MiCOM P541, P542, P543, P544, P545, 546

Technical Guide

Current Differential Protection Relays

Platform Hardware Version: J
Platform Software Version: 20 & 30
Publication Reference: P54x/EN T/I53

GRID

CURRENT DIFFERENTIAL RELAYS

MiCOM P541, P542, P543, P544, P545, P546

CONTENT

Manual Issue H			Amendments completed – 02.2005
Doc Ref.	Section	Page	Description
Throughout			Company name changed
IT	2	4/5	**Introduction to MiCOM Guides** 2 lines deleted
IT	3.3	9	**Menu structure** Sentence changed
IT	3.8	17	**First rear communication** Title & paragraph amended
IT	3.8.2	20/21	**Modbus communication** New cell added to end of section
IT	3.9	23	**Ethernet Rear Port (option)** New section inserted
AP	Throughout		All instances of "Courier Database chapter" replaced with "Relay Menu Database chapter".
AP	1.2.1	12	**Protection features** New bullet point added to end of section
AP	1.2.2	13	**Non-protection features** New bullet point added to end of section Two paragraphs replaced
AP	2.1	15	**Configuration column** Last 4 rows in table amended
AP	2.2.1	15/16	**Differential protection configuration** Data in table deleted Last 3 rows of table added
AP	2.2.2	18	**Phase differential characteristics** Data in table amended and line added
AP	2.2.11.3	33	**Teed feeder example** Figure 12: Diagram updated
AP	2.2.11.4	35	**Three winding transformer in zone with different rated CTs example** Figure 13: Diagram updated
AP	2.3	37	**Distance protection** Table 6: Data amended
AP	2.3.1	38	**Phase fault distance protection** Figure 14 & 15: Note 2 replaced
AP	2.3.7.6	47	**Residual compensation setting** Sentence replaced
AP	2.4	48	**Phase fault overcurrent protection** Data in table amended and line added
AP	2.4	49	**Phase fault overcurrent protection** Table 9: Data amended
AP	2.6	54	**Earth fault protection** Table 14: Data in table amended and line added
AP	2.6	55	**Earth fault protection** Table 15: Data in table amended and line added
AP	3.2.2	72/73	**Relay settings**

Manual Issue H			Amendments completed – 02.2005
Doc Ref.	Section	Page	Description
			Table 20: Data amended
AP	3.2.8.6	80	**System check on shot 1 (called "Check Sinchronising for fast 3 phase reclose" on software 13 or previous)** Paragraph amended
AP	3.2.8.7	80	**Immediate Autoreclose with Check Synchronism (since software 20 and onwards)** Title replaced
AP	3.2.9.5	81	**Discrimination Timer Setting (since software 20 and onwards)** Title replaced
AP	3.3.1	82	**System Checks (for version 20 and onwards)** Title replaced
AP	3.3.1.1	82	**Overview** Text moved to new section
AP	3.3.2	87/90	**Check synchronisation (applicable to P543 & P545) For version 13 and previous** Whole new section added
AP	3.4	90	**Autoreclose /Check Synchronisation Interface (Valid for sotfware 20 and onwards)** Title replaced
AP	3.7.1	94	**Circuit breaker condition monitoring features** Table 25: Data amended
AP	3.8	95	**Circuit breaker control** Bullet point replaced
AP	3.8.1	98	**CB Control using "Hotkeys" (Since software 20 and onwards)** Title replaced
AP	3.9.1.7	102	**Fault locator settings** Data in table amended
AP	3.10	103	**Event & fault records** Paragraph amended Data in table amended
AP	3.10.1.3	105	**Relay alarm conditions** Table 29: Data amended
AP	3.11	107	**Disturbance recorder** Paragraphs amended
AP	3.12	109	**Measurements** Bullet point replaced
AP	3.12.3	109	**Slip Frequency (Since software 20 and onwards)** Title replaced
AP	3.12.7	110	**Settings** Table 32: Data amended
AP	3.12.7.4	110	**Remote2 Values (Since software 12 and onwards)** Title replaced
AP	3.13	112	**Changing Setting Groups** First and second paragraph replaced

Manual Issue H			Amendments completed – 02.2005
Doc Ref.	Section	Page	Description
AP	3.14	112	**Control inputs (Since software 20 and onwards)** Title replaced
AP	3.15	113	**Real time clock synchronization via opto-inputs (Since software 20 and onwards)** Title replaced
AP	5.	118	**Current Transformer Requirements** Data replaced
AP	6.	119	**Commissioning Test Menu** Data in table amended Data added to end of table
AP	6.10	121	**Test autoreclose** Information replaced
AP	6.11	121	**Test Loopback** Whole section replaced
AP	6.12	122	**DDB Status** Existing section 6.13 renumbered and new section 6.12 added
AP	7.1	122	**Communications link options** Whole section replaced
AP	7.1.5	123	**IEEE C37.94 interface to multiplexer** Existing sections renumbered and new section 7.1.5 added
AP	7.1.5	123	**IEEE C37.94 interface to multiplexer** (since software 30) added to heading
AP	7.1.6.1	123	**Switched communication networks (P541, P542, P543 & P544)** Paragraph amended
AP	7.7	132	**Clock source** Line added to end of section
AP	7.8	133	**Data rate** Line added to end of section
AP	7.13	134	**Communications fail mode** Sentence replaced
HW	1.1.4	3	**Analogue / Digital Input module** Whole section replaced
HW	1.1.8	4	**Ethernet board** Figure 1: Diagram updated
HW	2.4.2	7	**Input board** Term replaced Figure 2: Diagram updated
HW	2.4.3	8	**Universal opto isolated logic inputs** Whole section replaced
HW	3.3	13	**Platform software** Term added to last sentence
HW	4.1.2	17	**Initialisation software** New bullet point added
HW	4.2	17	**Continuous self-testing**

Manual Issue H			Amendments completed – 02.2005
Doc Ref.	Section	Page	Description
			Replaced term Sentence replaced Sentence changed to bullet point
TD	1.	7	**Reference conditions** Data in table amended and line added
TD	2.1.4	9	**Inverse time (IDMT) characteristic** Data in table amended
TD	2.1.4.2	9	**Required Time Dial Settings for IEEE / US curves** Data in table amended and line added
TD	2.1.6	10	**Vectorial compensation settings (P541 and P542)** Data in table amended
TD	2.2.2.1	12	**Inverse Time (IDMT) Characteristic** Data in table amended
TD	2.2.2.3	12	**Time Dial Settings for IEEE/US curves** Data in table amended and line added
TD	2.2.5	15	**ANSI/IEEE IDMT curves** Figure 2.2.5: Diagram updated
TD	2.3.4.4	18	**Polarising Quantities** Data in table amended
TD	2.13.1	20	**Setting ranges** New line added to end of table
TD	6.1.1	25	**Features** Data added to table
TD	6.3.1	26	**Level settings** Data in table amended and line added
TD	8.2	27	**Rear Port 1** Table replaced
TD	10.1.4	31	**'Universal' Logic inputs (P540 range)** Table replaced
TD	11.1	33	**CT Requirements (P540 range)** Data replaced
TD	18.5	44	**Battery life (P540 range)** Line added to table
CT	1.	5	**Introduction** New section 1.1 added to end of introduction
CT	2.1	5	**Courier protocol** Text inserted
CT	2.7	10	**Disturbance record extraction** Whole section replaced
CT	3.1	11	**Communication Link** Text added to beginning of section
CT	3.6.6	21	**Record data** Sentence deleted
CT	3.8	22/24	**Date and Time Format (Data Type G12)** Whole section replaced

Manual Issue H			Amendments completed – 02.2005
Doc Ref.	Section	Page	Description
CT	4.1	25	**Physical connection and link layer** Text deleted
CT	5.1	28	**DNP3 Protocol** Text inserted
UC	3.4.3	12	**UCA2.0 Settings & Statistics** Data added to table
GC	-	-	**Courier menu database** Amended to reflect latest relay software
VC	-	-	**Hardware/software version history and compatibility** Amended to reflect latest relay software
LG	-	1	**Distance P543/P544/P545/P546 Zone 1 Tripping Logic** Figure 1: Diagram amended
LG	-	1	**Distance P543/P544/P545/P546 Zone 2 Tripping Logic** Figure 2: Diagram amended
LG	-	14	**CB failure for P541/P542 with Three Pole Tripping** Figure 25: Diagram amended
LG	-	8	**Autoreclose P543/P545 Single/Three Pole Tripping** Figure 17: Diagram amended
LG	-	9	**Autoreclose P543/P545 Inhibit Sequence Count** Figure 18: Diagram amended
LG	-	10	**Autoreclose P543/P545 Cycles** Figure 19: Diagram amended
LG	-	13	**Autoreclose P543/P545 Force 3 Pole Trip** Figure 22: Diagram amended
LG	-	14	**P543/P545 DDB Pole Discrepancy Trip** Figure24: Diagram amended
LG	-	16	**VTS Logic** Figure 29: Diagram amended
LG	-	24	**Autoreclose P543/P545 Repeat Closer** Figure 37: Diagram amended

HANDLING OF ELECTRONIC EQUIPMENT

A person's normal movements can easily generate electrostatic potentials of several thousand volts. Discharge of these voltages into semiconductor devices when handling circuits can cause serious damage, which often may not be immediately apparent but the reliability of the circuit will have been reduced.

The electronic circuits of ALSTOM Grid are immune to the relevant levels of electrostatic discharge when housed in their cases. Do not expose them to the risk of damage by withdrawing modules unnecessarily.

Each module incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to withdraw a module, the following precautions should be taken to preserve the high reliability and long life for which the equipment has been designed and manufactured.

1. Before removing a module, ensure that you are a same electrostatic potential as the equipment by touching the case.
2. Handle the module by its front-plate, frame, or edges of the printed circuit board. Avoid touching the electronic components, printed circuit track or connectors.
3. Do not pass the module to any person without first ensuring that you are both at the same electrostatic potential. Shaking hands achieves equipotential.
4. Place the module on an antistatic surface, or on a conducting surface which is at the same potential as yourself.
5. Store or transport the module in a conductive bag.

More information on safe working procedures for all electronic equipment can be found in BS5783 and IEC 60147-0F.

If you are making measurements on the internal electronic circuitry of an equipment in service, it is preferable that you are earthed to the case with a conductive wrist strap.

Wrist straps should have a resistance to ground between 500k – 10M ohms. If a wrist strap is not available you should maintain regular contact with the case to prevent the build up of static. Instrumentation which may be used for making measurements should be earthed to the case whenever possible.

ALSTOM Grid strongly recommends that detailed investigations on the electronic circuitry, or modification work, should be carried out in a Special Handling Area such as described in BS5783 or IEC 60147-0F.

CONTENT

1. SAFETY SECTION

This Safety Section should be read before commencing any work on the equipment.

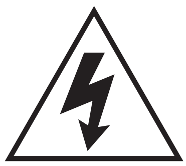
1.1 Health and safety

The information in the Safety Section of the product documentation is intended to ensure that products are properly installed and handled in order to maintain them in a safe condition. It is assumed that everyone who will be associated with the equipment will be familiar with the contents of the Safety Section.

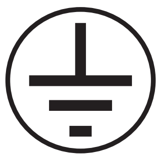
1.2 Explanation of symbols and labels

The meaning of symbols and labels may be used on the equipment or in the product documentation, is given below.

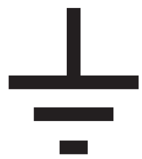
Caution: refer to product documentation



Caution: risk of electric shock



Protective/safety *earth terminal



Functional *earth terminal

Note: This symbol may also be used for a protective/safety earth terminal if that terminal is part of a terminal block or sub-assembly e.g. power supply.

*NOTE: THE TERM EARTH USED THROUGHOUT THE PRODUCT DOCUMENTATION IS THE DIRECT EQUIVALENT OF THE NORTH AMERICAN TERM GROUND.

2. INSTALLING, COMMISSIONING AND SERVICING

Equipment connections

Personnel undertaking installation, commissioning or servicing work on this equipment should be aware of the correct working procedures to ensure safety. The product documentation should be consulted before installing, commissioning or servicing the equipment.

Terminals exposed during installation, commissioning and maintenance may present a hazardous voltage unless the equipment is electrically isolated.

If there is unlocked access to the rear of the equipment, care should be taken by all personnel to avoid electrical shock or energy hazards.

Voltage and current connections should be made using insulated crimp terminations to ensure that terminal block insulation requirements are maintained for safety. To ensure that wires are correctly terminated, the correct crimp terminal and tool for the wire size should be used.

Before energising the equipment it must be earthed using the protective earth terminal, or the appropriate termination of the supply plug in the case of plug connected equipment. Omitting or disconnecting the equipment earth may cause a safety hazard.

The recommended minimum earth wire size is $2.5mm^2$, unless otherwise stated in the technical data section of the product documentation.

Before energising the equipment, the following should be checked:

- Voltage rating and polarity;
- CT circuit rating and integrity of connections;
- Protective fuse rating;
- Integrity of earth connection (where applicable)
- Remove front plate plastic film protection
- Remove insulating strip from battery compartment

3. EQUIPMENT OPERATING CONDITIONS

The equipment should be operated within the specified electrical and environmental limits.

3.1 Current transformer circuits

Do not open the secondary circuit of a live CT since the high level voltage produced may be lethal to personnel and could damage insulation.

3.2 External resistors

Where external resistors are fitted to relays, these may present a risk of electric shock or burns, if touched.

3.3 Battery replacement

Where internal batteries are fitted they should be replaced with the recommended type and be installed with the correct polarity, to avoid possible damage to the equipment.

3.4 Insulation and dielectric strength testing

Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, the voltage should be gradually reduced to zero, to discharge capacitors, before the test leads are disconnected.

3.5 Insertion of modules and pcb cards

These must not be inserted into or withdrawn from equipment whist it is energised since this may result in damage.

3.6 Fibre optic communication

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.

4. OLDER PRODUCTS

Electrical adjustments

Equipments which require direct physical adjustments to their operating mechanism to change current or voltage settings, should have the electrical power removed before making the change, to avoid any risk of electrical shock.

Mechanical adjustments

The electrical power to the relay contacts should be removed before checking any mechanical settings, to avoid any risk of electric shock.

Draw out case relays

Removal of the cover on equipment incorporating electromechanical operating elements, may expose hazardous live parts such as relay contacts.

Insertion and withdrawal of extender cards

When using an extender card, this should not be inserted or withdrawn from the equipment whilst it is energised. This is to avoid possible shock or damage hazards. Hazardous live voltages may be accessible on the extender card.

Insertion and withdrawal of heavy current test plugs

When using a heavy current test plug, CT shorting links must be in place before insertion or removal, to avoid potentially lethal voltages.

5. DECOMMISSIONING AND DISPOSAL

Decommissioning: The auxiliary supply circuit in the relay may include capacitors across the supply or to earth. To avoid electric shock or energy hazards, after completely isolating the supplies to the relay (both poles of any dc supply), the capacitors should be safely discharged via the external terminals prior to decommissioning.

Disposal: It is recommended that incineration and disposal to water courses is avoided. The product should be disposed of in a safe manner. Any products containing batteries should have them removed before disposal, taking precautions to avoid short circuits. Particular regulations within the country of operation, may apply to the disposal of lithium batteries.

6. TECHNICAL SPECIFICATIONS

Protective fuse rating

The recommended maximum rating of the external protective fuse for this equipment is 16A, Red Spot type or equivalent, unless otherwise stated in the technical data section of the product documentation.

Insulation class:	IEC 601010-1 : 1990/A2 : 2001 Class I EN 61010-1: 2001 Class I	This equipment requires a protective (safety) earth connection to ensure user safety.
Insulation Category (Overvoltage):	IEC 601010-1 : 1990/A2 : 1995 Category III EN 61010-1: 2001 Category III	Distribution level, fixed insulation. Equipment in this category is qualification tested at 5kV peak, 1.2/50μs, 500Ω, 0.5J, between all supply circuits and earth and also between independent circuits.
Environment:	IEC 601010-1 : 1990/A2 : 1995 Pollution degree 2 EN 61010-1: 2001 Pollution degree 2	Compliance is demonstrated by reference to generic safety standards.
Product Safety:	72/23/EEC	Compliance with the European Commission Low Voltage Directive.
CE	EN 61010-1: 2001 EN 60950-1: 2002	Compliance is demonstrated by reference to generic safety standards.

INTRODUCTION

CONTENTS

1. INTRODUCTION TO MiCOM

MiCOM is a comprehensive solution capable of meeting all electricity supply requirements. It comprises a range of components, systems and services from ALSTOM Grid - SAS.

Central to the MiCOM concept is flexibility.

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

The components within MiCOM are:

- P range protection relays;
- C range control products;
- M range measurement products for accurate metering and monitoring;
- S range versatile PC support and substation control packages.

MiCOM 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.

For up-to-date information on any MiCOM product, visit our website:

www.alstom.com/grid/sas

2. INTRODUCTION TO MiCOM GUIDES

The guides provide a functional and technical description of the MiCOM protection relay and a comprehensive set of instructions for the relay's use and application.

Divided into two volumes, as follows:

Volume 1 – Technical Guide, includes information on the application of the relay and a technical description of its features. It is mainly intended for protection engineers concerned with the selection and application of the relay for the protection of the power system.

Volume 2 – Operation Guide, contains information on the installation and commissioning of the relay, and also a section on fault finding. This volume is intended for site engineers who are responsible for the installation, commissioning and maintenance of the relay.

The chapter content within each volume is summarised below:

Volume 1 Technical Guide

Handling of Electronic Equipment

Safety Section

P54x/EN IT Introduction

A guide to the different user interfaces of the protection relay describing how to start using the relay.

P54x/EN AP Application Notes

Comprehensive and detailed description of the features of the relay including both the protection elements and the relay's other functions such as event and disturbance recording, fault location and programmable scheme logic. This chapter includes a description of common power system applications of the relay, calculation of suitable settings, some typical worked examples, and how to apply the settings to the relay.

P54x/EN HW Relay Description

Overview of the operation of the relay's hardware and software. This chapter includes information on the self-checking features and diagnostics of the relay.

P54x/EN TD Technical Data

Technical data including setting ranges, accuracy limits, recommended operating conditions, ratings and performance data. Compliance with technical standards is quoted where appropriate.

P54x/EN CT Communications and Interface Guide

This chapter provides detailed information regarding the communication interfaces of the relay, including a detailed description of how to access the settings database stored within the relay. The chapter also gives information on each of the communication protocols that can be used with the relay, and is intended to allow the user to design a custom interface to a SCADA system.

P54x/EN UC UCA2.0 Communications

The chapter gives information on the UCA2.0 communication protocol that can be used with the relay.

P54x/EN GC Relay Menu Database: User Interface / Courier / Modbus / IEC 60870-5-103/ DNP 3.0

Listing of all of the settings contained within the relay together with a brief description of each.

P54x/EN CO External Connection Diagrams

All external wiring connections to the relay.

P54x/EN VC Hardware / Software Version History and Compatibility

P54x/EN HI Menu Table Contents

Volume 2 Operation Guide

Handling of Electronic Equipment

Safety Section

P54x/EN IT Introduction

A guide to the different user interfaces of the protection relay describing how to start using the relay.

P54x/EN IN Installation

Recommendations on unpacking, handling, inspection and storage of the relay. A guide to the mechanical and electrical installation of the relay is provided incorporating earthing recommendations.

P594/EN IN P594 Installation Notes

P54x/EN CM Commissioning and Maintenance

Instructions on how to commission the relay, comprising checks on the calibration and functionality of the relay. A general maintenance policy for the relay is outlined.

P54x/EN PR Problem Analysis

Advice on how to recognise failure modes and the recommended course of action.

P54x/EN GC Relay Menu Database: User Interface / Courier / Modbus / IEC 60870-5-103/ DNP 3.0 / UCA2.0

Listing of all of the settings contained within the relay together with a brief description of each.

P54x/EN CO External Connection Diagrams

All external wiring connections to the relay.

P54x/EN VC Hardware / Software Version History and Compatibility

P54x/EN HI Menu Table Contents

Repair Form

3. USER INTERFACES AND MENU STRUCTURE

The settings and functions of the MiCOM protection relay can be accessed both from the front panel keypad and LCD, and via the front and rear communication ports. Information on each of these methods is given in this section to describe how to get started using the relay.

3.1 Introduction to the relay

3.1.1 Front panel

The front panel of the relay is shown in Figure 1, with the hinged covers at the top and bottom of the relay shown open. Extra physical protection for the front panel can be provided by an optional transparent front cover. With the cover in place read only access to the user interface is possible. Removal of the cover does not compromise the environmental withstand capability of the product, but allows access to the relay settings. When full access to the relay keypad is required, for editing the settings, the transparent cover can be unclipped and removed when the top and bottom covers are open. If the lower cover is secured with a wire seal, this will need to be removed. Using the side flanges of the transparent cover, pull the bottom edge away from the relay front panel until it is clear of the seal tab. The cover can then be moved vertically down to release the two fixing lugs from their recesses in the front panel.

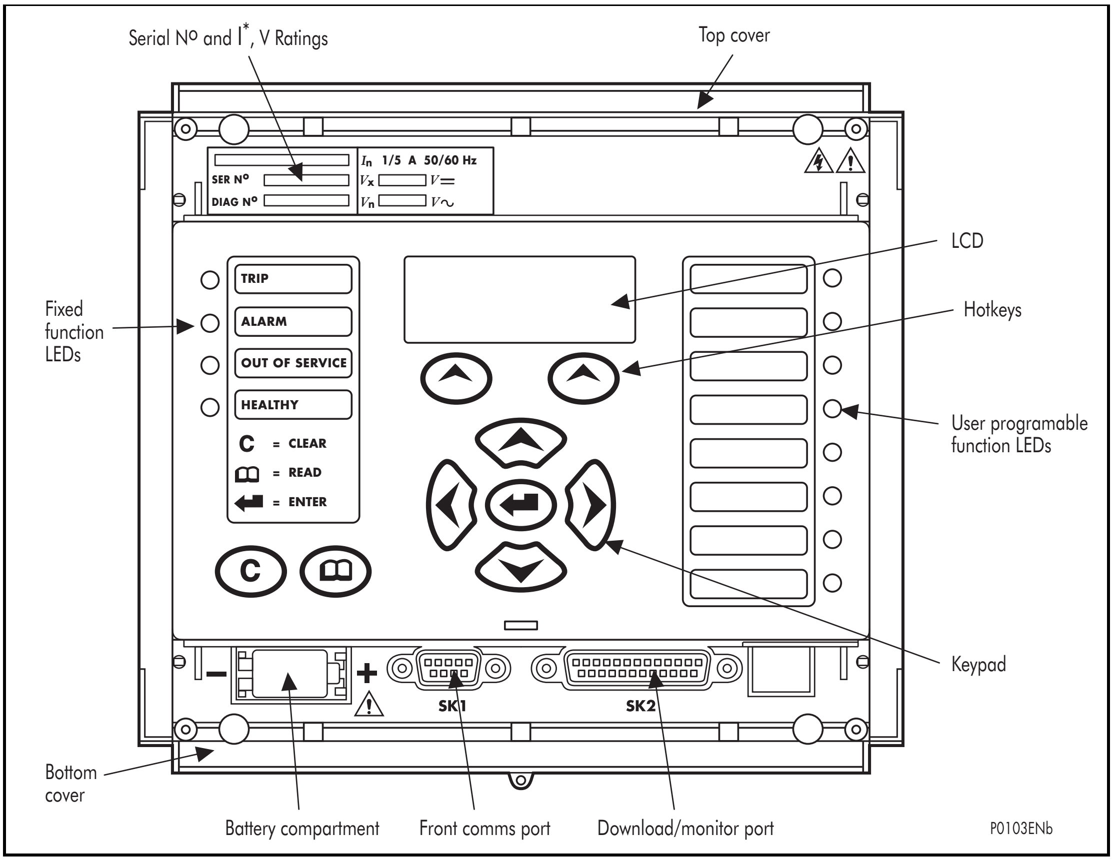


Figure 1: Relay front view

The front panel of the relay includes the following, as indicated in Figure 1:

- a 16-character by 3-line alphanumeric liquid crystal display (LCD).
- a 9 key keypad comprising 4 arrow keys (◄, ►, ▲ and ▼), an enter key (↵), a clear key (C), a read key (📖) and 2 additional hotkeys (▲).
- 12 LEDs; 4 fixed function LEDs on the left hand side of the front panel and 8 programmable function LEDs on the right hand side.

Hotkey functionality:

- SCROLL
  Starts scrolling through the various default displays
- STOP
  Stops scrolling the default display

Under the top hinged cover:

- the relay serial number, and the relay's current and voltage rating information*.

Under the bottom hinged cover:

- battery compartment to hold the $^1/_2$ AA size battery which is used for memory back-up for the real time clock, event, fault and disturbance records.
- a 9-pin female D-type front port for communication with a PC locally to the relay (up to 15m distance) via an EIA(RS)232 serial data connection.
- a 25-pin female D-type port providing internal signal monitoring and high speed local downloading of software and language text via a parallel data connection.

The fixed function LEDs on the left hand side of the front panel are used to indicate the following conditions:

Trip (Red) indicates that the relay has issued a trip signal. It is reset when the associated fault record is cleared from the front display. (Alternatively the trip LED can be configured to be self-resetting)*.

Alarm (Yellow) flashes to indicate that the relay has registered an alarm. This may be triggered by a fault, event or maintenance record. The LED will flash until the alarms have been accepted (read), after which the LED will change to constant illumination, and will extinguish when the alarms have been cleared.

Out of service (Yellow) indicates that the relay's protection is unavailable.

Healthy (Green) indicates that the relay is in correct working order, and should be on at all times. It will be extinguished if the relay's self-test facilities indicate that there is an error with the relay's hardware or software. The state of the healthy LED is reflected by the watchdog contact at the back of the relay.

To improve the visibility of the settings via the front panel, the LCD contrast can be adjusted using the "LCD Contrast" setting in the CONFIGURATION column.

3.1.2 Relay rear panel

The rear panel of the relay is shown in Figure 2. All current and voltage signals*, digital logic input signals and output contacts are connected at the rear of the relay. Also connected at the rear is the twisted pair wiring for the rear EIA(RS)485 communication port, the IRIG-B time synchronising input and the optical fibre rear communication port which are both optional.

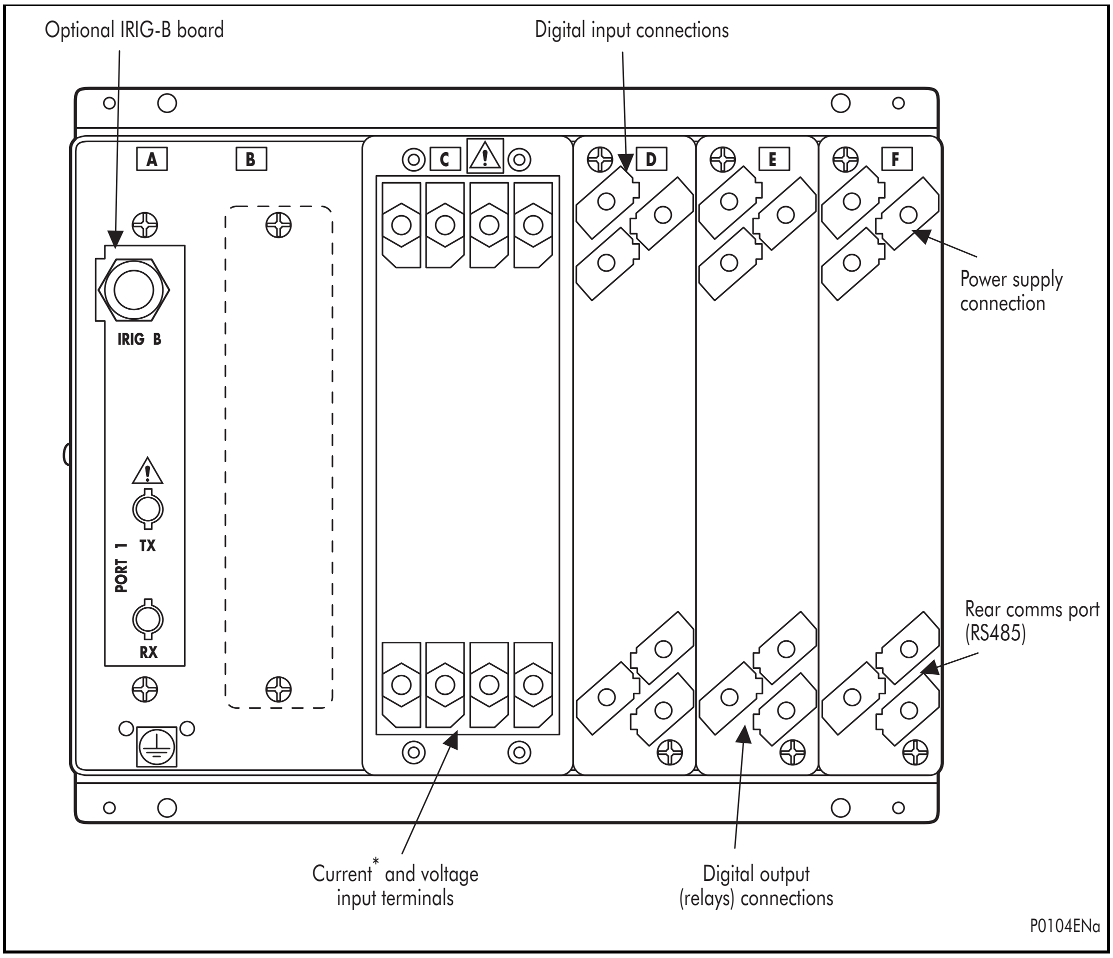


Figure 2: Relay rear view

Refer to the wiring diagram in the External Connection Diagrams chapter (P54x/EN CO) for complete connection details.

3.2 Introduction to the user interfaces and settings options

The relay has three user interfaces:

- the front panel user interface via the LCD and keypad.
- the front port which supports Courier communication.
- the rear port which supports one protocol of either Courier, Modbus, IEC 60870-5-103, DNP3.0 or UCA2.0. The protocol for the rear port must be specified when the relay is ordered.

The measurement information and relay settings which can be accessed from the five interfaces are summarised in Table 1.

	Keypad/ LCD	Courier	Modbus	IEC870 -5-103	DNP3.0	UCA2.0
Display & modification of all settings	•	•	•			•
Digital I/O signal status	•	•	•	•	•	•
Display/extraction of measurements	•	•	•	•	•	•
Display/extraction of fault records	•	•	•			
Extraction of disturbance records		•	•	•	•	•
Programmable scheme logic settings		•				
Reset of fault & alarm records	•	•	•	•	•	•
Clear event & fault records	•	•	•		•	•
Time synchronisation		•	•	•		•
Control commands	•	•	•	•	•	•

Table 1

3.3 Menu structure

The relay's menu is arranged in a tabular structure. Each setting in the menu is referred to as a cell, and each cell in the menu may be accessed by reference to a row and column address. The settings are arranged so that each column contains related settings, for example all of the disturbance recorder settings are contained within the same column. As shown in Figure 3, the top row of each column contains the heading which describes the settings contained within that column. Movement between the columns of the menu can only be made at the column heading level. A complete list of all of the menu settings is given the Relay Menu Database Chapter (P54x/EN GC) of the manual.

