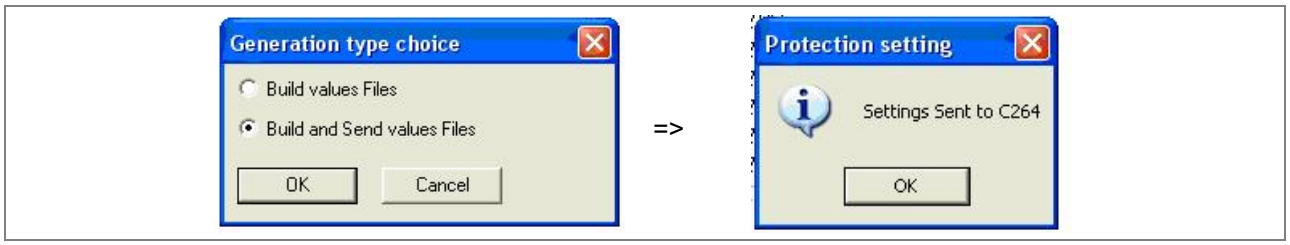
Select the new value using the slider or the list or the spin buttons.

After setting, a red star shows in the Edited column:



3.3.4 TRANSFERRING NEW VALUES

- Use the menu Transmission > Set Settings
- Select either option
  - Build: the application indicates that a .val file is available; this allows to checkout the file before sending (see 3.6)
  - Build and Send: C26x receives this indication, fetches the file, checks the coherency of this file and acknowledges it positively or negatively



3.4 LISTS OF PARAMETERS

The parameters list includes if applicable:

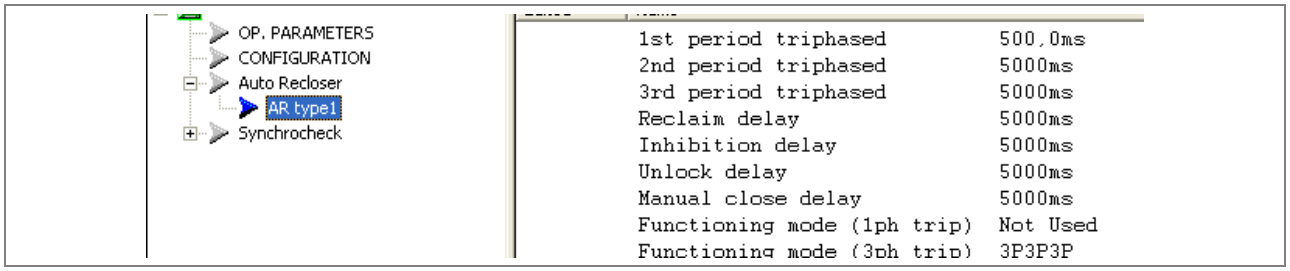
- CONFIGURATION: general parameters for protection functions (with TMU210)
- ARPCCN: legacy auto-reclose function (Type 2)
- PROTECTION GROUP 1: parameters for each protecton functions
- PROTECTION GROUP 2: parameters for each protecton functions
- AUTOMAT.CONTROL (with TMU210)
- AVR
- Auto-Recloser bay 1
- Auto-Recloser bay N
- Synchrocheck
- ISaGRAF Automatism 1
- …
- ISaGRAF Automatism N
- PSL Automatism 1
- …
- PSL Automatism M

Built-in functions such as ISaGRAF, PSL automatism (FBD …), AVR and Auto-Recloser are configured in SCE. It is possible to set the following functions:

- Automates' built-in as autorecloser, AVR (if applicable), synchrocheck (if applicable), protective function implemented for DS Agile
- ISaGRAF: (float or integer threshold & Boolean)
- Two kinds of parameters in FBD: The timeout used for (Ton / Toff) and the parameter (Boolean) validation

3.4.1 AUTORECLOSER (TYPE 1) PARAMETERS

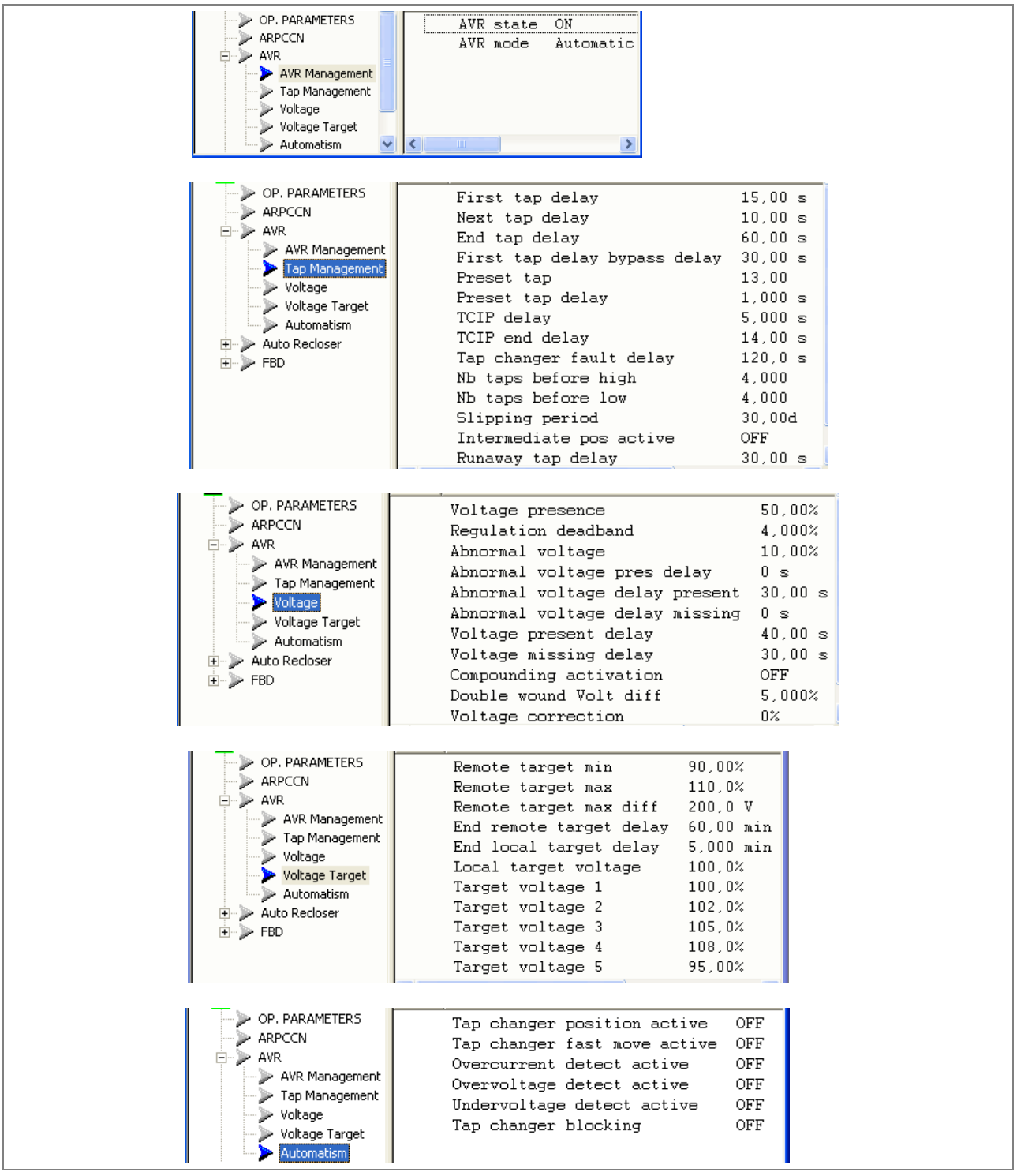
- Ist period triphased time min = 100, max = 60000, step = 10
- 2nd period triphased time min = 1000, max = 3600000, step = 10
- 3rd period triphased time min = 1000, max = 3600000, step = 1000
- Reclaim delay time min = 1000, max = 600000, step = 1000
- Inhibition delay min = 1000, max = 3600000, step = 1000
- Unlock delay min = 1000, max = 600000, step = 1000
- Manual close delay min = 1000, max = 600000, step = 1000
- Functioning mode (1 ph trip) types = 1P, 1P-3P, 1P-3P-3P, 1P-3P-3P-3P
- Functioning mode (3 ph trip) types = 3P, 3P-3P, 3P-3P-3P, 3P-3P-3P-3P



3.4.2 AUTORECLOSER (TYPE 2) PARAMETERS

- Numbers of fast cycle for earth fault min = 0 , max = 1 step = 1 cycle step
- Numbers of slow cycle for earth fault min = 0 , max = 2 , step = 1 cycle step
- Numbers of fast cycle for phase fault min = 0 , max = 1 , step = 1 cycle step
- Numbers of slow cycle for phase fault min = 0, max = 2, step = 1 cycle step
- Reclaim time fast cycle, min = 10000 , max = 15000 , step = 1000
- Reclaim time slow cycle, min = 3000 , max = 10000 , step = 1000
- Reclaim time manual close , min = 10000, max = 20000 , step =1000
- Timer cycle fast earth, min = 100, max = 500 , step =1
- Timer cycle slow1 earth, min = 10000, max = 30000 , step =1000
- Timer cycle slow2 earth, min = 10000, max = 30000 , step =1000
- Timer cycle fast phase, min = 100 , max = 500 , step =1
- Timer cycle slow1 phase, min = 10000 , max = 30000 , step =1000
- Timer cycle slow2 phase, min = 10000 , max = 30000 , step =1000

3.4.3 AVR PARAMETERS



To view the range allowed for each parameter, refer to the chapter C26x/EN AP.

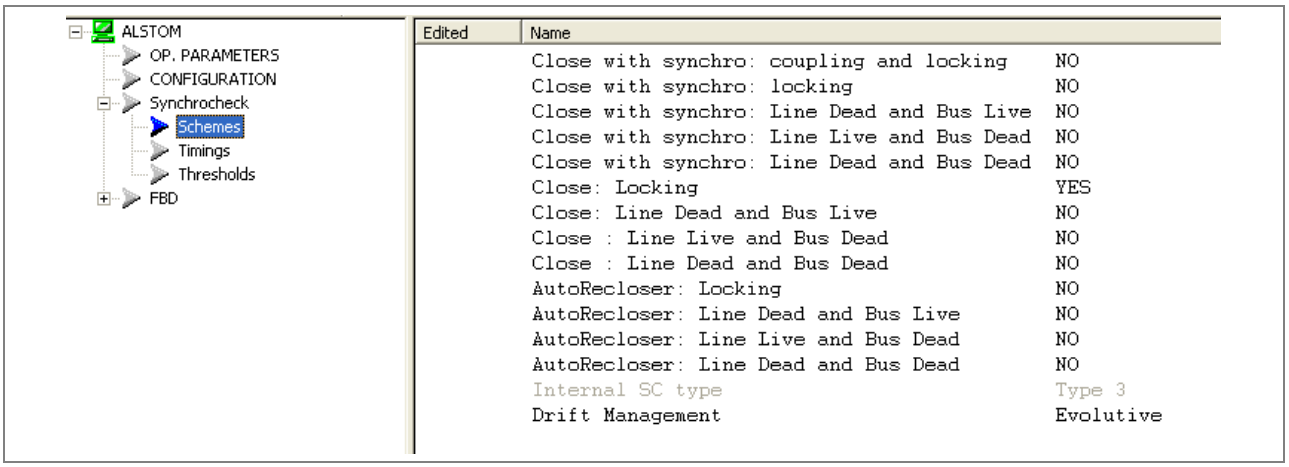
3.4.4 INTERNAL SYNCHROCHECK PARAMETERS

3.4.4.1 STANDARD TOPOLOGY (TYPES 1, 2, 4)

Note:
Not all the settings below are available or effective for all the S/C types. See Functional Description *chapter (*C26x/EN FT*) for details.*

Schemes

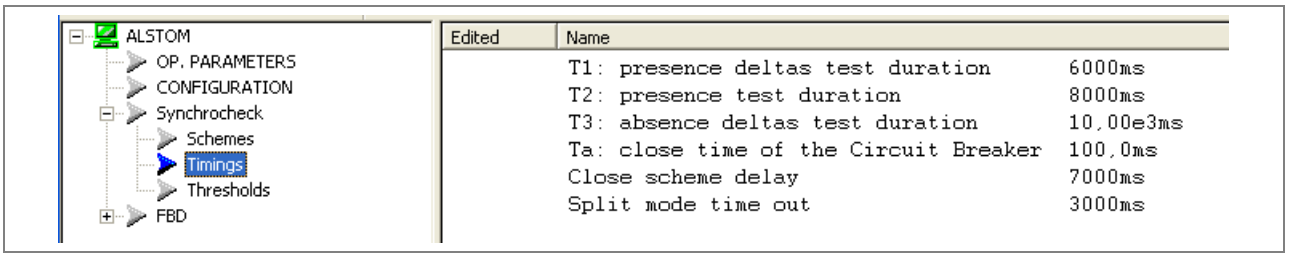
- Close with synchro: Coupling and locking = YES/NO
- Close with synchro: Locking = YES/NO
- Close with synchro: Line Dead and Bus Live = YES/NO
- Close with synchro: Line Live and Bus Dead = YES/NO
- Close with synchro: Line Dead and Bus Dead = YES/NO
- Close : Locking = YES/NO
- Close: Line Dead and Bus Live = YES/NO
- Close: Line Live and Bus Dead = YES/NO
- Close: Line Dead and Bus Dead = YES/NO
- Autorecloser Locking = YES/NO
- Autorecloser Line Dead and Bus Live: = YES/NO
- Autorecloser Line Live and Bus Dead: = YES/NO
- Autorecloser Line Dead and Bus Dead = YES/NO
- Internal SC type = Type 1/Type 2/Type 3/Type 4 (not settable)
- Drift Management = Evolutive/Exclusive/Split (not settable)



Timings

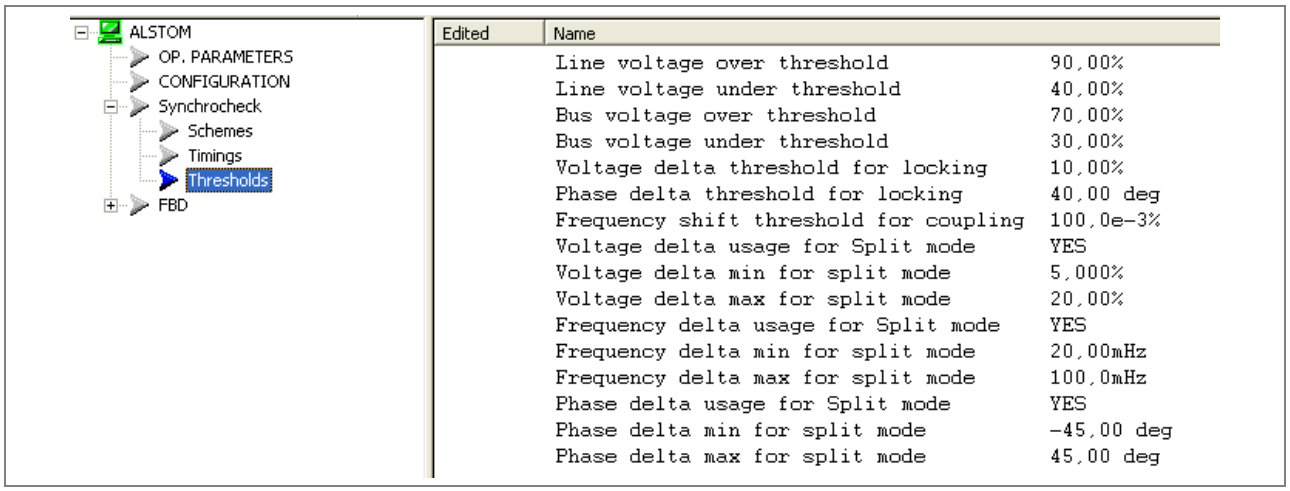
- T1: Presence deltas test duration: min = 20 ms, max = 10000 ms, step = 10 ms
- T2: Presence test duration: min = 200 ms, max = 10000 ms, step = 20 ms
- T3: absence deltas test duration: min = 200 ms, max = 10000 ms, step = 20 ms
- Ta: close time of circuit breaker: min = 0 ms, max = 1000 ms, step = 10 ms
- Delay for coupling: min = 1 s, max = 3600 s, step = 1 s
- Close with synchro scheme delay: min = 200 ms, max = 10000 ms, step = 10 ms (Synchrocheck type 1 only)
- Close scheme delay: min = 200 ms, max = 10000 ms, step = 10 ms
- Autorecloser scheme delay: min = 200 ms, max = 10000 ms, step = 10 ms
- Split mode time out: min = 0 ms, max = 10000 ms, step = 100 ms
- Control rejection timeout: min = 0 s, max = 60 s, step = 1 s (Synchrocheck type 4)

Note:
Control rejection timeout is used for Type 4. It replaces Close with synchro: delay which is used only for Type 1.



Thresholds

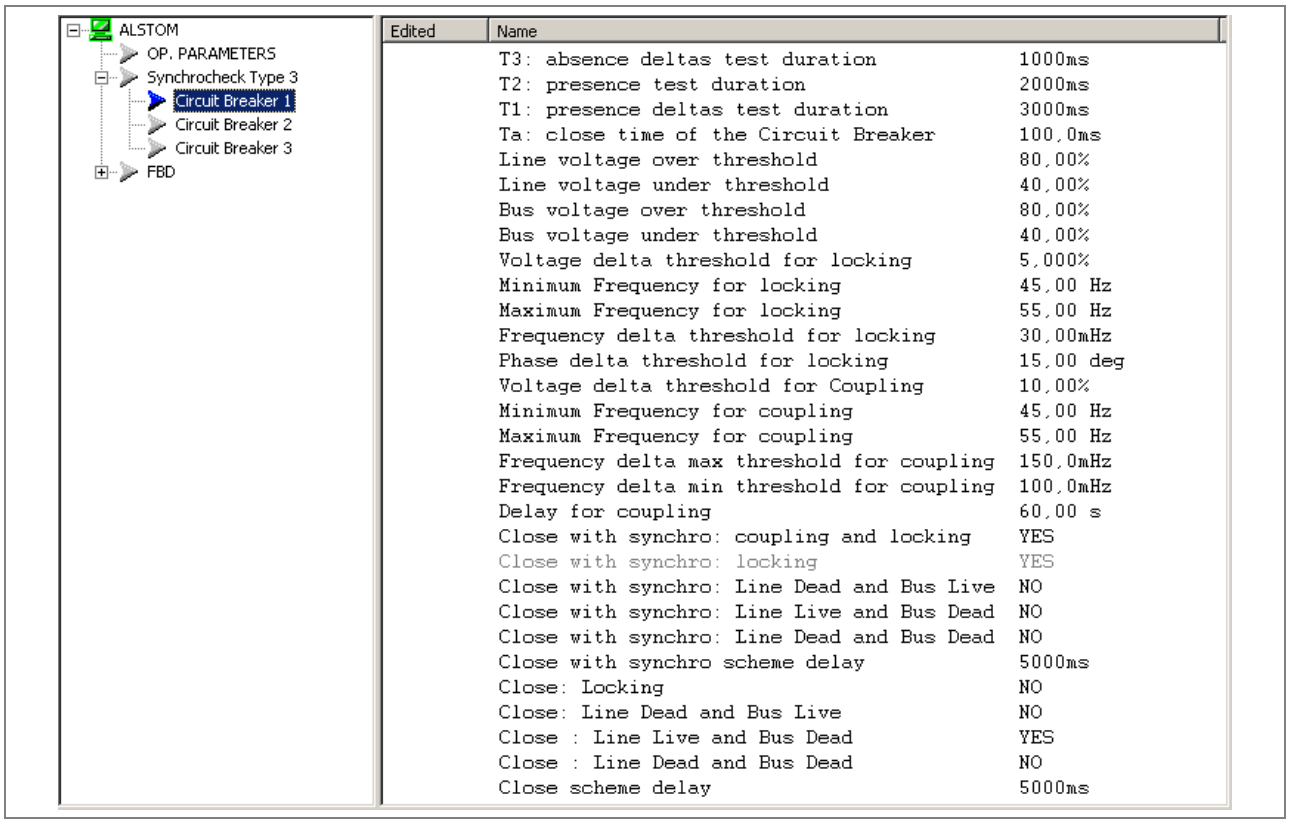
- Line voltage over threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Line voltage under threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Bus voltage over threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Bus voltage under threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Voltage delta threshold for locking: min = 0, max = 100 % Vn, step = 1 % Vn
- Minimum frequency for locking: min = 45.5 Hz, max = 59.5 Hz, step = 0.1 Hz
- Maximum frequency for locking: min = 50.5 Hz, max = 66 Hz, step = 0.1 Hz
- Frequency delta threshold for locking: min = 0, max = 1 Hz, step = 0.01 Hz
- Phase delta threshold for locking: min = 0, max = 90°, step = 1°
- Frequency shift threshold for locking: min = 0.02 Hz, max = 0.1 Hz, step = 0.01 Hz
- Voltage delta threshold for coupling: min = 0, max = 100 % Vn, step = 1 % Vn
- Minimum frequency for coupling: min = 45.5 Hz, max = 59.5 Hz, step = 0.1 Hz
- Maximum frequency for coupling: min = 50.5 Hz, max = 66 Hz, step = 0.1 Hz
- Minimum frequency delta threshold for coupling: min = 0, max = 1 Hz, step = 0.01 Hz
- Maximum frequency delta threshold for coupling: min = 0, max = 1 Hz, step = 0.01 Hz
- Phase delta threshold for coupling: min = 0, max = 90°, step = 1°
- Frequency shift threshold for coupling: min = 0.02 %, max = 0.1 %, step = 0.01 %
- Voltage delta usage for Split mode: NO/YES
- Voltage delta min for split mode: min = 0, max = 100 % Vn, step = 1 % Vn
- Voltage delta max for split mode: min = 0, max = 100 % Vn, step = 1 % Vn
- Frequency delta usage for Split mode: NO/YES
- Frequency delta min for split mode: min = 0, max = 1 Hz, step = 0.01 Hz
- Frequency delta max for split mode: min = 0, max = 1 Hz, step = 0.01 Hz
- Phase delta usage for Split mode: NO/YES
- Phase delta min for split mode: min = -180, max = 0°, step = 1°
- Phase delta max for split mode: min = 0, max = 180°, step = 1°
- Over Voltage threshold: min = 100 % Vn, max = 150 % Vn, step = 1 % Vn


ALSTOM
OP. PARAMETERS
CONFIGURATION
Synchrocheck
Schemes
Timings
Thresholds
FBD
Edited
Name
Line voltage over threshold 90,00%
Line voltage under threshold 40,00%
Bus voltage over threshold 70,00%
Bus voltage under threshold 30,00%
Voltage delta threshold for locking 10,00%
Phase delta threshold for locking 40,00 deg
Frequency shift threshold for coupling 100,0e-3%
Voltage delta usage for Split mode YES
Voltage delta min for split mode 5,000%
Voltage delta max for split mode 20,00%
Frequency delta usage for Split mode YES
Frequency delta min for split mode 20,00mHz
Frequency delta max for split mode 100,0mHz
Phase delta usage for Split mode YES
Phase delta min for split mode -45,00 deg
Phase delta max for split mode 45,00 deg

3.4.4.2 BREAKER-AND-A-HALF TOPOLOGY (TYPE3)

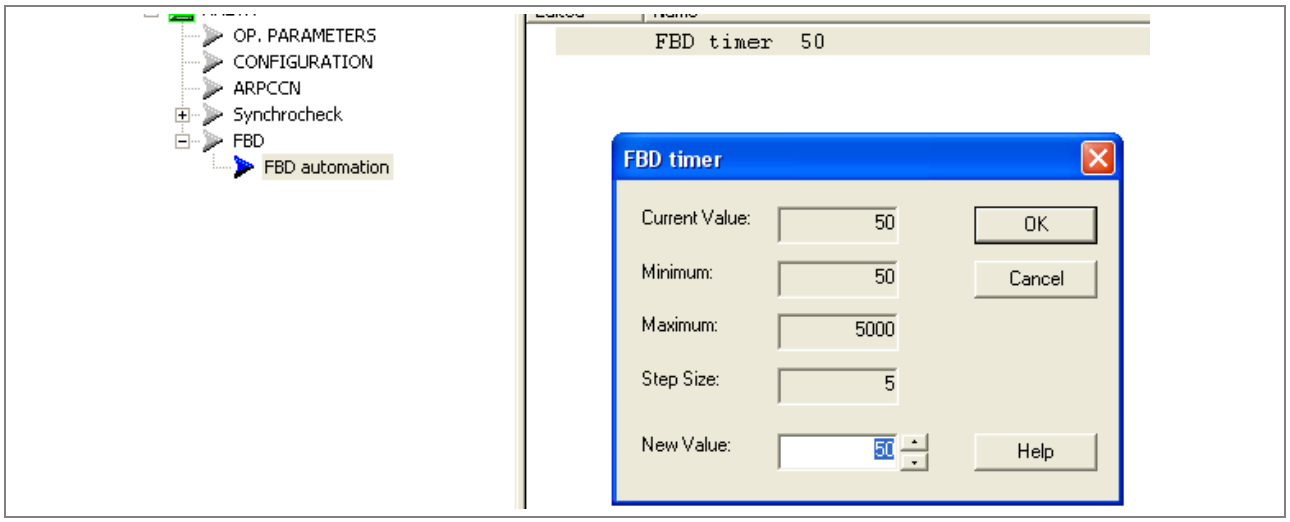
Circuit Breaker x (x = 1, 2 or 3)

- T3: absence deltas test duration: min = 200 ms, max = 10000 ms, step = 20 ms
- T2: presence test duration: min = 200 ms, max = 10000 ms, step = 20 ms
- T1: presence deltas test duration: min = 20 ms, max = 10000 ms, step = 10 ms
- Ta: close time of the Circuit Breaker: min = 0 ms, max = 1000 ms, step = 10 ms
- Line voltage over threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Line voltage under threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Bus voltage over threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Bus voltage under threshold: min = 0, max = 100 % Vn, step = 1 % Vn
- Voltage delta threshold for locking: min = 0, max = 100 % Vn, step = 1 % Vn
- Minimum Frequency for locking: min = 45.5 Hz, max = 59.5 Hz, step = 0.1 Hz
- Maximum Frequency for locking: min = 50.5 Hz, max = 66 Hz, step = 0.1 Hz
- Frequency delta threshold for locking: min = 0, max = 1 Hz, step = 0.01 Hz
- Phase delta threshold for locking: min = 0, max = 90°, step = 1°
- Voltage delta threshold for Coupling: min = 0, max = 100 % Vn, step = 1 % Vn
- Minimum Frequency for coupling: min = 45.5 Hz, max = 59.5 Hz, step = 0.1 Hz
- Maximum Frequency for coupling: min = 50.5 Hz, max = 66 Hz, step = 0.1 Hz
- Frequency delta max threshold for coupling: min = 0, max = 1 Hz, step = 0.01 Hz
- Frequency delta min threshold for coupling: min = 0, max = 1 Hz, step = 0.01 Hz
- Delay for coupling: min = 1 s, max = 3600 s, step = 1 s
- Close with synchro: coupling and locking: YES/NO
- Close with synchro: locking: YES/NO
- Close with synchro: Line Dead and Bus Live: YES/NO
- Close with synchro: Line Live and Bus Dead: YES/NO
- Close with synchro: Line Dead and Bus Dead: YES/NO
- Close with synchro scheme delay: min = 0.2 s, max = 10 s, step = 0.01 s
- Close: Locking: YES/NO
- Close: Line Dead and Bus Live: YES/NO
- Close : Line Live and Bus Dead: YES/NO
- Close : Line Dead and Bus Dead: YES/NO
- Close scheme delay: min = 0.2 s, max = 10 s, step = 0.01 s

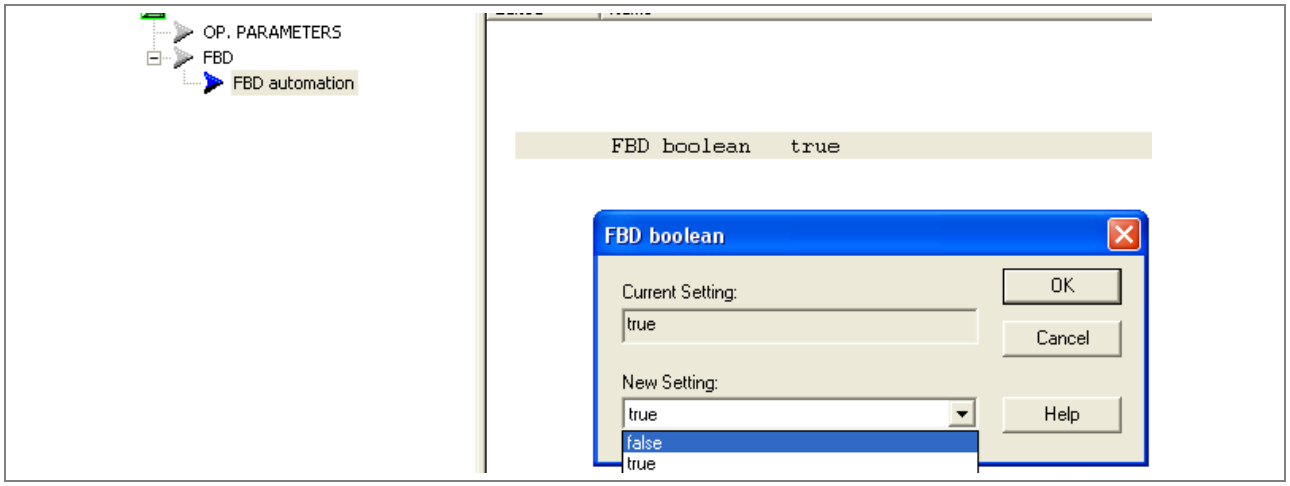


3.4.5 FBD PARAMETERS

FBD Timer:

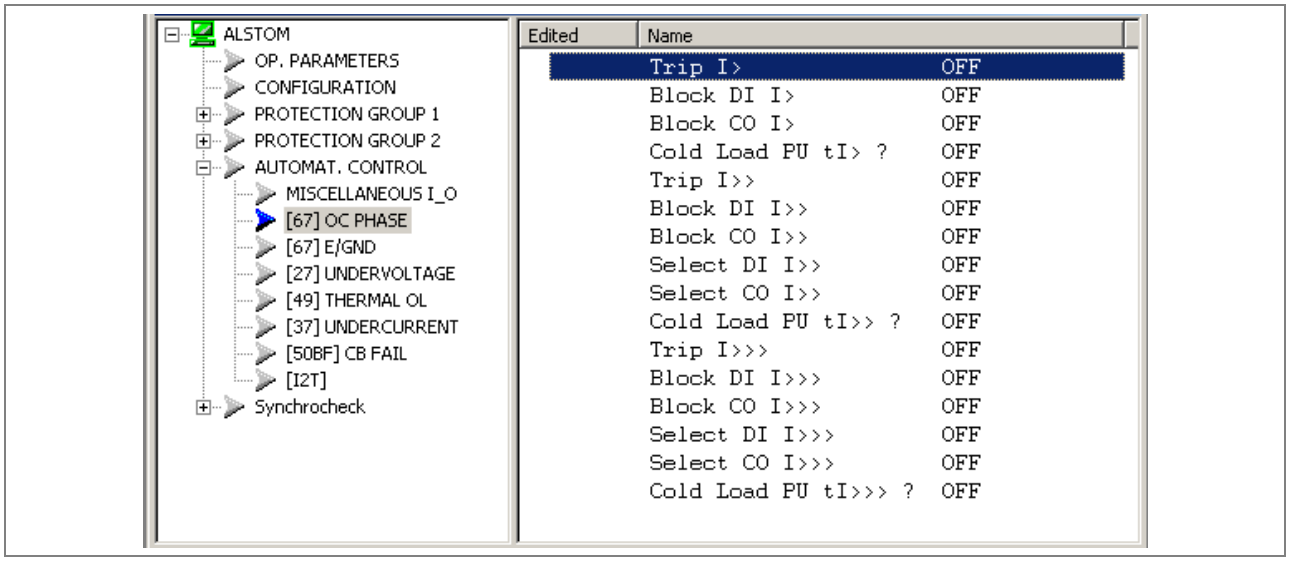


FBD Boolean: True/false

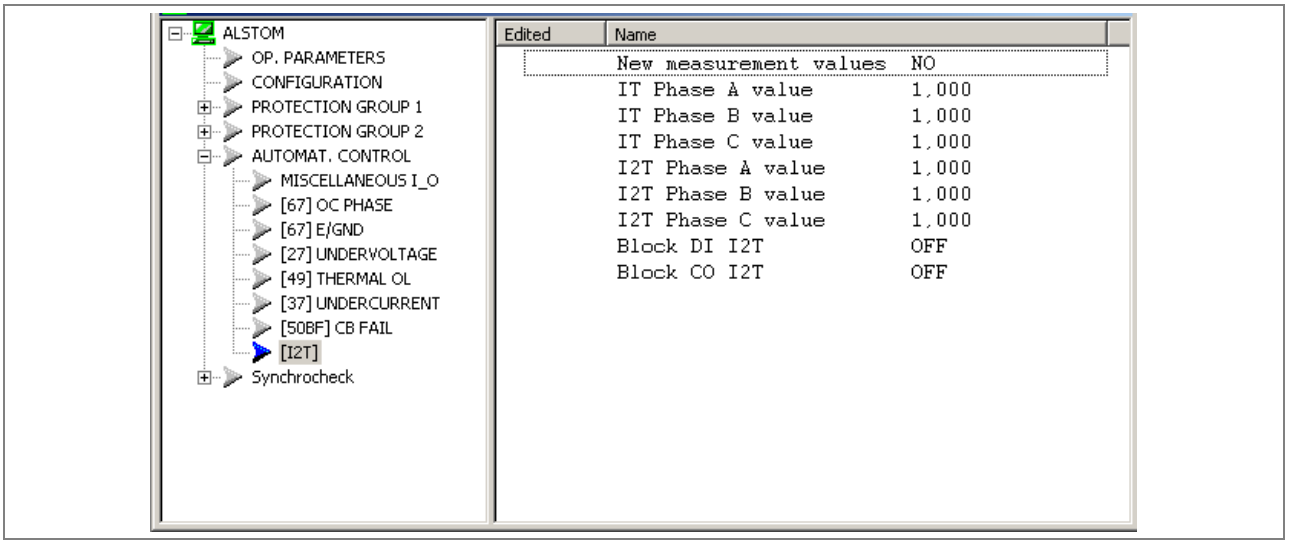


3.4.6 AUTOMATED CONTROL PARAMETERS

Example 1: Phase overcurrent ([67] OC PHASE)



Example 2: I²t



3.5 MICOM S1 MESSAGES

Receipt value	MiCOM S1 message
0	Setting done
1	Incorrect C26x DB Version revision
2	Number of protections incoherent with DB
3	No setting file in the C26x
4	FTP server problem. Verify that the FTP client is launched & try again
5	C26x internal error
6	C26x incorrect number
7	Setting impossible, command running
8	Error IED address
9	Incompatible data structure
10	IED setting failed
11	Compatibility error between C26x and SCE
12	Number of columns of the .VAL file incorrect
13	Error: label too long
14	Error PROTECTIONS C26x: Value not between MIN and MAX
15	Error ELECTRE d: Value not between MIN and MAX
16	Error FBD: Value not between MIN and MAX
17	Error ISaGRAF: Value not between MIN and MAX
18	Error AUTO RECLOSER: Value not between MIN and MAX
19	Error AUTO RECLOSER PCCN: Value not between MIN and MAX
20	Error SYNCHROCHECK: Value not between MIN and MAX *
21	Error AVR: Value not between MIN and MAX
22	Error PROTECTIONS C26x: Verification phase incorrect
23	Error ELECTRE d: Verification phase incorrect
24	Error FBD: Verification phase incorrect

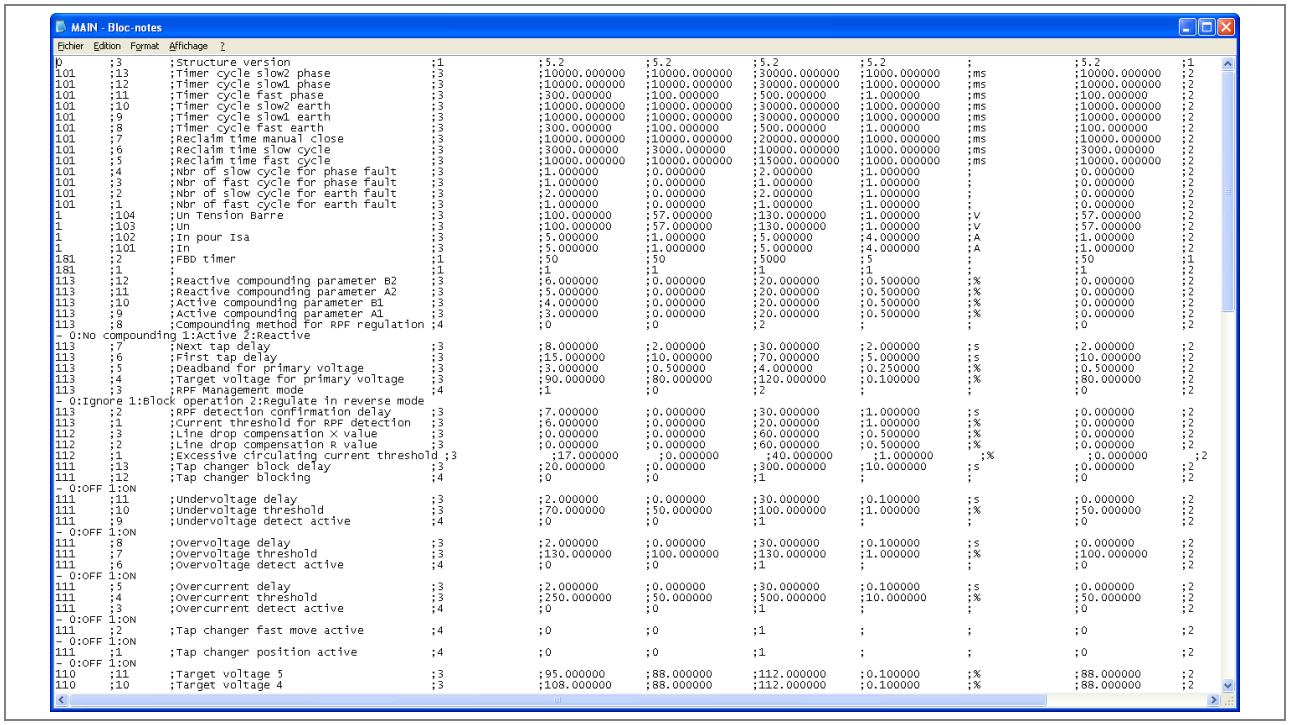
Receipt value	MiCOM S1 message
25	Error ISaGRAF: Verification phase incorrect
26	Error AUTO RECLOSER: Verification phase incorrect
27	Error AUTO RECLOSER PCCN: Verification phase incorrect
28	Error SYNCHROCHECK: Verification phase incorrect
29	Error AVR: Verification phase incorrect
30	Error: File OK but a problem occurred during file copy
31	Error: Setting file for CPU270 board sent to a CPU260 board (obsolete)
32	Error in file checksum
33	Error: MiCOM ALSTOM S1 task not present
34	Error: Trip in progress A MiCOM ALSTOM S1 session is already used

* This message might pop up without any reason. To make sure there is no reason, extract the .set file from the zip archive and open it directly in MiCOM S1 and repeat the transfer.

3.6 VAL FILE

The .val files are ASCII files generated on the desktop using the menu Transmission>Set settings. They can be opened using a text editor and saved for records.

Example:



Each line (maximum size: 256 characters) represents a setting.

Each setting is made of 7 fields:

- name (character string)
- type of the parameter (1, 2 or 3) where:
  - 1 is for INT32
  - 2 is for UINT32
  - 3 is for REAL32
- value (based on the type)
- minimum value (based on the type)
- maximum value (based on the type)
- step (based on the type)
- unit
- default value (based on the type)

The maximum size of a field is 32 characters.

Each member of the parameter record is delimited by “;”.

Comments can be added to the file using the character #.

All the lines starting with #, ' ' , LF or CR are ignored.

4 PROTECTION PARAMETERS

Parameter	Setting range	Description
PROTECTION GROUP 1		Setting Group 1
[67] OC PHASE		[67/50/51] Phase overcurrent submenu heading
I> ?	OFF, ON, DIR	Selection of the first alarm threshold function for phase OC (I>)
I> VALUE	0.1 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
I> Delay Type	DMT, STI (CEI), SI (CEI), VI(CEI), EI (CEI), LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t I> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
TMS	0.025 to 3.2, in steps of 0.025	Setting for the TMS value for the IDMT curve
K	0.1 to 10, in steps of 0.01	Setting for the K value of the RI curve
Reset delay type	DMT or IDMT	
treset	40 ms to 100 s, in steps of 10 ms	Setting for the reset time (IEC curve only)
RTMS	0.025 to 3.200, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice (ANSI & CO curves only)
I > TORQUE	0° to 359°, in steps of 1°.	Setting for the torque angle
I > TRIP ZONE	±10° to ±170°, in steps of 1°.	Setting for the angle value for the Trip Zone
I> >> >>> Interlock	OFF, ON	Interlock of the first threshold by the second and third thresholds
I>> ?	ON, OFF, DIR	Selection of the second alarm threshold function for phase OC (I>>)
I>> VALUE	0.1 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
I>> DELAY TYPE	DMT, STI (CEI), SI (CEI), VI(CEI),EI (CEI),LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t I>> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
TMS	0.025 o 3.2, in steps of 0.025	Setting for the TMS value of the IEC curve
K	0.1 to 10, in steps of 0.01	Setting for the K value of the RI curve
Reset delay type	DMT or IDMT	
treset	0 to 100 s, in steps of 10 ms	Setting for the reset time (IEC curve only)
RTMS	0.025 to 3.200, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice (ANSI & CO curves only)
I >> TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle

Parameter	Setting range	Description
I >> TRIP ZONE	±10° to ±170°, in steps of 1°	Setting for the angle value for the Trip Zone
I>>> ?	ON, OFF, DIR	Selection of the third alarm threshold function for phase OC (I>>>)
I>>> VALUE	0.1 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
t I>>> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
I >>> TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle
I>>> TRIP ZONE	±10° to ±170°, in steps of 1°	Setting for the angle value for the Trip Zone
[67N] E/GND		[50N/51N/67N] Directional Earth Faultsubmenu heading
Ie> ?	OFF, ON, DIR	Selection of the first alarm threshold function for earth OC (Ie>)
Ie> VALUE	0.1 to 25 Ien, in steps of 0.01 Ien	Setting for the alarm threshold
Ie> Delay Type	DMT, STI (CEI), SI (CEI), VI(CEI), EI (CEI), LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t Ie> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
TMS	0.025 to 3.2, in steps of 0.025	Setting for the TMS value for the IDMT curve
K	0.1 to 10, in steps of 0.01	Setting for the K value of the RI curve
Reset delay type	DMT, IDMT	Selection of the type of reset time-delay
treset	0 to 100 s, in steps of 10 ms	Setting for the reset time of IEC curves only
RTMS	0.025 to 3.200, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice for ANSI & CO curves only
Ie > TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle
Ie > TRIP ZONE	10° to 170°, in steps of 1°	Setting for the angle value of the Trip Zone
Ie> Min V	1 to 260 V, in steps of 0.1 V	Polarisation voltage
Ie> >> >>> Interlock	OFF, ON	Interlock of the first threshold by the second and third thresholds
Ie>> ?	ON, OFF, DIR	Selection of the second alarm threshold function for earth OC (Ie>>)
Ie>> VALUE	0.1 to 40 Ien, in steps of 0.01 Ien.	Setting for the alarm threshold
Ie>> Delay Type	DMT, STI (CEI), SI (CEI), VI(CEI),EI (CEI),LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t Ie>> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold

Parameter	Setting range	Description
TMS	0.025 to 3.2, in steps of 0.025	Setting for the TMS value of the IEC curves
K	0.1 to 10, in steps of 0.01	Selection of K value for the RI curve
Reset delay type	DMT, IDMT	Selection of the type of reset time-delay
treset	0 to 100 s, in steps of 10 ms	Setting for the reset time for IEC curves only
RTMS	0.025 to 3.200, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice for ANSI & COx curves only
Ie >> TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle
Ie >> TRIP ZONE	10° to 170°, in steps of 1°	Setting for the angle value of the Trip Zone
Ie>> Min V	1 to 260 V, in steps of 0.1 V	Polarisation voltage
Ie>>> ?	ON, OFF, DIR	Selection of the third alarm threshold function for earth OC (Ie>>>)
Ie>>> VALUE	0.1 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
t Ie>>> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
Ie >>> TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle
Ie>>> TRIP ZONE	10° to 170°, in steps of 1°	Setting for the angle value of the Trip Zone
Ie>>> Min V	1 to 260 V, in steps of 0.1 V	Polarisation voltage
[81] FREQUENCY		[81] Over-/Underfrequency submenu heading
[81] f1 ?	OFF, MIN, MAX	Selection of the first alarm threshold function for Frequency function
f1 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f1	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f2 ?	OFF, MIN, MAX	Selection of the second alarm threshold function for Frequency function
f2 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f2	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f3 ?	OFF, MIN, MAX	Selection of the Third alarm threshold function for Frequency function
f3 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f3	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f4 ?	OFF, MIN, MAX <	Selection of the 4th alarm threshold function for Frequency function
f4 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold

Parameter	Setting range	Description
t f4	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f5 ?	OFF, MIN, MAX	Selection of the fith alarm threshold function for Frequency function
f5 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f5	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f6 ?	OFF, MIN, MAX	Selection of the sixth alarm threshold function for Frequency function
f6 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f6>	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
VminFrequencyEnable	5 to 130 V, in steps of 0.1 V for Un range 57-130 V or 20 to 480 V, in steps of 0.1 V for Un range 220-480 V	Setting for the minimum voltage to run the [81] function
[81] FREQ CHANGE OF RATE		[81R] Rate of change of frequency submenu heading
[81] df/dt1 ?	OFF, ON	Selection of the first alarm threshold function for Frequency Rate of Change function
df/dt1 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt1	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt1 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 1
[81] df/dt2 ?	OFF, ON	Selection of the second alarm threshold function for Frequency Rate of Change function
df/dt2 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt2	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt2 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 2
[81] df/dt3 ?	OFF, ON	Selection of the third alarm threshold function for Frequency Rate of Change function
df/dt3 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt3	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt3 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 3
[81] df/dt4 ?	OFF, ON	Selection of the fourth alarm threshold function for Frequency Rate of Change function
df/dt4 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt4	0 to 600 s, in steps of 10 ms	Setting for the trip threshold

Parameter	Setting range	Description
df/dt4 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 4
[81] df/dt5 ?	OFF, ON	Selection of the fifth alarm threshold function for Frequency Rate of Change function
df/dt5 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt5	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt5 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 5
[81] df/dt6 ?	OFF, ON	Selection of the sixth alarm threshold function for Frequency Rate of Change function
df/dt6 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt6	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt6 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 6
AverageNumber	5 to 100, in steps of 1	Setting for DF/DT calculation based on instantaneous df/dt
ConfirmationNumber	2, 4	Selection of the value to confirm df/dt detection
[59] OVERVOLTAGE		[59] submenu heading
V> ?	OFF, AND, OR	Selection of the first alarm threshold function for phase Over Voltage function
V> VALUE	2 to 260 V, in steps of 0.1 V for Un range 57-130 V or 10 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold
t V>	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
V>> ?	OFF, AND, OR	Selection of the second alarm threshold function for phase Over Voltage function
V>> VALUE	2 to 260 V, in steps of 0.1 V for Un range 57-130 V or 10 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold
t V>>	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[27] UNDERVOLTAGE		[27] Undervoltage submenu heading
V< ?	OFF, AND, OR	Selection of the first alarm threshold function for phase Under Voltage function
V< VALUE	2 to 260 V, in steps of 0.1 V for Un range 57-130 V or 10 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold

Parameter	Setting range	Description
t V<	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
V<< ?	OFF, AND, OR	Selection of the second alarm threshold function for phase Over Voltage function
V<< VALUE	2 to 260 V, in steps of 0.1 V for Un range 57-130 V or10 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold
t V<<	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[59N] RESIDUAL O/V		[59N] Residual Overvoltage submenu heading
Uen> ?	OFF, ON	Selection of the first alarm threshold function for Residual Over Voltage function
Uen> VALUE	1 to 260 V, in steps of 0.1 V for Un range 57-130 V or 5 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold
t Uen>	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[32N] EARTH WATTMETRIC		[32N] Wattmetric earth fault submenu heading
Pe> ?	OFF, ON	Selection of the first alarm threshold function for Pe>
Pe>	Range 57 to 130 V 0.2 to 20 W 4 to 160 W 10 to 800 W Range 220 to 480 V 1 to 80 W 4 to 640 W 40 to 3200 W	Setting for the alarm threshold Pe>
Pe> Delay type	DMT, STI (CEI), SI (CEI), VI(CEI),EI (CEI),LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t Pe>	0 to 150 s, in steps of 10 ms	Selection of the setting value for the trip threshold.
TMS	0.025 to 1.5, in steps of 0.025	Setting for the TMS value for the IDMT curves
K	0.1 to 10 steps of 0.005	Selection of the K value for the RI curve
treset	0 to 100 s, in steps of 10 ms	Setting for the setting value for the reset time for IEC curves only
RTMS	0.025 to 1.5, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice for ANSI & COx curves only
Pe>> ?	No, Yes	Selection of the first alarm threshold function for Pe>>

Parameter	Setting range	Description
Pe>>	Range 57 to 130 V 0.2 to 20 W 4 to 160 W 10 to 800 W Range 220 to 480 V 1 to 80 W 4 to 640 W 40 to 3200 W	Setting for the values for the alarm threshold Pe>>
t Pe>>	0 to 150 s, in steps of 10 ms	Setting for the trip threshold.
Pe> Pe>>	0° to 359°, in steps of 1°	Setting for the setting angle for Pe. This item is only activated if at least one of the Pe thresholds is enabled.
[46] NEG SEQ O/C		[46] Negative sequence overcurrent submenu heading
I2> ?	OFF, ON	Selection of the first alarm threshold function for Negative Phase Sequence OC (I2>)
I2> VALUE	0.5 to 25 In, in steps of 0.01 In	Setting for the alarm threshold
I2> Delay type	DMT, STI (CEI), SI (CEI), VI(CEI), EI (CEI),LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t I2>	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
TMS	0.025 to 1.5, in steps of 0.025	Setting for the TMS value of the IDMT curve
K	0.1 to 10, in steps of 0.005	Setting for the K value of the RI curve
treset	40 to 100 s, in steps of 10 ms	Setting for the reset time
RTMS	0.025 to 1.5, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice
I2>> ?	OFF, ON	Selection of the second alarm threshold function for Negative Phase Sequence OC (I2>>)
I2>> VALUE	0.5 to 40 In, in steps of 0.01 In	Setting for the alarm threshold
t I2>>	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
I2>>> ?	OFF, ON	Selection of the third alarm threshold function for Negative Phase Sequence OC (I2>>>)
I2>>> VALUE	0.5 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
t I2>>>	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
[49] THERMAL OL		[49] Thermal overload submenu heading
Ith > VALUE	0.1 to 3.2 In, in steps of 0.01 In	Setting for the alarm threshold
K	1 to 1.50, in steps of 0.01	Setting for the K factor associated with the thermal overload function
Te	1 to 200 min, in steps of 1 min	Setting for the Te thermal constant associated with the thermal formula

Parameter	Setting range	Description
Thermal OL	OFF, ON	Selection of the first alarm threshold function for Thermal Overload function
th Trip	50 to 200%, in steps of 0.01	Setting for the percentage applicable to the thermal overload trip threshold
th Alarm	OFF, ON	Selection of the thermal overload alarm function
th Alarm VALUE	50 to 200%, in steps of 0.01	Setting for the percentage applicable to the thermal overload alarm threshold
[37] UNDERCURRENT		[37] Undercurrent submenu heading
I< ?	OFF, ON	Selection of the first alarm threshold function for Undercurrent function
I< VALUE	0.1 to 1 In, in steps of 0.01 In	Setting for the alarm threshold
t I<	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
PROTECTION GROUP 2		Setting Group 2
[67] OC PHASE		[67/50/51] Phase overcurrent submenu heading
I> ?	OFF, ON, DIR	Selection of the first alarm threshold function for phase OC (I>)
I> VALUE	0.1 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
I> Delay Type	DMT, STI (CEI), SI (CEI), VI(CEI), EI (CEI), LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t I> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
TMS	0.025 to 3.2, in steps of 0.025	Setting for the TMS value for the IDMT curve
K	0.1 to 10, in steps of 0.01	Setting for the K value of the RI curve
Reset delay type	DMT or IDMT	
treset	40 ms to 100 s, in steps of 10 ms	Setting for the reset time (IEC curve only)
RTMS	0.025 to 3.200, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice (ANSI & CO curves only)
I > TORQUE	0° to 359°, in steps of 1°.	Setting for the torque angle
I > TRIP ZONE	±10° to ±170°, in steps of 1°.	Setting for the angle value for the Trip Zone
I> >> >>> Interlock	OFF, ON	Interlock of the first threshold by the second and third thresholds
I>> ?	ON, OFF, DIR	Selection of the second alarm threshold function for phase OC (I>>)
I>> VALUE	0.1 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
I>> DELAY TYPE	DMT, STI (CEI), SI (CEI), VI(CEI), EI (CEI), LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8), VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t I>> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold

Parameter	Setting range	Description
TMS	0.025 o 3.2, in steps of 0.025	Setting for the TMS value of the IEC curve
K	0.1 to 10, in steps of 0.01	Setting for the K value of the RI curve
Reset delay type	DMT or IDMT	
treset	0 to 100 s, in steps of 10 ms	Setting for the reset time (IEC curve only)
RTMS	0.025 to 3.200, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice (ANSI & CO curves only)
I >> TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle
I >> TRIP ZONE	±10° to ±170°, in steps of 1°	Setting for the angle value for the Trip Zone
I>>> ?	ON, OFF, DIR	Selection of the third alarm threshold function for phase OC (I>>>)
I>>> VALUE	0.1 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
t I>>> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
I >>> TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle
I>>> TRIP ZONE	±10° to ±170°, in steps of 1°	Setting for the angle value for the Trip Zone
[67N] E/GND		[50N/51N/67N] Directional Earth Faultsubmenu heading
Ie> ?	OFF, ON, DIR	Selection of the first alarm threshold function for earth OC (Ie>)
Ie> VALUE	0.1 to 25 Ien, in steps of 0.01 Ien	Setting for the alarm threshold
Ie> Delay Type	DMT, STI (CEI), SI (CEI), VI(CEI), EI (CEI), LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t Ie> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
TMS	0.025 to 3.2, in steps of 0.025	Setting for the TMS value for the IDMT curve
K	0.1 to 10, in steps of 0.01	Setting for the K value of the RI curve
Reset delay type	DMT, IDMT	Selection of the type of reset time-delay
treset	0 to 100 s, in steps of 10 ms	Setting for the reset time of IEC curves only
RTMS	0.025 to 3.200, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice for ANSI & CO curves only
Ie > TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle
Ie > TRIP ZONE	10° to 170°, in steps of 1°	Setting for the angle value of the Trip Zone
Ie> Min V	1 to 260 V, in steps of 0.1 V	Polarisation voltage

Parameter	Setting range	Description
Ie> >> >>> Interlock	OFF, ON	Interlock of the first threshold by the second and third thresholds
Ie>> ?	ON, OFF, DIR	Selection of the second alarm threshold function for earth OC (Ie>>)
Ie>> VALUE	0.1 to 40 Ien, in steps of 0.01 Ien.	Setting for the alarm threshold
Ie>> Delay Type	DMT, STI (CEI), SI (CEI), VI(CEI),EI (CEI),LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t Ie>> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
TMS	0.025 to 3.2, in steps of 0.025	Setting for the TMS value of the IEC curves
K	0.1 to 10, in steps of 0.01	Selection of K value for the RI curve
Reset delay type	DMT, IDMT	Selection of the type of reset time-delay
treset	0 to 100 s, in steps of 10 ms	Setting for the reset time for IEC curves only
RTMS	0.025 to 3.200, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice for ANSI & COx curves only
Ie >> TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle
Ie >> TRIP ZONE	10° to 170°, in steps of 1°	Setting for the angle value of the Trip Zone
Ie>> Min V	1 to 260 V, in steps of 0.1 V	Polarisation voltage
Ie>>> ?	ON, OFF, DIR	Selection of the third alarm threshold function for earth OC (Ie>>>)
Ie>>> VALUE	0.1 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
t Ie>>> ?	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
Ie >>> TORQUE	0° to 359°, in steps of 1°	Setting for the torque angle
Ie>>> TRIP ZONE	10° to 170°, in steps of 1°	Setting for the angle value of the Trip Zone
Ie>>> Min V	1 to 260 V, in steps of 0.1 V	Polarisation voltage
[81] FREQUENCY		[81] Over-/Underfrequency submenu heading
[81] f1 ?	OFF, MIN, MAX	Selection of the first alarm threshold function for Frequency function
f1 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f1	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f2 ?	OFF, MIN, MAX	Selection of the second alarm threshold function for Frequency function
f2 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold

Parameter	Setting range	Description
t f2	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f3 ?	OFF, MIN, MAX	Selection of the Third alarm threshold function for Frequency function
f3 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f3	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f4 ?	OFF, MIN, MAX <	Selection of the 4th alarm threshold function for Frequency function
f4 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f4	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f5 ?	OFF, MIN, MAX	Selection of the fith alarm threshold function for Frequency function
f5 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f5	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[81] f6 ?	OFF, MIN, MAX	Selection of the sixth alarm threshold function for Frequency function
f6 VALUE	fn – 10 Hz to fn + 10 Hz, in steps of 0.01 Hz	Setting for the alarm threshold
t f6>	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
VminFrequencyEnable	5 to 130 V, in steps of 0.1 V for Un range 57-130 V or 20 to 480 V, in steps of 0.1 V for Un range 220-480 V	Setting for the minimum voltage to run the [81] function
[81] FREQ CHANGE OF RATE		[81R] Rate of change of frequency submenu heading
[81] df/dt1 ?	OFF, ON	Selection of the first alarm threshold function for Frequency Rate of Change function
df/dt1 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt1	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt1 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 1
[81] df/dt2 ?	OFF, ON	Selection of the second alarm threshold function for Frequency Rate of Change function
df/dt2 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt2	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt2 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 2
[81] df/dt3 ?	OFF, ON	Selection of the third alarm threshold function for Frequency Rate of Change function

Parameter	Setting range	Description
df/dt3 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt3	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt3 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 3
[81] df/dt4 ?	OFF, ON	Selection of the fourth alarm threshold function for Frequency Rate of Change function
df/dt4 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt4	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt4 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 4
[81] df/dt5 ?	OFF, ON	Selection of the fifth alarm threshold function for Frequency Rate of Change function
df/dt5 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt5	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt5 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 5
[81] df/dt6 ?	OFF, ON	Selection of the sixth alarm threshold function for Frequency Rate of Change function
df/dt6 VALUE	– 10 Hz/s to + 10 Hz/s, in steps of 0.1 Hz/s	Setting for the alarm threshold
t df/dt6	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
df/dt6 Id	0 to 6, in steps of 1 A	Setting for the frequency threshold [81R] 6
AverageNumber	5 to 100, in steps of 1	Setting for DF/DT calculation based on instantaneous df/dt
ConfirmationNumber	2, 4	Selection of the value to confirm df/dt detection
[59] OVERVOLTAGE		[59] submenu heading
V> ?	OFF, AND, OR	Selection of the first alarm threshold function for phase Over Voltage function
V> VALUE	2 to 260 V, in steps of 0.1 V for Un range 57-130 V or 10 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold
t V>	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
V>> ?	OFF, AND, OR	Selection of the second alarm threshold function for phase Over Voltage function
V>> VALUE	2 to 260 V, in steps of 0.1 V for Un range 57-130 V or 10 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold

Parameter	Setting range	Description
t V>>	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[27] UNDERVOLTAGE		[27] Undervoltage submenu heading
V< ?	OFF, AND, OR	Selection of the first alarm threshold function for phase Under Voltage function
V< VALUE	2 to 260 V, in steps of 0.1 V for Un range 57-130 V or 10 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold
t V<	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
V<< ?	OFF, AND, OR	Selection of the second alarm threshold function for phase Over Voltage function
V<< VALUE	2 to 260 V, in steps of 0.1 V for Un range 57-130 V or10 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold
t V<<	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[59N] RESIDUAL O/V		[59N] Residual Overvoltage submenu heading
Uen> ?	OFF, ON	Selection of the first alarm threshold function for Residual Over Voltage function
Uen> VALUE	1 to 260 V, in steps of 0.1 V for Un range 57-130 V or 5 to 960 V, in steps of 0.1 V for Un range 220-480 V	Setting for the alarm threshold
t Uen>	0 to 600 s, in steps of 10 ms	Setting for the trip threshold
[32N] EARTH WATTMETRIC		[32N] Wattmetric earth fault submenu heading
Pe> ?	OFF, ON	Selection of the first alarm threshold function for Pe>
Pe>	Range 57 to 130 V 0.2 to 20 W 4 to 160 W 10 to 800 W Range 220 to 480 V 1 to 80 W 4 to 640 W 40 to 3200 W	Setting for the alarm threshold Pe>
Pe> Delay type	DMT, STI (CEI), SI (CEI), VI(CEI),EI (CEI),LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t Pe>	0 to 150 s, in steps of 10 ms	Selection of the setting value for the trip threshold.
TMS	0.025 to 1.5, in steps of 0.025	Setting for the TMS value for the IDMT curves

Parameter	Setting range	Description
K	0.1 to 10 steps of 0.005	Selection of the K value for the RI curve
treset	0 to 100 s, in steps of 10 ms	Setting for the setting value for the reset time for IEC curves only
RTMS	0.025 to 1.5, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice for ANSI & COx curves only
Pe>> ?	No, Yes	Selection of the first alarm threshold function for Pe>>
Pe>>	Range 57 to 130 V 0.2 to 20 W 4 to 160 W 10 to 800 W Range 220 to 480 V 1 to 80 W 4 to 640 W 40 to 3200 W	Setting for the values for the alarm threshold Pe>>
t Pe>>	0 to 150 s, in steps of 10 ms	Setting for the trip threshold.
Pe> Pe>>	0° to 359°, in steps of 1°	Setting for the setting angle for Pe. This item is only activated if at least one of the Pe thresholds is enabled.
[46] NEG SEQ O/C		[46] Negative sequence overcurrent submenu heading
I2> ?	OFF, ON	Selection of the first alarm threshold function for Negative Phase Sequence OC (I2>)
I2> VALUE	0.5 to 25 In, in steps of 0.01 In	Setting for the alarm threshold
I2> Delay type	DMT, STI (CEI), SI (CEI), VI(CEI),EI (CEI),LTI (CEI), STI (CO2), MI (ANSI), LTI (CO8),VI (ANSI), EI (ANSI), RECT, RI	Selection of the type of time-delay associated with the threshold
t I2>	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
TMS	0.025 to 1.5, in steps of 0.025	Setting for the TMS value of the IDMT curve
K	0.1 to 10, in steps of 0.005	Setting for the K value of the RI curve
treset	40 to 100 s, in steps of 10 ms	Setting for the reset time
RTMS	0.025 to 1.5, in steps of 0.025	Setting for the RTMS value associated with the IDMT reset time choice
I2>> ?	OFF, ON	Selection of the second alarm threshold function for Negative Phase Sequence OC (I2>>)
I2>> VALUE	0.5 to 40 In, in steps of 0.01 In	Setting for the alarm threshold
t I2>>	0 to 150 s, in steps of 10 ms	Setting for the trip threshold
I2>>> ?	OFF, ON	Selection of the third alarm threshold function for Negative Phase Sequence OC (I2>>>)
I2>>> VALUE	0.5 to 40 In, in steps of 0.01 In.	Setting for the alarm threshold
t I2>>>	0 to 150 s, in steps of 10 ms	Setting for the trip threshold

Parameter	Setting range	Description
[49] THERMAL OL		[49] Thermal overload submenu heading
Ith > VALUE	0.1 to 3.2 In, in steps of 0.01 In	Setting for the alarm threshold
K	1 to 1.50, in steps of 0.01	Setting for the K factor associated with the thermal overload function
Te	1 to 200 min, in steps of 1 min	Setting for the Te thermal constant associated with the thermal formula
Thermal OL	OFF, ON	Selection of the first alarm threshold function for Thermal Overload function
th Trip	50 to 200%, in steps of 0.01	Setting for the percentage applicable to the thermal overload trip threshold
th Alarm	OFF, ON	Selection of the thermal overload alarm function
th Alarm VALUE	50 to 200%, in steps of 0.01	Setting for the percentage applicable to the thermal overload alarm threshold
[37] UNDERCURRENT		[37] Undercurrent submenu heading
I< ?	OFF, ON	Selection of the first alarm threshold function for Undercurrent function
I< VALUE	0.1 to 1 In, in steps of 0.01 In	Setting for the alarm threshold
t I<	0 to 150 s, in steps of 10 ms	Setting for the trip threshold

HUMAN INTERFACE

C26X/EN HI/D40

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1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the three User Interfaces (coded HI for Human Interface) of this device:

- Front Panel Local HMI (or LHMI)
- Computer Maintenance Tool (CMT)
- Printer

2 FRONT PANEL

2.1 OVERVIEW

The DS Agile C26x front panel exists in two versions:

- A simple FP with LEDs, L/R key and the serial link (GHU21x)
- A graphical FP with LEDs, L/R key, the Local Control Display and the serial link (GHU20x)

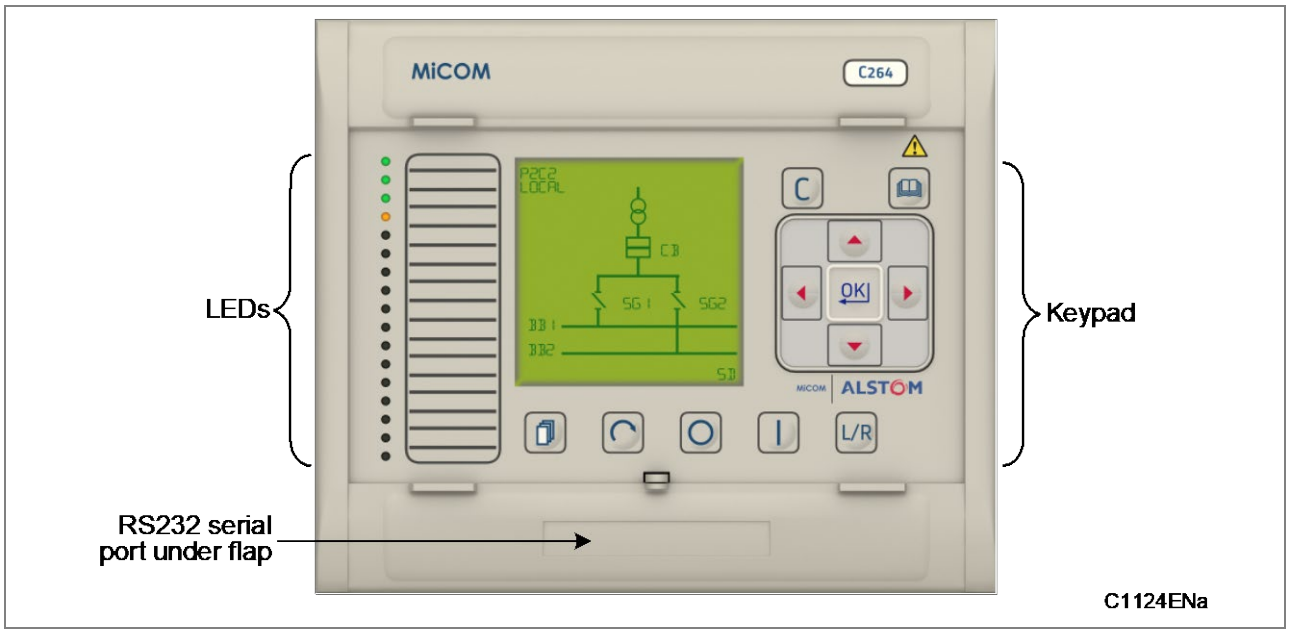


Figure 1: DS Agile C26x 40TE front panel (GHU20x)

The FP is detachable up to 5 meters from the DS Agile C26x base case using a specific front panel (GHU22x)

The graphic panel allows:

- Control of:
  - circuit breakers (open, close)
  - disconnecting switches (open, close)
  - transformers (raise, lower, go to min, go to max)
  - generic commands (start, stop or open/close)
  - setpoints
  - bay mode (local/remote)
  - C26x mode (operational, test/blocked, maintenance)
  - counters value
- Switching databases
- Changing the settings (menu tree)
- Alarm acknowledgement and clearing
- Datapoint suppression

- Display of:
  - Module positions
  - Alarm list
  - Disturbance records
  - Configuration
  - Events list
  - Fault list
  - Measurements, counters and TPI
  - Physical binary input/output states
  - Status information
  - Bay mode (local/remote, SBMC)
  - Bypass indications
  - Setting points
  - Board states
  - IED states
- Activating LEDs according to datapoint status

Note:
The Bay Local/Remote mode settable on the front panel of the C26x is L/R mode at C26x level, NOT the substation L/R mode per bay.