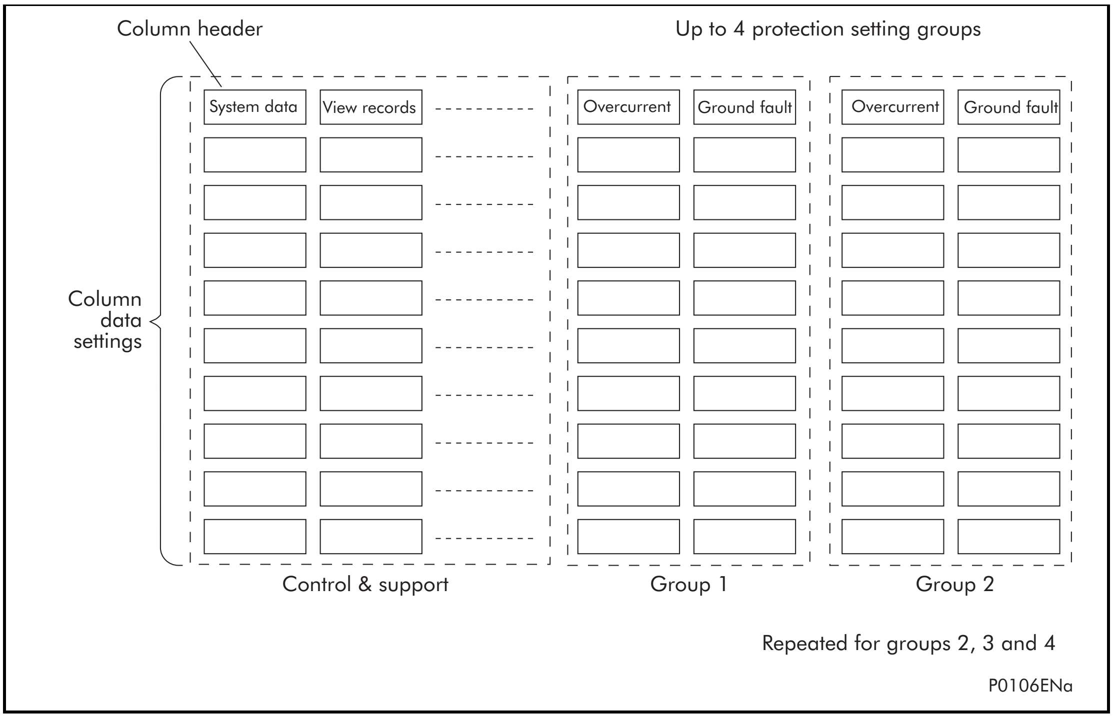


Figure 3: Menu structure

All of the settings in the menu fall into one of three categories: protection settings, disturbance recorder settings, or control and support (C&S) settings. One of two different methods is used to change a setting depending on which category the setting falls into. Control and support settings are stored and used by the relay immediately after they are entered. For either protection settings or disturbance recorder settings, the relay stores the new setting values in a temporary 'scratchpad'. It activates all the new settings together, but only after it has been confirmed that the new settings are to be adopted. This technique is employed to provide extra security, and so that several setting changes that are made within a group of protection settings will all take effect at the same time.

3.3.1 Protection settings

The protection settings include the following items:

- protection element settings
- scheme logic settings
- auto-reclose and check synchronisation settings (where appropriate)*
- fault locator settings (where appropriate)*

There are four groups of protection settings, with each group containing the same setting cells. One group of protection settings is selected as the active group, and is used by the protection elements.

3.3.2 Disturbance recorder settings

The disturbance recorder settings include the record duration and trigger position, selection of analogue and digital signals to record, and the signal sources that trigger the recording.

3.3.3 Control and support settings

The control and support settings include:

- relay configuration settings
- open/close circuit breaker*
- CT & VT ratio settings*
- reset LEDs
- active protection setting group
- password & language settings
- circuit breaker control & monitoring settings*
- communications settings
- measurement settings
- event & fault record settings
- user interface settings
- commissioning settings

3.4 Password protection

The menu structure contains three levels of access. The level of access that is enabled determines which of the relay's settings can be changed and is controlled by entry of two different passwords. The levels of access are summarised in Table 2.

Access level	Operations enabled
Level 0 No password required	Read access to all settings, alarms, event records and fault records
Level 1 Password 1 or 2	As level 0 plus: Control commands, e.g. circuit breaker open/close. Reset of fault and alarm conditions. Reset LEDs. Clearing of event and fault records.
Level 2 As level 1 plus:	Password 2 required All other settings

Table 2

Each of the two passwords are 4 characters of upper case text. The factory default for both passwords is AAAA. Each password is user-changeable once it has been correctly entered. Entry of the password is achieved either by a prompt when a setting change is attempted, or by moving to the 'Password' cell in the 'System data' column of the menu. The level of access is independently enabled for each interface, that is to say if level 2 access is enabled for the rear communication port, the front panel access will remain at level 0 unless the relevant password is entered at the front panel. The access level enabled by the password entry will time-out independently for each interface after a period of inactivity and revert to the default level. If the passwords are lost an emergency password can be supplied - contact ALSTOM Grid with the relay's serial number. The current level of access enabled for an interface can be determined by examining the 'Access level' cell in the 'System data' column, the access level for the front panel User Interface (UI), can also be found as one of the default display options. Additionally the current level of access for each interface is available for use in the PSL by mapping to the following DDB signals:

- HMI Access Lvl 1
- HMI Access Lvl 2
- FPort AccessLvl1
- FPort AccessLvl2
- RPrt1 AccessLvl1
- RPrt1 AccessLvl2
- RPrt2 AccessLvl1
- RPrt2 AccessLvl2

Each pair of DDB signals indicate the access level as follows:

- Lvl 1 off, Lvl 2 off = 0
- Lvl 1 on, Lvl 2 off = 1
- Lvl 1 off, Lvl 2 on = 2

The relay is supplied with a default access level of 2, such that no password is required to change any of the relay settings. It is also possible to set the default menu access level to either level 0 or level1, preventing write access to the relay settings without the correct password. The default menu access level is set in the 'Password control' cell which is found in the 'System data' column of the menu (note that this setting can only be changed when level 2 access is enabled).

3.5 Relay configuration

The relay is a multi-function device which supports numerous different protection, control and communication features. In order to simplify the setting of the relay, there is a configuration settings column which can be used to enable or disable many of the functions of the relay. The settings associated with any function that is disabled are made invisible, i.e. they are not shown in the menu. To disable a function change the relevant cell in the 'Configuration' column from 'Enabled' to 'Disabled'.

The configuration column controls which of the four protection settings groups is selected as active through the ‘Active settings’ cell. A protection setting group can also be disabled in the configuration column, provided it is not the present active group. Similarly, a disabled setting group cannot be set as the active group.

The column also allows all of the setting values in one group of protection settings to be copied to another group.

To do this firstly set the ‘Copy from’ cell to the protection setting group to be copied, then set the ‘Copy to’ cell to the protection group where the copy is to be placed. The copied settings are initially placed in the temporary scratchpad, and will only be used by the relay following confirmation.

To restore the default values to the settings in any protection settings group, set the ‘Restore defaults’ cell to the relevant group number. Alternatively it is possible to set the ‘Restore defaults’ cell to ‘All settings’ to restore the default values to all of the relay’s settings, not just the protection groups’ settings. The default settings will initially be placed in the scratchpad and will only be used by the relay after they have been confirmed. Note that restoring defaults to all settings includes the rear communication port settings, which may result in communication via the rear port being disrupted if the new (default) settings do not match those of the master station.

3.6 Front panel user interface (keypad and LCD)

When the keypad is exposed it provides full access to the menu options of the relay, with the information displayed on the LCD.

The , , and keys which are used for menu navigation and setting value changes include an auto-repeat function that comes into operation if any of these keys are held continually pressed. This can be used to speed up both setting value changes and menu navigation; the longer the key is held depressed, the faster the rate of change or movement becomes.

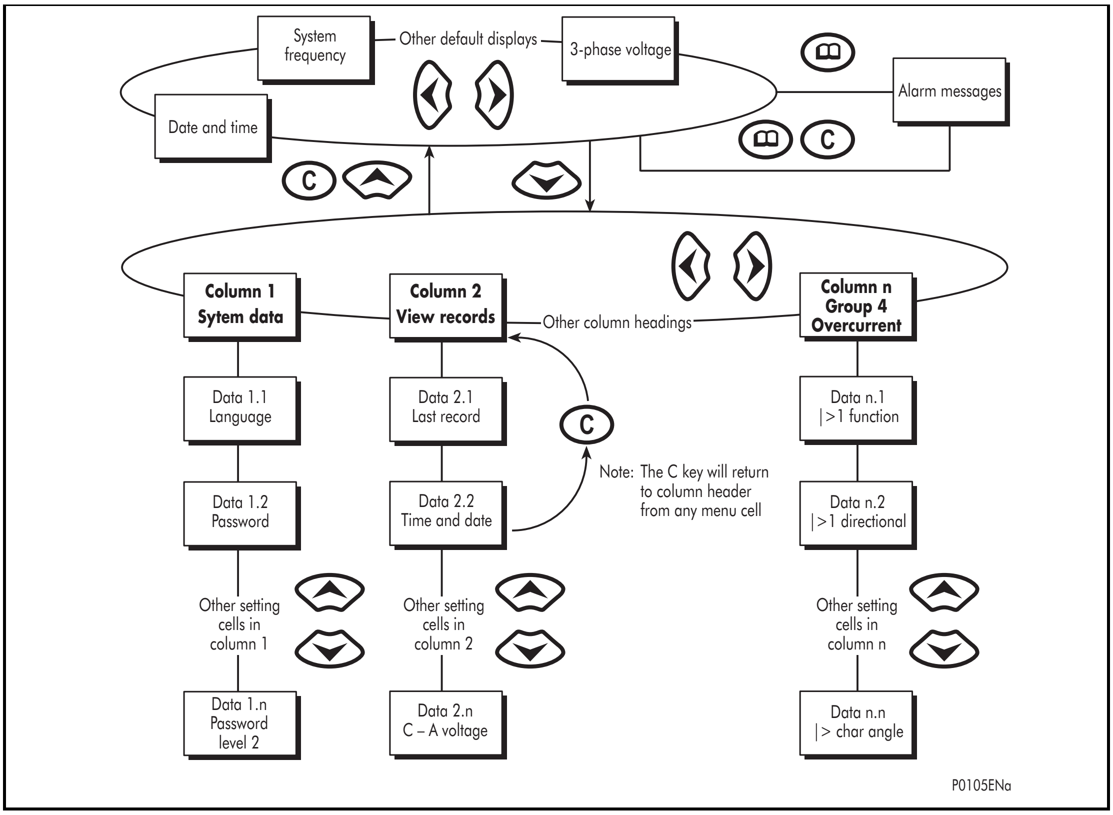


Figure 4: Front panel user interface

3.6.1 Default display and menu time-out

The front panel menu has a selectable default display. The relay will time-out and return to the default display and turn the LCD backlight off after 15 minutes of keypad inactivity. If this happens any setting changes which have not been confirmed will be lost and the original setting values maintained.

The contents of the default display can be selected from the following options: 3-phase and neutral current, 3-phase voltage, power, system frequency, date and time, relay description, or a user-defined plant reference*. The default display is selected with the ‘Default display’ cell of the ‘Measure’t setup’ column. Also, from the default display the different default display options can be scrolled through using the ← and → keys. However the menu selected default display will be restored following the menu time-out elapsing. Whenever there is an uncleared alarm present in the relay (e.g. fault record, protection alarm, control alarm etc.) the default display will be replaced by:

Alarms/Faults
Present

Entry to the menu structure of the relay is made from the default display and is not affected if the display is showing the ‘Alarms/Faults present’ message.

3.6.2 Menu navigation and setting browsing

The menu can be browsed using the four arrow keys, following the structure shown in Figure 4. Thus, starting at the default display the ↑ key will display the first column heading. To select the required column heading use the ← and → keys. The setting data contained in the column can then be viewed by using the ↓ and ↑ keys. It is possible to return to the column header either by holding the [up arrow symbol] key down or by a single press of the clear key C. It is only possible to move across columns at the column heading level. To return to the default display press the ↑ key or the clear key C from any of the column headings. It is not possible to go straight to the default display from within one of the column cells using the auto-repeat facility of the ↑ key, as the auto-repeat will stop at the column heading. To move to the default display, the ↑ key must be released and pressed again.

3.6.3 Hotkey menu navigation

The hotkey menu can be browsed using the two keys directly below the LCD. These are known as direct access keys. The direct access keys perform the function that is displayed directly above them on the LCD. Thus, to access the hotkey menu from the default display the direct access key below the “HOTKEY” text must be pressed. Once in the hotkey menu the ← and → keys can be used to scroll between the available options and the direct access keys can be used to control the function currently displayed. If neither the ← or → keys are pressed with 20 seconds of entering a hotkey sub menu, the relay will revert to the default display. The clear key C will also act to return to the default menu from any page of the hotkey menu. The layout of a typical page of the hotkey menu is described below.

The top line shows the contents of the previous and next cells for easy menu navigation.

The centre line shows the function.

The bottom line shows the options assigned to the direct access keys.

The functions available in the hotkey menu are listed below.

3.6.3.1 Setting group selection

The user can either scroll using <<NXT GRP>> through the available setting groups or <<SELECT>> the setting group that is currently displayed.

When the SELECT button is pressed a screen confirming the current setting group is displayed for 2 seconds before the user is prompted with the <<NXT GRP>> or <<SELECT>> options again. The user can exit the sub menu by using the left and right arrow keys.

For more information on setting group selection refer to “Changing setting group” section in the application guide.

3.6.3.2 Control Inputs – user assignable functions

The number of control inputs (user assignable functions – USR ASS) represented in the hotkey menu is user configurable in the “CTRL I/P CONFIG” column. The chosen inputs can be SET/RESET using the hotkey menu.

For more information refer to the “Control Inputs” section in the application guide.

3.6.3.3 CB Control

The CB control functionality varies from one Px40 relay to another. For a detailed description of the CB control via the hotkey menu refer to the “Circuit breaker control” section of the application guide.

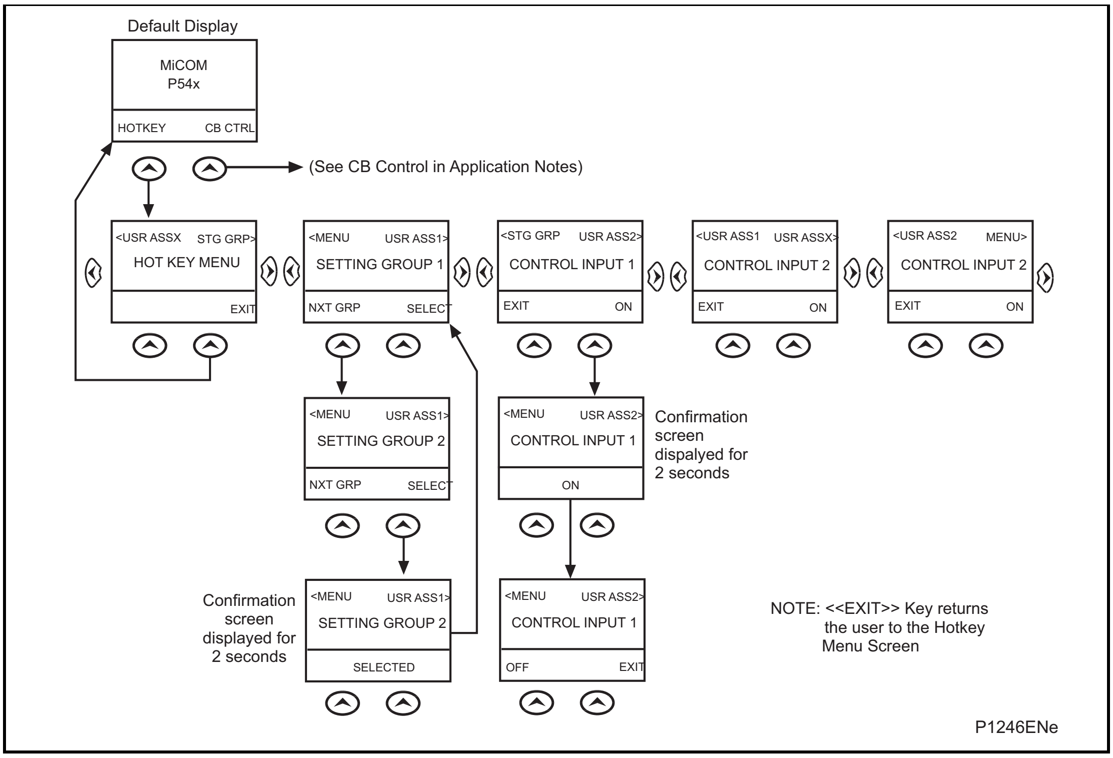


Figure 5: Hotkey menu navigation

3.6.4 Password entry

When entry of a password is required the following prompt will appear:

Enter password **** Level 1

Note: The password required to edit the setting is the prompt as shown above

A flashing cursor will indicate which character field of the password may be changed. Press the and keys to vary each character between A and Z. To move between the character fields of the password, use the and keys. The password is confirmed by pressing the enter key . The display will revert to ‘Enter Password’ if an incorrect password is entered. At this point a message will be displayed indicating whether a correct password has been entered and if so what level of access has been unlocked. If this level is sufficient to edit the selected setting then the display will return to the setting page to allow the edit to continue. If the correct level of password has not been entered then the password prompt page will be returned to. To escape from this prompt press the clear key ©. Alternatively, the password can be entered using the 'Password' cell of the 'System data' column.

For the front panel user interface the password protected access will revert to the default access level after a keypad inactivity time-out of 15 minutes. It is possible to manually reset the password protection to the default level by moving to the 'Password' menu cell in the 'System data' column and pressing the clear key © instead of entering a password.

3.6.5 Reading and clearing of alarm messages and fault records

The presence of one or more alarm messages will be indicated by the default display and by the yellow alarm LED flashing. The alarm messages can either be self-resetting or latched, in which case they must be cleared manually. To view the alarm messages press the read key. When all alarms have been viewed, but not cleared, the alarm LED will change from flashing to constant illumination and the latest fault record will be displayed (if there is one). To scroll through the pages of this use the key. When all pages of the fault record have been viewed, the following prompt will appear:

Press clear to reset alarms

To clear all alarm messages press ©; to return to the alarms/faults present display and leave the alarms uncleared, press. Depending on the password configuration settings, it may be necessary to enter a password before the alarm messages can be cleared (see section on password entry). When the alarms have been cleared the yellow alarm LED will extinguish, as will the red trip LED if it was illuminated following a trip.

Alternatively it is possible to accelerate the procedure, once the alarm viewer has been entered using the key, the © key can be pressed, this will move the display straight to the fault record. Pressing © again will move straight to the alarm reset prompt where pressing © once more will clear all alarms.

3.6.6 Setting changes

To change the value of a setting, first navigate the menu to display the relevant cell. To change the cell value press the enter key, which will bring up a flashing cursor on the LCD to indicate that the value can be changed. This will only happen if the appropriate password has been entered, otherwise the prompt to enter a password will appear. The setting value can then be changed by pressing the or keys. If the setting to be changed is a binary value or a text string, the required bit or character to be changed must first be selected using the and keys. When the desired new value has been reached it is confirmed as the new setting value by pressing. Alternatively, the new value will be discarded either if the clear button © is pressed or if the menu time-out occurs.

For protection group settings and disturbance recorder settings, the changes must be confirmed before they are used by the relay. To do this, when all required changes have been entered, return to the column heading level and press the key. Prior to returning to the default display the following prompt will be given:

Update settings? Enter or clear

Pressing will result in the new settings being adopted, pressing © will cause the relay to discard the newly entered values. It should be noted that, the setting values will also be discarded if the menu time out occurs before the setting changes have been confirmed. Control and support settings will be updated immediately after they are entered, without 'Update settings?' prompt.

3.7 Front communication port user interface

The front communication port is provided by a 9-pin female D-type connector located under the bottom hinged cover. It provides EIA(RS)232 serial data communication and is intended for use with a PC locally to the relay (up to 15m distance) as shown in Figure 5. This port supports the Courier communication protocol only. Courier is the communication language developed by ALSTOM Grid SAS to allow communication with its range of protection relays. The front port is particularly designed for use with the relay settings program MiCOM S1 which is a Windows 98/NT based software package.

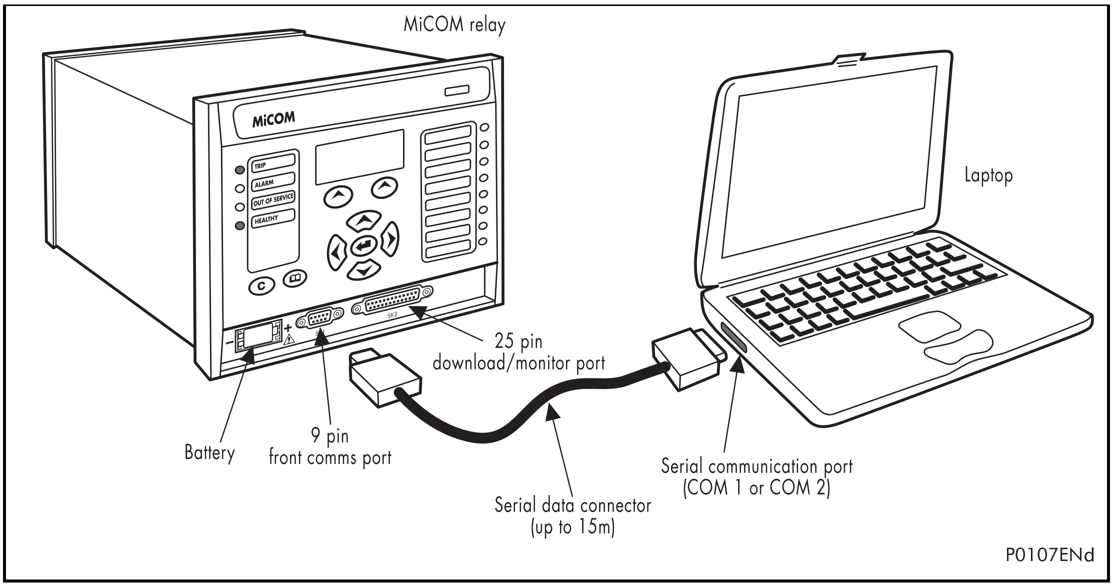


Figure 6: Front port connection

The relay is a Data Communication Equipment (DCE) device. Thus the pin connections of the relay's 9-pin front port are as follows:

Pin no. 2	Tx Transmit data
Pin no. 3	Rx Receive data
Pin no. 5	0V Zero volts common

None of the other pins are connected in the relay. The relay should be connected to the serial port of a PC, usually called COM1 or COM2. PCs are normally Data Terminal Equipment (DTE) devices which have a serial port pin connection as below (if in doubt check your PC manual):

25 Way	9 Way	
Pin no. 3	2	Rx Receive data
Pin no. 2	3	Tx Transmit data
Pin no. 7	5	0V Zero volts common

For successful data communication, the Tx pin on the relay must be connected to the Rx pin on the PC, and the Rx pin on the relay must be connected to the Tx pin on the PC, as shown in Figure 6. Therefore, providing that the PC is a DTE with pin connections as given above, a 'straight through' serial connector is required, i.e. one that connects pin 2 to pin 2, pin 3 to pin 3, and pin 5 to pin 5. Note that a common cause of difficulty with serial data communication is connecting Tx to Tx and Rx to Rx. This could happen if a 'cross-over' serial connector is used, i.e. one that connects pin 2 to pin 3, and pin 3 to pin 2, or if the PC has the same pin configuration as the relay.

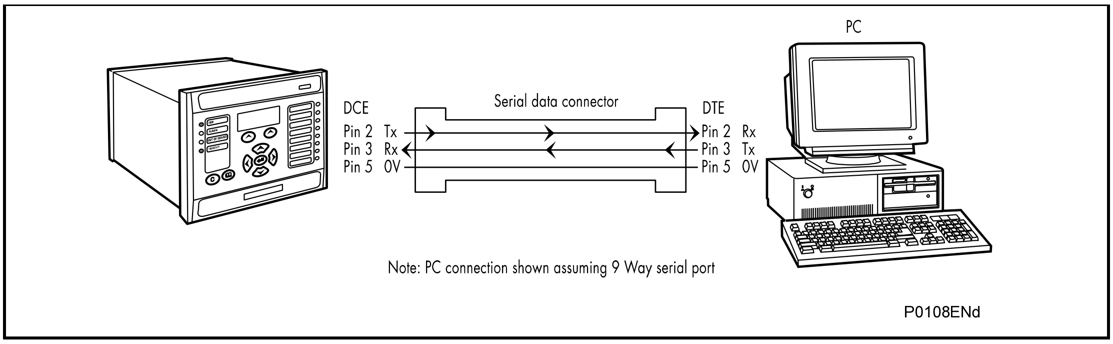


Figure 7: PC – relay signal connection

Having made the physical connection from the relay to the PC, the PC's communication settings must be configured to match those of the relay. The relay's communication settings for the front port are fixed as shown in the table below:

Protocol	Courier
Baud rate	19,200 bits/s
Courier address	1
Message format	11 bit - 1 start bit, 8 data bits, 1 parity bit (even parity), 1 stop bit

The inactivity timer for the front port is set at 15 minutes. This controls how long the relay will maintain its level of password access on the front port. If no messages are received on the front port for 15 minutes then any password access level that has been enabled will be revoked.

3.8 First rear communication port

Rear port 1 (RP1) support one of four communication protocols (Courier, Modbus, DNP3.0, IEC 60870-5-103), the choice of which must be made when the relay is ordered. The rear communication port is provided by a 3-terminal screw connector located on the back of the relay. See Appendix B for details of the connection terminals. The rear port provides K-Bus/EIA(RS)485 serial data communication and is intended for use with a permanently-wired connection to a remote control centre. Of the three connections, two are for the signal connection, and the other is for the earth shield of the cable. When the K-Bus option is selected for the rear port, the two signal connections are not polarity conscious, however for Modbus, IEC 60870-5-103 and DNP3.0 care must be taken to observe the correct polarity.

The protocol provided by the relay is indicated in the relay menu in the 'Communications' column. Using the keypad and LCD, firstly check that the 'Comms settings' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. The first cell down the column shows the communication protocol being used by the rear port.

3.8.1 Courier communication

Courier is the communication language developed by ALSTOM Grid - SAS to allow remote interrogation of its range of protection relays. Courier works on a master/slave basis where the slave units contain information in the form of a database, and respond with information from the database when it is requested by a master unit.

The relay is a slave unit which is designed to be used with a Courier master unit such as MiCOM S1, MiCOM S10, PAS&T or a SCADA system. MiCOM S1 is a Windows NT4.0/98 compatible software package which is specifically designed for setting changes with the relay.

To use the rear port to communicate with a PC-based master station using Courier, a KITZ K-Bus to EIA(RS)232 protocol converter is required. This unit is available from ALSTOM Grid – SAS. A typical connection arrangement is shown in Figure 7. For more detailed information on other possible connection arrangements refer to the manual for the Courier master station software and the manual for the KITZ protocol converter. Each spur of the K-Bus twisted pair wiring can be up to 1000m in length and have up to 32 relays connected to it.

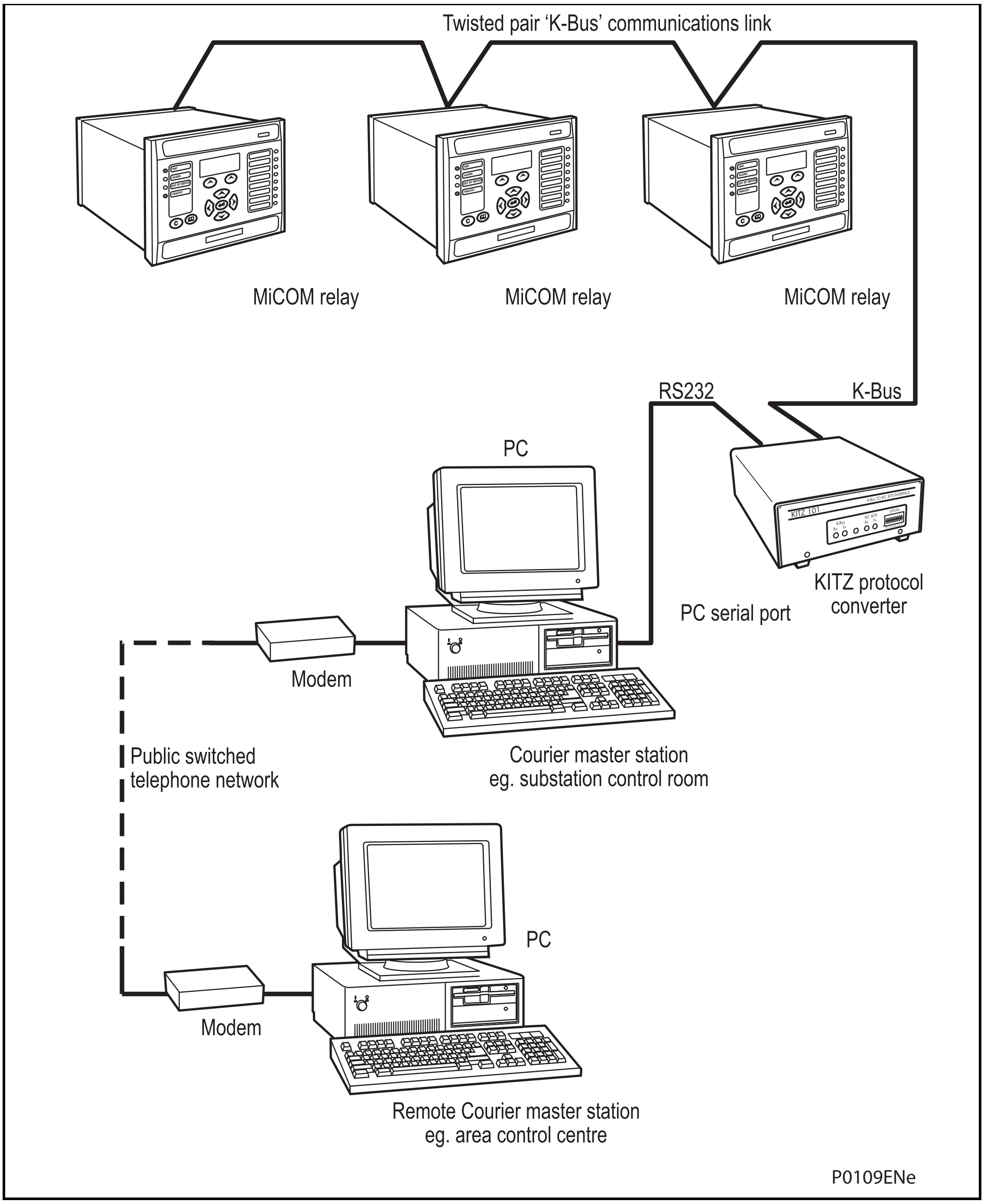


Figure 8: Remote communication connection arrangements

Having made the physical connection to the relay, the relay's communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the 'Comms settings' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. Only two settings apply to the rear port using Courier, the relay's address and the inactivity timer. Synchronous communication is used at a fixed baud rate of 64kbits/s.

Move down the 'Communications' column from the column heading to the first cell down which indicates the communication protocol:

RP1 Protocol Courier

The next cell down the column controls the address of the relay:

RP1 Address 1

Since up to 32 relays can be connected to one K-bus spur, as indicated in Figure 7, it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. Courier uses an integer number between 0 and 254 for the relay address which is set with this cell. It is important that no two relays have the same Courier address. The Courier address is then used by the master station to communicate with the relay.