2.2 LED BEHAVIOUR

There are 17 LEDs available:

- 16 LEDs are managed by the firmware
- 1 LED is directly connected to the internal power rail

2.2.1 FIRST LEDS

The first 5 LEDs indicate the DS Agile C26x status information. The LEDs indicate from top to down:

LED id	Colour	LED on	LED slow blinking	LED fast blinking	LED off
1	Red	There is at least one major fault (hardware, database) (1)	There is at least 1 minor fault (I/O board, communication to IEDs, …) (2)	Not used	No fault
2	Amber	All alarms are acknowledged, but one alarm at least is still active (3)	All alarms displayed in the alarm panel are inactive & acknowledged	At least 1 not acknowledged alarm displayed in the alarm panel	No alarm
3	Amber	C26x in operational mode	C26x in maintenance mode	C26x in test/blocked mode	C26x rebooting
4	Green	Power on	Not used	Not used	Power off
5 (4)	Red	All bays managed by the C26x are in LOCAL mode	Bays managed by the C26x are not in the same control mode	Not used	All bays managed by the C26x are in REMOTE mode

(1) Major fault: DS Agile C26x not available due to internal failure (database error, CPU board failure, etc…).

(2) A minor fault is a fault causing only the non-availability of a part of the functionality.

(3) When the alarm disappears, the LED automatically returns to OFF.

(4) Assigned by C26x only for front panel without LCD: GHU2x1 or for an extension C26x.

2.2.2 OTHER LEDS

Other LEDs' default assignment:

- LED 7: DIU board fault
- LED 8: AIU board fault
- LED 9: DOU or HBU board fault
- LED 10: CCU board fault
- LED 11: AOU board fault
- LED 12: At least one IED is disconnected (Single rack / main rack / extension rack)
- LED 13:
  - The extension rack arrangement does not match the arrangement in the active configuration database, for instance there could be a disconnected rack or the C26x could be in maintenance mode (main rack);
  - Connection status with main rack (extension rack)

These default assignments cannot be modified for the extension racks.

LEDS 14 to 17 can be used only on the main rack.

Summary table:

<table>
<tr><th rowspan="3">LED</th><th colspan="3">Single rack architecture</th><th colspan="3">Multi rack architecture</th></tr>
<tr><th colspan="2">C26x</th><th colspan="2">Main Rack</th><th>Ext. Rack</th></tr>
<tr><th>Graphic Panel</th><th>Simple Panel</th><th>Graphic Panel</th><th>Simple Panel</th><th>Simple Panel</th></tr>
<tr><td>1</td><td rowspan="3">Assigned by C26x</td><td rowspan="3">Assigned by C26x</td><td rowspan="3">Assigned by C26x</td><td rowspan="3">Assigned by C26x</td><td rowspan="3">Assigned by C26x</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td colspan="5">Linked to power supply</td></tr>
<tr><td>5</td><td rowspan="13">Freely assignable</td><td>Not used</td><td>Local/Remote</td><td rowspan="13">Freely assignable</td><td>Not used</td><td>Local/Remote</td><td>L/R</td></tr>
<tr><td>6</td><td rowspan="12">Freely assignable</td><td>Not used</td><td rowspan="12">Freely assignable</td><td rowspan="12">Freely assignable</td><td>Not used</td><td>Not used</td></tr>
<tr><td>7</td><td rowspan="6">Pre-defined</td><td rowspan="6">Pre-defined</td><td rowspan="6">Pre-defined</td><td rowspan="6">Pre-defined</td><td rowspan="6">Pre-defined</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td><td rowspan="5">Not used</td><td rowspan="5">Not used</td><td rowspan="5">Not used</td><td rowspan="5">Not used</td><td rowspan="5">Not used</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td></tr>
<tr><td>16</td></tr>
<tr><td>17</td></tr>
</table>

2.3 CONFIGURATION DATA

The behaviour of the user-configurable LEDs is defined in the C26x DataBase.

When using a simple LHMI, the 11 user-configurable LEDs give the status of the associated BI. Each BI state is displayed using the ON / OFF / BLINKING led state.

When using a graphical LHMI (with LCD), the 13 user-configurable LEDs can be configured to have 2 different behaviours:

1 give the status of the associated BI. Each BI state is displayed using the ON / OFF / BLINKING led state (same way as with a Simple LHMI),

2 provide a way to manage BIs as alarms.

Behaviour #2 is detailed below:

- if the BI is “transient”:
  - if the BI is SET, the associated LED is ON or Blinking Slow (depends of the DB),
  - after pressing the key C, the LED’s state goes OFF.
- if the BI is “permanent”:
  - if the BI is SET, the associated LED is Blinking Slow,
  - after pressing the key C, the LED goes ON,

- if the BI is RESET, the associated LED remains Blinking if the key C has not been pressed or is OFF if it has.

Notes:
- The key C is used for the navigation in the menu tree. Therefore alarm acknowledgement is not allowed from the menu tree.
- The alarm acknowledgement function is not available with the simple panel (no C key available).

The 11 other LED's are freely configurable: they can be attached to a datapoint. Furthermore, the datapoint state is displayed through a led state: on, off, slow blinking, fast blinking.

For a Single Point, the Set / Reset / Invalid (i.e. all other states) can be attached to a LED. For a Double Point, the Open / Close / Invalid (i.e. all other states) can be attached to a LED.

2.3.1 GENERAL DISPLAY MANAGEMENT

The local HMI is composed of several "panels" and one "menu tree". The panels allow displaying information and issuing control commands whilst the menu tree is used to display and modify the DS Agile C26x unit's settings.

Note:
If a TMU210 acquisition board is present, the protection settings and associated automation settings can be viewed and modified from a dedicated panel "Settings" rather than in the menu tree.

During the menu navigation, the key C is used to return to the previous panel and has no effect on LED management.

The key is used to display the next panel.

From each panel, the key OK allows access to the menu tree, except from the **Settings** panel.

The keys and allow access to the various panels in a group.

List of panels

- **Service** panel, **Board** panel and **IED** panel: General device information (serial number, software version, version and state of both databases in memory, operating hours, operating mode and redundancy mode), list and states of the boards present in the device, and states of external IEDs connected to the device.
- Binary **Inputs** panel and Binary **Outputs** panel (information on the digital input and output states): available in active and in maintenance mode, except if there is no database present.
- **Bay** panels: One or two panels for each bay with sub-panels for:
  - measurement, counter and TPI
  - single, double and multiple datapoints status
  - controls

- **Settings** panel (optional): This panel is only available if it has been selected during the configuration process. It is only relevant when the C26x is fitted with a TMU210 acquisition board as it is used to display and modify protection settings and is empty if none are available.
- **Alarm** panel: Displays the alarm list and allow acknowledgement and clearing of alarms.
- **Event** panel: Displays the event list.
- **Fault** panel: Displays the fault list.
- **Disturbance** panel: Displays the header of the disturbance file.
- **Login** panel: Allows the user to log in and out of the DS Agile C26x front panel interface. It is displayed upon the first key stroke when no session is active.

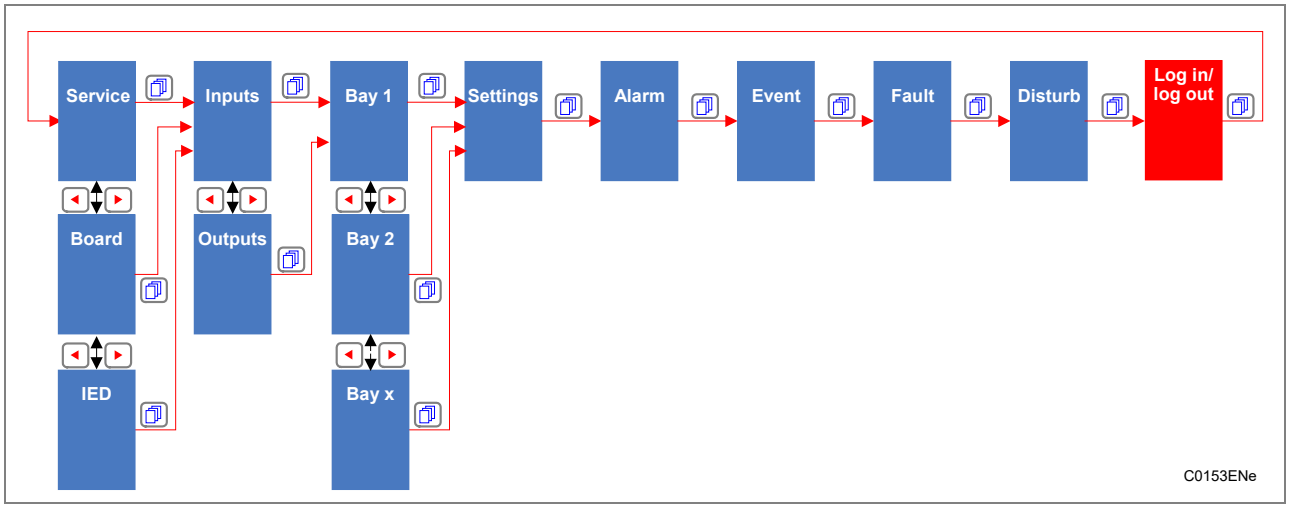


Figure 2: Panel browsing

Notes:
The default panels (after start-up and after an inactivity time-out) are defined during the configuration process: ***Service*** *Panel,* ***Fault*** *Panel or one of the* ***Bay*** *Panels*
Pressing the key  *from any panel will return the display to the* ***Service*** *Panel.*

2.3.2 LANGUAGE SUPPORT

The display on the LCD supports 2 language versions, selected during the configuration process.
A parameter in the menu tree allows switching between both language versions.

2.3.3 TIME AND DATE DISPLAY

The front panel HMI displays the time, date and time synchronisation state of the unit.

Time: time of day is displayed in all the panels of the LCD. For each panel, time of day is displayed in the first line of the panel.

The display format of the time is **THH:MM:SS** where T is the time synchronisation state (* or nothing), HH the hour (0 to 23), MM the minutes (00 to 59) and SS the seconds (0 to 59).

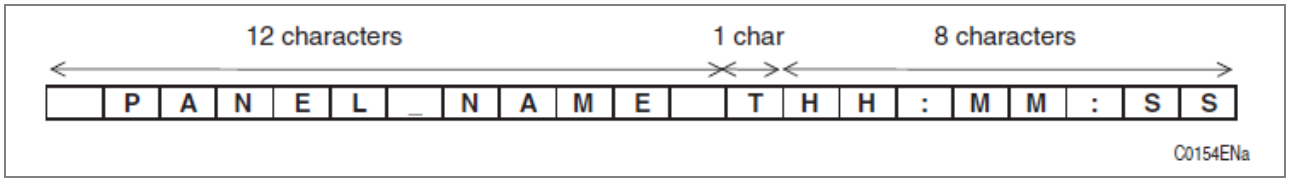


Figure 3: Time display

In the Event panel, in the Alarm panel and in the Disturbance panel, the time-stamp must be given in milliseconds. Therefore, the format for the time is **THH:MM:SS.MMM**

Date: the date is displayed only in the Event panel and in the Alarm panel. Each event and each alarm are displayed with their date and time of occurrence (time-stamp).

There are 3 configurable date formats, where DD is the day of the month (01 to 31), MM the month (01 to 12) and YY the year (00 to 99):

- DD/MM/YY
- MM/DD/YY
- YY/MM/DD

Time synchronisation state: the C26x's firmware manages the following time synchronisation states:

- not synchronised (“*”): the date/time has never been synchronised
- synchronised (“ “): date/time is synchronised

The date and time are settable in the menu tree, see chapter C26x/EN ST for setting instructions.

2.3.4 SERVICE INFORMATION PANEL

The local HMI displays information relevant to the C26x on one panel:

- C26x serial number
- software version
- version number and revision number of the first database
- version number and revision number of the second database
- state of both databases
- operating hours of the unit
- operating mode
- redundancy mode

S	E	R	V	I	C	E						*	1	2	:	3	4	:	5	6
S	E	R	I	A	L		N	B												
	0	0	0	0	3	9	6	2												
S	O	F	T	W	A	R	E		V	E	R	S	I	O	N					
					A	4	.	3	1	A										
D	B	1		V	E	R	S	I	O	N		S	T	A	T	E				
00	.	3											A	C	T	I	V	E		
D	B	2		V	E	R	S	I	O	N		S	T	A	T	E				
													N	O		B	D			
O	P	E	R	A	T	I	N	G		H	O	U	R	S						
													6	0	1					
O	P	E	R	A	T	I	N	G		M	O	D	E							
										O	P	E	R	A	T	I	O	N	A	L
R	E	D	U	N	D	A	N	C	Y		M	O	D	E						
										N	O	T		R	E	D	U	N	D	E

Figure 4: Example of Service information panel

2.3.5 LOGIN PANEL

The C264 local HMI may be configured in 2 modes:

- **Secure mode**: any action on the front panel requires authentication (Login panel is displayed).
- **Free mode**: display and controls are authorized without authentication (no Login panel is displayed).

Note: The Login panel is available when no local or remote user is logged in. It is not possible to log in locally while a remote user is already connected via the DS Agile CMT.

By default, the C264 is configured in **Secure** mode with the optional disclaimer banner set to TRUE in the SCE database properties.

2.3.6 DISCLAIMER BANNER

Banner not configured

When no disclaimer banner is set in the SCE, the C264 local HMI is in **Free** mode.

In that case, no Login panel is displayed. In the CMT, the secure mode management button is unavailable. When the **Free** mode is enabled, any action done on the local HMI is managed without verifying user permissions.

Banner configured

When the disclaimer banner is configured in the SCE, the **Secure** mode is enabled by default.

Any key that is pressed on the C264 local HMI checks if the user is logged in.

If no user is logged in, the login panel displays and prompts the user to enter his/her credentials

If the CMT is connected to the C264, then a button in the CMT allows SECADM users to disable or enable the secure mode.

When the mode is changed through the CMT button, the parameter value is stored in the C264, whatever action is done on the database (download, switch ...), and even after a reboot of the C264.

Refer to the CMT chapter for further information about the LHMI authentication management.

2.3.6.1 LOGIN STATUS

The Login panel has two states: logged in to the C264 or logged out of the C264.

L	O	G	I	N							<time sync. state> <time>									
	L	O	G	I	N	:														
	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
	P	A	S	S	W	O	R	D												
	*	*	*	*	*	*	*	*	*	*	*	*								
	1	2	3	4	5	6	7	8	9	0	-	=			E	N	T	E	R	
	Q	W	E	R	T	Y	U	I	O	P	[	]			R	E	S	E	T	
	A	S	D	F	G	H	J	K	L	;	'	`			B	A	C	K		
	>	Z	X	C	V	B	N	M	,	.	/									

Figure 5: Example of Login panel (the user was logged out)

Logging in

When the Login panel appears, the user must fill in his/her LOGIN (log in account name) and PASSWORD.

- Press the L/R key to switch between the fields.
- To fill in the LOGIN and PASSWORD fields, use the virtual QWERTY keyboard under them.
- Select a character using the arrow keys (inverted text cursor), then press OK.
- To switch between the upper- and lower-case keyboards, press .
- Repeat the process until the field is filled in, then select ENTER and press OK.

If a wrong login/password combination is entered, the message "WRONG LOGIN PASSWORD" blinks at the bottom of the screen. The login and password sections are cleared.

The number of incorrect password entries (failed log in attempts) is defined by a security administrator using DS Agile CMT and can be limited. These failed attempts are cumulative with any failed attempts to log in to the C26x from DS Agile CMT. If the sum of the failed attempts exceeds the set permitted number, the user account is locked for a duration that is also defined by a security administrator using DS Agile CMT. This is indicated by the message "Your account is locked". The account can be unlocked early from the DS Agile CMT by a security administrator.

After logging in, if the user tries to perform an action that is not permitted by his/her account's roles, the message "INSUFFICIENT RIGHTS" is displayed at the bottom of the page and the action is denied.

After a user has logged in, the unit displays a message, usually a security warning (banner), which has been configured using DS Agile SCE:

L	O	G	I	N							<time sync. state> <time>										
	T	H	I	S		I	S		T	H	E		B	A	N	N	E	R			
	T	E	X	T																	
			O	K					C	A	N	C	E	L							

Figure 6: Example of banner

Using the  and  keys, select *OK* or *Cancel*, then press  .

- Selecting *OK* unlocks the LHMI.
- Selecting *Cancel* aborts log in and returns to the **Login** panel.

At any time during the login process, you can abort by pressing  :

- If the **Secure mode** is enabled, the default LHMI page is displayed.
- If the **Free mode** is enabled, the display reverts to the previous page (the page from which the login was called).

Inactivity Timeout

A keypad inactivity timer can be configured in the CMT to ensure that a session will not remain open after the user has left: When the timer elapses, the user is disconnected, and the default start panel is displayed.

Remote Disconnection

A security administrator may connect remotely to the unit using the DS Agile CMT even if a session is already open locally. In this case he/she will “steal” the session: The local user is disconnected, and the default start panel is displayed.

Logging out

The **Login** panel is also used to log out of the LHMI.

To reach it, repeatedly press the key  until the **Login** panel is displayed.

It shows the name of the user currently logged in:

LOGIN											<time sync. state> <time>									
	L	**O**	**G**	**I**	**N**	**:**														
	G	**E**	**R**	**R**	**Y**	**.**	**S**	**M**	**I**	**T**	**H**									
					L	**O**	**G**		**O**	**U**	**T**									

Figure 7: Example of Logout panel (the user is logged in)

Press  to log out.

The display will lock up and return to the log in screen for the duration of the configured timeout period.

2.3.7 BOARD PANEL

The Board panel is a text list indicating the states of I/O boards. For each board, the following information is displayed:

- its configured name,
- its state, among the following ones: *OK* (board connected and operational), *Failure* (self-check fault), *Missing* (board configured but not present).

Note: These state labels are manually set in configuration and that the exact text could slightly vary due to customer preference, but not their actual meaning (as indicated in brackets).

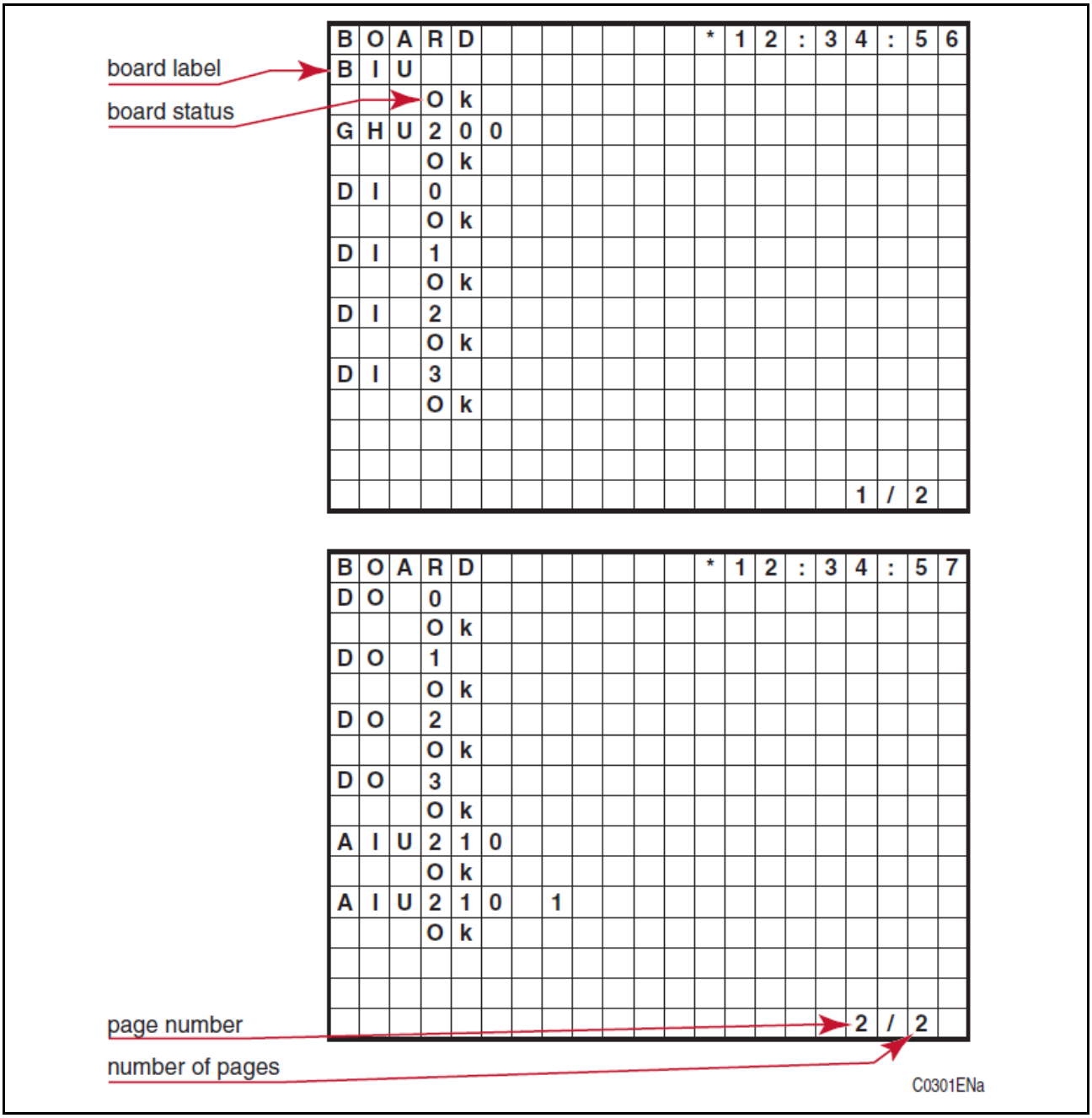


Figure 8: Example of Board panel

2.3.8 EXTERNAL DEVICE PANEL

This panel display all external devices connected to the unit by a legacy protocol and by the IP protocols (as IEC61850). This panel contains 3 sub-sets:

- IP client connection number: it defines the number of client currently connected to the unit.
- IP server connection state: it defines the list of the server connected to the unit. Each server is displayed with its name, its IP address, and the state of its connection.

| | | |

```
IED      *12:34:56
IP CLIENT NB  :  000
SCADA IED
 T101        DISCONN
                001/002
```

```
IED      *12:34:57
IED s    :  T1 03
P442_33
   003       DISCONN
P632_44
   004       DISCONN
P139_2
   002       DISCONN
P127_1
   001       DISCONN
                002/002
```

Figure 9: Example of External device panel

2.3.9 DISPLAY OF BINARY INPUT INFORMATION

For each input board defined in the configuration, the state of all the "physical" binary inputs is displayed in the **Inputs** panel.

Each panel contains:

- The board number and its type (DIU, CCU)
- A list of all the binary inputs present on the board, defined by:
  - The input number: DI xxx
  - The physical state of the input with 3 possible values (On, off , faulty)

I	N	P	U	T	S						<time sync. state> <time>									
			B	O	A	R	D		X	X				Board type						
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		
D	I		X	X	X		value				D	I		X	X	X		value		

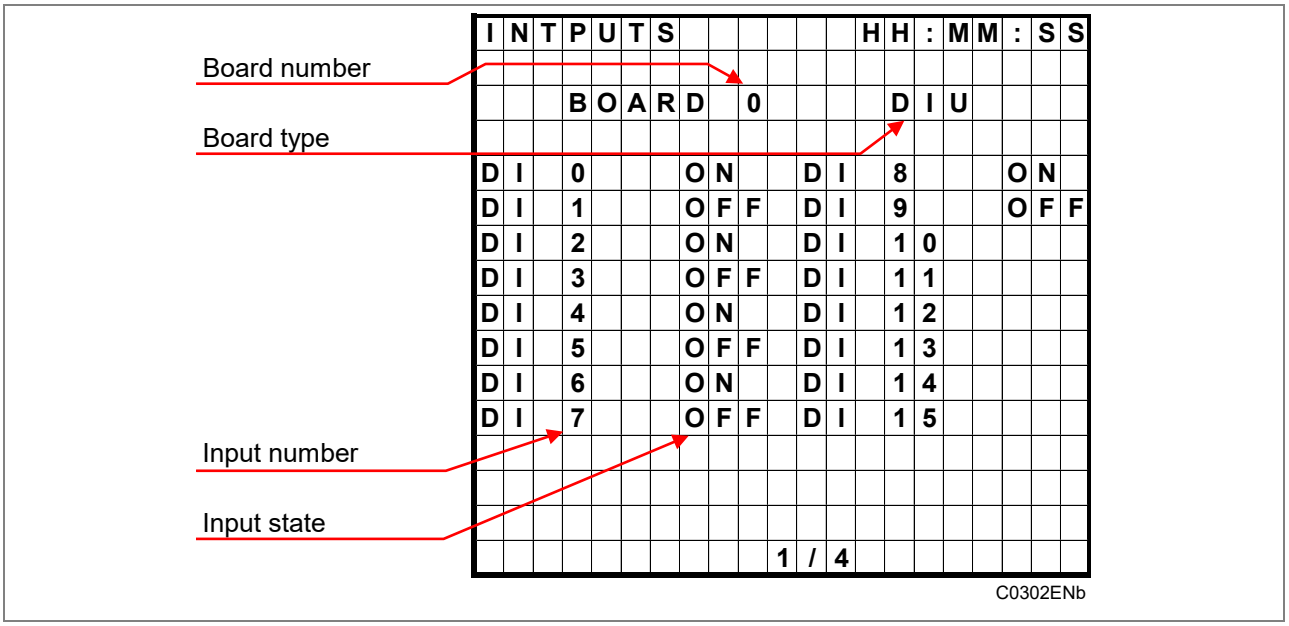


Figure 10: Example of binary input sub-panel

2.3.10 DISPLAY OF BINARY OUTPUT INFORMATION

For each output board defined in the configuration, the state of all the "physical" binary outputs is displayed in the **Outputs** panel.

Each panel contains:

- The board number and its type (DOU, HBU, CCU)
- A list of all the binary outputs present on the board, defined by:
  - The output identifier: DO xxx
  - The physical state of the output with 3 possible values (on, off, faulty)

O	**U**	**T**	**P**	**U**	**T**	**S**					<time sync. state> <time>										
			B	**O**	**A**	**R**	**D**		**X**	**X**											
D	**O**		**X**	**X**	**X**		**value**				**D**	**O**		**X**	**X**	**X**		**value**			
D	**O**		**X**	**X**	**X**		**value**				**D**	**O**		**X**	**X**	**X**		**value**			
D	**O**		**X**	**X**	**X**		**value**				**D**	**O**		**X**	**X**	**X**		**value**			
D	**O**		**X**	**X**	**X**		**value**				**D**	**O**		**X**	**X**	**X**		**value**			
D	**O**		**X**	**X**	**X**		**value**				**D**	**O**		**X**	**X**	**X**		**value**			
D	**O**		**X**	**X**	**X**		**value**				**D**	**O**		**X**	**X**	**X**		**value**			
D	**O**		**X**	**X**	**X**		**value**				**D**	**O**		**X**	**X**	**X**		**value**			
D	**O**		**X**	**X**	**X**		**value**				**D**	**O**		**X**	**X**	**X**		**value**			
D	**O**		**X**	**X**	**X**		**value**				**D**	**O**		**X**	**X**	**X**		**value**			

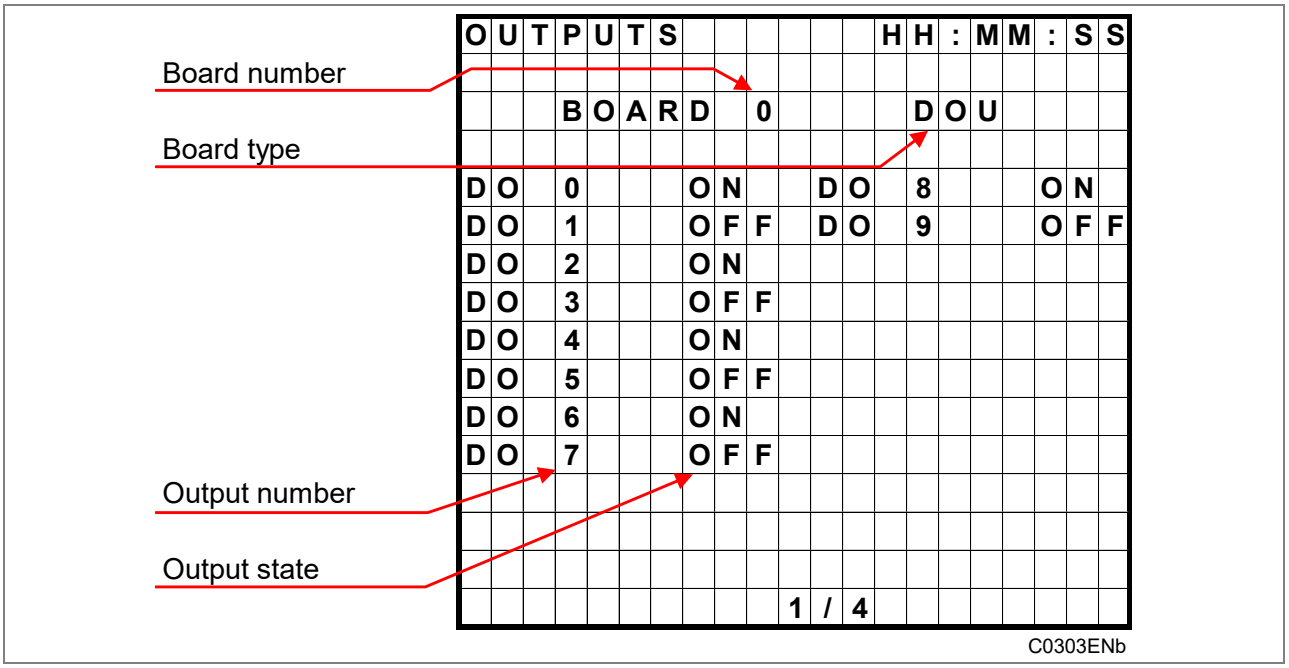


Figure 11: Example of binary output sub-panel

2.3.11 BAY PANELS

Graphical representations of bays are visible in panels. Each bay has its own panels (up to 2). Up to 12 bays can be displayed via the Front Panel of the C26x. A maximum of 9 devices can be displayed on each panel.

All the information in these panels is configurable, except for time indication.

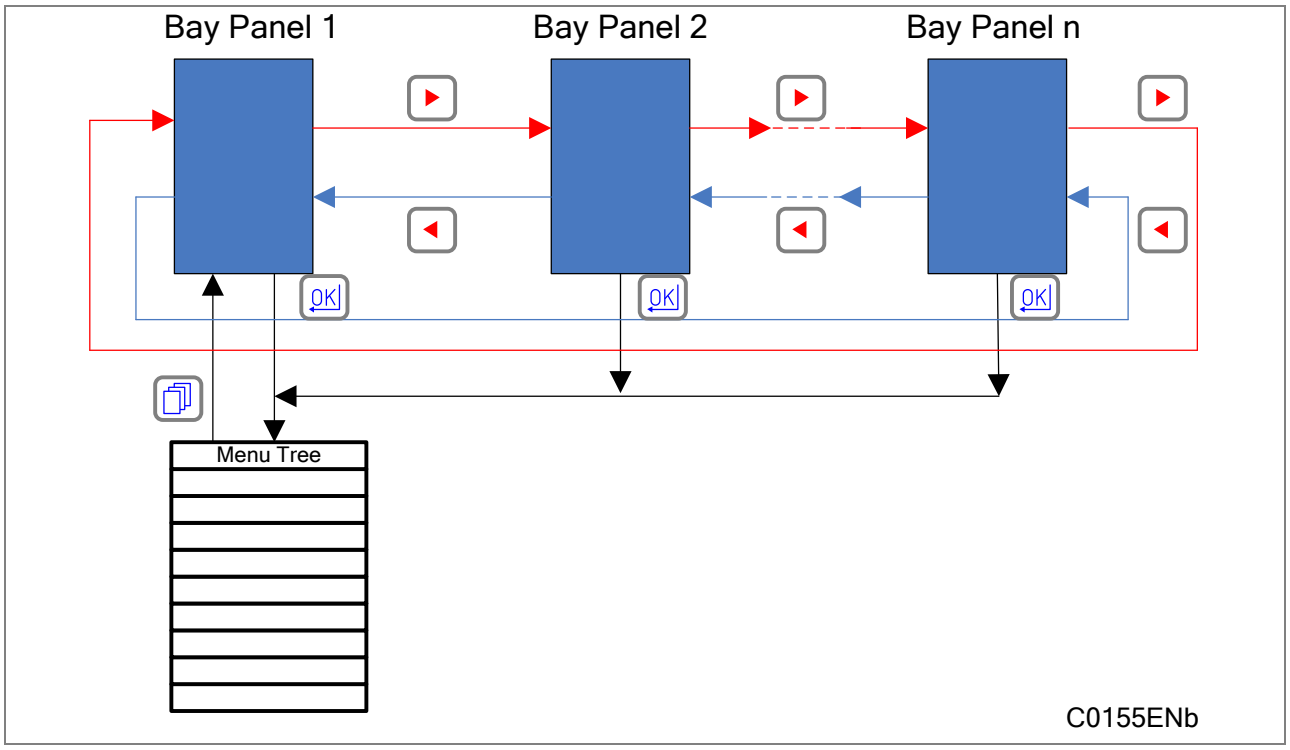


Figure 12: Bay management

When a bay is displayed over two pages, and are used to move from one page to the other.

For one bay:

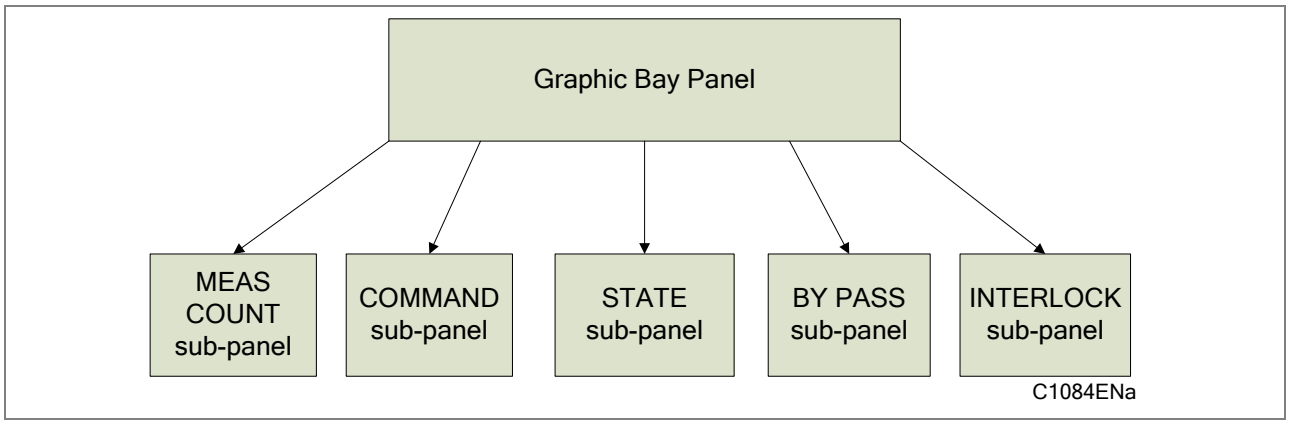


Figure 13: Bay management (cont'd)

The information displayed in the bay panel is:

- the bay's name (fixed position), 16 characters maximum
- the time (hh:mm:ss), preceded by its state (* means not synchronised)
- the bay graphical representation: the bay is displayed as a single-line diagram. Graphical pictures are made of bitmaps for modules representation, vertical and horizontal lines and labels
- the SBMC mode
- the Local / Remote bay mode
- the synchrocheck bypass activation, if it is applicable and if it exists
- the interlock bypass activation, if it exists
- a CT/VT measurement, displayed on a vertical graphical bargraph (Vertical Measurement Graphical Area) or on a horizontal graphical bargraph (Horizontal Measurement Graphical Area). VMGA and HMGA are exclusive. Only CT/VT measurements can be displayed on a bargraph. Up to four CT/VT measurements can be associated with a bargraph. The keys  and  are used to select the measurement to display on the bargraph. The totality of the bargraph represents either 120% or 200% of the nominal value
- the name of the measurement (fixed position)
- the value of the measurement (fixed position)
- the command report (fixed position)
- the access to datapoints panels

Example:

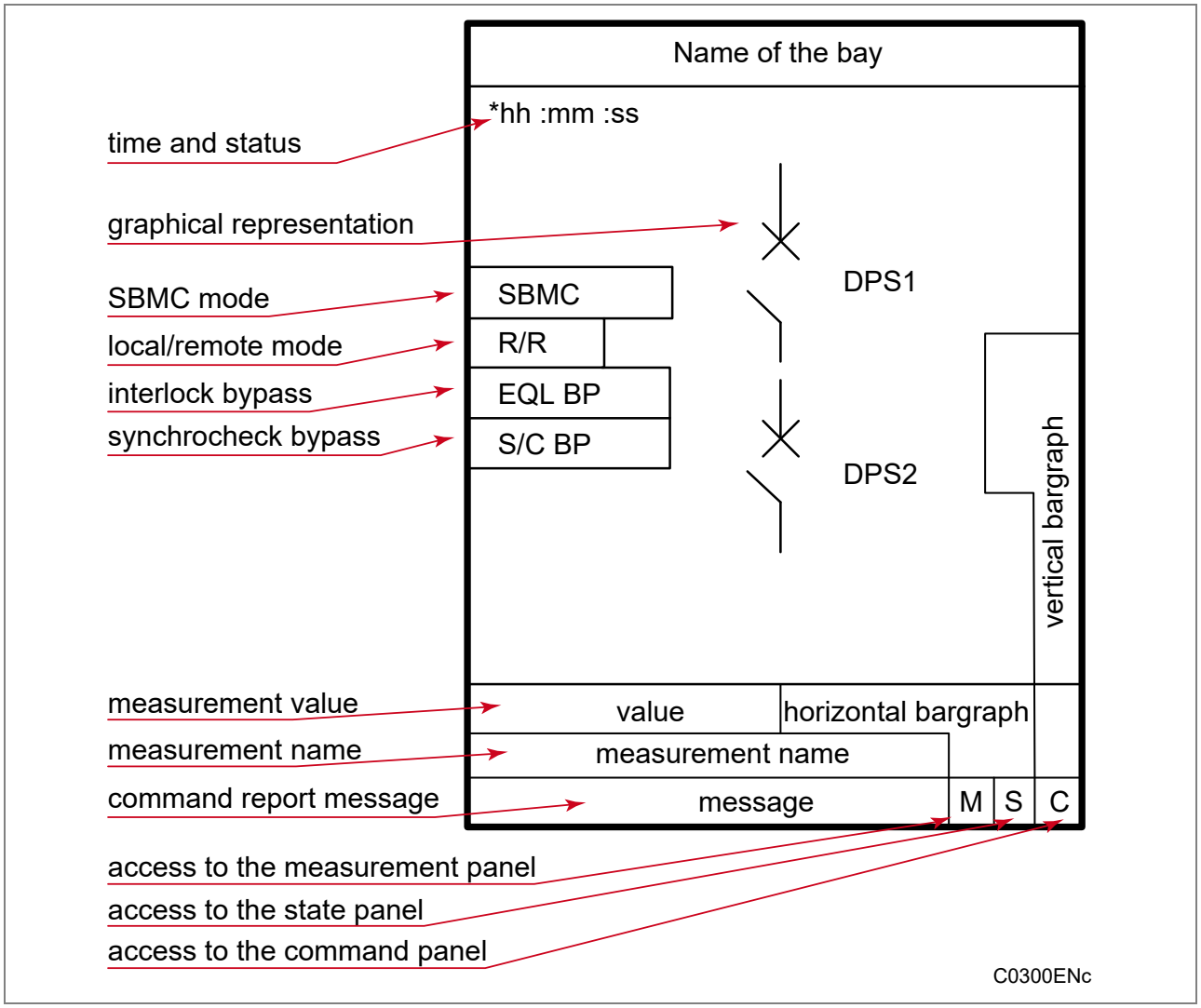


Figure 14: Example of a bay panel

2.3.11.1 STATE SUB-PANEL

This panel is used to display the state of the digital datapoints (single points, double points and multiple points).

3 lines are necessary to display any information.

S	**T**	**A**	**T**	**E**							<time sync. state> <time>									
						B	**A**	**Y**		**i**										
SPS, DPS or MPS 1 (3 lines)																				
SPS, DPS or MPS 2 (3 lines)																				
SPS, DPS or MPS 3 (3 lines)																				
SPS, DPS or MPS 4 (3 lines)																				

An SPS / DPS / MPS is defined by:

<Label of the datapoint > = 16 characters maximum																				
					Module of the BI = 16 characters maximum																
State of the BI = 21 characters maximum																				

From this panel, the operator can suppress a datapoint.

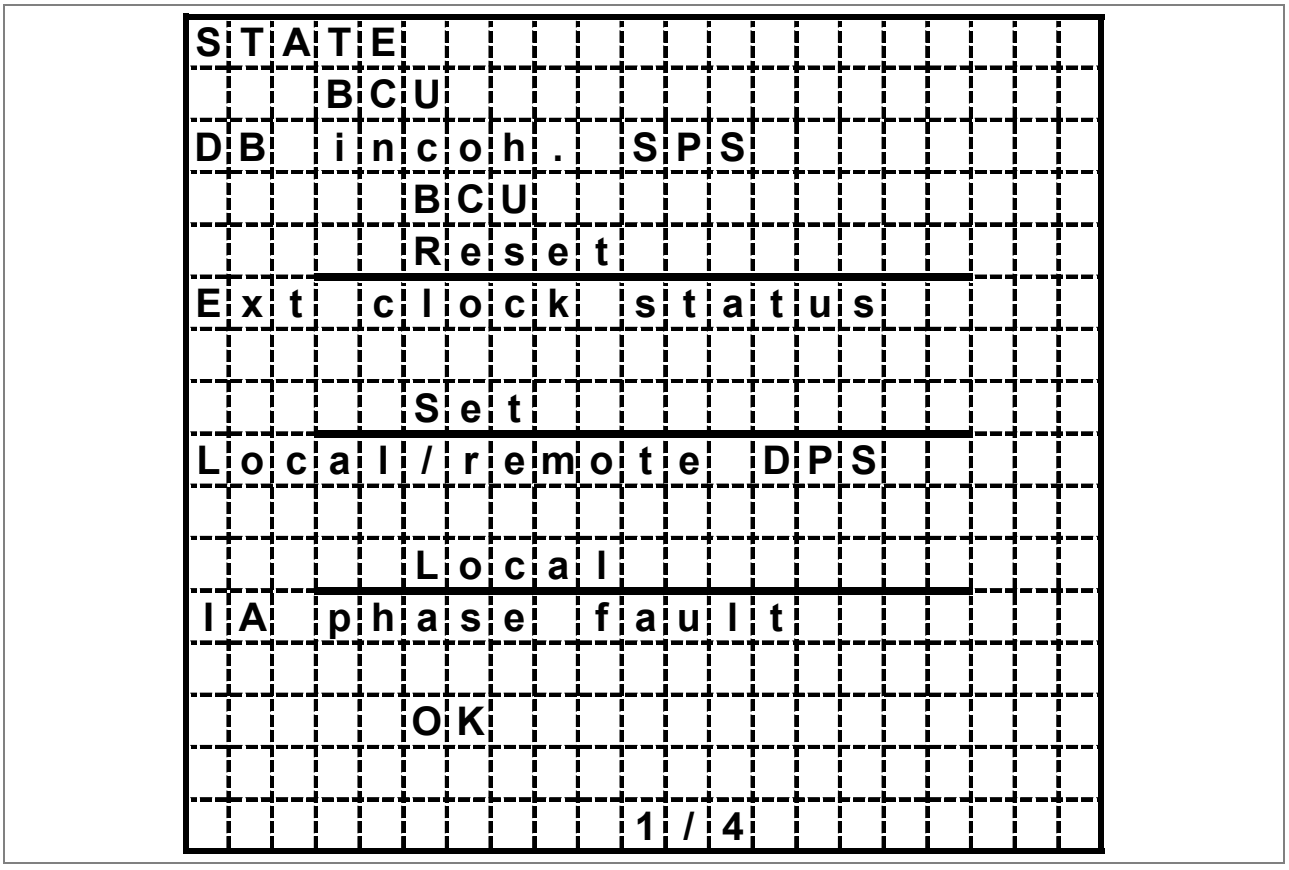


Figure 15: Example of state sub-panel

2.3.11.2 MEASUREMENT, COUNTING AND TPI SUB-PANEL

This panel allows displaying the state of the measurement, the counter and the TPI. It is defined by 3 lists of elements (Measurement, Counter and TPI), each list is distributed over several pages (3 pieces of information per page).

M	**E**	**A**	**S**		**C**	**O**	**U**	**N**	**T**		<time sync. state> <time>									
B	A	Y		i																
Measurement 1																				
Measurement 2																				
Measurement 3																				
																			...	

Display of measurements

Analogue values or digital measurements can be displayed in this panel if defined in the database. The value is displayed with 2 digits after the dot and 5 before.

<Label of the measurement > = 16 characters maximum												
					Module of the measurement = 16 characters maximum							
				Value: 7 char						Unit (5 characters)		
State of the measurement = 21 characters maximum												

Note:
If, in the database, the attribute ***value after tracking lost*** *is set to* value=0*, an invalid value, "SELF-CHECK", may be displayed for a few seconds while frequency tracking is restarting.*

Display of counters

A counter value can be displayed in this panel if defined in the database. The value is displayed with 2 digits after the dot and 5 before.

<Label of the counter > = 16 characters maximum												
					Module of the counter = 16 characters maximum							
				Value: 7 char						Unit (5 characters)		
State of the counter = 21 characters maximum												

Display of TPI

TPI can be displayed in this panel if defined in the database.

<Label of the TPI > = 16 characters maximum												
					Module of the counter = 16 characters maximum							
				Value: 3 characters								
State of the TPI = 21 characters maximum												

From this panel, you can suppress a measurement or a TPI (this option is not available for counters).

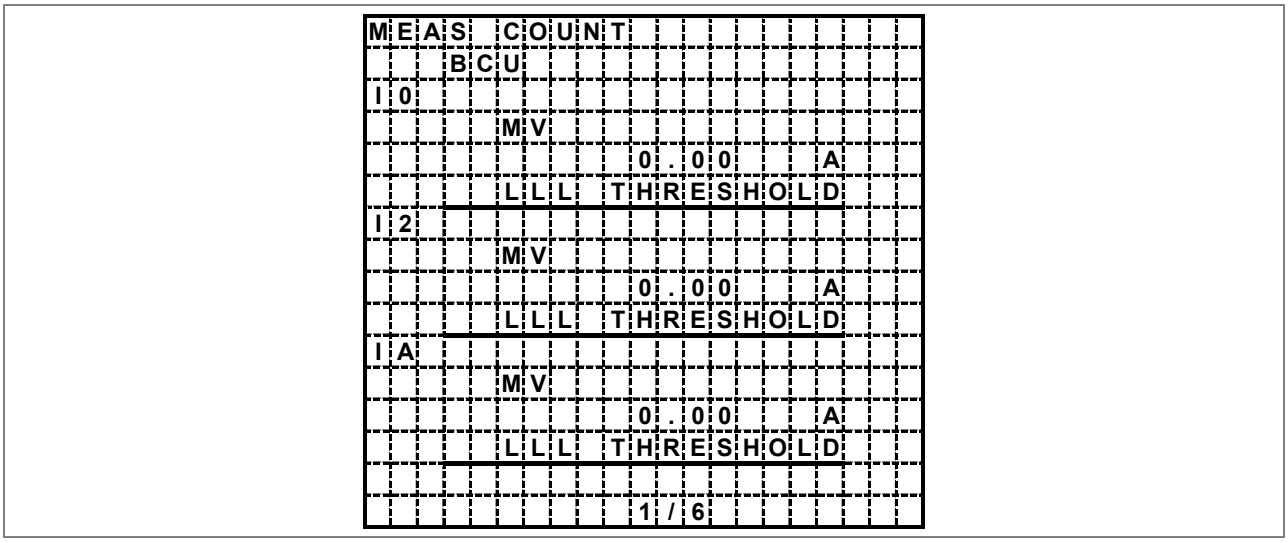


Figure 16: Example of measurement sub-panel

2.3.11.3 CONTROLS SUB-PANEL

The operator is allowed to control modules from the controls sub-panel.

The commands are displayed as following:

Name of the control			
			Name of the module
state			Label order

On this panel, the operator selects the chosen command using the key .

SBO and DE controls are possible according to the configuration

To send a DE control, operator uses the keys and for OFF and ON

To send a SBO control, operator uses the keys and to select OFF or ON. Then the execution is sent using the key .

The current state is displayed on the third line (only ON or OFF).

The key allows aborting the control.

C	**O**	**M**	**M**	**A**	**N**	**D**					<time sync. state> <time>									
			N	**A**	**M**	**E**		**O**	**F**		**T**	**H**	**E**		**B**	**A**	**Y**			
Command 1																				
Command 2																				
Command 3																				
Command 4																				
									Page											

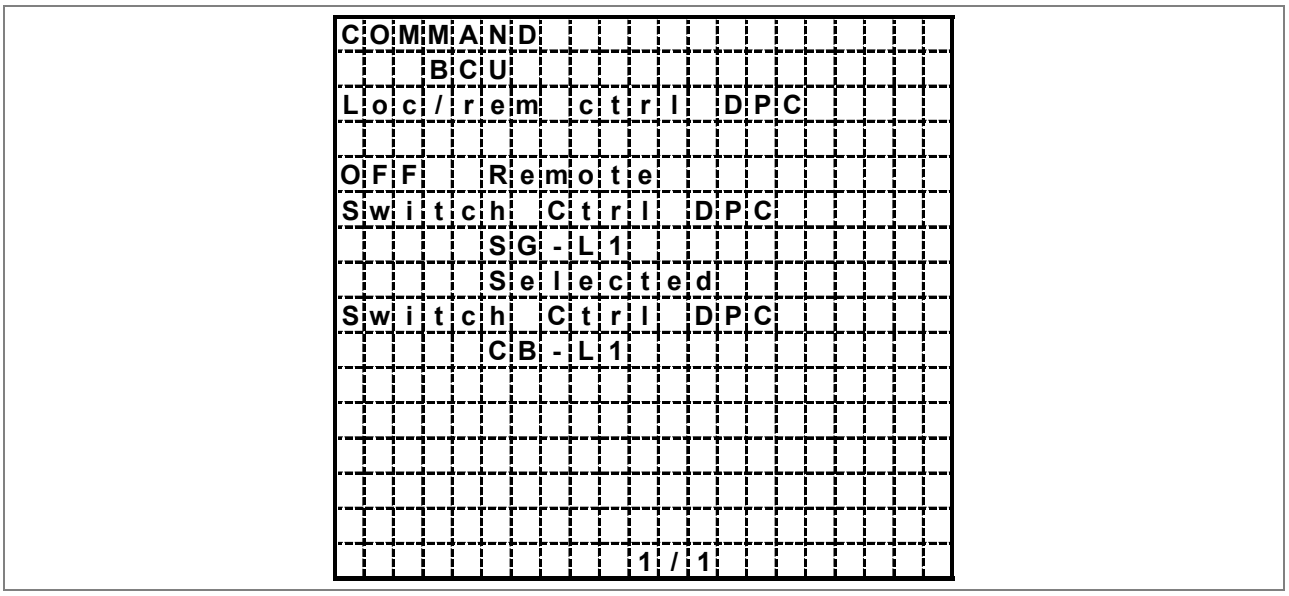


Figure 17: Example of control sub-panels

2.3.11.4 INTERLOCKING SUB-PANEL

When a module is selected in the graphic bay panel, the key allows access to the interlocking panel. Press any key to leave this panel and return to the graphic bay panel.

This panel displays the interlocking equation result (TRUE / FALSE) associated with a module control.

I	**N**	**T**	**E**	**R**	**L**	**O**	**C**	**K**			<time sync. state> <time>										
		< Label of the module > = 16 characters																			
E	**Q**	**L**		**O**	**P**	**E**	**N**		**:**				state								
E	**Q**	**L**		**C**	**L**	**O**	**S**	**E**		**:**			state								
																E	**X**	**I**	**T**		

2.3.12 SETTINGS PANEL (OPTIONAL)

This panel is only available if it has been selected during the configuration process.

It is only relevant when the C26x is fitted with a TMU210 acquisition board as it is used to display and modify protection settings and would basically be empty if none were available.

For the protection settings to be correctly displayed here they must have been downloaded using MiCOM S1 AFTER the configuration databases (see *Settings* Chapter).

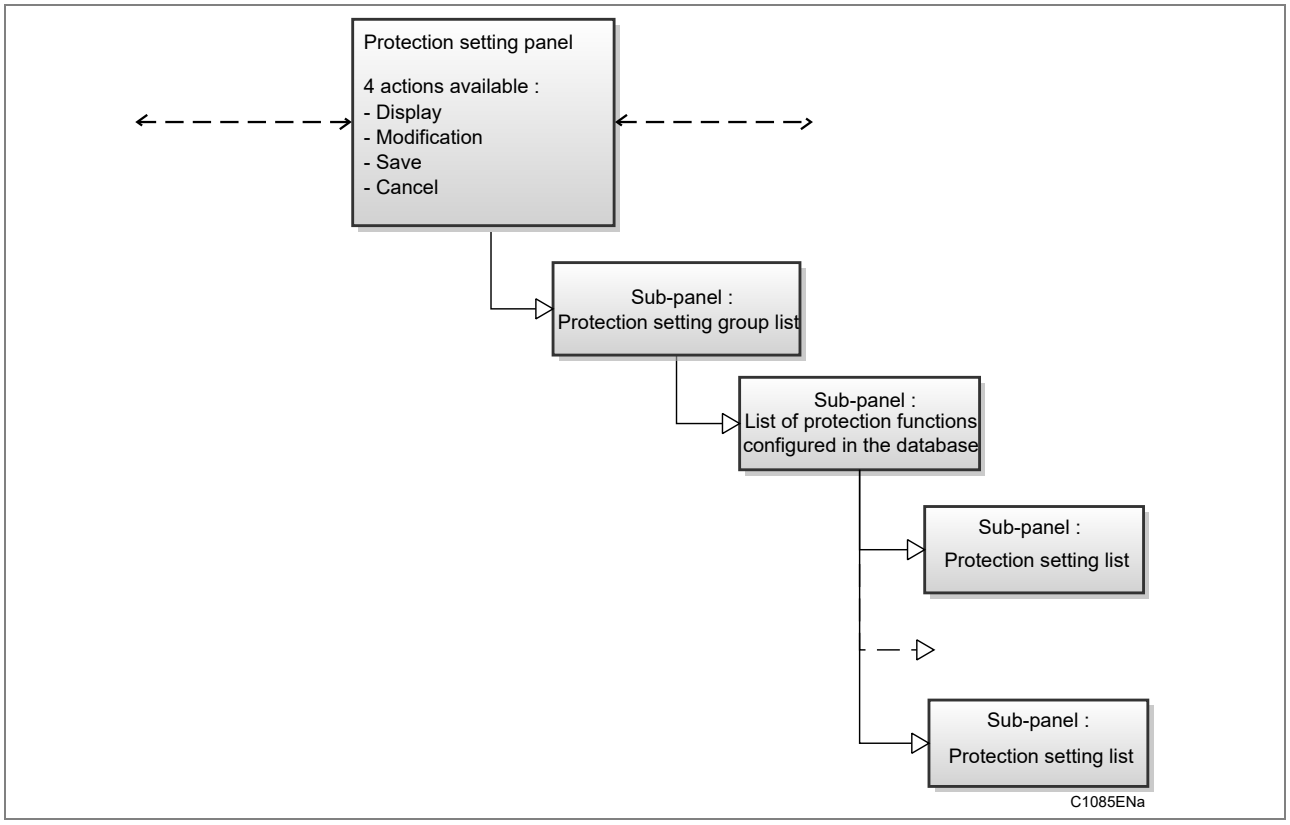


Figure 18: Setting selection menu tree

To navigate the Settings panel and its sub-panels:

- Use the keys and to switch between the Settings menu and sub-menus,
- Use the keys and to reach the setting fields.

The first page is used to choose whether to simply read the settings or modify them, in which case a password must be entered before any setting change is allowed. If some settings are changed, 2 more choices will be displayed to either cancel the changes or save them. There can be 4 operating modes:

- Read only: No password has been entered. In this mode, it is not possible to change any settings.
- Writable: A correct password has been entered and settings may be changed
- Modified: A correct password has been entered and at least one setting has been changed.
- Saving: The setting changes are being saved.

The second page displays a choice of 3 setting groups: Group 1, Group 2 and Group Auto.

These groups contain the same basic settings as if the setting file was opened in MiCOM Alstom S1.

GROUP 1 and GROUP 2 contain the protection settings: One is the active group and the other is inactive. GROUP AUTO contains the various trip and control automations and is equivalent to the AUTOMAT. CTRL menu in MiCOM Alstom S1.

The settings for the three groups are displayed over several pages. The labels are generally identical to the first 18 characters of those used in MiCOM Alstom S1.

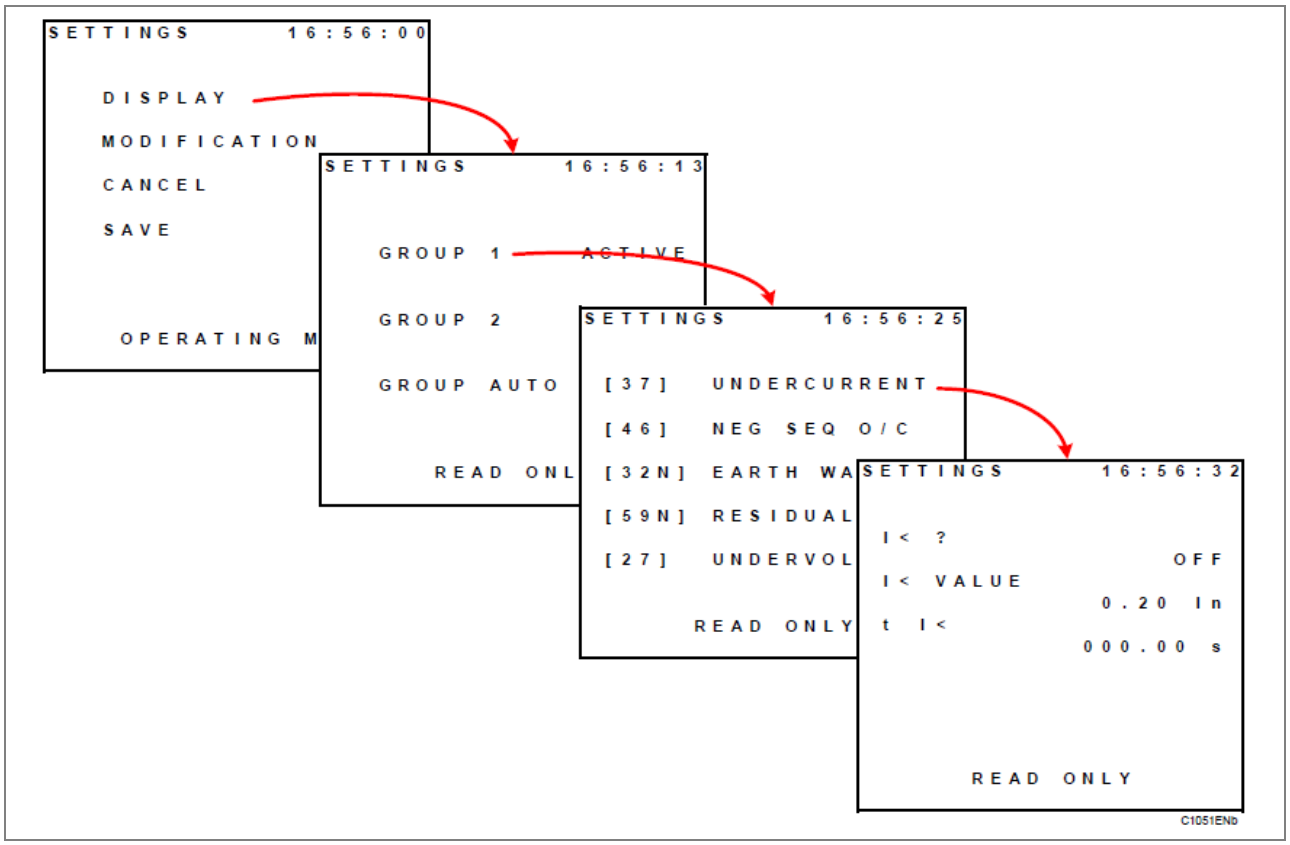


Figure 19: Typical setting selection

Note:
Unlike the display in the PC-based setting software, the C26x's front panel HMI does not hide the settings for unselected protection functions, i.e., for instance, even if I> ? is set to ON (without direction), the polarising parameters (I> TORQUE and I> TRIP ZONE) will still be displayed and appear settable.

2.3.13 ALARM PANEL (OPTIONAL)

This panel is only available if it has been selected during the configuration process.

Alarms are displayed in the form of one list in the panel. This list is a circular buffer and is displayed in a scrollable view in the same way as for the events panel.

One screen of the LCD can contain a maximum of 2 alarms:

A	**L**	**A**	**R**	**M**							<time sync. state> <time>									
<Date, time and state of time of the last alarm state change > =21 char.																				
<State of the alarm>=19 char. Max.																				Gr
<Information about the event that caused the occurrence or the state change of the alarm> 5 lines * 21 char./line maximum.																				
<Date, time and state of time of the last alarm state change > =21 char.																				
<State of the alarm>=19 char. Max.																				Gr
<Information about the event that caused the occurrence or the state change of the alarm> 5 lines * 21 char./line maximum																				

An alarm is composed of 7 lines:

- Line 1: alarm apparition time-stamp
- Line 2: alarm state and gravity
- Line 3: label of the bay
- Line 4: label of the module
- Line 5: label of the datapoint
- Line 6: state of the datapoint
- Line 7: value and unit of the datapoint (if exists)

Alarms acknowledgement and clearing is defined in the “Controls” section.

A	L	A	R	M								*	1	2	:	3	4	:	5	6
0	6	/	0	5	/	0	4	*	1	1	:M	2	2	:	3	3	.	1	2	3
I	N	C	T		A	C	T		U	N	A	C	K		A	L				1
C	2	6	4	P																
D	S	1																		
D	S	1		C	t	r	l		D	P	C									
S	E	L	E	C	T	E	D													
K	O	-	I	N	T	E	R	L	O	C	K									
0	6	/	0	5	/	0	4	*	1	1	:M	2	2	:	3	2	.	4	5	6
A	C	T		U	N	A	C	K		A	L									1
C	2	6	4	P																
C	2	6	4	P																
G	O	S	M	S	G															
					R	E	S	E	T											
														0	0	1	/	0	0	2

A	L	A	R	M								0	1	:	0	2	:	0	3
0	6	/	0	5	/	0	4	*	1	1	:M	2	2	:	3	3	.	7	8	9
A	C	T		U	N	A	C	K		A	L									1
C	A	L	C	U	1															
D	a	t	a	p	o	i	n	t	s		C	1								
S	P	S	7																	
					R	E	S	E	T											
0	6	/	0	5	/	0	4	*	1	1	:M	2	2	:	3	1	.	9	6	3
A	C	T		U	N	A	C	K		A	L									1
C	A	L	C	U	1															
D	a	t	a	p	o	i	n	t	s		C	1								
S	P	S	7																	
					R	E	S	E	T											
														0	0	1	/	0	1	6

Figure 20: Example of alarm sub-panel

2.3.14 AVR PANEL (OPTIONAL)

The AVR function is embedded in the C26x. When the AVR panel is selected during the configuration process, the local HMI interface shows the Voltage regulation function Statuses, Tap position, Voltages, Target Voltages, Various measurements, Circulating Currents and allows manual commands.

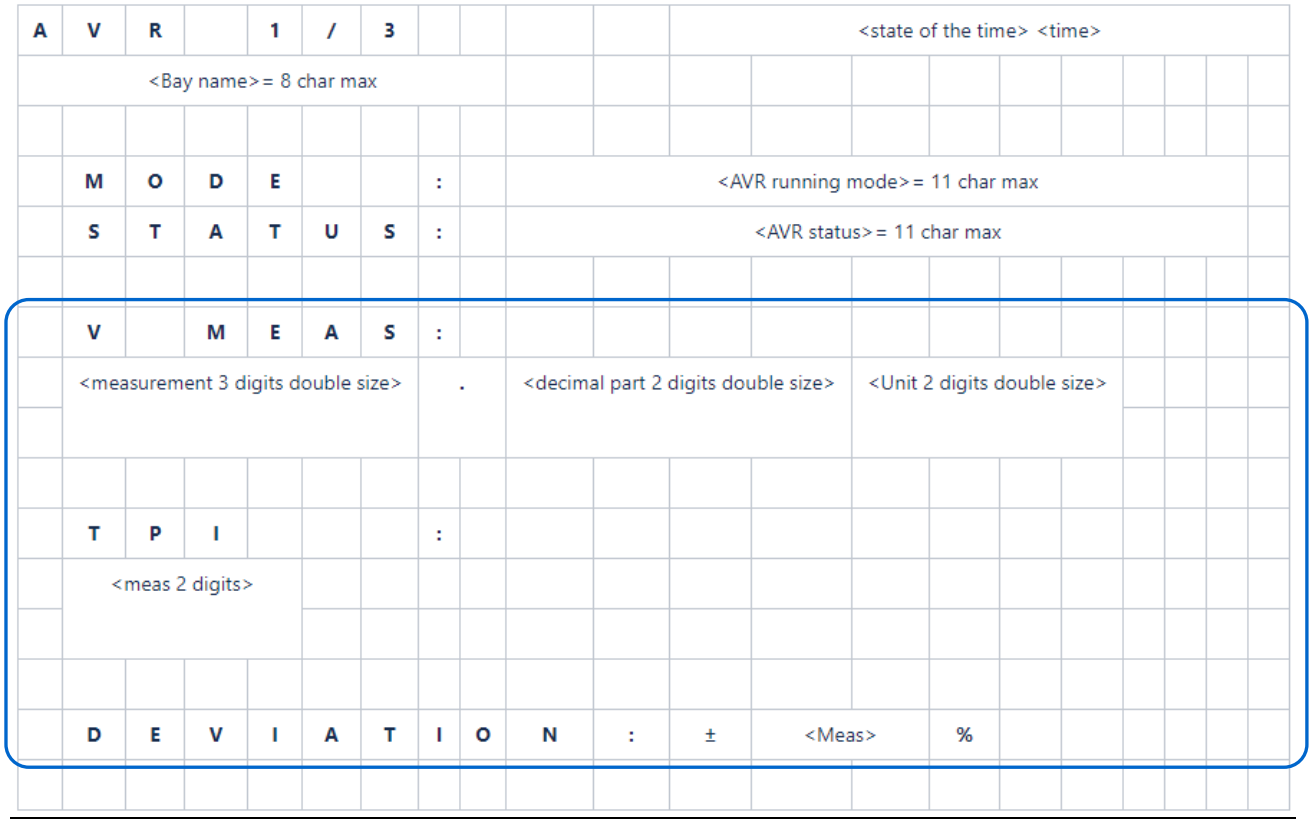
The AVR panel consists of three views (General information, details & control and analysis).

Each view shows common information:

- Line 1: **State of the time**: clock time status (* updated), **time**: system clock time
- Line 2: **Bay Name** (short name of the bay defined in configuration)
- Line 4: **Mode**: Actual AVR running mode (MANUAL, AUTOMATIC)
- Line 5: **Status**: Actual AVR status (ON, OFF)

Plus specific information in each sub panel, as detailed below.

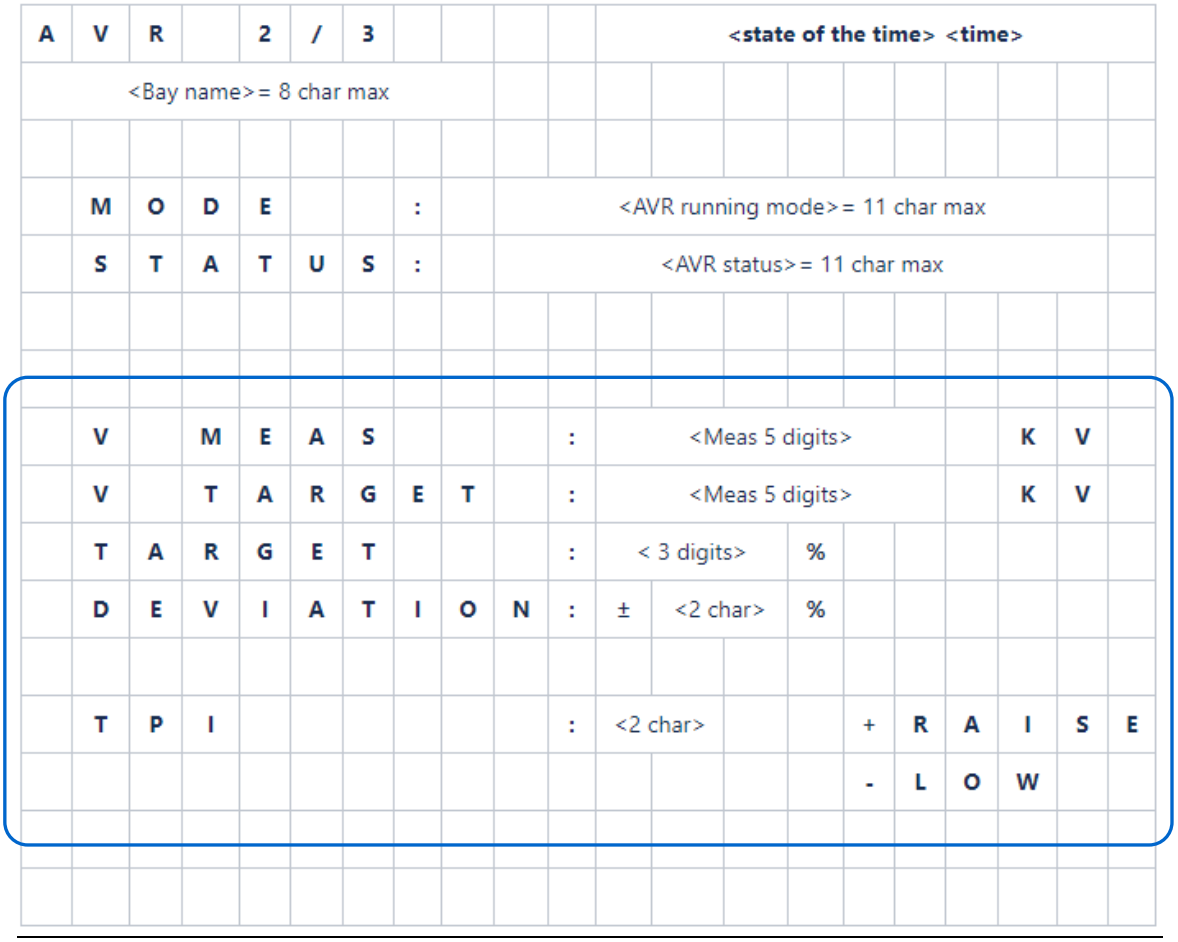
AVR panel #1: Overview



The information displayed in the ARV panel is:

- **V Meas**: Measured Voltage (regulated). Fixed format on 5 digits (xxx.xx)
- **TPI**: actual Tap Position (TPI). Fixed format on 2 digits (xx)
- **Deviation**: delta between Target voltage value and Measured Value. Fixed format on 2 digits (xx)

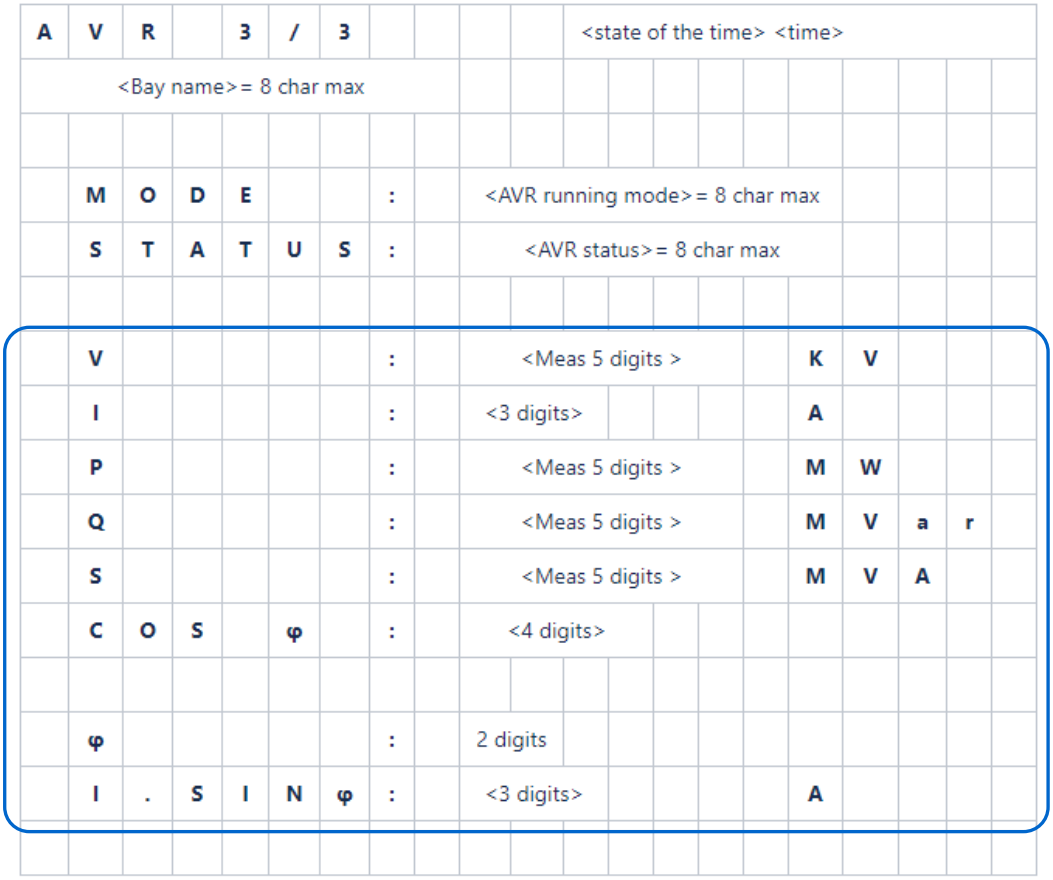
AVR panel #2: Details & Control



The information displayed in the ARV panel is:

- **V Meas**: Measured Voltage (regulated) over 5 digits (xxx.xx)
- **V Targe**t: Target Voltage for the concerned transformer (comes from a remote Setpoint or from local command, or from predefined value in database) over 5 digits (xxx.xx)
- **TARGET**: Voltage Target shown as a % of the Nominal Value (Configurable option on the Page) over 3 digits (xxx)
- **Deviation**: Delta between Target voltage value and Measured Value over 2 digits (xx).
- **TPI**: actual Tap Position over 2 digits.
- **+RAISE** / **-LOW**: selectable button for control. Control sequence for Raise/Lower.

AVR panel #3: Analysis view



- **V**: measured Voltage (regulated). Fixed format over 5 digits (xxx.xx)
- **I**: measured current. Fixed format over 3 digits (xxx)
- **P**: calculated active power. Fixed format over 5 digits (xxx.xx)
- **Q**: calculated reactive power. Fixed format over 5 digits (xxx.xx)
- **R**: calculated apparent power. Fixed format over 5 digits (xxx.xx)
- **COSPHI**: calculated power factor. Fixed format over 4 digits (xx.xx)
- **PHI**: calculated phase. Fixed format over 2 digits (x.x)
- **I.SINPHI**: calculated reactive factor. Fixed format over 4 digits (xx.xx

2.3.15 EVENT PANEL

The event panel allows displaying the event list of the C26x in a chronological order. Display of events is done from newest to oldest: that means that the newest event declared is displayed at the top of the events panel (i.e. newest event is always rank 1).

This event list is a circular queue. List maximum size depends of C26x version series. This list is displayed in a scrollable view using arrows keys. When the circular queue is full and a new event appears, then the rank of each event is increased and the oldest event in the queue is removed.

One screen of the LCD contains at maximum 2 events.

At first time the user enters the events' panel, the 2 newest events are displayed.

E	**V**	**E**	**N**	**T**							<time sync. state> <time>									
0	**0**	**1**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<Date, time and state of time of the event> =21 char.																				
<Information about event> **5 lines * 21 char./line maximum:**																				
0	**0**	**2**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<Date, time and state of time of the event> =21 char.																				
<Information about event> **5 lines * 21 char./line maximum**																				

An event is composed of 7 lines:

Line 1: rank of the event in the circular queue
Line 2: event time stamp
Line 3: label of the bay
Line 4: label of the module
Line 5: label of the datapoint
Line 6: state of the datapoint
Line 7: value and unit of the datapoint (if exists)

Display mechanism for the first page:

- If the operator displays the first page, it is assumed that s/he is looking for the newest events. Therefore, the page will be updated at the apparition of any new event.

Display mechanism for an intermediate page:

- The operator displays one page between the first page and the last one, it is assumed that s/he examines more precisely these events.
- Therefore, when n events appear, the user keeps displaying the 2 same events. However, the rank of each event is incremented by n in real time in the list. When the displayed event is removed from the FIFO, the oldest event is displayed.

Display mechanism for the last page:

- Last page means displaying the two oldest event of the FIFO and the FIFO is full. When the displayed event is removed from the FIFO, the new oldest event is displayed.

E	V	E	N	T							*	1	2	:	3	4	:	5	6
0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0A	6	/	0	5	/	103	2	*	1	1	:M	2	2	:	3	3	.	1	2	3
C	2	6	4	P															
C	2	6	4	P															
L	O	C	A	L	/	R	E	M	O	T	E		D	P	S				
					R	E	M	O	T	E									
0	0	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0A	6	/	0	5	/	103	2	*	1	1	:M	2	2	:	3	3	.	5	6	7
C	2	6	4	P															
C	2	6	4	P															
I	S	A	G	R	A	F		S	T	A	T	U	S						
W	A	I	T	I	N	G													
														0	0	1	/	100	0	0

Figure 21: Example of event sub-panel

2.3.16 FAULT PANEL

The first LED of the local HMI indicates 2 levels of fault.

When the LED is ON, a major fault is present. It can be:

- A database inconsistency
- A hardware fault

If there is a minor fault the fault LED is blinking. It can be:

- A disconnected IED
- A problem about IRIG-B
- A problem about ISaGRAF

The Fault panel displays these faults.

2.3.17 DISTURBANCE RECORD PANEL

Display of disturbance records corresponds to the list of available disturbance records of the C26x. Two types of files are managed:

- Disturbance file from an IED
- Waveform computed inside the C26x

D	**I**	**S**	**T**	**U**	**R**	**B**					<time sync. state> <time>									
FileName											—	—	—	—	—	—	—	—	—	—
<Record beginning date, time and state of time > =21 char.																				
<Information about event that causes the recording>: 2 lines * 21 char./line maximum for controller waveform record Name of the IED for IED disturbance record																				
FileName											—	—	—	—	—	—	—	—	—	—
<Record beginning date, time and state of time > =21 char.																				

The records are displayed on the panel using 2 lists according to the origin. Displayed information depends on the origin of the file:

- waveform records are in COMTRADE format, 3 files can be displayed per page. Only the .cfg file name is displayed on the panel (the .dat files are only available to be uploaded).

Name of the file (format name . cfg)							**Type (F,S)**
Time stamp							
Bay Name / Module Name / Datapoint label (up to 2 lines)							

(F for fast waveform, S for slow waveform)

- From an IED: 3 files can be displayed per page.

Name of the file (format name . ext)									
Time stamp									
Name the IED									

2.3.18 MENU TREE

Some parameters of the C26x can be set by the operator from local HMI. The display / modification of the parameter value is done in the menu tree from the local HMI. All the parameters are group in the same path of the menu tree.

The parameters that can be modified on-line are:

- language
- counters value
- synchrocheck parameters (if applicable)
- autorecloser parameters
- pulse delay for open / close controls
- motion 00 and motion 11 delays
- persistence filtering delays
- toggling parameters
- measurements thresholds, deadband and hysteresis
- serial communication parameters

The controls that can be performed from the menu tree are:

- reset of operating hours
- change of C26x operating mode
- global alarm acknowledgement
- global alarm clearing
- database switching
- date and time setting
- modify counters value
- modify energy counters value

Note:

The key  *is used to browse the menu tree. Therefore alarm acknowledgement is not possible from the menu tree.*

The following figures show the menu tree in the three operating modes.

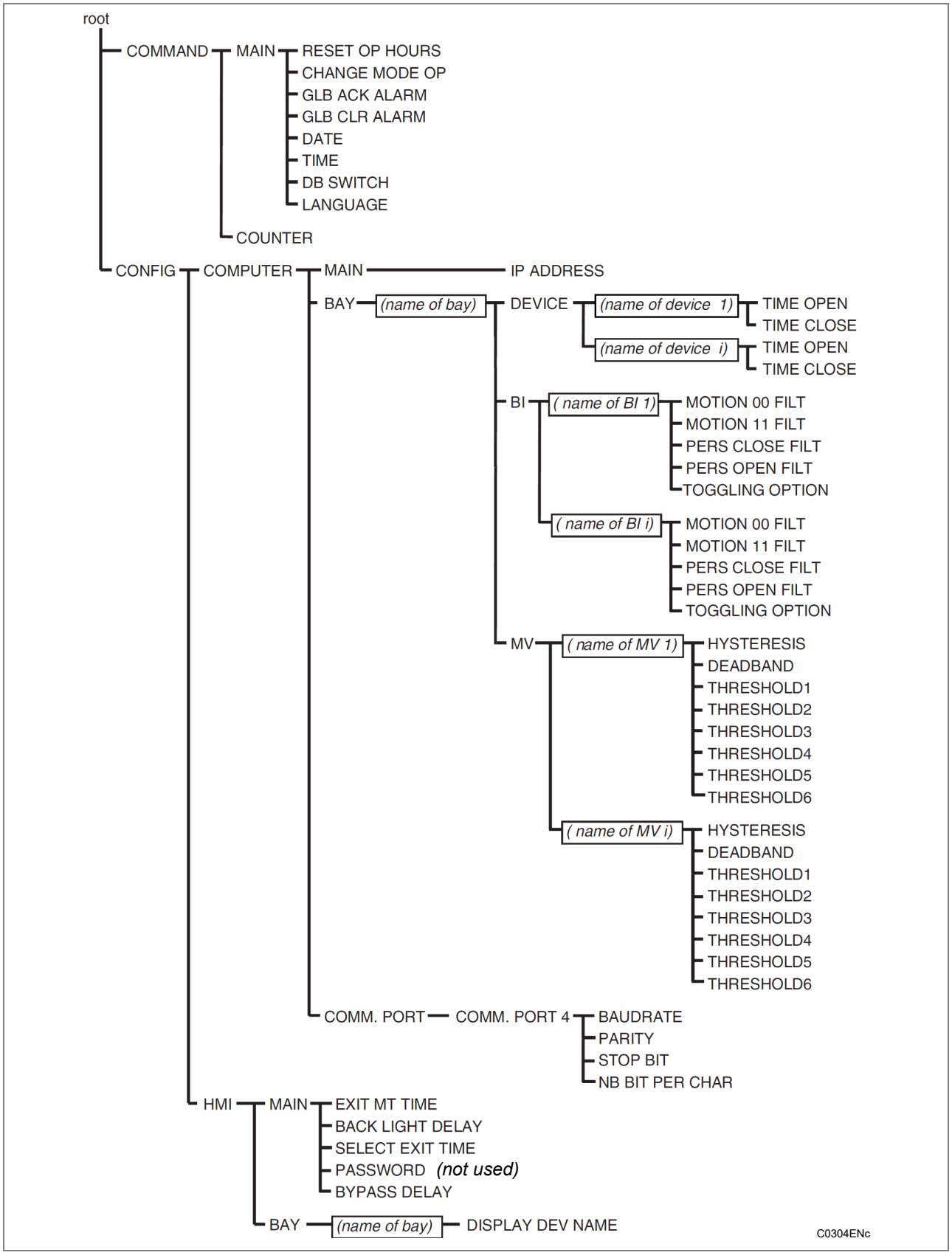


Figure 22: Menu tree in operational and test/blocked modes (example)

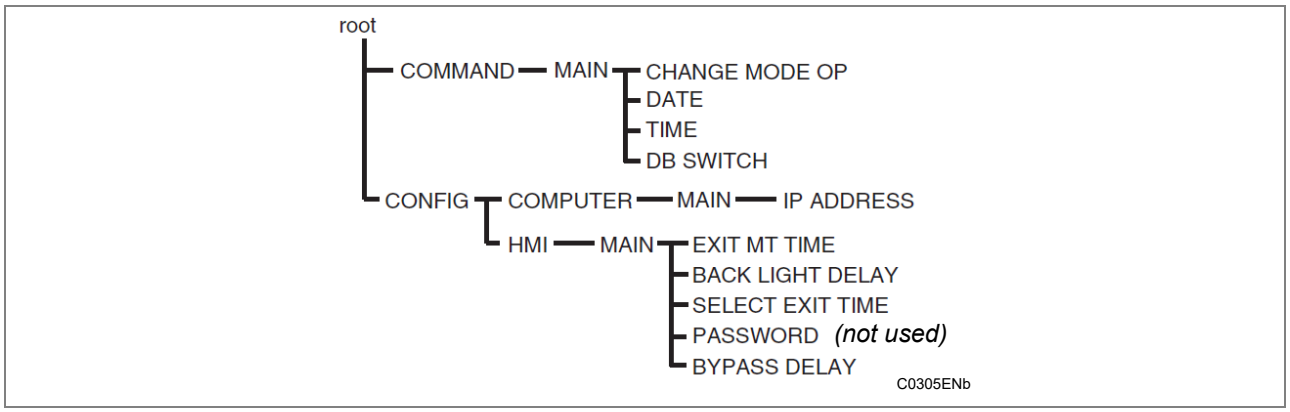


Figure 23: Menu tree in maintenance mode

2.3.19 CONTROLS

Some controls can be performed from the local HMI:

- Bay Local / Remote mode
- Control of circuit breakers or disconnecting switches
- Tap changer control
- C26x mode
- Database switch
- Reset of operating hours
- Time and date setting
- Manual reset/modification of counters and energy counters
- Alarms acknowledgement
- Alarms clearing

Some of these commands are accessible in a panel (bay panel or alarm panel), the others are accessible in the menu tree.

2.3.19.1 LOCAL / REMOTE CONTROL OF BAY

Local / Remote control of bay for LCD front panel (GHU20x)

The operator is allowed changing the bay mode:

- From local to remote
- From remote to local

If the C26x manages several bays, the state local / remote of bays is set bay by bay. Change of bay mode is enabled if a bay panel is defined. It means that, if a bay is not associated with a bay panel, its local/remote control mode cannot be controlled through the L/R key of the panel.

Local / Remote control of bay for simple panel with LEDs (GHU21x)

In case of simple panel, the operator controls all the bays of the C26x in the same time. To change mode, he has to press of the key during at least 3 seconds. A LED is necessary to display the current mode, so the 5th LED is required for that. If all the bays are NOT in the same state, the command will switch them all to local mode.

2.3.19.2 COMMANDS OF CIRCUIT BREAKERS, DISCONNECTING SWITCHES AND GENERIC MODULES

Module command is possible by 2 ways:

- From the graphical panel
- From the sub panels command

Circuit breakers, disconnecting switches or generic command are ordered from the local HMI by the operator. Commands allowed from the local HMI are:

- open
- close
- close a synchronised circuit breaker
- close with bypass on a synchronised circuit breaker (forcing closure), available only when the DI “Accept Forcing is configured

The key C allows aborting the choice in event of command on a close_synchrocheck.

SBO command

In case of the select/execution order (SBO) for opening or closing a module, make on the local HMI a selection before an execution command.

For that, press the command key (key O for OFF or key I for ON) a first time for the selection command, and press key OK for the execution command.

After a positive acknowledgement of the selection command, the module is displayed in reverse video.

DE command

In event of the Direct execute order (DE) for opening or closing module, the operator sends directly the command using the command keys.

Interlocking bypass (if not inhibited in SCE)

To get access to the bypass flag modification panel once a module is selected, press the key 

.

Set the interlocking bypass command BEFORE you send the execute order.

To send the bypass command, use the bypass flag on the interlocking equation (EQL).

B	**Y**	**P**	**A**	**S**	**S**						<time sync. state> <time>									
	N	**A**	**M**	**E**		**O**	**F**		**T**	**H**	**E**		**M**	**O**	**D**	**U**	**L**	**E**		
	E	**Q**	**L**		**B**	**Y**	**P**	**A**	**S**	**S**						**O**	**N**			
															E	**X**	**I**	**T**		

Note:
The flag is not displayed if the related function has been set to spare in the graphic part of SCE.

Synchrocheck bypass

The operator can send the command using bypass flag on synchrocheck (forcing closure).

The S/C bypass flag is present when the “Accept Forcing” DI is configured. It can be set BEFORE or AFTER the execute order sending.

To gain access to the bypass flag modification panel, press the key 

.

B	Y	P	A	S	S						<time sync. state> <time>									
	N	A	M	E		O	F		T	H	E		M	O	D	U	L	E		
	E	Q	L		B	Y	P	A	S	S						O	N			
	S	/	C		B	Y	P	A	S	S						O	N			
															E	X	I	T		

Interface with the operator on local control panel

The key  is used to select graphically the module or the command of the bay. When a module is selected, its label flashes.

The operator sends this command from the bay panel with key  (for OFF) or key  (for ON).

The key  is used to abort the choice during the selection step (in event of SBO order).

2.3.19.3 TAP CHANGER CONTROL REQUEST

The key  allows selecting one by one the modules of the bay. When a transformer is selected, the operator can control it from local control panel by dealing with associated tap changer positions.

In order to command the tap changer, the bay that the transformer belongs to has to be in local mode.

The commands that can be sent through the local HMI are:

- Raise (= current tap position + 1) with the key 
  - for a Double Wound transformer the Low Voltage is increased
  - for an Auto-wound transformer the Low Voltage is reduced

Note:
A "raise" control is refused if the current tap position value corresponds to the maximum position of the tap.

- Lower (= current tap position -1) with the key 
  - for a Double Wound transformer the Low Voltage is reduced
  - for an Auto-wound transformer the Low Voltage is increased

Note:
A "lower" control is refused if the current tap position value corresponds to the minimum position of the tap.

- In case of "go to min", "go to max" or "go to position x" request, the C26x uses an internal automatic function (via ISaGRAF) which generates the desired controls sequences in order to reach automatically the expected position. This function may generate "Direct execute", "SBO once" or "SBO many" sequences according the configuration of the module.

2.3.19.4 C26X MODE

The operator is allowed to change the C26x mode between:

- Operational
- Maintenance
- Test/blocked

Note:
For redundant C26x units, the "test/blocked" mode's behaviour is different from that of the IEC 61850-compliant test/blocked mode used in non-redundant C26x units. See Functional Description chapter (C26x/EN FT for details).

2.3.19.5 DATA BASE SWITCH

The DS Agile C26x carries 2 databases: a current (i.e. operational) database, and a stand-by database. The operator can switch between both databases.

The operator sends this command from the menu tree.

2.3.19.6 RESET OPERATING HOURS

The operator is allowed to reset the operating hours counter.

The operator sends this command from the menu tree.

2.3.19.7 TIME AND DATE SETTING

The operator is allowed to set time and date of the C26x from the local HMI.

Time and date are set from the menu tree.

2.3.19.8 MANUAL VALUE CHANGE OF COUNTERS

Counters can be reset or assigned a new value manually by the operator at BCP.

Counters are changed from the menu tree.

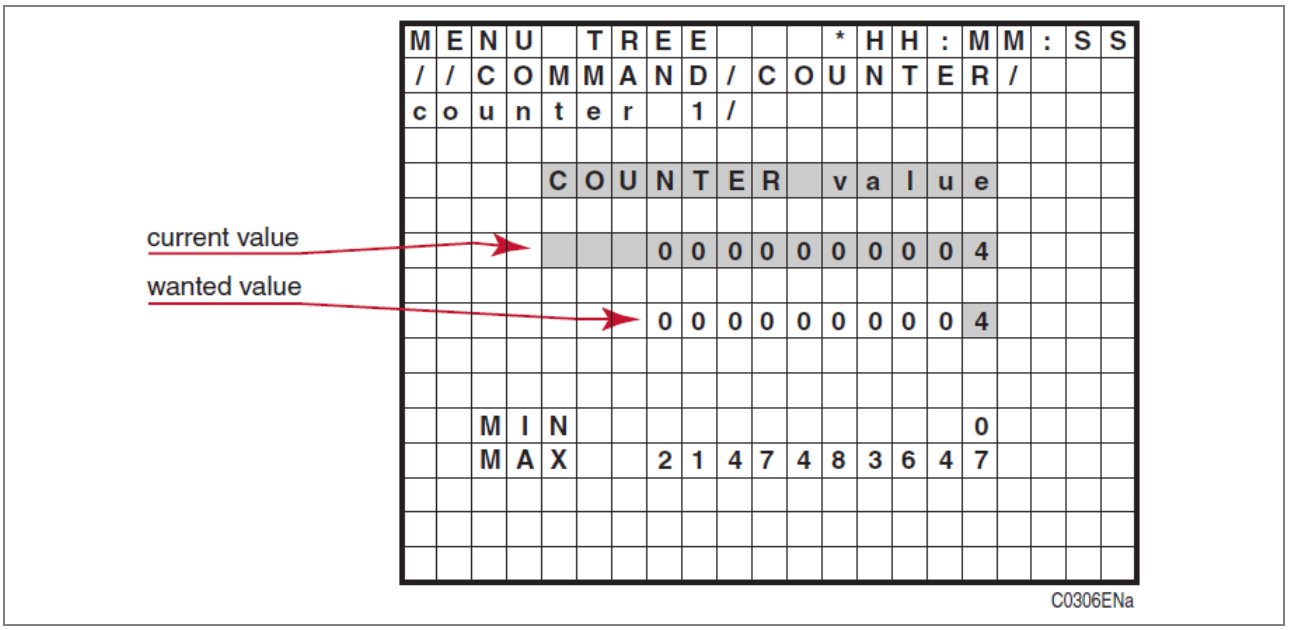


Figure 24: Example of manual value change for a counter

When this panel is displayed the most right digit of the wanted value is in inverse video.

Keys and are used to select the digit of the wanted value that has to be modified, and to change the value of the selected digit.

Once the correct wanted counter value is defined, it can be validated by pressing the key OK.

2.3.19.9 ACKNOWLEDGEMENT OF ALARMS

Acknowledgement of alarms is performed globally or on a per alarm basis:

- Global acknowledgement: the operator can acknowledge all the unacknowledged alarms of the C26x. It is performed from the menu tree.
- Alarm per alarm acknowledgement: the operator can perform the alarm acknowledgement one by one. It is done from the alarm panel.

2.3.19.9.1 Global acknowledge

The operator can acknowledge all the unacknowledged alarms of the C26x

Interface with the operator on local control panel

Acknowledgement of all alarms is done from the menu tree.

2.3.19.9.2 Alarm per alarm acknowledge

The operator can perform the alarm acknowledge one by one.

In this case, in the “alarm panel”, selects an alarm and can activate the acknowledgement.

Interface with the operator on local control panel

Acknowledgement alarm by alarm is done from the alarm panel.

The procedure of acknowledgement by the operator is the following one:

- select (in the alarm panel) one alarm with the select key  . Once the alarm is selected, the two first lines of the alarm in the alarm panel are blinking. Deselecting is performed by the key  .
- press the ‘enter’ key  .

The key  is used to abort the command.

If the key sequence is correct, the selected unacknowledged alarm is acknowledged.

The state of the alarm is then changed depending of its initial state:

- active unacknowledged ➔ active acknowledged
- inactive unacknowledged ➔ inactive acknowledged if the disappearance of the alarm has to be acknowledged

The alarm list is updated with the new state of the alarm. The alarm in the inactive acknowledged state is automatically cleared and removed from the alarm list if the automatic clearing mode is set for this alarm in the database.

2.3.19.10 ALARMS CLEARING

Clear of alarms is performed globally or on a per alarm basis:

- Global clearing: the operator can clear all the inactive acknowledged alarms of the C26x. It is performed from the menu tree.
- Alarm per alarm clearing: the operator can perform the alarm clearing one by one. It is done from the alarm panel.

2.3.19.10.1 Global clearing

The operator can clear all the inactive acknowledged alarms of the C26x

Interface with the operator on local control panel

Clear of all alarms is done from the menu tree.

2.3.19.10.2 Alarm per alarm clearing

The operator can perform the alarm clear one by one.

In this case, in the “alarm panel” he selects an alarm and can activate the clearing.

Interface with the operator on local control panel

Clearing alarm by alarm is done from the alarm panel.

The procedure of clear by the operator is as follows:

- The operator selects (in the alarm panel) one alarm with the select key  .

Only the inactive acknowledged alarm can be selected.

- Once the alarm is selected, the two first lines of the alarm in the alarm panel are blinking (deselect by pressing the key )
- Press the ‘enter’ key  .

The key  is used to abort the command.

If the key sequence is correct, the selected alarm is cleared and disappears from the list.

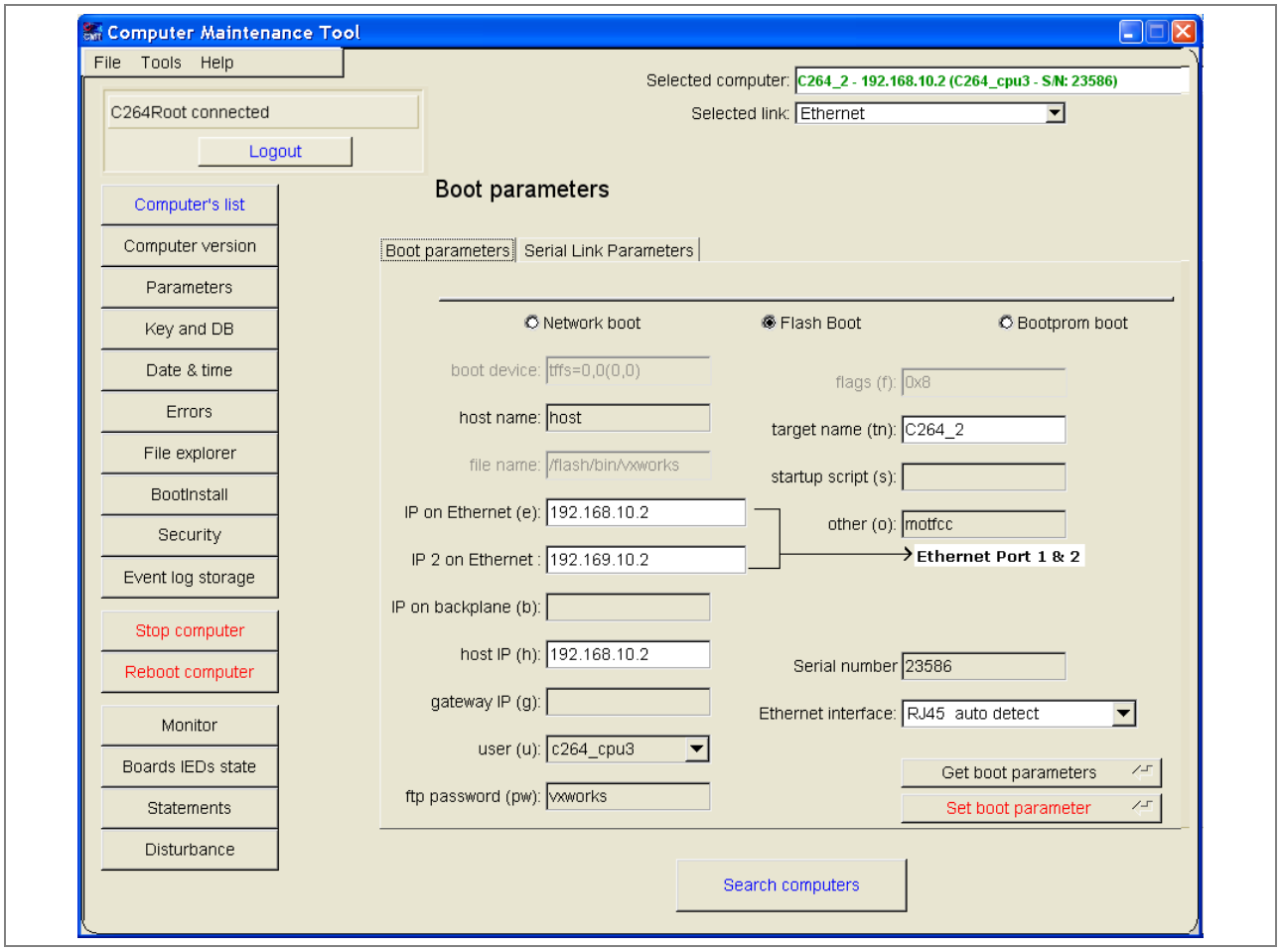
3 COMPUTER MAINTENANCE TOOL

The Computer Maintenance Tool is a graphical tool that gives access to standard commands and secures the basic maintenance interventions.

The CMT communicates with the C26x on Ethernet in direct addressing mode.

The CMT's functions are:

- Access to C26x software version and facility to download new software
- Access to C26x databases versions and descriptions and facility to download, switch new database, and upload database (for some restricted applications)
- Access to boot parameters and facility to change them
- Access to date and time and facility to change them
- Access to sequence of events



4 LOG PRINTING

Some specific events (the events to log are declared in the database) are printed and chronologically sorted on logbook printers. They are printed with their time stamping and a complete description (location and event description).

Logbook printers can be connected to SCP system HMI or to a bay level controller. The printout format, which can be defined by user during the system configuration phase, is the same across the whole log book printers connected.

A C26x does not print information coming from other controllers.

4.1 INPUTS

A C26x receives acquisition from various pieces of equipment (protection, sensors, etc.) and, after processing, may generate events that have to be printed. These kinds of events are defined in the database during the configuration phase.

Types of events can be:

- Binary inputs (SP, DP, MP, SI and Groups)
- Tap position indication
- Measurement
- Operator action:
- Log-in and log-off,
- Modules control
- Alarm acknowledgement / clearing

4.2 OUTPUTS

The 5 following properties can be printed. Each property is separated from the other by one blank character. The position of each property in the printed line (i.e. position 1, 2, 3, 4 or 5) is defined in configuration:

- **Chronology** – 1 character: refer to section “SOE events”
- **TimeStamp** – 24 or 26 characters: refer to section “SOE events”
- **Origin** - 67 characters: for BI, TPI, measurements, controls and alarms, the origin gives the access path to the object (refer to section “SOE events”)
- **ObjectName** - 16 characters
- **ObjectMessage** - 16 characters

The Origin, ObjectName and ObjectMessage properties contain different information depending of the associated event type.

4.3 PRINTER MANAGEMENT

4.3.1 HEADER & FOOTER

A header and footer can be printed at each page. They are composed of one line, separated from the events by a blank line.

Site name – Computer	name	Date /Hour
	Blank line	
	Log Book	
	Blank line	
		Page number

The page number is in the range [1..999]. It is reset at 1 after reaching 999 and at each new day.

The date could have the following format: DD/MM/YY or MM/DD/YY or YY/MM/DD or DD/MM/YYYY or MM/DD/YYYY or YYYY/MM/DD. The time has the following format: hh:mm:ss.

4.3.2 CHRONOLOGY & TIME STAMP

The printers are managed in a real-time printing mode.

All synchronised information is printed in a chronological order.

Events are printed with their time-stamping and a complete description (location and event description). The equipment detecting the event does the time-stamping (time-stamping at source).

4.3.3 PRINTER OUT OF SERVICE

If a printer fails, all the messages are stored in a circular buffer

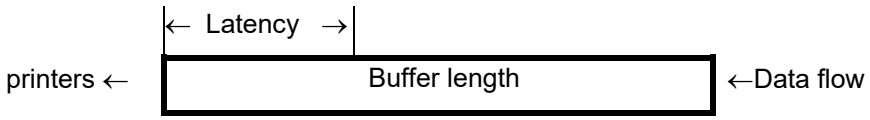
When the buffer is full, any new message replaces the oldest one.

An indication (Printer status) is generated to indicate the printer failure.

4.3.4 CIRCULAR FIFO MANAGEMENT

Before being printed, all information goes into a circular buffer

A latency delay is configured to sort information.



The size of the buffer is 2000.

When the buffer is full, the oldest information are deleted (300 pieces of information suppressed) in order to have place for new ones.

A specific message is inserted in the buffer to indicate the lost of information, this message has the following information:

TimeStamp	= date of the oldest suppress information
Origin	= Name of the C26x (configurable)
ObjectName	= SUPPRESSED INFOS (configurable)
ObjectMessage	= number of lost information

The figure below shows an example of SOE page:

```
substation-C264_GTW                                          05/07/06 09:08:35.232

* 05/07/06 09:08:35.232    CALC C264N3 /Generic module   Group Permanent  Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group            Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 1          Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 2          Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 3          Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 4          Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 5          Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 6          Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 7          Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 8          Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 9          Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 10         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 11         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 12         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 13         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 14         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 15         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 16         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 17         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 18         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 19         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 21         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 22         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 23         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 24         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 25         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 26         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 27         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 28         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 29         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 30         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 31         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 32         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 33         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 34         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 35         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 36         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 37         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 38         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 39         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 40         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 41         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 42         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 43         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 44         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 45         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 46         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 47         Self Check fault
* 05/07/06 09:08:35.232    CALC C264N3 /Group 0 to 499   Group 48         Self Check fault

                                                                          PAGE  001
                                                                            C1114ENa
```

COMMISSIONING

C26X/EN CM/D40

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1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x manuals. It describes the database downloading and C26x commissioning and should not be confused with application commissioning. This chapter follows the chapter C26x/EN IN (Installation).

1.1 INTRODUCTION

To commission DS Agile C26x, it is necessary to verify that the hardware is functioning correctly and that the application-specific software settings have been applied to the C26x.

To verify that the DS Agile C26x is operating correctly, a database has to be loaded into the C26x. Once the database has been loaded, tests should be performed on each single C26x unit.

As the DS Agile C26x's menu language is user-selectable, it is acceptable for the Commissioning Engineer to change it to allow accurate testing as long as the menu is restored to the customer's preferred language on completion.



Caution:
Before carrying out any work on the equipment, the user should be familiar with the contents of the chapter C26x/EN SA (Safety), of the GE Grid Solutions Safety Guide: SFTY/4L M, and of all the C26x technical data.

1.2 DEFINITION

The objective of commissioning is to prove that the equipment, and any interconnections to process and other system components, is suitable for its intended purpose.

Commissioning is the activity that demonstrates that the equipment is acceptable for service. As digital devices are configured for specific application, the commissioning can be split into two main parts:

- Commissioning the product.
- Commissioning the application (when product has had its database loaded). This second part is documented and carried out through FAT (Factory Acceptance Tests), and SAT (Site Acceptance Tests) activities.

The scope of this chapter is the description of commissioning tests that prove that the C26x unit is suitable for further application tests.

1.3 COMMISSIONING THE PRODUCT

Commissioning the product starts with product reception and is continued through all off the installation procedures. Activities are divided between: -

- Visual inspection at reception.
- Inspection at Front Panel when DS Agile C26x is powered up.
- The starting point is the delivery form that describes all of the delivered hardware components that constitute the DS Agile C26x.

1.4 RESPONSIBILITY

Most commissioning activities involve a power supply that can damage the installation or cause injury to the operator. The chapter C26x/EN SA (Safety) should be read carefully before any handling.

Before starting commissioning, the contractual and human responsibilities should be clearly defined.

Only qualified and competent persons should carry out commissioning and the validation tests.

1.5 SETTING FAMILIARISATION

Commissioning the DS Agile C26x requires operation of its Human Machine Interface (the Local Control Display). The chapter C26x/EN HI contains a detailed description of the menu structure of the DS Agile C26x.

The commissioning engineer should have had training on the HMI or sufficient time should be allowed to become familiar with it (with an already commissioned device).

1.6 REQUIREMENTS

It is essential that all requirements expressed in the chapter C26x/EN IN (Installation) have been fulfilled.

The delivery form is the starting document.

2 DOWNLOADING A DATABASE

The DS Agile C26x requires a database to operate. It stores up to two databases, named “current” and “stand-by”. Only the current database is used for operation. The second database can be downloaded when the C26x is in operational or maintenance mode. A specific control allows switching between the two stored databases.

DS Agile SCE (System Configuration Editor) is used to generate the databases. SMT (System Management Tool) or CMT (Computer Maintenance Tool) are used to download and switch the databases.

The use of SMT or CMT depends on the number of controllers. For several controllers on the same Ethernet network, it is recommended to use SMT in order to ensure database consistency between units.

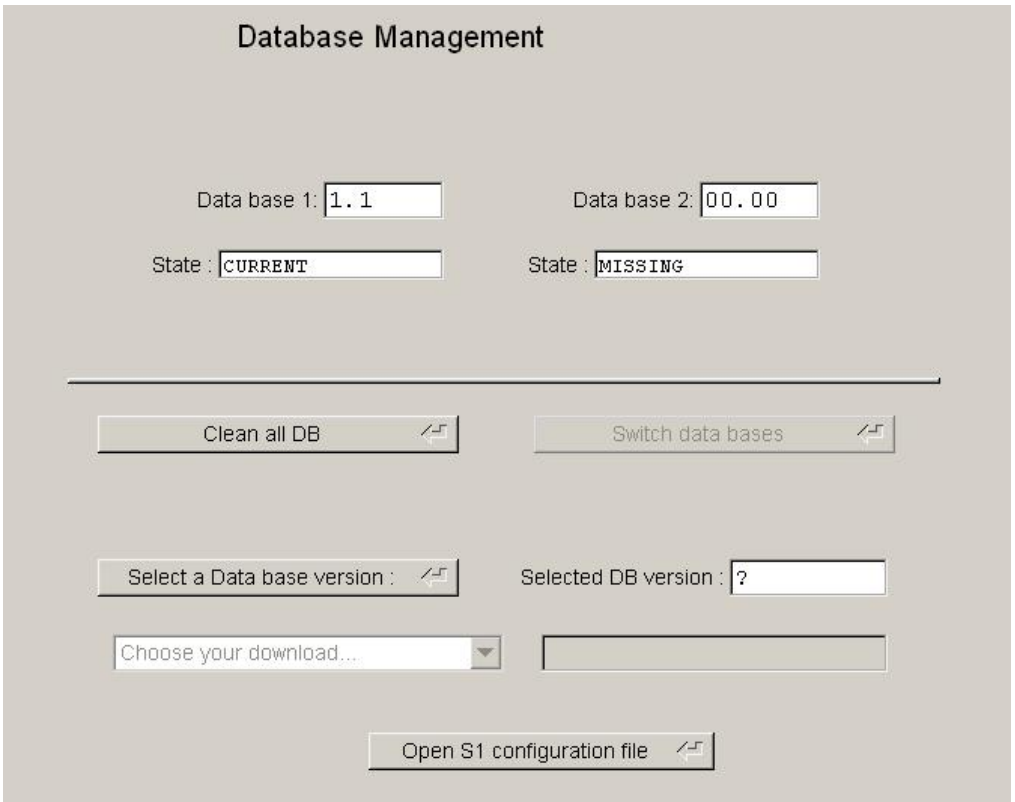
2.1 DATABASE DOWNLOAD WITH CMT

First copy the .zip database issued by SCE to the host.

Note:
Do not put the archive on the desktop nor in the My Documents folder (the path must not include any blanks).
Do not keep it in a USB drive.

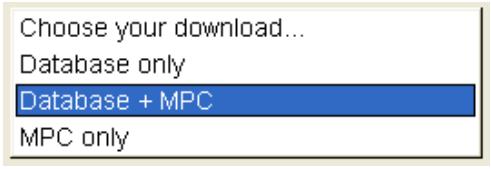
In the CMT application:

- Click the **Search computers** button in the bottom part
- Select the targeted C26x in the list
- Click the **Data Base** menu button:



- Click the **Select a Data base version** button, select the bd.x.xx.zip file corresponding to the database to use and click OK; as a result, the .adb files in the archive are transferred into the folder <installation folder>/Computer/Cmt/db
- In the **Choose your download** list**,** select **Database only**; this opens a dialog box: choose the .adb file corresponding to the selected C26x and click **OK**
- Click the **Switch data bases** button; the DS Agile C26x restarts on the database you have downloaded. It starts in operational mode.

Note:
On a C26x-Standalone application (C26x not associated to any other DS Agile IEC 61850-8-1 devices), the source database (MPC file) can be stored on the CPU270 (up to 20MB file size); this will be possible by selecting DATABASE + MPC, on the download list box:



For more information, refer to the section *CMT In-depth description* in the *Installation chapter: C26x/EN IN*.

2.2 DATABASE DOWNLOAD WITH SMT

2.2.1 LOADING DB UNDER SMT

First load the DB version (menu Databases > Add database…). The DB is then stored on the hard disk and appears in the database list.

Right click to “set current” the DB, then to send a “connect all”, then SMT communicates with the C26x; otherwise check wiring and settings.

2.2.2 DOWNLOAD DB ONTO C26X

Still using right buttons choose the “download all” option and wait for the acknowledgement of a successful transfer.

Note:
After a format and a bootInstall of VB6.19 version C26x and a C26x reboot using the CMT, the SMT cannot find the connected C26x; therefore it is not possible to load a DB. To retrieve the C26x, reboot it from the shell (Telnet button).

2.2.3 SWITCH TO DOWNLOADED DATA BASE

If no database has previously been installed then the database is automatically set to be the running database. If there is a database already installed then the downloaded database will become the standby database. In this event, the new database has to be switched to make it the running database. In both cases it is necessary to reboot the C26x to put the database into running mode.

For more information, refer to the *DS Agile system Commissioning chapter: DS Agile/EN CM*.

3 COMMISSIONING TESTS WITH GHU200 OR GHU201 (WITH LCD)

3.1 PREPARATION

After the C26x has been installed and connected as described in chapters C26x/EN IN and C26x/EN CO, the commissioning procedure can begin.

Before turning on the power supply voltage, the following items must be checked:

- Is the device connected to the protective ground at the specified location?
- Does the nominal (and measured) voltage of the battery agree with the nominal auxiliary voltage of the device?
- Are the current and voltage transformer (if used) connections, grounding, and phase sequences correct?

After the wiring work is completed, check the system to make sure it is properly isolated.

Once all checks have been made, the power supply voltage may be turned on.

After the voltage has been applied, the C26x starts up.

During start-up, various tests are carried out; the results show on the LEDs and LCD.

If a database is present in the C26x, the fourth LED will stay on.

After approximately 30 s, the C26x is ready for operation.

In initial, factory-set condition or after a cold restart, the front panel displays a splash “Alstom”.

After the settings have been made, the following checks should be carried out before any interlocks or isolation is cancelled:

- Are the software and database versions compatible with the hardware?
- Has the setting file been uploaded into the C26x?
- Are all boards correctly assigned within the C26x?
- Are all IOs correctly configured and recognised by the C26x?
- Are all communications (S-BUS, T-BUS and L-BUS) correctly configured and recognised?
- Are the control functions fully operational?
- Are the protection settings fully operational (TMU210 only)?
- Is the automation running?

The following sections describe the checks to be performed to answer these questions and ensure that the C26x is fully operational in its application.

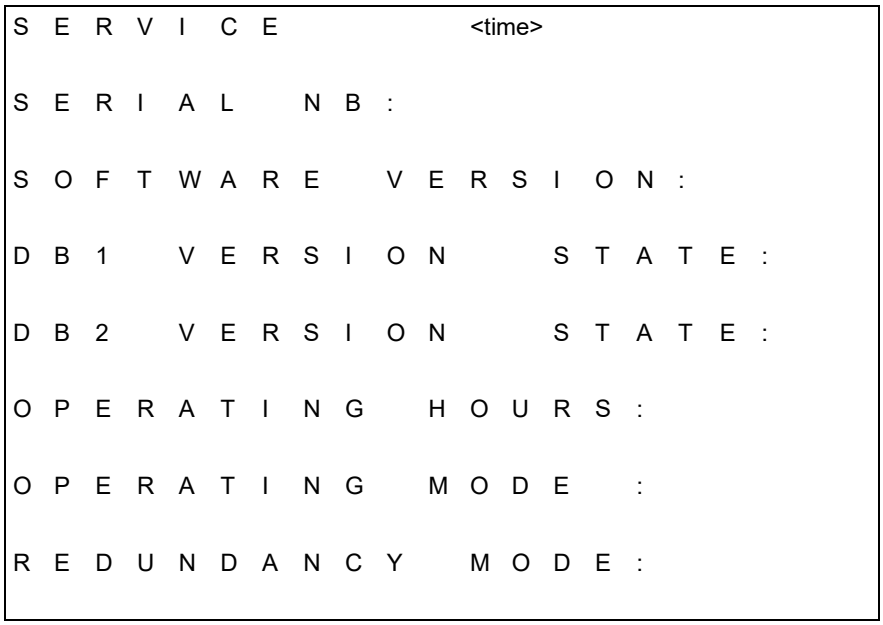
3.2 CHECK VERSION & NUMBER

In the commissioning process this panel is the first to check. The C26x serial number tells if the C26x is the ordered one, and indirectly gives the hardware version.

The software version from the VC document gives features and limits of the DS Agile C26x.

The database version is given by DS Agile SCE database version and describes all the settings on the DS Agile C26x.

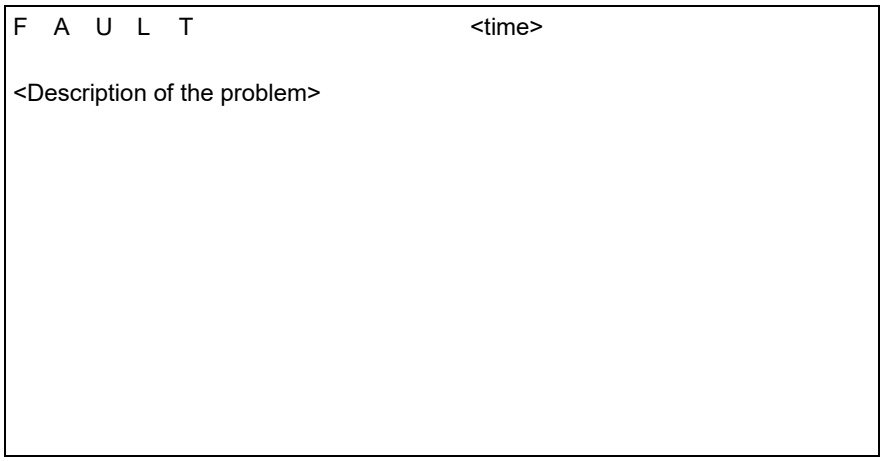
The operational mode indicates whether the device is in a maintenance or operational mode.



3.3 FAULTS

If the first LED is on, this means that there is something wrong inside the C26x.

The FAULT panel gives information about the problem.



3.4 CHECK THE BOARDS STATUS

The C26x's front panel gives access to C26x boards status (refer to chapter C26x/EN HI).

Board labels are defined during the configuration phase. They are based on short names and are indexed automatically. The default configuration model is:

- AIU Analogue Input Unit (DC current and voltage inputs)
- AOU Analogue Output Unit (4 current analogue outputs)
- BIU Basic Interface Unit (power supply)
- CCU Circuit breaker Control Unit (SBO board)
- DIU Digital Input Unit
- DOU Digital Output Unit
- GHU Graphical Human Unit
- HBU High Break Unit
- TMU Transducerless Measurements Unit (CT/VT board)

The product checks whether the number of installed boards matches with the number of boards configured, the following messages are generated depending on the results:

- OK Board configured present and operational
- Failure Board configured present and faulty
- Missing Board configured not present
- Too many Board not configured but present (spare)

Note that these state labels are manually set in configuration and that the exact text could slightly vary due to customer preference, but not their actual meaning.

B O A R D <time>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

<Board Label><Number>
<Board Status>

N°page/Number of Pages

3.5 CHECKING THE BINARY SIGNAL INPUTS

The C26x front panel gives access to input status for all DI boards (DIU200, DIU210, DIU211, CCU211 or CCU200).

For DIU200, DIU210 and DIU211 boards:

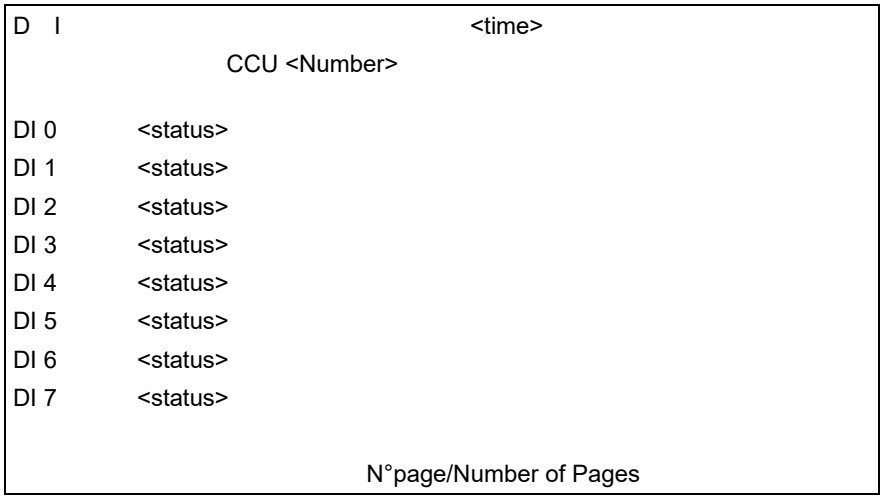
D I <time>

DIU <Number>

DI 0	<status>	DI 8	<status>
DI 1	<status>	DI 9	<status>
DI 2	<status>	DI 10	<status>
DI 3	<status>	DI 11	<status>
DI 4	<status>	DI 12	<status>
DI 5	<status>	DI 13	<status>
DI 6	<status>	DI 14	<status>
DI 7	<status>	DI 15	<status>

N°page/Number of Pages

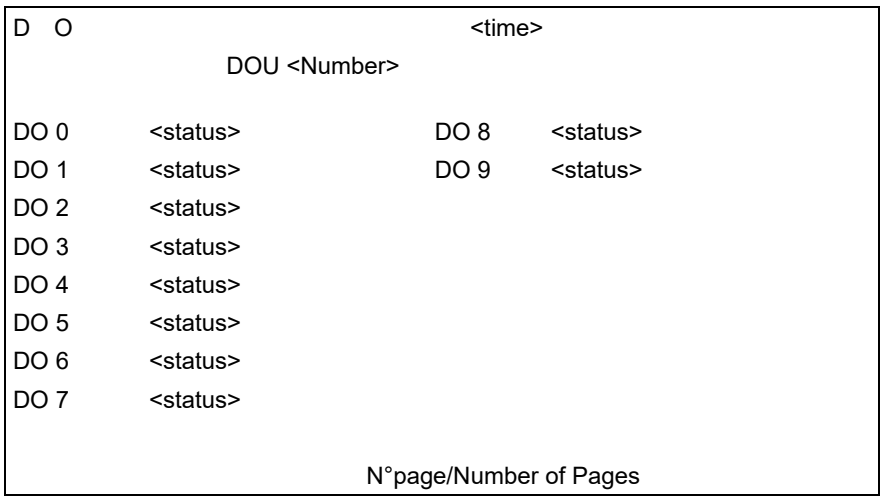
For CCU200 and CCU211boards:



3.6 CHECKING THE OUTPUT RELAYS

The C26x's front panel gives access to output relays status for all DO boards (DOU200, DOU201, HBU200, CCU211 or CCU200).