The next cell down controls the inactivity timer:

RP1 Inactivity timer 10.00 mins

The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

As an alternative to running courier over K-Bus, courier over EIA485 may be selected. The next cell down indicates the status of the hardware, e.g.

RP1 Card Status EIA232 OK

The next cell allows for selection of the port configuration

RP1 Port Config EIA232 (EIA(RS)232)

The port can be configured for EIA485 or K-Bus.

In the case of EIA485 the next cell selects the communication mode.

RP1 Comms Mode IEC60870 FT1.2

The choice is either IEC60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.

In the case of EIA485 the next cell down controls the baud rate. For K-Bus the baud rate is fixed at 64kbit/second between the relay and the KITZ interface at the end of the relay spur.

RP2 Baud Rate 19200

Courier communications is asynchronous. Three baud rates are supported by the relay, ‘9600 bits/s’, ‘19200 bits/s’ and ‘38400 bits/s’,

Note that protection and disturbance recorder settings that are modified using an on-line editor such as PAS&T must be confirmed with a write to the ‘Save changes’ cell of the ‘Configuration’ column. Off-line editors such as MiCOM S1 do not require this action for the setting changes to take effect.

3.8.2 Modbus communication

Modbus is a master/slave communication protocol which can be used for network control. In a similar fashion to Courier, the system works by the master device initiating all actions and the slave devices, (the relays), responding to the master by supplying the requested data or by taking the requested action. Modbus communication is achieved via a twisted pair connection to the rear port and can be used over a distance of 1000m with up to 32 slave devices.

To use the rear port with Modbus communication, the relay’s communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the ‘Comms settings’ cell in the ‘Configuration’ column is set to ‘Visible’, then move to the ‘Communications’ column. Four settings apply to the rear port using Modbus which are described below. Move down the ‘Communications’ column from the column heading to the first cell down which indicates the communication protocol:

RP1 Protocol Modbus

The next cell down controls the Modbus address of the relay:

RP1 Address 23

Up to 32 relays can be connected to one Modbus spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. Modbus uses an integer number between 1 and 247 for the relay address. It is important that no two relays have the same Modbus address. The Modbus address is then used by the master station to communicate with the relay.

The next cell down controls the inactivity timer:

RP1 InactivTimer 10.00 mins

The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

The next cell down the column controls the baud rate to be used:

RP1 Baud rate 9600 bits/s

Modbus communication is asynchronous. Three baud rates are supported by the relay, ‘9600 bits/s’, ‘19200 bits/s’ and ‘38400 bits/s’. It is important that whatever baud rate is selected on the relay is the same as that set on the Modbus master station.

The next cell down controls the parity format used in the data frames:

RP1 Parity None

The parity can be set to be one of ‘None’, ‘Odd’ or ‘Even’. It is important that whatever parity format is selected on the relay is the same as that set on the Modbus master station.

The next cell down controls the format of the Date/Time (software 30 or later)

Modbus IEC Time Standard

The format can be selected to either ‘Standard’ (as per IEC60870-5-4 ‘Binary Time 2a’), the default, or to ‘Reverse’ for compatibility with MICOM product ranges. For further information see P54x/EN CT section 3.8.

3.8.3 IEC 60870-5 CS 103 communication

The IEC specification IEC 60870-5-103: Telecontrol Equipment and Systems, Part 5: Transmission Protocols Section 103 defines the use of standards IEC 60870-5-1 to IEC 60870-5-5 to perform communication with protection equipment. The standard configuration for the IEC 60870-5-103 protocol is to use a twisted pair connection over distances up to 1000m. As an option for IEC 60870-5-103, the rear port can be specified to use a fibre optic connection for direct connection to a master station. The relay operates as a slave in the system, responding to commands from a master station. The method of communication uses standardised messages which are based on the VDEW communication protocol.

To use the rear port with IEC 60870-5-103 communication, the relay’s communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the ‘Comms settings’ cell in the ‘Configuration’ column is set to ‘Visible’, then move to the ‘Communications’ column. Four settings apply to the rear port using IEC 60870-5-103 which are described below. Move down the ‘Communications’ column from the column heading to the first cell which indicates the communication protocol:

RP1 Protocol IEC 60870-5-103

The next cell down controls the IEC 60870-5-103 address of the relay:

RP1 Address 162

Up to 32 relays can be connected to one IEC 60870-5-103 spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. IEC 60870-5-103 uses an integer number between 0 and 254 for the relay address. It is important that no two relays have the same IEC 60870-5-103 address. The IEC 60870-5-103 address is then used by the master station to communicate with the relay.

The next cell down the column controls the baud rate to be used:

RP1 Baud rate 9600 bits/s

IEC 60870-5-103 communication is asynchronous. Two baud rates are supported by the relay, ‘9600 bits/s’ and ‘19200 bits/s’. It is important that whatever baud rate is selected on the relay is the same as that set on the IEC 60870-5-103 master station.

The next cell down controls the period between IEC 60870-5-103 measurements:

RP1 Meas period 30.00 s

The IEC 60870-5-103 protocol allows the relay to supply measurements at regular intervals. The interval between measurements is controlled by this cell, and can be set between 1 and 60 seconds.

The next cell down the column controls the physical media used for the communication:

RP1 Physical link
EIA(RS)485

The default setting is to select the electrical EIA(RS)485 connection. If the optional fibre optic connectors are fitted to the relay, then this setting can be changed to 'Fibre optic'.

3.8.4 DNP 3.0 Communication

The DNP 3.0 protocol is defined and administered by the DNP User Group. Information about the user group, DNP 3.0 in general and protocol specifications can be found on their website: www.dnp.org

The relay operates as a DNP 3.0 slave and supports subset level 2 of the protocol plus some of the features from level 3. DNP 3.0 communication is achieved via a twisted pair connection to the rear port and can be used over a distance of 1000m with up to 32 slave devices.

To use the rear port with DNP 3.0 communication, the relay's communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the 'Comms setting' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. Four settings apply to the rear port using DNP 3.0, which are described below. Move down the 'Communications' column from the column heading to the first cell which indicates the communications protocol:

RP1 Protocol
DNP 3.0

The next cell controls the DNP 3.0 address of the relay:

RP1 Address
232

Upto 32 relays can be connected to one DNP 3.0 spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by only one relay. DNP 3.0 uses a decimal number between 1 and 65519 for the relay address. It is important that no two relays have the same DNP 3.0 address. The DNP 3.0 address is then used by the master station to communicate with the relay.

The next cell down the column controls the baud rate to be used:

RP1 Baud rate
9600 bits/s

DNP 3.0 communication is asynchronous. Six baud rates are supported by the relay '1200bits/s', '2400bits/s', '4800bits/s', '9600bits/s', '19200bits/s' and '38400bits/s'. It is important that whatever baud rate is selected on the relay is the same as that set on the DNP 3.0 master station.

The next cell down the column controls the parity format used in the data frames:

RP1 Parity
None

The parity can be set to be one of 'None', 'Odd' or 'Even'. It is important that whatever parity format is selected on the relay is the same as that set on the DNP 3.0 master station.

The next cell down the column sets the time synchronisation request from the master by the relay:

RP1 Time Sync Enabled

The time synch can be set to either enabled or disabled. If enabled it allows the DNP 3.0 master to synchronise the time.

3.9 Second Rear Communication Port (option)

For relays with Courier, Modbus, IEC60870-5-103 or DNP3 protocol on the first rear communications port there is the hardware option of a second rear communications port, which will run the Courier language. This can be used over one of three physical links: twisted pair K-Bus (non polarity sensitive), twisted pair EIA485 (connection polarity sensitive) or EIA232.

The settings for this port are located immediately below the ones for the first port as described in previous sections of this chapter. Move down the settings until the following sub heading is displayed.

REAR PORT2 (RP2)

The next cell down indicates the language, which is fixed at Courier for RP2.

RP2 Protocol Courier

The next cell down indicates the status of the hardware, e.g.

RP2 Card Status EIA232 OK

The next cell allows for selection of the port configuration

RP2 Port Config EIA232 (EIA(RS)232)

The port can be configured for EIA232, EIA485 or K-Bus.

In the case of EIA232 and EIA485 the next cell selects the communication mode.

RP2 Comms Mode IEC60870 FT1.2

The choice is either IEC60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.

3.10 Ethernet Rear Port (option)

If UCA2.0 is chosen when the relay is ordered, the relay is fitted with an Ethernet interface card.
See P54x/EN UC section 4.4 for more detail of the Ethernet hardware.

APPLICATION NOTES

CONTENTS

1. INTRODUCTION

1.1 Protection of overhead lines and cable circuits

Overhead lines, typically ranging from 10kV distribution lines to 800kV transmission lines, are probably the most fault susceptible items of plant in a modern power system. It is therefore essential that the protection associated with them provides secure and reliable operation.

For distribution systems, continuity of supply is of paramount importance. The majority of faults on overhead lines are transient or semi-permanent in nature. Multi-shot autoreclose cycles are therefore commonly used in conjunction with instantaneous tripping elements to increase system availability. For permanent faults it is essential that only the faulted section of plant is isolated. As such, high speed, discriminative fault clearance is often a fundamental requirement of any protection scheme on a distribution network.

The requirements for a transmission network must also take into account system stability. Where systems are not highly interconnected the use of single phase tripping and high speed autoreclosure is often required. This in turn dictates the need for very high speed protection to reduce overall fault clearance times.

Many line configurations exist which need to be addressed. Transmission applications may typically consist of 2 or 3 terminal applications, possibly fed from breaker and a half or mesh arrangements. Lower voltage applications may again be 2 or 3 terminal configurations with the added complications of in zone transformers or small teed load transformers.

Charging current may also adversely affect protection. This is a problem particularly with cables and long transmission lines. Both the initial inrush and steady state charging current must not cause relay maloperation and preferably should not compromise protection performance.

Physical distance must be taken into account. Some EHV transmission lines can be up to several hundred kilometres in length. If high speed, discriminative protection is to be applied, it will be necessary to transfer information between line ends. This not only puts the onus on the security of signalling equipment but also on the protection in the event of loss of this signal.

Back-up protection is also an important feature of any protection scheme. In the event of equipment failure, such as signalling equipment or switchgear, for example, it is necessary to provide alternative forms of fault clearance. It is desirable to provide back-up protection which can operate with minimum time delay and yet discriminate with both the main protection and protection elsewhere on the system.

1.2 P540 relay

Using the latest numerical technology, MiCOM relays include devices designed for the application to a wide range of power system plant such as motors, generators, busbars, feeders, overhead lines and cables.

Each relay is designed around a common hardware and software platform in order to achieve a high degree of commonality between products. One such product in the range is the P540 relay. The relay has been designed to cater for the protection of a wide range of overhead lines and underground cables from distribution to the highest transmission voltage levels.

The relay also includes a comprehensive range of non-protection features to aid with power system diagnosis and fault analysis.

1.2.1 Protection features

There are 6 separate models available - P541, P542, P543 P544, P545 and P546, to cover a wide range of applications. Each model can be configured to protect 2 or 3 terminal lines. Models for single and three pole tripping (P543/P544/P545/P546) or three pole tripping only (P541/P542) are available. The P545 and P546 are also designed for use within switched networks for example an SDH/SONET ring. The protection features of each model are summarised overleaf:

- Phase current differential protection - Phase segregated biased differential protection provides the main protection element for the relay. Provides high speed, discriminative protection for all fault types.
- Transformer inrush restraint and ratio/vector compensation - Allows the differential elements to be applied on transformer feeders where the transformer forms part of the protected zone, (P541 & P542 only).
- Distance protection - 3 zones of distance protection providing parallel main protection or back-up to the current differential, (P543, P544, P545 & P546).
- Phase fault overcurrent protection - Four stage back-up protection, (elements can be directionalised for P543 P544, P545 & P546).
- Earth Fault Protection - four stage backup protection (elements can be directionalised for P543, P544, P545 & P546).
- Sensitive earth fault protection - four stage directional/non-directional backup protection. Can be configured to provide earth fault protection on arc suppression coil earthed systems, (P543, P544, P545 & P546).
- Thermal protection - 2 stage thermal protection for line/cable/transformer.
- Broken conductor protection - To detect open circuit faults
- Stub bus protection: Applied for 1 & 1/2 switched and mesh corner arrangements, (P544 and P546 only).
- Circuit breaker fail protection - Two stage breaker fail protection
- Autoreclose facility: Integral three phase (P542) or single/three phase (P543 & P545) multi-shot autoreclose.
- Check synchronism facility - To provide a synchronism check function for manual or automatic reclosure of circuit breakers, (P543 & P545).
- Direct/permissive intertrip and control bit transfer - Independent intertripping facility using the relay's protection communications channels, plus 8 inter-relay communications bits for command and status transfer.
- Dual redundant communications - Option for dual communications channels to provide a high degree of security ("hot standby" approach).
- Protection communications supervision - To detect failure of protection communications and enable remedial action to be taken, i.e. switch in communication independent back-up protections
- Voltage transformer supervision - To prevent maloperation of voltage dependent protection elements upon loss of a VT input signal, (P543, P544, P545 and P546).
- Graphical programmable scheme logic (PSL) - Allowing user defined protection and control logic to suit particular customer applications
- Direct interface to IEEE C.37.94 optical multiplexers - (software 30 or later)

1.2.2 Non-protection features

Below is a summary of the P540 relay non-protection features.

- Local/remote measurements - Various measurement values from the local and remote line ends available for display on the relay or accessed from the serial communications.
- Fault/event/disturbance records - Available from the serial communications or on the relay LCD display (fault and event records only).
- Fault locator (P543, P544, P545 and P546).
- Real time clock/time synchronisation - Time synchronisation possible from relay IRIG-B input, or a SCADA command.

- Four setting groups - Independent setting groups to cater for switched feeding or customer specific applications.

- Circuit breaker state monitoring - Provides indication of discrepancy between circuit breaker auxiliary contacts.

- Circuit breaker control - Control of the circuit breaker can be achieved either locally via the user interface or remotely.

- Circuit breaker condition monitoring - Provides records/alarm outputs regarding the number of CB operations, pole by pole cumulative interruption duty, and the breaker operating time, (P541, P542, P543 & P545 only).

- Commissioning test facilities.

- Remote serial communications - To allow remote access to the relays. The following communications protocols are supported: Courier, MODBUS, IEC60870-5, UCA2 (software 20 or later) and DNP3.0.

- Continuous self monitoring - Power on diagnostics and self checking routines to provide maximum relay reliability and availability.

- Time synchronisation via opto input (software 20 or later).

- Choice of pickup/drop-off levels for optical isolators - (software 30 or later)

2. APPLICATION OF INDIVIDUAL PROTECTION FUNCTIONS

The following sections detail the individual protection functions in addition to where and how they may be applied. Each section also gives an extract from the respective menu columns to demonstrate how the settings are actually applied to the relay.

The P540 relays each include a column in the menu called the 'CONFIGURATION' column. As this affects the operation of each of the individual protection functions, it is described in the following section.

2.1 Configuration column

The following table shows the configuration column:-

MENU TEXT	DEFAULT SETTING	AVAILABLE SETTINGS
CONFIGURATION		
Restore Defaults	No Operation	No Operation All Settings Setting Group 1 Setting Group 2 Setting Group 3 Setting Group 4
Setting Group	Select via Menu	Select via Menu Select via Optos
Active Settings	Group 1	Group1 Group 2 Group 3 Group 4
Save Changes	No Operation	No Operation
		Save
		Abort
Copy From	Group 1	Group1, 2, 3 or 4
Copy To	No Operation	No Operation Group1, 2, 3 or 4
Setting Group 1	Enabled	Enabled or Disabled
Setting Group 2	Disabled	Enabled or Disabled
Setting Group 3	Disabled	Enabled or Disabled
Setting Group 4	Disabled	Enabled or Disabled
Phase Diff	Enabled	Enabled or Disabled
Distance	Enabled	Enabled or Disabled
Tripping Mode	3 Pole	3 Pole1 & 3 Pole
Filter Control	Enabled	Enabled or Disabled
Overcurrent	Enabled	Enabled or Disabled
Broken Conductor	Disabled	Enabled or Disabled
Earth Fault	Enabled	Enabled or Disabled
Sensitive E/F	Disabled	Enabled or Disabled
Thermal Overload	Disabled	Enabled or Disabled
CB Fail	Disabled	Enabled or Disabled

MENU TEXT	DEFAULT SETTING	AVAILABLE SETTINGS
CONFIGURATION		
Supervision	Enabled	Enabled or Disabled
Fault Locator	Enabled	Enabled or Disabled
System Checks	Disabled	Enabled or Disabled
Auto-Reclose	Disabled	Enabled or Disabled
Input Labels	Visible	Invisible or Visible
Output Labels	Visible	Invisible or Visible
CT & VT Ratios	Visible	Invisible or Visible
Event Recorder	Invisible	Invisible or Visible
Disturb Recorder	Invisible	Invisible or Visible
Measure't Setup	Invisible	Invisible or Visible
Comms Settings	Visible	Invisible or Visible
Commission Tests	Visible	Invisible or Visible
Setting Values	Primary	Primary or Secondary
Control Inputs	Visible	Invisible or Visible
Ctrl I/P Config (software 20 or later)	Visible	Invisible or Visible
Ctrl I/P Lables (software 20 or later)	Visible	Invisible or Visible
Direct Access (software 20 or later)	Visible	Disabled/Enabled
LCD Contrast (software 20 or later)	11	0-31

Table 1.

The aim of the Configuration column is to allow general configuration of the relay from a single point in the menu. Any of the functions that are disabled or made invisible from this column do not then appear within the main relay menu.

2.2 Phase current differential protection

The primary protection element of the P540 relays is phase segregated current differential protection. This technique involves the comparison of the currents at each line terminal. A communications path is therefore an essential requirement of any such scheme. The P540 relays utilise a 56/64 Kbits/s digital communications system either for direct optical connection between ends, or via a multiplexed link.

2.2.1 Differential protection configuration

Following is a copy of the 'I DIFF CONFIG' column on the relay menu. All configuration settings relating to the differential protection within the relay can be found in this column.

I DIFF CONFIG	Default Setting	Min	Max	Step
Scheme Set-up	2 Terminal	3 Terminal, 2 Terminal, Dual Redundant		
Address	0-0	0-0, 1-A, 2-A, 3-A, 4-A, …….. 20-A 1-B, 2-B, 3-B, 4-B, 5-B, ……..20-B 1-C, 2-C, 3-C, 4-C, 5-C, ……..20-C		
Baud Rate Ch1	64kbits/s	56kbits/s, 64kbits/s		

I DIFF CONFIG	Default Setting	Min	Max	Step
Clock Source Ch1	Internal	Internal, External		
Clock Source Ch2	Internal	{Where Multiplexer has its own clock set External, otherwise set to Internal}		
Comm Delay Tol (See 0)	0.00025s	0.00025s	0.001s	0.00005s
Comm Fail Timer	10s	0.1s	10s	0.1s
Comm Fail Mode	Channel 1+2	Channel 1, Channel 2, Channel1+2		
Char Mod Time (See 0)	0.5s	0s	0.5s	0.0001s
I Cap Correction (See 2.2.4)	Disabled	Enabled, Disabled		
Susceptance (See 2.2.4)	10nmho*In	10nmho*In	10mho*In	10nmho*In
Inrush Restraint	Disabled	Enabled, Disabled		
Vectorial Comp	Yy0	Yy0, Yd1, Ydy2, Yd3, Ydy4, Yd5, Yy6, Yd7, Ydy8, Yd9, Ydy10, Yd11, Ydy0, Ydy6		
Ph CT Correction	1	1	8	0.01
Re-Configuration	Three Ended	Three Ended, Two Ended (L&R1), Two Ended (L&R2), Two Ended (R1&R2)		
GPS Sync (see 2.2.3.2)	Disabled	Enabled/Disabled		
Baud Rate Ch2	64kbit/s	56kbit/s, 64kbits		
Comms Mode (software 30 or later)	Standard	Standard, IEEE C37.94		
Ch1 N*64kbits/s (software 30 or later)	1	Auto, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12		
Ch2 N*64kbits/s (software 30 or later)	1	Auto, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12		

Table 2. Menu configuration column

2.2.2 Phase differential characteristics

The basic operating principle of differential protection is to calculate the difference between the currents entering and leaving a protected zone. The protection operates when this difference exceeds a set threshold.

Differential currents may also be generated during external fault conditions due to CT saturation. To provide stability for through fault conditions, the relay adopts a biasing technique. This method effectively raises the setting of the relay in proportion to the value of through fault current to prevent relay maloperation. Figure 1 shows the operating characteristics of the P540 phase differential element.

The differential current is calculated as the vector summation of the currents entering the protected zone. The bias current is the average of the measured current at each line end. It is found by the scalar sum of the current at each terminal, divided by two.

Each of these calculations is done on a phase by phase basis. The level of bias used for each element is the highest of the three calculated for optimum stability.

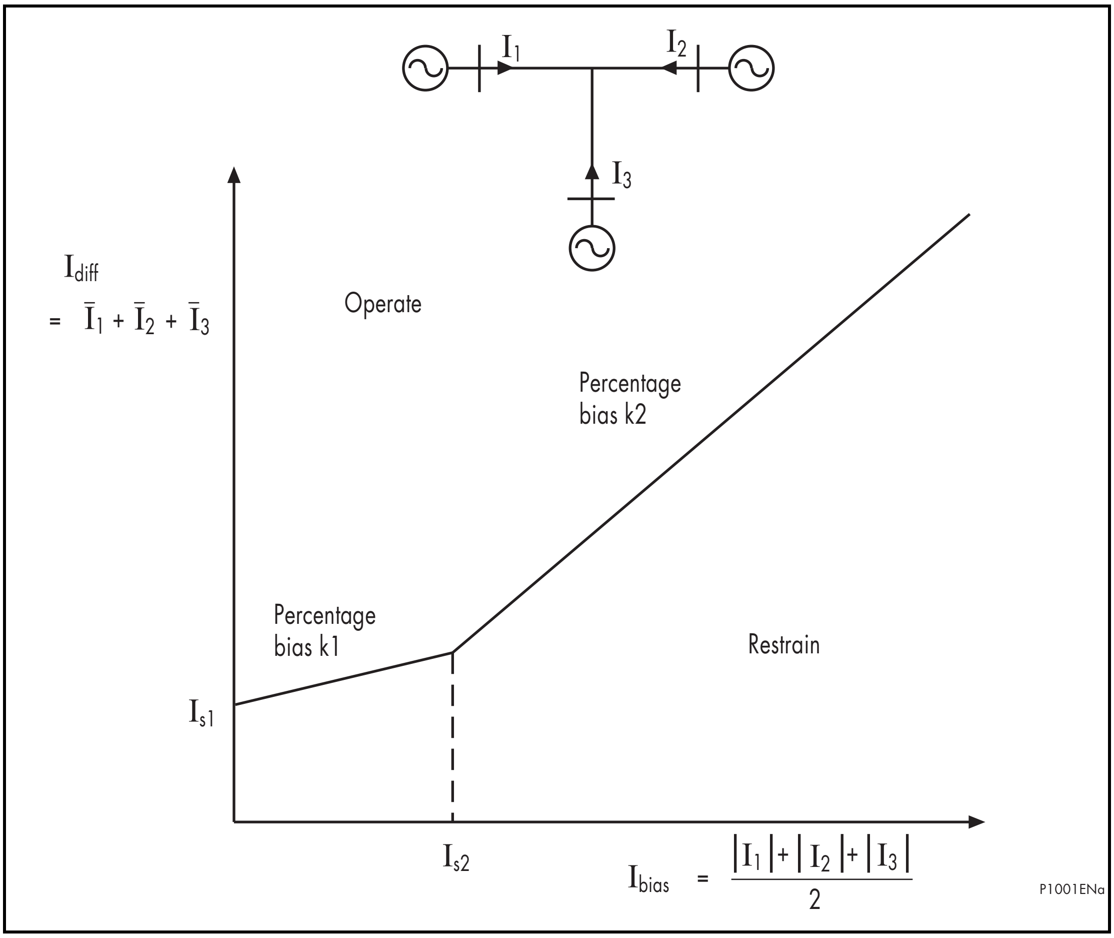


Figure 1: Relay bias characteristic

The characteristic is determined by four protection settings:

Is1	The basic differential current setting which determines the minimum pick-up level of the relay.
k1	The lower percentage bias setting used when the bias current is below Is2. This provides stability for small CT mismatches, whilst ensuring good sensitivity to resistive faults under heavy load conditions.
Is2	A bias current threshold setting, above which the higher percentage bias k2 is used.
k2	The higher percentage bias setting used to improve relay stability under heavy through fault current conditions.

The tripping criteria can be formulated as:

1. for |Ibias| < Is2,

   |Idiff| > k1.| Ibias| + Is1

2. for |Ibias| > Is2,

   |Idiff| > k2.| Ibias| - (k2 - k1). Is2 + Is1

When a trip is issued by the differential element, in addition to tripping the local breaker, the relay will send a differential intertrip signal to the remote terminals. This will ensure tripping of all ends of the protected line, even for marginal fault conditions.

The differential protection can be time delayed using either a definite or inverse time characteristic. The table below details the settings available for the Phase Differential protection element.

PHASE DIFF	Default Setting	Min	Max	Step
Phase Is1	0.2In	0.2In	2In	0.5In
Phase Is2	2In	1In	30In	0.05In
Phase k1	30%	30%	150%	5%
Phase k2	150%	30%	150%	5%
Phase Char (see 2.6 for characteristic data)	DT	DT, IEC S Inverse, IEC V Inverse, IEC E Inverse, UK LT Inverse, IEEE M Inverse, IEEE V Inverse, IEEE E Inverse, US Inverse US ST Inverse		
Phase Time Delay	0	0s	100s	0.01s
Phase TMS	1	0.025	1.2	0.025
Phase Time Dial (Software 30 and later)	1	0.1	100	0.05
Phase Time Dial	7	0.5	15	0.1
PIT Time	0.2s	0s	0.2s	0.005s
Inrush High	4In	4In	32In	0.01In

Table 3. Menu phase differential column

The Id High Set element is an unrestrained element designed to provide high speed operation in the event of CT saturation. Where transformer inrush restraint is used, the resultant second harmonic current produced from CT saturation may cause slow relay operation. The high set element will be automatically enabled when inrush restraint is enabled, otherwise it is not operational. The high set element should be set in excess of 40% of the peak magnetising inrush level.

2.2.3 Time alignment of current vectors

2.2.3.1 Time alignment of current vectors without GPS input (Traditional Technique)

This section relates to P541, P542, P543 & P544 and also to P545 & P546 when the GPS synchronisation is not used.

To calculate differential current between line ends it is necessary that the current samples from each end are taken at the same moment in time. This can be achieved by time synchronising the sampling, or alternatively, by the continuous calculation of the propagation delay between line ends. The P540 range of relays has adopted this second technique.

Consider a two-ended system as shown in Figure 2.

Two identical relays, A and B are placed at the two ends of the line. Relay A samples its current signals at time tA1, tA2 etc., and relay B at time tB1, tB2 etc. Note that the sampling instants at the two ends will not, in general, be coincidental or of a fixed relationship, due to slight drifts in sampling frequencies.

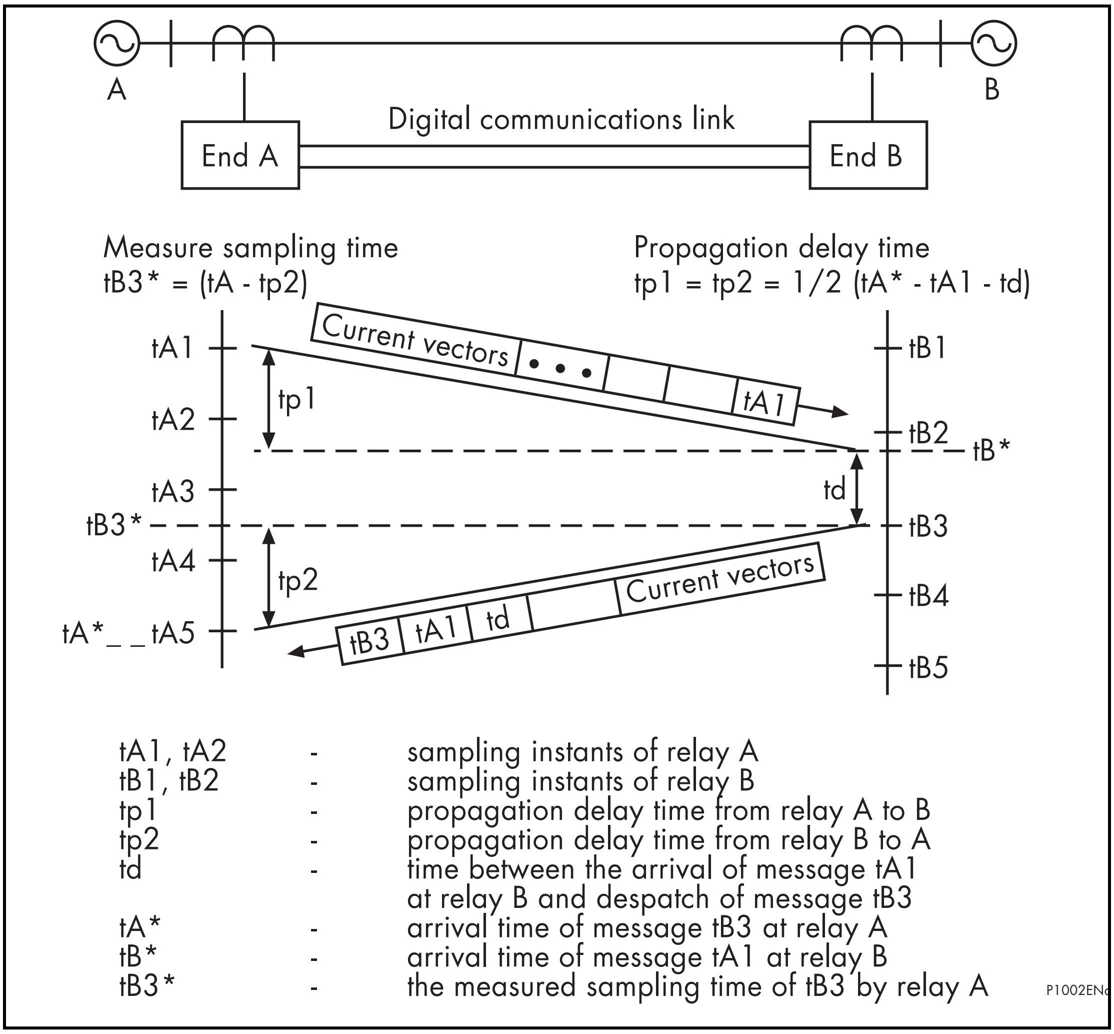


Figure 2: Propagation delay measurement

Assume that at time tA1, relay A sends a data message to relay B. The message contains a time tag, tA1, together with other timing and status information and the current vector values calculated at tA1. The message arrives at end B after a channel propagation delay time, tp1. Relay B registers the arrival time of the message as tB*.

Since relays A and B are identical, relay B also sends out data messages to end A. Assume relay B sends out a data message at tB3. The message therefore contains the time tag tB3. It also returns the last received time tag from relay A (i.e. tA1) and the delay time, td, between the arrival time of the received message, tB*, and the sampling time, tB3, i.e. td = (tB3 - tB*).

The message arrives at end A after a channel propagation delay time, tp2. It’s arrival time is registered by relay A as tA*. From the returned time tag, tA1, relay A can measure the total elapsed time as (tA* - tA1). This equals the sum of the propagation delay times tp1, tp2 and the delay time td at end B.

Hence,

(tA* - tA1) = (td + tp1 + tp2)

The relay assumes that the transmit and receive channels follow the same path and so have the same propagation delay time. This time can therefore be calculated as:

tp1 = tp2 = ½(tA* - tA1 - td)

Note that the propagation delay time is measured for each received sample and this can be used to monitor any change on the communication link.

As the propagation delay time has now been deduced, the sampling instant of the received data from relay B (tB3*) can be calculated. As shown in Figure 2, the sampling time tB3* is measured by relay A as:

tB3* = (tA* - tp2)

In Figure 2, tB3* is between tA3 and tA4. To calculate the differential and bias currents, the vector samples at each line end must correspond to the same point in time. It is necessary therefore to time align the received tB3* data to tA3 and tA4. This can be achieved by rotating the received current vector by an angle corresponding to the time difference between tB3* and tA3 (and tA4). For example a time difference of 1ms would require a vector rotation of $^{1}/_{20}$ * 360° = 18° for a 50Hz system.

As two data samples can be compared with each data message, the process needs to be done only once every two samples, thus reducing the communication bandwidth required. Note that the current vectors of the three phases need to be time aligned separately.

2.2.3.2 Time Alignment of Current Vectors with GPS input P545 & P546

The effect of the deployment of switched SDH (Synchronous Digital Hierarchy) networks on telecommunications circuits used in the application of numerical current differential protection to transmission lines.

Such telecommunications networks can be deployed in flexible, self-healing topologies. Typically, ring network topologies are employed and these are characterised by the ability to self-heal in the event of a failure of an interconnection channel.

Consider a simple ring topology with 6 nodes, A – F, and consider two equipment situated at nodes B and C. Under healthy conditions equipment at B communicates with equipment at C directly between nodes B and C and equipment at C communicates with equipment at B directly between nodes C and B. In this condition the communications propagation time between nodes B and C will be the same as that between nodes C and B and so the traditional technique described in could be used to apply numerical current differential protection (see figure 3).

If the link fails in one direction, say between the transmitter at node B and the receiver at node C, the self-healing ring can continue to transfer signals from node B to node C via the standby route through nodes B, A, F, E, D and then C (obviously a longer path). In this case the communication propagation delay times between nodes B and C differ in the two directions, and if the difference is greater than 1ms the traditional time alignment technique described in section 2.2.3.1 is no longer adequate.

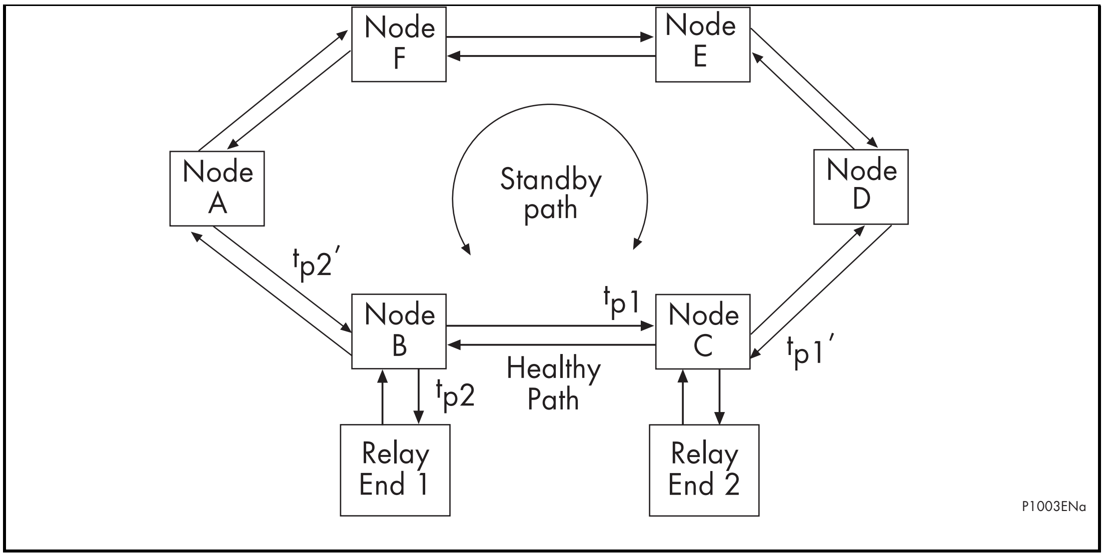


Figure 3: Example of switched Synchronous Digital Hierarchy

P545 & P546 make use of the timing information available from the GPS system to overcome the limitation of the traditional technique, and thus allow application to communications that can provide a permanent or semi-permanent split path routing.

A 1 pulse per second output from a GPS receiver is used to ensure that the re-sampling of the currents at each relay occurs at the same instant in time. The technique is thus not dependant on equal transmit and receive propagation delay times; changes in one or both of the propagation delay times also do not cause problems. These factors make it suitable for use with switched SDH networks.

The GPS technique is taken further, however, to overcome concerns about the reliability of the GPS system. Consider a similar two ended system to that of Figure 1 where the re-sampling instants (tAn, tBn) are synchronised using the GPS timing information. Here the re-sampling instants at the two ends will be coincidental as shown in Figure 4. Note that Figure 4 demonstrates a case where the communications path propagation delay times are not the same.

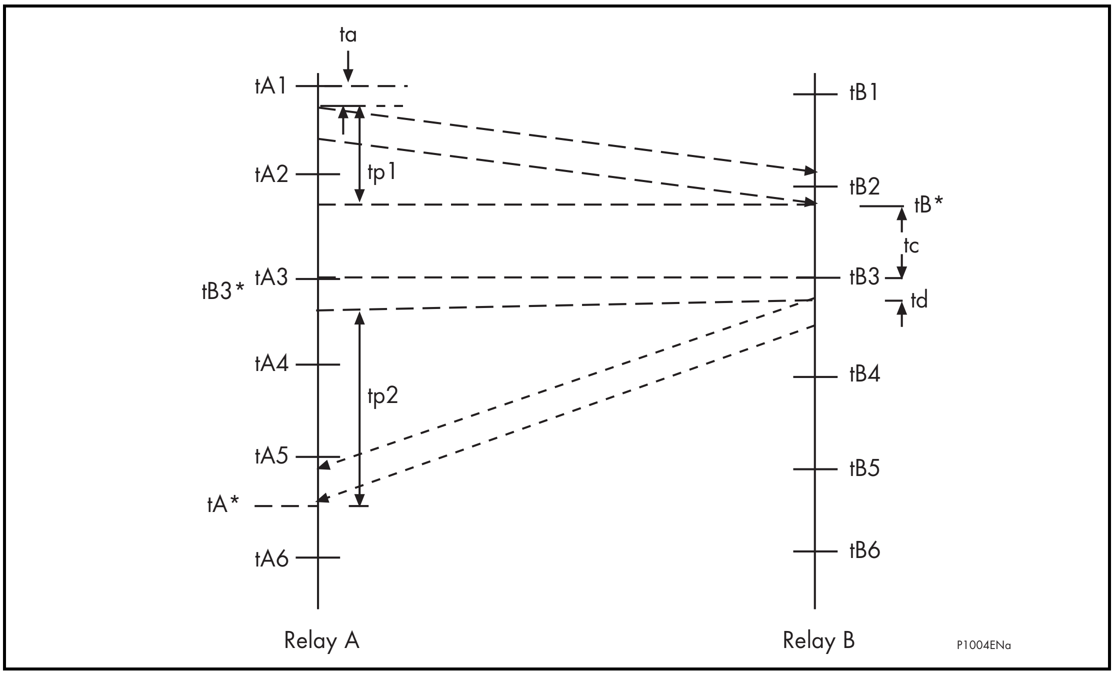


Figure 4: Data Transmission

Note : Relay A can measure the total elapsed time = (tA* - tA1). This equals the sum of the propagation delay times tp1 and tp2, the delay in sending out the initial message ta, and the delay time tc+td at end B. Hence

tp1 + tp2 = tA* - tA1 - ta - tc - td

However, because of the GPS synchronisation of the re-sampling instants, tA3 is at the same instant as tB3 (therefore tB3* = tA3) we can use this knowledge to calculate the receive path delay

tp2= tA* - tA3 – td

And, by the same process the relay can also calculate tp1.

In the event of the GPS synchronising signal becoming unavailable, the synchronisation of the re-sampling instants at the different ends will be lost and the sampling will become asynchronous as in the existing P540 relay design. However, time alignment of the current data can still be performed, by measuring the total elapsed time (as per the traditional measurement technique in 2.2.3.1) and using the memorised value of tp2 prior to the GPS outage. If the overall propagation delay sum of tp1 + tp2 has not changed significantly since the GPS synchronising signal became unavailable, then the communication path has not been switched and tp2 remains valid. This patented “fallback” strategy ensures protection continuity even in the event of antenna vandalism, maintenance error, extremely adverse atmospheric conditions etc – all of which could result in GPS outage. Note that tp1 and tp2 do not need to be equal for the fallback strategy to become operational.

2.2.4 Capacitive charging current

The charging current of a line or cable will be seen as differential current. If this current is of a sufficiently high magnitude, as is the case for cables and long feeders, then relay maloperation could occur. Two issues are apparent with charging current; the first being inrush during line energisation and the second being steady state charging current.

Inrush charging current is predominately high order harmonics (9th and 11th for example). The Fourier filtering used by the P540 relays will remove these frequency components and hence provide stability.

Steady state charging current is nominally at fundamental frequency and hence may cause relay maloperation.

To overcome this problem the P540 relays include a feature to extract the charging current from the measured current before the differential quantity is calculated. This feature requires a voltage input and as such is only available on the P543, P544, P545 and P546 relays.

The table below shows some typical steady state charging currents for various lines and cables.

Voltage (kV)	Core formation and spacing	Conductor size in mm2	Charging current A/km
11 kV Cable	Three-core	120	1.2
33 kV Cable	Three-core	120	1.8
33 kV Cable	Close-trefoil	300	2.5
66 kV Cable	Flat, 127mm	630	10
132 kV Overhead Line	-	175	0.22
132 kV Overhead Line	-	400	0.44
132 kV Cable	Three-core	500	10
132 kV Cable	Flat, 520mm	600	20
275 kV Overhead Line	-	2 x 175	0.58
275 kV Overhead Line	-	2 x 400	0.58
275 kV Cable	Flat, 205mm	1150	19
275 kV Cable	Flat, 260mm	2000	24
400 kV Overhead Line	-	2 x 400	0.85
400 kV Overhead Line	-	4 x 400	0.98
400 kV Cable	Flat, 145mm	2000	28
400 kV Cable	Tref., 585mm	3000	33

Table 4. Typical cable/line charging currents (UK, 50Hz)

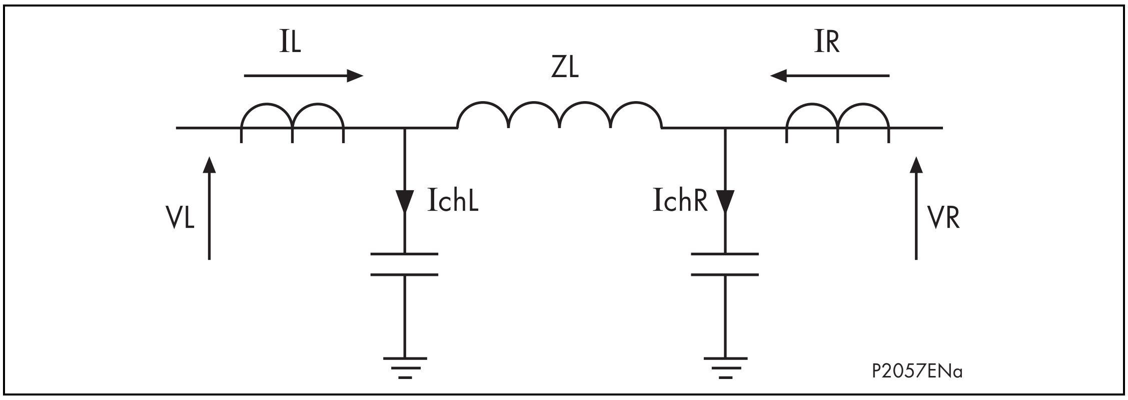


Figure 5: Capacitive charging current

I_L	=	Local end line current
I_r	=	Remote end line current
V_L	=	Local end voltage
V_R	=	Remote end voltage
Z_L	=	Line impedance
I_{chL}	=	Local end charging current
I_{chR}	=	Remote end charging current

By considering Figure 5 it is evident that the line charging current at a particular location is equal to the voltage at that location multiplied by the line positive sequence susceptance. It is therefore possible for the relays at each line end to calculate the respective line charging currents and compensate accordingly.

The differential current (Id) can be calculated as follows:

$$I_d = I_L + I_R - (jV_L B_S /2) - (jV_R B_S /2)$$

$$I_d = \{I_L - (jV_L B_S /2)\} + \{I_R - (jV_R B_S /2)\}$$

$$I_d = \text{Local relay current} + \text{remote relay current}$$

Where B_S is the line positive sequence susceptance.

This feature can be selectively enabled or disabled. If selected, the normal phase current data in the protection message is replaced by $\{I - (jVB_S/2)\}$.

When applying a three end scheme with ends local (L), remote 1 (R_1) and remote 2 (R_2), the differential current is calculated as follows:

$$I_d = I_L + I_{R_1} + I_{R_2} - (jV_L B_s/3) - (jV_{R_1} B_s/3) - (jV_{R_2} B_s/3)$$

$$I_d = \{I_L - (jV_L B_s/3) \} + \{I_{R_1} - (jV_{R_1} B_s/3) \}+ \{I_{R_2} - (jV_{R_2} B_s/3) \}$$

$$I_d = \text{Local relay current} + \text{remote 1 relay current} + \text{remote 2 relay current}$$

Where B_s is the total teed line positive sequence susceptance

i.e. $B_s = B_s$ from L-Tee + Bs from R_1 – Tee + B_s from R_2 - Tee

The display of currents in the 'Measurements 3' column will be affected by this feature when selected.

Where the P541 and P542 relays are used, or where this feature is disabled, it must be ensured that the base current setting on the relay (Is1) is set to at least 2.5x the line steady state charging current to avoid possible maloperation.

2.2.5 Protection of transformer feeders

In applying the well established principles of differential protection to transformers, a variety of considerations have to be taken into account. These include compensation for any phase shift across the transformer, possible unbalance of signals from current transformers either side of windings, and the effects of the variety of earthing and winding arrangements. In addition to these factors, which can be compensated for by correct application of the relay, the effects of normal system conditions on relay operation must also be considered. The differential element must restrain for system conditions which could result in maloperation of the relay, such as high levels of magnetising current during inrush conditions.

In traditional transformer feeder differential schemes, the requirements for phase and ratio correction were met by correct selection of line current transformers. Within the P541 and P542, software interposing CTs (ICTs) are provided which can give the required compensation. The advantage of having replica interposing CTs is that it gives the P540 relays the flexibility to cater for line CTs connected in either star or delta, as well as being able to compensate for a variety of system earthing arrangements. The P541 and P542 relays also include a magnetising inrush restraint facility.

Note that the P543, P544, P545 and P546 relays do not include any of the above features, except CT ratio mismatch compensation, and as such would not be suitable for the protection of in-zone transformer feeders.

2.2.5.1 Transformer magnetising inrush and High set differential setting

The magnetising inrush current to a transformer appears as a large operating signal to the differential protection. Special measures are taken with the relay design to ensure that no maloperation occurs during inrush.

Figure 6 shows a transformer magnetising characteristic. To minimise material costs, weight and size, transformers are generally operated near to the 'knee point' of the magnetising characteristic. Consequently, only a small increase in core flux above normal operating levels will result in a high magnetising current.

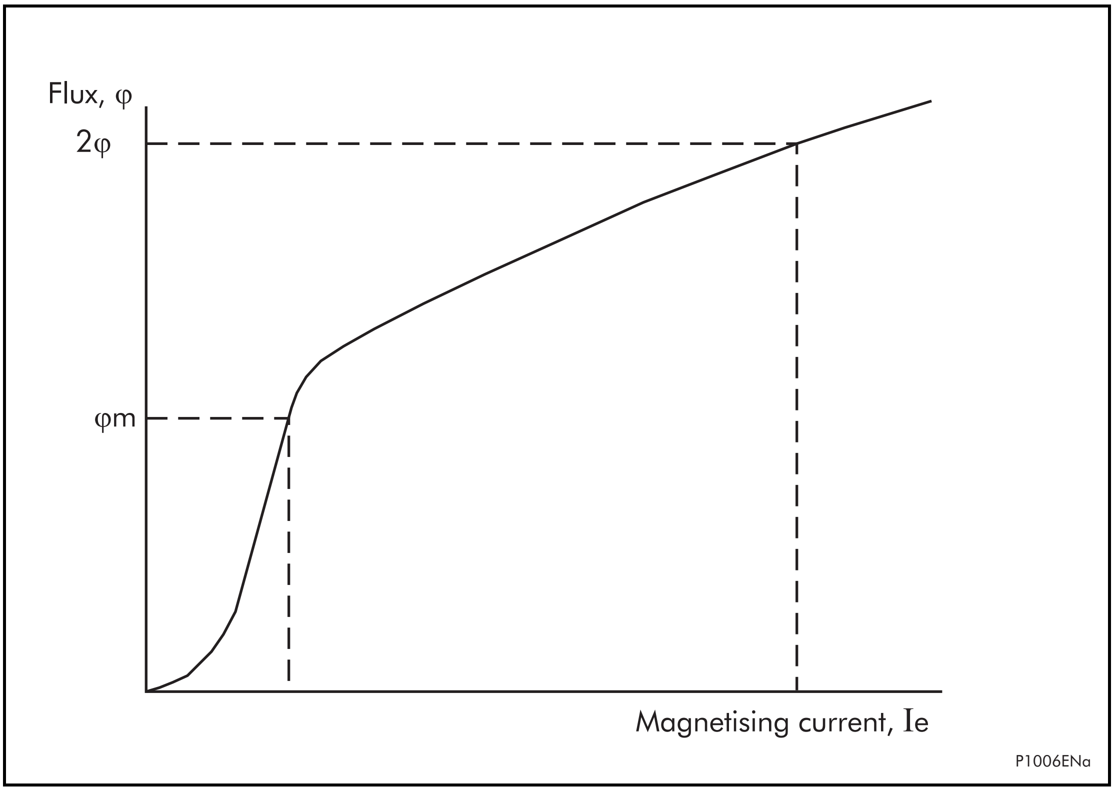


Figure 6: Transformer magnetising characteristic

Under normal steady state conditions, the magnetising current associated with the operating flux level is relatively small (usually less than 1% of rated current). However, if a transformer winding is energised at a voltage zero, with no remnant flux, the flux level during the first voltage cycle (2 x normal max. flux) will result in core saturation and in a high, non-sinusoidal magnetising current waveform. This current is commonly referred to as magnetising inrush current and may persist for several cycles. The magnitude and duration of magnetising inrush current waveforms are dependent upon a number of factors, such as transformer design, size, system fault level, point on wave of switching, number of banked transformers, etc. Figure 7 shows typical transformer magnetising currents for steady state and inrush conditions.

The magnetising inrush current contains a high percentage of second harmonic. The P541 and P542 relays filter out this component of the waveform and use it as an additional bias quantity. The total bias used by the relay will therefore be a combination of the average load current on the line plus a multiple of the second harmonic component of the current. The multiplying factor is used to ensure stability and is a factory pre-set value.

Where P541 and P542 relays are used and inrush restrain function is enable, it must be ensure that this function is enabled at each end to avoid possible maloperation.

High set differential setting:

When inrush restrain is enabled, a high set differential protection becomes active. This unrestrained instantaneous ' Id High Set ' is provided to ensure rapid clearance for heavy internal faults with saturated CTs. The high set is not restrained by magnetising inrush, hence the setting must be set such that it will not operate for the largest inrush currents expected. It is difficult to accurately predict the maximum anticipated level of inrush current. Typical waveforms peak values are of the order of 8-10x rated current. A worst case estimation of inrush could me made by dividing the transformer full load current by the per unit leakage reactance quoted by the transformer manufacturer. A setting range 4In -32In (RMS values) is provided on P541 and P542 relays

2.2.5.2 Ratio correction (all models)

To ensure correct operation of the differential element, it is important that under load and through fault conditions, the currents into the differential element of the relay balance. In many cases, the HV and LV current transformer primary ratings will not exactly match the transformer winding rated currents. Ratio correction factors are therefore provided. The CT ratio correction factors are applied to ensure that the signals to the differential algorithm are correct. A ratio correction factor is provided which is adjustable from 1 to 8 in steps of 0.01.

To minimise unbalance due to tap changer operation, current inputs to the differential element should be matched for the mid-tap position.

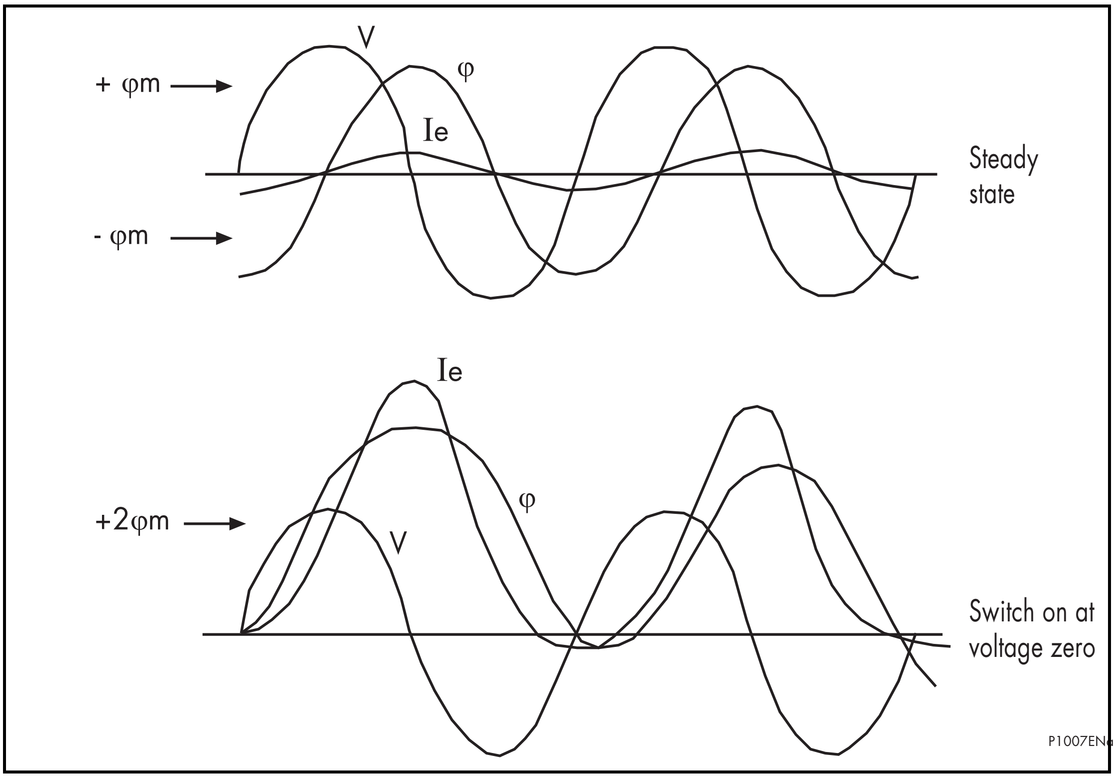


Figure 7: Magnetising inrush waveforms

Ideally, the compensated current values should be arranged to be as close as possible to relay rated current to provide optimum relay sensitivity. The corrected currents should not, however, be arranged to exceed relay rated current under through load conditions.

2.2.5.3 Phase correction and zero sequence current filtering

To compensate for any phase shift between two windings of a transformer, it is necessary to provide phase correction. This was traditionally provided by the appropriate delta connection of main line CTs.

Phase correction is provided in the P540 relays via software interposing CTs. The phase correction settings available with P540 relays are given in Table 2.

In addition to compensating for the phase shift of the protected transformer, it is also necessary to mimic the distribution of primary zero sequence current in the protection scheme.

Figure 8 shows the need for zero sequence current filtering for differential protection across a transformer. The power transformer delta winding acts as a ‘trap’ to zero sequence current. This current is therefore only seen on the star connection side of the transformer and hence as differential current.

The filtering of zero sequence current has traditionally been provided by appropriate delta connection of main line CT secondary windings. In the P540 relays, zero sequence current filtering is automatically implemented in software when a delta connection is set for a software interposing CT. Where a transformer winding can pass zero sequence current to an external earth fault, it is essential that some form of zero sequence current filtering is employed. This would also be applicable where in zone earthing transformers are used.

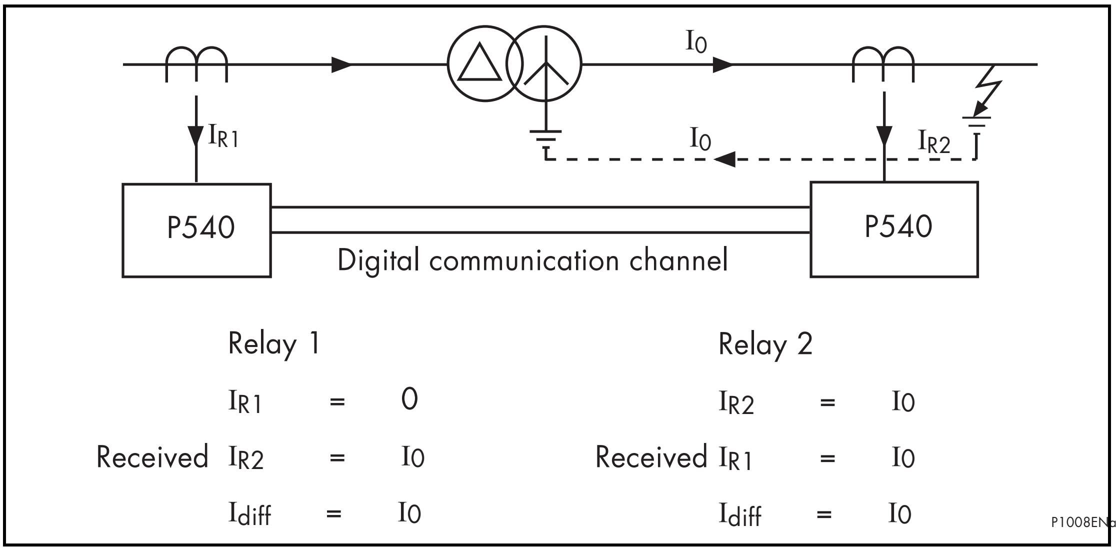


Figure 8: Need for zero-sequence current filtering

Some examples of selection of phase compensation factors are shown in the table 5

Transformer Connection	Transformer Phase Shift	Vectorial Compensation (Relay setting)	
		HV	LV
Dy1	- 30°	Yy0 (0 deg)	Yd11 (+30 deg)
Yd1	- 30°	Yd1 (-30 deg)	Yy0 (0 deg)
Dy5	- 150°	Yy0 (0 deg)	Yd7 (+150 deg)
Yd5	- 150°	Yd5 (-150 deg)	Yy0 (0 deg)
Dy7	+ 150°	Yy0 (0 deg)	Yd5 (-150 deg)
Yd7	+ 150°	Yd7 (+150 deg)	Yy0 (0 deg)
Dy11	+ 30°	Yy0 (0 deg)	Yd1 (-30 deg)
Yd11	+ 30°	Yd11 (+30 deg)	Yy0 (0 deg)

Table 5. Examples of selection of phase compensation factors

2.2.6 3 to 2 terminal reconfiguration

The P540 relays can be configured for the protection of two or three terminal lines. This allows any of the relays to be applied to a two-ended line which may be converted to a three terminal line at a later date. Since only the ‘configuration’ setting needs to be changed to configure the relay for two or three terminal operation, no hardware changes are required when the third terminal is added, provided that 2 channels of fibre optics are already fitted.

For operational reasons, it may be necessary, under certain circumstances, to switch out one line end and its associated relay on a three terminal circuit. By altering the 'Reconfiguration' setting at any end of the line, an operator can command any pair of relays to work as a two terminal system. The 'configured out' relay can then be switched off, leaving the line to be protected by the other two relays. A restore command can be issued to reconfigure the system back to three terminal operation.

Four reconfiguration settings are available:

- Three ended
- Two ended local and remote 1 (L & R1)
- Two ended local and remote 2 (L & R2)
- Two ended remote 1 and remote 2 (R1 & R2)

Before a configuration command can be successfully initiated, it is necessary to energise the 'reconfiguration interlock' and 'Inhibit Current Differential' opto isolated inputs. The latter input will disable tripping via the current differential elements from all three relays to ensure that the scheme will remain stable during reconfiguration.

It must be ensured that the line end to be 'configured out' is open before issuing a reconfiguration command. If this is not done, any current flowing in or out of the 'configured out' end will be seen as fault current and may cause the other relays to operate.

If the new configuration setting issued to the local relay is L & R1 or L & R2, the trip outputs of the two '2-ended' relays will remain inhibited by the 'Inhibit Current Differential' input at the local relay. The 'inhibit trip/alarm outputs' opto should be de-energised to enable the trip outputs reconfigured scheme. If the new configuration setting is R1 & R2, the output contacts of the two remote relays will not be inhibited as they will ignore all commands from the local relay.

The scheme may be restored to a three terminal configuration by selecting 'three ended' at any terminal. This will occur irrespective of the status of the opto inputs but is subject to a healthy communications channel being detected.

2.2.7 Mesh corner and 1½ breaker switched substations

Where a line is fed from a mesh corner or 1½ breaker switched substation, as shown in Figure 9, then two options are available for CT connections to the relay. The first is by parallelling the two sets of line CTs into a common input, 'A'. The second is by using two separate inputs for each set of line CTs, 'B'. The P544 and P546 relays are designed with an additional set of input CTs specifically for this purpose.

In the case of a through fault as shown, the relay connected to circuit 'A' should see no current and as such, will remain stable. Under this condition, it should be noted that no bias is produced in the relay. To ensure relay stability, the two sets of line CTs should be as near as identical in all characteristics, and equally loaded, such that the relaying connection is at the equipotential point of the secondary leads.

In the case of circuit 'B' no differential current should result. A large bias current will however exist, providing a high degree of stability in the event of a through fault. This bias will also ensure stability where CTs are not closely matched. Thus, circuit 'B' is the preferred connection for such applications and so the P544 and P546 relay models would normally be specified.