For DOU200 and DOU201 boards:



For CCU200 and CCU211 boards:

```
D   O                                   <time>
                    CCU <Number>

DO 0        <status>
DO 1        <status>
DO 2        <status>
DO 3        <status>




                                  N°page/Number of Pages
```

3.7 TESTING THE COMMUNICATION WITH EXTERNAL DEVICES

The IED panel gives access to the connection state with external devices on Ethernet protocol or serial links:

```
I    E   D                              <time>

IP   CLIENT   NB:

IP SERVER :                        <protocol>
<Server 1 Name>
<Server 1 IP address>          <connection state>
<Server 2 Name>
<Server 2 IP address>          <connection state>
…
LEGACY DEVICE :                    <protocol>
<IED 1 name>
<IED 1 address>                <connection state>
<IED 1 name>
<IED 1 address>                <connection state>
…
                                  N°page/Number of Pages
```

3.8 TESTING THE CONTROL FUNCTIONS

The selected bay type is displayed on the Bay Panel. The activation of the Bay Panel display is described in Chapter C26x/EN HI.

If the position signals of the switchgear units are connected correctly to the C26x, then the updated switching status of the switchgear units will be displayed on the bay panel.

If the switching status is not displayed correctly, the user can check the physical state signals of the binary inputs to determine whether the status signals in the C26x are correct.

3.9 SWITCHING FROM LOCAL TO REMOTE CONTROL

Bays can be controlled locally using the keys on the local control panel or remotely through the communication interface (SCADA or system HMI).

The control point – Local or Remote – is selected either by means of the L/R key on the local control panel or via appropriately configured binary signal input. If binary signal input has been configured, then the L/R key has no effect.

Switching from Remote to Local using the L/R key on the local control panel is only possible if the L/R password has been entered. The selected control point is displayed on the Bay Panel.

3.9.1 LOCAL CONTROL

Bay to be controlled is selected by pressing the Selection key on the local control panel.

If the bay is to be controlled through binary signal inputs, then the appropriate signal input must be triggered.

3.9.2 REMOTE CONTROL

The switchgear units can be controlled via the communication interface or appropriately configured binary signal inputs.

4 COMMISSIONING TESTS WITH GHU210 OR GHU211 (WITHOUT LCD)

After the C26x has been installed and connected as described in chapters C26x/EN IN and C26x/EN CO, the commissioning procedure can begin.

Before turning on the power supply voltage, the following items must be checked:

- Is the device connected to the protective ground at the specified location?
- Does the nominal (and measured) voltage of the battery agree with the nominal auxiliary voltage of the device?
- Are the current and voltage transformer (if used) connections, grounding, and phase sequences correct?

After the wiring work is completed, make sure the system is properly isolated.

Once all checks have been made, the power supply voltage may be turned on.

After the voltage has been applied, the C26x starts up.

During start-up, various tests are carried out; the results show on the LEDs.

If a database is present in the C26x, the fourth LED will stay on.

After approximately 30 s, the C26x is ready for operation.

After the settings have been made, it is necessary to check that the software and the database versions are compatible with the hardware.

Carry put checks using the CMT (see chapter C26x/EN IN).

With the CMT, the “Computer version” button gives access to the current C26x software version, the active database and the C26x operational mode.

For a normal behaviour, the C26x mode is “ACTIVE”.

5 PROTECTION COMMISSIONING TESTS

5.1 PROTECTION COMMISSIONING TEST ENVIRONMENT

5.1.1 IMPORTANT NOTES

All the commissioning tests of the DS Agile C26x are carried out by injecting currents and voltages to the secondary of the earth and/or phase CTs and VTs using appropriate injection test sets provided for this purpose.

5.1.1.1 INJECTION TEST SETS

The test of directional protection within the DS Agile C26x requires at least a phase current, phase to phase and residual voltage injection.

The test equipment must provide tools to change the phase between voltage and current.

For reasons of convenience (weight, spatial requirement, transportation), a single-phased current injection and single voltage test set is more suitable for commissioning and is able to perform all commissioning tests regarding overcurrent directional/non directional protection of DS Agile C26x.

Thus, the following descriptions indicate how to conduct the commissioning tests with a single-phase injection test set.

However, for certain commissioning tests, the three-phase wiring diagrams are easier to understand and in this case the description is also given in three-phase format.

Single-phase injection test set:

- 1 current (0 to 50 A), timer (precision 1 ms)
- 1 voltage (30 to 130 V), timer (precision 1 ms)

Three-phase injection test set:

- 3 currents (0 to 50 A), timer (precision 1 ms)
- 3 voltage (30 to 130 V), timer (precision 1 ms)

Possibility to lag the current respect to voltage injection.

Additional commissioning test equipment:

- 1 multimeter (precision 1%)
- 1 connecting terminal to measure the currents exceeding 10 A (precision 2%)

Test plugs and wires to carry out injections to the CT's secondary (dimension according to the currents injected).

5.1.2 PROTECTION COMMISSIONING TEST SHEETS

Commissioning test sheets are available in the chapter C26x/EN RS.

The presentation of the Commissioning test sheets follows the description of the tests of this chapter.

The contents of these Protection Commissioning test sheets enable you to log:

- The characteristics of the DS Agile C26x for the protection features
- The various settings
- The results of the protection checks
- The result of the test records after commissioning.

5.2 PRODUCT VERIFICATION TESTS



Caution:
Before carrying out any work on the equipment, the user should be familiar with the contents of the safety guide SFTY/4LM/E11 or later issue, or the safety and technical data sections of the technical manual and also the ratings on the equipment rating label.

5.3 ALLOCATION OF TERMINALS

It is necessary to consult the appropriate wiring diagram provided in the chapter C26x/EN CO of this Technical Guide whilst observing the various polarities and ground/earth connection.

5.4 ELECTROSTATIC DISCHARGE (ESD)

Before any handling of the module (active part of the relay), please refer to the recommendations in C26x/EN SA.

5.5 CURRENT TRANSFORMERS (CTS)



Warning:
Never open circuit the secondary circuit of a current transformer since the high voltage produced may be lethal and could damage insulation.

5.6 USE OF A CORE BALANCE CT FOR EARTH FAULTS

If a core balance CT is used to detect earth faults, prior to any test, the user must check the following points:

- MV or HV cable screens and core CT
- No current flow through the MV or HV cables
- Orientation of the core CT (P1-S1, P2-S2)

5.6.1 CABLE SHIELDS AND CORE CT

When mounting a core balance CT around electric cables, check the connection to the earth of the cable shields. It is vital that the earth cable of the shield moves in the opposite direction through the core CT. This cancels the currents carried by the cable shields through the core CT.

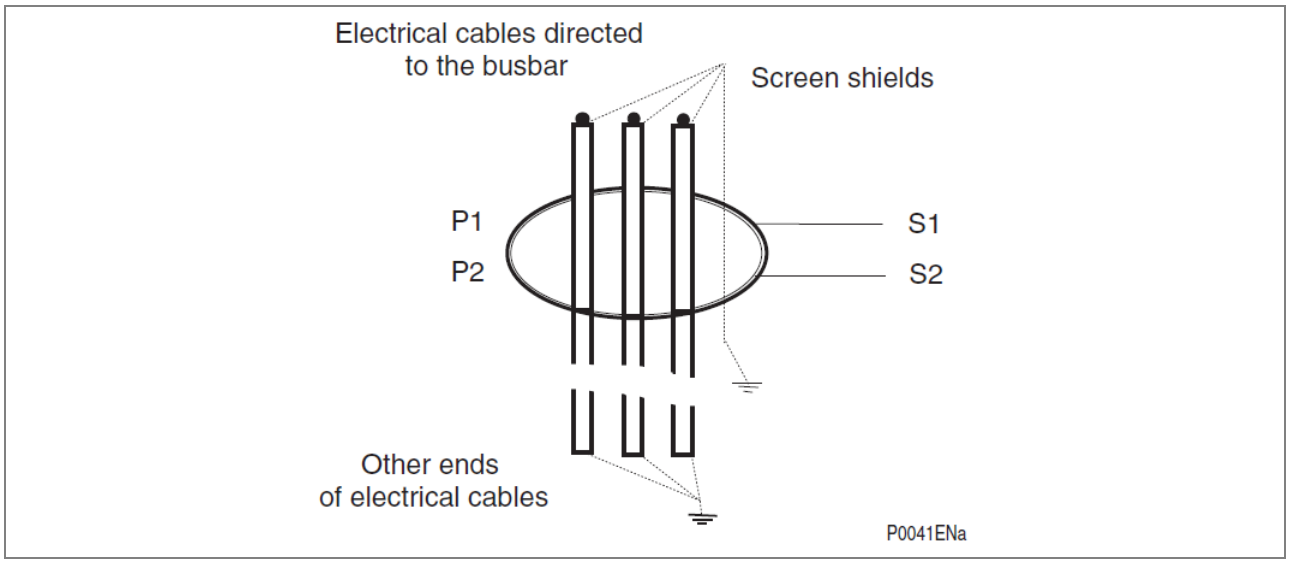


Figure 1: Screen shields and core CT

5.6.2 CORE CT POLARITY

It is necessary to check the polarity of the core CT by following the figure below:

Momentarily connect the battery + to P1 and – to P2. The centre zero ammeter connected with + to S1 and – to S2 will deflect in the positive direction if the wiring is correct.

The phase CT may be tested using the same method.

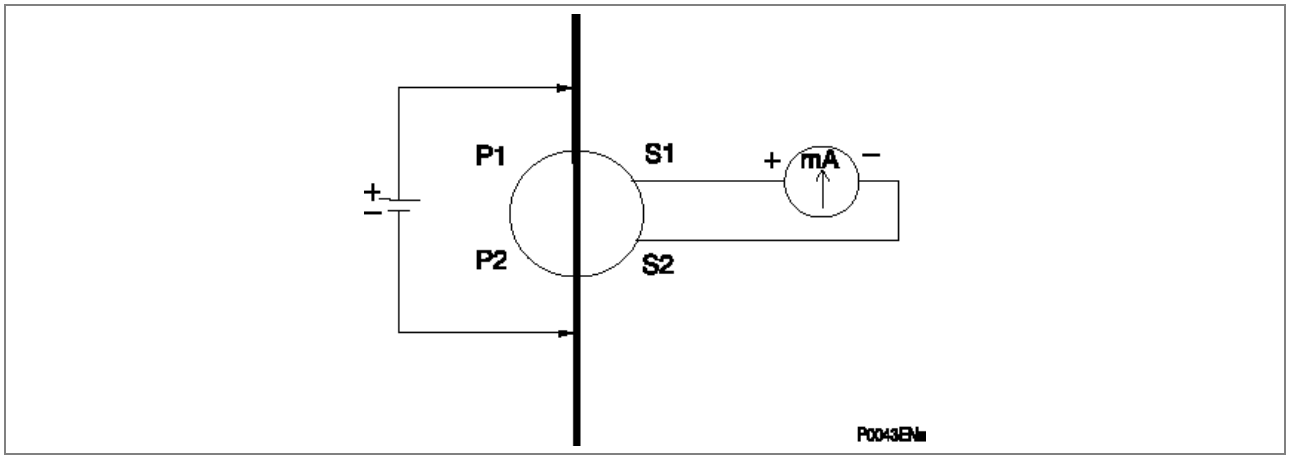


Figure 2: CORE CT ORIENTATION TEST

Note:
De-magnetise the CT after polarity test. Inject an ac current starting from zero and increase to slowly exceed the CT nominal value and then decrease slowly to zero.

5.7 PROTECTION PARAMETERS CHECK

The C26x protection parameters checks must ensure that all C26x parameters have been correctly applied to the C26x for the specific application.

Transfer the Protection parameters file to the C26x using a laptop PC running the appropriate software (DS Agile S1) via the Ethernet port.

Note:
The DS Agile SCE settings are consider to be correctly download and compliant with the application including the different DIs, Dos and AIs assignment.

The commissioning checks are as follows:

19 Protection parameters verify and delivery to customer

20 Validation of the measurements

21 Validation of the thresholds and associated timers.

5.8 SETTINGS

Log the Protection parameters on the commissioning test sheets.

5.9 MEASUREMENTS

The DS Agile C26x measures phase and earth currents, phase (phase to phase) voltage, zero sequence voltage as a true RMS value up to the 15th harmonics. The value(s) indicated take account of the phase and/or earth CT ratio and VT ratio.



Caution:
The DS Agile C26x has 1 and 5 A current inputs,
and 57 – 130 V or 220 – 480 V voltage input.
Check that the injected current and voltage are compatible with the selected range.

5.10 PROCEDURE

- Note the select phase and earth CTs ratio, phase voltage VTs ratio and neutral voltage VTs ratio as configured in the SCE and S1V4 files
- Energise the DS Agile C26x relay.
- Apply current to TMU210 inputs terminals 15-16 and verify the I_A value shown on the LCD or on the CMT.
- Apply current to TMU210 inputs terminals 11-12 and verify the I_B value shown on the LCD or on the CMT.
- Apply current to TMU210 inputs terminals 7-8 and verify the I_C value shown on the LCD or on the CMT.
- Apply current to TMU210 inputs terminals 3-4 and verify the I_N value shown on the LCD or on the CMT.
- Apply voltage to TMU210 inputs terminals 21-22 and verify the V_A value shown on the LCD or on the CMT.
- Apply voltage to TMU210 inputs terminals 23-24 and verify the V_B value shown on the LCD or on the CMT.
- Apply voltage to TMU210 inputs terminals 25-26 and verify the V_C value shown on the LCD or on the CMT.
- Apply voltage to TMU210 inputs terminals 27-28 and verify the V_N or V_{BB} value shown on the LCD or on the CMT.

Log the results to the Commissioning test sheets (Applied values and C26x values displayed).

5.11 THRESHOLD CHECKS

This test type demonstrates that the C26x is operating correctly at the application specific protection parameters.

5.11.1 PROTECTION PARAMETERS

Set the following parameters for the DS Agile C26x

Applying the voltage and current to terminals as in wiring diagrams in chapter C26x/EN CO.

The applied current and voltage must be great than setting value.

5.11.2 OVERCURRENT PARAMETERS

CONFIGURATION	
General Options	
2Vpp+Vr	
Transfo. Ratio	
Line CT primary	1 A
Line CT Sec	1 A
E/Gnd CT primary	1 A
E/Gnd CT Sec	1 A
Line VT primary	0.100 kV
Line VT Sec	100.0 V
E/Gnd VT primary	0.100 kV
E/Gnd VT Sec	100.0 V

CONFIGURATION	
Protection Menu G1	
I>	Yes
I> VALUE	1 In
tI>	DT or IDMT or RI
tI> (if DT)	10 s
Curve (if IDMT)	IEC VI or IEEE VI
TMS value (if IDMT)	1
K value (if RI)	1
U>	OR
U> VALUE	20V
tU>	10 s
U<	OR
U< VALUE	20V
tU<	10 s
Ie>	Yes
Ie> VALUE	1 In
tIe>	DT or IDMT or RI
tIe> (if DT)	20 s
Curve (if IDMT)	IEC VI or IEEE VI
TMS value (if IDMT)1	K value (if RI)=1
Un>	10 V
tUn>	10 s
Automation Menu	
TRIP tI>	YES
TRIP tU>	YES
TRIP tIe>	YES
TRIP Un>	YES

5.11.2.1 EARTH CURRENT AND VOLTAGE TEST

After the setting is completed connect the relay using the wiring diagram in chapter C26x/EN CO.

5.11.2.1.1 Phase overcurrent I> threshold test

Phase overcurrent threshold check:

- If the time-delay tI> is short, gradually increase the injection current up to the value of the I> threshold.
- If the time-delay tI> is long, inject 0.95 x I threshold and check that there is no tripping. Then inject 1.1 x I threshold and check the trip.
- Gradually decrease the injected current and record the value of the drop out off (I> threshold).

Checks:

- Alarm message on the LCD display. (if configured).
- Alarm LED flashes (if configured).
- Trip LED on (if configured).
- I> threshold LED on (if configured).
- Trip output closes (if configured).
- I> threshold output closes (if configured).

Delay type: Definite time tI>

- Apply a current into one of the phases and measure the time-delay tI> by pre-setting the current above the I> threshold (I injected > 2 x I threshold).
- Apply a current onto one of the phases and measure the time-delay tI> by pre-setting the current above the I> threshold (I injected > 10 x I threshold).

Checks:

- Alarm message on the LCD display for I> after that the setting trip time-delay has elapsed (if configured).
- Alarm LED flashes > after that the setting trip time-delay has elapsed (if configured).
- Trip LED on after that the setting trip time-delay has elapsed (if configured).
- I> threshold LED on (if configured).> after that the setting trip time-delay has elapsed.
- Trip output closes > after that the setting trip time-delay has elapsed (if configured).
- I> threshold output closes (if configured).> after that the setting trip time-delay has elapsed.

Delay type: Inverse time (IDMT)

Used threshold for this test:

- I>, tI>
- Supply the C26x, inject a current equal to 2 x I> threshold into one of the earth current inputs. Repeat the operation for various current values (n x Ie threshold with n ranging from 4 to 10, for example). Check that the values measured correspond to those indicated in the table below (for TMS=1).

IEC curves

Type of curve	Tripping time (in seconds) for TMS =1			
IEC	2 x I threshold		10 x I threshold	
	Nominal	Min - Max	Nominal	Min - Max
STI	1.78	1.62 - 1.98	0.5	0.45 - 0.55
SI	10.1	9.1 - 11.1	3	2.7 - 3.3
VI	13.5	12.2 - 14.9	1.5	1.35 - 1.65
EI	26.7	24 - 29.5	0.8	0.72 - 0.88
LTI	120	108 - 132	13.3	12 - 14.6

IEEE/ANSI curves

Type of curve	Tripping time (in seconds) for TMS =1			
IEEE/ANSI	2 x I threshold		10 x I threshold	
	Nominal	Min - Max	Nominal	Min - Max
STI	0.25	0.22 - 0.28	0.08	0.07- 0.09

Type of curve	Tripping time (in seconds) for TMS =1			
MI	3.8	3.4 - 4.2	1.2	1.08 - 1.32
I	2.2	1.9 - 2.4	0.3	0.27 - 0.33
VI	7.2	6.5 - 8	0.7	0.63 - 0.77
EI	9.5	8.5 - 10.5	0.4	0.36 - 0.44

RI electromechanical curve

Type of curve	Tripping time (in seconds) for K =1			
Electromechanical	2 x I threshold		10 x I threshold	
	Nominal	Min - Max	Nominal	Min - Max
RI	4.5	4 - 5	3.2	2.8 - 3.6

For other injected current values, compare the values found with the theoretical values calculated according to the formula of the curves.

Note:
Equations of IEC, IEEE/ANSI and RI curves are given in chapter C26x/EN TD.

Checks:

- I> Alarm message on the LCD display (if configured)
- Alarm LED flashes (if configured)
- Trip LED on (if configured)
- I> threshold LED on (if configured)
- Trip output closes (if configured)
- I> threshold output closes (if configured)

5.11.2.1.2 Phase to phase (phase to neutral) over-voltage U> threshold

Phase overcurrent threshold check:

- If the time-delay tU> is short, gradually raise the injection voltage up to the value of U> threshold.
- If the time-delay tU> is long, inject 0.95 x U> threshold setting and check there is no trip. Then inject 1.1 x U> threshold setting and check the trip output is close.
- Gradually lower the injected current and note the value of the drop out U> threshold.

Checks:

- Alarm message on the LCD display for U> after that the setting trip time-delay has elapsed (if configured).
- Alarm LED flashes (if configured). after that the setting trip time-delay has elapsed.
- Trip LED on, after that the setting trip time-delay has elapsed (if configured).
- U> threshold LED on (if configured) > after that the setting trip time-delay has elapsed.
- Trip output closes U> after that the setting trip time-delay has elapsed (if configured).
- U> threshold output closes (if configured) after that the setting trip time-delay has elapsed.

5.11.2.1.3 Earth fault overcurrent and residual over voltage test.

Delay type: Definite time

Used thresholds for this test:

- Ie>, tIe>, Un >, tUn>.
- Supply the C26x, inject current and voltage with magnitude greater then Ie> and Un> setting value.
- If the time-delay tIe> is short, gradually increases injection current up to the value of the Ie> threshold.
- If the time-delay tIe> is long, inject 0.95 x I threshold and check that there is no tripping. Then inject 1,1 x Ie threshold and check the trip.
- Gradually decreases the injected current and record the value of the drop out Ie> threshold.
- The same procedure above for Un>

Checks:

- Alarm message on the LCD display (if configured)
- Alarm LED flashes (if configured)
- Trip LED on (if configured)
- Ie>, Un> threshold LED on (if configured)
- Trip output closes (if configured)
- Ie>, Un> threshold output closes (if configured)

Delay type: Inverse time (IDMT)

Used thresholds for this test:

- Ie>, tIe>
- Supply the C26x inject a current equal to 2 x Ie> threshold into one of the earth current inputs. Repeat the operation for various current values (n x Ie threshold with n ranging from 4 to 10, for example). Check that the values measured correspond to those indicated in the table below (for TMS=1).

IEC curves

Type of curve	Tripping time (in seconds) for TMS =1			
IEC	2 x I threshold		10 x I threshold	
	Nominal	Min - Max	Nominal	Min - Max
STI	1.78	1.62 - 1.98	0.5	0.45 - 0.55
SI	10.1	9.1 - 11.1	3	2.7 - 3.3
VI	13.5	12.2 - 14.9	1.5	1.35 - 1.65
EI	26.7	24 - 29.5	0.8	0.72 - 0.88
LTI	120	108 - 132	13.3	12 - 14.6

IEEE/ANSI curves

Type of curve	Tripping time (in seconds) for TMS =1			
IEEE/ANSI	2 x I threshold		10 x I threshold	
	Nominal	Min - Max	Nominal	Min - Max
STI	0.25	0.22 - 0.28	0.08	0.07- 0.09
MI	3.8	3.4 - 4.2	1.2	1.08 - 1.32
I	2.2	1.9 - 2.4	0.3	0.27 - 0.33
VI	7.2	6.5 - 8	0.7	0.63 - 0.77

Type of curve	Tripping time (in seconds) for TMS =1			
EI	9.5	8.5 - 10.5	0.4	0.36 - 0.44

Checks:

- Ie> Alarm message on the LCD display (if configured)
- Alarm LED flashes (if configured)
- Trip LED on (if configured)
- Ie> threshold LED on (if configured)
- Trip output closes (if configured)
- Ie> threshold output closes (if configured)

5.11.3 FREQUENCY PARAMETERS

CONFIGURATION	
General Options	
3Vpp+Vr	
Transfo. Ratio	
Line VT primary	0.100 kV
Line VT Sec	100.0 V
E/Gnd VT primary	0.100 kV
E/Gnd VT Sec	100.0 V
Protection Menu G1	
- [81] f1?	MIN
- f1 VALUE	49Hz
- tf1	1s
- [81] f2?	MAX
- f2 VALUE	51 Hz
- tf2	1s
- df/dt1?	ON
- df/dt1 VALUE	+0.5 Hz/s
- t df/dt1	1s
- df/dt1 Id	1A
- df/dt2?	ON
- df/dt2 VALUE	-0.5 Hz/s
- t df/dt2	1s
- df/dt2 Id	1A
Automation Menu	
TRIP f1	YES
TRIP f2	YES
TRIP df/dt1	YES
TRIP df/dt2	YES

5.11.3.1 OVER- AND UNDERFREQUENCY TEST

Values to be measured:

1 stages (f1) and (f2)

2 time-delay (tf1) and (tf2)

Stage (f1) check:

1 Gradually increase the frequency from the nominal frequency fn to the value of the stage (f1): tripping should occur for a frequency in the range
[(f1) – 10 mHz, (f1) + 10 mHz].

2 Adjust the frequency to [(f1) – 50 mHz] and check that tripping does not occur. Increase the frequency to 1.2 x (f1) and check that tripping occurs.

3 Gradually reduce the frequency and measure the value of the drop-off stage (f1): the function must reset for a frequency less than or equal to [(f1) – 50 mHz].

Stage (f2) check:

1 Gradually decrease the frequency from the nominal frequency fn to the value of the stage (f2): tripping should occur for a frequency in the range [(f2) – 10 mHz, (f2) + 10 mHz].

2 Adjust the frequency to [(f2) + 50 mHz] and check that tripping does not occur. Increase the frequency to 0.8 x (f2) and check that tripping occurs.

3 Gradually increase the frequency and measure the value of the drop-off stage (f2): the function must reset for a frequency less than or equal to [(f2) + 50 mHz].

Checks:

- f1 & f2 Alarm messages on the LCD display (if configured).
- Alarm LED flashes (if configured).
- Trip LED on (if configured).
- f1 & f2 thresholds LED on (if configured).
- Trip output closes (if configured).
- f1 & f2 threshold outputs close (if configured).

5.11.3.2 RATE OF CHANGE OF FREQUENCY TEST

Values to be measured:

- Stages (df/dt1) and (df/dt2)
- Time delay (t df/dt1) and (t df/dt2)

Stage (df/dt1) check:

Gradually increase the frequency from the nominal frequency from 50 Hz to 51 Hz with a variation of 1 mHz every 1 ms and check for the tripping and information.

Stage (df/dt2) check:

Gradually decrease the frequency from the nominal frequency from 50 Hz to 49 Hz with a variation of 1 mHz every 1 ms and check for the tripping and information.

Checks:

- df/dt1 & df/dt2 Alarm messages on the LCD display (if configured).
- Alarm LED flashes (if configured).
- Trip LED on (if configured).
- df/dt1 & df/dt2 thresholds LED on (if configured).
- Trip output closes (if configured).
- df/dt1 & df/dt2 threshold outputs close (if configured).

5.12 FINAL CHECKS

1 Remove all test or temporary shorting leads, etc… If it is necessary to disconnect any of the external wiring from the relay in order to perform the wiring verification tests, it should be ensured that all connections are replace in accordance with the relevant external connection or scheme diagram.

2 If a test block is installed, remove the test plug and replace the cover so that the C26x can be commissioned.

3 Ensure that all event, fault and disturbance records, alarm and LEDs have been reset before leaving the C26x.

MAINTENANCE

C26X/EN MF/D40

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1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the Maintenance and Fault Finding procedures of the DS Agile C26x. Reading chapter C26x/EN SA is mandatory.

2 STANDARD MAINTENANCE OPERATION

The aim of this chapter is to describe standard methods to diagnose the DS Agile C26x status, and provide common maintenance procedures for the replacement and/or addition of components.

Before any maintenance operation, please refer to the chapter C26x/EN SA (Safety) and to the GE Grid Solutions Safety Guide: SFTY/4L M/C11 (or later issue).

2.1 LEVEL 1 DIAGNOSIS FACILITIES

When maintenance action is planned, the operator should prepare, act and report.

The minimal preparation is to get the commissioning Record Sheet (see the chapter C26x/EN RS) of installed DS Agile C26x in order to see the product configuration and its history. Refer to your own experience besides this manual. It is also recommended to extract the logbook history in order to be informed of the intervention conditions.

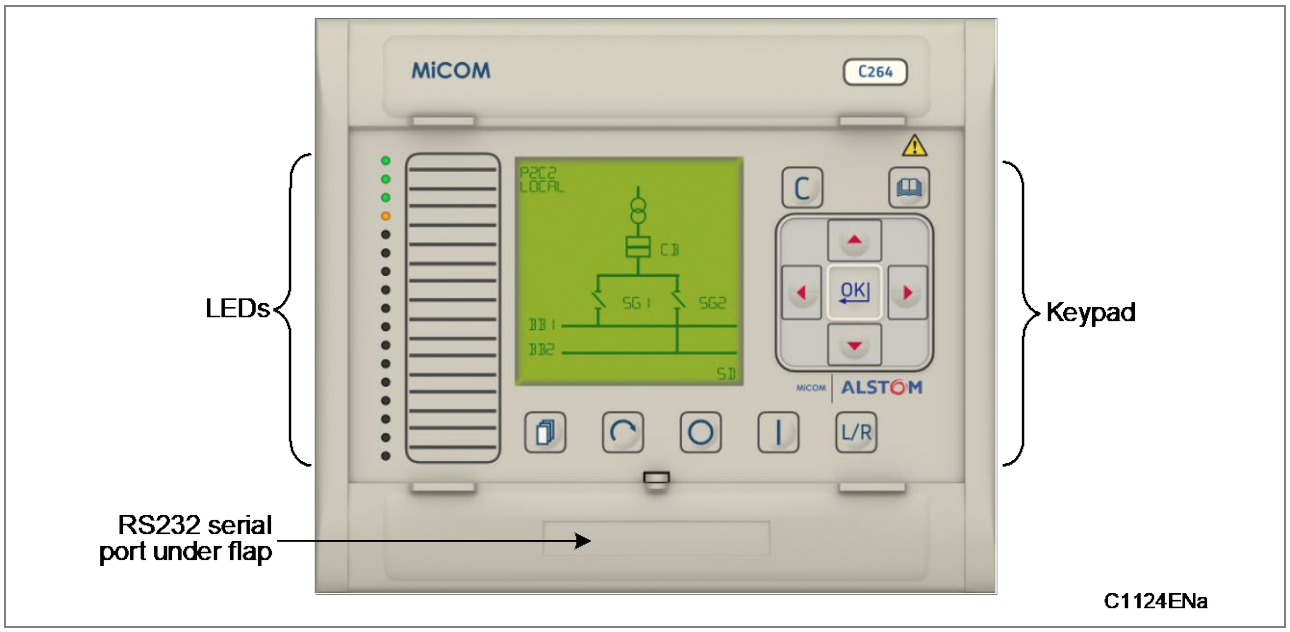
At a first level the product provides several methods to check the context of the fault. The main ones are:

- LEDs
- LCD (Liquid Crystal Display)

2.1.1 FRONT PANEL LED INDICATIONS

Refer to chapter C26x/EN HI for the precise LED's description.

On the main rack:



The first 5 LEDs indicate the DS Agile C26x status information. With reference to the chapter C26x/EN HI (Human Interface), the LEDs indicate from top to down:

LED id	Colour	LED on	LED slow blinking	LED fast blinking	LED off
1	Red	There is at least one major fault (hardware, database) (1)	There is at least one minor fault (I/O board, communication to IEDs)(2)	Not used	No fault
2	Yellow	All the alarms are ac-knowledged, but there is at least one alarm still active (3)	All alarms displayed in the alarm panel are inactive and acknowledged	There is at least 1 not acknowledged alarm displayed in the alarm panel	No alarm
3	Amber	C26x in operation	C26x in maintenance	C26x in test	C26x in reboot
4	Green	Power on	Not used	Not used	Power off
5 (4)	Red	All bays managed by the C26x are in LOCAL mode	Bays managed by the C26x are not in the same control mode	Not used	All bays managed by the C26x are in REMOTE

(1) Major fault: DS Agile C26x not available due to internal failure (database error, CPU board failure, …).

(2) A minor fault is a fault causing only the non availability of a part of the functionality.

(3) When the alarm disappears, the LED automatically returns to OFF.

(4) Assigned by the C26x only for front panel without LCD: GHU2x1 or for an extension C26x

A minor fault is a fault causing only the non-availability of a part of the functionality:

Symptom	LED status	Possible reason	Way to solve
Functions as commu-nication, automation, printing are well ope-rating & the watchdog on BIU is SET	All LEDs are OFF	The cable between CPU and GHU2xx, or GHU2xx itself is not operational	Verify the connection between CPU or GHU2xx. If connection is OK and the problem is not already solved then change the GHU2xx board.
The supply is ON and the watch dog on BIU is RESET.	LED6 is ON (but LED7 thru 13 are OFF if predefined)	Problem with BIU board or CPU board	Replace BIU board or CPU board.
The C26x is not running or not fully operational	LED1 ON	Incoherent database	Download a coherent database
	At least one prede-fined LED among LED7 thru 13 is ON	Hardware fault	Go in Fault display and Board display to determine the faulty board and change it.
The C26x is not fully operational	LED1 is blinking	An IED is disconnected (LED 6 and/or 12 ON)	Go into IED display to determine the disconnected IED and verify the cable, the BIU configuration, the communication parameters inside the DS Agile configurator, the communication parameters inside the relay.
		The printer is disconnected	Go into Fault display and verify that paper is available, the printer is switch ON, the printer cable
		A problem with clock synchronisation	Go into Fault display & verify that the external clock is switch ON, the external clock is connected to the antenna, the external clock is connected to the C26x.
		A problem with PLC (ISaGRAF)	Go into Fault display & connect the ISaGRAF work bench to the C26x. Verify the behaviour of the PLC.

Note:
After a reboot using the CMT, the PSL might do not work. Use the serial link instead and type 'reboot' in Hyperterminal.

2.1.2 FRONT PANEL LCD INDICATIONS

The GHU200 or GHU210 board gives access to the status of the boards, the state of digital inputs, the state of digital outputs, the connection state with external devices. The CM chapter describes this.

2.1.3 ADJUSTMENT OF THE BRIGHTNESS OF THE FRONT PANEL LCD

When the keys C and OK are pressed simultaneously it is possible to decrease (resp. increase) the brightness of the front panel LCD by pressing key ▲ (resp. ▼).

2.2 MAINTENANCE PERIOD

It is recommended that GE Grid Solutions products receive periodic monitoring after their installation. Deterioration may occur over time. Because of the electrical and disturbed environment, it is recommended to confirm at regular intervals that the DS Agile C26x is operating correctly.

The DS Agile C26x has been designed for a life cycle of over 15 years.

The DS Agile C26x is self-supervising and therefore requires less maintenance than previous products. Most problems will lead to an alarm so fast and appropriate action can be done. However, carry out periodic tests to ensure the DS Agile C26x is operating correctly and that the external wiring in a good condition.

If a Preventative Maintenance Policy exists within the customer's organisation then the recommended product checks should be included in the regular programme. Maintenance periods will depend on many factors, such as:

- the operating environment
- the accessibility of the site
- the amount of available manpower
- the importance of the installation in the power system
- the consequences of failure

2.3 METHOD OF REPAIR

If the DS Agile C26x should develop a fault whilst in service, depending on the nature of the fault, the watchdog contacts will change state and an alarm condition will be flagged. Due to the extensive use of surface-mount components (SMC) faulty boards should be replaced, as it is not possible to perform repairs on damaged circuits with SMC technology. Thus either the complete DS Agile C26x or just the faulty board, identified by the built-in diagnostic software, can be replaced.

The preferred method is to replace the complete DS Agile C26x as it ensures that the internal circuitry is protected against electrostatic discharge and physical damage at all times and overcomes the risk of incoherency with the new boards. In some cases, it may be difficult to remove an installed DS Agile C26x due to limited access in the back of the cubicle and rigidity of the scheme wiring then only the faulty elements will be replaced.

Replacing boards can reduce transport costs but requires clean, dry on site conditions and higher skills from the person performing the repair. If an unauthorized service centre performs the repair, the warranty will be invalidated.



Caution:
Before carrying out any work on the device, the user should be familiar with the contents of the safety and technical data chapters, as well as GE Grid Solutions' Safety Guide: Pxxx-SG-4LM-1 or later issue, and have read the ratings on the equipment's rating label.
This should avoid incorrect handling of the electronic components and damage.



Caution:
Only qualified personnel may carry out maintenance operations.
Always hold boards by their sides: Do not touch either the component side or the soldering side.
Always wear anti-static protection when handling printed circuit boards.

2.3.1 REPLACING THE COMPLETE DS AGILE C26X

The case and rear terminal blocks have been designed to facilitate removal of the complete DS Agile C26x.

Before working at the rear of the DS Agile C26x, isolate all the voltages and currents connected to the DS Agile C26x.

Note:
The DS Agile C26x units have current transformer shorting switches which close when terminal block is removed.

2.3.1.1 REPLACING THE COMPLETE DS AGILE C26X

Note:
Before any disconnection, check the labels correctly define the connectors and match with the wishing description you have. Otherwise, note the current wiring in order to prepare the new C26x installation.

1 Disconnect the power supply connector.

2 Disconnect the DS Agile C26x IRIG-B, fibre optic, Ethernet RJ45 and serial links connected on CPU board.

3 Disconnect the input/output connectors.

4 Disconnect the earth connection.

There are two types of terminal blocks used on the DS Agile C26x:

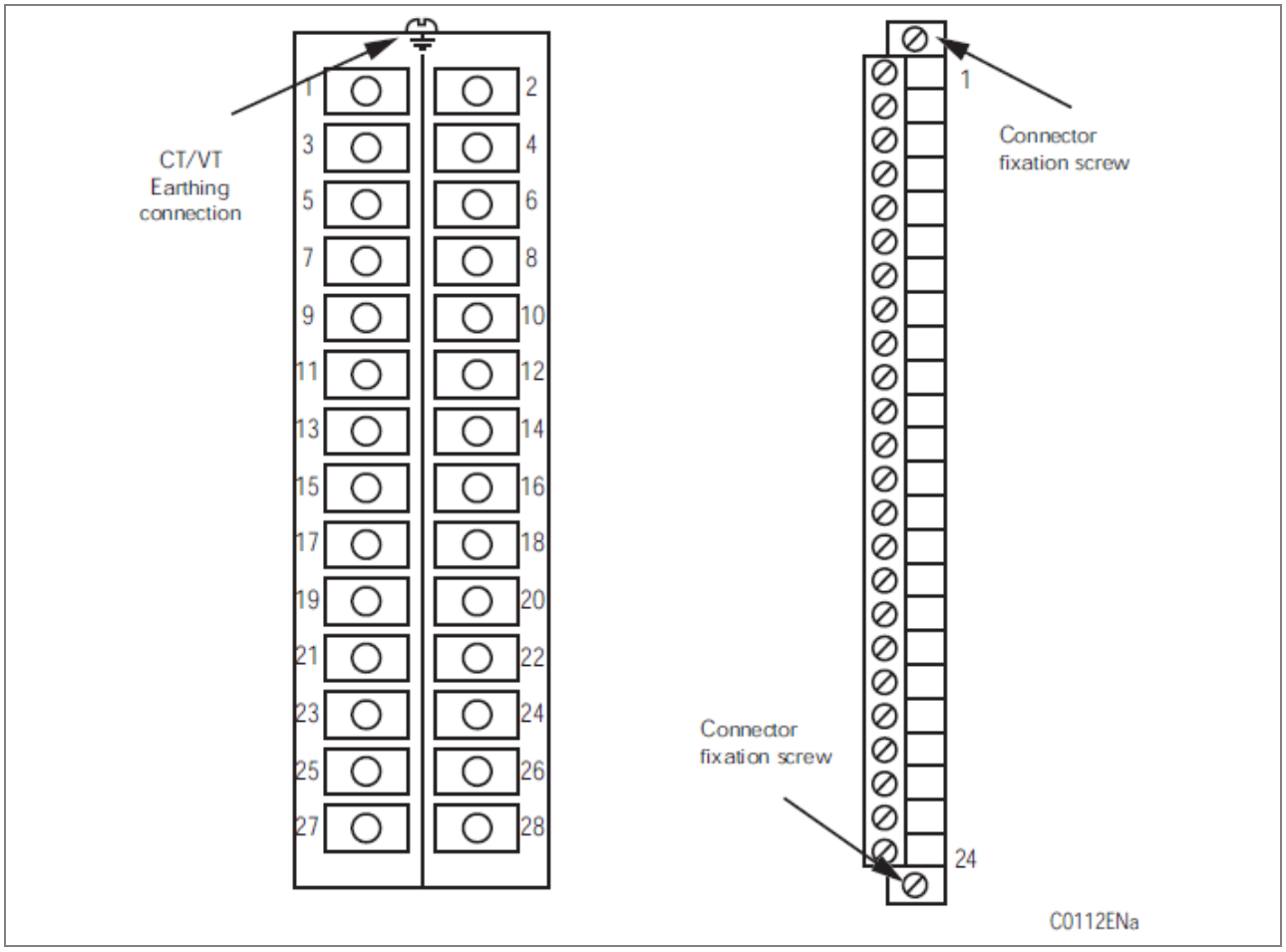


Figure 1: Location of securing screws for terminal blocks

Note:
The use of a magnetic bladed screwdriver is recommended to minimise the risk of the screws being left in the terminal block or lost. A 3 mm flat head screwdriver is recommended for fixation screws. A 6 mm flat head screwdriver is recommended for CT/VT earthing connections.

Without exerting excessive force or damaging the scheme wiring, pull the terminal blocks away from their internal connectors.

Remove the screws used to fasten the DS Agile C26x to the panel, rack, etc. These are the screws with the larger diameter cross heads that are accessible when the access covers are fitted and open.



Caution:
If the top and bottom access covers have been removed, do not remove the screws with the smaller diameter heads even if they are accessible. These screws hold the front panel on the DS Agile C26x.

Withdraw the DS Agile C26x from the panel or rack carefully and take care of its weight because there are some heavy parts due to the internal transformers.

2.3.1.2 INSTALLATION OF A NEW C26X

To reinstall the repaired or new DS Agile C26x, follow the above procedure in reverse. Ensure that each terminal block is relocated in the correct position and the case correctly earthed, IRIG-B and fibre optic connections are put back in place.

Once reinstallation is complete the DS Agile C26x should be commissioned again using the instructions in the chapter C26x/EN CM.

2.3.2 REPLACING A BOARD

To replace any of the DS Agile C26x unit's boards it is necessary to remove the front panel.

Before removing the front panel the auxiliary supply must be switched off. It is also strongly recommended that the voltage and current transformer connections and trip circuit are isolated.

Open the top and bottom access covers. With size 80TE cases the access covers have two hinge-assistance T-pieces which clear the front panel molding when the access covers are opened by more than 120°, thus allowing their removal.

If fitted, remove the transparent secondary front cover. A description of how to do this is given in Chapter C26x/EN IT (Introduction).

By applying outward pressure to the middle of the access covers, they can be bowed sufficiently so as to disengage the hinge lug allowing the access cover to be removed. The screws that fasten the front panel to the case are now accessible.

The size 40TE case has four cross head screws fastening the front panel to the case, one in each corner, in recessed holes. The size 80TE case has an additional two screws, one midway along each of the top and bottom edges of the front plate. Undo and remove the screws.



Caution:
Do not remove the screws with the larger diameter heads, accessible when the access covers are fitted and open.
These screws hold the DS Agile C26x in its mounting (panel or cubicle).

When the screws have been removed, the complete front panel can be pulled forward and separated from the metal case.



Warning:
Caution should be observed at this stage because a cable connects the front panel to the rest of the DS Agile C26x circuitry.

Additionally, from here on, the internal circuitry of the DS Agile C26x is exposed and not protected against electrostatic discharges, dust ingress, etc. Therefore ESD precautions and clean working conditions should be maintained at all times.

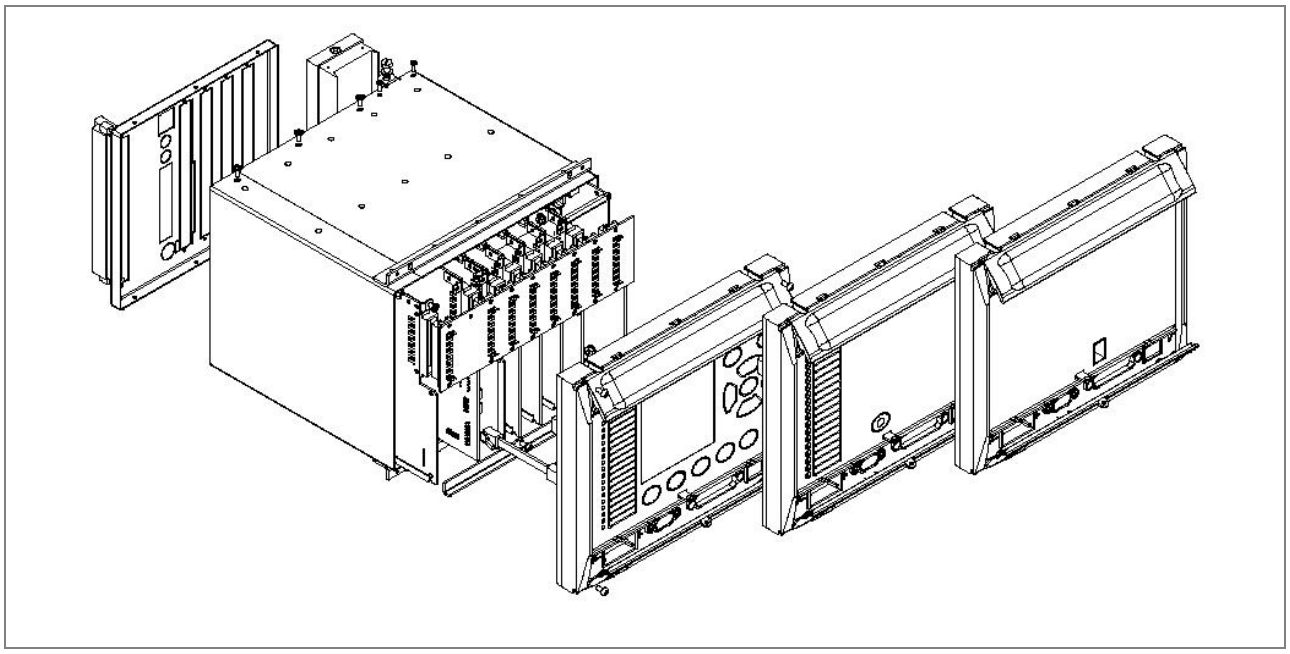


Figure 2: 40TE case with TMU2xx board

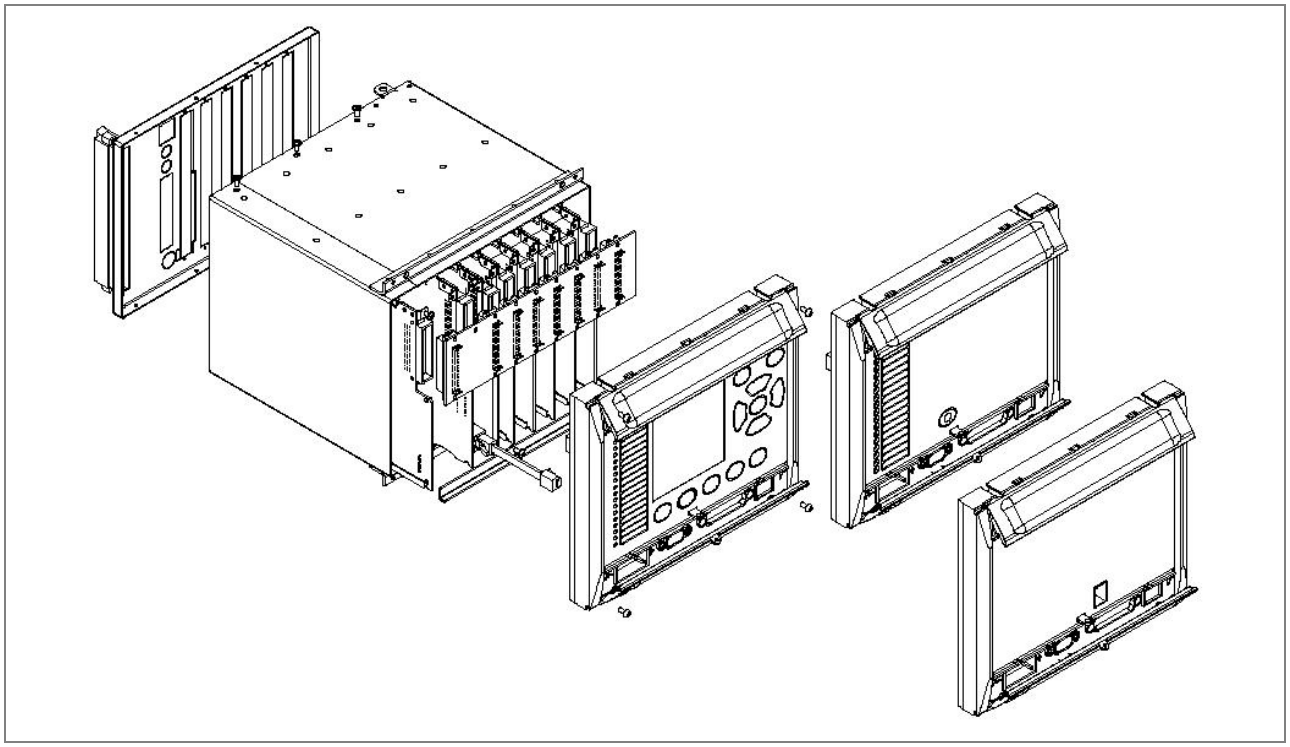


Figure 3: 40TE case without TMU2xx board

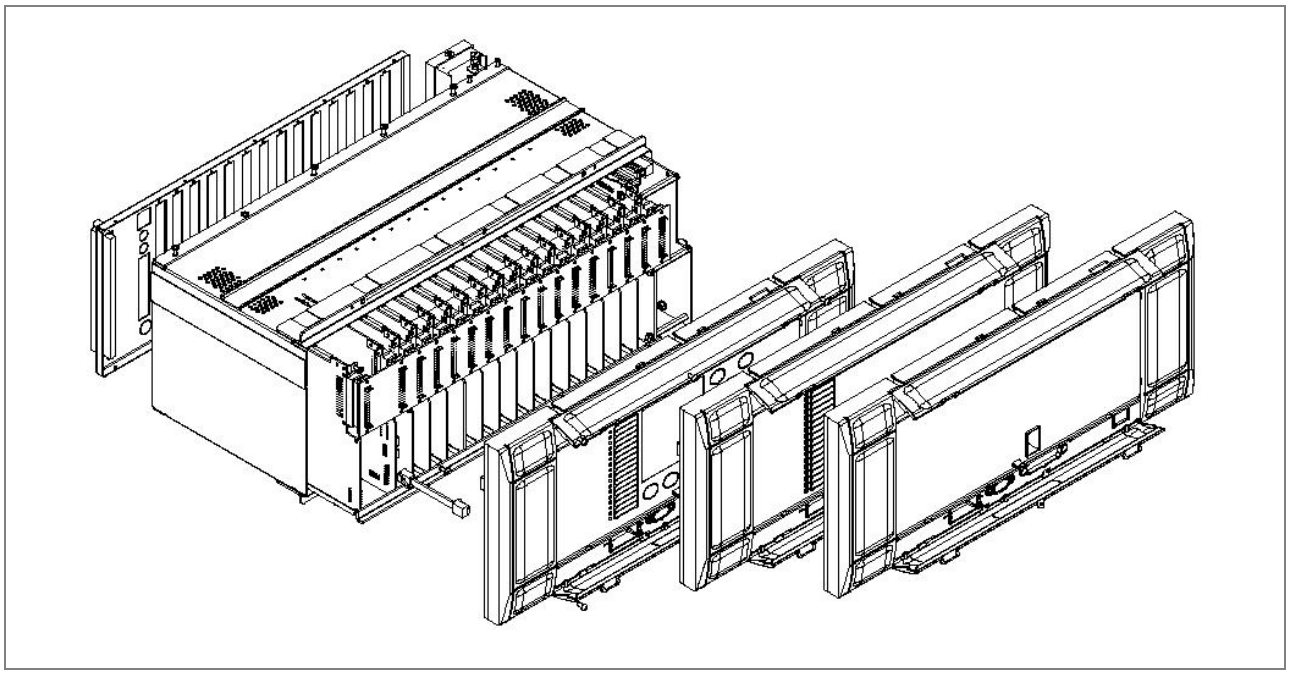


Figure 4: 80TE case with TMU2xx board

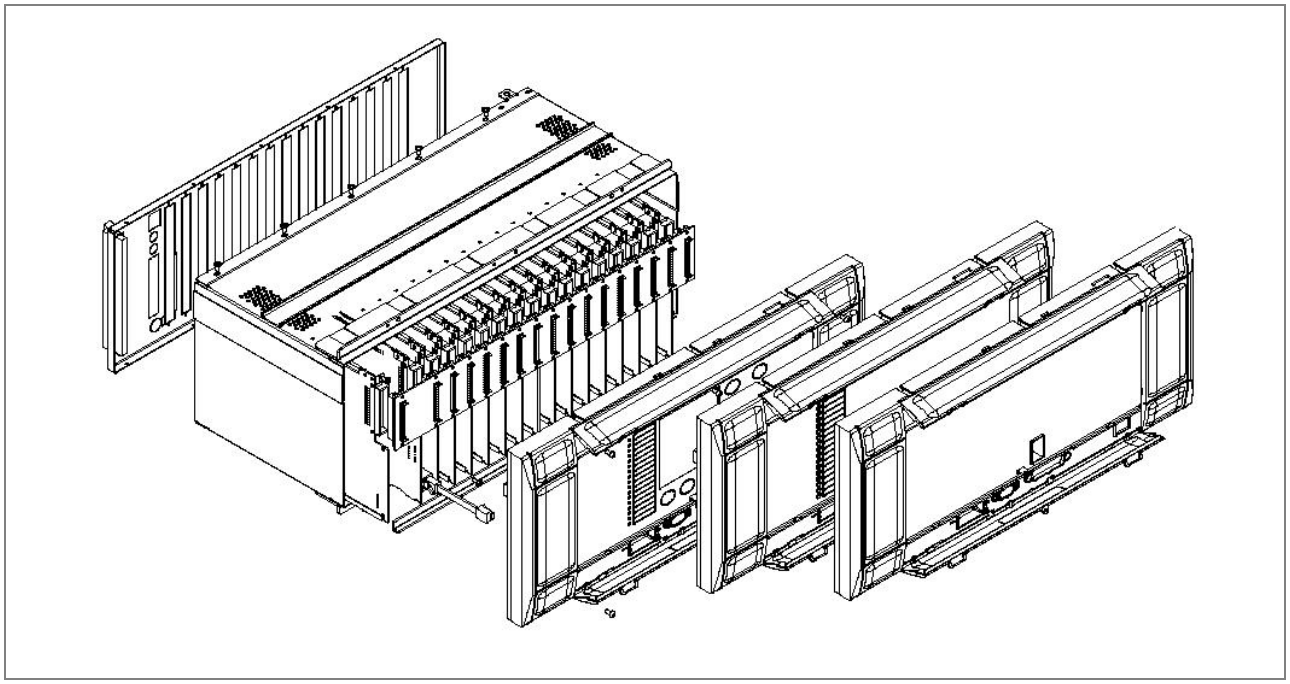


Figure 5: 80TE case without TMU2xx board

The boards within the DS Agile C26x are now accessible. Figures above show the board locations for the DS Agile C26x units in sizes 40TE and 80TE (C26x) cases.

Looking to the front of the DS Agile C26x with the front panel off, you can have access to a printed circuit that connects all the boards together: this is the backplane board.

To remove a board you need to:

- Pull the backplane board (FBP280 for 80TE case or FBP242 for 40TE case) out by holding it by the two extremities.
- Remove the screws and the maintain bar at the bottom of the case.

Note:
To ensure compatibility, always replace a faulty board with one of an identical part number and set jumpers in identical position.

All the boards are shown and described in the chapter C26x/EN HW.

2.3.2.1 REPLACEMENT OF THE BASIC INTERFACE UNIT (BIU241 OR BIU261)

The BIU is the power supply board located on the extreme left-hand side (slot A) of DS Agile C26x.

Pull the power supply module forward, away from the rear terminal blocks and out of the case. A reasonable amount of force will be required to achieve this due to the friction between the contacts of the two medium duty terminal blocks. It is then recommended to use the special tool for extracting board (internal reference is 2070860).

Do not forget to set the jumpers on the new board in the same position as the previous one. If a BIU241 board is being replaced with a BIU261 board or module, refer to chapter Hardware for jumper positions.

Note:
For a 2-board BIU261 module, it will be necessary to remove the back-up power supply daughter board. It is held in place by 4 spacers attached to the boards using 2 x 4 pan head, 6 mm M3 screws and associated washers (standard washers on the outside of the module and tooth shakeproof washers inside). Unfasten the 4 screws on the daughter board and pull it slowly. After checking/setting the jumpers, carefully put the daughter board and washers back into place, insert the screws and fasten them.

2.3.2.2 REPLACEMENT OF THE MAIN PROCESSOR BOARD (CPU270)

Depending on the model of the DS Agile C26x the processor board carried out the IRIG-B functionality's so if you identify an IRIG-B connection problem you will have to replace the processor board.

After replacement of the main processor board, all the settings required for the application must be re-loaded, i.e.

1 the firmware must be updated,
2 the configuration database must be uploaded,
3 the S1 setting file must be uploaded.

The CPU board is located next to the BIU board (slot B).

Do not forget to disconnect the rear cables (RJ45 Ethernet, optical fibers, IRIG-B connector and serial links) before replacing the board and to reconnect them after.

Do not forget to set the jumpers on the new board in the same position as the previous one.

2.3.2.3 REPLACEMENT OF THE ETHERNET SWITCH BOARDS (SWU20X, SWR21X, SWD21X,SWT212, SRP28X OR SRP29X)

The Ethernet switch board is located on slot C or D.

Do not forget to disconnect the rear cables (RJ45 Ethernet and optical fibres) before replacing the board and to reconnect them after.

Do not forget to set the jumpers on the new board in the same position as the previous one.

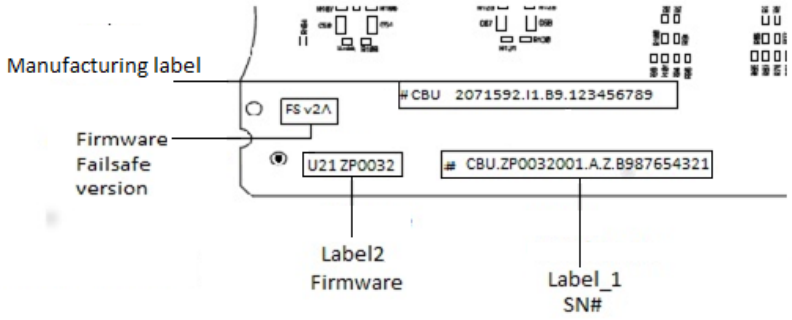
SWT212 board replacement note

The SWT212 labelling of the board is different from other SWx boards.

Before filling out the repair and modification form the Serial number and firmware version are required.

The labels are found in the bottom left corner on the solder side of the board:

- Label_1 (Serial number)
- Label2 (Firmware version)



2.3.2.4 REPLACEMENT OF THE I/O BOARDS (DIU200, DIU210, DIU211, CCU200, CCU211, AOU200, DOU200, DOU201, HBU200, AIU201, AIU210, AIU211)

The I/O boards can be located in any slot from C to Q.

Do not forget to set the jumpers on the new board in the same position as the previous one.



Caution:
A skewed AOU200 board could lead a capacitor (C27) to touch an iron corner. Boards must therefore be handled carefully..

2.3.2.5 REPLACEMENT OF THE TRANSDUCERLESS MEASUREMENTS UNIT (TMU)

The measurement unit is on the extreme right-hand side of DS Agile C26x.

2.3.2.6 RE-ASSEMBLE THE DS AGILE C26X

Before re-assembling the module with a replacement board, make sure that the address for the replacement board is the same address that the board replaced by checking the jumpers on the boards.

Insert the FBP board back into the rack.

Screw the bar to the bottom of the case.

Replace the front panel. After refitting and closing the access covers, press at the location of the hinge-assistance T-pieces so that they click back into the front panel moulding.

Once the device has been reassembled after repair, it must be commissioned again (see chapter C26x/EN CM).

2.4 CLEANING

Before cleaning the DS Agile C26x ensure that all AC/DC supplies, current transformer and voltage transformer connections are isolated to prevent any risk of electric shock whilst cleaning.

Front panel cleaning: use a smooth cloth. Do not use abrasive material or detergent chemicals.

3 MAINTENANCE OPERATIONS

The CMT software is able to:

- Upgrade the C26x software
- Download and switch the databases
- Download the software key

These functions are needed for customizing the C26x.

Expert-level maintenance operations require the use of an SSH terminal. It is launched from the Security tab-pane. See *Installation chapter, C26x/EN IN*, for details.

3.1 REQUIREMENTS

A Personal Computer is needed. The PC hardware requirement is:

- COM port in RS232C (setting)
- 100 MB of free space on hard disk

The needed software is: Serial COM terminal (TeraTerm, HyperTerminal…).

- The Serial COM terminal is configured for serial communication with:
  - TTY mode
  - 19200 Baud/s
  - 8 bits no parity

Select into PC application the PORT 1 or 2 that is physically wired to the DS Agile C26x.

The serial link between PC PORT and DS Agile C26x Maintenance port is made via RS232C with straight-through cable.

3.2 INSTALLATION AND GENERAL USE

Connect the RS cable between the DS Agile C26x front panel and the PC, and run the Telnet software If the parameters and wiring are correct, the connection is established.

Restart the C26x with a power reset and stop the first count down with any key. The following prompt is displayed: [VxWorks Boot]:

Each parameter is displayed one by one with each CR. If a mistake is made, press CR several times, then restart the operation again.

The stored value is displayed. If nothing is entered, pressing CR will keep the stored parameter.

The **.** key allows the replacement of the stored value by nothing.

Example of console listing (start-up):



3.3 HOW TO DETERMINE THE BOOTROM VERSION

The version is displayed after **BSP version** (B0.21C in the above screenshot).

For BOOTROM versions lower than B015: at the prompt, type: [VxWorks Boot]: v

For BOOTROM versions upper or equal to B015: just read the first lines

3.4 HOW TO RESTORE THE C26X BOOT PARAMETERS

Restoring the C26x boot parameters could be useful after a wrong maintenance action if boot parameters have been suppressed.

Checking default settings: p command

At the prompt, type: [VxWorks Boot]:p

The following information should be displayed:

- “boot device : tffs=0,0
- “processor number : 0
- “host name : <factory host PC name>
- “file name : /flash/bin/vxWorks
- “inet on ethernet : <factory C26x IP addres xxx.xxx.xxx.xxx>
- “inet on backplane :
- “host inet : <factory host IP adresse xxx.xxx.xxx.xxx>
- “gateway inet : 0.0.0.0
- “user : <user name>
- “ftp password : <password>
- “flags : 0x0
- “target name : <factory target name>
- “startup script :
- “other : motfec

[VxWorks Boot]:

Settings to enter

The settings to enter are:

- factory host PC name: your maintenance laptop network name
- factory host IP address: your maintenance laptop IP@
- factory target name: should be the controller name defined by SCE for its database
- factory C26x IP address: should be the controller IP address defined by SCE for its database
- user name and ftp: password: FTP user name, defined for the FTP server - it is good practice to keep factory setting and to define on the PC user C264_cpu3 according to your CPU type with the password vxWorks

Do not modify other parameters.

Input new settings: c command

Configure with the **c** command the communication settings of the DS Agile C26x.

Enter the Configuration Command: [VxWorks Boot]: c

Wait till the display of [VxWorks Boot]:

Enter the Default settings Command: [VxWorks Boot]: p

The following information should be displayed:

- “boot device : tffs=0,0
- “processor number : 0
- “host name : <Enter host PC name>
- “file name : /flash/bin/vxWorks
- “inet on ethernet : <Enter C26x IP address: xxx.xxx.xxx.xxx>
- “inet on backplane :
- “host inet : <Entrer host IP address: xxx.xxx.xxx.xxx>
- “gateway inet : 0.0.0.0
- “user : <user name>
- “ftp password : <password>
- “flags : 0x0
- “target name : <target name>
- “startup script :
- “other : motfec

[VxWorks Boot]:

Now restart the controller with the new parameters, either with a power reset, or by typing:

[VxWorks Boot]: @

After the reboot the C26x is ready for receiving the application software. Refer to the chapter C26x/EN IN to go ahead.

4 C264 FIRMWARE UPGRADE FROM V6.3.1 TO V5.1

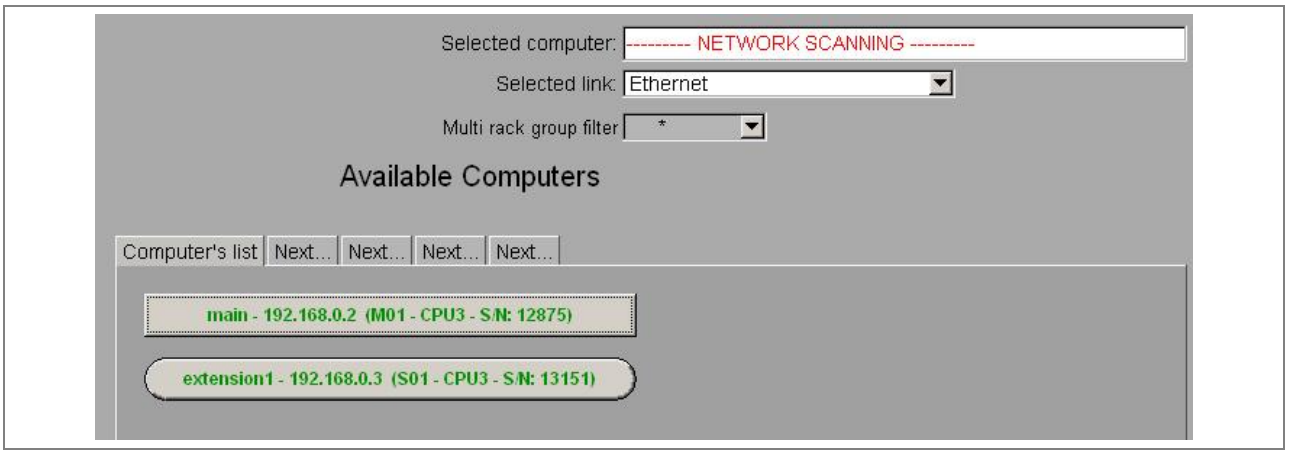
Before starting the upgrade, both the dsagile-v5.1.35.0-base and the dsagile-v6.3.1.0.0-base versions of the CMT must be installed.

Note:
Note that the update is not applicable for the DSagile-v5.1.35.0-build01 and older versions.

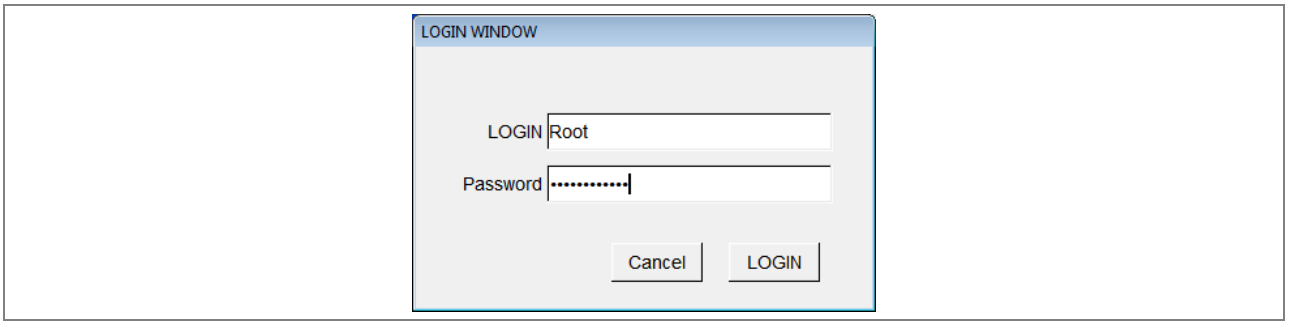
4.1 CPU270 BOARD REBOOT AND SET-UP

1 Launch the CMT application of the c264-6.7.0.0-buildxx (dsagile-v6.3.1-base) by clicking the Computer Maintenance Tool shortcut icon.

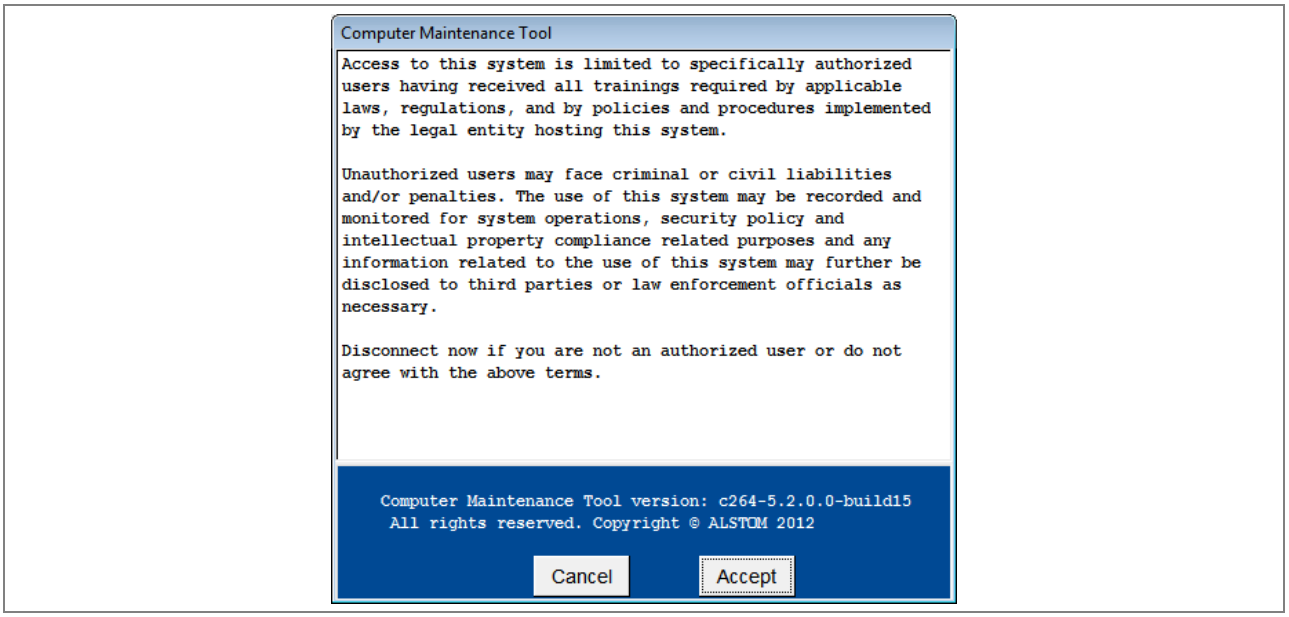
2 Click the **Search computers** button to find your C26x and wait a couple of minutes until a label with an IP address is displayed in the Computer's list tab-pane and then, select your C26x.



3 In the login popup, enter your credentials (default user: root; password: Root1234#).

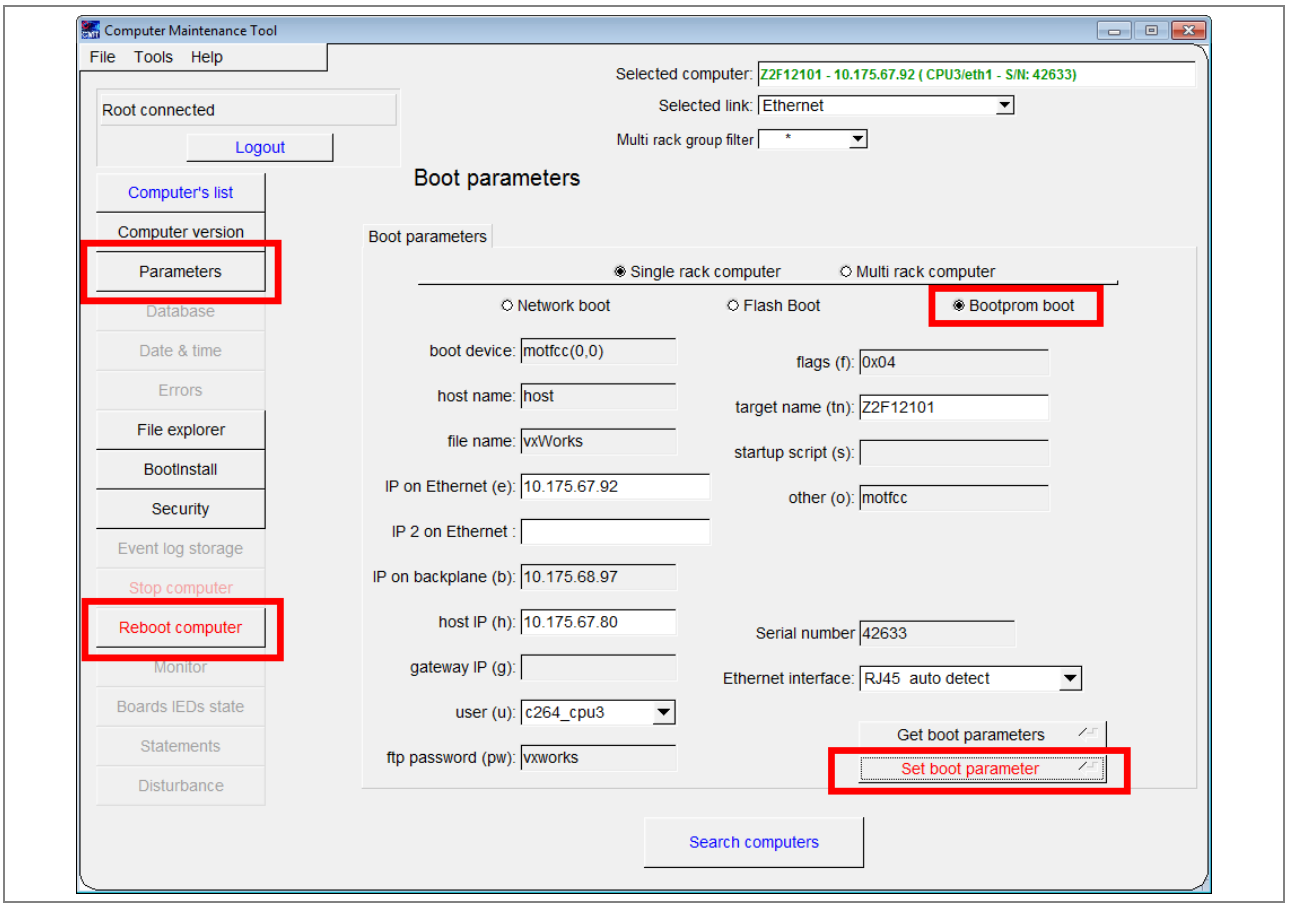


4 Read the disclaimer and then click **Accept** or **Cancel** to abort.



5 Click the **Parameters** menu button.

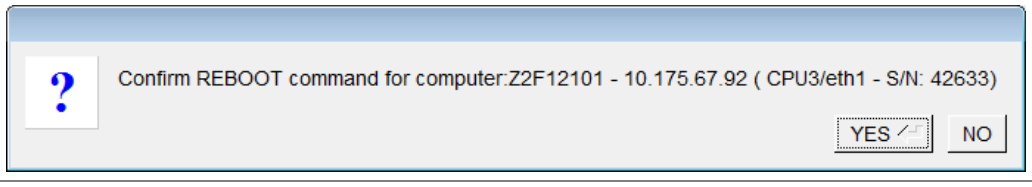
6 Select the *Bootprom* boot option.



7 Select Reboot Computer to restart the C26x.

8 Click **Yes** to confirm.

The label becomes red for a while. The C26x restarts with the software installed on the PC. In the event of a failure, **experts** may type `reboot` in the Telnet or SSH terminal (depending on which version is currently running), and then press any key to prevent the C26x from stopping.



4.2 FIRMAWRE INSTALLATION (BOOTROM UPDATE)

4.2.1 FIRMWARE UPDATE

In the c264-6.1.0.0-buildxx CMT application:

1 With Cyber-security firmware only: If you are logged in, log out first (click **Logout** under your login name).

2 Click the **Search computers** button to find your C26x.

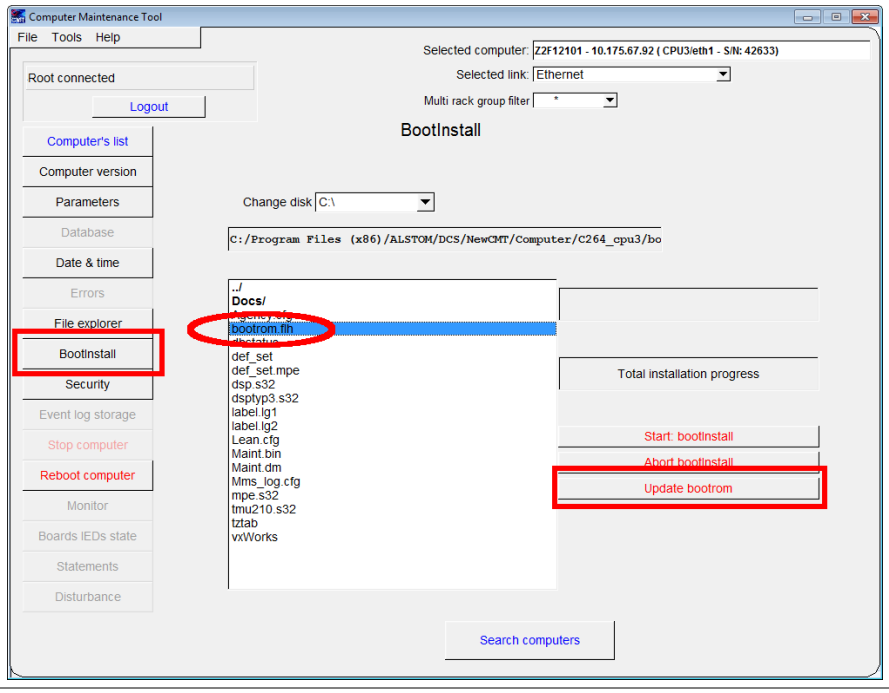
3 Select your DS Agile C26x in the list.

4 Login using an account with the *System administrator* role.

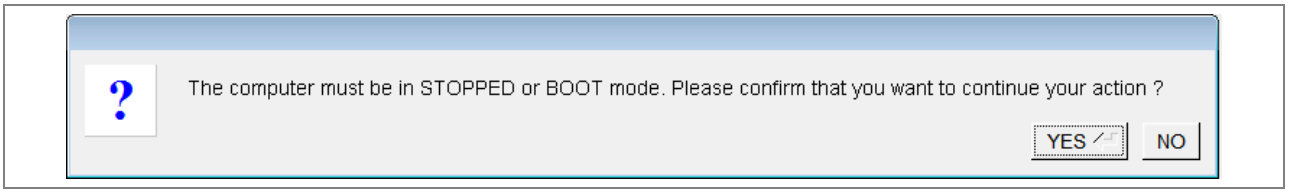
5 Read the disclaimer, and then click **Accept.**

6 Click the **BootInstall** menu button.

7 Locate and open the “new” **C26x_cpu3** directory for the **CPU264** board (in our example: `C:/Program Files (x86)/ALSTOM/DCS/NewCMT/Computer/c264_cpu3`).

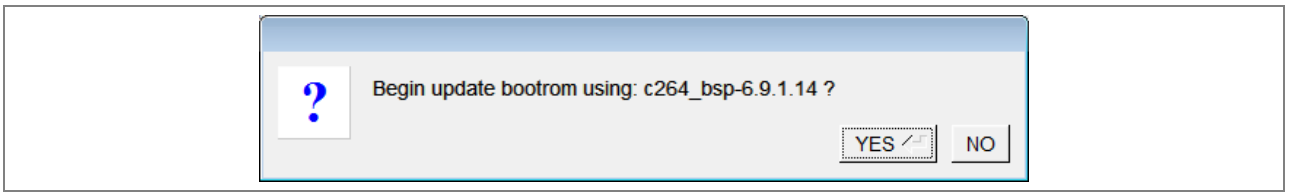


8 Click on **Update Bootrom.**
This message may be displayed if the board has been used before:



9 Click **YES** if prompted.

This message is displayed:



10 Click **YES.**
Messages indicating the progression of the installation are displayed.
Wait until **Update bootrom: OK** is displayed.
If there were an error messages during the update, reboot the C26x and restart the bootrom update.

11 Perform a ”**hard reboot**”, i.e. remove the power supply and re-apply it.
The C26x will take several minutes to restart.



Caution:
Clicking the CMT’s “Reboot computer” button is NOT sufficient.
You MUST disconnect and then reconnect the power supply.

4.2.2 ERASE AND FORMAT FLASH MEMORY

After the C26x has restarted from a “**hard reboot**”:

1 Close the c264-6.7.0.0-buildxx CMT application.

2 Launch the new c264-5.1.35.0-buildxx CMT application.

3 Click the **Search Computers** button to find your C26x.

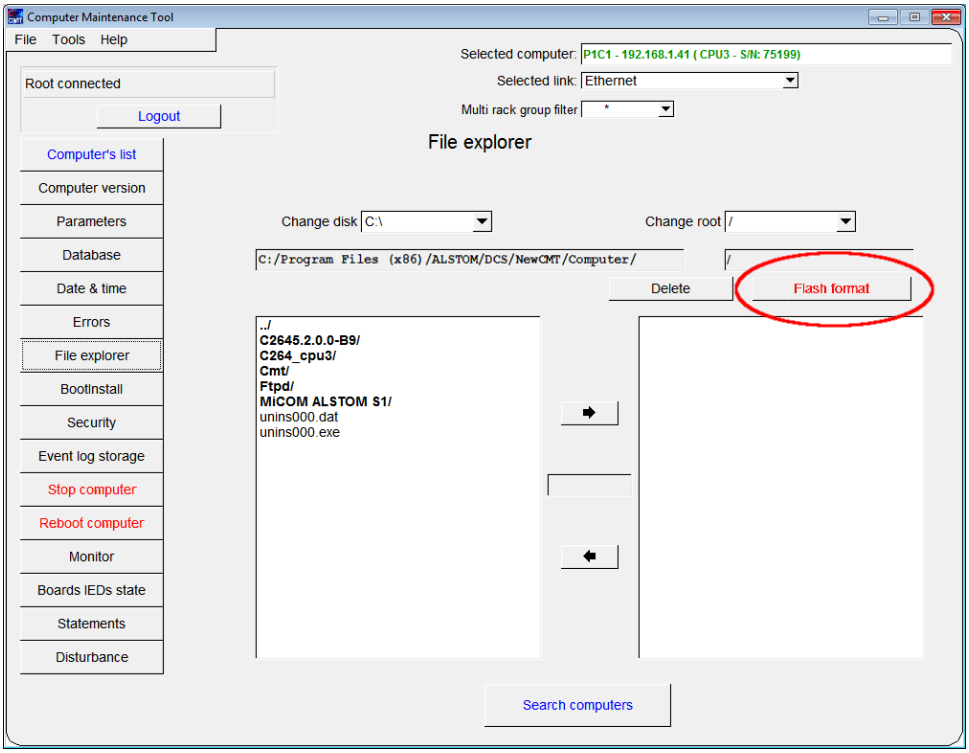
4 Login using an account with the System administrator role.

5 Read the disclaimer and then click **Accept**.

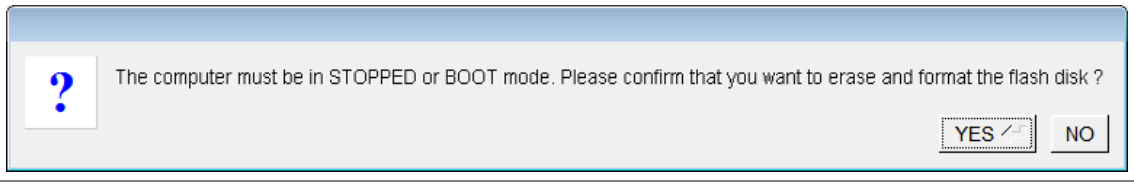
6 Click the **Computer version** menu button and verify that the C26x’s version is as expected the newly installed version.

7 Click the **Parameters** menu button and verify that the C26x is in *Bootprom boot mode*:
Select *Bootprom boot* click **Set boot parameter**.

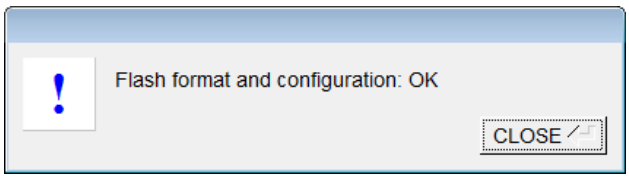
8 Click the **File explorer** menu button.



9 Click **Flash format.**
The following message is displayed.



10 Click **YES** to confirm.
Progress information messages are displayed during the update, which takes few minutes to complete. Wait until the completion window is displayed:



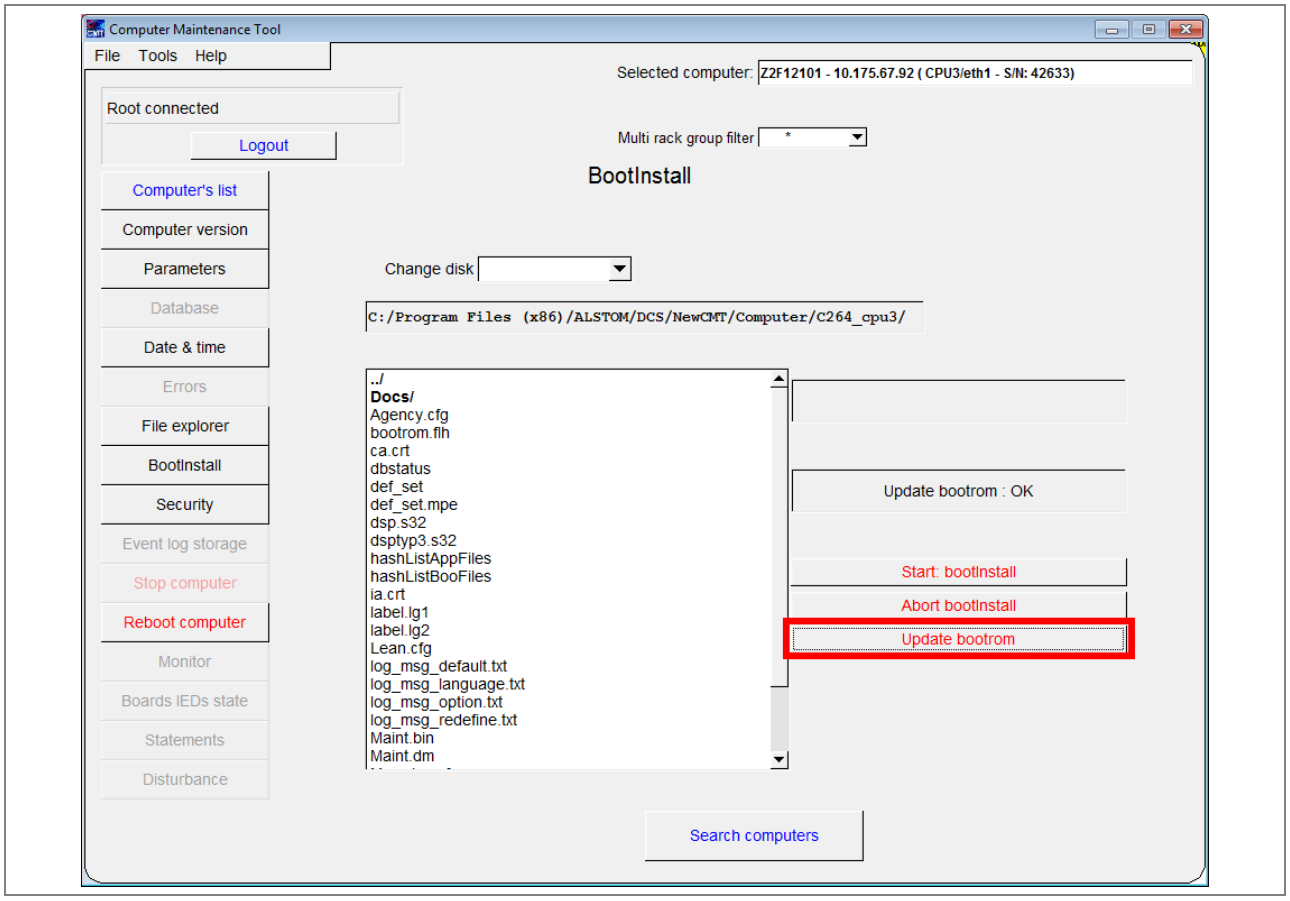
11 Click **CLOSE** to confirm.

4.2.3 BOOTINSTALL

In the CMT application:

1 Click the menu button **Bootinstall.**

2 Find the **C26x_cpu3** directory containing the **CPU264** board's new firmware (in our example: `C:/Program Files (x86)/ALSTOM/DCS/NewCMT/Computer/c264_cpu3`) should already be selected.



3 Click **Update bootrom**

Wait until the C26x is ready:

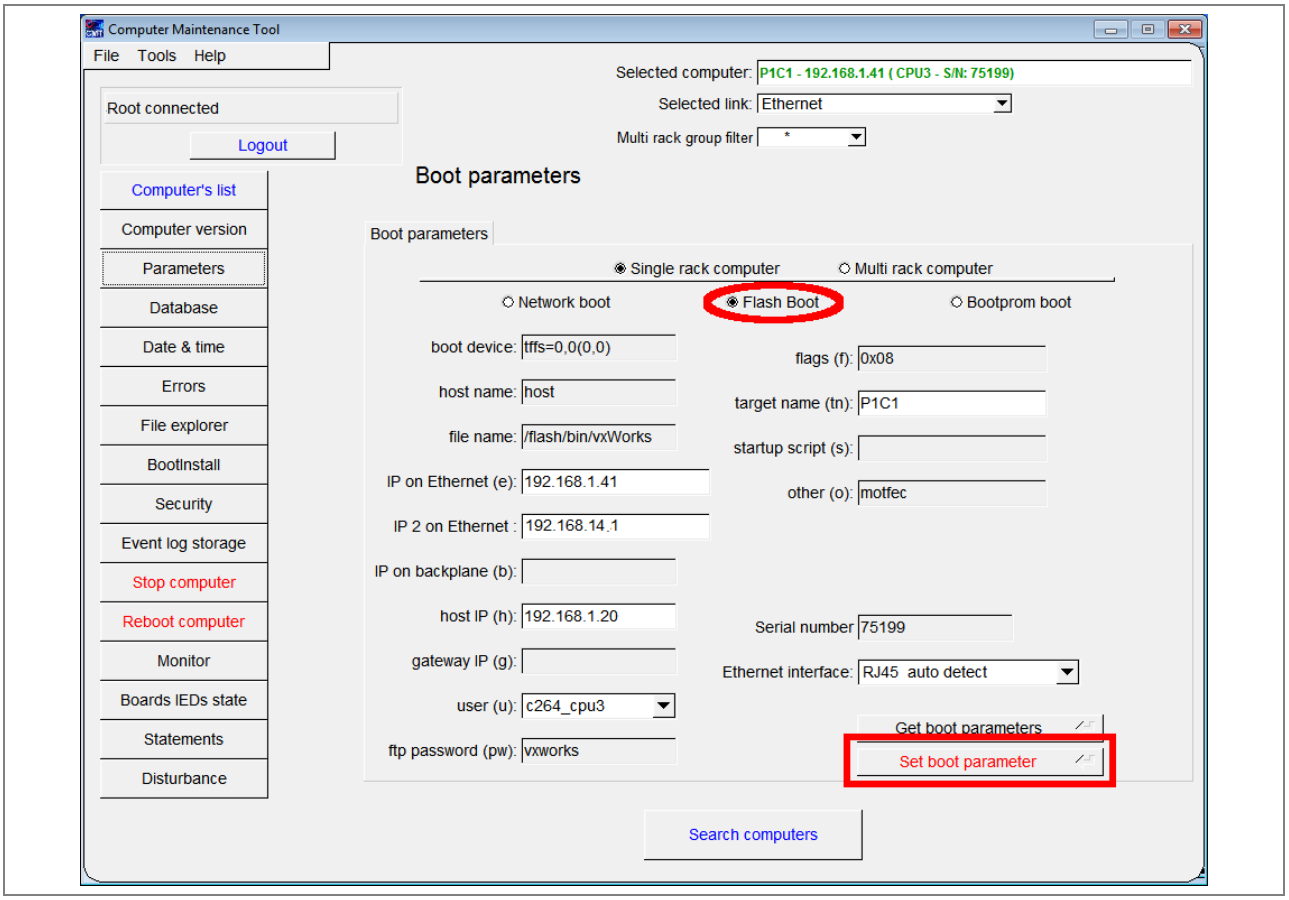
- The service panel is displayed on the front panel LHMI, or
- The CMT displays the message "Update bootrom: OK" above the button Start: Bootinstall, or
- Experts may also check the shell messages.

4.2.4 FINAL STEPS

Caution:
If you uninstall the "Old CMT", registry keys needed by the "New CMT" will be deleted and you will need to re-install the "New CMT" afterwards.

1 Click the **Parameters** menu button.

2 Select "Flash Boot", and then click **Set boot parameter**.



Note:
The value of IP 2 on Ethernet may be lost after the restart. Re-enter it if necessary.

3 Reboot the C26x (Click the **Reboot computer** menu button).



RECORD SHEET

C26X/EN RS/D40

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3 MAINTENANCE RECORD SHEET 5

1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation. It describes the Commissioning record sheet and the Maintenance Record of this unit.

The purpose of this chapter is to follow the history of the DS Agile C26x hardware replacement.

2 COMMISSIONING RECORD

Commissioning Date:

Engineer:

Station Name:

Circuit Name:

Front Plate Information

Under the top access cover, there is the following type of label:

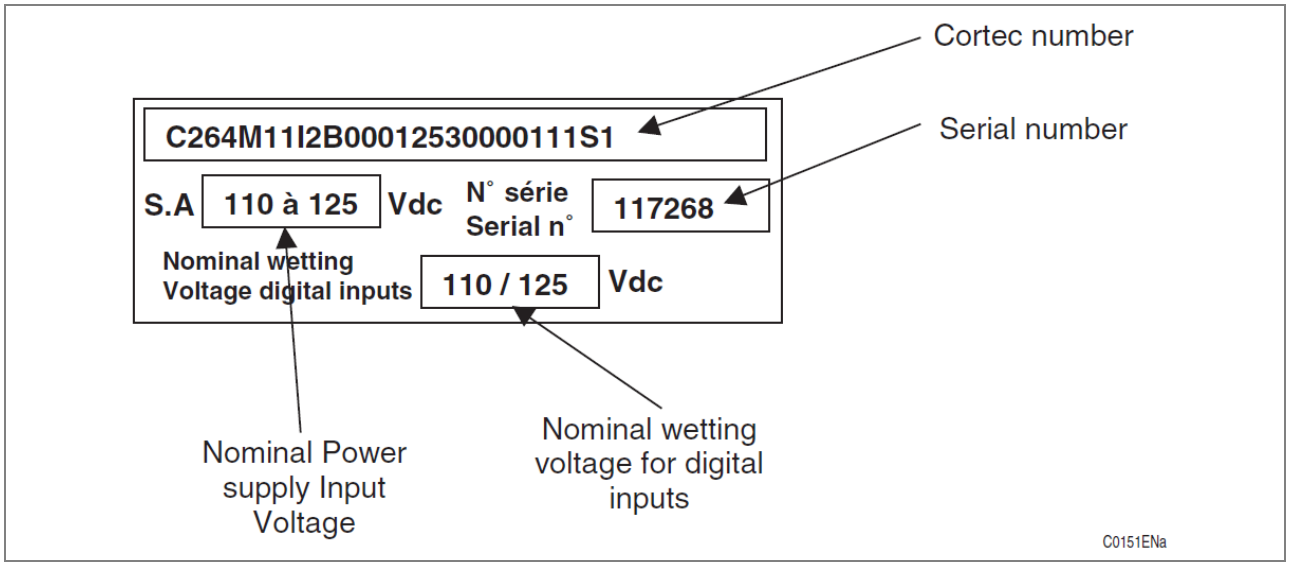


Figure 1: Front plate information

Fill in the following array according to the label under the top access cover:

Serial number	
Cortec number	
Auxiliary voltage for power supply	
Nominal wetting voltage for digital inputs	

	*Delete as appropriate
Have all relevant safety instructions been followed?	Yes/No*

Product checks

Visual inspection with the unit de-energized

Relay damaged?	Yes/No*
Rating information correct for installation?	Yes/No*
Case earth installed?	Yes/No*

3 MAINTENANCE RECORD SHEET

Product Serial number	

DATE	Engineer	Board type	Slot letter in the rack (between A and Q)	Previous board Serial number	New board Serial number
/ /					
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TECHNICAL DATA

C26x/EN TD/D40

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1 SCOPE OF THE DOCUMENT

This document is a chapter of the DS Agile C26x documentation, listing its technical characteristics.

2 GENERAL DATA

2.1 DESIGN

Compliant with the European Commission Low Voltage Directive 2014/EU/35 using EN 60255-27: 2006 reference.

Surface-mounted case suitable for wall mounting or flush-mounted case for 19” cubicles and for control panels.

2.2 INSTALLATION POSITION

Vertical ±15°

2.3 DEGREE OF PROTECTION

In conformance with DIN VDE 0470 and EN 60255-27:2006, or with IEC 60255-27:2005:

- Protection of equipment against ingress of solid foreign objects and water (Environmental)
  - Front panel with RJ11 connector ("blind"): No claim
  - Front panel without RJ11 connector (with LCD and/or LEDs): IP52
  - Sides for standard 40TE case: IP52
  - Sides for ventilated 40TE and 80TE cases: No claim
  - Rear: No claim
- Protection of persons against access to hazardous parts (Safety)
  - Front panel with RJ11 connector ("blind"): IP1X
  - Front panel without RJ11 connector (with LCD and/or LEDs): IP2X
  - Sides for standard 40TE and ventilated 40TE/80TE cases: IP2X
  - Rear for standard 40TE and ventilated 40TE/80TE cases: IP1X

2.4 WEIGHT

- Standard 40TE and ventilated 40TE cases: approximately 4 kg
- Ventilated 80TE case: approximately 8 kg

2.5 DIMENSIONS AND CONNECTIONS

Please refer to the dimensional drawings (C26x/EN HW, hardware description chapter) and to the terminal connection diagrams (C26x/EN CO).

2.6 DS AGILE C26X: CONFIGURATION

The DS Agile C26x includes:

- A case
- A rack with slots for the boards
- A combination of the C26x's boards fitted in dedicated slots

There are many types of DS Agile C26x units. Each has a specific purpose and includes some combination of boards to achieve that purpose:

- C26x in 80TE case (ventilated only)
- C26x in compact 40TE case (standard or ventilated)
- C26x-Standalone in 80TE case (ventilated only)
- C26x-Standalone in compact 40TE case (standard or ventilated)
- C26x-Multirack
- C26x-Multirack Redundancy

Note:
The C26x-Multirack includes a C26x controller and one or more extension racks. Each of these units, through its inter-rack communication port, can connect to its own group of IEDs. This extension possibility through the inter-rack communications port to multiple devices, allows for more racks with many more slots for additional boards, hence the name, Multirack. The C26x-Multirack can function as a redundant C26x.

2.6.1 C26X – COMPARISON OF BOARD INSTALLATIONS BETWEEN MODELS

Board	Purpose	C26x 80TE	C26x 40TE	C26x-Stand-alone 80TE	C26x-Stand-alone 40TE	C26x-Multi-rack Main Rack	C26x-Multirack Exten-sion Rack
BIU2xx	Power supply board	X	X	X	X	X	X
CPU270 (CPU3)	2 Ethernet communication channels	X	X	X	X	X	X
CCU200	Circuit breaker control unit	X	X	X	X	X	X
CCU211	Circuit breaker control unit	X	X	X	X	X	X
DIU200	Digital and counter acquisition Digital measurement acquisition Datapoints: SPS DPS SCT DCT DM	X	X	X	X	X	X
DIU210	Digital and counter acquisition Digital measurement acquisition Datapoints: SPS DPS SCT DCT DM	X	X	X	X	X	X
DIU211	Digital and counter acquisition Digital measurement acquisition Datapoints: SPS DPS SCT DCT DM	X	X	X	X	X	X
DOU200	Execution of single or dual, transient or permanent conditions Set datapoints	X	X	X	X	X	X
DOU201	Execution of single or dual, transient or permanent conditions Set datapoints	X	X	X	X	X	X
HBU200	Execution of single or dual, transient or permanent conditions	X	X	X	X	X	X
AIU201	Analogue measurement acquisition	X	X	X	X	X	X
AIU211	Analogue measurement acquisition	X	X	X	X	X	X
TMU210	CT and VT sampling acquisition MV calculations with acquired samples	X	X			X	
DSPIO for TMU210		X	X			X	
TMU220	CT and VT sampling acquisition MV calculations with acquired samples	X	X			X	
DSP220 for TMU220		X	X			X	
AOU200	Analogue output board	X	X	X	X	X	X
SWU20x	Networking	X	X	X	X	X	X
SWR21x	Networking	X	X	X	X	X	X
SWD21x	Networking	X	X	X	X	X	X
SWT21x	Networking	X	X	X	X	X	X

Board	Purpose	C26x 80TE	C26x 40TE	C26x-Stand-alone 80TE	C26x-Stand-alone 40TE	C26x-Multi-rack Main Rack	C26x-Multirack Exten-sion Rack
SRP28x	Networking	X	X	X	X	X	X
SRP29x	Networking	X	X	X	X	X	X
GHU2AB, see note 1	Graphic panel board with LED channels	GHU 2A1	GHU 2A0	GHU 2A1	GHU 2A0	GHU 2AB	GHU 2AB
Note 1: For GHU2 1 or 2	A B: B for the size B=B includes all possibilities: B=0 or 1 B=0 Small B=1 Large A for the LCD A=A includes all possibilities: A=0, 1, or 2 A=0 Has LCD A=1 Has no LCD A=2 Has remote LCD						

2.6.2 C26X-80TE – BOARD INSTALLATION

Board	Slots - Viewed from the rear of the case																Maximum Nr of Installed Boards	
	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	With TMU	Without TMU
BIU2xx																	X	1	1
CPU270 (CPU3)																X		1	1
CCU200, see note 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14	≤ 15
CCU211, see note 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14	≤ 15
DIU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14	≤ 15
DIU210	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			see note 2	see note 2
DIU211	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14	≤ 15
DOU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14, see note 5	≤ 15, see note 5
DOU201	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 14, see note 5	≤ 15, see note 5
HBU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 2	≤ 2
AIU201	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 6	≤ 6
AIU211	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 6	≤ 6
TMU210, see note 1	X																	1	0
TMU220, see note 1	X																	1	0
AOU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 4	≤ 4
SWU20x														X	X			see note 3	see note 3
SWR21x														X	X			see note 3	see note 3
SWD21x														X	X			see note 3	see note 3
SWT21x														X	X			see note 3	see note 3
SRP28x														X	X			see note 3	see note 3
SRP29x														X	X			see note 3	see note 3
GHU2A1, see note 4																		1	1

Note 1: If you install a TMU, do not install the CCU in slot P and do not install the CCU in the slot adjacent to the TMU.

Note 2: The maximum number of DIU210 boards installed in one C26x rack depends on the rack type and on the voltage level of the inputs. Please refer to the topic, DIU210 Digital Inputs

Note 3: If the board is installed in Slot C; if the rack is full; and if you have no DSPIO installed; ≤ 1 If the board is installed in Slot D; if the rack is full; and if you have a DSPIO or others installed: ≤ 1

Note 4: For an explanation of the GHU2AB codes, please refer to C26x – Comparison of Board Installations Between Models

Note 5: If the application causes all of the DOs to be activated at the same time: ≤ 6

2.6.3 C26X-40TE – BOARD INSTALLATION

Board	Slots - Viewed from the rear of the case								Maximum Number of Installed Boards	
	H	G	F	E	D	C	B	A	With TMU	Without TMU
BIU2xx								X	1	1
CPU270 (CPU3)							X		1	1
CCU200, see note 1	X	X	X	X	X	X			≤ 3	≤ 6
CCU211, see note 1	X	X	X	X	X	X			≤ 3	≤ 6
DIU200	X	X	X	X	X	X			≤ 3	≤ 6
DIU210	X	X	X	X	X	X			see note 2	see note 2
DIU211	X	X	X	X	X	X			≤ 4	≤ 6
DOU200	X	X	X	X	X	X			≤ 4	≤ 6
DOU201	X	X	X	X	X	X			≤ 4	≤ 6
HBU200	X	X	X	X	X	X			≤ 2	≤ 2
AIU201	X	X	X	X	X	X			≤ 4	≤ 6
AIU211	X	X	X	X	X	X			≤ 4	≤ 6
TMU210, see note 1	X = 1								1	0
TMU220, see note 1	X = 1								1	0
AOU200	X	X	X	X	X	X			≤ 4	≤ 4
SWU20x					X	X			see note 3	see note 3
SWR21x					X	X			see note 3	see note 3
SWD21x					X	X			see note 3	see note 3
SWT21x					X	X			see note 3	see note 3
SRP28x					X	X			see note 3	see note 3
SRP29x					X	X			see note 3	see note 3
GHU2A0, see note 4									1	1

Note 1: If you install a TMU, do not install the CCU in slot F and do not install the CCU in the slot adjacent to the TMU.

Note 2: The maximum number of DIU210 boards installed in one C26x rack depends on the rack type and on the voltage level of the inputs. Please refer to the topic, DIU210 Digital Inputs

Note 3: If you do not install a DSP/DSPIO: ≤ 2. If you do install a DSP/DSPIO: ≤ 1

Note 4: For an explanation of the GHU2xx codes, please refer to *C26x – Comparison of Board Installations Between Models*

2.6.4 C26X-STANDALONE 80TE – BOARD INSTALLATION

Board	Slots - Viewed from the rear of the case																Maximum Number of Installed Boards
	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Without TMU
BIU2xx																	X	1
CPU270 (CPU3)																X		1
CCU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 15
CCU211	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 15
DIU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 15
DIU210	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			see note 1
DIU211	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 15
DOU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 15, see note 3
DOU201	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 15, see note 3
HBU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 2
AIU201	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 6
AIU211	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 6
TMU210																		
TMU220																		
AOU200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			≤ 4
SWU20x														X	X			≤ 1
SWR21x														X	X			≤ 1
SWD21x														X	X			≤ 1
SWT21x														X	X			≤ 1
SRP28x														X	X			≤ 1
SRP29x														X	X			≤ 1
GHU2A1, see note 2																		1

Note 1: The maximum number of DIU210 boards installed in one C26x rack depends on the rack type and on the voltage level of the inputs. Please refer to the topic, DIU210 Digital Inputs

Note 2: For an explanation of the GHU2xx codes, please refer to *C26x – Comparison of Board Installations Between Models*

Note 3: If the application causes all of the DOs to go active at the same time: ≤ 6

2.6.5 C26X-STANDALONE 40TE – BOARD INSTALLATION

Board	Slots - Viewed from the rear of the case								Maximum Number of Installed Boards
	H	G	F	E	D	C	B	A	Without TMU
BIU2xx								X	1
CPU270 (CPU3)							X		1
CCU200	X	X	X	X	X	X			≤ 6
CCU211	X	X	X	X	X	X			≤ 6
DIU200	X	X	X	X	X	X			≤ 6
DIU210	X	X	X	X	X	X			see note 2
DIU211	X	X	X	X	X	X			≤ 6
DOU200	X	X	X	X	X	X			≤ 6
DOU201	X	X	X	X	X	X			≤ 6
HBU200	X	X	X	X	X	X			≤ 2
AIU201	X	X	X	X	X	X			≤ 6
AIU211	X	X	X	X	X	X			≤ 6
TMU210, see note 1									0
TMU220, see note 1									0
AOU200	X	X	X	X	X	X			≤ 4
SWU20x					X	X			≤ 1
SWR21x					X	X			≤ 1
SWD21x					X	X			≤ 1
SWT21x					X	X			≤ 1
SRP28x					X	X			≤ 1
SRP29x					X	X			≤ 1
GHU2A0, see note 3									1

Note 1: TMU is not installed in the C26x-Standalone RTU

Note 2: The maximum number of DIU210 boards installed in one C26x rack depends on the rack type and on the voltage level of the inputs. Please refer to the topic, DIU210 Digital Inputs

Note 3: For an explanation of the GHU2xx codes, please refer to *C26x – Comparison of Board Installations between Models*

2.6.6 C26X-80TE – SIGNALS

Board	Signals						Maximum Number of Boards: Maximum number of configurable signals	
	AI	AO	DI	DO	CI	VI	With TMU	Without TMU
BIU2xx			2	2				
CPU270 (CPU3)								
CCU200, see note 1			8	4			13: 104 DI + 52 DO	15: 120 DI + 60 DO
CCU211, see note 1			8	4			13: 104 DI + 52 DO	15: 120 DI + 60 DO
DIU200			16				14: 224 DI	15: 240 DI
DIU210			16				see note 2	see note 2
DIU211			16				14: 224 DI	15: 240 DI
DOU200				10			14: 140 DO	15: 150 DO
DOU201				10			14: 140 DO	15: 150 DO
HBU200				10			2: 20 DO	2: 20 DO
AIU201	4						6: 24 AI	6: 24 AI
AIU211	8						6: 48 AI	6: 48 AI
TMU210, see note 1	8				4	4	1: 4 CI, 4 VI	
TMU220, see note 1	9				4	5	1: 4 CI, 5 VI	
AOU200		4					6: 24 AO	6: 24 AO
SWU20x								
SWR21x								
SWD21x								
SWT21x								
SRP28x								
SRP29x								
GHU2A1, see note 3								

Note 1: Do not install the CCU in the slot adjacent to the TMU.

Note 2: The maximum number of DIU210 boards installed in one C26x rack depends on the rack type and on the voltage level of the inputs. Please refer to the topic, DIU210 Digital Inputs

Note 3: For an explanation of the GHU2xx codes, please refer to *C26x – Comparison of Board Installations between Models*

2.6.7 C26X-40TE – SIGNALS

Board	Signals						Maximum Number of Boards: Maximum number of configurable signals	
	AI	AO	DI	DO	CI	VI	With TMU	Without TMU
BIU2xx			2	2				
CPU270 (CPU3)								
CCU200, see note 1			8	4			3: 24 DI + 12 DO	6: 48 DI + 24 DO
CCU211, see note 1			8	4			3: 24 DI + 12 DO	6: 48 DI + 24 DO
DIU200			16				4: 64 DI	6: 96 DI
DIU210			16				see note 2	see note 2
DIU211			16				4: 64 DI	6: 96 DI
DOU200				10			4: 40 DO	6: 60 DO
DOU201				10			4: 40 DO	6: 60 DO
HBU200				10			2: 20 DO	2: 20 DO
AIU201	4						4: 16 AI	6: 24 AI
AIU211	8						4: 32 AI	6: 48 AI
TMU210, see note 1	8				4	4	1: 4 CI, 4 VI	
TMU220, see note 1	9				4	5	1: 4 CI, 5 VI	
AOU200		4					4: 16 AO	6: 24 AO
SWU20x								
SWR21x								
SWD21x								
SWT21x								
SRP28x								
SRP29x								
GHU2A0, see note 3								

Note 1: Do not install the CCU in the slot adjacent to the TMU.

Note 2: The maximum number of DIU210 boards installed in one C26x rack depends on the rack type and on the voltage level of the inputs. Please refer to the topic, DIU210 Digital Inputs

Note 3: For an explanation of the GHU2xx codes, please refer to *C26x – Comparison of Board Installations between Models*

2.6.8 C26X-STANDALONE 80TE – SIGNALS

Board	Signals						Maximum Number of Boards: Maximum number of configurable signals
	AI	AO	DI	DO	CI	VI	Without TMU
BIU2xx			2	2			
CPU270 (CPU3)							
CCU200			8	4			15: 120 DI + 60 DO
CCU211			8	4			15: 120 DI + 60 DO
DIU200			16				15: 240 DI
DIU210			16				see note 2
DIU211			16				15: 240 DI
DOU200				10			15: 150 DO
DOU201				10			15: 150 DO
HBU200				10			2: 20 DO
AIU201	4						6: 24 AI
AIU211	8						6: 48 AI
TMU210, see note 1							Not installed
TMU220, see note 1							Not installed
AOU200		4					6: 24AO
SWU20x							
SWR21x							
SWD21x							
SWT21x							
SRP28x							
SRP29x							
GHU2A1, see note 3							

Note 1: Do not install the CCU in the slot adjacent to the TMU.

Note 2: The maximum number of DIU210 boards installed in one C26x rack depends on the rack type and on the voltage level of the inputs. Please refer to the topic, DIU210 Digital Inputs

Note 3: For an explanation of the GHU2xx codes, please refer to *C26x – Comparison of Board Installations between Models*

2.6.9 C26X-STANDALONE 40TE – SIGNALS

Board	Signals						Maximum Number of Boards: Maximum number of configurable signals
	AI	AO	DI	DO	CT	VT	Without TMU
BIU2xx			2	2			
CPU270 (CPU3)							
CCU200			8	4			6: 48 DI + 24 DO
CCU211			8	4			6: 48 DI + 24 DO
DIU200			16				6: 96 DI
DIU210			16				see note 2
DIU211			16				6: 96 DI
DOU200				10			6: 60 DO
DOU201				10			6: 60 DO
HBU200				10			2: 20 DO
AIU201	4						6: 24 AI
AIU211	8						6: 48 AI
TMU210, see note 1							Not installed
TMU220, see note 1							Not installed
AOU200		4					6: 24 AO
SWU20x							
SWR21x							
SWD21x							
SWT21x							
SRP28x							
SRP29x							
GHU2A0, see note 3							

Note 1: Do not install the CCU in the slot adjacent to the TMU.

Note 2: The maximum number of DIU210 boards installed in one C26x rack depends on the rack type and on the voltage level of the inputs. Please refer to the topic, DIU210 Digital Inputs

Note 3: For an explanation of the GHU2xx codes, please refer to *C26x – Comparison of Board Installations between Models*

2.6.10 C26X: ELEMENT LIMITS



Caution:
The global performance of C26x is less than the sum of the performances of its components. For a detailed performance check, please contact us.



Caution:
The size of a C26x database, i.e. the relevant .adb file included in the .zip databag generated using DS Agile SCE must not exceed 16 MB.

Element	Limits for 1 C26x with extensions
Number of IEC 61850-8-1 servers for a C26x client	32
Number of IEC 61850-8-1 clients for a C26x server	10 (two redundant system HMI servers at most)
Number of IEC 61850-8-1 clients for buffered reports	2 redundant system HMI servers & 2 redundant gateways
GOOSE size (IEC 61850-8-1)	128 binary inputs, 64 measurements
Measurements / Wired MV	2400 / 48
Receiving flux of MV	200 values / sec
T104 server protocols	4 Each with as many as 4 clients: only 1 client is active at a time.
PSL: Number of items see note 1 Number of elements see note 2 Numberof PSLs with timer or boolean settings Number of timer or boolean settings	 256 256 50 100
Printers at C26x level	1 (only on rear RS port)
Serial Communication port (for SCADA and/or legacy protocols)	4
SCADA protocols	Serial/Ethernet: 2 Ethernet IEC104, T104: 4
Master legacy protocols (for IED communication)	4
IEDs allowed for each Legacy Bus	16 with a max of 32 per C26x
Voltage level	2 per C26x if ATCC used
Bays	128 (a maximum of 12 bays show on the local HMI)
Circuit breakers	128
Disconnectors	512
Transformers	128
Digital Input Points / Wired DI / System DI	5600 / 240 / 100
Output Control Points / Wired DO	1 200 / 150
Tap Position Indication	128
Counters / Wired	128 / 8
Setpoints, digital	128

Element		Limits for 1 C26x with extensions
ISaGRAF	TPI CO SP CT MPS MV SPS/DPS	128 256 256 512 512 512 512
Interlock		200 operands per equation, 200 equations
Report buffer capacity (BCU)		100 xPS events per C26x
Events buffer capacity (RTU)		1000 events per SCADA (T101/T104)
Time discrimination and tagging of events		1 ms
Input bandwidth		100 alarms/s and 100 events/s
Slow waveform file storage capacity		5000 records for 24 analogue values+ 48 logical states
Fast waveform (disturbance) file storage capacity		480 cycles for 8 analogue values + 128 logical statuses 32 samples/period

Note 1: Item: for the interlock / PSL, an item is the output of an Interlock / PSL, or an intermediate variable used as an output (such as for the TON/TOFF/SR latch operators). In an interlock equation, an interlock output is equal to one item. A datapoint can be included in as many as 255 ILK equations.

Note 2: Element: After the decomposition of the equation into the sum of multiplications, an element is the operand of an operator.

2.6.11 C26X: C26X WITH TWO EXTENSION RACKS WITH IEDS

The C26x connects through Ethernet Port 1 to the SBUS and uses the IEC 61850-8-1 protocol

The C26x connects through Ethernet Port 2 to the two extension racks

Each extension rack connects through the LBUS to the IEDs

The C26x includes a CPU270.



Caution: The global performance of the C26x is not equivalent to the sum of the performances of each component. For a detailed performance analysis, please contact GE Grid Solutions.

Global Limits for the C26x connected to the two extension racks and to the IEDs:

Element	Maximum Number (NB)	Limits
BI Total	2800	Including the system BI (approximately 500)
DI IED	2800 minus wired DI, minus system BI	
SP	128	
TPI	128	
MPS	308 + TBD	reserved to the system info (state of HW)
Command	1200	
CT Total:wired+IED	Total maximum 128	
CT wired	16 CT at 20 Hz for each extension rack 8 CT at 20 Hz for the MAIN rack 128 CT for a full C26x	Total frequency for the 16 counters is 160Hz
CT IED	128	
AI TOTAL	600	
Wired DI & AI	limits of the hardware	
AI IED	600	
Extension racks	16	If you have 4 or more extension racks, make sure that the MAIN rack has no I/O boards.
IED Total	128	More than for a C26x with no extension rack. For the best performance, we recom-mend a maximum of 10 IEDs for each link.
State / bay	2300	Including wired DI, IED DI, system BI & MPS
Analogue bay	221	Including wired AI, IED AI, TPI and counter
Command / bay	430	Including CO and SP
Sending of BI	10 digital inputs per rack change state 12 times in 10 s (16 * 10 * 12 = 1920 state changes / 10 s)	
Sending of measurement	1 change of value of all measurements in 1 second (at same time than previous state changes)	Read cycle of wired AI = 1 second

Limits for the C26x Main Rack:

Element	Maximum Number (NB)	Limits
BI Total	2800	Including the system BI (approximately 500)
Wired DI	limits of the hardware	
DI IED IEC 61850-8-1	TBD	
SP	128	
TPI	128	
MPS	308 + TBD	
Command	1200	
CT Total	8 CT at 20 Hz	
AI TOTAL	600	
Wired AI	limits of hardware	
AI IED	600	
Extension racks	16	If you have 4 or more extension racks, make sure that the MAIN rack has no I/O boards.

Element	Maximum Number (NB)	Limits
DIU	15	
DOU	15	
HBU	2	
CCU	15	
AIU	6	
CT/VT	1	
AOU	4	
serial lines	4	
SCADA	Serial/Ethernet: 2, IT104: 4	
IED Total	0	
State / bay	2300	Including wired DI, IED DI, system BI and MPS
Analogue bay	221	Including wired AI, IED AI, TPI and counter
Command / bay	430	Including CO and SP
GOOSE Tx	1 GOOSE xPS, 1 GOOSE MV	128 xPS / GOOSE 64 MV / GOOSE A.C.U.
GOOSE Rx	128 A.C.U.	128 xPS / GOOSE 64 MV / GOOSE A.C.U.
PSL	For example: 256 items see note 1 256 elements see note 2	
ISaGRAF	128 TPI 256 CO 256 SP 512 CT 512 MPS 512 MV 512 SPS / DPS	

Note 1: Item: For the interlock / PSL, an item is the output of an Interlock / PSL, or an intermediate variable used as an output (such as for the TON/TOFF/SR latch operators). In an interlock equation, an interlock output is equal to one item.

Note 2: Element: After the decomposition of the equation into the sum of multiplications, an element is the operand of an operator.

Limits for the Extension Racks:

Element	Maximum Number (NB)	Limits
General	BLANK	If you have 4 or more extension racks, make sure that the MAIN rack has no I/O boards
Wired DI	limits of the hardware	
DI IED	1000	
SP	128	
TPI	128	
Command	1200	
CT Total	128	
CT wired	16 CT at 20 Hz for each extension rack 8 CT at 20 Hz for the MAIN rack 128 CT for a full C26x	Total frequency for the 16 counters is 160 Hz
CT IED	128	
AI TOTAL	600	
Wired AI	limits of the hardware	

Element	Maximum Number (NB)	Limits
AI IED	600	
DIU	15	
DOU	15	
HBU	2	
CCU	15	
CT/VT	0	
AIU	6	
AOU	4	
serial lines	4	
SCADA	0	
IED	64	For the best performance, we recommend a maximum of 10 IEDs for each link

2.6.12 C26X: TWO REDUNDANT C26X CONTROLLERS WITH TWO EXTENSION RACKS WITH IEDS

Each C26x connects through the Ethernet Port 1 to the SBUS and uses the IEC 61850-8-1 protocol

Each C26x connects through Ethernet Port 2 to two extension racks

Each extension rack connects through the LBUS to the IEDs

The C26x includes a CPU270.



Caution:
The global performance of the C26x is not equivalent to the sum of the performances of each component. For a detailed performance check, please contact GE Grid Solutions.

Global Limits for the two redundant C26xs connected to the two extension racks and to the IEDs:

Element	Maximum Number (NB)	Limits
BI Total	2800	Including the system BI (about 500)
DI IED	2800 minus wired DI, minus system BI	
SP	128	
TPI	128	
MPS	308 + TBD	Reserved to the system information (state of hardware) + TBD
Command	1200	
CT Total	128	
CT wired	16 CT at 20 Hz for each extension rack 8 CT at 20 Hz for the MAIN 1 rack 128 CT for a full C26x	Total frequency for the 16 counters is 160 Hz
CT IED	128	
AI TOTAL	600	
Wired DI	limits of the hardware	
Wired AI	limits of the hardware	

Element	Maximum Number (NB)	Limits
AI IED	600	
Extension racks	2*16	If you have 4 or more extension racks, make sure MAIN rack has no I/O boards
IED Total	128	More than for a C26x with no extension rack.For the best performance, we recom-mend a maximum of 10 IEDs per link
State / bay	2300	Including wired DI, IED DI, system BI & MPS
Analogue bay	221	Including wired AI, IED AI, TPI & counter
Command / bay	430	Including CO and SP
Sending of BI	10 digital inputs per rack change state 12 times in 10 seconds (16 * 10 * 12 = 1920 status changes in 10 s)	
Sending of measurement	1 change of value of all measurements in 1 second (at same time than previous status changes)	Read cycle of wired AI = 1 second

Limits of the C26x Main 1 Rack:

Element	Maximum Number (NB)	Limits
BI Total	2800	Including the system BI (approximately 500)
Wired DI	limits of the hardware	
SP	128	
TPI	128	
MPS	308 + TBD	
Command	1200	
CT Total	8 CT at 20 Hz	
AI TOTAL	600	
Wired AI	limits of the hardware	No AI in the MAIN 1 rack
AI IED	600	
Extension racks	16	If you have 4 or more extension racks, make sure that the MAIN rack has no I/O boards
DIU	15	
DOU	15	
HBU	2	
CCU	15	
AIU	6	
CT/VT	1	
AOU	0	Cause of redundancy
serial lines	4	2 SCADA with 2 links.
SCADA	Serial/Ethernet: 2 Ethernet IEC104, T104: 4	
IED Total	0	
State / bay	2300	Including wired DI, IED DI, system BI and MPS
Analogue bay	221	Including wired AI, IED AI, TPI and counter
Command / bay	430	Including CO and SP
GOOSE Tx IEC 61850-8-1	1 GOOSE xPS, 1 GOOSE MV	128 xPS / GOOSE 64 MV / GOOSE A.C.U.

Element	Maximum Number (NB)	Limits
GOOSE Rx IEC 61850-8-1	128 A.C.U.	128 xPS / GOOSE 64 MV / GOOSE A.C.U.
PSL	e.g. 256 items, see note 1 256 elements, see note 2	
ISaGRAF	128 TPI 256 CO 256 SP 512 CT 512 MPS 512 MV 512 SPS / DPS	On a redundant system and after switchover, ISaGRAF does not operate on the MAIN 2 Rack

Note 1: Item: for the interlock / PSL, an item is the output of an Interlock / PSL, or an intermediate variable used as an output (such as for the TON/TOFF/SR latch operators). In an interlock equation, an interlock output is equal to one item.

Note 2: Element: After the decomposition of the equation into the sum of multiplications, an element is the operand of an operator.

Limits for the extension racks:

Element	Maximum Number (NB)	Limits
General	BLANK	If you have 4 or more extension racks, make sure that the MAIN rack has no I/O boards
Wired DI	limits of the hardware	
DI IED	1000	
SP	128	
TPI	128	
Command	1200	
CT Total	128	
CT wired	16 CT at 20 Hz for each extension rack 8 CT at 20 Hz for the MAIN rack 128 CT for a full C26x	Total frequency for the 16 counters is 160 Hz
CT IED	128	
AI TOTAL	600	
Wired AI	limits of the hardware	
AI IED	600	
DIU	15	
DOU	15	
HBU	2	
CCU	15	
CT/VT	0	
AIU	6	
AOU	0	
serial lines	4	
IED	64	For the best performance, we recommend a maximum of 10 IEDs for each link

2.7 TERMINALS

PC Maintenance Interface:

- DIN 41652 connector, type female D-Sub, 9-pin, installed on the front panel
- A direct wired cable is required.

Ethernet LAN (installed on the CPU270 board):

- Two of the RJ-45 female connector, 8-pin for the 10/100Base-T self-negotiation

IRIG-B interface (standard NF S 87-500, May 1987), installed on the CPU270 board:

- BNC plug
- Modulated amplitude, 1 kHz carrier signal
- Time-of-year code: BCD
- Compatible with IRIG B122 code

Conventional communication links:

- M3 threaded terminal ends, self-centring with wire protection for conductor cross sections from 0.2 to 2.5 mm² for BIU2xx board
- DIN 41652 connector; type D-Sub, 9-pin, installed on the CPU270 board.
- Optical fibres through ECU200 (external RS232/optical converter): optical plastic fibre connection in agreement with IEC 874-2 or DIN 47258 or ST ® glass fibre optic connection (ST ® is a registered trademark of AT&T Lightguide Cable Connectors).

Input /Output or power supply modules:

M3 threaded terminal ends, self-centring with wire protection for conductor cross sections from 0.2 to 2.5 mm² for these boards:

- AIU201, AIU210, AIU211
- AOU200
- BIU241, BIU261
- CCU200, CCU211
- DIU200, DIU210, DIU211
- DOU200, DOU201
- HBU200
- DSP260, DSPIO

The I/O and BIU2xx boards include a 24-pin, 5.08 mm pitch male-connector.