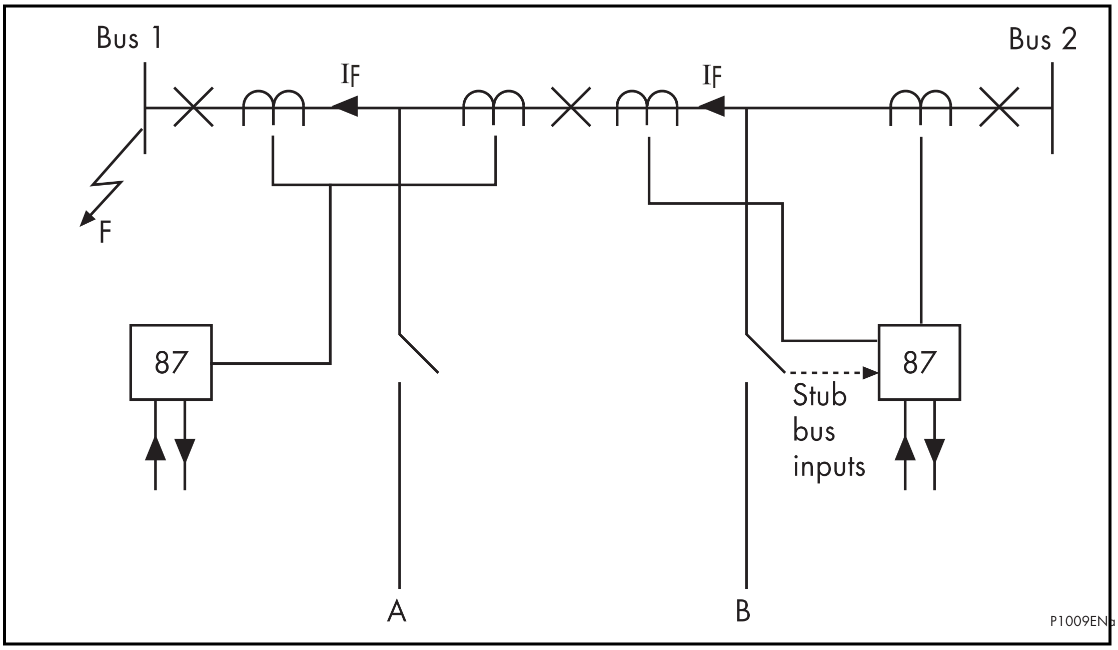


Figure 9: Breaker and a half switched substation

2.2.8 Stub bus protection

The P544 and P546 relays include a facility to provide stub bus protection. When the line isolator is open, an auxiliary contact from the isolator can energise an input on the relay to enable this protection. When enabled, all current values transmitted to the remote relays, and all those received from remote relays, are set to zero. The protection will now provide differential protection for the stub zone.

For an internal fault the relay will operate, tripping the two local circuit breakers. When in stub bus mode, the relay will not send a differential intertrip signal.

2.2.9 Small Tapped Loads (Tee Feeds)

Where transformer loads are tapped off the protected line it is not always necessary to install CTs at this location. Provided that the tee-off load is light, differential protection can be configured for the main line alone. The settings 'Phase Char', 'Phase Time Delay' and 'TMS' or 'Time Dial' in table 3 allow the differential element to time grade with IDMT overcurrent relays or fuses protecting the tap. This keeps stability of the differential protection for external faults on the tee circuit.

2.2.10 Additional protection considerations

2.2.10.1 The minimum operating current

It should be noted that the minimum operating current is related, but not equal to, the Is1 setting.

Consider a single end fed fault with no load but fault current, I:-

$|I_{diff}| = I$

$|I_{bias}| = ½I$

Assuming $|I_{bias}| < I_{s2}$, then, using the equations from section 2.1, the relay will operate if:-

$|I_{diff}| > k1.|I_{bias}| + I_{s1}$ or

$I > k1.½I + I_{s1}$ or

$I > I_{s1} / (1 - 0.5\ k1)$

The minimum operating current is therefore a function of the Is1 and k1 settings. Since k1 is recommended to be set to 30%, the minimum operating current will be:-

$I_{min} = 1.176\ I_{s1}$

For most applications a minimum setting of 0.2 pu is recommended. This will give the relay a sensitivity of 0.235 pu.

2.2.10.2 Relay sensitivity under heavy load conditions

The sensitivity of the relay is governed by its settings and also the magnitude of load current in the system. For a three-ended system, with relays X, Y and Z, the following applies:

$$|Idiff| = |(I_X + I_Y + I_Z)|$$

$$|Ibias| = 0.5\ (|I_X| + |I_Y| + |I_Z|)$$

Assume a load current of I_L flowing from end X to Y and Z. Assume also a high resistance fault of current I_F being singly fed from end X. For worst case analysis, we can assume also I_F to be in phase with I_L :-

$$I_X = I_L + I_F$$

$$I_Y = -yI_L \text{ where } 0<y<1$$

$$I_Z = -(1-y)\ I_L$$

$$|Idiff| = |I_F|$$

$$|Ibias| = |I_L| + 0.5\ |I_F|$$

Relay sensitivity when $|Ibias| < Is2$:

For $|Ibias| < Is2$, the relay would operate if $|Idiff| > k1\ |Ibias| + Is1$

or $|I_F| > k1\ (|I_L| + 0.5\ |I_F|) + Is1$

or $(1 - 0.5\ k1)\ |I_F| > (k1\ |I_L| + Is1)$

or $|I_F| > (k1\ |I_L| + Is1) / (1 - 0.5\ k1)$

For $Is1 = 0.2$ pu, k1 = 30% and $Is2 = 2.0$ pu, then

1. for $|I_L| = 1.0$ pu, the relay would operate if $|I_F| > 0.59$ pu
2. for $|I_L| = 1.59$ pu, the relay would operate if $|I_F| > 0.80$ pu

If $|I_F| = 0.80$ pu and $|I| = 1.59$ pu, then $|Ibias| = 1.99$ pu which reaches the limit of the low percentage bias curve.

Relay sensitivity when $|Ibias| > Is2$:

For $|Ibias| > Is2$, the relay would operate if

$|Idiff| > k2\ |Ibias| - (k2 - k1)\ Is2 + Is1$

or $|I_F| > k2\ (|I_L| + 0.5\ |I_F|) - (k2 - k1)\ Is2 + Is1$

or $(1 - 0.5\ k2)\ |I_F| > (k2\ |I_L| - (k2 - k1)\ Is2 + Is1)$

or $|I_F| > (k2\ |I_L| - (k2 - k1)\ Is2 + Is1) / (1 - 0.5\ k2)$

For $Is1 = 0.2$ pu, k1 = 30%, $Is2 = 2.0$ pu and k2 = 100%, then,

1. for $|I_L| = 2.0$ pu, the relay would operate if $|I_F| > 1.6$ pu
2. for $|I_L| = 2.5$ pu, the relay would operate if $|I_F| > 2.6$ pu

Fault resistance coverage:

Assuming the fault resistance, R_F, is much higher than the line impedance and source impedance, then for a 33kV system and 400/1 CT:-

$$|I_F| = (\text{Vph-n} / R_F) * (1/\text{CT ratio})\ \text{pu}$$

$$= ((33000 / \sqrt{3}) / R_F) / 400\ \text{pu}$$

$$= 47.63/R_F\ \text{pu}$$

Based on the above analysis, the relay will detect a fault current in excess of 0.59 pu with a load current of 1 pu flowing. The fault resistance would have to be less than 47.63/0.59 = 81Ω in this case.

With a short time overload current of 2.0 pu, the relay will be able to detect a fault resistance of 47.63/1.6 = 30Ω or lower.

2.2.11 Example setting

2.2.11.1 Differential element

All four settings are user adjustable. This flexibility in settings allows the relay characteristic to be tailored to suit particular sensitivity and CT requirements. To simplify the protection engineer's task, we strongly recommend three of the settings be fixed to:

Is2 = 2.0 pu

k1 = 30%

k2 = 150% (2 terminal applications) or 100% (3 terminal applications)

These settings will give a relay characteristic suitable for most applications. It leaves only the Is1 setting to be decided by the user. The value of this setting should be in excess of any mismatch between line ends, if any, and should also account for line charging current, where necessary.

By considering the circuit shown in Figure 10, the settings for the phase current differential element can be established.

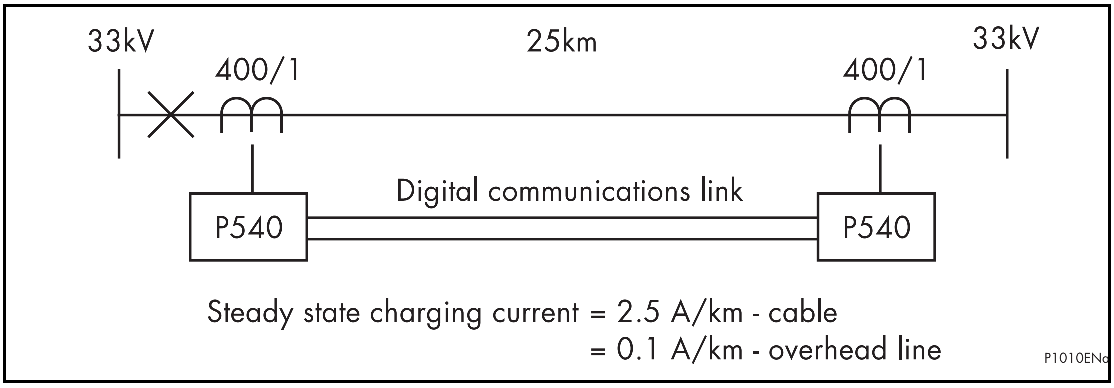


Figure 10: Typical plain feeder circuit

The following settings should be set as follows:

Is2 = 2.0 pu

k1 = 30 %

k2 = 150 % (for a two terminal application)

This leaves the setting of Is1 to be established.

In the case of a P541 relay being used, no facility to account for line charging current is available. The setting of Is1 must therefore be set above 2.5 times the steady state charging current value. In this example, assume a cable is used:-

$$Is1 > 2.5 \times Ich$$

$$Is1 > 2.5 \times (25km \times 2.5 A/km)$$

$$Is1 > 156.25 A$$

The line CTs are rated at 400 amps primary. The setting of Is1 must therefore exceed 156.25/400 = 0.391 pu.

Therefore select:

$$Is1 = 0.4 pu$$

If the P543 were chosen, a facility exists to overcome the effects of the line charging current. It will be necessary in this case to enter the line positive sequence susceptance value. This can be calculated from the line charging current as follows (assuming a VT ratio of 33kV / 110V):

$$Ich = 25 \times 2.5 A = 62.5A$$

$$\text{Susceptance } B = \omega C = Ich/V$$

$$B = 62.5 A / (33/\sqrt{3}) \text{ kV primary}$$

$$B = 3.28 \times 10^{-3} \text{ S primary}$$

Therefore set:

$$B = 3.28 \text{ mS primary } (= 2.46 \text{ mS secondary})$$

Is1 may now be set below the value of line charging current if required, however it is suggested that Is1 is chosen only sufficiently below the charging current to offer the required fault resistance coverage as described in section 2.2.10. Where charging current is low or negligible, the recommended factory default setting of 0.2 In should be applied.

2.2.11.2 Transformer feeder examples

Ratio correction example:

The P541 relay is suitable for the protection of transformer feeders. An example is shown in Figure 11.

20MVA Transformer, Dyn1, 33/11kV

HV CT ratio - 400/1

LV CT ratio - 1500/1

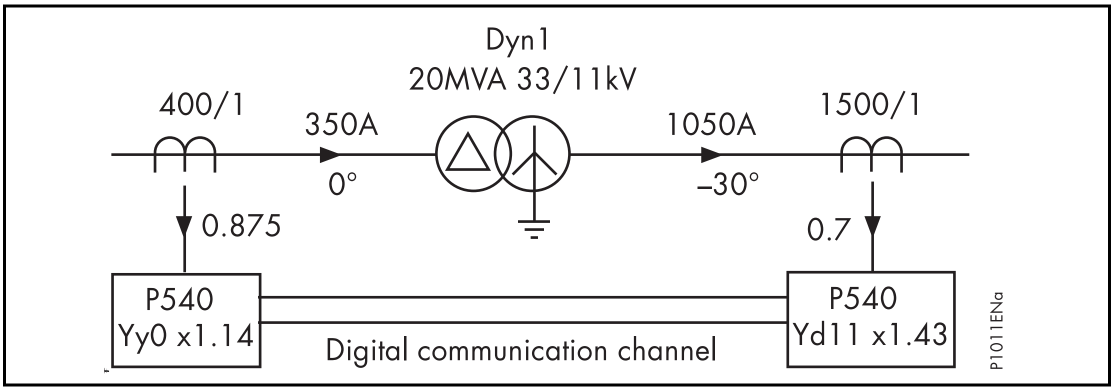


Figure 11: Typical transformer feeder circuit

It is necessary to calculate the required ratio correction factor to apply to the relays' at each line end.

33kV full load current = 20 MVA / (33kV.$\sqrt{3}$) = 350A

Secondary current = 350 x 1/400 = 0.875A

11kV full load current = 20 MVA / (11kV.$\sqrt{3}$)= 1050A

Secondary current = 1050 x 1/1500 = 0.7A

Each of these secondary currents should be corrected to relay rated current; in this case 1A.

HV ratio correction factor 1 / 0.875 = 1.14 [Setting applied to relay]

LV ratio correction factor 1 / 0.7 = 1.43 [Setting applied to relay]

When a Star/Delta software interposing CT is chosen, no additional account has to be taken for the $\sqrt{3}$ factor which would be introduced by the delta winding. This is accounted for by the relay.

<u>Phase Correction Example:</u>

Using the same transformer as shown in Figure 11 it is now necessary to correct for the phase shift between the HV and LV windings.

The transformer connection shows that the delta connected high voltage line current leads the low voltage line current by 30°. To ensure that this phase shift does not create a differential current, the phase shift must be corrected in the LV secondary circuit. The LV relay software interposing CT is effectively a winding replica of the main power transformer. It not only provides a +30° phase shift, but also performs the necessary function of filtering out any LV zero sequence current component.

Hence, the HV relay setting requires no phase shift or zero sequence current filtering (as HV winding is delta connected). The LV relay setting requires phase shifting by +30° and also requires zero sequence current filtering (as LV winding is star connected).

Set:

HV = Yy0

LV = Yd11 (+30°)

It is important when considering the software ICT connection, to account for both the phase shift and zero sequence current filtering. For example, with the transformer in Figure 11, it would have been possible to provide phase compensation by applying Yd1 and Yy0 settings to the HV and LV relays respectively. Although this provides correct phase shift compensation, no zero sequence current filtering exists on the LV side and hence relay maloperation could occur for an external earth fault.

2.2.11.3 Teed feeder example

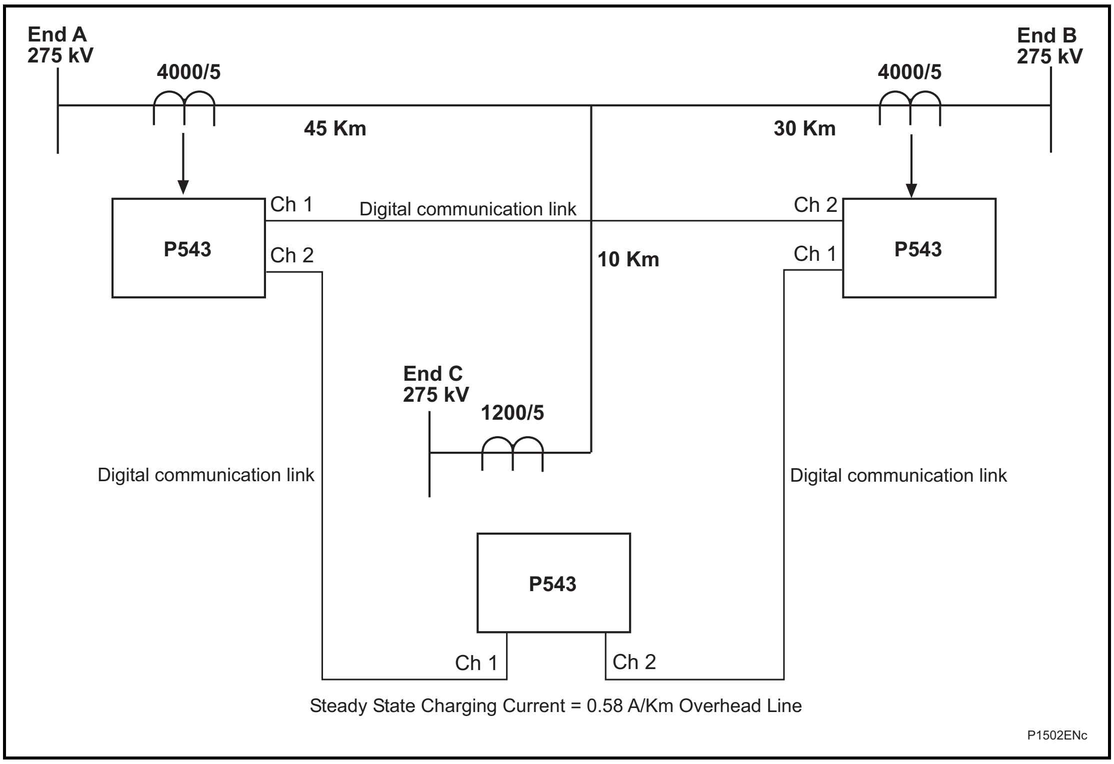


Figure 12: Typical Teed Feeder Application

P541 and P542 relays have not facilities to account for charging line current, therefore the setting Is1 must be 2.5 times the steady state charging current.

For P543, P544, P545 and P546 there is a facility to overcome the effect of charging current. As mentioned before, it is necessary to enter the positive sequence susceptance value.

Considering the charging current on the circuit shown in Figure 14, the following calculation is done:

- Ich = 0.58 A (45 + 30 + 10) = 49.3 A
- Susceptance = ω C = Ich/V
- B = 49.3 A / (275/ $\sqrt{3}$) kV primary
- B = 0.31 x 10^{-3} S primary.

As the CT ratio on the three ends are different, it is necessary to apply a correction factor in order to ensure secondary currents balance for all conditions:

To calculate the correction factor (CF), the same primary current must be used even this current is not the expected load transfer for every branch. This will ensure secondary current balance for all conditions.

A good approximation to calculate the correction factor, would be to use the primary rated current of the smallest CT ratio as a base current. In this case we will use the primary rated CT current at End C, in order to correct the secondary currents to the relay rated current:

For End A **1200 A**

Secondary current =1200x 5/4000 = 1.5 A

CF = 5/1.5 = 3.33

For End B **1200 A**

Secondary current =1200x 5/4000 = 1.5 A

CF = 5/1.5 = 3.33

For End C **1200 A prim = 5 A sec.**

Secondary current =1200x 5/1200 = 5 A

CF = 5/5 = 1

As mentioned on example 2.2.11.1, the following settings are recommended:

Is1 = 0.2 In

Is2 = 2 In

K1 = 30%

K2 = 100%

Therefore , settings in secondary values for each end are:

Is1 = 0.2In =1 A

Is2 = 2In =10 A

Note that settings shown in primary values at ends A and B appear different compared with end C. This is not a problem as the currents at ends A and B will be multiplied by the Correction Factor, when the differential calculation is done. There would not be a requirement to alter settings by CF as the relay works in secondary values.

Susceptance settings:

For Ends A and B

With a VT ratio 275kV/110V and CT ratio 4000/5

RCT = 800

RVT = 2500

B = 310 μS

Secondary susceptance = 310 μS x RVT/ RCT = 968 μS

For End C

With a VT ratio 275kV/110V and CT ratio 1200/5

B = 310 μS

Secondary susceptance = 310 μS x RVT/ RCT = 3.22mS sec.

2.2.11.4 Three winding transformer in zone with different rated CTs example

P541 and P542 relays are suitable for the protection of three winding transformers in zone. An example is shown in Figure 14.

100MVA/100MVA/30MVA Transformer, Ynyn0d1, 400kV/110kV/30kV

HV, 400kV CT ratio – 600/1

MV,110 kV CT ratio – 1200/1

LV, 30kV CT ratio – 2000/5

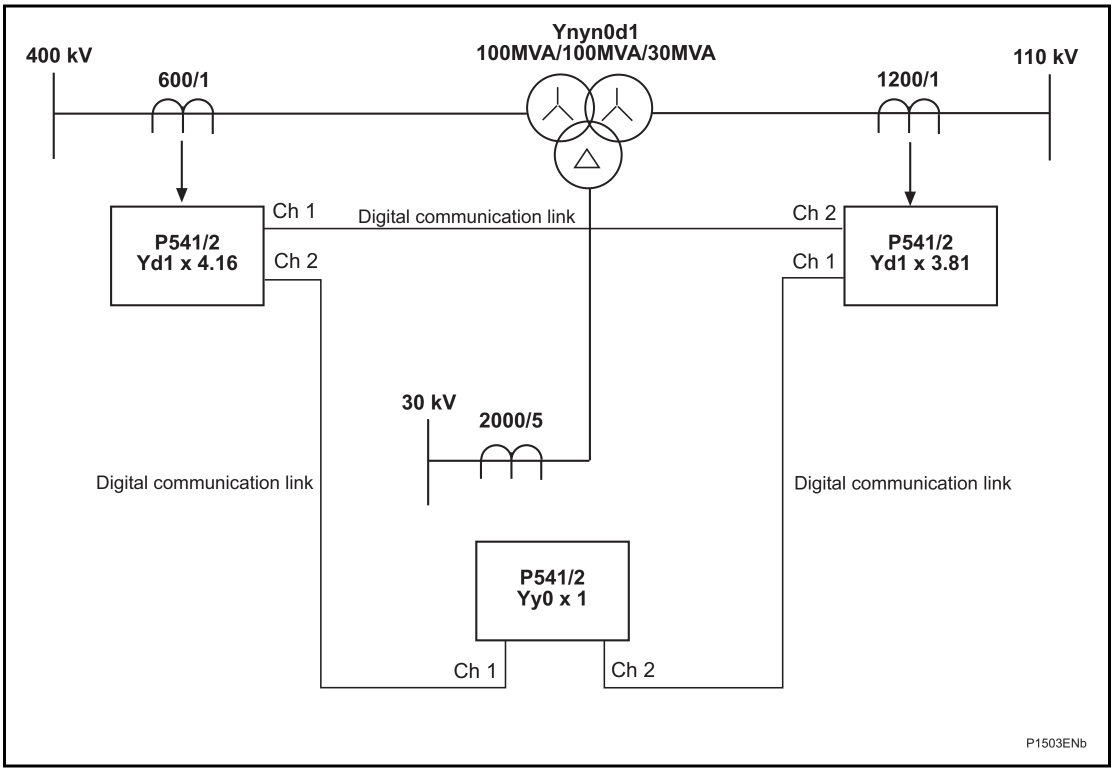


Figure 13: Three Winding Transformer in Zone Application

These three relays must be rated differently, i.e. 1A for HV and MV side and 5 A for 30 kV side. This does not present a problem for P54x relays as the digital signals representing the currents are in pu.

It is necessary to calculate the required ratio correction factor (CF) as well as the phase correction factor for each end. To choose the appropriate vector compensation, it is necessary to account for phase current and zero sequence current filtering as explained in example 2.2.11.2.

To calculate the correction factor range, it is necessary to use the same MVA base for the three sides of the transformer although the third winding actually has a lower rated MVA. This is to ensure secondary current balance for all conditions.

For HV side : 100 MVA/ (400 kV.$\sqrt{3}$) = 144.34 A.

Secondary current = 144.34 x 1/600 = 0.24 A

For MV side : 100 MVA/ (110 kV.$\sqrt{3}$) = 524.86 A.

Secondary current = 524.86 x 1/1200 = 0.44 A

For LV side : 100 MVA/ (30 kV.$\sqrt{3}$) = 1924.5 A.

Secondary current =1924.5x 5/2000 = 4.81 A

Each secondary current should be corrected to relay rated current, in this case 1A for HV and MV side and 5 A for 30 kV side

HV ratio correction factor = 1/0.24 = 4.16

MV ratio correction factor = 1/0.44 = 2.29

LV ratio correction factor = 5/4.81 = 1.04

To choose the vector compensation connection, it should be noted that the Wye connected HV line is in phase with the MV line current and leads the LV line current by 30^{o}. Therefore for LV side, the phase shift must be compensated.

To account for the zero sequence current filtering in the case of an external earth fault, it is necessary to connect the Wye connected power transformer windings to an interposing current transformer (internal relay ICT) to trap the zero sequence current (the secondary side being connected delta).

To account for both vector compensation and zero sequence current filtering, the following vectorial compensation setting is recommended:

- For HV side = Yd1 (-30 deg)
- For MV side = Yd1 (-30 deg)
- For LV side = Yy0 (0 deg)

Note that it is not necessary to include the √3 factor in the calculation as this is incorporated in the relay algorithm.

P541 and P542 relays are suitable for transformer applications, as such an inrush restrain is provided on these relay models. By enabling inrush restrain, an additional current differential high setting (Id High set) becomes enable.

When the inrush restrain feature is enabled, it is necessary that this function is enabled in the relay at each line end (3 ends).

For the differential calculation the same recommended settings for the previous examples are recommended:

- Is1 = 0.2 In
- Is2 = 2 In
- K1 = 30%
- K2 = 100%

Therefore, settings in secondary values are:

For relays rated to 1A (HV and MV sides)   Is1 = 200 mA and Is2 = 2 A

For relay rated to 5A (LV side) Is1 = 1A and Is2 = 10 A

For the current differential high setting (Id High set) the setting must be in excess of the anticipated inrush current after ratio correction. Assuming that maximum inrush is 12 times the nominal transformer current, it would be safe to set the relays at 15 times the nominal current, therefore the setting would be:

- Id high set :   for HV side = 15In = 15A

  for MV side = 15In = 15A

  for LV side = 15In = 75 A

2.3 Distance protection

Differential protection provides high speed, discriminative protection of an item of plant, with relatively few application problems. One disadvantage of a differential scheme, however, is the lack of inherent back-up protection. For this reason, the MiCOM current differential relays include various other forms of integrated protection. The P543, P544, P545 and P546 offer distance elements that can be used as complementary main protection elements along with the current differential, or enabled as back-up. (Distance elements are not provided in P541 and P542 relays as these have no VT inputs.)

The distance protection associated with the P540 relays can be selectively enabled or disabled. It is also possible to set the relay such that the distance protection is only enabled upon detection of a failure of the protection communications channel being used by the differential elements. This can be set on a per Zone basis.

The distance elements can also be configured to initiate an intertrip to the remote terminal. This can also be set on a per Zone basis.

The distance protection settings are given in Table 6.

DISTANCE	Default Setting	Min	Max	Step
Z1 Status	Enabled	Disabled, Enabled, Enabled Ch Fail		
Z1	5/InΩ	0.1/InΩ	250/InΩ	0.01/InΩ
tZ1	0s	0s	10s	0.01s
Z1 Intertrip	Disabled	Enabled, Disabled		
Z2 Status	Enabled	Disabled, Enabled, Enabled Ch Fail		
Z2	5/InΩ	0.1/InΩ	250/InΩ	0.01/InΩ
tZ2	0s	0s	10s	0.01s
Z2 Intertrip	Disabled	Enabled, Disabled		
Z3 Status	Enabled	Disabled, Enabled, Enabled Ch Fail		
Z3	5/IΩ	0.1/InΩ	250/InΩ	0.01/InΩ
tZ3	0s	0s	10s	0.01s
Z3 Intertrip	Disabled	Enabled, Disabled		
Line Angle	70°	20°	85°	1°
kZN Res Comp	1	0	7	0.01
kZN Angle	0°	-90° (Software 12 or previous) -180° (Software 13 or later)	90°	1°
RPh	10/InΩ	0.1/InΩ	400/InΩ	0.01/InΩ
RG	10/InΩ	0.1/InΩ	400/InΩ	0.01/InΩ
PSB Status	Disabled	Enabled, Disabled		
Z3 Direction	Reverse	Forward/Reverse		
Direction (software 20 or later)	Forward	Forward/Reverse		

Table 6. Distance protection settings

2.3.1 Phase fault distance protection

Distance protection involves the measurement of impedance by monitoring both the system voltage and current. If the measured impedance falls within a pre-set impedance characteristic, the element will operate following a user selectable time delay. The relay can be set in accordance with the impedance of the line to provide discriminative protection.

The P543, P544, P545 and P546 relays have 3 zones of phase fault protection, as shown in the impedance diagram Figure 14 overleaf.

All phase fault protection elements are quadrilateral shaped, and are directionalised as follows:

- Zones 1 and 2 - Directional forward zones.
- Zone 3 - Directional forward or reverse zone.

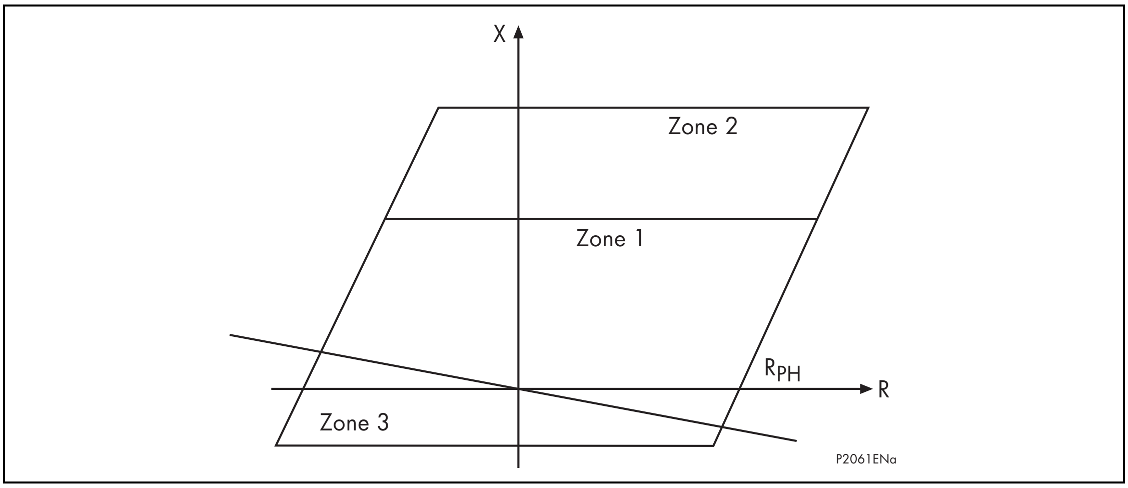


Figure 14: Phase fault distance characteristics

Note 1: Zone 3 may be set directional forward in a traditional 3-Step scheme.

2: It is possible to reverse the direction of all characteristics (software 20 or later).

2.3.2 Earth fault distance protection

The P543, P544, P454 & P546 relays have 3 zones of earth fault protection, as shown in Figure 15 below.

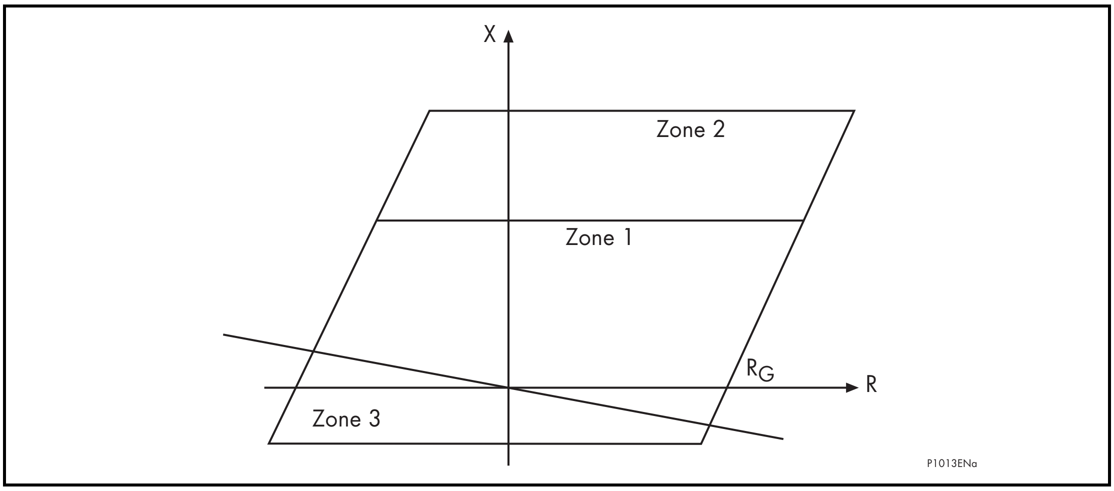


Figure 15: Earth fault distance characteristics

Note 1: Zone 3 may be set directional forward in a traditional 3-Step scheme

2: It is possible to reverse the direction of all characteristics (software 20 or later).