Current-measuring and Voltage-measuring inputs:

- M5 threaded terminal ends, self-centring with wire protection for conductor cross sections between 2.5 and 4 mm² for the TMU board.
- The TMU board includes this connector: MIDOS 28 terminal block.

2.8 CREEPAGE DISTANCES AND CLEARANCES

In accordance with essential requirements of IEC 60255-27:2005.

Pollution degree 2, working voltage 250 V.

Overvoltage category III, impulse test voltage 5 kV.

3 RATINGS

3.1 AUXILIARY VOLTAGE

3.1.1 SINGLE-SOURCE POWER SUPPLY (BIU241)

The BIU241 single-source power supply board is available in four auxiliary voltage variants, as follows:

Board variant	Nominal ranges	Operative DC range	Operative AC range
A01	24 V_{DC}	19.2 to 28.8 V_{DC}	-
A02	48 to 60 V_{DC}	38.4 to 72 V_{DC}	-
A03	110 to 125V_{DC}	88 to 150 V_{DC}	-
A04	220 V_{DC} and 230 V_{AC}	176 to 264 V_{DC}	176 to 264 V_{AC}

The nominal frequency (f_n) for the AC auxiliary voltage is dual rated at 50/60 Hz; the operating range is 45 Hz to 65 Hz.

The BIU241 board includes these attributes:

- Inrush current: 6.2 A at 125 V_{DC} during the first 50 ms at startup
- Power supply: 40 W
- Nominal output voltage: + 5 V and 12 V
- Supply monitoring
- Permitted power outage: 50 ms
- Protection against polarity reversal
- Insulation resistance: >100 MΩ (CM) at 500 V_{DC}
- Dielectric strength: 2 kV (CM) – 50 Hz for 1 minute

3.1.2 UNIVERSAL, SINGLE- OR DUAL-INPUT POWER SUPPLY (BIU261S/BIU261D)

The power supply input(s) of the BIU261S board and of the BIU261 dual-input power supply module are available with the following auxiliary voltage ranges:

BIU261S

Nominal ranges	Operative DC range	Operative AC range
48 to 250 V_{DC}	40.8 (48-15%) to 300 (250+20%) V_{DC}	-
110 to 250 V_{AC}	-	88 (110-20%) to 300 (250+20%) V_{AC}

BIU261D: Main power supply input

Nominal ranges	Operative DC range	Operative AC range
110 to 250 V_{DC}	88 (110-20%) to 300 (250+20%) V_{DC}	-
110 to 250 V_{AC}	-	88 (110-20%) to 300 (250+20%) V_{AC}

BIU261D: Backup power supply input (DC range only)

Nominal ranges	Operative DC range
110 to 250 V_{DC}	88 (110-20%) to 300 (250+20%) V_{DC}

Note:
The main and backup power supply inputs can use identical or different operating ranges (rating and/or AC/DC type).

The nominal frequency (f_n) for the AC auxiliary voltage is dual rated at 50/60 Hz, the operating range is 44 Hz to 66 Hz.

The BIU261 board has the following characteristics:

- Inrush current: 10 A at 125 V_{DC} during the first 50 ms at start-up
- Power supply: 60 W
- Nominal output voltage: + 5 V and +12 V
- Full load permitted power outage of both power supply inputs: 20 ms
- Protection against polarity reversal
- Insulation resistance: >100 MΩ (common mode) at 500 V_{DC}
- Dielectric strength: 2 kV (common mode) – 50 Hz for 1 minute

Power supply input selection

A power supply source is considered available if its level is above 80% of the minimum value of the operative range, i.e. 80% x 48 V = 38.4 V or 80% x 110 V = 88 V. A 5% hysteresis is added in order to avoid any toggling in the availability status, i.e. the availability status will pick up at 80% $V_{AUX\ MIN}$ and drop off at 75% $V_{AUX\ MIN}$.

If the primary power supply input is lost while it is being used, the BIU261 switches to the secondary power supply input. It will switch back to the primary power supply when the latter becomes available again and has been stable for a few seconds.

If the secondary power supply is lost while it is being used, the BIU261 instantly switches to the primary power supply. It will continue to use the primary power supply source as long as it is available, even when the secondary power supply becomes available again.

3.1.3 BIU241/BIU261S/BIU261D DIGITAL OUTPUTS

On the BIU241 and BIU261S boards, as well as on the BIU261D's mother board, the characteristics of the Watchdog Relay Contacts are the same as the characteristics for the NO+NC contacts fitted on the DOU201 board.

On the BIU241 and BIU261S boards, as well as on the BIU261D's mother board, the characteristics of the two output relays used for C26x redundancy are the same as for the single-pole output-relay fitted on the DOU201 board.

3.1.4 BIU241/BIU261S/BIU261D DIGITAL INTPUTS

On the BIU241 board, two isolated digital input characteristics depend on the case:

BIU241 Case	A01	A02	A03	A04
Nominal Voltage range	24VDC	48/60VDC	110/125VDC	220 VDC
Changeover threshold (VDC)	5 to 10.1	13.5 to 17.4	34.4 to 50	63 to 108
Changeover current (mA)	> 0.1	0.2 to 0.1	0.5 to 0.1	0.5 to 0.1
Current at nominal voltage (mA)	3.5	5 @ 48VDC 6.8 @ 60VDC	2.5 @ 110VDC 3 @ 125VDC	2
Maximum input voltage (VDC)	40	72	210	300
Maximum power (W)	0.15	0.64	0.59	0.7

BIU261S/BIU264D provide two isolated logic inputs intended to be driven from the volt-free contacts on Output1 and Output2. The inputs are designed to operate from 48V DC to 250VDC (+/- 20%) allowing them to be powered by the local supply voltage.

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Characteristic of the isolated inputs:

- Guaranteed Logic 0 level = 10V
- Guaranteed Logic 1 level = 38V
- Threshold Level 0 to 1 = 29V
- Threshold Level 1 to 0 = 19V
- Maximum input voltage = 300VDC

3.2 CIRCUIT BREAKER CONTROL UNIT (CCU) DIGITAL INPUTS

3.2.1 CCU200 DIGITAL INPUTS

For the CCU200 board, for the variants A01 to A04, the eight inputs have the same attributes as the inputs for the DIU200 board.

The CCU200 board is available in five nominal voltage variants, as follows:

Board variant	Nominal voltage (+/-20%)	Triggering threshold (V_{DC})	Same for DIU200
A01	$24V_{DC}$	if V >$10.1V_{DC}$ Input status is set if V < $5V_{DC}$ Input status is reset	Yes
A02	48 to $60V_{DC}$	if V >$17.4V_{DC}$ Input status is set if V < $13.5V_{DC}$ Input status is reset	Yes
A03	110 to $125V_{DC}$	if V > $50V_{DC}$ Input status is set if V< $34.4V_{DC}$ Input status is reset	Yes
A04	$220V_{DC}$	if V > $108V_{DC}$ Input status is set if V< $63V_{DC}$ Input status is reset	Yes
A07	110 to $125V_{DC}$	if V > $86V_{DC}$ input status is set if V < $67V_{DC}$ input status is reset	No

3.2.2 CCU211 DIGITAL INPUTS

There are six variants of the CCU211 board, as follows:

Board variant	Nominal voltage (+/-20%)	Triggering threshold (V_{DC})
A01	24 V_{DC}	if V >10 V_{DC} Input status is set if V < 8 V_{DC} Input status is reset
A02	48 to 60 V_{DC}	if V >17.4 V_{DC} Input status is set if V < 12.5 V_{DC} Input status is reset
A03	110 to 125 V_{DC}	if V > 50 V_{DC} Input status is set if V< 29.9 V_{DC} Input status is reset
A04 or A07	220 V_{DC} or 110 to 125 V_{DC} (with 80% Threshold)	if V > 86 V_{DC} Input status is set if V< 67 V_{DC} Input status is reset
A08	220 V_{DC} (with 80% Threshold)	if V > 176 V_{DC} Input status is set if V < 132 V_{DC} Input status is reset

3.3 CIRCUIT BREAKER CONTROL UNIT (CCU) DIGITAL OUTPUTS

3.3.1 CCU200 DIGITAL OUTPUTS

Each relay of the CCU board has double pole contacts. To get the attributes described below, you must wire the two output contacts of each relay in series.

In the table that follows, the Break attribute shows in two cases:

- You use each of the output contacts separately
- You wire the two output contacts of each relay in serial. In this event, you make the best use of the Break function for each relay

On the CCU200 board, the details of the 4 Output Relay Contacts show in this table:

Description	Values
Nominal operating voltage range	24 to 250 VDC / 230 VAC
Carry (steady state current)	5 A
Making capacity (rated inrush current)	5 A continuously 30 A for 500 ms or 250 A for 30 ms
Breaking capacity (Output contacts used separately)	DC: 50 W resistive, 30 W inductive (L/R = 40 ms) AC: 1250 VA resistive, 1250 VA inductive (power factor = 0.7) In these conditions, the contact resistance is still lower than 250 mΩ for 10 000 operations
Breaking capacity (Output contacts wired in serial)	DC: 80 W resistive for currents lower than 1 A, 100 W resistive for currents higher than 1 A, 30 W inductive (L/R = 40 ms) AC: 1250 VA resistive, 1250 VA inductive (power factor = 0.7) In these conditions, the contact resistance is still lower than 250 mΩ for 10 000 operations
Breaking time	< 7 ms
Double pole contacts	Normally open
Number of operations	Unloaded contact: > 100 000 Loaded contact: >10 000

Dielectric strength of the coil and the contacts: 5000 V_{RMS}

Dielectric strength of adjacent contacts: 2500 V_{RMS}

Isolation: 2 kV (CM) at 50 Hz for 1 minute

The board is designed and monitored to prevent any unwanted event.

3.3.2 CCU211 DIGITAL OUTPUTS

For the CCU211 board, the Digital Output (DO) attributes include:

- 4 double-pole switch-relays with normally open (NO) contacts
- 1 common +ve and 1 common -ve contact for 2 relays
- A self-monitoring device for the output control chain: address check, state monitoring
- The +5V voltage is monitored to prevent issuing an unwanted signal
- You can configure the digital outputs only in the double remote signalling configuration
- Dielectric strength of the coil and the contacts: 5000 V_{RMS}
- Dielectric strength of adjacent contacts: 2500 V_{RMS}
- The board is designed and monitored to prevent issuing an unwanted signal

In the table that follows, the Break attribute shows in two cases:

- You use each of the output contacts separately
- You wire the two output contacts of each relay in serial. In this event, you make the best use of the Break function for each relay
- For more details, please refer to the table that follows.

Description	Values
Nominal operating voltage range	24 to 250 V_{DC} / 230 V_{AC}
Carry (steady state current)	5 A

Description	Values
Making capacity (rated inrush current)	5 A continuously 30 A for 500 ms or 250 A for 30 ms
Breaking capacity (output contact used separately)	DC: 50 W resistive, 30 W inductive (L/R = 40 ms) AC: 1250 VA resistive, 1250 VA inductive (power factor = 0.7) In these conditions, the contact resistance is still lower than 250 mΩ for 10000 operations
Breaking capacity (Output contacts wired in serial)	DC: 80 W resistive for currents lower than 1 A, 100 W resistive for currents higher than 1 A, 30 W inductive (L/R = 40 ms) AC: 1250 VA resistive, 1250 VA inductive (power factor = 0.7) In these conditions, the contact resistance is still lower than 250 mΩ for 10 000 operations
Breaking time	< 7 ms
Double pole contacts	Normally open
Number of operations	Unloaded contact: > 100 000 Loaded contact: >10 000

3.4 DIGITAL INPUT UNIT (DIU) DIGITAL INPUTS

3.4.1 DIU200 DIGITAL INPUTS

The DIU200 board has 16 digital inputs and is available in four nominal voltage variants:

Board variant	Field voltage	Triggering threshold		Trigger current	Current at rated voltage	Max. power
		Pick-up	Drop-off			
A01	24 V_{DC}	10.1 V_{DC}	5 V_{DC}	>0.17 mA	3 mA	0.12 W
A02	48-60 V_{DC}	17.9 V_{DC}	13.5 V_{DC}	>0.17 mA	5.22 mA (48 V_{DC})/ 7 mA (60 V_{DC})	0.66 W
A03	110-125 V_{DC}	52.3 V_{DC}	34.4 V_{DC}	>0.33 mA	2.6 mA (110 V_{DC})/ 3.5 mA (125 V_{DC})	0.62 W
A04	220 V_{DC}	108 V_{DC}	63 V_{DC}	>0.46 mA	2 mA	0.66 W

3.4.2 DIU210 DIGITAL INPUTS

The DIU210 board operates for all voltages between 24V_{DC} and 220V_{DC} (+/- 20%).

The DIU210 board has 16 digital inputs.

For each voltage, the triggering threshold is 19V_{DC}.

As a result of thermal dissipation, the maximum number of DIU210 boards installed in one C26x rack depends on the rack type and on the voltage level of the inputs as shown in the table that follows:

Volts	Maximum number of DIU210 boards	
	in 40TE racks	in 80TE racks
24 V	2	8
48 V	6	15
110 to 125 V	3	10
220 V	1	5

Note:
This table only applies to the DIU210 board.

3.4.3 DIU211 DIGITAL INPUTS

In the C26x case, the DIU211 board can replace a DIU200 board or a DIU210 board. The external connections are the same as for these boards.

The DIU211 board includes 16 opto-isolated digital-inputs, with one common for two inputs.



Warning:
Where digital inputs are energized at 300 V the C26x ambient operating temperature is limited to 40°C and the maximum number of simultaneously energized digital inputs must not exceed 50% per DIU211 module.

The inputs are suitable for use on systems with nominal battery voltages from 24 V_{DC} to 220 V_{DC} (+/- 20%). The inputs respond to negative input voltages. The inputs are not self-checked. The threshold voltage depends on the voltage range which is set by positioning a jumper on the board (see *Hardware* chapter):

Variant	Input voltage	Triggering threshold		Trigger current	Current at rated voltage	Rated power
		Pick-up	Drop-off			
A01	24 V_{DC}	10 V_{DC}	8 V_{DC}	30 mA for 2 ms	3.2 mA	0.077 W
A02	48 V_{DC} – 60 V_{DC}	17.4 V_{DC}	12.5 V_{DC}	30 mA for 2 ms	2.9 mA at 48 V	0.14 W
A03	110 V_{DC} – 125 V_{DC}	50 V_{DC}	29.9 V_{DC}	30 mA for 2 ms	2.4 mA at 110 V	0.26 W
A04	220 V_{DC}	86 V_{DC}	67 V_{DC}	30 mA for 2 ms	1.9 mA	0.42 W
A07	110 V_{DC} – 125 V_{DC} with 80% threshold	86 V_{DC}	67 V_{DC}	30 mA for 2 ms	2.4 mA at 110 V	0.26 W
A08	220 V_{DC} with 80% threshold	176 V_{DC}	132 V_{DC}	30 mA for 2 ms	1.9 mA	0.42 W

For an input voltage from the threshold value to 18 V, the input current is 30 mA. The voltage applied to the input terminals, with an amplitude between 19 V_{DC} and 264 V_{DC} powers the pulse generation circuit. The circuit drives a current pulse with an amplitude of 30 mA. The pulse duration is between 1 ms and 2 ms.

To reduce thermal dissipation, especially at high input voltages, the inputs draw a current of less than 1.6 mA.

A high current circulation inside binary contacts for a short period cleans them and thus allows the boards to be used in contaminated environments.

3.4.4 DIU221 DIGITAL INPUTS

In the C26x case, the DIU221 board can replace a DIU200 board, a DIU210 board or a DIU211 board. The external connections are the same as for these boards.

The DIU221 board includes 16 galvanically isolated (40 kΩ) digital-inputs, with one common for two inputs.

The inputs are suitable for use on systems with nominal battery voltages of 158-170 V_{DC} (A09 variant) or 250 V_{DC} ±20% (A10 variant). The inputs do not respond to negative input voltages. The inputs are not self-checked.

Variant	Input voltage	Triggering threshold	
		Pick-up	Drop-off
A09	170 V_{DC}	170 V_{DC}	154 V_{DC}
A10	250 V_{DC}	200 V_{DC}	150 V_{DC}

The voltage applied to the input terminals powers the pulse generation circuit. The circuit drives a high-current "rejection" pulse with an amplitude of up to 140 mA. The pulse duration is approximately 3 ms. It carries an electric charge of at least 200 µC. It allows the boards to be used in contaminated environments by burning off possible deposits on the contacts.

In order to reduce thermal dissipation, the 40 kΩ resistance is switched off when the input voltage level crosses the pick-up threshold.

The rejection pulse is allowed to fire only once every 4 seconds in order to prevent the risk of component damage. It is fired before the input channel turns on. By the time it has finished, the voltage has continued to rise enough to cross the input pick-up threshold and the 40 kΩ resistance is switched off.

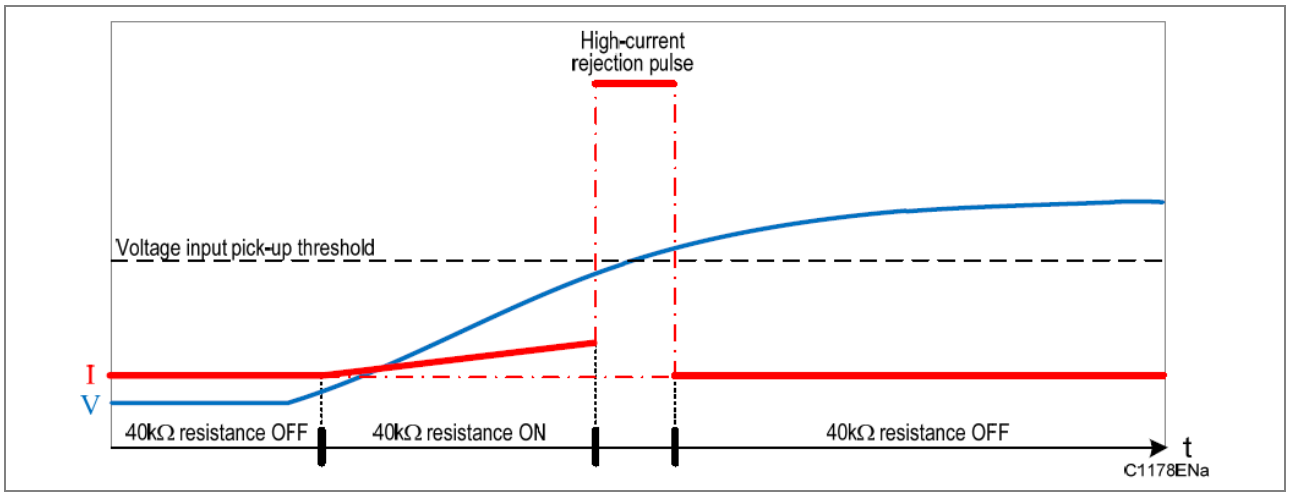


Figure 1: Input channel response curve

3.5 DIGITAL OUTPUT UNIT (DOU) DIGITAL OUTPUTS

3.5.1 DOU200 DIGITAL OUTPUTS

On the DOU200 board, the attributes of the Output Relay Contacts are shown in this table:

Description	Values
Nominal operating voltage range	24 to 250 V_{DC} / 230 V_{AC}
Carry (steady state current)	2.5 A
Making capacity (rated inrush current)	2.5 A continuously 30 A for 500 ms or 250 A for 30 ms
Making time	< 7 ms
Breaking capacity	DC: 50 W resistive, 15 W inductive (L/R = 20 ms) AC: 1250 VA resistive, 1250 VA inductive (power factor = 0.7) In these conditions, the contact resistance is still lower than 250 mΩ for 10000 operations
8 single pole relays	Normally open contacts
2 double pole relays	1 common for 2 output contacts (NO/NC changeover)
Number of operations	Unloaded contact: > 100 000 Loaded contact: >10 000

- Dielectric strength of the coil and the contacts: 5000 V_{AC}
- Isolation: 2 kV (CM) at 50 Hz for 1 minute
- The board is designed and monitored to prevent issuing an unwanted signal.

3.5.2 DOU201 DIGITAL OUTPUTS

The DOU201 board provides:

- 10 insulated digital outputs (with relays)
- 8 single pole relays with one normally open (NO) contact
- 2 double pole relays with 1 common for 2 output contacts (NO/NC changeover)

In the C26x rack, a DOU201 board replaces a DOU200 board. External connections remain the same as for earlier versions of the board.

The characteristics of the output relay contacts of a DOU201 board are given in this table:

Description	Values
Nominal operating voltage range	24 to 250 V_{DC} / 230 V_{AC}
Carry (steady state current)	5 A
Making capacity (rated inrush current)	5 A continuously 30 A for 500 ms (open for 40 s afterwards) or 250 A for 30 ms
Making time	< 7 ms
Breaking capacity	Breaking capacity for 100 000 operations: DC: 150 W resistive, 15 W inductive (L/R = 20 ms) AC: 1500 VA resistive, Breaking capacity reduced to 90 000 operations: AC: 1500 VA inductive (power factor = 0.7) Breaking capacity confirmed after 10 000 operations (contact resistance still lower than 250 mΩ): DC: 30 W inductive (L/R = 40 ms)

Description	Values
8 single-pole relays	Normally open contacts
2 double-pole relays	1 common for 2 output contacts (NO/NC changeover)
Number of operations	Unloaded contact: > 100 000 Loaded contact: >10 000

The location of the DOU201 in the C26x rack defines the address of the board. If you use the DOU201 as a spare of a previous board, you can use the jumper to define the address of the board. Use the SCE to define this location (refer to C26x/EN AP).

- Dielectric strength of the coil and the contacts: 5000 V_{AC}.
- Isolation: 2 kV (CM) at 50 Hz for 1 minute
- The board is designed and monitored to prevent issuing an unwanted signal.

3.6 HIGH BREAK UNIT (HBU) HIGH BREAK/HIGH SPEED DIGITAL OUTPUTS

The HBU200 board is used for applications requiring high rupture capacity. It provides 10 single pole output relays with normally open (NO) contacts.

The characteristics of the output relay contacts of an HBU200 board are given in this table:

Description	Values
Nominal operating voltage range	up to 250 V_{DC} / 250 V_{AC} + 20%
Transient impulse clamping level	450 V minimum
Carry (steady state current)	Single pole: 10 x 10 A at 55°C Double pole: 5 x 16 A at 40°C
Making capacity (rated inrush current)	33 A for 3 s
Maximum inrush current	100 A for 30 ms
Making time	< 0.5 ms
I^2t rating	300 A^2/s
Contact resistance	Make: 33 mΩ Carry: 10 mΩ
Breaking capacity	Breaking capacity for 10 000 operations: DC: 7500 W resistive, 2500 W inductive (L/R = 40 ms) AC: 7500 W resistive, 2500 W inductive
Number of operations	Unloaded contact: > 100 000 Loaded contact: >10 000

The location of the HBU200 board in the C26x rack defines the address of the board. . If you use the HBU200 as a spare of a previous board, you can use the jumper to define the address of the board. Use the SCE to define this location (refer to C26x/EN AP).

- Isolation: 2 kV (CM) at 50 Hz for 1 minute, 4 kV impulse
- The board is designed and monitored to prevent issuing an unwanted signal.

3.7 ANALOGUE INPUT UNIT (AIU) ANALOGUE INPUTS

3.7.1 AIU201 ANALOGUE INPUTS

The AIU201 board provides 4 independent analogue inputs (AI). You can set each AI input current range or input voltage range as shown in the table that follows:

Type	Ranges
Current input range	[–1 mA .. +1 mA] [–5 mA .. +5 mA] [–10 mA .. +10 mA] [–20 mA .. +20 mA] (see C26x/EN AP for settable sensor ranges)
Voltage input range	[–1.25 V .. +1.25 V] [–2.5 V .. +2.5 V] [–5 V .. +5 V] [–10 V .. +10 V]
Sampling period	100 ms
Accuracy	0.1% full scale at 25°C
AD conversion	16 bits (15 bits + sign bit)
Common mode rejection ratio (CMMR)	> 100 dB
Serial mode rejection ratio (SMMR)	> 40 dB
Range of Gain: user-selectable	1, 2, 4, 16
Input impedance for voltage inputs	11 kΩ
Input impedance for current inputs	75 Ω

You can set the ranges during the configuration phase.

To select the current or voltage, choose the input number of the connector.

AD conversion

The zero offset value is computed by the conversion of a 0 V voltage reference.

The gain is adjusted automatically by software by connecting a known voltage reference to the amplifier.

The zero offset values and the gain are adjusted regularly in order to compensate for the deviations caused by variations of temperature (drift: as much as 30 ppm/°C) and ageing.

3.7.2 AIU211 ANALOGUE INPUTS

Transducers deliver the DC current signals to the AIU211 board. The AIU211 board provides 8 insulated analogue input values on 8 independent galvanic-isolated channels. This means that there is no common point of contact between two analogue inputs.

You can configure each analogue input in the current range as shown in the table that follows:

Type	Ranges
Current input range	[–1 mA .. +1 mA] [–5 mA .. +5 mA] [–10 mA .. +10 mA] [–20 mA .. +20 mA] (see AP chapter for settable sensor ranges)
Sampling period	100 ms
Accuracy	0.1% full scale for each range at 25°C
AD conversion	16 bits (15 bits + sign bit)
Common mode rejection ratio (CMMR) 50Hz, 60Hz	> 100 dB
Serial mode rejection ratio (SMMR)	> 40 dB

Type	Ranges
Input impedance for current inputs	75 Ω

Temperature drift: as much as 30 ppm/°C between 0°C and 70°C

You can set the ranges during the configuration phase.

To select the current range, choose the input number of the connector.

The AIU211 board replaces the AIU210 Board: the interface on the internal Bus is compatible with the AIU210.

3.7.3 SATURATION VALUES

Range	Saturation values
[–10 V .. +10 V]	-12.6 V / +12.6 V
[–5 V .. +5 V]	-6.3 V / +6.3 V
[–2.5 V .. +2.5 V]	-3.2 V / +3.2 V
[–1.25 V .. +1.25 V]	-1.26 V / +1.26 V
[–1 mA .. +1 mA]	-1.26 mA / +1.26 mA
[–5 mA .. +5 mA]	-6.3 mA / +6.3 mA
[–10 mA .. +10 mA]	-12.6 mA / +12.6 mA
[–20 mA .. +20 mA]	-25.2 mA / +25.2 mA

3.8 TRANSDUCERLESS MEASUREMENT UNIT (TMU) CT/VT ANALOGUE INPUTS

3.8.1 GENERAL

For C26x BCUs, you can install TMU210, and TMU220 boards.

For C26x-Standalone RTUs, there are no TMU2xx boards installed.

The TMU220 provides 4 Current Transformer (CT) inputs & 5 Voltage Transformer (VT) inputs.

The TMU210 provides 4 Current Transformer (CT) inputs & 4 Voltage Transformer (VT) inputs.

3.8.2 TMU220 – CURRENT TRANSFORMERS (CT)

On the terminal block, there are two available nominal currents, each with different attributes.

The current measurement inputs to each of the 4 Current Transformers (CT) include the following attributes:

Description	Operating range	
	1 A	5 A
Nominal AC current (In)	1 A_{RMS}	5 A_{RMS}
Minimum measurable current with same accuracy	0.2 A_{RMS}	0.2 A_{RMS}
Maximum measurable continuous current	4 A_{RMS} (4*In)	20 A_{RMS} (4*In)
Frequency	50 or 60 Hz ± 10%	50 or 60 Hz ± 10%

TMU220 CT overload withstand:

Duration	Strength	
	1 A	5 A
3 seconds: not measurable, with no destruction	6 A_{RMS} (6*In)	30 A_{RMS} (6*In)
1 second: not measurable, with no destruction	20 A_{RMS} (20*In)	100 A_{RMS} (20*In)

3.8.3 TMU220 – VOLTAGE TRANSFORMERS (VT)

The voltage measurement inputs to each of the 5 Voltage Transformers (VT) include the following attributes:

Description	Operating range
Nominal AC voltage (Vn) range	57.73 V_{RMS} to 270 V_{RMS}
Minimum measurable voltage	7 V_{RMS}
Maximum continuous, measurable voltage	300 V_{RMS}
Frequency operating range	50 or 60 Hz ± 10%

VT overload withstand:

Duration	Strength
10 seconds with no destruction	880 V_{RMS}

3.8.4 TMU210 – PROTECTIVE CURRENT TRANSFORMERS (CT)

On the terminal block, there are two available nominal currents: 1A and 5A. Each has different attributes. Use jumpers to set the 1A or 5A nominal current (refer to the block diagram, in the connection chapter).

The current measurement inputs to each of the 4 Current Transformers (CT) include the following characteristics:

I PHASE		
Standard values for rated secondary current (In)	**1A**	**5A**
Minimal current validity threshold (with upper threshold hysteresis of 2mA)	0.01A_{eff}	0.05A_{eff}
Minimal operating current*	0,1A_{eff}	0,5Aeff
Rated continuous thermal value*	4A_{eff} (400%)	20A_{eff} (400%)
Maximal operating currents*	30A_{eff} / 10s 40A_{eff} / 5s	150A_{eff} / 10s 200A_{eff} / 5s
Rated short-time thermal value**	100A_{eff} / 1s	500A_{eff} / 1s
Rated frequency range	50 or 60Hz ±10% (45 to 66 Hz)	
Consumption	<0.007VA at In	<0.144VA at In

I SENSIBLE		
Standard values for rated secondary current (Ien)	**1A**	**5A**
Minimal current validity threshold (with upper threshold hysteresis of 2mA)	0.01A_{eff}	0.05A_{eff}
Minimal operating current*	0,01A_{eff}	0,05A_{eff}
Rated continuous thermal value*	0.8A_{eff} (80%)	4A_{eff} (80%)
Maximal operating current*	8A_{eff} / 10s	40A_{eff} / 10s
Rated short-time thermal values**	30A_{eff} / 10s 100A_{eff} / 1s	150Aeff / 10s 500A_{eff} / 1s
Rated frequency range	50 or 60Hz ±10% (45 to 66 Hz)	
Consumption	< 500µVA at 0.1In	< 500µVA at 0.1In

I VERY SENSIBLE		
Standard values for rated secondary current (Ien)	**1A**	**5A**
Minimal current validity threshold (with upper threshold hysteresis of 2mA)	0,002A_{eff}	0,01A_{eff}
Minimal operating current*	0,002A_{eff}	0,01A_{eff}
Rated continuous thermal value*	0.01A_{eff} (1%)	0.05A_{eff} (1%)
Maximal operating current*	1A_{eff} / 10s	5A_{eff} / 10s
Rated short-time thermal values**	30A_{eff} / 10s 100A_{eff} / 1s	150A_{eff} / 10s 500A_{eff} / 1s
Rated frequency range	50 or 60Hz ±10% (45 to 66 Hz)	
Consumption	< 500µVA at 0.1In	< 500µVA at 0.1In

** at full scale value, rated frequency (Fn) and into operating temperature range*

*** not measurable without destruction*

3.8.5 TMU210 – PROTECTIVE VOLTAGE TRANSFORMERS (VT)

The 3 or 4 phase voltage measurement inputs to each of the 4 Voltage Transformers (VT) include the following characteristics:

Voltage Transformer (VT)	
Standard values for rated secondary voltage (Vn)	100V/$\sqrt{3}$, 100V/3, 100V, 110V/$\sqrt{3}$, 110V/3, 110V
Minimal voltage validity threshold (with upper threshold hysteresis of 1.0V)	1,0 V_{eff}
Minimal operating voltage*	5,7 V_{eff}
Rated continuous thermal value*	110V_{eff}
Maximum operating voltage	260 V_{eff} / 10s
Rated short-time thermal values**	338 V_{eff} / 10s
Consumption	<0,08VA at 57.7V <0,4VA at 130V <1.5VA at 260V
Rated frequency range	50 or 60Hz ±10% (45 to 66 Hz)

** at full scale value, rated frequency (Fn) and into operating temperature range*

*** not measurable without destruction*

Connection option by setting:

For 3 phase voltage input: 3Vpn / 2 Vpn + Vr / 2Vpp + Vr

For 4 phase voltage input: 3Vpn / 3 Vpn + Vr / 2 Vpn + Vr / 3 Vpp + Vr / 2 Vpp + Vr

All voltage and power phase protection are done on Vpp voltage directly measured or derived, and Vr is directly measured or derived.

3.8.6 TMU2XX - A/D CONVERTER

On the TMU2xx boards, the A/D converter includes the following attributes:

Description	Values
Width	16 bits
Conversion period	< 30 µs
Scanning period	64 samples/period
Linearity error	± 2 LSB
SINAD ratio as much as 1kHz	>80 db
Low passed filter at 1kHz	-40 db/decade

3.9 ANALOGUE OUTPUT UNIT (AOU)

3.9.1 AOU200 ANALOGUE OUTPUTS

The AOU200 board provides 4 analogue current outputs. Each output is related to a Read Inhibit relay. An external power supply supplies power to the outputs.

The analogue outputs, the relays and the power supply are one isolated group.

The external power supply must supply a regulated voltage of +48V±5% and a power of 10 W for each AOU200 board

For the AOU200 board, the output attributes are as follows:

Value	Maximal Impedance
± 5 mA (± 20% ⇨ ± 6 mA)	4 kΩ
± 10 mA (± 20% ⇨ ± 12 mA)	2 kΩ
± 20 mA (± 20% ⇨ ± 24 mA)	1 kΩ
+ 4 mA to +20 mA	

After calibration, and at 25°C, precision = 0.1% X (the full scale + 20%)
Between -10°C and +70°C, maximum deviation <100ppm/°C

100 ms after the command, the current output is stable. The management of the AOU200 board with an RI relay shows in the figure below. When the RI relay is in the closed position, you can read the value.

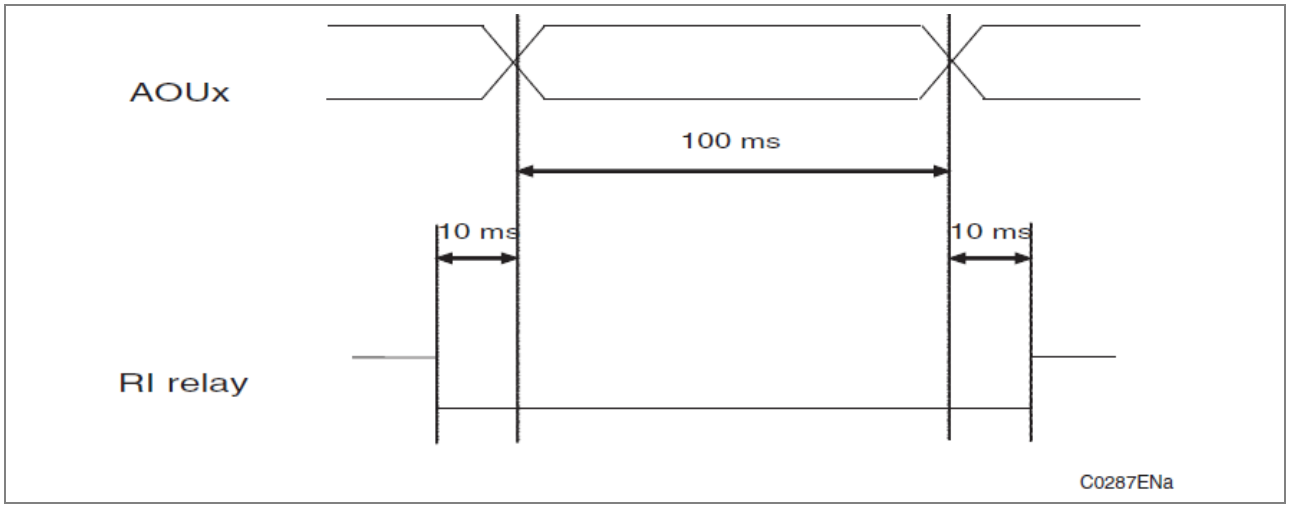


Figure 2: AOU board management with an RI relay

Watchdog relay and RI relays characteristics:

Contact type	NO
Max operating voltage	250 V_{DC} / 230 V_{AC}
Make and Carry	2.5 A continuously 30 A for 500 ms 100 A for 30 ms
Break	DC: 50 W resistive, 15 W inductive (L/R = 40 ms) AC: 1250 VA resistive 1250 VA inductive (power factor cosφ = 0.7 – relay duration is lower)
Operating time	< 7ms
Maximum frequency of switching	360 operations each hour, on nominal load
Life Period	100 000 operations, on resistive load at 250 V_{AC}, 8 A

The watchdog feature is used to send an alarm signal in case of an AOU200 board failure: This signal is sent (alarm) if:

- the automatic cyclical refresh (“I’m alive” periodic signal from the CPU, part of the communication protocol) of the WD function is interrupted, or
- communications with the CPU board are no longer possible, or
- the field voltage used by the analogue outputs is lost.

The associated green LED is lit when there is no alarm present.

3.10 DSPIO BOARD

3.10.1 DSPIO DIGITAL INPUTS

For the DSPIO board, for the variants A01 to A04, the five inputs, that are separated in 3 electrical groups isolated, have the following attributes:

Case	Voltage	Consumption current	Threshold OFF	Threshold ON
A01	24V	5 mA +- 10 %	7 V	11 V
A02	48V	5 mA +/- 10 %	15 V	22 V
A03	110V	2,4 mA +/- 10 %	36 V	56 V
A04	220V	2 mA +/- 10 %	75 V	115 V

3.10.2 DSPIO DIGITAL OUTPUTS

The board is designed for 5 digitals output, that are separated in 7 electrical groups isolated, have the following attributes:

Description	Values
Maximum voltage	250Vac
Maximum current	8 A
Limiting making capacity, max 4s	15 A
Maximum switching power	2000 VA
Contact	2 C/O

3.11 TABLE OF THE DIELECTRIC STRENGTH OF THE SPECIFIC INPUTS AND OUTPUTS

Type of board	Type of terminals (Numbers of Terminals)	Dielectric withstand (CM, 60s)
BIU241, BIU261	Digital Outputs (1 to 3)	2000 VAC 2800VDC
	Watchdog (4 to 6)	2000 VAC 2800VDC
	Digital Inputs (7 to 9)	2000 VAC 2800VDC
	RS232/RS485 (12 to 21)	2000 VAC 2800VDC
	Main Power Supply (23, 24)	2000 VAC 2800VDC
BIU261 Daughter Board	Backup Power Supply (1, 2)	2200 VAC 3100VDC
CPU2xx IRIG-B	IRIG-B (1, 2)	2000 VAC 2800VDC
CPU270 Ethernet	Ethernet Port 1 (port1 pin 1 to 8)	1000 VAC 1500VDC
	Ethernet Port 2 (port2 pin 1 to 8)	1000 VAC 1500VDC
AIU201	Analog Inputs (1 to 5, 7 to 11, 13 to 17, 19 to 23)	2000VAC 2800VDC
AIU211	Analog Inputs (1 to 5, 7 to 11, 13 to 17, 19 to 23)	2000VAC 2800VDC
AOU200	External Power Supply (1, 3)	2000VAC 2800VDC
	Watchdog (5, 6)	2000VAC 2800VDC
	Read Inhibit AO no. 1 to 4 (8 to 15)	2000VAC 2800VDC
	Analog Output no. 1 to 4 (17 to 24)	2000VAC 2800VDC
DIU200, DIU210, DIU211	16 x Digital Inputs (1 to 24)	2000VAC 2800VDC
DOU200, DOU201	10 x Digital Outputs (1 to 24)	2000VAC 2800VDC
CCU200, CCU211	8 x Digital Inputs (1 to 12)	2000VAC 2800VDC
	4 x Digital Outputs (13 to 24)	2000VAC 2800VDC
HBU200	10 x High Break Outputs (1 to 24)	2000VAC 2800VDC
DSPIO	5 x Digital Inputs (1 to 8)	2000VAC 2800VDC
	5 x Digital Outputs (9 to 24)	2000VAC 2800VDC
SWR21x or SWU20x	4 x Ethernet Port (ports pins 1 to 8)	1000 VAC 1500VDC
	Alarm (1 to 3)	2000 VAC 2800VDC
SWT214	4 x Ethernet Port (ports pins 1 to 8)	1000 VAC 1500VDC
	Alarm (1 to 3)	2000 VAC 2800VDC
SRP28x, SRP29x	3 x Ethernet Port (ports pins 1 to 8)	1000 VAC 1500VDC
	Alarm (1 to 3)	2000 VAC 2800VDC
	IRIG-B (1,2)	2000VAC 2800VDC
SVU 282/284	3 x Ethernet Port (ports pins 1 to 8)	1000 VAC 1500VDC
	Alarm (1 to 3)	2000 VAC 2800VDC
	IRIG-B (1,2)	2000VAC 2800VDC
TMU2x0	Current Inputs (1 to 16)	2200 VAC 2800VDC
	Voltage Inputs (19 to 28)	2200 VAC 2800VDC

4 BURDENS

4.1 AUXILIARY VOLTAGE

The C26x unit's burdens depend on the number of boards installed in the unit and shown in the table that follows:

Case	Nominal	Maximum
40TE	15 W	25 W
80TE	20 W	BIU241: 40 W / BIU261: 52 W

4.2 POWER SUPPLY BOARD/MODULE

4.2.1 BIU241 AND BIU261S

For the BIU241 board or the BIU261 module, the input burden on the internal 5 V rail is 1.25 W. This includes the watchdog, redundancy relays and communication ports.

The minimum efficiency of the power supply is 78%.

Note:
During the DS Agile C26x start-up process, there is a peak current. During the first 50 ms, the peak current can reach 6.2 A, as measured on the BIU-A03 board with a source of 125 V_{DC}.

Nominal voltage	Current at Un (mA) - after peak
24 V_{DC}	2.6 mA
48 V_{DC}	2.2 mA
110 V_{DC}	1.9 mA
125 V_{DC}	1.5 mA
220 V_{DC}	1 mA

4.2.2 BIU261D

In addition to the above characteristics, the auxiliary power-supply must meet the following minimum specifications for inrush current withstand:

- 20 A for 1.5 ms
- 10 A for 150 ms
- 1.2 x In for 500 ms

4.3 CPU BOARD

The CPU270 board (also referred to as the CPU type 3 or CPU3) burden on the internal 12 V rail is 2.7 W.

4.4 CIRCUIT BREAKER CONTROL UNITS (CCU) INPUT BURDENS

4.4.1 CCU200 INPUT BURDEN

On the CCU200 board, the input burdens are as follows:

Board variant	Nominal voltage	Current at Un (mA)
A01	24 V_{DC}	3.5
A02	48 to 60 V_{DC}	5 at 48 V_{DC} 6.8 at 60 V_{DC}
A03	110 to 125 V_{DC}	2.5 at 110 V_{DC} 3 at 125 V_{DC}
A04	220 V_{DC}	2
A07	110 to 125 V_{DC}	3.4 at 110 V_{DC} 5.4 at 132 V_{DC}

The CCU200 board burden on the internal 5 V rail is 0.4 W plus 0.4 W for each energised relay.

4.4.2 CCU211 INPUT BURDEN

On the CCU211 board, the input burdens are as follows:

Nominal voltage	Current at Un (mA)- after peak
24V_{DC}	2.6 mA
48V_{DC}	2.2 mA
110V_{DC}	1.9 mA
125V_{DC}	1.5 mA
220V_{DC}	1 mA

For the CCU211 board, the input burden on the internal 5 V rail is 0.29 W plus 0.4 W for each energised relay.

4.5 DIGITAL INPUT UNIT (DIU) INPUT BURDEN

4.5.1 DIU200 INPUT BURDEN

On the DIU200 board, the input burdens are as follows:

Board variant	Nominal voltage	Current at Un (mA)
A01	24 V_{DC}	3.5 mA
A02	48 to 60 V_{DC}	5 mA at 48 V_{DC} 6.8 mA at 60 V_{DC}
A03	110 to 125 V_{DC}	2.5 mA at 110 V_{DC} 3 mA at 125 V_{DC}
A04	220 V_{DC}	2 mA

The burden of the DIU200 board on the internal 5 V rail is 75 mW

4.5.2 DIU210 INPUT BURDEN

The DIU210 board includes the input burdens as follows:

Nominal voltage	Current at Un (mA)
24 V_{DC}	>25 mA
48 to 60 V_{DC}	3.8 mA
110 to 125 V_{DC}	4 mA
220 V_{DC}	4.1 mA

The burden of the DIU210 board on the internal 5 V rail is 75 mW.

Power consumption for each input:

Un = 24 V_{DC} to 110 V_{DC}: 0.5 W ± 30% for each input
Un > 110 V_{DC}: 5 mA ± 30%

From 48 V_{DC} to 220V $_{DC}$ voltage, a high current consumption is created on binary inputs during a short period and circulates through external binary contacts to clean them. Please refer to the peak current response curve.

Important note:
For the 24 V_{DC} voltage, there is no short peak current because of the permanent high consumption on inputs > 25 mA.

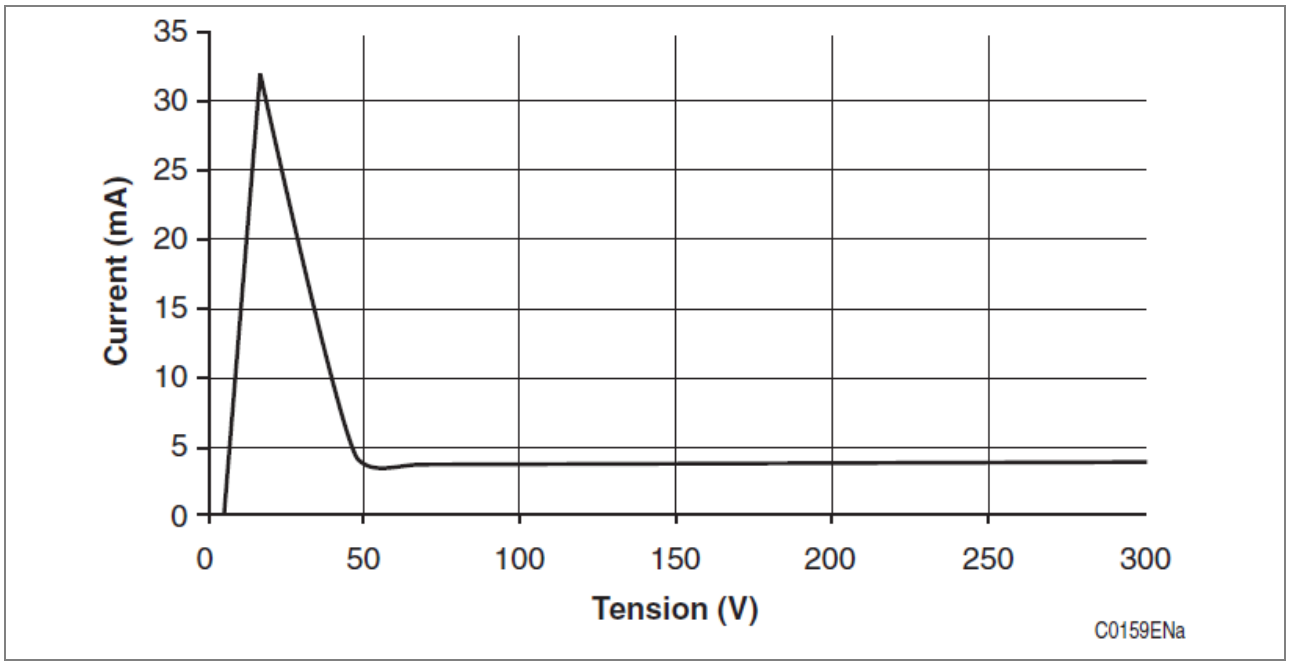


Figure 3: Peak current response curve

4.5.3 DIU211 INPUT BURDEN

To reduce thermal dissipation, especially at high input voltage levels, the inputs use less than 1.6mA.

The DIU211 board includes the following input burdens:

Nominal voltage	Current at Un (mA)- after peak
24 V_{DC}	2.6 mA
48 V_{DC}	2.2 mA
110 V_{DC}	1.9 mA
125 V_{DC}	1.5 mA
220 V_{DC}	1 mA

The burden of the DIU211 board on the internal 5 V rail is 75 mW

From 24 V_{DC} to 220 V_{DC}: a peak current (>27 mA) circulates during a short time (approximately 2 ms) to clean external relays' contacts:

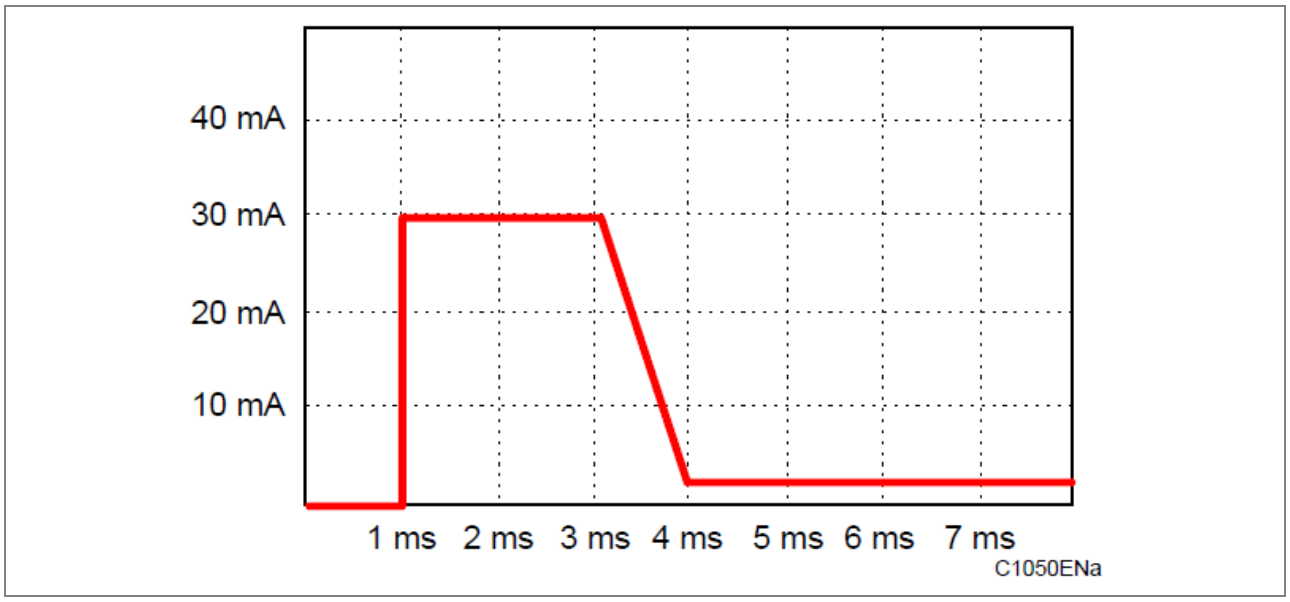


Figure 4: Peak current response curve

4.5.4 DIU221 INPUT BURDEN

The DIU221 board includes the following input burdens:

Nominal voltage	Current at Un (mA) - after peak
170 V_{DC}	0.2 mA
250 V_{DC}	0.2 mA

The burden of the DIU221 board is below 1.2 W on the internal 5 V rail and below 0.5 W on the internal 12 V rail.

A high current (up to 140 mA) circulates during a short time (approximately 3 ms). It is used to clean external relays' contacts in contaminated environments:

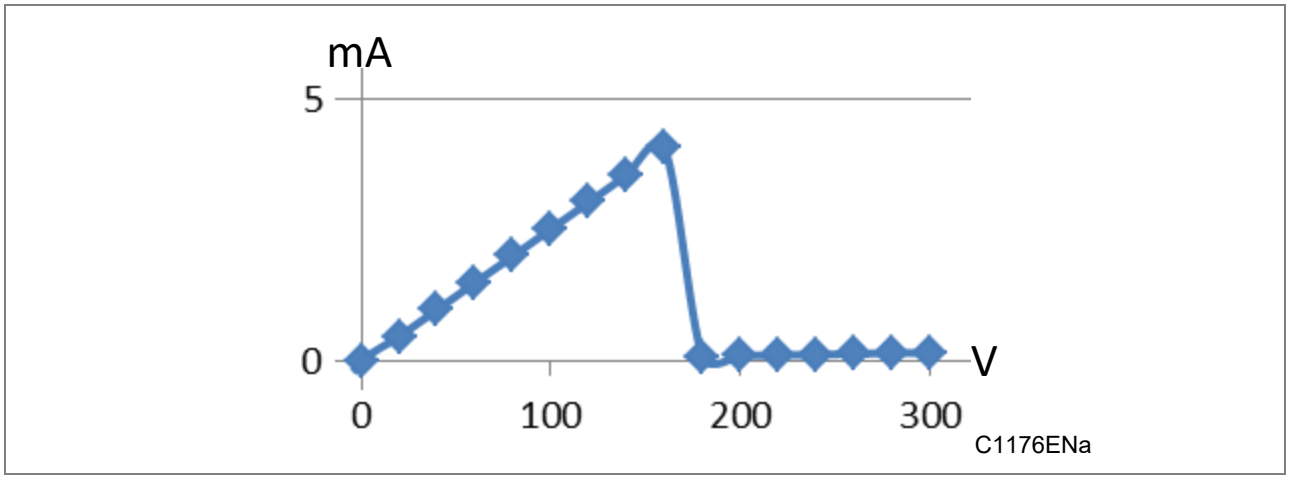


Figure 5: High current response curve

4.6 DIGITAL OUTPUT UNIT (DOU) INPUT BURDEN

DOU200 board

The input burden on the internal 5 V rail is 0.25 W, plus 0.2 W for each energised relay.

DOU201 board

The input burden on the internal 5 V rail is 0.25 W plus 0.2 W for each energised relay.

4.7 HIGH BREAK UNIT (HBU) INPUT BURDEN

HBU200 board:

The input burden on the internal 5 V rail is 0.15 W.

The input burden on the internal 12 V rail is 7.2 W, plus 0.36 W for each energised relay.

4.8 ANALOGUE INPUT UNIT (AIU) INPUT BURDEN

AIU201 board:

The input burden on the internal 5 V rail is 1 W.

AIU211 board:

The input burden on the internal 5 V rail is 1.1 W.

4.9 TRANSDUCERLESS MEASUREMENT UNIT (TMU) CT/VT INPUT BURDEN

For the TMU210 / TMU220 boards, the input burdens on the internal transformers are as follows:

CT burden (at nominal current – In)	Nominal consumption (VA)	
	TMU210	TMU220
1 A	< 0.02	< 0.02
5 A	< 0.2	< 0.2

VT burden (at nominal voltage – Vn)	Nominal consumption (VA)	
	TMU210	TMU220
Vn = 130 VRMS	< 0.1	< 0.01

TMU210 board:

The input burden on the internal 5 V rail is 0.3 W.

TMU220 board:

The input burden on the internal 5 V rail is 0.3 W.

4.10 ANALOGUE OUTPUT UNIT (AOU) INPUT BURDEN

AOU200 board:

The input burden on the internal 5 V rail is 120 mA (maximum).

4.11 ETHERNET SWITCH BOARDS' INPUT BURDEN ON THE INTERNAL 5 V RAIL

SWU20x: 3.85 W with 2 optical ports

SWx202 / SWx204: 4 W

SWD212 / SWD214: 6 W

SWR212 / SWR214: 7 W

SWT212 / SWT214: 6 W

SRP282 / SRP284: 6 W

SRP292 / SRP294: 6 W

4.12 FRONT PANEL BOARD INPUT BURDEN ON THE INTERNAL 5 V RAIL

GHU200 / GHU210:

- 600 mW when the LCD screen is not back-lit
- 3 W when the LCD screen is back-lit.

GHU201 / GHU211: 0.6 W

GHU202 / GHU212: < 0.001 W

5 ACCURACY

To secure the proper accuracy for calculations, the sampling frequency must be exactly adapted to the signal frequency that fluctuates around the basic frequency (50 / 60 Hz).

For all specified accuracy, the repeatability is ± 2.5% unless otherwise specified.

If no range is specified for the validity of the accuracy, then the specified accuracy is valid over the full setting range.

5.1 REFERENCE CONDITIONS

Quantity	Reference conditions	Test tolerance
General		
Ambient temperature	20 °C	±2 °C
Atmospheric pressure	86kPa to 106kPa	-
Relative humidity	45 to 75 %	-
Input energising quantity		
Current	In	±5%
Voltage	Vn	±5%
Frequency	50 or 60Hz	±0.5%
Auxiliary supply	$24V_{DC}$, $48V_{DC}$-$60V_{DC}$, $110V_{DC}$-$125V_{DC}$, $220V_{DC}$ $230V_{AC}$	±5%

5.2 MEASUREMENT ACCURACY

5.2.1 MEASUREMENT ACCURACY – TMU220

Quantity	Accuracy
Current (with measurement CT)	0.2% full scale
Voltage (with voltage droppers)	0.2% full scale
Power (with measurement CT)	0.5% at best
Frequency	± 0.014 Hz
Amplitude	< 1%
Phase	± 1°
Overall temperature coefficient	± 10 ppm/°C
Harmonics	H15

5.2.2 MEASUREMENT ACCURACY – TMU210

Measurement	Range	Deviation
Phase current (with measurement CT)	0.1 to 40 In	Typical ±0.5% In at In
Earth current	0.002 to 1 I0n 0.01 to 8 I0n 0.1 to 40 I0n	Typical ±0.5% Vn at I0n
Voltage (with voltage droppers)	57 to 260V 220 to 960V	Typical ±0.5% Vn at Vn

Active Power		Reactive Power	
Cos	Deviation	Sin	Deviation
0.866	<1.5%	0.866	<3%
0.5	< 3%	0.5	< 1.5%

5.3 HOW TO MEASURE THE ISOLATION RESISTANCE

To measure the isolation resistance, execute the following steps:

1 Apply a continuous voltage of 500 V to both points.

2 Wait a minimum of 5 seconds to stabilize the reading.

3 Make a record of the isolation resistance.

4 The isolation resistance must be higher than 100 M ohms, in agreement with procedure LQD/P52/1

6 TYPE TESTS

6.1 DIELECTRIC STRENGTH TESTS

6.1.1 C26X UNIT – DIELECTRIC STRENGTH TEST

Type Test Name	Type Test Standard	Conditions
Insulation Resistance	IEC 60255-5 (2000)	100 MΩ at 500 V_{DC} (CM and DM)
Dielectric Strength	IEC 60255-5 (2000) IEEE C37.90 (1989)	50 Hz for 1 minute, 2 kV (CM), 1 kV (DM)
High Voltage Impulse Test	IEC 60255-5 (2000)	5 kV CM and 3 kV DM

6.1.2 AIU211 – DIELECTRIC STRENGTH TEST

Type Test description	Type Test Standard	Conditions
Insulation Resistance	IEC 60255-5 (2000)	100 MΩ at 500V_{DC} (CM)
Dielectric Strength	IEC 60255-5 (2000) IEEE C37.90 (1989)	50Hz for 1 minute, 2kV (CM),
Impulse Voltage Strength for inputs of the AIU211	IEC 60255-5 (2000)	5kV (CM)

6.1.3 ECU200/ECU201 – DIELECTRIC STRENGTH TEST

Type Test description	Type Test Standard	Conditions
Insulation Resistance	IEC 60255-5 (2000)	100 MΩ at 500 V_{DC} (CM and DM) (between groups)

6.1.4 SRP282/SRP284 – DIELECTRIC STRENGTH TEST

Type Test description	Type Test Standard	Conditions
Insulation resistance	IEC 60255-5	100 MΩ at 500 V
Dielectric strength Alarm Relay RJ45 ports	IEC 60255-5	 2 kV_{AC} for 1 minute 1.5 kV_{DC} for 1 minute
Impulse voltage Alarm Relay RJ45 ports	IEC 60255-5	 5 kV common mode 2 kV common mode

6.1.5 SRP292/SRP294 – DIELECTRIC STRENGTH TEST

Type Test description	Type Test Standard	Conditions
Insulation resistance	IEC 60255-5	100 MΩ at 500 V
Dielectric strength Alarm Relay RJ45 ports	IEC 60255-5	 2 kV_{AC} for 1 minute 1.5 kV_{DC} for 1 minute
Impulse voltage Alarm Relay RJ45 ports	IEC 60255-5	 5 kV common mode 2 kV common mode

6.2 MECHANICAL TEST

Type Test Name	Type Test Standard	Conditions
Free Fall Test Free Fall Packaging Test	IEC 60068-2-31 (1969) + A1 (1982) IEC 60068-2-32 (1975) +A1 (1982) + A2 (1990)	2 falls of 5 cm (C26x not powered)
		25 falls of 50 cm (Packaged C26x)
Vibration Response – Powered On	IEC 60255-21-1 (1988)	Class 2: Acceleration: 1g from 10 to 150 Hz
Vibration Response – Not Powered On	IEC 60255-21-1 (1988)	Class 2: Acceleration: 2g from 10 to 500 Hz
Vibration Endurance – Not Powered On	IEC 60068-2-6 (1995)	Class 2: Acceleration: 1g from 10 to 500 Hz
Shocks – Not Powered On	IEC 60255-21-2 (1988)	Class 1: 15g, 11 ms
Shocks – Powered On	IEC 60255-21-2 (1988)	Class 2: 10g, 11 ms
Bump Test – Not Powered On	IEC 60255-21-2 (1988)	Class 1: 10g, 16 ms, 2000/axis
Seismic Test – Powered On	IEC 60255-21-3 (1993)	Class 2: Acceleration: 2g Displacement: 7.5 mm upon axis H Acceleration: 1g Displacement: 3.5 mm upon axis V

6.3 ATMOSPHERIC TEST

Type Test Name	Type Test Standard	Conditions
Damp Heat Test – Operating	IEC 60068-2-3 (1969)	Test Ca: +40°C / 10 days / 93% RH
Cold Test - Operating	IEC 60068-2-1 (1990)	Test Ab: - 25°C / 96 h
Cold Test - Storage	IEC60068-2-1 (1990)	Test Ad: -40°C / 96 h Powered On at –25°C (for information)
Dry Heat Long Test – Operating	DICOT HN 46-R01-06 (1993)	55°C / 10 days
Dry Heat Test – Storage	IEC 60068-2-1 (1990)	Test Bd: +70°C / 96 h Powered On at +70°C
Enclosure Protection	IEC 60529 (1989) + A1 (1999)	Front: IP52

6.4 DC AUXILIARY SUPPLY TEST

Type Test Name	Type Test Standard	Conditions
Inrush current (start-up)	DICOT HN 46-R01-4 (1993)	T < 1.5 ms / I < 20 A 1.5ms < T < 150 ms / I < 10 A T > 500 ms / I < 1.2 In
Supply variation	IEC 60255-6 (1988)	Vn ± 20% Vn+30% & Vn-25% for information
Overvoltage (peak strength)	IEC 60255-6 (1988)	1.32 Vn max 2 Vn for 10 ms (for information)
Ramp down to zero	N/A	From Vn down to 0 within 1 minute From Vn down to 0 within 100 minutes

Type Test Name	Type Test Standard	Conditions
Ramp up from zero	N/A	From 0 to Vn within 1 minute From 0 to Vn within 100 minutes
Supply interruption	IEC 60255-11 (1979)	From 2.5 ms to 1 s at 0.8 Vn 50 ms at Vn, no malfunction
Reverse polarity	N/A	Polarity – for the lower potential of the supply Polarity + for the lower potential of the supply
Ripple (frequency fluctuations)	IEC 60255-11 (1979)	12% Vn at f=100Hz or 120Hz 12% Vn at f=200Hz for information

6.5 AC AUXILIARY SUPPLY TEST

Type Test Name	Type Test Standard	Conditions
Supply variations	IEC 60255-6 (1988)	Vn ± 20%
AC Voltage dips & short interruptions	EN 61000-4-11 (1994)	2 ms to 20 ms & 50 ms to 1s 50 ms at Vn, no malfunction
Frequency fluctuations	IEC 60255-6 (1988)	50 Hz: from 47 to 54 Hz 60 Hz: from 57 to 63 Hz
Voltage strength	N/A	2 Vn for 10 ms (for information)

6.6 ELECTROMAGNETIC COMPATIBILITY (EMC) TESTS

Type Test Name	Type Test Standard	Conditions
High Frequency Disturbance	IEC 60255-22-1 (1988) IEC 61000-4-12 (1995) IEEE C37.90.1 (1989)	Class 3: 2.5 kV (CM) / 1 kV (DM)
Electrostatic discharge	IEC 60255-22-2 (1996) IEC 61000-4-2 (1995) + A1 (1998) + A2 (2001)	Class 3: 6 kV contact / 8 kV air
Radiated Immunity	IEC 60255-22-3 (2000) IEC 61000-4-3 (2002) + A1 (2002) IEEE C37.90.2 (1987)	Class 3: 10 V/m – 80 to 1000 MHz & spot tests
		35 V/m – 25 to 1000 MHz
Fast Transient Burst	IEC 60255-22-4 (2002) IEC 61000-4-4 (1995) + A1 (2001) IEEE C37.90.1 (1989)	Class 4: 2 kV – 2.5 kHz (CM) Class 4: 2.5 kV – 2.5 kHz (DM) on DI/DO
Surge immunity	IEC 61000-4-5 (1995) + A1 (2001)	Class 4: 4kV (CM) – 2kV (DM)
High frequency conducted immunity	IEC 61000-4-6 (2003)	Class 3: 10 V, 0.15 – 80 MHz
Harmonics Immunity	IEC 61000-4-7 (2002)	5% & 10% from H2 to H17
Power Frequency Magnetic Field Immunity	IEC 61000-4-8 (1993)	Class 5: 100A/m for 1mn 1000A/m for 3s
Pulse magnetic field immunity	IEC 61000-4-9 (1993)	Class 5: 6.4 / 16 µs 1000A/m for 3s
Damped oscillatory magnetic field immunity	IEC 61000-4-10 (1993) + A1 (2001)	Class 5: 100 kHz & 1 MHz – 100A/m
Power Frequency	IEC 61000-4-16 (1998)	CM 500 V / DM 250 V via 0.1 µF
Conducted emission	EN 55022 (1998) + A1 (2000) + A2 (2003)	Gr. I, class A: from 0.15 to 30 MHz
Radiated emission	EN 55022(1998) + A1 (2000) + A2 (2003)	Gr. I, class A: from 30 to 1000 MHz

7 PROTECTION FUNCTIONS

7.1 DIRECTIONAL/NON-DIRECTIONAL PHASE OC PROTECTION (ANSI CODE 67/50/51)

- Phase Current — Fundamental only
- Phase Voltage — Fundamental only
- Phase Current Range — 0.1 to 40 x rated current, step of 0.01 In
- Thresholds — 3 independent (I>, I>>, I>>>)

I>	0.1 to 40 In (see note)
I>>	0.5 to 40 In (see note)
I>>>	0.5 to 40 In

Note:
When I> or I>> is associated to an IDMT curve, the maximum setting recommended should be 2In.