All earth fault protection elements are also quadrilateral shaped, and are directionalised as per the phase fault elements. Residual compensation is used to ensure the correct reach for the earth fault elements. The residual compensation factor (kZN Res Comp ∠kZN Angle), is applied to the respective phase fault reaches in order to obtain the earth fault characteristics.

Note that the resistive reach of the earth fault zones is independent of the phase fault resistive reach settings.

2.3.3 Setting guidelines

2.3.3.1 Zone reaches

The Zone 1 elements of a distance relay should typically be set to 80% of the positive phase sequence line impedance, in order to provide instantaneous tripping for faults over the majority of the line. 80% is chosen to ensure that instantaneous tripping does not occur for faults beyond the protected line. This margin of 20% allows for errors arising from the relay measurement, VTs, CTs and inaccurate line impedance data.

The Zone 2 elements should be set to cover at least 120% of the protected line, thereby ensuring coverage of the remaining section not covered by Zone 1. This margin of 20% accounts for the same errors given previously for Zone 1. As the Zone 2 element overreaches the protected line length, it is necessary to time delay this element in order to co-ordinate with protection on the adjacent line.

The Zone 2 element may be set to reach up to 50% into the shortest adjacent line impedance. This provides the maximum possible amount of Zone 2 coverage, whilst preventing loss of co-ordination with the Zone 2 elements of a downstream relay. Where this is not possible, it will be necessary to time grade the respective Zone 2 elements.

When setting Zone 2 earth fault elements on parallel circuits, the effects of zero sequence mutual coupling will need to be accounted for. This may result in the Zone 2 ground fault elements underreaching. To ensure adequate coverage, the reach setting may need to be modified but this is further discussed in Section 2.3.7.2.

The Zone 3 elements would usually be used to provide overall back-up protection for adjacent circuits when set forward-looking. The Zone 3 reach is therefore set to approximately 120% of the combined impedance of the protected line plus the longest adjacent line. A higher apparent impedance of the adjacent line may need to be allowed where fault current can be fed from multiple sources or flow via parallel paths.

Alternatively, the Zone 3 elements may be used to provide back-up protection for the busbars behind the relay, when directionalised reverse. The Zone 3 reach is nominally set to 25% of the zone 1 reach of the relay for short lines (<30km) or 10% of the zone 1 reach for long lines.

2.3.3.2 Zone time delay settings

The Zone 1 time delay is generally set to zero, giving instantaneous operation.

The Zone 2 time delay is set to co-ordinate with the Zone 1 fault clearance time for the protection on adjacent lines. The total fault clearance time will consist of the downstream Zone 1 operating time plus the associated circuit breaker operating time. Allowance must also be made for the Zone 2 elements resetting, following clearance of a fault on an adjacent line, plus a safety margin. A typical minimum Zone 2 time delay may be in the order of 200ms. This time may have to be adjusted where the relay is required to grade with other Zone 2 protections, or slower forms of back-up protection, on adjacent circuits.

The Zone 3 time delay is typically set with the same considerations made for the Zone 2 time delay, in that it should co-ordinate with any other protections that can operate for faults in it's zone. A typical minimum Zone 3 operating time may be in the region of 400ms. Again, this may need to be modified to co-ordinate with any slower forms of back-up protection.

2.3.3.3 Residual compensation for earth fault elements

During an earth fault condition, the fault impedance comprises both the phase fault impedance, plus the residual impedance. The combination of these impedances is termed the earth loop impedance. The residual impedance is set as a multiple of the phase fault reach setting and can be determined from the following formula:-

kZN Res Comp = (Z0 – Z1) / 3.Z1

kZN Angle = ∠ ((Z0 – Z1) / Z1)

Where:

Z1 = Positive sequence impedance for the line or cable;

Z0 = Zero sequence impedance for the line or cable.

2.3.3.4 Resistive reach calculation - phase fault elements

The P540 relays have quadrilateral distance characteristics, i.e. the resistive reach (RPh) is set independently of the impedance reach along the protected line/cable. RPh defines the maximum amount of fault resistance, additional to the line impedance, for which a distance zone will trip. Thus, the right hand and left hand resistive reach constraints of each zone are displaced by +RPh and -RPh either side of the characteristic impedance of the line.

The resistive reach of the phase fault elements must be set to cover any expected levels of fault resistance. It is important to note that the maximum phase fault resistive reach must be limited to avoid incorrect tripping due to the impedance of the load falling within the relay characteristic. Thus, the phase fault resistive reach settings must be set to avoid the heaviest allowable loading on the feeder. Typically, the resistive reach should not exceed 80% of the minimum load impedance. An example is shown in Figure 16.

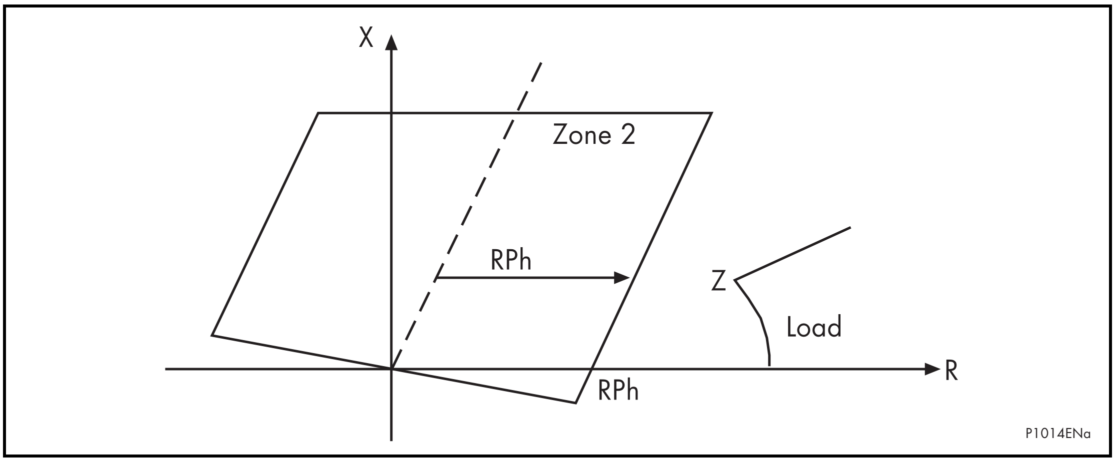


Figure 16: Setting of resistive reach to avoid load

Where power swing blocking (PSB) is enabled, a larger impedance characteristic surrounds Zone 2, and it is also essential that load does not encroach upon this characteristic. For this reason, RPh may typically have to be set to approximately 60% of the minimum load impedance. This will then allow the PSB characteristic to avoid the minimum load impedance.

In primary impedance terms, R_{Ph} reaches must be set to cover the maximum expected phase-to-phase fault resistance. Ideally, R_{Ph} must be set <u>greater than</u> the maximum fault arc resistance for a phase-phase fault, calculated as follows:

$$R_a = (28710 \times L) \;/\; I_f^{1.4}$$

Where:

I_f = Minimum expected phase-phase fault current (A);

L = Maximum phase conductor separation (m);

R_a = Arc resistance, calculated from the van Warrington formula (Ω).

Typical figures for R_a (primary Ω) are given in the table below, for different values of minimum expected phase fault current.

Conductor spacing (m)	Typical system voltage (kV)	I_f = 1kA	I_f = 2kA	I_f = 3kA
4	110 - 132	7.2Ω	2.8Ω	1.6Ω
8	220 - 275	14.5Ω	5.5Ω	3.1Ω
11	380 - 400	19.9Ω	7.6Ω	4.3Ω

Table 7. Van Warrington Arc Resistance Formula (for quadrilaterals)

Note that dual-end infeed effects will make a fault resistance appear higher, because each relay cannot measure the current contribution from the remote line end. The apparent fault resistance increase factor could be 2 to 8 times the calculated resistance. Therefore it is recommended that the Zone resistive reaches are set to say, 4 times the primary arc resistance calculation.

Note that the Rph setting applied defines the complete fault arc resistance that can be detected for a phase-phase fault. This means that the setting Rph is the actual fault resistance and not half (which most injections test sets will plot).

2.3.3.5 Resistive reach calculation - earth fault elements

The resistive reach setting of the relay earth fault elements should be set to cover the desired level of earth fault resistance, but to avoid operation with minimum load impedance. Fault resistance could comprise of arc-resistance, tower footing resistance etc.

A typical resistive reach coverage would be 40Ω on the primary system. The same load impedance as in Section 2.3.3.4 must be avoided. Thus, the resistive reach is set to avoid point Z by a suitable margin, typically 20%, as previously stated for phase fault elements. In addition for best accuracy, the resistive reach would not normally be greater than 10 times the corresponding earth loop reach.

2.3.3.6 Effects of mutual coupling on distance settings

Where overhead lines are connected in parallel, or run in close proximity for the whole or part of their length, mutual coupling exists between the two circuits. The positive and negative sequence coupling is small and can be neglected. The zero sequence coupling is more significant and will affect relay measurement during earth faults with parallel line operation.

Zero sequence mutual coupling will cause a distance relay to underreach or overreach, depending on the direction of zero sequence current flow in the parallel line. However, it can be shown that this underreach or overreach will not affect relay co-ordination during parallel line operation (i.e. it is not possible to overreach for faults beyond the protected line and neither will it be possible to underreach to such a degree that no Zone 1 overlap exists). Some applications exist, however, where the effects of mutual coupling should be addressed, as explained in the following sections.

2.3.3.7 Effect of mutual coupling on Zone 1 setting

For the case shown in Figure 17, where one circuit of a parallel line is out of service and earthed at both ends, an earth fault at the remote bus may result in incorrect operation of the Zone 1 earth fault elements. It may be desirable to reduce the Zone 1 earth loop reach for this application. This can be achieved using an alternative setting group within the P540 relay, in which the residual compensation factor KZN is set at a lower value than normal.

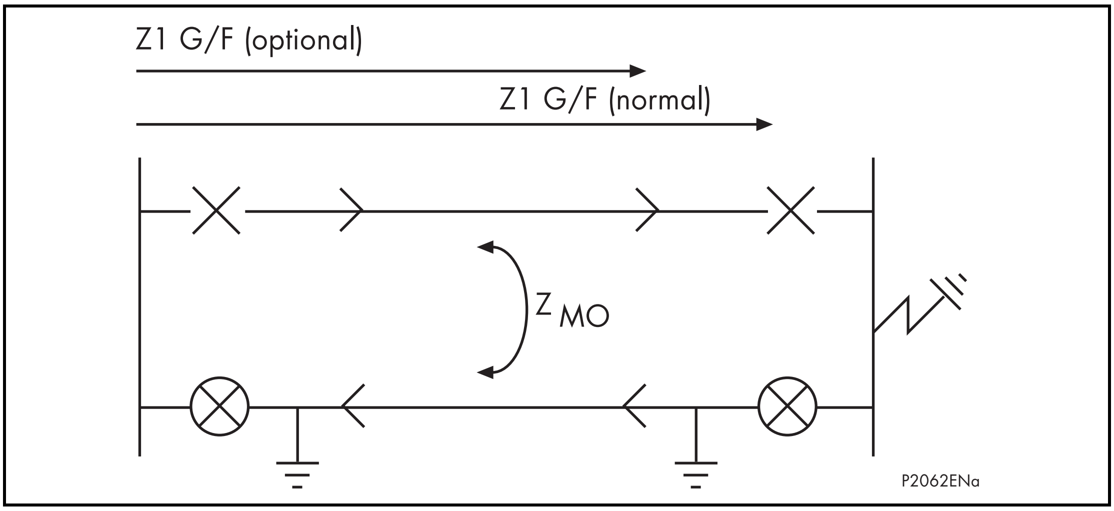


Figure 17: Zone 1 reach settings for parallel lines

2.3.3.8 Effect of mutual coupling on Zone 2 setting & Zone 3 when set in the forward direction

For parallel circuit operation, the relay Zone 2 & Zone 3 earth fault elements will tend to underreach. Therefore, it is desirable to boost the setting of the earth fault elements such that they will have a comparable reach to the phase fault elements. However, if the double circuit line to be protected is long and there is a relatively short adjacent line, it is difficult to set the reach of the Zone 2 & Zone 3 elements to cover 120% of the protected line impedance for all faults, but not more than 50% of the adjacent line. This problem is exacerbated when a significant additional allowance has been made for the zero-sequence mutual impedance in the case of earth faults. Under single circuit operation, no mutual coupling exists, and the Zone 2 & Zone 3 earth fault elements may now overreach beyond 50% of the adjacent line, necessitating time discrimination with other Zone 2 & Zone 3 elements. Therefore, it is desirable to reduce the earth fault settings to that of the phase fault elements for single circuit operation, as shown in Figure 18. Changing between appropriate settings can be achieved by using the alternative setting groups available in the P540 relays. Changing of the ground fault reach is achieved by altering the residual compensation factor accordingly.

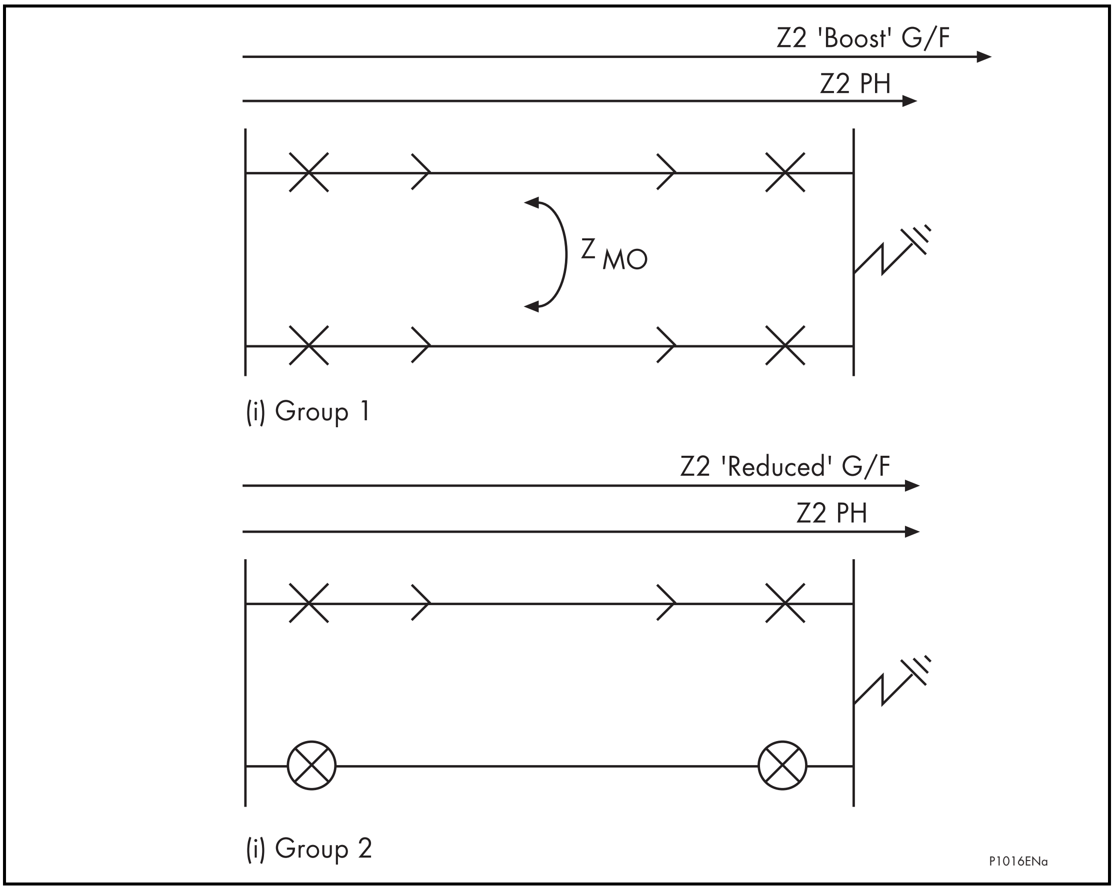


Figure 18: Mutual coupling example – Zone 2 reach considerations

2.3.4 Power swing blocking (PSB)

Power swings are oscillations in power flow which can occur following a power system disturbance. They can be caused by sudden removal of faults, loss of synchronism across a power system or changes in direction of power flow as a result of switching. Such disturbances can cause generators on the system to accelerate or decelerate to adapt to new power flow conditions, which in turn leads to a power swing condition. A power swing may cause the impedance presented to a distance relay to move away from the normal load area and into one or more of the relays tripping characteristics. In the case of a stable power swing, it is important that the relay should not trip. Depending on the power utility strategy, blocking of the distance elements may or may not be required during a serious power swing which results in loss of stability.

2.3.4.1 The power swing blocking element

Operation of the PSB element is menu selectable to block the operation of all of the distance zones or to allow tripping. Power swing detection uses an impedance band which surrounds the entire phase fault trip characteristic. This band is shown as ΔR and ΔX in Figure 19 overleaf:

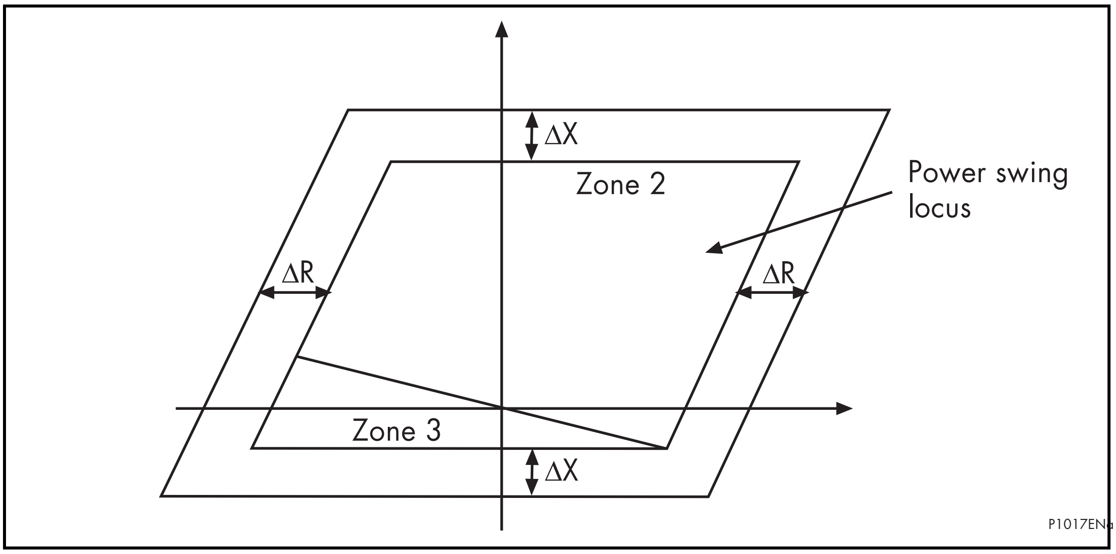


Figure 19: Power swing blocking characteristic

Note: Zone 3 may be set directional forward.

A fault on the system results in a rapid change in the measured impedance. However, power swings follow a much slower impedance locus. A power swing is detected where the phase-phase measured impedance has remained within the ΔR band for in excess of tZ6. PSB is indicated on reaching Zone 2 or Zone 3.

Note that the PSB characteristic will be set around whichever Zones are enabled, i.e. if only Zone 1 is enabled, then the PSB zone will surround Zone 1 only.

2.3.4.2 Unblocking of the relay for faults during power swings

The relay can operate normally for any unbalanced fault occurring during a power swing, as there is one condition that can unblock the relay:

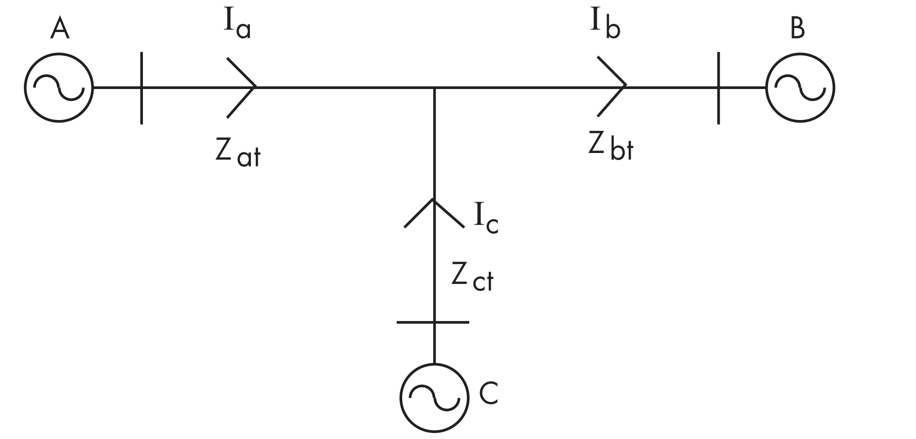
- A negative sequence current threshold is exceeded – this allows tripping for phase-phase and phase to ground faults occurring during a power swing. This unblocking condition (I2>) can be removed as it is available in the Programmable Scheme Logic.

The threshold is fixed to twice the value of the sensitivity for Z1 (see Technical Data Chapter P54x/EN TD).

2.3.5 Teed feeder protection

The application of distance relays to three terminal lines is fairly common. However, care must be taken when calculating reach settings for distance elements to account for the apparent impedance seen by the relay, as a result of the current infeed from the third terminal.

Figure 20 shows a typical three terminal line arrangement.



$$V_a = I_a Z_{at} + I_b Z_{bt}$$

$$I_b = I_a + I_c$$

$$V_a = I_a Z_{at} + I_a Z_{bt} + I_c Z_{bt}$$

$$\text{Impedance seen by relay A} = \frac{V_a}{I_a}$$

$$Z_a = Z_{at} + Z_{bt} + \left(\frac{I_c}{I_a} Z_{bt}\right)$$

Figure 20: Teed feeder application – apparent impedance seen by distance relay

For a fault at the busbars of terminal B, the impedance seen by a relay at terminal A is shown to be equal to:

Za = Zat + Zbt + [Zbt.(Ic / Ia)]

Relay A will underreach for faults beyond the tee-point with infeed from terminal C. When terminal C is a relatively strong source, the underreaching effect can be substantial. For a Zone 2 element which is set to 120% of the protected line, this effect may result in non-operation of the element for internal faults. Therefore, where infeed is present, it must be ensured that Zone 2 elements at all line terminals overreach both remote terminals, with adequate allowance for the effect of tee-point infeed. Similarly, the relay Zone 1 elements could be set to 80% of the line allowing for the underreaching effect of the third terminal infeed. However, where the third terminal is out of service, the Zone 1 elements may now overreach the protected line. It may therefore be necessary to alter the reach of the distance elements, depending upon the system configuration. This can be achieved by the use of alternative setting groups within the relay.

2.3.6 Distance Zone Characteristic Generation

The directional line used to determine the forward and reverse decisions for the distance elements uses a combination of self polarising voltage and cross polarising from other (unfaulted) phases. In Switch on To Fault (SOTF) cases it is possible that a solid three phase fault may be present at the relay location, due to maintenance earth clamps inadvertently left in position on line energisation. In such cases, the fault voltage may drop less than 1V on all three phases, and valid directional polarising cannot occur. In such SOFT cases the use of overcurrent elements to supplement the distance protection should be considered.

The top line (reactance reach line) of each earth fault quadrilateral zone incorporates a dynamic tilt. This line will tilt up or down to avoid under or overreach of zones when load flow is present. Under no-load conditions the reactance lines have a fixed 3 degree droop to account for typical CT and VT tolerances.

2.3.7 Setting example

The distance protection option is available on the P543, P544, P545 and P546 relays. These models are generally more applicable to higher voltage sub-transmission and transmission systems. This example is therefore based around a 100km, 230kV overhead line, as shown in Figure 21.

Line length:	100Km	
Line impedances:	Z1	= 0.089 + j0.476 = 0.484 ∠79.4° ohm/km
	Z0	= 0.426 + j1.576 = 1.632 ∠74.8° ohm/km
	Z0/Z1	= 3.372 ∠-4.6°
CT ratio:	1,200/5	
VT ratio:	230,000/115	

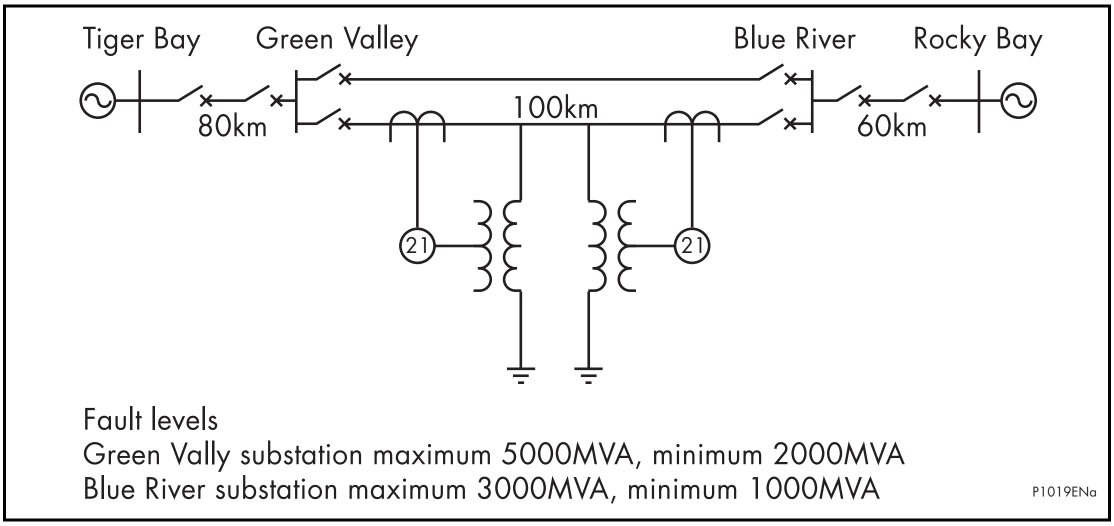


Figure 21: Example system

Settings on the relay can be performed in primary or secondary quantities and impedances can be expressed as polar quantities (menu selectable). For the purposes of this example, secondary quantities will be used.

2.3.7.1 Zone 1 reactive reach setting

Required Zone 1 reach is to be 80% of the line impedance between Green Valley and Blue River substations. This is to provide instantaneous protection for as large a section of line as possible.

Ratio of secondary to primary impedance =

Required Zone 1 reach = 0.8 x 100 x 0.484 ∠79.4° x 0.12

= 4.64 ∠79.4 ohms secondary

Relay characteristic angle (line angle) settings 20° to 85° in 1° steps

Therefore Z1 = 4.64

Line angle = 80°

2.3.7.2 Zone 2 reactive reach setting

Required Zone 2 impedance =

(Green Valley-Blue River) line impedance + 50% (Blue River-Rocky Bay) line impedance

= (100+30) x 0.484 ∠79.4° x 0.12

= 7.56 ∠79.4° ohms secondary

Therefore Z2 = 7.56

Line angle = 80°

2.3.7.3 Zone 3 reactive reach setting

Required Zone 3 reach = 25% of forward Zone 1 reach

= 0.25 *4.64 $\angle 80°$

= 1.16 $\angle 80°$ ohms secondary

Therefore Z3 = 1.16

Line angle = 80°

2.3.7.4 Load avoidance

Relay reach settings must be below the minimum load impedance (The maximum load flow of the line)

Minimum load impedance = [(Line kV^2) / maximum load flow MVA)]

Taking the 5A CT secondary rating as a guide to the maximum load current, the minimum load impedance presented to the relay would be:

Zmin = (Rated voltage Vn) / 5

= 66.4 / 5 = 13.3 ohms (secondary)

2.3.7.5 Phase element resistive reach settings

In the example, the minimum phase fault level is 1000MVA. This is equivalent to an effective short-circuit fault feeding impedance of:

Z = kV ^{2} / MVA = 230^2 / 1000 = 53Ω (primary)

The lowest phase fault current level is equivalent to:

I_{fault} = (MVA x 1000) / (√3 x kV)

= (1000 x 1000) / (√3 x 230)

= 2.5kA

And this fault current in the van Warrington formula would give an arc resistance of:

Ra = 4Ω

As this impedance is relatively small compared to the value “Z” calculated above, there is no need to perform an iterative equation to work out the actual expected I_{fault} (which would in reality be lower due to the added Ra arc resistance in the fault loop). It will suffice to increase the calculated Ra by the recommended factor of four, and a little extra to account for the fault current being lower than that calculated. So, in this case use a minimum setting of 5 x Ra, which is 20Ω primary.

It is obvious that the setting could easily be set above <u>20Ω</u> on the primary system. Typically, all zone resistive reaches would be set greater than this figure, and ideally less than the load impedance (see “load avoidance” section).

Minimum resistive reach setting = 20 x 0.12 = 2.4 ohms (secondary)

For parallel lines typically phase fault distance zones would avoid the minimum load impedance by a margin of at least 50% if possible,

Maximum resistive reach setting = 0.5 X 13.3 = 6.65 (secondary)

2.3.7.6 Residual compensation setting

Residual compensation factor - kZN = $\frac{ZL0 - ZL1}{3\ ZL1}$

$$ZL0 - ZL1 = (0.426 + j1.576) - (0.089 + j0.476)$$

$$= 0.337 + j1.1$$

$$= 1.15 \angle 72.9°$$

$$kZN = \frac{1.15 \angle 72.9°}{3 \times 0.484 \angle 79.4°} = 0.79 \angle -6.5°$$

kZN settings 0 to 7 in steps of 0.01

kZN angle = -180° (software 13 or later) or -90° (software 12 or previous) to +90° in 1° steps

Therefore, select kZN Res Comp = 0.79 and kZN angle = –6.5°

2.3.7.7 Ground element resistive reach settings

The resistive reach of the ground fault elements should be set, typically, to cover fault arc resistance and tower footing resistance. A typical figure of 40Ω primary can be used for this example.

RG > 40 * 0.12Ω secondary

> 4.8Ω secondary

Set RG = 4.8Ω secondary

This setting would be below the minimum load impedance required for this application:

Maximum resistive reach setting = 0.5 X 13.3 = 6.65 (secondary).

2.4 Phase fault overcurrent protection

Phase fault overcurrent protection is provided as an alternative form of back-up protection. The P541 and P542 relays have four overcurrent stages. The first two stage have a selectable IDMT or DT characteristic. The third and fourth stages have a DT characteristic only. The overcurrent stages within the P543, P544, P545 and P546 relays are identical but also have the option of being set directional forward or directional reverse. The overcurrent protection can be selectively enabled or disabled. A feature also exists whereby the protection can be enabled upon failure of the differential protection communication channel.

The VTS element of the relay can be selected to either block the directional element or simply remove the directional control.

The overcurrent elements will need to be co-ordinated with any other protection elements on the system, in order to provide discriminative fault clearance. The overcurrent menu column is shown in Table 7.

OVERCURRENT	Default Setting	Min	Max	Step
I>1 Status	Enabled	Disabled, Enabled, Enabled Ch Fail		
I>1 Function	IEC S Inverse	DT, IEC S Inverse, IEC V Inverse, IEC E Inverse, UK LT Inverse, IEEE M Inverse, IEEE V Inverse, IEEE E Inverse, US Inverse, US ST Inverse		
I>1 Directional {P543, P544, P545, P546 only}	Non-directional	Non-directional, Directional Fwd, Directional Rev		
I>1 Current Set	1In	0.08In	4.0In	0.01In
I>1 Time Delay	1s	0s	100s	0.01s
I>1 TMS	1	0.025	1.2	0.025

OVERCURRENT	Default Setting	Min	Max	Step
I>1 Time Dial (Software 30 or later)	1	0.1	100	0.05
I>1 Time Dial	7	0.5	15	0.1
I>1 Reset Char	DT		DT, Inverse	
I>1 tRESET	0s	0s	100s	0.01s
I>2 {Cells as for I>1 above}				
I>3 Status	Disabled	Disabled, Enabled, Enabled Ch Fail		
I>3 Directional {P543, P544 only}	Non-directional	Non-directional, Directional Fwd, Directional Rev		
I>3 Current Set	1In	0.8In	32In	0.01In
I>3 Time Delay	1s	0s	100s	0.01s
I>3 Intertrip	Enabled	Enabled, Disabled		
I>4 {Cells as for I>3 above but no intertrip}				
I> Char Angle {P543, P544, P545, P546 only}	30°	-95°	95°	1°
I> Function Link {See comment below}	00001111	00000000	11111111	1

Table 8. Overcurrent protection settings.

The I> Function Link settings have the following effect:

VTS Block - When the relevant bit is set to 1, operation of the Voltage transformer Supervision (VTS) will block the stage if it is directionalised. When set to 0 the stage will revert to non-directional upon operation of the VTS.

A/R Block - The autoreclose logic can be set to block instantaneous overcurrent elements after a prescribed number of shots. This is set in the autoreclose column when a block instantaneous signal is generated then only those overcurrent stages selected to a '1' in the I> Function Link will be blocked.

For the IDMT characteristics the following options are available.

The IEC/UK IDMT curves conform to the following formula:

$$t = T \times \left(\frac{K}{(I/Is)^{\alpha} - 1} + L \right)$$

The IEEE/US IDMT curves conform to the following formula:

$$t = TD \times \left(\frac{K}{(I/Is)^{\alpha} - 1} + L \right)$$

t = operation time

K = constant

I = measured current

Is = current threshold setting

α = constant

L = ANSI/IEEE constant (zero for IEC curves)

T = Time multiplier setting for IEC/UK curves

TD = Time multiplier setting for IEEE/US curves

IDMT characteristics

IDMT Curve description	Standard	K constant	α constant	L constant
Standard Inverse	IEC	0.14	0.02	0
Very Inverse	IEC	13.5	1	0
Extremely Inverse	IEC	80	2	0
Long Time Inverse	UK	120	1	0
Moderately Inverse	IEEE	0.0515	0.02	0.114
Very Inverse	IEEE	19.61	2	0.491
Extremely Inverse	IEEE	28.2	2	0.1217
Inverse	US-C08	5.95	2	0.18
Short Time Inverse	US-C02	0.16758	0.02	0.11858

Table 9.

Note: That the IEEE and US curves are set differently to the IEC/UK curves, with regard to the time setting. A time multiplier setting (TMS) is used to adjust the operating time of the IEC curves, whereas a time dial setting is employed for the IEEE/US curves. Both the TMS and Time Dial settings act as multipliers on the basic characteristics but the scaling of the time dial is approximately 10 times that of the TMS, as shown in the previous menu. The menu is arranged such that if an IEC/UK curve is selected, the 'I> Time Dial' cell is not visible and vice versa for the TMS setting.

2.4.1 Overcurrent intertripping feature

Where the third stage of the overcurrent protection is being used for instantaneous high set operation, it is possible to configure the relay to send an intertrip signal to the remote relay from this stage. This intertrip command is phase segregated and so can be used in conjunction with single phase tripping arrangements.

Note that when instantaneous overcurrent elements are used, they must still provide discriminative fault clearance. This must be achieved through choice of setting such that the pick up level of the element is greater than the fault level at the remote line terminal under maximum generation conditions. This will ensure that the element will only operate for faults within the protected line.

2.4.2 Overcurrent back-up on communication channel failure

An application advantage of enabling overcurrent protection following differential protection communications channel failure, is the ability to reduce back-up protection fault clearance times. This can be best demonstrated on a ring main application as shown in Figure 22.

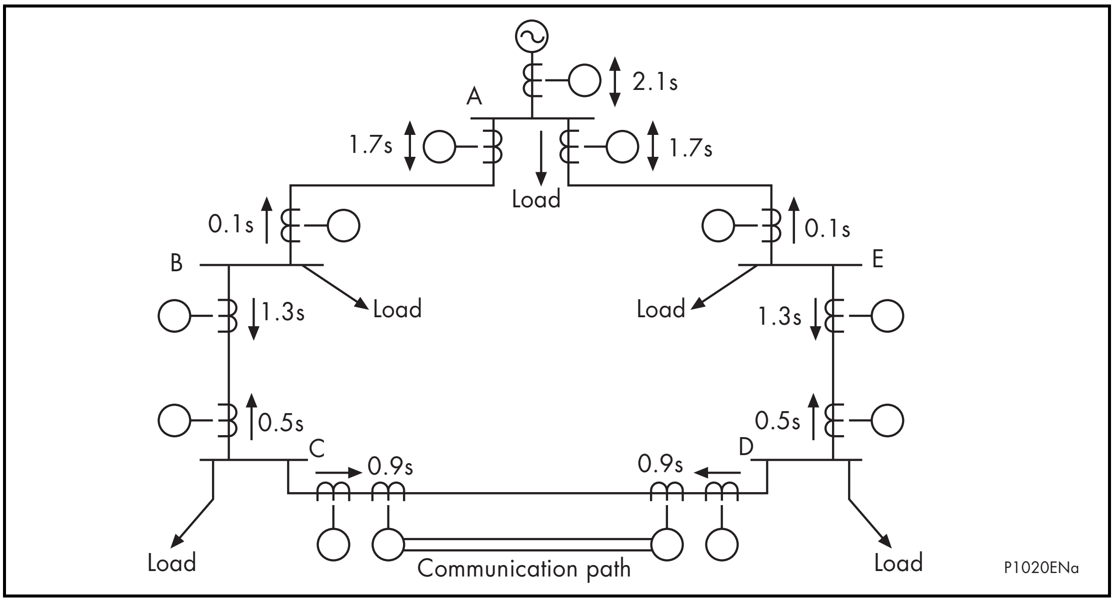


Figure 22: Ring main application – overcurrent back-up

If directional overcurrent protection were applied to the ring circuit, conventional grading of relays would lead to typical operating times as shown. This tends to result in long protection operating times, particularly at the source substation, ‘A’ (1.7s in this case).

If a differential scheme is applied to each circuit as main protection, with directional overcurrent (DOC) as back-up protection, then it is possible to greatly reduce the DOC operating times. Considering the circuit between ‘C’ and ‘D’, the DOC operating times were 0.9s at each terminal respectively. If the DOC protection is only enabled when the differential communications channel has failed, then these operating times may be reduced. In this case the only overcurrent devices in service will be those associated with circuit ‘C-D’ and those on the source incomers at ‘A’. Discrimination is therefore only necessary between these relays. Hence the relays between ‘C’ and ‘D’ can be set to 0.1s, for example, and the incomer relays set to 0.5s. This principle applies equally to the other circuits around the ring such that all the relays at substations ‘B’, ‘C’, ‘D’, and ‘E’ can be given typical operating times of 0.1s.

This philosophy would work equally well with non-directional overcurrent protection, as discrimination for faults on other circuits can be maintained by the differential protection on those circuits.

The above operating times are typical only. Care must be taken when setting these relays such that discrimination is still achieved with any downstream protection on any of the load circuits.

2.4.3 Example setting

Settings for the time delayed overcurrent element should be selected to ensure discrimination with surrounding protection. It is not intended to include a grading example in this section. Information on grading can be found in the Network Protection and Automation Guide (NPAG). The setting example shown below is thus only concerned with correct application of the second element when used to provide high speed, instantaneous protection.

It must be ensured that the element will only respond to faults on the protected line. The system under consideration is that shown in Figure 24. The worst case scenario for this is when only one of the parallel lines is in service, resulting in the largest branch current.

Two cases must be considered. The first is a fault at Blue River substation, the relay seeing fault current contribution via Green Valley, and the second is a fault at Green Valley, the relay seeing fault current contribution via Blue River.

Case 1:

$$\text{Source impedance} = \frac{230^2 \text{ kV}}{5000 \text{ MVA}} = 10.58 \text{ ohms}$$

$$\text{Line impedance} = 48.4 \text{ ohms}$$

$$\text{Fault current seen by relay} = \frac{230000}{\sqrt{3} * [10.58 + 48.4]}$$

$$= 2251\text{A}$$

Case 2:

$$\text{Source impedance} = \frac{230^2}{3000} = 17.63 \text{ ohms}$$

$$\text{Line impedance} = 48.4 \text{ ohms}$$

$$\text{Fault current seen by relay} = \frac{230000}{\sqrt{3} * [17.63 + 48.4]}$$

$$= 2011\text{A}$$

The overcurrent setting must therefore be in excess of 2251A. To provide an adequate safety margin, a setting of 130% of the minimum requirement should be chosen (i.e. 1.3 x 2251 = 2961A).

The relay is connected to a 1200/5A CT. A setting of (2961/1200) x In = 2.468 In must be chosen

Therefore set I>2 Current Set = 2.47 In

2.4.4 Directional overcurrent characteristic angle settings

The relay uses a 90° connection angle for the DOC elements. The relay characteristic angles in this case are nominally set to:

+30° Plain feeders, zero sequence source behind relay.

+45° Transformer feeder, zero sequence source in front of relay.

2.5 Thermal overload protection

Thermal overload protection can be used to prevent electrical plant from operating at temperatures in excess of the designed maximum withstand. Prolonged overloading causes excessive heating, which may result in premature ageing of the insulation, or in extreme cases, insulation failure.

The relay incorporates a current based thermal replica, using load current to model heating and cooling of the protected plant. The element can be set with both alarm and trip stages.

The heat generated within an item of plant, such as a cable or a transformer, is the resistive loss (I^2R x t). Thus, heating is directly proportional to current squared. The thermal time characteristic used in the relay is therefore based on current squared, integrated over time. The relay automatically uses the largest phase current for input to the thermal model.

Equipment is designed to operate continuously at a temperature corresponding to its full load rating, where heat generated is balanced with heat dissipated by radiation etc. Overtemperature conditions therefore occur when currents in excess of rating are allowed to flow for a period of time. It can be shown that temperatures during heating follow exponential time constants and a similar exponential decrease of temperature occurs during cooling.

In order to apply this protection element, the thermal time constant for the protected item of plant is therefore required.

The following sections will show that different items of plant possess different thermal characteristics, due to the nature of their construction. The relay provides two characteristics which may be selected according to the application.

2.5.1 Single time constant characteristic

This characteristic is used to protect cables, dry type transformers (e.g. type AN), and capacitor banks.

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;

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».

2.5.2 Dual time constant characteristic

This characteristic is used to protect oil-filled transformers with natural air cooling (e.g. type ONAN). The thermal model is similar to that with the single time constant, except that two time constants must be set. The thermal curve is defined as:

$$0.4 \exp(-t/\tau 1) + 0.6 \exp(-t/\tau 2) = (I^2 - (k.I_{FLC})^2) / (I^2 - I_P^2)$$

Where:

$\tau 1$ = Heating and cooling time constant of the transformer windings;

$\tau 2$ = Heating and cooling time constant for the insulating oil.

For marginal overloading, heat will flow from the windings into the bulk of the insulating oil. Thus, at low current, the replica curve is dominated by the long time constant for the oil. This provides protection against a general rise in oil temperature.

For severe overloading, heat accumulates in the transformer windings, with little opportunity for dissipation into the surrounding insulating oil. Thus, at high current, the replica curve is dominated by the short time constant for the windings. This provides protection against hot spots developing within the transformer windings.

Overall, the dual time constant characteristic provided within the relay serves to protect the winding insulation from ageing, and to minimise gas production by overheated oil. Note, however, that the thermal model does not compensate for the effects of ambient temperature change.

The following table shows the menu settings for the thermal protection element:

THERMAL	Default	Min	Max	Step
Thermal Char	Single	Disabled, Single, Dual		
Thermal Trip	1In	0.08In	3.2In	0.01In
Thermal Alarm	70%	50%	100%	1%
Time Constant 1	10 minutes	1 minutes	200 minutes	1 minutes
Time Constant 2	5 minutes	1 minutes	200 minutes	1 minutes

Table 10.

The thermal protection also provides an indication of the thermal state in the measurement column of the relay. The thermal state can be reset by either an opto input (if assigned to this function using the programmable scheme logic) or the relay menu. The reset function in the menu is found in the measurement column with the thermal state.

2.5.3 Setting guidelines

2.5.3.1 Single time constant characteristic

The current setting is calculated as:

Thermal Trip = Permissible continuous loading of the plant item/CT ratio.

Typical time constant values are given in the following tables. The relay setting, 'Time Constant 1', is in minutes.

Paper insulated lead sheathed cables or polyethylene insulated cables, laid above ground or in conduits. The table shows τ in minutes, for different cable rated voltages and conductor cross-sectional areas:

CSA mm^2	6 -11 kV	22 kV	33 kV	66 kV
25 - 50	10	15	40	-
70 - 120	15	25	40	60
150	25	40	40	60
185	25	40	60	60
240	40	40	60	60
300	40	60	60	90

Table 11.

Other plant items:

	Time constant τ (minutes)	Limits
Dry-type transformers	40 60 – 90	Rating < 400 kVA Rating 400 - 800 kVA
Air-core reactors	40	
Capacitor banks	10	
Overhead lines	10	Cross section $\geq$ 100 mm^2 Cu or 150mm^2 Al
Busbars	60	

Table 12.

An alarm can be raised on reaching a thermal state corresponding to a percentage of the trip threshold. A typical setting might be 'Thermal Trip' = 70% of thermal capacity.

2.5.3.2 Dual time constant characteristic

The current setting is calculated as:

Thermal Trip = Permissible continuous loading of the transformer / CT ratio.

Typical time constants:

	τ1 (minutes)	τ2 (minutes)	Limits
Oil-filled transformer	5	120	Rating 400 - 1600 kVA

Table 13.

An alarm can be raised on reaching a thermal state corresponding to a percentage of the trip threshold. A typical setting might be 'Thermal Alarm' = 70% of thermal capacity.

Note that the thermal time constants given in the above tables are typical only. Reference should always be made to the plant manufacturer for accurate information.

2.6 Earth fault protection

The P540 relays include backup earth fault protection. Two elements are available; a derived earth fault element (where the residual current to operate the element is derived from the addition of the three line CT currents) and a sensitive earth fault element (P543, P544, P545 and P546 only) where low current settings are required. The sensitive earth fault element has a separate CT input and would normally be connected to a core balance CT. The derived and sensitive earth fault elements both have four stages of protection. The first two stages can be set either inverse time or definite time only. Each stage can be configured to be directional forward, directional reverse or non-directional (P543, P544, P545 and P546 only).

A feature also exists whereby the protection can be enabled upon failure of the differential protection communication channel (not applicable to sensitive earth fault).

The VTS element of the relay can be selected to either block the directional element or simply remove the directional control.

The earth fault elements will need to be co-ordinated with any other protection elements on the system, in order to provide discriminative fault clearance.

The earth fault and sensitive earth fault menu columns are shown in Tables 14 and 15.

EARTH FAULT	Default Setting	Min	Max	Step
IN>1 Status	Enabled	Disabled, Enabled, Enabled Ch Fail		
IN>1 Function	IEC S Inverse	DT, IEC S Inverse, IEC V Inverse, IEC E Inverse, UK LT Inverse, IEEE M Inverse, IEEE V Inverse, IEEE E Inverse, US Inverse, US ST Inverse		
IN>1 Directional {P543, P544, P545, P546 only}	Non-directional	Non-directional, Directional Fwd, Directional Rev		
IN>1 Current Set	0.2In	0.08In	4.0In	0.01In
IN>1 Time Delay	1s	0s	100s	0.01s
IN>1 TMS	1	0.025	1.2	0.025
IN>1 Time Dial (Software 30 or later)	1	0.1	100	0.05
IN>1 Time Dial	7	0.5	15	0.1
IN>1 Reset Char	DT	DT, Inverse		
IN>1 tRESET	0s	0s	100s	0.01s
IN>2 {Cells as for IN>1 above}	{IN>2 stage is disabled as default}			
IN>3 Status	Disabled	Disabled, Enabled, Enabled Ch Fail		
IN>3 Directional {P543, P544, P545, P546 only}	Non-directional	Non-directional, Directional Fwd, Directional Rev		
IN>3 Current Set	10In	0.08In	32.0In	0.01In
IN>3 Time Delay	0s	0s	200s	0.01s
IN>4 {Cells as for IN>3}				
IN> Function Link {See comment below}	00001111	00000000	11111111	1
IN DIRECTIONAL {P543, P544, P545, P546 only}	{Sub-heading}			
IN Char Angle	-60°	-95°	95°	1°
IN> Polarisation	Zero Sequence	Zero Sequence, Neg Sequence		
IN> Vnpol Set	5V	0.5V	25V	0.5V
IN> V2pol Set	5V	0.5V	25V	0.5V
IN> I2pol Set	0.08In	0.08In	1	0.01In

Table 14. Derived earth fault protection settings

The IN> Function Link settings have the following effect:

VTS Block - When the relevant is set to1, operation of the Voltage Transformer Supervision (VTS) will block the stage if it directionalised. When set to 0 the stage will revert to non-directional upon operation of the VTS.

A/R Block - The autoreclose logic can be set to block instantaneous earthfault elements after a prescribed number of shots. This is set in the autoreclose column. When a block instantaneous signal is generated then only those earthfault stages selected to a '1' in the IN> Function Link will be blocked.

The inverse time characteristic available for the earth fault protection are the same as those for the overcurrent element.

SENSITIVE E/F {P543, P544, P545, P546 only}	Default Setting	Min	Max	Step
Sens E/F Options	SEF Enabled	SEF Enabled, Wattmetric SEF		
ISEF>1 Function	DT	Disabled, DT, IEC S Inverse, IEC V Inverse, IEC E Inverse, UK LT Inverse, IEEE M Inverse, IEEE V Inverse, IEEE E Inverse, US Inverse, US ST Inverse		
ISEF>1 Direction	Non-directional	Non-directional, Directional Fwd, Directional Rev		
ISEF>1 Current	0.05In	0.005In	0.1In	0.00025In
ISEF>1 Time Delay	1s	0s	200s	0.01s
ISEF>1 TMS	1	0.025	1.2	0.025
ISEF>1 Time Dial (Software 30 or later)	1	0.1	100	0.05
ISEF>1 Time Dial	7	0.5	15	0.1
ISEF>1 Reset Chr	DT	DT, Inverse		
ISEF>1 tRESET	0s	0s	100s	0.01s
ISEF>2 {Cells as for ISEF>1 above}	{ISEF>2 stage is disabled as default}			
ISEF>3 Status	Disabled	Disabled, Enabled		
ISEF>3 Directional	Non-directional	Non-directional, Directional Fwd, Directional Rev		
ISEF>3 Current	0.4In	0.005In	0.8In	0.001In
ISEF>3 Time Delay	0.5s	0s	200s	0.01s
ISEF>4 {Cells as for ISEF>3}	ISEF>4 stage is disabled as default			
ISEF> Func Link {See comment below}	00001111	00000000	11111111	1
ISEF DIRECTIONAL	{Sub-heading}			
ISEF Char Angle	-60°	-95°	95°	1°
ISEF> Polarisation	Zero Sequence	Zero Sequence, Neg Sequence		
ISEF> 3VN pol	5V	0.5V	22V	0.5V
Wattmetric SEF	{Sub-heading}			
PN> Setting	9W	0.9In W	20. In W	0.05. In W

Table 15. Sensitive earthfault protection settings

The ISEF> Function Link settings have the following effect:

VTS Block - When the relevant is set to1, operation of the Voltage Transformer Supervision (VTS) will block the stage if it directionalised. When set to 0 the stage will revert to non-directional upon operation of the VTS.

A/R Block - The autoreclose logic can be set to block instantaneous earthfault elements after a prescribed number of shots. This is set in the autoreclose column. When a block instantaneous signal is generated then only those earthfault stages selected to a '1' in the ISEF> Function Link will be blocked.

The inverse time characteristic available for the earth fault protection are the same as those for the overcurrent element.

2.6.1 Directional earth fault protection (P543, P544, P545 and P546 only)

As stated in the previous sections, each of the four stages of earthfault and sensitive earthfault protection may be set to directional if required. Consequently, as with the application of directional overcurrent protection, a suitable voltage supply is required by the relay to provide the necessary polarisation.

With the standard earth fault protection element in the relay (IN>), two options are available for polarisation; Residual Voltage or Negative Sequence.

2.6.1.1 Residual voltage polarisation

With earth fault protection, the polarising signal requires to be representative of the earth fault condition. As residual voltage is generated during earth fault conditions, this quantity is commonly used to polarise DEF elements. The relay internally derives this voltage from the 3 phase voltage input which must be supplied from either a 5-limb or three single phase VTs. These types of VT design allow the passage of residual flux and consequently permit the relay to derive the required residual voltage. In addition, the primary star point of the VT must be earthed. A three-limb VT has no path for residual flux and is therefore unsuitable to supply the relay.

It is possible that small levels of residual voltage will be present under normal system conditions due to system imbalances, VT inaccuracies, relay tolerances etc. Hence, the relay includes a user settable threshold (IN>VNPol Set) which must be exceeded in order for the DEF function to be operational. In practice, the typical zero sequence voltage on a healthy system can be as high as 1% (i.e.: 3% residual), and the VT error could be 1% per phase. This could equate to an overall error of up to 5% of phase-neutral voltage, although a setting between 2% and 4% is typical. On high resistance earthed and insulated neutral systems the settings might need to be as high as 10% or 20% of phase-neutral voltage, respectively. The residual voltage measurement provided in the "Measurements" column of the menu may assist in determining the required threshold setting during the commissioning stage, as this will indicate the level of standing residual voltage present.

Note that residual voltage is nominally 180° out of phase with residual current. Consequently, the DEF relays are polarised from the '-Vres' quantity. This 180° phase shift is automatically introduced within the relay.

2.6.1.2 Negative sequence polarisation

In certain applications, the use of residual voltage polarisation of DEF may either be not possible to achieve, or problematic, in particular applications. An example of the former case would be where a suitable type of VT was unavailable, for example if only a three-limb VT was fitted. An example of the latter case would be an HV/EHV parallel line application where problems with zero sequence mutual coupling may exist.

In either of these situations, the problem may be solved by the use of negative phase sequence (nps) quantities for polarisation. This method determines the fault direction by comparison of nps voltage with nps current. The operate quantity, however, is still residual current.

This is available for selection on the standard earth fault but not on the SEF protection. It requires a suitable voltage and current threshold to be set in cells 'IN> V2pol Set' and 'IN> I2pol Set', respectively.

2.6.2 General setting guidelines for DEF

When setting the relay characteristic angle (RCA) for the directional overcurrent element, a positive angle setting was specified. This was due to the fact that the quadrature polarising voltage lagged the nominal phase current by 90°; i.e. the position of the current under fault conditions was leading he polarising voltage and hence a positive RCA was required. With DEF, the residual current under fault conditions lies at an angle lagging the polarising voltage. Hence, negative RCA settings are required for DEF applications. This is set in cell 'I>Char Angle' in the relevant earth fault menu.

The following angle settings are recommended for residual voltage polarised relay:-

Resistance earthed systems ⇒ 0°

Distribution systems (olidly earthed) ⇒ -45°

Transmissions systems (solidly earthed) ⇒ -60°

For negative sequence polarisation, the RCA settings must be based on the angle of the nps source impedance.

The sensitive earth fault element is also suitable for use on insulated Petersen coil earthed systems. For further information on these applications, please contact ALSTOM GRID.

2.7 Circuit breaker fail protection (CBF)

Following 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/further damage to the power system. For transmission/sub-transmission systems, slow fault clearance can also threaten system stability. It is therefore common practice to install circuit breaker failure protection, 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 (CBF) will operate.

CBF operation can be used to backtrip upstream circuit breakers to ensure that the fault is isolated correctly. CBF operation can also reset all start output contacts, ensuring that any blocks asserted on upstream protection are removed.

In the case of the P544 and P546 two circuit breakers are monitored. If all inputs relevant to each of the circuit breaker's status are available the relay will be able to determine which circuit breaker has failed and act accordingly.

2.7.1 Breaker failure protection configurations

The circuit breaker failure protection incorporates two timers, 'CB Fail 1 Timer' and 'CB Fail 2 Timer', allowing configuration for the following scenarios:

Simple CBF, where only 'CB Fail 1 Timer' is enabled. For any protection trip, the 'CB Fail 1 Timer' is started, and normally reset when the circuit breaker opens to isolate the fault. If breaker opening is not detected, 'CB Fail 1 Timer' times out and closes an output contact assigned to breaker fail (using the programmable scheme logic). This contact is used to backtrip upstream switchgear, generally tripping all infeeds connected to the same busbar section.

A re-tripping scheme, plus delayed backtripping. Here, 'CB Fail 1 Timer' is used to route a trip to a second trip circuit of the same circuit breaker. This requires duplicated circuit breaker trip coils, and is known as re-tripping. Should re-tripping fail to open the circuit breaker, a backtrip may be issued following an additional time delay. The backtrip uses 'CB Fail 2 Timer', which is also started at the instant of the initial protection element trip.

CBF elements 'CB Fail 1 Timer' and 'CB Fail 2 Timer' can be configured to operate for trips triggered by protection elements within the relay or via an external protection trip. The latter is achieved by allocating one of the relay opto-isolated inputs to ‘External Trip’ using the programmable scheme logic.

2.7.2 Reset mechanisms for breaker fail timers

It is common practice to use low set undercurrent elements in protection relays to indicate that circuit breaker poles have interrupted the fault or load current, as required. This covers the following situations:

Where circuit breaker auxiliary contacts are defective, or cannot be relied upon to definitely indicate that the breaker has tripped.

Where a circuit breaker has started to open but has become jammed. This may result in continued arcing at the primary contacts, with an additional arcing resistance in the fault current path. Should this resistance severely limit fault current, the initiating protection element may reset. Thus, reset of the element may not give a reliable indication that the circuit breaker has opened fully.

For any protection function requiring current to operate, the relay uses operation of undercurrent elements (I<) to detect that the necessary circuit breaker poles have tripped and reset the CB fail timers. However, the undercurrent elements may not be reliable methods of resetting circuit breaker fail in all applications.

Resetting of the CBF is possible from a breaker open indication (from the relay’s pole dead logic) or from a protection reset. In these cases resetting is only allowed provided the undercurrent elements have also reset. The resetting options are summarised in the following table.

Initiation (menu-selectable)	CB fail timer reset mechanism
Current based protection - (e.g. 50/51/46/21/87..)	The resetting mechanism is fixed. [IA< operates] & [IB< operates] & [IC< operates] & [IN< operates]
Sensitive earth fault element	The resetting mechanism is fixed. [ISEF< operates]
External protection-	Three options are available. The user can select any or all of the options. [All I< and IN< elements operate] [External trip reset] [All I< and IN< elements operate CB open (all 3 poles) AND [All I< and IN< elements operate]

The selection in the relay menu is grouped as follows:

CB FAIL + I<	Default	Min	Max	Step
Breaker Fail	{Sub-Heading}			
CB Fail 1 Status	Enabled	Enabled, Disabled		
CB Fail 1 Timer	0.2s	0s	10s	0.01s
CB Fail 2 Status	Disabled	Enabled, Disabled		
CB Fail 2 Timer	0.4s	0s	10s	0.01s
CBF Ext Reset	CB Open & I<	I< Only, CB Open & I<, Prot Reset & I<		
Under Current	{Sub-Heading}			
I< Current Set	0.1In	0.02In	3.2In	0.01In
ISEF< Current	0.02In	0.001In	0.8In	0.00025In
Blocked O/C	{Sub-Heading}			
Remove I> Start	Disabled	Enabled, Disabled		
Remove IN> Start	Disabled	Enabled, Disabled		

Table 16.

The ‘Reset I> Start‘ and ‘Reset IN> Start‘ settings are used to remove starts issued from the overcurrent and earth elements respectively following a breaker fail time out. The start is removed when the cell is set to Enabled.

2.7.3 Typical settings

2.7.3.1 Breaker fail timer settings

Typical timer settings to use are as follows:

CB Fail Reset mechanism	tBF time delay	Typical delay for 2½ cycle circuit breaker
Initiating element reset	CB interrupting time + element reset time (max.) + error in tBF timer + safety margin	50+50+10+50 = 160 ms
CB open	CB auxiliary contacts opening/closing time (max) + error in tBF timer + safety margin	50+10+50 = 110 ms
Undercurrent elements	CB interrupting time + undercurrent element operating time (max) + safety margin	50+12+50 = 125 ms

Table 17.

Note that all CB Fail resetting involves the operation of the undercurrent elements. Where element reset or CB open resetting is used the undercurrent time setting should still be used if this proves to be the worst case.

The examples above consider direct tripping of a 2½ cycle circuit breaker. Note that where auxiliary tripping relays are used, an additional 10-15 ms must be added to allow for trip relay operation.

2.7.3.2 Breaker fail undercurrent settings

The phase undercurrent settings (I<) must be set less than load current, to ensure that I< operation indicates that the circuit breaker pole is open. A typical setting for overhead line or cable circuits is 20% In, with 5% In common for generator circuit breaker CBF.

The sensitive earth fault protection (SEF) undercurrent element must be set less than the respective trip setting, typically as follows:

ISEF< = (ISEF> trip) / 2

2.8 Broken conductor detection

The majority of faults on a power system occur between one phase and ground or two phases and ground. These are known as shunt faults and arise from lightning discharges and other overvoltages which initiate flashovers. Alternatively, they may arise from other causes such as birds on overhead lines or mechanical damage to cables etc. Such faults result in an appreciable increase in current and hence in the majority of applications are easily detectable.

Another type of unbalanced fault that can occur on the system is the series or open circuit fault. These can arise from broken conductors, maloperation of single phase switchgear, or single-phasing of fuses. Series faults will not cause an increase in phase current on the system and hence are not readily detectable by standard protection. However, they will produce an unbalance and a resultant level of negative phase sequence current, which can be detected.

It is possible to apply a negative phase sequence overcurrent relay to detect the above condition. However, on a lightly loaded line, the negative sequence current resulting from a series fault condition may be very close to, or less than, the full load steady state unbalance arising from CT errors, load unbalance etc. A negative sequence element therefore would not operate at low load levels.

The relay incorporates an element which measures the ratio of negative to positive phase sequence current (I2/I1). This will be affected to a lesser extent than the measurement of negative sequence current alone, since the ratio is approximately constant with variations in load current. Hence, a more sensitive setting may be achieved.

2.8.1 Setting guidelines

When a conductor open circuit occurs, current from the positive sequence network will be series injected into the negative and zero sequence networks across the break.