- Minimum voltage operation — 0.6V (Un: 57 to 130V)
- Minimum voltage operation — 3.0V (Un: 220 to 480V)
- Synchronous Polarisation
  Minimum phase voltage fixed threshold enabling synchronous polarising: 0.6V
  Synchronous polarising permanence time phase voltage thresholds: 5 s
- Hysteresis — 95%
- Instantaneous time — < 30 ms
- Drop out time — 30 ms
- Phase time-delays — (tI>, tI>>, tI>>>)
- DMT — 0 ms to 150 s, step of 10 ms
- Reset time (for DMT) — 0 ms to 600 s, step of 10 ms

Accuracy

- Deviation: 2%
- Trigger: DT: Is ± 2%
  IDMT: 1.1Is ± 2%
- Reset: 0.95 Is ± 2%
  1.05 Is ± 2%
- Standard Time Deviation: 2% or 50mA whichever is greater
- Time deviation for overload current (>1.5): 5%

  The time deviation must be interpreted in correlation with current value in IDMT curve: 2% is a worst case of time error versus fault current (from 1.1 to 1.5In).

  Due to the inverse time curve characteristics, time error will be more important with high currents.
- Relay characteristic angle / RCA-Torque angle: Range: 0° to 359°, Deviation: ≤ 3°
- Trip zone: Range: ± 10° to ± 170°, Deviation: ≤ 3°

IDMT curves:

- IEC: Short time inverse (GE Grid Solutions),
  Standard Inverse (IEC),
  Very inverse (IEC),
  Extremely inverse (IEC),
  Long time inverse (GE Grid Solutions)
- RI: (Electromechanical type).
- RECT: Rectifier.
- IEEE/ANSI: Short time inverse (CO2),
  Moderately inverse (ANSI),
  Inverse (CO8),
  Very inverse (ANSI),
  Extremely inverse (ANSI)
- Time Multiplier Setting (TMS): 0.025 to 1.5, step of 0.025
- Reset time
  - If IEEE/ANSI phase time-delay: Short time inverse (CO2),
    Moderately inverse (ANSI),
    Inverse (CO8),
    Very inverse (ANSI),
    Extremely inverse (ANSI).
- Reset Time Multiplier Setting (RTMS): 0.025 to 3.2, step of 0.025
  - or DMT: 0.04s to 100s; step of 0.01 s
  - If IEC curves phase time-delay: 0.04s to 100s; step of 0.01 s

7.2 DIR. /NON-DIR. NEUTRAL/GROUND/EARTH OC PROTECTION (ANSI CODE 67N/50N/51N)

• Residual Current	Fundamental only
• Residual voltage	Fundamental only
• Earth current Ranges	0.01 to 8 x rated current, step of 0.005 Ien 0.1 to 40 x rated current, step of 0.005 Ien
• Thresholds	3 independent (I_e>, I_e>>, I_e>>>)
Range:	0.01 to 8 x Ien I_e> 0.01 to 1 Ien (see note) I_e>> 0.01 to 8 Ien (see note) I_e>>> 0.01 to 8 Ien
Range:	0.1 to 40 x Ion I_e> 0.1 to 25 Ien (see note) I_e>> 0.5 to 40 Ien (see note) I_e>>> 0.5 to 40 Ien

Note: When Ie> or Ie>> is associated to an IDMT curve the maximum setting recommended should be the maximum of the range /20.

• Minimum residual voltage operation	0.7V (U_{en}: 57 to 130V)
• Minimum residual voltage operation	3.0V (U_{en}: 220 to 480V)
• Hysteresis	95%
• Instantaneous time	< 30 ms
• Drop out time	30 ms
• Earth time-delays	(tI_e>, tI_e>>, tI_e>>>)
DMT	0 ms to 150 s, step of 10 ms
Reset time (for DMT)	0 ms to 600 s, step of 10 ms

IDMT Curves

• IEC:	Short time inverse (GE Grid Solutions), Standard Inverse (IEC), Very inverse (IEC), Extremely inverse (IEC), Long time inverse (GE Grid Solutions).
• RI:	(Electromechanical type)
• RECT:	Rectifier.
• IEEE/ANSI:	Short time inverse (CO2), Moderately inverse (ANSI), Inverse (CO8), Very inverse (ANSI), Extremely inverse (ANSI).
• Time Multiplier Setting (TMS)	0.025 to 3.2, step of 0.025

- Reset time

if IEEE/ANSI Earth time-delay	Short time inverse (CO2), Moderately inverse (ANSI), Inverse (CO8), Very inverse (ANSI), Extremely inverse (ANSI).
or DMT:	0.04s to 100s ; step of 0.01 s
• Reset Time Multiplier Setting (RTMS)	0.025 to 3.2, step of 0.025
if IEC Curves Earth time-delay	0.04s to 100s; step of 0.01 s

7.3 DIR. /NON-DIR. SENSITIVE GROUND/EARTH OC PROTECTION (ANSI CODE 67N/50N/51N)

• Residual Current	Fundamental only
• Residual Voltage	Fundamental only
• Sensitive Earth current Range	0.002 to 1 x rated current, step of 0.001 Ien
• Thresholds	3 independent (I_e>, I_e>>, I_e>>>)
	Range: 0.002 to 1 x Ien I_e> 0.002 to 1 Ien (see note) I_e>> 0.002 to 1 Ien (see note) I_e>>> 0.002 to 1 Ien

Note:
When Ie> or Ie>> is associated to an IDMT curve the maximum setting recommended should be 0.05 Ien.

• Minimum residual voltage operation	0.7V (Uen: 57 to 130V)
• Minimum residual voltage operation	3.0V (Uen: 220 to 480V)
• Hysteresis	95%
• Instantaneous time	< 30 ms
• Drop-out time	30 ms
• Earth fault time-delays	(tI_e>, tI_e>>, tI_e>>>)
DMT	0 ms to 150 s, step of 10 ms
Reset time (for DMT)	0 ms to 600 s, step of 10 ms

IDMT curves

IEC:	Short time inverse (GE Grid Solutions), Standard Inverse (IEC), Very inverse (IEC), Extremely inverse (IEC), Long time inverse (GE Grid Solutions).
RI:	(Electromechanical type)

RECT:	Rectifier.
IEEE/ANSI:	Short time inverse (CO2), Moderately inverse (ANSI), Inverse (CO8), Very inverse (ANSI), Extremely inverse (ANSI).
Time Multiplier Setting (TMS)	0.025 to 1.5, step of 0.025
• Reset time	
▪ if IEEE/ANSI Earth time-delay:	Short time inverse (CO2), Moderately inverse (ANSI), Inverse (CO8), Very inverse (ANSI), Extremely inverse (ANSI).
▪ or DMT:	0.04s to 100s ; step of 0.01 s
• Reset Time Multiplier Setting (RTMS)	0.025 to 3.2, step of 0.025
▪ if IEC curves Earth time-delay:	0.04s to 100s ; step of 0.01 s

7.4 THERMAL OVERLOAD PROTECTION (ANSI CODE 49)

• Current	RMS
• Current threshold	I θ> 0.1 to 3.2 x rated current, step of 0.01
• Thermal state (alarm and trip)	50 to 200 % x θ, step of 1 %
• Constant Time Te	1 to 200 mn, step of 1 mn
• k factor	1 to 1.5, step of 0.01

7.5 UNDERCURRENT PROTECTION (ANSI CODE 37)

• Current	Fundamental only
• Phase Current Range	I< 2 to 100 % x rated current, step of 1%
• Time delay	tI< 0 to 150 s, step of 10 ms
• Hysteresis	105%

7.6 EARTH WATTMETRIC PROTECTION (ANSI CODE 32N)

• Earth fault current	Fundamental only
• Residual voltage	Fundamental only
• Minimum Operating Voltage	
Range from:	57 to 130V, step 0.7 V
Range from:	220 to 480V, step 3.0 V

- Minimum Operating Current with Ien=1A and Ien=5A

Range from:	0.002 to 1 Ien, step 1 mA
Range from:	0.01 to 8 Ien, step 5 mA
Range from:	0.1 to 40 Ien, step 50 mA

Note:
When Pe> or Iecos> is associated to an IDMT curve, the maximum setting recommended should be the maximum of the range divided by 20.

7.7 NEGATIVE SEQUENCE OC PROTECTION (ANSI CODE 46)

- Current — Fundamental only
- Phase Current Range I2> & I2>> — 0.1 to 40 x rated current

Note:
When I2> is associated to IDMT curve the maximum setting recommended should be 2In.

- Hysteresis — 95%
- I2> Time delay

DMT		0 ms to 150 s, step of 10 ms
IDMT curves	IEC:	Short time inverse (GE Grid Solutions), Standard Inverse (IEC), Very inverse (IEC), Extremely inverse (IEC), Long time inverse (GE Grid Solutions).
	RI:	(Electromechanical type)
	RECT:	Rectifier
	IEEE/ANSI:	Short time inverse (CO2), Moderately inverse (ANSI), Inverse (CO8), Very inverse (ANSI), Extremely inverse (ANSI).
Time Multiplier Setting (TMS)		0.025 to 1.5, step of 0.025

- Reset time

If IEEE/ANSI I2> Time delay:	Short time inverse (CO2), Moderately inverse (ANSI), Inverse (CO8), Very inverse (ANSI), Extremely inverse (ANSI).
or DMT:	0.04s to 100s ; step of 0.01 s

- Reset Time Multiplier Setting (RTMS) — 0.025 to 3.2, step of 0.025

If IEC I2> Time delay: 0.04s to 100s ; step of 0.01 s

- I2>> Time delay

DMT	0 ms to 150 s, step of 10 ms

7.8 UNDERVOLTAGE (ANSI CODE 27)

7.8.1 THRESHOLD SETTINGS (SECONDARY VALUES)

- Nominal voltage range: 57 – 130V

Setting	Range	Step size
V<= Voltage Set	5 – 130V	0.1V
V<<= Voltage Set	5 – 130V	0.1V

- Nominal voltage range: 220 – 480V

Setting	Range	Step size
V<= Voltage Set	20 – 480V	0.5V
V<<= Voltage Set	20 – 480V	0.5V

7.8.2 TIME DELAY SETTINGS

Each voltage element is associated to an independent time-delay.

Element	Time delay type
1st stage	Definite Time (DT)
2nd stage	Definite Time (DT)
3rd stage	Definite Time (DT)

7.8.3 DEFINITE TIME-DELAY CHARACTERISTICS

Setting	Range	Step Size
tV<	0 – 600s	0.01s
tV<<	0 – 600s	0.01s

7.8.4 ACCURACY

- Nominal voltage range: 57 – 130V (V< and V<<)
  - Range 2 to 130V
  - Deviation 2%
  - Trigger DT: Us ± 2%
  - Reset 0.95 Us ± 2%
  - Time Deviation ± 2% +20…40ms
- Nominal voltage range: 220 – 480V (V< and V<<)
  - Range 10 to 480V
  - Deviation 2%
  - Trigger DT: Us ± 2%
  - Reset 0.95 Us ± 2%
  - Time Deviation ± 2% +20…40ms

Trigger time and reset times: 2% or 40ms whichever is greater.

7.9 OVERVOLTAGE (ANSI CODE 59)

7.9.1 THRESHOLD SETTINGS (SECONDARY VALUES)

- Nominal voltage range: 57 – 130V

Setting	Range	Step Size
V>= Voltage Set	5 – 200V	0.1V
V>>= Voltage Set	5 – 260V	0.1V

- Nominal voltage range: 220 – 480V

Setting	Range	Step Size
V>= Voltage Set	20 – 720V	0.5V
V>>= Voltage Set	20 – 960V	0.5V

7.9.2 TIME DELAY SETTINGS

Each voltage element is associated to an independent time-delay.

Element	Time delay type
1st stage	Definite Time (DT)
2nd stage	Definite Time (DT)
3rd stage	Definite Time (DT)

7.9.3 DEFINITE TIME-DELAY CHARACTERISTICS

Setting	Range	Step Size
tV>	0 – 599s	0.01s
tV>>	0 – 599s	0.01s

7.9.4 ACCURACY

- Nominal voltage range: 57 – 130V (V> and V>>)
  - Range 2 to 260V
  - Deviation 2%
  - Trigger DT: Us ± 2%
  - Reset 0.95 Us ± 2%
  - Time Deviation ± 2% +20…40ms
- Nominal voltage range: 57 – 130V (V> and V>>)
  - Range 10 to 960V
  - Deviation 2%
  - Trigger DT: Us ± 2%
  - Reset 0.95 Us ± 2%
  - Time Deviation ± 2% +20…40ms

7.10 RESIDUAL OVERVOLTAGE / NEUTRAL DISPLACEMENT (ANSI CODE 59N)

Threshold settings (secondary values)

- Nominal voltage range: 57 – 130V

Setting	Range	Step Size
V0> Voltage set	0.5 – 130V	0.1V

- Nominal voltage range: 220 – 480V

Setting	Range	Step Size
V0> Voltage set	2 – 480V	0.5V

Time delay settings

Each voltage element is associated to an independent time-delay.

Each measuring element time-delay can be blocked by the operation of a user defined logic (optically isolated) input (see “Blocking logic1” or “Blocking logic2” functions).

Element	Time delay type
1st stage	Definite Time (DT) or IDMT

Definite time-delay characteristics

Setting	Range	Step Size
tV0>	0 – 599s	0.01s

7.11 UNDER-/OVERFREQUENCY (ANSI CODES 81U/81O)

Setting	Range	Step Size
f1 threshold	Fn – 5 Hz, Fn + 5 Hz	0.01 Hz
tf1 (definite time-delay)	0 – 600s	0.01s
f2 threshold	Fn – 5 Hz, Fn + 5 Hz	0.01 Hz
tf2 (definite time-delay)	0 – 600s	0.01s
f3 threshold	Fn – 5 Hz, Fn + 5 Hz	0.01 Hz
tf3 (definite time-delay)	0 – 600s	0.01s
f4 threshold	Fn – 5 Hz, Fn + 5 Hz	0.01 Hz
tf4 (definite time-delay)	0 – 600s	0.01s
f5 threshold	Fn – 5 Hz, Fn + 5 Hz	0.01 Hz
tf5 (definite time-delay)	0 – 600s	0.01s
f6 threshold	Fn – 5 Hz, Fn + 5 Hz	0.01 Hz
tf6 (definite time-delay)	0 – 600s	0.01s

Where: Fn: nominal frequency

7.12 RATE OF CHANGE OF FREQUENCY (ANSI CODE 81R)

Threshold settings

Setting	Range	Step Size
df/dt1 threshold	–10 Hz/s, +10 Hz/s	0.1 Hz/s
df/dt2 threshold	–10 Hz/s, +10 Hz/s	0.1 Hz/s
df/dt3 threshold	–10 Hz/s, +10 Hz/s	0.1 Hz/s
df/dt4 threshold	–10 Hz/s, +10 Hz/s	0.1 Hz/s
df/dt5 threshold	–10 Hz/s, +10 Hz/s	0.1 Hz/s
df/dt6 threshold	–10 Hz/s, +10 Hz/s	0.1 Hz/s

Integration time

Setting	Range	Step Size
cycle number	1 – 200	1 cycle

Validation number of protection

Setting	Range	Step Size
Validation	2 or 4	2

Under voltage blocking

- Nominal voltage range: 57-130V

Setting	Range	Step Size
protection block	5.7 – 130V	0.1

- Nominal voltage range: 220-480V

Setting	Range	Step Size
protection block	20 – 480V	0.1

7.13 ANCILLARY FUNCTIONS

7.13.1 CIRCUIT BREAKER FAILURE (50BF)

- Under current threshold I< 2% to 100% x rated current, step of 1%
- Threshold accuracy from 0.02 In to 0.1 In: 0.006 In
from 0.1 In to 1 In: 2% Is
- Threshold hysteresis max. 0.008 In or 0.95 Is
- CB failure time tBF 30 ms to 10 s; step of 10 ms
- Operate Time 14ms
- Reset time 30ms minimum to 10s maximum

7.13.2 COLD LOAD PICK-UP

- Range 100 to 500 % x nominal settings, step of 1%
- Time delay tCL 0.1 s to 3600 s, step of 100 ms

7.13.3 RSE (CUSTOMER-SPECIFIC FUNCTION)

- Time delay in RSEA 1.5 s
- Time delay in RSEB 130 ms

7.13.4 TRIP MANAGEMENT

Automation external to the protection functions but used by them: global trip Ctrl & trip status.

8 PROTECTION CURVES

8.1 IDMT CURVES

8.1.1 MATHEMATICAL FORMULA

8.1.1.1 IDMT THRESHOLD

Inverse Time Curves:

The first and second phases (earth) overcurrent threshold can be selected with a dependent time characteristic. The time-delay is calculated with a mathematical formula.

In all, there are eleven inverse time characteristics available.

The mathematical formula applicable to the first ten curves is:

$$t = T \times \left(\frac{K}{(I/I_S)^{\alpha} - 1} + L \right)$$

Where:

t = Tripping time

K = Coefficient (see table)

I = Value of measured current

I_S = Value of the programmed threshold (Pick-up value)

α = Coefficient (see table)

L = ANSI/IEEE coefficient (zero for IEC curves)

T = Time multiplier between 0.025 and 1.5

Type of curve	Standard	K factor	α factor	L factor
Short Time Inverse	GE Grid Solutions	0.05	0.04	0
Standard inverse	IEC	0.14	0.02	0
Very inverse	IEC	13.5	1	0
Extremely inverse	IEC	80	2	0
Long time inverse	GE Grid Solutions	120	1	0
Rectifier	GE Grid Solutions	45 900	5.6	0
Short Time Inverse	C02	0.02394	0.02	0.01694
Moderately Inverse	ANSI/IEEE	0.0515	0.02	0.114
Long Time Inverse	C08	5.95	2	0.18
Very Inverse	ANSI/IEEE	19.61	2	0.491
Extremely Inverse	ANSI/IEEE	28.2	2	0.1215

The RI curve (electromechanical) is given by the following formula:

$$t = K \times \left(\frac{1}{0.339 - 0.236 / (I / Is)} \right)$$

With K settable from 0.10 to 10 in steps of 0.05

This equation is valid for 1.1<= (I/Is) <= 20

Although the curves tend towards infinite when the current approaches Is, the minimum guaranteed value of the operating current for all the curves with the inverse time characteristic is 1.1Is (with a tolerance of ± 0,05Is).

8.1.1.2 RESET TIMER

The first phase overcurrent threshold [I>/tI>] ([Ie>/tIe>] for the earth) has a reset time. The fixed period for this determines the minimum time during the current need to remain lower than 95% of the phase (earth) threshold before the time-delay associated with the phase (earth) overcurrent threshold resets.

Note:
There is an exception to this rule when the protection function is triggered. In fact, in this situation, the time-delays tI>/tIe> are immediately reset.

The value of the Reset Timer depends on the type of the timer associated to the pick-up first phase (Earth) threshold.

Type of timer associated to the first & second phase (earth) threshold	Reset Timer
DMT + RECT	0 ms
IDMT IEC or RI	Settable from 40 ms to 100s
IDMT IEEE or COx	Inverse Time

Reset timer:

The first phase and earth overcurrent stages are provided with a timer hold facility "t Reset", which may be set to a definite time value or to an inverse time characteristic (IEEE/ANSI curves only). This may be useful in certain applications, for example when grading with upstream electromechanical overcurrent relays which have inherent reset time-delays.

Another possible situation where the timer hold facility may be used to reduce fault clearance times is where intermittent faults occur. An example of this may occur in a plastic insulated cable . In this application it is possible that the fault energy melts and reseals the cable insulation, thereby extinguishing the fault. This process repeats to give a succession of fault current pulses, each of increasing duration with reducing intervals between the pulses, until the fault becomes permanent.

When the reset time of the overcurrent relay is minimum the relay will be repeatedly reset and not be able to trip until the fault becomes permanent. By using the Timer Hold facility the relay will integrate the fault current pulses, thereby reducing fault clearance time.

The reset timer "t Reset" facility can be found in the following menu:

- If the first phase (earth) threshold is selected with an IDMT IEC or RI curve, the reset timer "t Reset" with DMT characteristic is settable in the menu:
  - Protection [67/50/51] Phase OC/t Reset for the phase
  - Protection [67N/50N/51N] E/Gnd/t Reset for the earth.
  - If the first phase (earth) threshold is selected with an IDMT IEEE or CO curve, the reset timer "t Reset" with IDMT characteristic is not settable.

Reset Time "t Reset" with an IDMT characteristic:

The mathematical formula applicable to the five curves is:

$$t = T \times \left(\frac{K}{1 - (I/I_s)^{\alpha}} \right)$$

Where:

t = Reset time

K = Coefficient (see table)

I = Value of the measured current

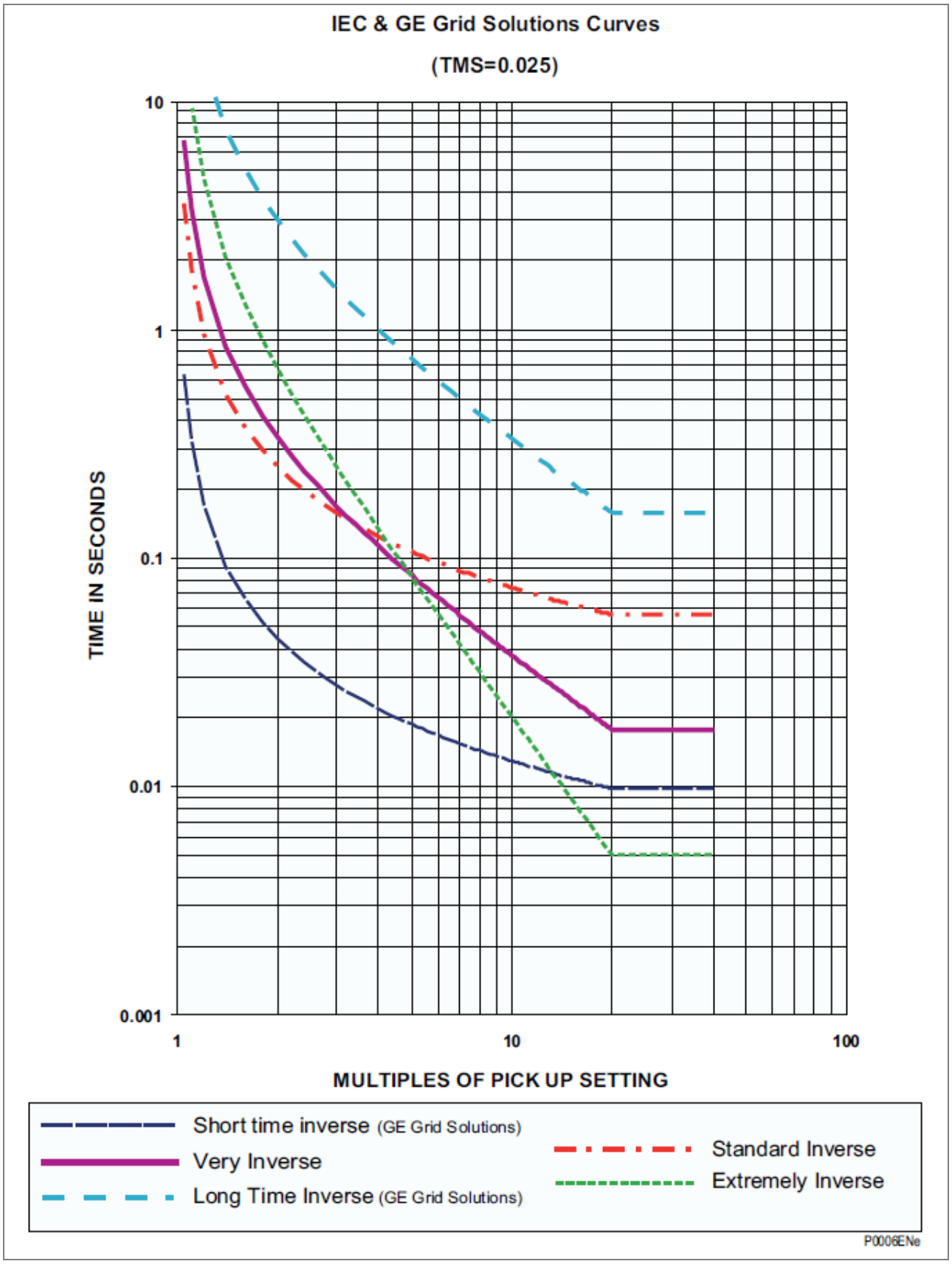
I_S = Value of the programmed threshold (pick-up value)

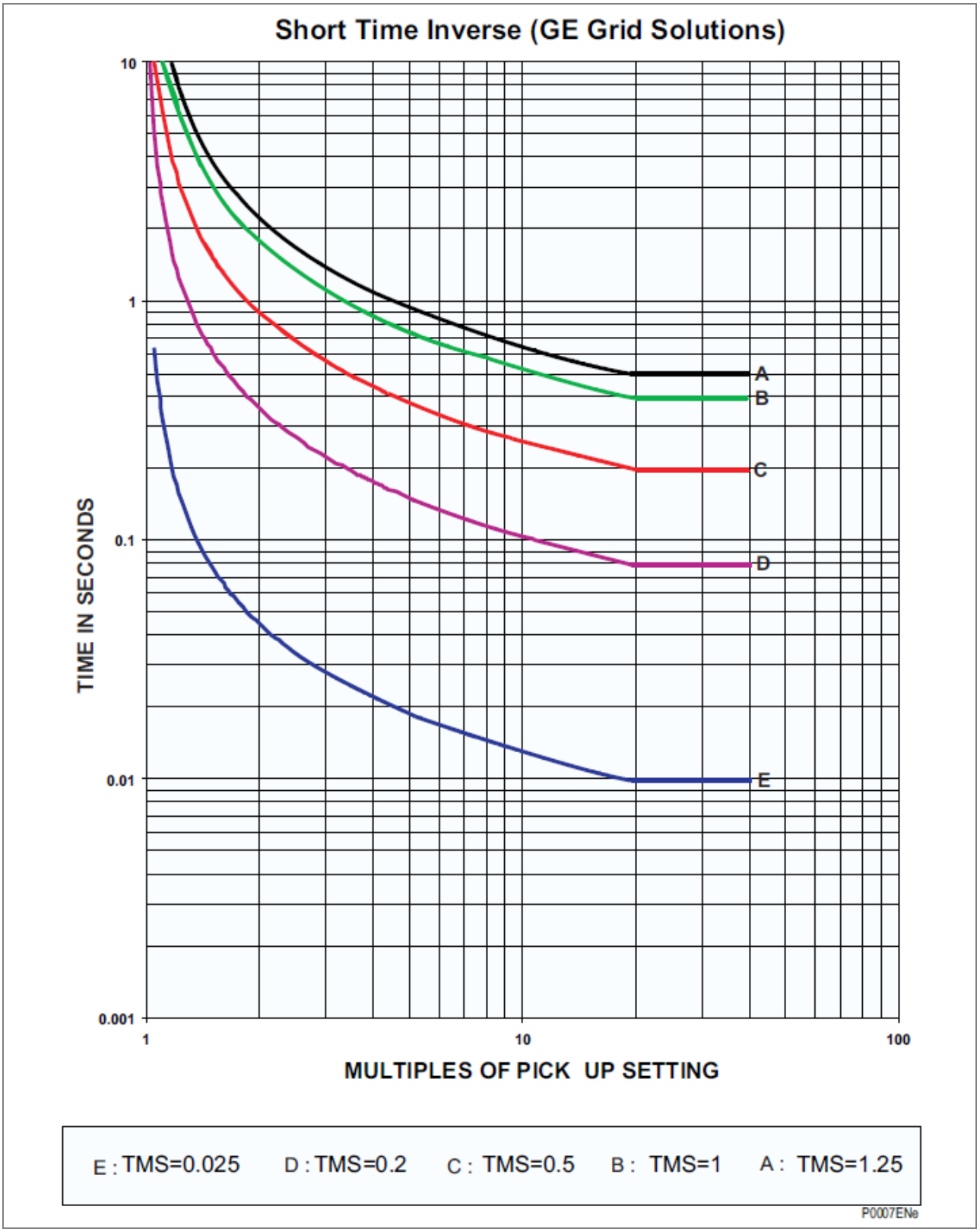
α = Coefficient (see table)

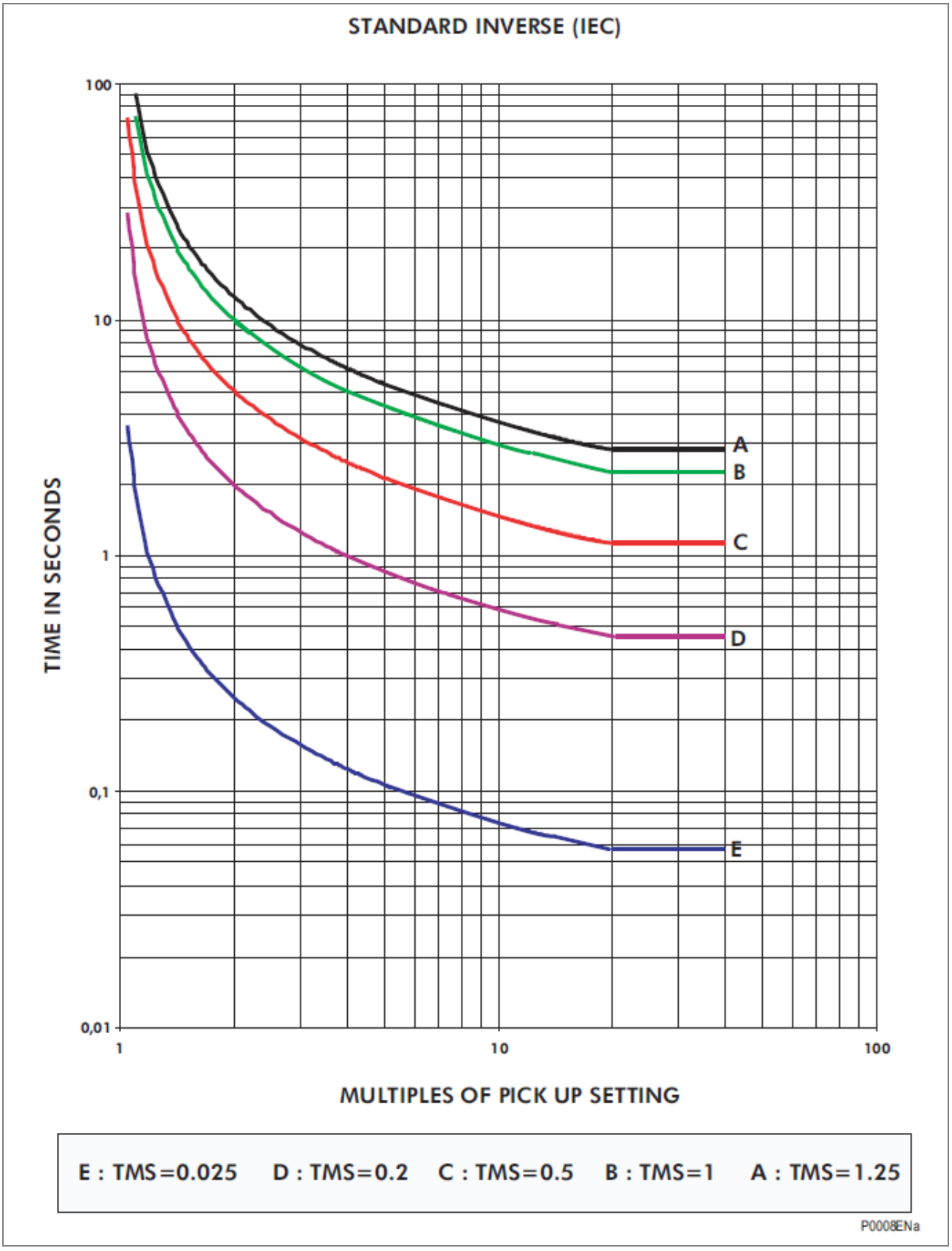
T = Reset Time Multiplier (Rtms) between 0.025 and 3.2

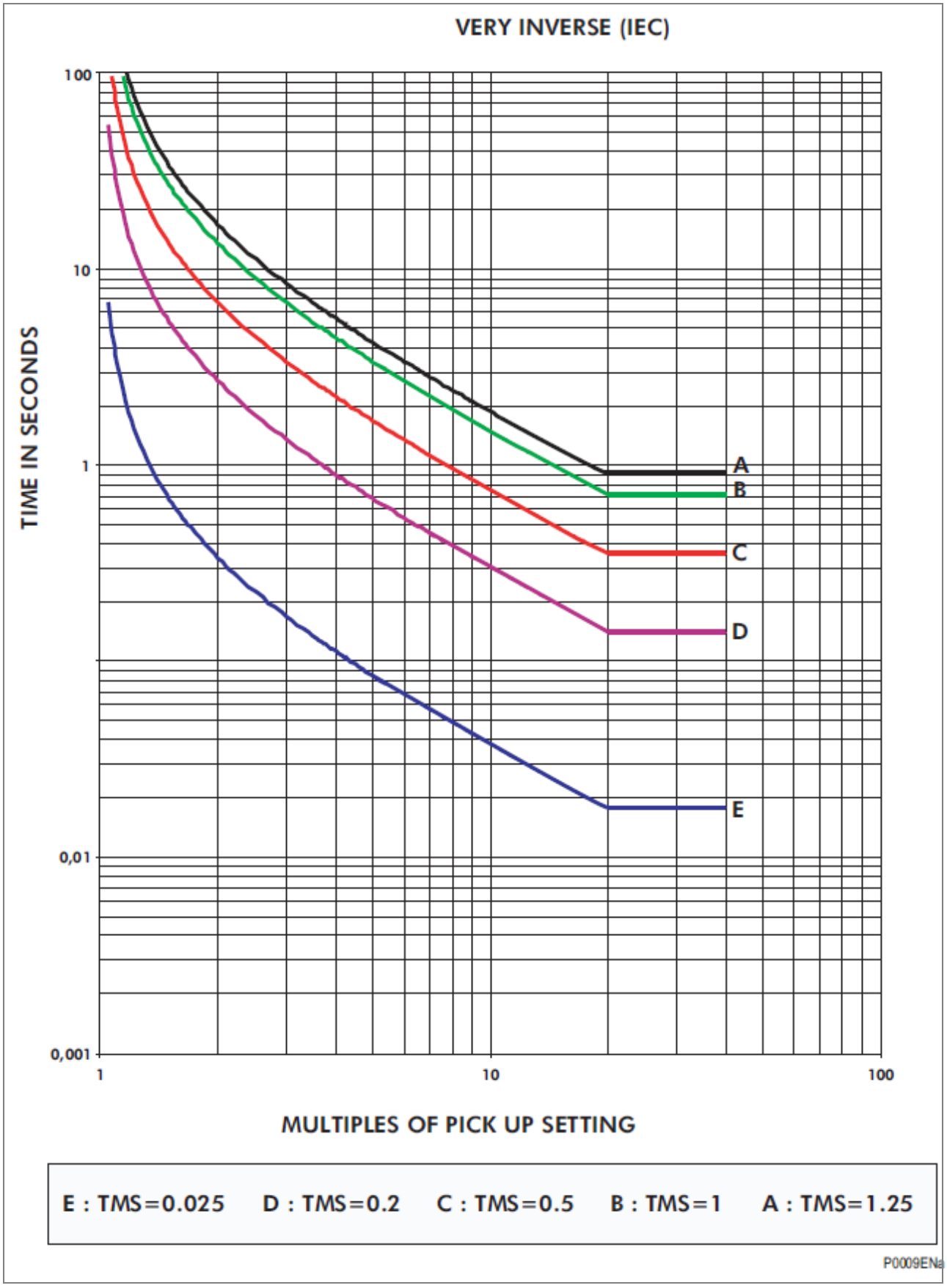
Type of curves	Standard	K factor	α factor
Short time inverse	C02	2.261	2
Moderately Inverse	ANSI/IEEE	4.85	2
Long time Inverse	C08	5.95	2
Very inverse	ANSI/IEEE	21.6	2
Extremely inverse	ANSI/IEEE	29.1	2

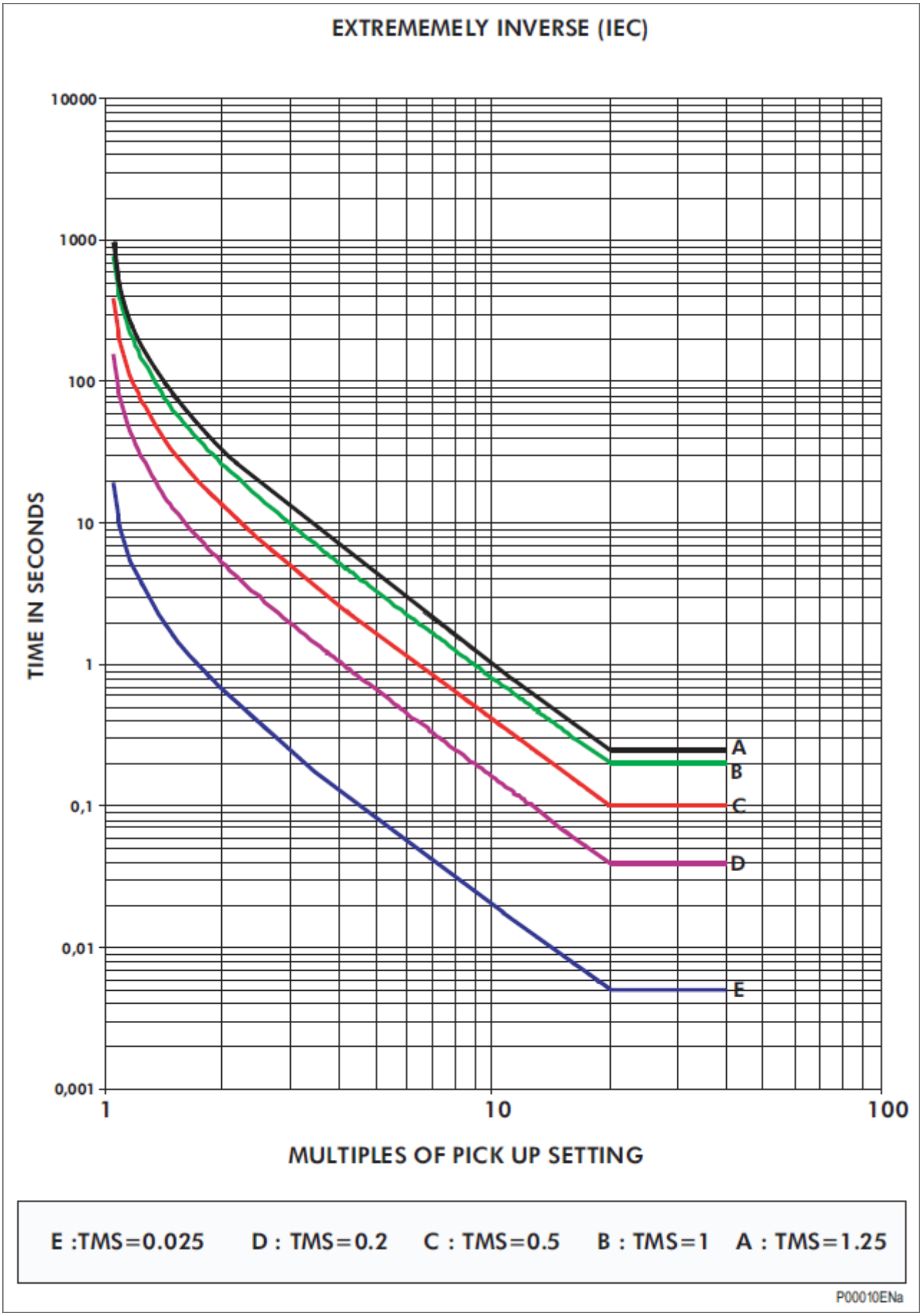
8.1.2 IEC CURVES



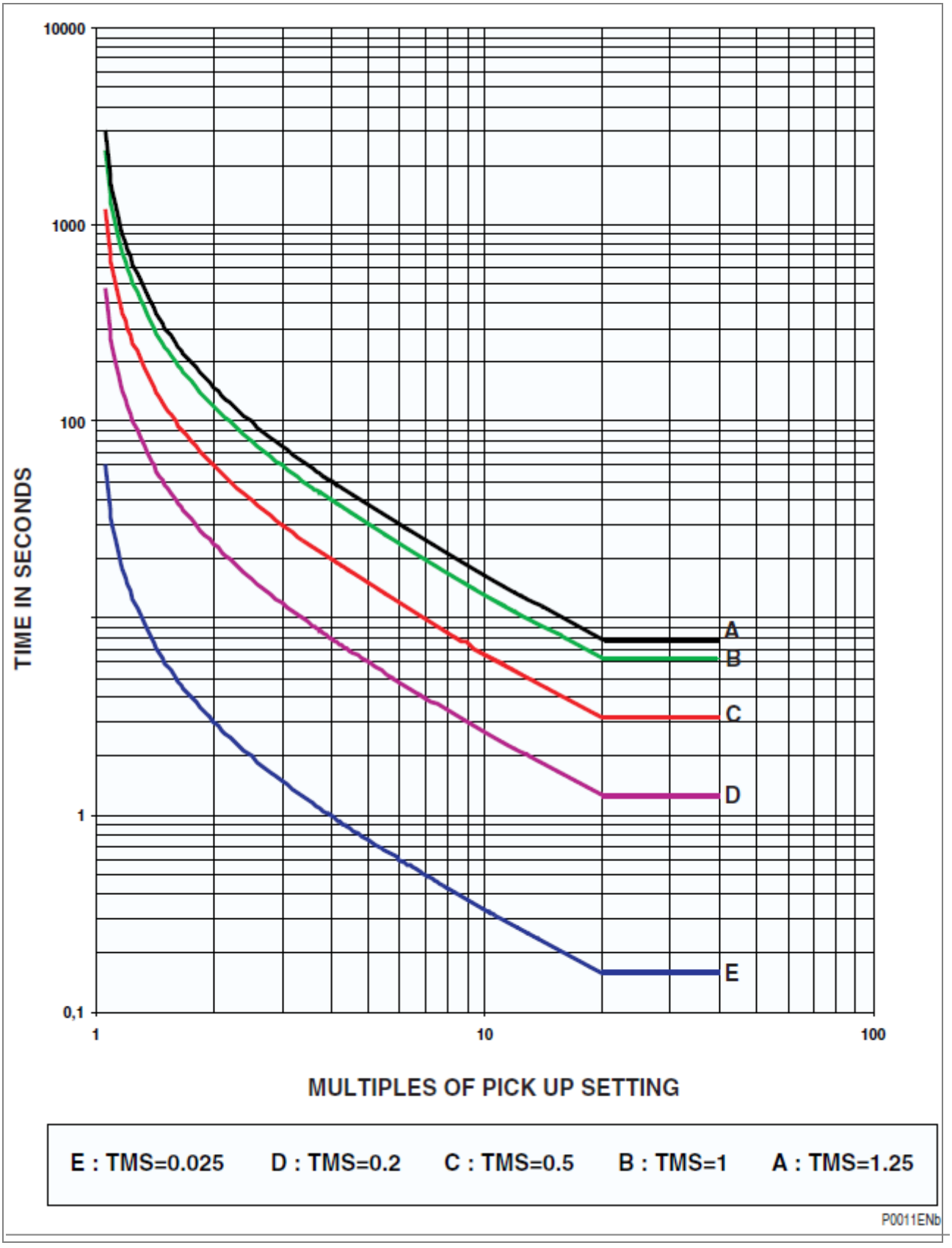

Short Time Inverse (GE Grid Solutions)
10
1
0.1
0.01
0.001
TIME IN SECONDS
1
10
100
MULTIPLES OF PICK UP SETTING
A
B
C
D
E
E : TMS=0.025
D : TMS=0.2
C : TMS=0.5
B : TMS=1
A : TMS=1.25
P0007ENa


STANDARD INVERSE (IEC)
100
10
1
0,1
0,01
TIME IN SECONDS
1
10
100
MULTIPLES OF PICK UP SETTING
A
B
C
D
E
E : TMS=0.025 D : TMS=0.2 C : TMS=0.5 B : TMS=1 A : TMS=1.25
P0008ENa

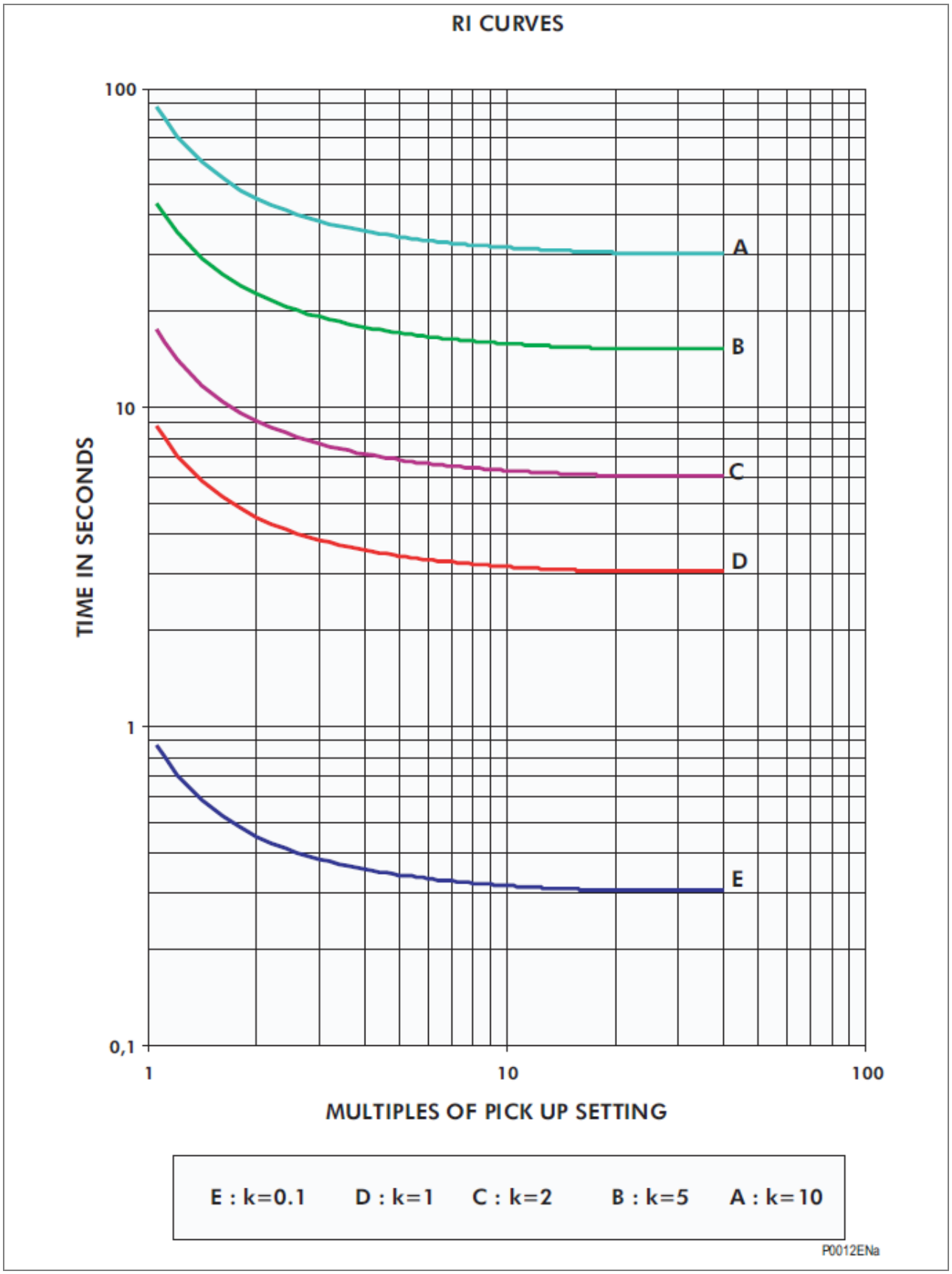

VERY INVERSE (IEC)
TIME IN SECONDS
100
10
1
0,01
0,001
1
10
100
A
B
C
D
E
MULTIPLES OF PICK UP SETTING
E : TMS=0.025
D : TMS=0.2
C : TMS=0.5
B : TMS=1
A : TMS=1.25
P0009ENa


EXTREMEMELY INVERSE (IEC)
10000
1000
100
10
1
0,1
0,01
0,001
TIME IN SECONDS
1
10
100
MULTIPLES OF PICK UP SETTING
A
B
C
D
E
E :TMS=0.025
D : TMS=0.2
C : TMS=0.5
B : TMS=1
A : TMS=1.25
P00010ENa

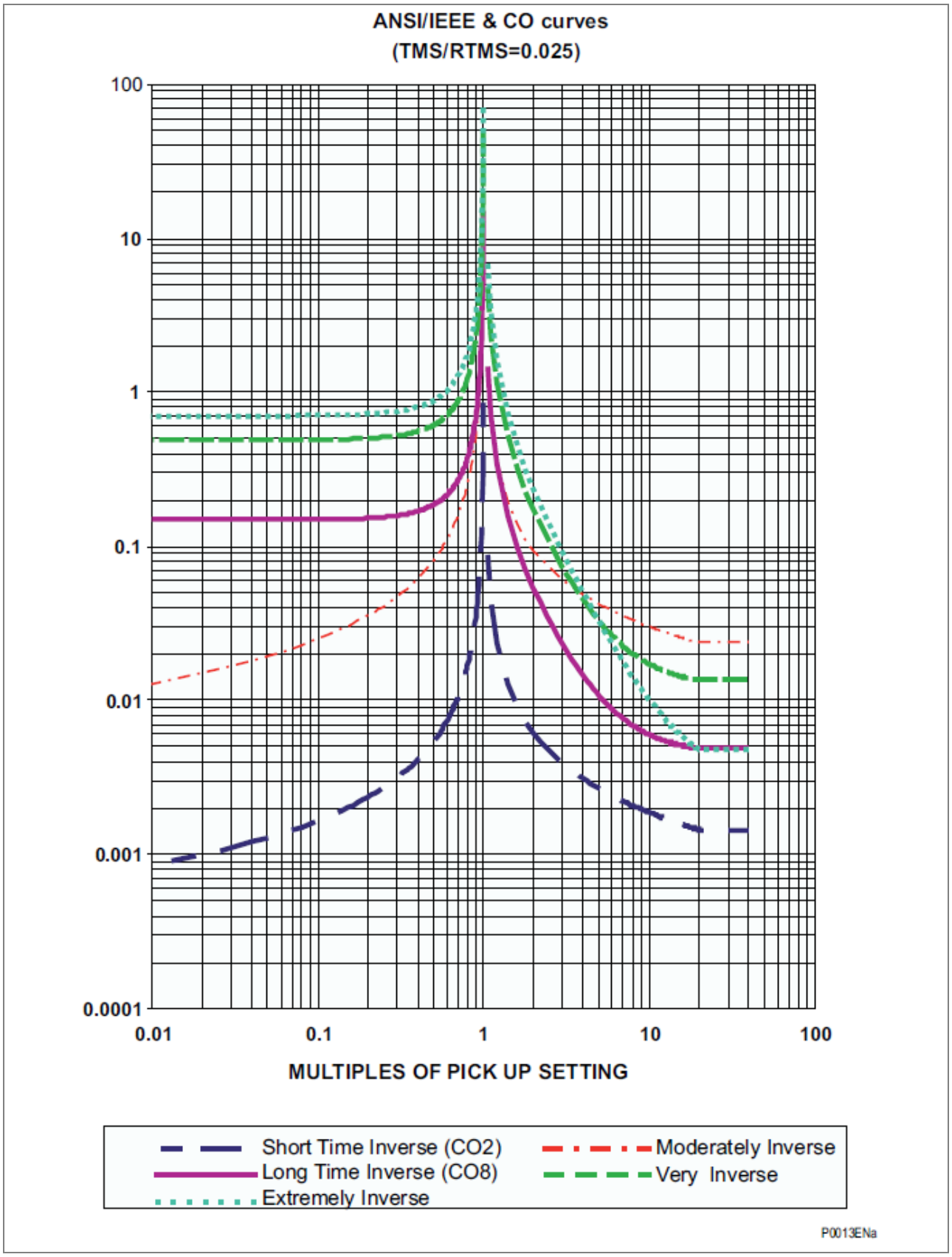
Long Time Inverse (GE Grid Solutions)

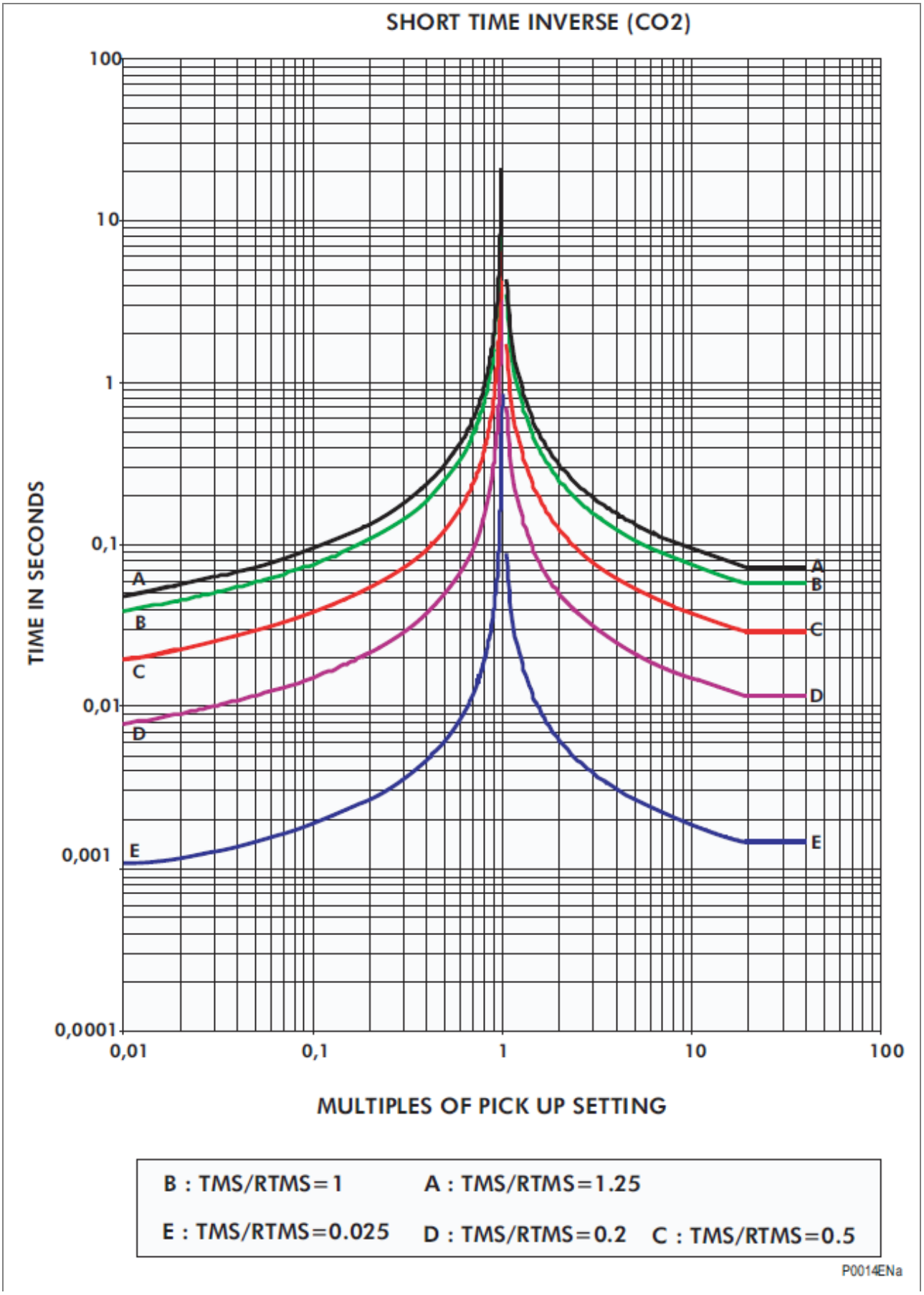


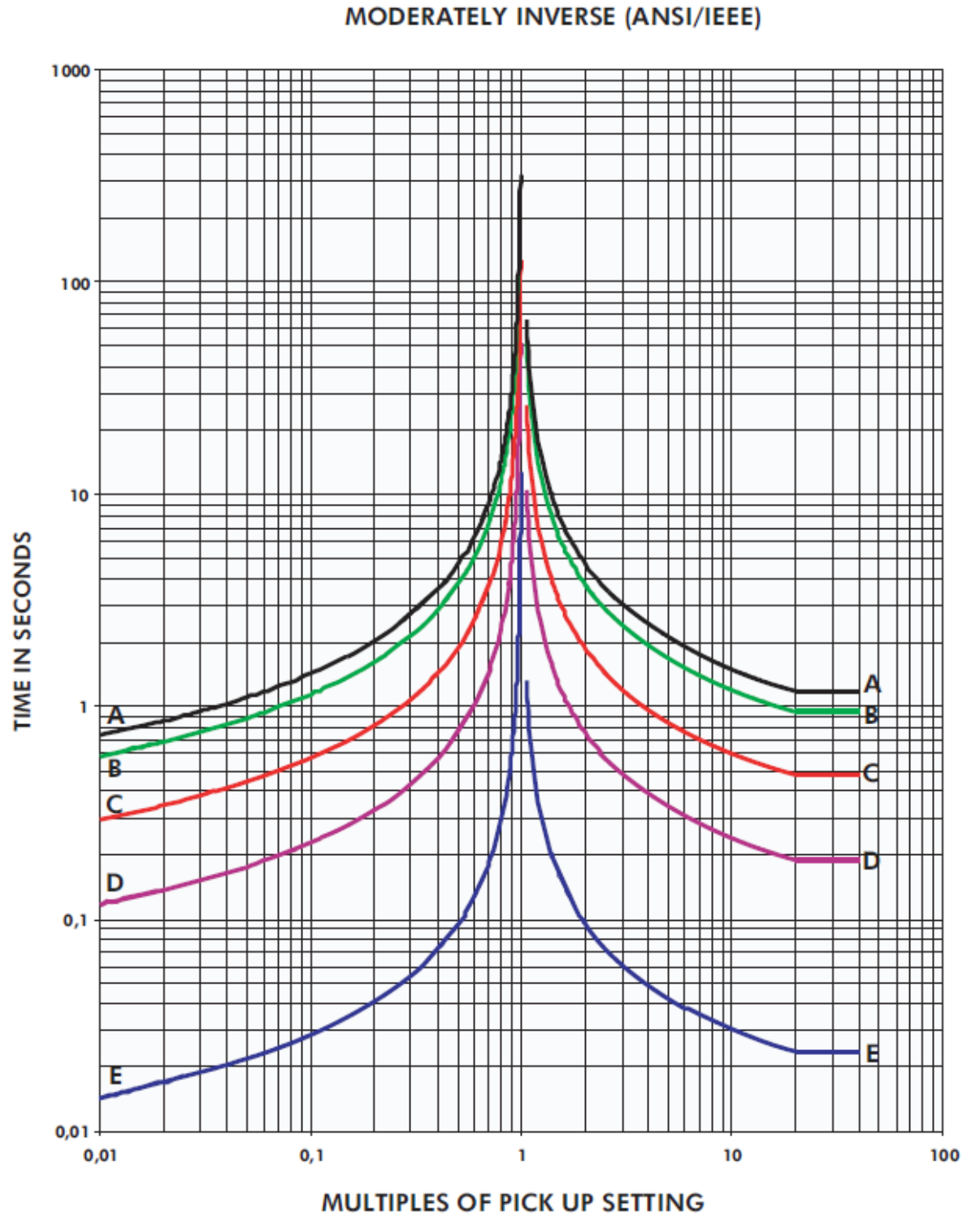
8.1.3 RI CURVES

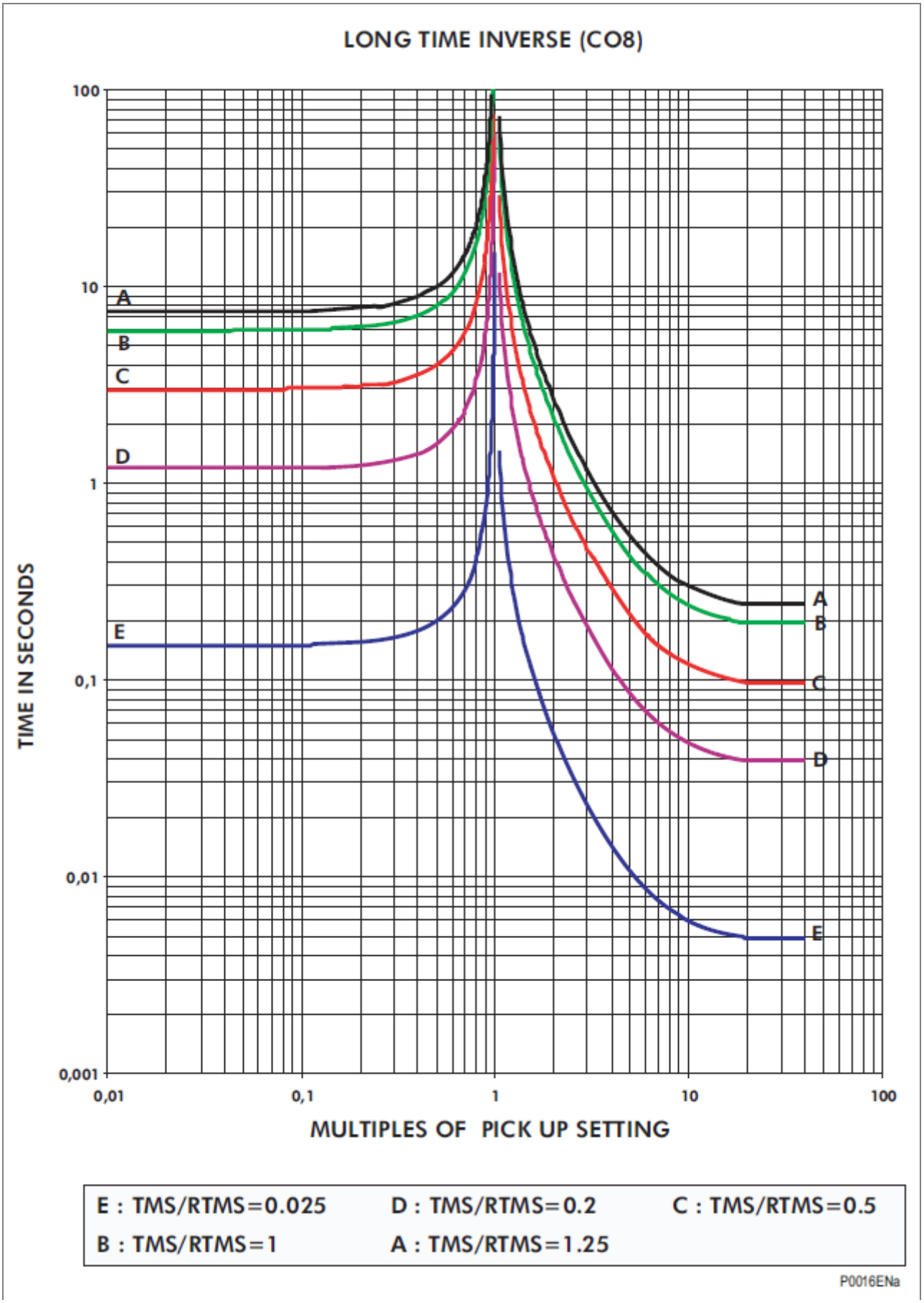


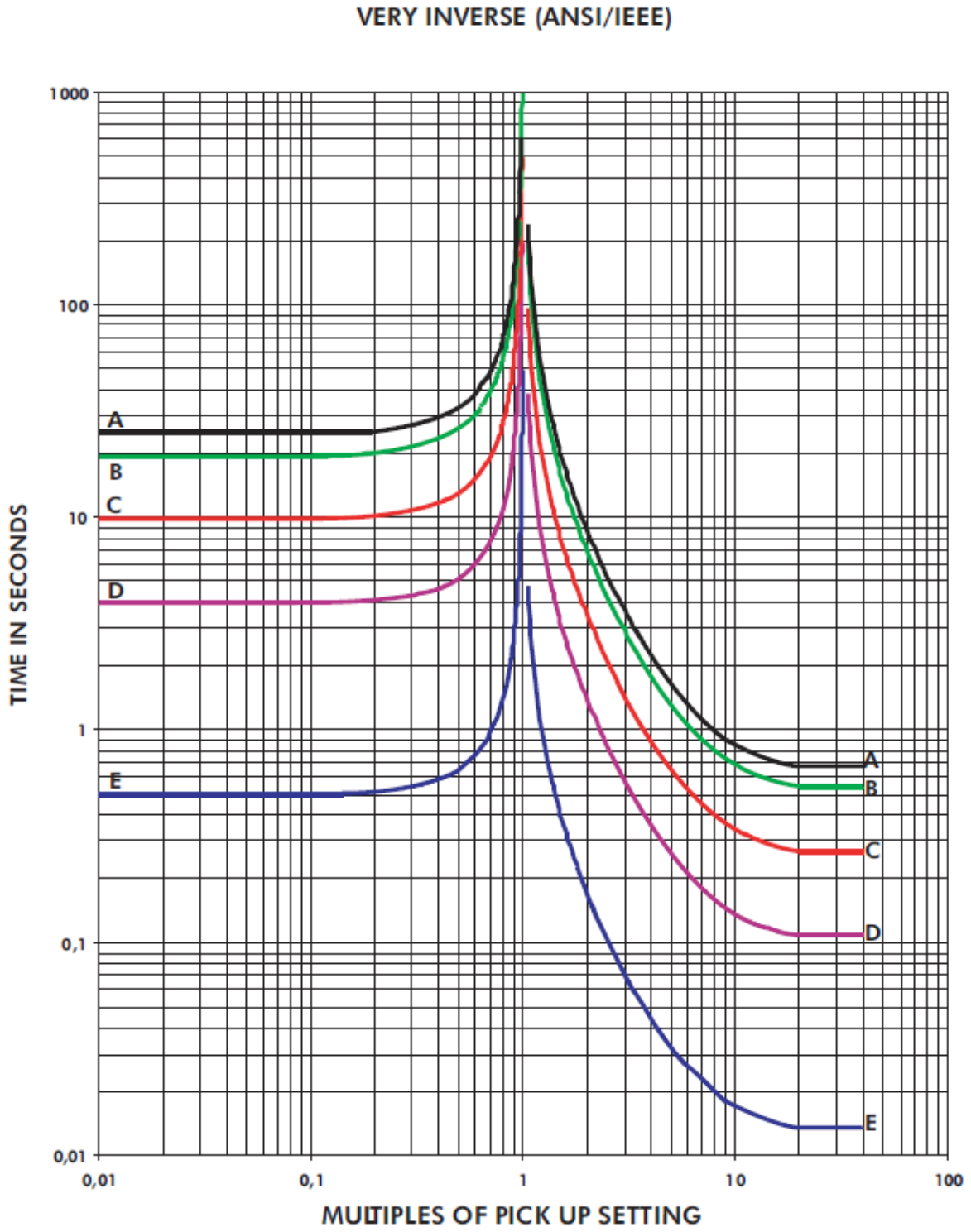
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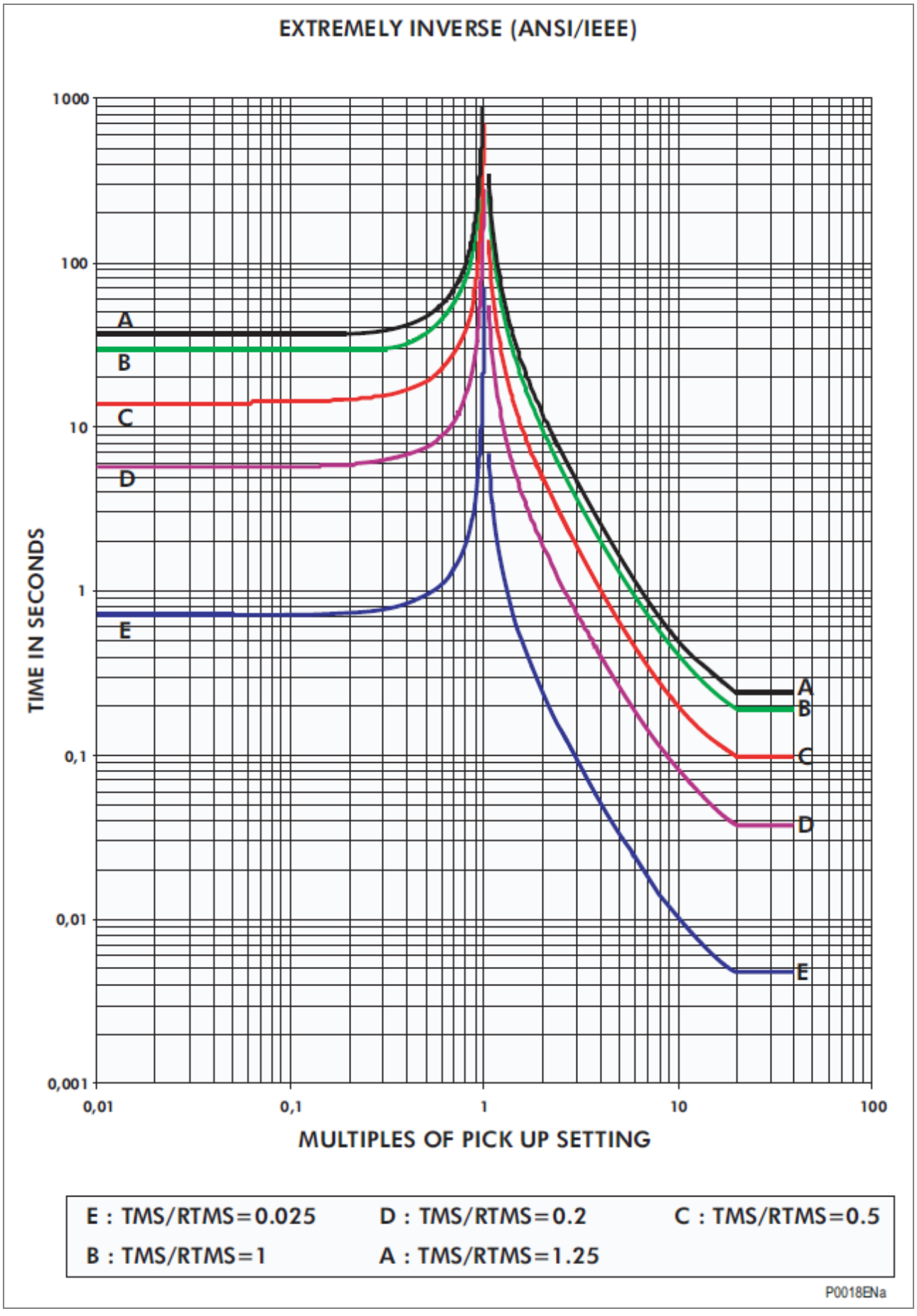



SHORT TIME INVERSE (CO2)
TIME IN SECONDS
100
10
1
0,1
0,01
0,001
0,0001
0,01
0,1
1
10
100
MULTIPLES OF PICK UP SETTING
A
B
C
D
E
B : TMS/RTMS=1
A : TMS/RTMS=1.25
E : TMS/RTMS=0.025
D : TMS/RTMS=0.2
C : TMS/RTMS=0.5
P0014ENa


MODERATELY INVERSE (ANSI/IEEE)
TIME IN SECONDS
1000
100
10
1
0,1
0,01
0,01
0,1
1
10
100
MULTIPLES OF PICK UP SETTING
A
B
C
D
E
E : TMS/RTMS=0.025
D : TMS/RTMS=0.2
C : TMS/RTMS=0.5
B : TMS/RTMS=1
A : TMS/RTMS=1.25
P0015ENa


LONG TIME INVERSE (CO8)
TIME IN SECONDS
100
10
1
0,1
0,01
0,001
0,01
0,1
1
10
100
A
B
C
D
E
MULTIPLES OF PICK UP SETTING
E : TMS/RTMS=0.025
D : TMS/RTMS=0.2
C : TMS/RTMS=0.5
B : TMS/RTMS=1
A : TMS/RTMS=1.25
P0016ENa


VERY INVERSE (ANSI/IEEE)
TIME IN SECONDS
1000
100
10
1
0,1
0,01
0,01
0,1
1
10
100
MULTIPLES OF PICK UP SETTING
A
B
C
D
E
E : TMS/RTMS=0.025
D : TMS/RTMS=0.2
C : TMS/RTMS=0.5
B : TMS/RTMS=1
A : TMS/RTMS=1.25
P0017ENa


EXTREMELY INVERSE (ANSI/IEEE)
1000
100
10
1
0,1
0,01
0,001
TIME IN SECONDS
A
B
C
D
E
0,01
0,1
1
10
100
MULTIPLES OF PICK UP SETTING
E : TMS/RTMS=0.025
D : TMS/RTMS=0.2
C : TMS/RTMS=0.5
B : TMS/RTMS=1
A : TMS/RTMS=1.25
P0018ENa

8.2 THERMAL OVERLOAD CURVES

8.2.1 MATHEMATICAL FORMULA

The thermal time characteristic is given by:

$\exp(-t/\tau) = (I^2 - (k.I_{FLC})^2) / (I^2 - I_P^2)$

Where:

t = Time to trip, following application of the overload current, I

τ = Heating and cooling time constant of the protected plant

I = Largest phase current; (RMS value)

I_{FLC} = Full load current rating (relay setting 'Thermal Trip')

k = 1.05 constant, allows continuous operation up to < 1.05 I_{FLC}.

I_P = Steady state pre-loading before application of the overload

The time to trip varies depending on the load current carried before application of the overload, i.e. whether the overload was applied from "hot" or "cold".

Mathematical formula applicable to the DS Agile C26x:

The calculation of the Time to Trip is given by:

$$Ttrip = Te\ln\left(\frac{|K^2 - \theta^2|}{|K^2 - \theta trip^2|}\right)$$

With:

Ttrip = Time to trip (in seconds)

Te = Thermal time constant of the protected element (in seconds)

K = Thermal overload equal to Ieq/k Iθ>

Ieq = Equivalent current corresponding to the RMS value of the largest phase current

Iθ> = Full load current rating given by the national standard or by the supplier

k = Factor associated to the thermal state formula

θ^2 = Initial thermal state. If the initial thermal state = 30% then $\theta^2 = 0.3$

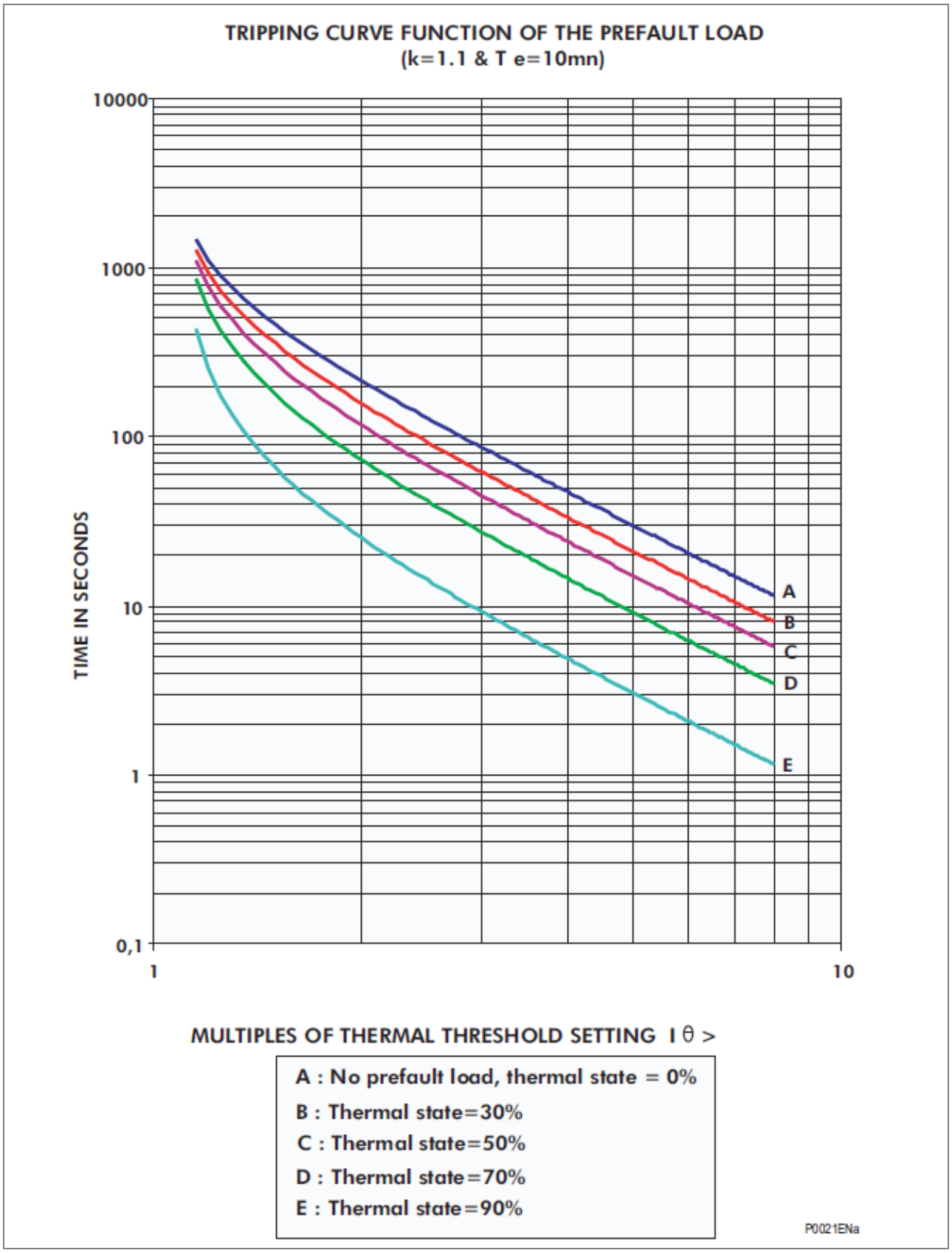
$\theta trip^2$ = Trip thermal state. If the trip thermal state is set at 100%, then $\theta\ trip^2 = 1$

The calculation of the thermal state is given by the following formula:

$\theta_{\iota+1} = (Ieq/\ k\ I\theta>)^2\ [1- \exp(-t/Te)] + \theta\iota\ \exp(-t/Te)$

θ being calculated every 100ms

8.2.2 TRIPPING CURVE



CURRENT TRANSFORMER TECHNICAL DATA

C26X/EN CD/D40

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Glossary of terms

The following abbreviations are used in this document:

Symbol	Description
ALF	Accuracy Limit Factor
ANSI	American National Standards Institute
C	IEEE standard C57.13 "C" classification
CT	Current Transformer
DIN	Deutsches Institut für Normung (German standards body)
DT	Definite Time
E/F	Earth Fault
IDMT	Inverse Definite Minimum Time
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
MCB	Mini Circuit Breaker
Metrosil	Brand of non-linear resistor produced by M&I Materials Ltd.
O/C	Overcurrent
ph	Phase
REF	Restricted Earth Fault
rms	Root mean square
SEF	Sensitive Earth Fault
SIR	Source Impedance Ratio
VA	Current transformer rated burden
VT	Voltage Transformer

The following terms are used in the equations in this document:

Symbol	Description	Units
<	As well as the usual “less than”, this symbol also depicts undercurrent	N/A
>	As well as the usual “greater than”, this symbol also depicts overcurrent	N/A
ω	System angular frequency	rad
f_{min}	Minimum required operating frequency	Hz
f_{max}	Minimum required operating frequency	Hz
f_n	Nominal operating frequency	Hz
I'_f	Maximum internal secondary fault current (may also be expressed as a multiple of In)	A
$I >>$	Second stage current setting of short circuit element (overcurrent)	In
I_{diff}	Current setting of first stage biased differential	A
I_f	Maximum secondary through fault current	A
$I_{f\,max}$	Maximum secondary fault current (same for all feeders)	A
$I_{f\,max\,int}$	Maximum secondary contribution from a feeder to an internal fault	A

Symbol	Description	Units
I_{fZ1}	Maximum secondary phase fault current at Zone 1 reach point	A
I_{fe}	Maximum secondary through fault earth current	A
I_{feZ1}	Maximum secondary earth fault current at Zone 1 reach point	A
I_{fn}	Maximum prospective secondary earth fault current or 31 x I> setting (whichever is lowest)	A
I_{fp}	Maximum prospective secondary phase fault current or 31 x I> setting (whichever is lowest)	A
I_n	Current transformer nominal secondary current	A
I_0	Earth fault current setting	A
I_{Rm2}	Second knee-point bias current threshold setting of P63x biased differential element	A
I_{ref}	Reference current of P63x calculated from the reference power and nominal voltage	A
I_s	Value of stabilizing current	A
I_{S1}	Differential current pick-up setting of biased differential element	A
I_{S2}	Bias current threshold setting of biased differential element	A
I_{sn}	Rated secondary current (I secondary nominal)	A
I_{sp}	Stage 2 and 3 setting	A
I_{st}	Motor start up current referred to CT secondary side	A
K	Dimensioning factor	None
K_1	Lower bias slope setting of biased differential element	%
K_2	Higher bias slope setting of biased differential element	%
K_e	Dimensioning factor for earth fault	None
K_{max}	Maximum dimensioning factor	None
K_{rpa}	Dimensioning factor for reach point accuracy	None
K_s	Dimensioning factor dependent upon through fault current	None
K_{ssc}	Short circuit current coefficient or ALF	None
K_t	Dimensioning factor dependent upon operating time	None
m_1	Lower bias slope setting of P63x biased differential element	None
m_2	Higher bias slope setting of P63x biased differential element	None
P_n	Rotating plant rated single phase power	W
R_{ct}	Secondary winding resistance	Ω
R_l	Resistance of single lead from C26x protection and control unit to current transformer	Ω
R_r	Resistance of any other protection units sharing the current transformer	Ω
R_{rn}	Resistance of C26x neutral current input at 30In	Ω
R_{rp}	Resistance of C26x phase current input at 30In	Ω

Symbol	Description	Units
R_s	Value of stabilizing resistor	Ω
t'	Duration of first current flow during auto-reclose cycle	s
T_1	Primary system time constant	s
t_{fr}	Auto-reclose dead time	s
t_{IDiff}	Current differential operating time	s
T_s	Secondary system time constant	s
V_f	Theoretical maximum voltage produced if CT saturation did not occur	V
V_{in}	Input voltage e.g. to an opto-input	V
V_n	Nominal voltage	V
V_k	Required CT knee-point voltage	V
V_s	Value of stabilizing voltage	V
$\frac{X}{R}$	Primary system reactance/resistance ratio	None
$\frac{X_e}{R_e}$	Primary system reactance/resistance ratio for earth loop	None
X_t	Transformer reactance (per unit)	p.u.

1 INTRODUCTION TO CURRENT TRANSFORMERS

The role of current transformers in the transmission and distribution of electrical energy is extremely important. They are used to enable accurate metering and effective protection of transmission and distribution circuits.

Current transformers isolate the secondary circuits, which are used for protection and metering, from the primary circuit, which carries the power. They also provide quantities in the secondary which are proportional to those in the primary. The role of current transformers in protection applications is not as specific as for metering and instrumentation. The role of a measuring transformer is to deliver from its secondary winding a voltage or current waveform that accurately represents that of the primary side. The role of a protecting transformer, however, varies depending on the type of protection it is designed to offer.

There is no major difference between a protection voltage transformer and a measuring voltage transformer, the difference being only in the nature of the voltage transformed. Normally the same transformer can serve both purposes. This cannot be said for current transformers, however, as the requirements for protection current transformers are often radically different from those of measuring current transformers. Occasionally the same transformer may serve both purposes but in modern practice this is rare. The main difference is that a measuring current transformer must be accurate over the normal range of load currents, whereas a protection current transformer must be capable of providing an adequate output over a wide range of fault conditions, from a fraction of full load to many times full load.

1.1 CURRENT TRANSFORMER MAGNETIZATION

The primary current contains two components:

1 The secondary current referred to the primary

2 The excitation current, which supplies the core magnetization, eddy currents and hysteresis losses.

The excitation current flows in the primary winding only and is therefore the cause of transformer errors. The amount of excitation current drawn by a current transformer depends on the core material and the amount of flux that must be developed in the core to satisfy the burden requirements of the current transformer.

It is, therefore, not sufficient to assume a value of secondary current and to work backwards to determine the value of primary current by using the constant ampere-turns rule, since this approach does not take into account the excitation current. When the core saturates, a disproportionate amount of primary current is required to magnetize the core and the secondary current does not accurately reflect the primary current.

1.2 LIMITING SECONDARY VOLTAGE (V_K)

IEC60044 defines the limiting secondary voltage of the excitation characteristic as the point at which a 10% increase in secondary voltage requires a 50% increase in excitation current. This is also commonly referred to as the knee-point voltage. The knee-point may be regarded as the practical limit beyond which a specified current ratio may not be maintained, as the current transformer enters saturation. Since the shunt admittance is not linear in this region, both the excitation and secondary currents depart from their sinusoidal form. ANSI and IEEE have a different definition of the knee-point voltage.

1.3 RATED ACCURACY LIMIT FACTOR

A current transformer is designed to maintain its ratio within specified limits up to a certain value of primary current, expressed as a multiple of its rated primary current. This multiple is known as the current transformer's rated accuracy limit factor (ALF).

1.4 PRIMARY WINDING CURRENT RATING

The current transformer primary rating is usually chosen to be equal to or greater than the normal full load current of the protected circuit. This avoids overloading and consequent overheating of the CT. Standard primary ratings are specified in IEC 60044-1. The maximum ratio of current transformers is typically limited to 3000:1 for two reasons:

1 Size limitation of the current transformer

2 Maximum safe open circuit voltage

Some transformers, like large turbo alternators, have very high primary ratings (e.g. 5000A). In such cases it is standard practice to use a cascade arrangement. For example a 5000:20A in series with a 20:1A interposing auxiliary current transformer.

1.5 SECONDARY WINDING CURRENT RATING

The total secondary burden of a current transformer includes the internal impedance of the secondary winding, the impedance of the connected instruments and protection units and the impedance of the secondary leads. A typical value of rated secondary current is 5A, provided that the length of the leads between the current transformers and the connected apparatus does not exceed 25 meters. Up to this length the lead resistance is small in relation to the total output of the transformer. In installations with longer lead lengths, transformers with 1A secondary windings are used to keep the lead losses within reasonable limits. Power losses vary as the square of the current, thus losses in 1A windings are $1/25^{th}$ of losses in 5A windings.

2 CURRENT TRANSFORMER STANDARDS AND CLASSES

2.1 TYPES

Generally, there are three different types of CT:

1 High-remanence

2 Low-remanence

3 Non-remanence

Remanence is the magnetization left behind in a medium after an external magnetic field is removed. In our case, the amount of residual magnetization left in the core.

High-remanence CT

The high-remanence type has no given limit for the remanent flux. The CT has a magnetic core without any air gaps and the remanent flux is very high. The remanent flux can be up to 70-80% of the saturation flux. Examples of high-remanent type CTs are:

- IEC60044-1 classes P, PX
- IEC60044-6 classes TPS and TPX

Low-remanence CT

The low-remanence type has a specified limit for the remanent flux. The magnetic core is provided with small air gaps to reduce the remanent flux to a level that does not exceed 10% of the saturation flux. Examples of low-remanent type CTs are:

- IEC60044-1 class PR
- IEC 60044-6 class TPY

Non-remanence CT

The non-remanence type has a negligible level of remanent flux. The magnetic core has relatively large air gaps, which reduce the remanent flux to practically zero level. An example of a non-remanent type CT is:

- IEC 60044-6 class TPZ

IEC 60044-1 and IEEE C57.13 specify the behavior of inductive current transformers for steady state symmetrical AC currents. The more recent standard IEC 60044-6 specifies the performance of inductive current transformers (classes TPX, TPY and TPZ) for currents containing exponentially decaying DC components.

2.2 IEC 60044-1 STANDARD

The IEC60044-1 standard defines class P and class PX current transformers.

2.2.1 CLASS P CTS

Class P CTs are high remanence types, typically used for general applications, such as overcurrent protection. What happens after the relay has been tripped is of no consequence, so there is no point in having a secondary accuracy limit greatly in excess of the value needed to cause operation. A rated accuracy limit of 5 is therefore usually adequate (Secondary current accurately reflects primary current for primary currents of 5 times greater than its rating).

When protection units (such as instantaneous ‘high set’ overcurrent relays) are set to operate at high values of overcurrent (say 5 to 15 times the rated current of the transformer), the accuracy limit factor must be at least as high as the value of the setting current used in order to ensure fast protection operation.

Rated output burdens higher than 15VA and rated accuracy limit factors higher than 10 are not recommended for general purposes. It is possible, however, to combine a higher rated accuracy limit factor

with a lower rated output and vice versa. When the product of these two exceeds 150, the resulting current transformer may be uneconomical or unduly large.

Class P CTs are defined such that the current, phase and composite errors do not exceed the values given in *Table 1*, at the rated frequency and burden.

Accuracy Class	Current Error at Rated Primary Current	Phase Displacement at Rated Primary Current	Composite Error at Rated Accuracy Limit Primary Current
5P	±1%	±60 minutes (±0.018 radians)	5%
10P	±3%	±60 minutes (±0.018 radians)	10%

Table 1: Errors v accuracy class for class P CTs

2.2.2 CLASS PX

Class PX CTs are typically used for high impedance circulating current protection. They are also suitable for most other protection applications.

Class PX CTs have high remanence and low leakage reactance. To assess their performance in relation to the protection unit in which they are to be used, you only need knowledge of:

- the transformer secondary excitation characteristic
- the secondary winding resistance
- the secondary burden resistance
- the turns ratio

Class PX is the IEC 60044-1 definition for quasi-transient current transformers, formerly covered by BS 3938 class X.

2.3 IEC 60044-6 STANDARD

The IEC60044-6 standard defines current transformers in the classes TPS, TPX, TPY and TPZ.

2.3.1 CLASS TPS

Class TPS CTs are high remanence types. They are typically used for high impedance circulating current protection, and are generally applied to unit systems where the balancing of outputs from each end of the protected plant is vital.

This balance, or stability during through-fault conditions, is essentially of a transient nature and thus the extent of the unsaturated (or linear) zones is of paramount importance. Using heavy current test results, it is normal to derive a formula stating the lowest permissible value of V_k for stable operation to be guaranteed.

IEC 60044-6 defines the performance of low secondary reactance, TPS class current transformers for transient performance. They are specified in terms of each of the following characteristics:

- Rated primary current
- Turns ratio (the error in turns ratio cannot exceed ±0.25%)
- Secondary limiting voltage
- Resistance of secondary winding

2.3.2 CLASS TPX

The basic characteristics for class TPX current transformers are generally similar to those of class TPS current transformers except for the different error limits prescribed and possible influencing effects which may necessitate a physically larger construction. Class TPX CTs have no air gaps in the core and therefore a high remanence factor (70-80% remanent flux). The accuracy limit is defined by the peak instantaneous error during the specified transient duty cycle.

Class TPX CTs are typically used for line protection.

2.3.3 CLASS TPY

Class TPY CTs have a specified limit for the remanent flux. The magnetic core is provided with small air gaps to reduce the remanent flux to a level that does not exceed 10% of the saturation flux. They have a higher error in current measurement than TPX during unsaturated operation and the accuracy limit is defined by peak instantaneous error during the specified transient duty cycle.

Class TPY CTs are typically used for line protection with auto-reclose function.

2.3.4 CLASS TPZ

For class TPZ CTs the remanent flux is negligible due to large air gaps in the core. These air gaps also minimize the influence of the DC component from the primary fault current, but reduce the measuring accuracy in the unsaturated (linear) region of operation. The accuracy limit is defined by the peak instantaneous alternating current component error during a single excitation, with maximum DC offset at a specified secondary loop time constant.

Class TPZ CTs are typically used for special applications such as differential protection of large generators.

3 DS AGILE C26X FEEDER MANAGEMENT SOLUTION

3.1 DS AGILE C26X FEATURES

Optimized for HV and MV IEC 61850-8-1 Digital Control Solutions, the DS Agile C26x combines powerful I/O management, Ethernet communication capabilities and fast automation schemes with an independent dedicated Feeder Protection module.

The DS Agile C26x is the ultimate solution for your electrical asset optimisation and quality improvement in an evolving environment. The DS Agile C26x takes directly benefits from the engineering flexible tools and maintenance applications.

DS Agile C26x supports the following protection functions:

- Phase & earth Overcurrent (50/51, 50N/51N),
- Phase & earth Directional Overcurrent (67, 67N),
- Wattmetric (32N),
- Negative sequence overcurrent (46).
- Undercurrent (37),
- Undervoltage (27) and Over-voltage (59) and residual Over-voltage (59N)
- Over and Under-frequency (81O/81U),
- Rate of frequency change (81R)
- Thermal overload (49)
- Breaker failure (50BF)

3.2 BURDENS

CT Input	In	CT Burden
Phase	1 A	< 0.1 VA at In
Earth	1 A	< 0.005 VA at 0.1In
Phase	5 A	< 0.25 VA at In
Earth	5 A	< 0.01 VA at 0.1In

Table 1: Current circuit for C26x

Vn	VT Burden
57 - 130V	0.08 VA at 57 V
57 - 130V	0.4 VA at 130 V
57 - 130V	1.5 VA at 260 V

Table 2: Voltage circuit for C26x

Relay	Case Size	Nominal Burden*	Maximum Burden
C26x	Size 40TE/80TE	< 15W	< 40W
C26x Additional Board	DIU	< 0.1 W	< 1 W
	DOU (10 Relays)	0.25 W	2 W (max. 10 relays)
	CCU (DI&DO)	0.4 W	1.4 W (4 Relays)
	HBU	< 10.6 W	15.4 W (max. 10 relays)

Relay	Case Size	Nominal Burden*	Maximum Burden
	AIU (Analog Input)	1.1 W	1.1 W
	AOU (Analog Output)	0.5 W	0.5 W
	SW Switch Ethernet	4 W	4 W
	SRP/DPU/SVU	6 W	6 W

Table 3: Auxiliary supply and boards burden for C26x

* Typical minimum burden with no opto-inputs or output contacts energized.

Additional Burden	Inputs Voltage	Burden
Per energized opto-input	12 V	0.12 W/Input
Per energized opto-input	48 V	0.66 W/Input
Per energized opto-input	110 V	0.62 W/Input
Per energized opto-input	220 V	0.66 W/Input
Per energized output contact (DOU/CCU)		0.25 W

Table 4: Additional burdens for C26x

3.3 CURRENT TRANSFORMER REQUIREMENTS

The current transformer requirements are based on a maximum fault current of 40 x In and the relay having an instantaneous setting of 20 x In. These CT requirements are designed to provide operation of all protection elements.

Nominal Rating	Nominal Output	Accuracy Class	Accuracy Limit Factor (ALF)	Limiting Lead Resistance
1 A	2.5 VA	10P*	20	1.30 □
5 A	7.5 VA	10P*	20	0.11 □

Note:
If a better accuracy than 10P20 is requested, the internal DS Agile C26x CT inputs are able to support CT : 5P20 .

Table 5: CT Specification for C26x

Where the criteria (for a specific application) are in excess of those detailed above, or the actual lead resistance exceeds the limiting values, the CT requirements may need to be increased according to the formulae in the following sections. For specific applications such as SEF, refer to the sections below for CT accuracy class and knee-point voltage requirements as appropriate.

3.4 PROTECTION

Protection type	Knee-point voltage
Non-directional/directional DT/IDMT overcurrent and earth fault protection	
Time-delayed phase overcurrent	$V_k \geq \frac{I_{fp}}{2}\left(R_{ct} + R_l + R_{rp}\right)$

Protection type	Knee-point voltage
Time-delayed earth fault overcurrent	$V_k \geq \frac{I_{fn}}{2}\left(R_{ct} + 2R_l + R_{rp} + R_{rn}\right)$
Non-directional instantaneous overcurrent and earth fault protection	
Instantaneous phase overcurrent	$V_k \geq I_{sp}\left(R_{ct} + R_l + R_{rp}\right)$
Instantaneous earth fault overcurrent	$V_k \geq \frac{I_{fn}}{2}\left(R_{ct} + 2R_l + R_{rp} + R_{rn}\right)$
Directional instantaneous overcurrent and earth fault protection	
Instantaneous phase overcurrent	$V_k \geq \frac{I_{fp}}{2}\left(R_{ct} + R_l + R_{rp}\right)$
Instantaneous earth fault overcurrent	$V_k \geq \frac{I_{fn}}{2}\left(R_{ct} + 2R_l + R_{rp} + R_{rn}\right)$
Non-directional/directional DT/IDMT SEF protection - residual CT connection	
Non-directional time-delayed SEF	$V_k \geq \frac{I_{fn}}{2}\left(R_{ct} + 2R_l + R_{rp} + R_{rn}\right)$
Directional time-delayed SEF	$V_k \geq \frac{I_{fn}}{2}\left(R_{ct} + 2R_l + R_{rp} + R_{rn}\right)$
Non-directional instantaneous SEF	$V_k \geq I_{sn}\left(R_{ct} + 2R_l + R_{rp} + R_n\right)$
Directional instantaneous SEF	$V_k \geq \frac{I_{fn}}{2}\left(R_{ct} + 2R_l + R_{rp} + R_{rn}\right)$
Non-directional/directional DT/IDMT SEF protection - core-balance CT connection Core-balance current transformers of metering class accuracy are required and should have a limiting secondary voltage satisfying the formulae given below:	
Non-directional time-delayed SEF	$V_k \geq \frac{I_{fn}}{2}\left(R_{ct} + R_l + R_{rp}\right)$
Directional time-delayed SEF	$V_k \geq \frac{I_{fn}}{2}\left(R_{ct} + R_l + R_{rp}\right)$
Non-directional instantaneous SEF	$V_k \geq I_{sn}\left(R_{ct} + 2R_l + R_{rn}\right)$
Directional instantaneous SEF	$V_k \geq \frac{I_{fn}}{2}\left(R_{ct} + R_l + R_{rp}\right)$

Table 6: Knee-point voltages for C26x

APPENDIX A: CONVERTING TO A LIMITING SECONDARY VOLTAGE

The suitability of a standard protection current transformer can be checked against the limiting secondary voltage requirements, specified in this document.

An estimated limiting secondary voltage can be obtained as follows:

$$V_k \geq \frac{VA \times ALF}{I_n} + \left(ALF \times I_n R_{ct}\right)$$

If R_{ct} is not available, then the second term in the above equation can be ignored as it typically only adds a small amount to the estimated secondary limiting voltage.

To ensure that the current transformer has a high enough rating for the relay's burden it is necessary to work out the current transformer's continuous VA rating using the following formula:

$$VA_{ct} > I_n^{\,2}\left(R_l + R_r\right)$$

Example 1:

An estimate of the secondary limiting voltage of a 400/5 A current transformer of class 5P 10 with a rated output burden of 15 VA and a secondary winding resistance of 0.2 Ω will be:

$$V_k \approx \frac{15 \times 10}{5} + 10 \times 5 \times 0.2 \; = \; 40V$$

Example 2:

For a particular application of a 1 A DS Agile C26x it is required to determine the most appropriate class P current transformer to be used. The secondary limiting voltage required has been calculated at 87.3 V using a current transformer secondary winding resistance of 2 Ω.

The current transformer rated output burden must be:

$$VA_{ct} > I_n^{\,2}\left(R_l R_r\right)$$

$$VA_{ct} \geq 1^2 \times \left(1 + 0.025\right) \; = 1.025 \; VA$$

The nearest rating above this will be 2.5 VA.

The accuracy limit factor required can be determined by:

$$V_k = \frac{VA \times ALF}{I_n} + ALF \times I_n R_{ct}$$

$$87.3 = \frac{2.5 \times ALF}{1} + ALF \times 1 \times 2 = 4.5 \times ALF$$

$$\therefore \; ALF = 19.4$$

The nearest accuracy limit factor above 19.4 is 20.

Therefore the current transformer required to supply the DS Agile C26x will be a 2.5 VA 10P 20. (i.e. 2.5 VA is the rated burden, 10 (%): nominal accuracy class, 20 is the ALF).

APPENDIX B: CONVERTING TO IEEE STANDARD VOLTAGE RATING

The DS Agile C26x are compatible with ANSI/IEEE CTs as specified in the IEEE C57.13 standard. The applicable class for protection is class "C", which specifies a non air-gapped core. The CT design is identical to the IEC class P but the rating is specified differently.

The IEEE C class standard voltage rating required will be lower than an IEC knee-point voltage. This is because the IEEE voltage rating is defined in terms of useful output voltage at the terminals of the CT, whereas the IEC knee-point voltage includes the voltage drop across the internal resistance of the CT secondary winding added to the useful output. The IEC knee-point is also typically 5% higher than the IEEE knee-point.

Where IEEE standards are used to specify CTs, the C class voltage rating can be checked to determine the equivalent knee-point voltage (V_k) according to IEC. The equivalence formula is:

$$V_k = 1.05C + K_{ssc} I_n R_{ct}$$

$$V_k = 1.05C + 100R_{ct}$$

Note:
IEEE CTs are always 5A secondary rated, i.e. In =5A, and are defined with an accuracy limit factor of 20, i.e. Kssc =20.

The following table allows C57.13 ratings to be converted to a typical IEC knee-point voltage:

CT Ratio	Rct*	Vk - C50	Vk - C100	Vk - C200	Vk-- C400	Vk - C800
100/5	0.04 □	56.5 V	109 V	214 V	424 V	844 V
200/5	0.08 □	60.5 V	113 V	218 V	428 V	848 V
400/5	0.16 □	68.5 V	121 V	226 V	436 V	856 V
800/5	0.32 □	84.5 V	137 V	242 V	452 V	872 V
1000/5	0.40 □	92.5 V	145 V	250 V	460 V	880 V
1500/5	0.60 □	112.5 V	165 V	270 V	480 V	900 V
2000/5	0.80 □	132.5 V	185 V	290 V	500 V	920 V
3000/5	1.20 □	172.5 V	225 V	330 V	540 V	960 V

Table 7: C57.13 ratings

* Assuming 0.002 ohms per turn typical secondary winding resistance for 5A CTs.

APPENDIX C: USE OF METROSIL NON-LINEAR RESISTORS

"Metrosils" (non-linear resistors) are used to limit the peak voltage developed by the current transformers under internal fault conditions, to a value below the insulation level of the current transformers, relay and interconnecting leads, which are normally able to withstand 3000V peak.

The following formulae should be used to estimate the peak transient voltage (V_p) that could be produced for an internal fault. The peak voltage produced during an internal fault will be a function of the current transformer knee-point voltage and the prospective voltage (V_f) that would be produced for an internal fault if current transformer saturation did not occur.

$$V_p = 2\sqrt{2V_k\left(V_f - V_k\right)}$$

$$V_f = I'_f\left(R_{ct} + 2R_l + R_s\right)$$

When the value given by the formulae is greater than 3000V peak, Metrosils should be applied. They are connected across the relay circuit and serve the purpose of shunting the secondary current output of the current transformer from the relay in order to prevent very high secondary voltages.

Metrosils are externally mounted and take the form of annular discs. Their operating characteristics follow the expression:

$$V = CI^{0.25}$$

where:

V = *Instantaneous voltage applied to the Metrosil*

C = *Characteristic constant of the Metrosil*

I = *Instantaneous current through the Metrosil*

With a sinusoidal voltage applied across the Metrosil, the rms current would be approximately 0.52 times the peak current. This current value can be calculated as follows:

$$I_{rms} = 0.52\left(\frac{\sqrt{2}V_{\sin(rms)}}{C}\right)^4$$

Where

$V_{sin(rms)}$ = rms value of the sinusoidal voltage applied across the Metrosil.

This is due to the fact that the current waveform through the metrosil is not sinusoidal but appreciably distorted.

For satisfactory application of a Metrosil, it's characteristic should be such that it complies with the following requirements:

At the relay voltage setting, the Metrosil current should be as low as possible, and no greater than ≈ 30 mA_{rms} for 1 A CTs and ≈ 100 mA_{rms} for 5 A CTs.

At the maximum secondary current, the Metrosil should limit the voltage to 1500V_{rms} or 2120 V peak for 0.25 s. At higher relay voltage settings, it is not always possible to limit the fault voltage to 1500 V_{rms}, so higher fault voltages may have to be tolerated.

The following tables show the typical Metrosil types that will be required, depending on relay current rating, REF voltage setting etc.

Metrosil units for relays using 1 A CTs

The Metrosil units for 1 A CTs have been designed to comply with the following restrictions:

At the relay voltage setting, the Metrosil current should be less than 30 mA_{rms}.

At the maximum secondary internal fault current the Metrosil should limit the voltage to 1500 V_{rms} if possible.

The Metrosil units normally recommended for use with 1 A CTs are as shown in the following table:

C26x Voltage Setting	Nominal Characteristics		Recommended Metrosil Type	
	C	β	Single Pole Relay	Triple Pole Relay
Up to 125 Vrms	450	0.25	600A/S1/S256	600A/S3/1/S802
125 - 300 Vrms	900	0.25	600A/S1/S1088	600A/S3/1/S1195

Table 8: Metrosil units

Note:
Single pole Metrosil units are normally supplied without mounting brackets unless otherwise specified by the customer.

Metrosil units for relays using 5 A CTs

These Metrosil units have been designed to comply with the following requirements:

At the relay voltage setting, the Metrosil current should be less than 100 mA_{rms} (the actual maximum currents passed by the units is shown below their type description).

At the maximum secondary internal fault current the Metrosil unit should limit the voltage to 1500 V_{rms} for 0.25 s. At the higher relay settings, it is not possible to limit the fault voltage to 1500 V_{rms} hence higher fault voltages have to be tolerated (indicated by *, **, ***).

The Metrosil units normally recommended for use with 5 A CTs and single pole relays are as shown in the following table:

Secondary Internal Fault Current	Recommended Metrosil Type			
	C26x Voltage Setting			
	Up to 200Vrms	250Vrms	275Vrms	300Vrms
50 Arms	600A/S1/S1213 C = 540/640 35 mArms	600A/S1/S1214 C = 670/800 40 mArms	600A/S1/S1214 C = 670/800 50 mArms	600A/S1/S1223 C = 740/870* 50 mArms
100 Arms	600A/S2/P/S1217 C = 470/540 70 mArms	600A/S2/P/S1215 C = 570/670 75 mArms	600A/S2/P/S1215 C = 570/670 100 mArms	600A/S2/P/S1196 C = 620/740* 100 mArms
150 Arms	600A/S3/P/S1219 C = 430/500 100 mArms	600A/S3/P/S1220 C = 520/620 100 mArms	600A/S3/P/S1221C = 570/670** 100 mArms	600A/S3/P/S1222C = 620/740*** 100 mArms

Table 9: Metrosil units for 5A CTs

* 2400V peak, ** 2200V peak, *** 2600V peak

In some situations single disc assemblies may be acceptable. Metrosil units for higher relay voltage settings and fault currents can also be supplied if required. Contact Alstom for detailed applications.

Note:
The Metrosil unit recommended for use with 5A CTs can also be applied for use with triple pole relays and consist of three single pole units mounted on the same central stud but electrically insulated from each other. To order these units please specify "Triple pole Metrosil type", followed by the single pole type reference.

GLOSSARY

C26X/EN LX/D40

Term/Acronym	Description
100Base Fx	Fiber optic ports are full/half duplex at 100 Mbps only.
10Base Tx and 100Base TX	The copper ports are full/half duplex and auto-sense the transmission speed. They will auto-negotiate with the connected device to determinate the optimal speed. When the connected device is only capable of transmitting at 10 Mbps, the Ethernet switch unit or board follows 10 Mbps.
A/D	Analog/Digital
ACSI	Abstract Communication Service Interface Mapping from standard IEC 61850 abstract specification of a communication service to a concrete communication infrastructure based on the CORBA standard.
ADC	Analog to Digital Converter
AE qualifier	Application Entity qualifier (Used internally by IEC 61850 to identify a server Application)
AI	Analogue Input (Measurement Value including state attribute) Usually voltage or current DC signals delivered by transducers, and representing an external value (refer to CT/VT for AC).
AIU	Analogue Input Unit C264 controller's board for DC analogue inputs
Alarm	An alarm is any event set as alarmed during the configuration process
AO	Analogue Output Value corresponding to a desired output current applied to a DAC
AOU	Analogue Output Unit (C264 controller's board for analogue outputs)
ASCII	American Standard Code for Information Interchange
ASDU	Application Specific Data Unit Name given in the OSI protocol for applicative data (T101, T104)
AVR	Automatic Voltage Regulation built-in automation used to regulate secondary voltage using an automatic tap change control. A set of features can be added, refer to C264/EN FT
Bay	Set of LV, MV or HV apparatus (switching devices and transformers) and IEDs (Protection, Measurement…) usually built around a Circuit Breaker and controlled by a Bay Controller Unit.
BCD	Binary Coded Decimal C264-supported coding on a set of Digital Inputs that determines a Digital Measurement, then a Measurement value (with a specific invalid code when coding is not valid). Each decimal digit is coded over 4 binary digits.
BCP	Bay Control Point Name given to the device or part used to control a bay. It can be a Mosaic Panel, a C264 unit's LCD,… Usually associated with Remote/Local control.
BCU	Bay Control Unit Name given to the C264 that manages a bay.
BI	Binary Input (or Information) Name given in the C264 controller to information that has already been filtered, before it becomes an SPS, DPS… with time tag and quality attributes.
BIU	Basic Interface Unit C264 controller's board for auxiliary power supply, watchdog relay, redundancy I/O.
BRCB	Buffered Report Control Block
CB	Circuit Breaker Specific dipole switch with capability to make line current and break fault current. Some have isolation capability (nominal earth on each side)
CCU	Circuit breaker Control Unit C264 controller's board dedicated to switch control with 8 DIs, and 4 DOs
CDM	Conceptual Data Modeling Modeling of system/device data using a hierarchy of structured data (called object of class) with their attributes, method or properties and the relations between them. It maps common data to devices or components of devices, with a guaranty of interoperability.

Term/Acronym	Description
Class	Defined in IEC 61850 as the description of a set of objects that share the same attributes, services, relationships, and semantics.
Client	Defined in IEC 61850 as an entity that requests a service from a server and that receives unsolicited messages from a server.
CMT	Controller Management Tool
CO	Command, logic information Output (Functional Component) / Contact Open
COMTRADE	COMmon format for TRAnsient Data Exchange (IEC 60255-24 international standard)
CPU4	Central Processing Unit C264 controller's main board
CT	Current Transformer Basically the device connected to the electrical process used to extract a current measurement. By extension part of a device (C264) that receives AC values and converts it to a numerical measurement value.
CT/VT conventional	Current and Voltage transformers By extension, it is the C264 controller's TMU board.
DAC	Data Acquisition component of the GPT
DAC	Digital to Analogue Converter Used to generate analogue signals (usually DC) from a digital value.
DANP	Double Attached Node implementing PRP (defined by IEC 62439-3) Such an IED sends the messages over two separate networks.
DB	DataBase Tool or set of data that define all the configuration of a system or specific device such as a substation computer or bay controller. Contrary to setting parameters, a DB has a structure that cannot be modified on-line. DBs are always versioned.
DCF77	External master clock and protocol transmission LF transmitter located at Mainflingen, Germany, about 25 km south-east of Frankfurt , broadcasting legal time on a 77.5 kHz standard frequency.
DCO	Double Control Output
DCS	Digital Control System Generic name of system based on numeric communication and devices, to be opposed to traditional electrically wired control.
DCT	Double CounTer Counter based on 2 DIs with complementary states (counting switchgear operations for example).
DE	Direct Execute
DFT	Discrete Fourier Transform
DI	Digital Input Binary information related to the presence or to the absence of an external signal, delivered by a voltage source.
DIU	DC Input Unit C264 controller's board hosting digital inputs
DM	Digital Measurement Measurement value acquired from DIs with a specific encoding: BCD, Gray, 1 among N…
DNP3.0	Distributed Network Protocol DNP3 is a set of communication protocols used between components in process automation systems.
DO	Digital Output Used to apply a voltage to an external device via a relay, in order to execute single or dual, transient or permanent commands.
DOF	Degree Of Freedom Used for a template attribute, that can be modified or not when used. An attri-bute has a degree of freedom if a user can modify the values of its instances.

Term/Acronym	Description
DOU	Digital Output Unit C264 controller's board hosting digital outputs.
DP	Data Point, low-level object in the structure, wired or not, with or without links
DPC	Double (Point) Control Two digit and/or relays outputs with complementary states (OPEN, CLOSE) used for device control.
DPS	Double Point Status, information derived from 2 digital inputs Usually used for Position indication of switching devices (OPEN, CLOSE).
EPATR	"Ensemble de Protection Ampèremétrique de Terre Résistante" (French legacy very resistive earth current module).
EQL	Equation Logic, especially for interlocking.
Event	An event is a time-stamped change of state/value acquired or transmitted by a digital control system.
FAT	Factory Acceptance Test Validation procedures executed with the customer at the factory.(i.e. SAT)
FBD	Functional Block Diagram One of the IEC 61131-3 programming languages (language used to define configurable automations).
FIFO	First In First Out
FP	Front Panel
FSS	Force Suppress Substitute
FTP	Foil Twisted Pair
Gateway	Level 6 session of OSI, the gateway can be any device transferring data between different networks and/or protocols. The RTU function of the C264 behaves like a gateway at the SCADA or RCP level. The DS Agile Gateway is a separate PC-based application dedicated to this function.
GHU	Graphic Human interface Unit C264 controller's front panel interface (LCD, buttons, front RS port)
GIS	Gas Insulated Substation
GMT	Greenwich Mean Time, former absolute time reference. Replaced by UTC.
GOOSE	Generic Object Oriented Substation Event
GPS	Global Positioning System Based on triangulation from satellite signal, that transmit also absolute GMT time used to synchronise a master clock.
GPT	Generic Protocol Translator software, supplied by ASE
Group	Logical combination of BIs (i.e. SP, DP, SI or other groups)
Half-duplex	A system that allows packets to transmitted and received, but not at the same time. Contrasts with full-duplex.
HBU	High Break Unit: BCU board used in applications requiring high rupture capacity.
HMGA	Horizontal Measurement Graphical Area
HMI	Human Machine Interface Can be DS Agile aView (system HMI) or C264 LCD (Local HMI) or LEDs, Mosaic...
HSBP	High Speed BackPlane (internal Ethernet link between 2 SRP-Vx boards through the HSBP bus)
HSR	High availability Seamless Redundancy protocol. HSR is typically used in a ring topology, however redundant connections to other networks are possible, in particular to PRP networks.
HV	High Voltage (for example 30 kV to 150 kV)
I/O	Input/Output
IEC	International Electro-technical Commission

Term/Acronym	Description
IED	Intelligent Electronic Device Global term covering a whole range of microprocessor-based products capable of data collection and information processing.
IRIG-B	Inter-Range Instrumentation Group standard format B. This is an international standard for time-synchronisation based on an analogue signal.
JAMMED	Invalid state of a Double Point: Occurs when the 2 associated digital inputs are still in state 0 after a user- settable time-delay, i.e. when the transient state “motion” is considered as ended.
L/R	Local / Remote
L-BUS	Legacy Bus Generic name of Legacy or field networks and protocols used to communicate between C264 (Legacy Gateway function) and IED on field bus. Networks are based on (RS232,) 422, 485. Protocols are IEC 60850-5-103 (T103 is not supported in this version or VDEW), Modbus.
LC	Fibre optic snap-on connector, IEC 61754-20-compliant, for high density connection.
LCD	Liquid Crystal Display on the C264 front panel HMI
LD	Ladder Diagram, one of the IEC 1131-3 programming languages (language used to define configurable automations).
LD	Logical Device, defined in IEC 61850 as: An entity that represents a set of typical substation functions.
LDBI	Database identity brick
LHMI	Front panel Local HMI of the C264 controller
LN	Logical Node Defined in IEC 61850 as an entity that represents a typical substation function.
LOC	Local Operator Console, dedicated to maintenance operations
LPHD	Logical node PHysical Device
LSB	Least Significant Bit
LSP	Load Shedding Pre-selection
LV	Low Voltage
MAC address	The Media Access Control address is a unique 48-bit hardware address assigned to every network interface card. Usually written in the form 01:23:45:67:89:ab
MCB	Miniature Circuit Breaker. In the SCE configuration, its position is associated with the tap changer.
MEAS	Values acquired through digital or analogue inputs (with value, state, and time stamp)
Metering (non-tariff)	Values computed depending on the values of digital or analogue inputs during variable periods of time (time integration).
Metering (tariff)	Values computed depending on the values of digital or analogue inputs during variable periods and dedicated to energy tariff metering. These values are provided by dedicated “tariff computers” which are external to the control system.
MIDOS connector	Alstom 28-pin terminal block used for CT/VT acquisition
MMS	Manufacturing Message Specification (ISO 9506)
Modbus	Communication protocol used on secondary networks with IEDs or with a SCADA RCP. There are 2 versions: standard MODICON and Alstom.
Module	Term used in DS Agile SCE to encompass all electrical HV devices: switchgear, transformers, motors, generators, capacitors, …
MOTION	Transient state of a Double Point Occurs when the two associated digital inputs are momentarily in state 0 (e.g. position indication when a switching device is operating). The acceptable duration of the transient state is user-settable.

Term/Acronym	Description
MU	Merging Unit Interface device which takes signals from the instrument transformer sensors and performs digital signal processing to generate and distribute output sampled value streams according to IEC 61850-9-2LE standardised definitions for communication with substation IEDs and controllers.
MV	Medium Voltage or Measurement Value
NC	Normally Closed (for a relay/contact)
NCIT	Non-Conventional Instrument Transformers New generation of captor-based, for example using light diffraction under an electric field, CT/VTs, without spires, that provide direct voltage and current numerical values to the communicating IEDs.
NO	Normally Open (for a relay/contact)
OSI	Open System Interconnection ISO standard that splits and defines communication in 7 layers : physical, link, network, transport, session, presentation, application.
OWS	Operator WorkStation (DS Agile aView)
PHY	OSI Physical Layer: The physical layer provides for transmission of cells over a physical medium.
PLC	Programmable Logic Control: Includes PSL and ISaGRAF Within the PLC-programs are defined the configurable control sequences or automations used by DS Agile IEDs and Gateway (ISaGRAF only).
PRP	Parallel Redundancy Protocol (defined in IEC 62439-3:2010)
PSL	Programmable Scheme Logic
PTP	Precision Time Protocol: Protocol used to synchronize clocks throughout a computer network. Defined in the standard IEEE 1588.
RCC	Remote Control Centre: computer or system that is not part of the substation control system. RCC communicates with and supervises the DS Agile system using a protocol.
RCP	Remote Control Point Name given to the device or part used to remotely control several bays or substations. Usually associated with Remote/Local substation control. It is a SCADA interface managed through the Telecontrol BUS. Several RCPs can be managed with different protocols.
RedBox	PRP or HSR Redundancy Box
RI	Read Inhibit, output that indicates the availability of an analogue output (e.g. during DAC processing time).
RMON	Short for remote monitoring, a network management protocol that allows network information to be gathered at a single workstation. Whereas SNMP gathers network data from a single type of Management Information Base (MIB), RMON 1 defines nine additional MIBs that provide a much richer set of data about network usage. For RMON to work, network devices, such as hubs and switches, must be designed to support it. The newest version of RMON, RMON 2, provides data about traffic at the network layer in addition to the physical layer. This allows administrators to analyze traffic by protocol.
RMS	Root Mean Square Average value of a sinusoid that is used for calculations.
RTU	Remote Terminal Unit Standalone controller that acquires data and transmits it to RCP or SCADA. The RTU is attached to the T-BUS.
SAN	Single Attached Node (defined by IEC 62439-3). Unlike DANP, such an IED requires a REDundancy Box to send the messages over two separate networks or over an HSR network.
SAT	Site Acceptance Test Validation procedures performed on site with the customer.
SBMC	Site-Based Maintenance Control mode A bay in SBMC mode does not take into account the commands issued from the RCP; moreover, some of its digital points and measurements (defined during the configuration process) are no longer sent to the RCP (they are “automatically” suppressed).

Term/Acronym	Description
SBO	Select Before Operate Control made of two steps, selection and execution. The selection step returns a feedback. It can be used to select a circuit before execution of the command. Commands are included in a protocol frame between the system HMI and the BCU and sent over wired outputs to the switching device (e.g. DO select with DI Select, then DO execute).
S-BUS	Station Bus, federal network between DS Agile devices.
SCADA	Supervisory Control And Data Acquisition, equivalent to RCC.
SCE	System Configuration Editor
SCL	System Configuration Language (IEC 61850-6) for substation automation
SCP	Substation Control Point Name given to the device or part used to control locally several bays or substations. Usually associated with Remote/Local substation control. It normally refers to DS Agile's system HMI, aView.
SCS	Substation Control System
SCT	Single Counter
SCU	Switchgear Control Unit used in Process Bus applications.
Server	Defined in IEC 61850 as an entity that provides services to clients or issues unsolicited messages.
Setpoints (analogue)	Analogue setpoints are analogue outputs delivered as current loops. Used to send instruction values to the process or auxiliary device.
Setpoints (digital)	Digital values sent on multiple parallel wired outputs. Each wired output represent one bit of the value. Digital setpoints are used to send instruction values to the electrical process or to auxiliary devices.
SFC	Sequential Function Chart IEC 61131-3 programming language (used to define configurable automation)
SFP	Small Form-factor Pluggable transceiver Hot-pluggable transceiver used for both telecommunication and data communications applications.
SI	Single Input or System Indication: Binary information that does not come from an external interface, but is related to an internal state of the controller (time status, hardware faults…) or the result of an inner function (AR, …) PSL or ISaGRAF.
SIG	Status Input Group (idem MPS)
SINAD	Signal-plus-Noise-plus-Distorsion to Noise-plus-Distorsion ratio, in dB
SIT	Status Input Double Bit (idem DPS)
SNMP	Simple Network Management Protocol: protocol governing network management and monitoring of network devices and their functions.
SNTP	Simple Network Time Protocol
SOE	Sequence Of Events, i.e. the event list
SP SPS SPC	Single Point Single Point Status Single Point Control
SPI	Step Point Indication (same as TPI)
SRP	Switch Redundancy Protocol, PRP Ethernet switch board fitted in H38x Ethernet switch and in C264 BCU.
ST	Structured Text An IEC 61131-3 programming language to define configurable automation.
STP	Shielded Twisted Pair.
Suppression (Automatic)	A binary information belonging to a bay in SBMC mode is automatically suppressed for the remote controller. However changes of state are indicated locally, at SCP level.

Term/Acronym	Description
Suppression (Manual)	A binary information can be suppressed by a command issued by an operator. No subsequent change of state on a “suppressed information” can trigger any action such as display, alarm or transmission.
T-BUS	Telecontrol Bus, generic name of networks and protocols used for communications between DS Agile Gateway or the C264 Telecontrol Interface function and the RCP. Networks use RS232, RS485, or Ethernet (T104). Protocols are IEC 60850-5-101 (T101) or MODICON Modbus.
TC	True Contact A double counter is acquired on two contacts. One is called the true contact (TC), the other is the complemented contact (CC). Normally these contacts have complementary states.
TCIP	Tap Changer In Progress
TDD	Total Demand Distortion, similar to the THD but applied to currents and with a rated current (In) used as reference.
THD	Total Harmonic Distortion, sum of all voltage harmonics.
TMU	Transducerless Measurement Unit
TPI	Tap Position Indication (for transformers). Frequently acquired via a Digital Measurement.
TS	Tele-Signalling Logic position transmitted by a remote signal
UCA	Utility Communications Architecture Communications standard mainly used in the US
URCB	Unbuffered Report Control Block
UTC	Universal Time Co-ordinates (or Universal Time Code) UTC replaces GMT and it is identical.
VdBS	Versioned data Base System, SCE-generated databag ready for download.
VDEW	German subset of the IEC 60870-5-103 protocol.
VMGA	Vertical Measurement Graphical Area
Voltage level	Set of bays in which plants and devices operate at the same voltage (e.g. 275 kV).
VT	Voltage Transformer Basically the device connected to the electrical process used to extract a voltage measurement. By extension part of a device (C264) that receives this AC value & converts it to a numerical measurement value. VTs are wired in parallel.



GE Grid Solutions
Parc Eurêka,
81 rue Euclide,
CS11140
34060 Montpellier Cedex 2, France

Worldwide Contact Center
Web: www.GEGridSolutions.com/contact
Phone: +44 (0) 1785 250 070

www.gegridsolutions.com/contact

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