In the case of a single point earthed power system, there will be little zero sequence current flow and the ratio of I2/I1 that flows in the protected circuit will approach 100%. In the case of a multiple earthed power system (assuming equal impedances in each sequence network), the ratio I2/I1 will be 50%.

It is possible to calculate the ratio of I2/I1 that will occur for varying system impedances, by referring to the following equations:-

$$I1F = \frac{Eg\,(Z_2 + Z_0)}{Z_1 Z_2 + Z_1 Z_0 + Z_2 Z_0}$$

$$I2F = \frac{-Eg\,Z_0}{Z_1 Z_2 + Z_1 Z_0 + Z_2 Z_0}$$

where;

Eg = System voltage

Z0 = Zero sequence impedance

Z1 = Positive sequence impedance

Z2 = Negative sequence impedance

Therefore;

$$\frac{I2F}{I1F} = \frac{Z_0}{Z_0 + Z_2}$$

It follows that, for an open circuit in a particular part of the system, I2/I1 can be determined from the ratio of zero sequence to negative sequence impedance. It must be noted however, that this ratio may vary depending upon the fault location. It is desirable therefore to apply as sensitive a setting as possible. In practice, this minimum setting is governed by the levels of standing negative phase sequence current present on the system. This can be determined from a system study, or by making use of the relay measurement facilities at the commissioning stage. If the latter method is adopted, it is important to take the measurements during maximum system load conditions, to ensure that all single phase loads are accounted for.

Note that a minimum value of 8% negative phase sequence current is required for successful relay operation.

Since sensitive settings have been employed, it can be expected that the element will operate for any unbalance condition occurring on the system. Hence, a long time delay is necessary to ensure co-ordination with other protective devices. A 60 second time delay setting may be typical.

Note that during a single pole open condition, which would occur for single phase tripping/reclosing applications, the broken conductor protection is disabled.

Table 17 overleaf shows the relay menu for the Broken Conductor protection, including the available setting ranges and factory defaults:-

MENU TEXT	DEFAULT SETTING	SETTING RANGE		STEP SIZE
		MIN	MAX	
GROUP 1 BROKEN CONDUCTOR				
Broken Conductor	Disabled	Enabled/Disabled		N/A
I2/I1	1	0.2	1	0.01
I2/I1 Time Delay	0	0s	100s	1s

Table 18.

2.8.2 Example setting

The following information was recorded by the relay during commissioning;

$I_{full\ load}$ = 1000A

I2/I1= 50A

therefore the quiescent I2/I1 ratio is given by;

I2/I1 = 50/1000 = 0.05

To allow for tolerances and load variations a setting of 200% of this value may be typical: Therefore set I2/I1 = 0.1

Set I2/I1 Time Delay = 60s to allow adequate time for short circuit fault clearance by time delayed protections.

2.9 Intertripping facilities

2.9.1 Permissive Intertrip

The P540 relays include a facility to send a permissive intertrip command over the protection communication channel, as shown in Figure 23 overleaf.

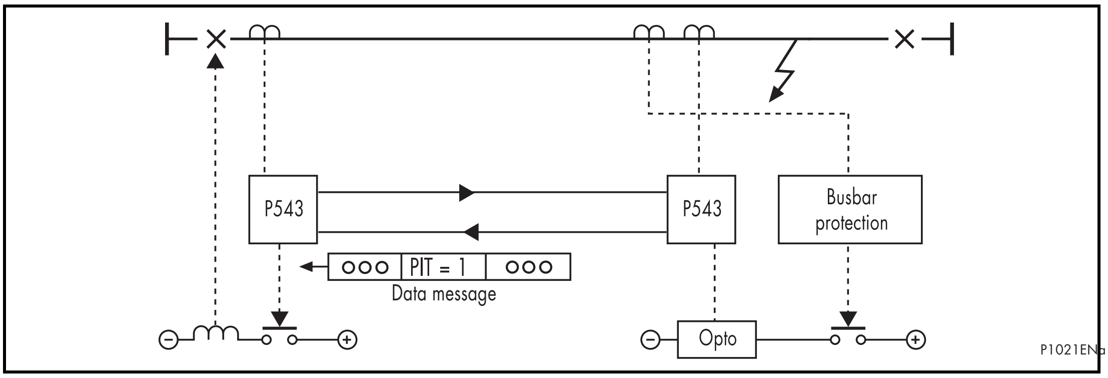


Figure 23: Permissive intertrip

An opto input can be assigned for this purpose. When energised, the PIT flag is set in the communication message. Upon receipt of this message the remote relay initiates a timer which, when the timer, providing that the current at this end is above it's basic current threshold setting (Is1), times out, the relay closes it's three phase differential trip contacts. The remote relay provides indication of the permissive intertrip.

The permissive intertrip timer is settable between 0 and 200ms. This time should be set to provide discrimination with other protection. For example, in Figure 23, the time delay should be set to allow the busbar protection to clear the fault in the event of a genuine busbar fault. A typical setting may be 100 - 150ms.

2.9.2 User Defined Intertrip/Inter-Relay Commands

The P540 relays include a facility to send 8 user defined commands per channel over the protection communication channel.

These commands can be used for direct intertripping as explained below or alternatively can be used for applications such as distance and DEF aided channel schemes, breaker fail backtripping to upstream circuit breakers, forcing remote end autoreclosing for successful local autoreclosure or providing SCADA information from the remote end substation. In such applications the functionality of each of the 8 bits in P540 relay's data message is programmed in the programmable scheme logic (PSL). The logic condition to assert a logic "1" for transmitting each bit, and the response of the relay upon receipt of an active bit must both be set.

2.9.2.1 Direct intertrip

This is an example of user defined intertripping. The P540 relays include a facility to send a direct intertrip command over the protection communication channel as shown in Figure 24.

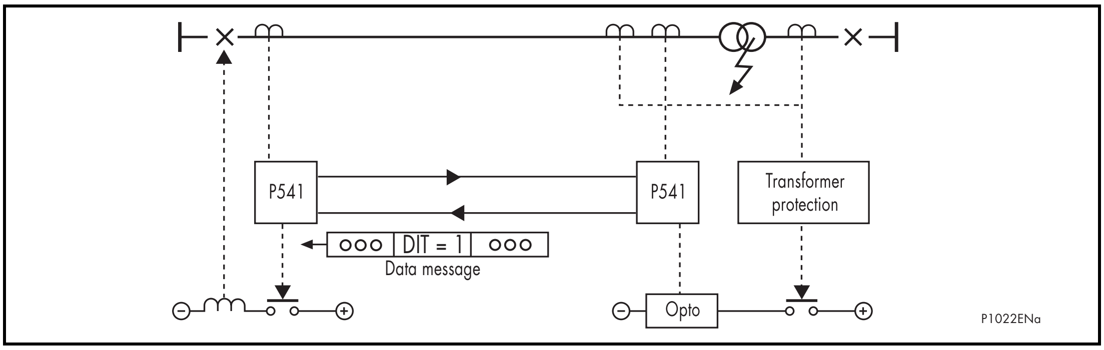


Figure 24: Direct intertrip

An opto input can be assigned for this purpose. When energised, the DIT flag is set in the communication message. Upon receipt of this message the remote relay will operate a user specified output contact. The remote relay will also provide indication of the direct intertrip. Indication at the local terminal would be provided by the initiating device.

3. APPLICATION OF NON PROTECTION FUNCTIONS

3.1 Three phase auto-reclosing (applicable to P542)

An analysis of faults on any overhead line network has shown that 80-90% are transient in nature.

A transient fault, such as an insulator flash-over, is a self clearing ‘non-damage’ fault. This type of fault can be cleared by the immediate tripping of one or more circuit breakers to isolate the fault, and does not recur when the line is re-energised. Lightning is the most common cause of transient faults, other possible causes being clashing conductors and wind blown debris. The remaining 10 - 20% of faults are either semi-permanent or permanent.

A semi-permanent fault could be caused by a small tree branch falling on the line. Here the cause of the fault would not be removed by the immediate tripping of the circuit, but could be burnt away during a time delayed trip.

Permanent faults could be broken conductors, transformer faults, cable faults or machine faults which must be located and repaired before the supply can be restored.

In the majority of fault incidents, if the faulty line is immediately tripped out, and time is allowed for the fault arc to de-ionise, reclosure of the circuit breakers will result in the line being successfully re-energised. Autoreclose schemes are employed to automatically reclose a switching device a set time after it has been opened due to operation of protection, where transient and semi-permanent faults are prevalent.

On HV/MV distribution networks, autoreclosing is applied mainly to radial feeders where system stability problems do not generally arise. The main advantages to be derived from using autoreclose can be summarised as follows:

- Minimises interruptions in supply to the consumer.
- Reduces operating costs - less man hours in repairing fault damage and the possibility of running substations unattended. With autoreclose instantaneous protection can be used which means shorter fault duration’s which gives rise to less fault damage and fewer permanent faults.

As 80% of overhead line faults are transient, elimination of loss of supply from such faults, by the introduction of autoreclosing gives obvious benefits. Furthermore, auto-reclosing may allow a particular substation to be run unattended. In the case of unattended substations, the number of visits by personnel to reclose a circuit breaker manually after a fault can be substantially reduced, an important consideration for substations in remote areas.

The introduction of autoreclosing gives an important benefit on circuits using time graded protection, in that it allows the use of instantaneous protection to give a high speed first trip. With fast tripping, the duration of the power arc resulting from an overhead line fault is reduced to a minimum, thus lessening the chance of damage to the line, which might otherwise cause a transient fault to develop into a permanent fault. Using instantaneous protection also prevents blowing of fuses in teed circuits and reduces circuit breaker maintenance by eliminating pre-arc heating when clearing transient faults.

It should be noted that when instantaneous protection is used with autoreclosing, the scheme is normally arranged to block the instantaneous protection after the first trip. Therefore, if the fault persists after reclosure, the time graded protection will give discriminative tripping with fuses or other protection devices, resulting in the isolation of the faulted section. However, for certain applications, where the majority of the faults are likely to be transient, it is not uncommon to allow more than one instantaneous trip before the instantaneous protection is blocked.

Some schemes allow a number of reclosures and time graded trips after the first instantaneous trip, which may result in the burning out and clearance of the semi-permanent faults. Such a scheme may also be used to allow fuses to operate in teed feeders where the fault current is low.

When considering feeders which are partly overhead line and partly underground cable, any decision to install auto-reclosing would be influenced by any data known on the frequency of transient faults. When a significant proportion of the faults are permanent, the advantages of auto-reclosing are small, particularly since reclosing on to a faulty cable is likely to aggravate the damage.

The following table shows the relay settings for the auto-reclose function, including the available setting ranges and factory defaults:-

MENU TEXT	DEFAULT SETTING	SETTING RANGE		STEP SIZE
		MIN	MAX	
CB CONTROL				
AR Telecontrol	No Operation (Control Cell)	Auto/Non Auto		
AR Status	Auto	Auto/ Non Auto	Indicates if AR is enabled or not, as selected by AR Telecontrol	
Total Reclosures	X		Total number of AR closures performed by the relay	
Reset Total A/R	No (Control Cell)		No/Yes	
GROUP 1: AUTORECLOSE				
Number of Shots	1	1	4	1
Dead Time 1	10s	0.01s	300s	0.01s
Dead Time 2	60s	0.01s	300s	0.01s
Dead Time 3	180s	0.01s	9999s	0.01s
Dead Time 4	180s	0.01s	9999s	0.01s
CB Healthy Time	5s	0.01s	9999s	0.01s
tReclaim Extend	Continue	Suspend/Continue		
Reclaim Time	180s	1s	600s	0.01s
AR Inhibit Time	5s	0.01s	600s	0.01s
EFF Maint Lock	Allow Tripping	Allow Tripping/ Block Tripping		
Trip 1 Main	No Block	No Block/ Block Inst Prot		
Trip 2 Main	Block Inst Prot	No Block/Block Inst Prot		
Trip 3 Main	Block Inst Prot	No Block/ Block Inst Prot		
Trip 4 Main	Block Inst Prot	No Block/ Block Inst Prot		
Trip 5 Main	Block Inst Prot	No Block/ Block Inst Prot		
Reset Lockout by	User Interface	User Interface, Select NonAuto		
AR INITIATION	Sub Heading			
Phase Diff AR	Initiate AR	No Action/Initiate AR/Block AR		
Neutral Diff AR	No Action	No Action/Initiate AR/Block AR		
I>1 AR	No Action	No Action/Initiate AR/Block AR		
I>2 AR	No Action	No Action/Initiate AR/Block AR		
I>3 AR	No Action	No Action/Initiate AR/Block AR		
I>4 AR	No Action	No Action/Initiate AR/Block AR		
IN>1 AR	No Action	No Action/Initiate AR/Block AR		
IN>2 AR	No Action	No Action/Initiate AR/Block AR		
IN>3 AR	No Action	No Action/Initiate AR/Block AR		
IN>4 AR	No Action	No Action/Initiate AR/Block AR		

Table 19.

In addition to these settings, function links in the OVERCURRENT AND EARTH FAULT columns are also required to fully integrate the autoreclose logic in the relay. Refer to the relevant sections in this manual.

CB Status signals must also be available within the relay.

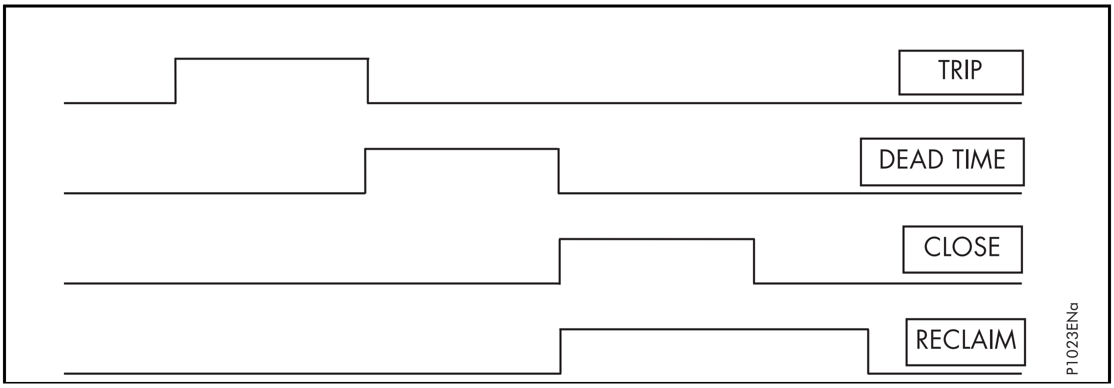


Figure 25: P542 Auto Reclose Timing Diagram

3.1.1 Logic functions

3.1.1.1 Opto-isolated logic inputs

The autoreclose function uses three inputs in the logic, which can be allocated to any of the opto-isolated inputs on the relay via the programmable scheme logic. Contacts from external equipment may be used to influence the auto-recloser via such inputs. The function of these inputs is described below, identified by their DDB signal text.

The inputs can be selected to accept either a normally open or a normally closed contact, programmable via the PSL editor.

3.1.1.1.1 CB healthy

The majority of circuit breakers are only capable of providing one trip-close-trip cycle. Following this, it is necessary to re-establish sufficient energy in the circuit breaker before the CB can be reclosed. The DDB 296: CB Healthy input is used to ensure that there is sufficient energy available to close and trip the CB before initiating a CB close command. If on completion of the dead time, sufficient energy is not detected by the relay from the DDB 296: CB Healthy input for a period given by the CB Healthy time timer, lockout will result and the CB will remain open.

This check can be disabled by not allocating an opto input to this function, and deliberate application of a logic "1" onto this DDB signal within the PSL. Assigning a PSL gate with no inputs and an inverted output will mean that the signal is always high, and the circuit breaker deemed to be "healthy". Alternatively, it is possible to energise the CB healthy opto input from a circuit breaker open auxiliary contact (52b).

3.1.1.1.2 BAR

The DDB 308: BAR input will block autoreclose and cause a lockout if autoreclose is in progress. It can be used when protection operation without autoreclose is required. A typical example is on a transformer feeder, where autoreclosing may be initiated from the feeder protection but blocked from the transformer protection.

3.1.1.1.3 Reset lockout

The DDB 306: Reset Lockout input can be used to reset the autoreclose function following lockout and reset any autoreclose alarms, provided that the signals which initiated the lockout have been removed.

3.1.1.2 Autoreclose logic outputs

The following DDB signals can be masked to a relay contact in the PSL or assigned to a Monitor Bit in Commisioning Tests, to provide information about the status of the autoreclose cycle. These are described below, identified by their DDB signal text.

3.1.1.2.1 AR in progress

The DDB 531: AR 3 pole in Progress signal is present during the complete reclose cycle from initiation to the end of the reclaim time.

3.1.1.2.2 Successful close

The DDB 539: Successful Close output indicates that an autoreclose cycle has been successfully completed. A successful autoreclose signal is given after the CB has tripped from the protection and reclosed whereupon the fault has been cleared and the reclaim time has expired resetting the autoreclose cycle. The successful autoreclose output is reset at the next CB trip or from one of the reset lockout methods; see Section 3.1.3.6.1 'Reset from lockout'.

3.1.1.2.3 AR status

The DDB 542: AR Status output indicates whether the autoreclose is in or out of service. Autoreclose is in service when the relay is in Auto mode and out of service when in the Non Auto mode.

3.1.1.2.4 Block main prot

The DDB 529: Block Main Prot output indicates that the instantaneous protection (I>3, I>4, IN>3, IN>4) is being blocked by the autoreclose logic during the autoreclose cycle. Blocking of the instantaneous stages for each trip of the autoreclose cycle is programmed using the Overcurrent and Earth Fault function link settings, I> Function Link, IN> Func Link and the Trip 1/2/3/4/5 Main settings.

3.1.1.2.5 Dead T in prog

The DDB 540: Dead T in Prog output indicates that the dead time is in progress. This signal may be useful during relay commissioning to check the operation of the autoreclose cycle.

3.1.1.2.6 Auto-close

The DDB 541: Auto Close output indicates that the autoreclose logic has issued a close signal to the CB. This output feeds a signal to the control close pulse timer and remains on until the CB has closed. This signal may be useful during relay commissioning to check the operation of the autoreclose cycle.

3.1.1.3 Auto reclose alarms

The following DDB signals will produce a relay alarm. These are described below, identified by their DDB signal text.

3.1.1.3.1 AR CB unhealthy (latched)

The DDB 164: AR CB Unhealthy alarm indicates that the DDB 296: CB Healthy input was not energised at the end of the CB Healthy Window time, leading to a lockout condition. The DDB 296: CB Healthy input is used to indicate that there is sufficient energy in the CB operating mechanism to close and trip the CB at the end of the dead time. This alarm can be reset using one of the reset lockout methods; see Section 3.1.3.6.1 'Reset from lockout'.

3.1.1.3.2 AR lockout (self reset)

The DDB163: AR Lockout alarm indicates that the relay is in a lockout status and that further reclose attempts will not be made; see Section 3.1.3.6 'AR Lockout' for more details. This alarm can be reset using one of the reset lockout methods; see Section 3.1.3.6.1 'Reset from lockout'.

3.1.2 Auto-reclose logic operating sequence

The autoreclose function provides multishot three phase autoreclose control. It can be adjusted to perform a single shot, two shot, three shot or four shot cycle, selectable via Number of Shots. Dead times for all shots (reclose attempts) are independently adjustable. The number of shots is directly related to the type of faults likely to occur on the system and the voltage level of the system. Generally, on medium voltage networks where the percentage of transient and semi-permanent faults is likely to be high, a multi-shot autoreclose device will increase the possibility of the distribution line being successfully re-energised following reclosure of the circuit breaker. For more information, please refer to Section 3.1.4 'Setting guidelines'.

An autoreclose cycle is internally initiated by operation of a protective element, provided the circuit breaker is closed until the instant of protection operation. The dead time (Dead Time 1, Dead Time 2, Dead Time 3, Dead Time 4) starts when the protection has reset. At the end of the relevant dead time, a CB close signal is given, provided system conditions are suitable. The system conditions to be met for closing are that the system voltages are in synchronism, from the internal check synchronising element and that the circuit breaker closing spring, or other energy source, is fully charged indicated from the DDB 296: CB Healthy input. The CB close signal is cut-off when the circuit breaker closes.

When the CB has closed the reclaim time (Reclaim Time) starts. If the circuit breaker does not trip again, the autoreclose function resets at the end of the reclaim time. If the protection operates during the reclaim time the relay either advances to the next shot in the programmed autoreclose cycle, or, if all programmed reclose attempts have been made, goes to lockout.

The total number of autoreclosures is shown in the CB Control menu under Total Reclosures. This value can be reset to zero with the Reset Total A/R command.

For more information please refer to setting guidelines.

3.1.3 Main operating features

3.1.3.1 Operation modes

The autoreclose function has two operating modes:

1. AUTO Autoreclose is in service
2. NON AUTO Autoreclose is out of service

A/R Telecontrol, under the CB CONTROL column, can be used to temporarily disable the autoreclose function, as may be required during CB maintenance. This is achieved by setting A/R Telecontrol to Non-Auto. Autoreclose can be re-enabled by setting A/R Telecontrol to Auto.

The enabled/disabled status of the autoreclose function can be checked by viewing the AR Status cell under the CB CONTROL column.

3.1.3.2 Autoreclose initiation

Autoreclose is initiated from the internal protection on the relay. Each stage of overcurrent and earth fault protection can be programmed to initiate autoreclose, Initiate AR, not initiate autoreclose, No Action, or for high set instantaneous stages, block autoreclose, Block AR. High set instantaneous protection may be used to indicate a transformer fault on a transformer feeder and so be set to Block AR. For example if I>1 is set to Initiate Main AR, operation of the I>1 protection stage will initiate autoreclose; if IN>1 is set to No Action, operation of the IN>1 protection stage will lead to a CB trip but no reclose.

A selection must be made for each protection stage that is enabled.

3.1.3.3 Blocking instantaneous protection during autoreclose cycle

Instantaneous protection may be blocked during each for each trip in the autoreclose cycle. This is selected using the Trip 1/2/3/4/5 Main settings. These allow the Instantaneous elements of phase and earth fault protection to be selectively disabled for a CB trip sequence. For example, if Trip 1 Main is set to No Block and Trip 2 Main is set to Block Inst Prot, the instantaneous elements of the phase and earth fault protection will be enabled during normal healthy line conditions but will be blocked for the first shot of autoreclose following a protection operation.

Instantaneous protection can also be blocked when the CB maintenance lockout counter or excessive fault frequency lockout has reached its penultimate value. For example, if No. CB Ops Lock is set to 100 and the CB Operations = 99, the instantaneous protection can be blocked to ensure that the last CB trip before lockout will be due to discriminative protection operation. This is controlled using the EFF Maint Lock setting, if this is set to

Block Inst Protection the instantaneous protection will be blocked for the last CB Trip before lockout occurs.

Note: The instantaneous protection stages must be identified in the Overcurrent, Earth Fault function link settings, I> Function Link, IN> Func Link, respectively.

3.1.3.4 Reclaim timer initiation

The tReclaim on Strt setting allows the user to control whether the timer is suspended from the protection element start or not. When a setting of Continue is used the Reclaim Timer will operate from the instant that the CB is closed and will continue until the timer expires. The Reclaim Time must, therefore, be set in excess of the time delayed protection operating time to ensure that the time delayed protection can operate before the autoreclose function is reset. If the autoreclose function resets before the time delayed protection has operated instantaneous protection could be re-enabled and discriminating tripping lost.

For certain applications it is advantageous to set tReclaim on Strt to Suspend. This facility allows the operation of the reclaim timer to be suspended, after CB reclosure, by a signal from the main protection start or SEF protection start signals. The main protection start signal is initiated from the start of any protection which has been selected to Initiate AR (initiate autoreclose) or No Action (not initiate autoreclose) from the AR Initiation settings. This feature ensures that the reclaim time cannot time out and reset the autoreclose before the time delayed protection has operated. Since the Reclaim Timer will be suspended, it is unnecessary to use a timer setting in excess of the protection operating time, therefore a short reclaim time can be used. Short reclaim time settings can help to prevent unnecessary lockout for a succession of transient faults in a short period, for example during a thunderstorm. For more information, please refer to Section 3.1.4 ‘Setting guidelines’.

3.1.3.5 Autoreclose inhibit following manual close

The "AR Inhibit Time" timer setting can be used to prevent autoreclose being initiated when the CB is manually closed onto a fault. Autoreclose is disabled for the AR Inhibit Time following manual CB Closure.

3.1.3.6 AR lockout

If protection operates during the reclaim time, following the final reclose attempt, the relay will be driven to lockout and the autoreclose function will be disabled until the lockout condition is reset. This will produce an alarm, DDB163: AR Lockout. The DDB 308: BAR input will block autoreclose and cause a lockout if autoreclose is in progress.

Lockout will also occur if the CB energy is low and the CB fails to close, i.e. the CB Healthy input has not operated at the end of the CB Healthy Time (see section 3.1.1.1.1), as indicated by DDB 164: AR CB Unhealthy alarm.

Note: Lockout can also be caused by the CB condition monitoring functions maintenance lockout, excessive fault frequency lockout, broken current lockout, CB failed to trip and CB failed to close and manual close no check synchronism and CB unhealthy.

3.1.3.6.1 Reset from lockout

The DDB 188: Reset Lockout input can be used to reset the autoreclose function following lockout and reset any autoreclose alarms, provided that the signals which initiated the lockout have been removed. Lockout can also be reset from the clear key or the CB CONTROL command Lockout Reset.

The Reset Lockout by setting, CB Close/ User interface in CB CONTROL is used to enable/ disable reset of lockout automatically from a manual close after the manual close time AR Inhibit Time.

3.1.4 Setting guidelines

3.1.4.1 Number of shots

There are no clear-cut rules for defining the number of shots for any particular application. In general, medium voltage systems utilise only two or three shot autoreclose schemes. However in certain countries, for specific applications, four shots is not uncommon. Four shots have the advantage that the final dead time can be set sufficiently long to allow any thunderstorms to pass before reclosing for the final time, this arrangement will prevent unnecessary lockout for consecutive transient faults.

Typically, the first trip, and sometimes the second, will result from instantaneous protection - since 80% of faults are transient, the subsequent trips will be time delayed, all with increasing dead times to clear semi-permanent faults.

In order to determine the required number of shots the following factors must be taken into account;

- An important consideration is the ability of the circuit breaker to perform several trip close operations in quick succession and the effect of these operations on the maintenance period.
- If statistical information on a particular system shows a moderate percentage of semi-permanent faults which could be burned out, two or more shots are justified. In addition to this, if fused 'tees' are used and the fault level is low, the fusing time may not discriminate with the main I.D.M.T. relay and it would then be useful to have several shots. This would warm up the fuse to such an extent that it would eventually blow before the main protection operated.

3.1.4.2 Dead timer setting

The factors which influence the choice of dead timer setting are detailed next.

3.1.4.2.1 Load

Due to the great diversity of load which may exist on a system it may prove very difficult to arrive at an optimum dead time. However, it is possible to address each type of load individually and thereby arrive at typical dead time. The most common types of load are addressed below;

Synchronous motors are only capable of tolerating extremely short interruptions of supply without loss of synchronism. In practice it is desirable to disconnect the motor from the supply in the event of a fault; the dead time should be sufficient to allow the motor no-volt device to operate. Typically, a minimum dead time of 0.2-0.3 seconds has been suggested to allow this device to operate. Induction motors, on the other hand, can withstand supply interruptions, up to a maximum of 0.5 seconds and re-accelerate successfully. In general dead times of 3-10 seconds are normally satisfactory, but there may be special cases for which additional time is required to permit the resetting of manual controls and safety devices.

Loss of supply to lighting circuits, such as street lighting may be important for safety reasons as intervals of 10 seconds or more may be dangerous for road traffic. The main considerations for domestic customers are those of inconvenience. An important measurement criteria for many power utilities is the number of minutes lost per year to customers which will be reduced on feeders using autoreclose and will also be affected by the dead time settings used.

These are only suggested guidelines, for more information please refer to the Network Protection and Automation Guide (NPAG).

3.1.4.2.2 Circuit breaker

For high speed autoreclose the minimum dead time of the power system will depend on the minimum time delays imposed by the circuit breaker during a tripping and reclosing operation.

Since a circuit breaker is a mechanical device, it will have an inherent contact separation time. This operating time for a modern circuit breaker is usually within the range of 50-100ms, but could be longer with older designs.

After tripping, time must be allowed for the mechanism to reset before applying a closing pulse. This resetting time will vary depending on the circuit breaker, but is typically 0.1 seconds.

Once the circuit breaker has reset, the breaker can begin to close. The time interval between the energisation of the closing mechanism and the making of the contacts is termed the closing time. Owing to the time constant of the solenoid closing mechanism and the inertia of the plunger, a solenoid closing mechanism may take 0.3s. A spring operated breaker, on the other hand, can close in less than 0.2 seconds.

Where high speed reclosing is required, for the majority of medium voltage applications, the circuit breaker mechanism itself dictates the minimum dead time. However, the fault de-ionising time may also have to be considered. High speed autoreclose may be required to maintain stability on a network with two or more power sources. For high speed autoreclose the system disturbance time should be minimised by using fast protection, <50 ms, such as distance or feeder differential protection and fast circuit breakers < 100 ms. Fast fault clearance can reduce the required fault arc de-ionising time. For stability between two sources a dead time of <300 ms may typically be required. The minimum system dead time only considering the CB is the mechanism reset time plus the CB closing time. A solenoid mechanism will not be suitable for high speed autoreclose as the closing time is generally too long.

3.1.4.2.3 Fault de-ionising time

For high speed autoreclose the fault de-ionising time may be the most important factor when considering the dead time. This is the time required for ionised air to disperse around the fault position so that the insulation level of the air is restored. This can be approximated from:

De-ionising time = (10.5 + ((system voltage in kV) / 34.5)) / frequency

For 66 kV = 0.25 s (50Hz)

For 132 kV = 0.29 s (50 Hz)

3.1.4.2.4 Protection reset

It is essential that the protection fully resets during the dead time, so that correct time discrimination will be maintained after reclosure onto a fault. For high speed autoreclose instantaneous reset of protection is required.

Typical 11/ 33kV dead time settings in the UK are as follows;

1st dead time = 5 - 10 seconds

2nd dead time = 30 seconds

3rd dead time = 60 - 100 seconds

4th dead time = 60 - 100 seconds
(uncommon in the UK, however elsewhere such as in South Africa)

3.1.4.3 Reclaim timer setting

A number of factors influence the choice of the reclaim timer, such as;

Supply continuity - Large reclaim times can result in unnecessary lockout for transient faults.

Fault incidence/Past experience - Small reclaim times may be required where there is a high incidence of lightning strikes to prevent unnecessary lockout for transient faults.

Spring charging time - For high speed autoreclose the reclaim time may be set longer than the spring charging time to ensure there is sufficient energy in the circuit breaker to perform a trip-close-trip cycle. For delayed autoreclose there is no need as the dead time can be extended by an extra CB healthy check window time if there is insufficient energy in the CB. If there is insufficient energy after the check window time the relay will lockout.

Switchgear Maintenance - Excessive operation resulting from short reclaim times can mean shorter maintenance periods. A minimum reclaim time of >5s may be needed to allow the CB time to recover after a trip and close before it can perform another trip-close-trip cycle. This time will depend on the duty (rating) of the CB.

The reclaim time must be long enough to allow any time delayed protection initiating autoreclose to operate. Failure to do so would result in premature resetting of the autoreclose scheme and re-enabling of instantaneous protection. If this condition arose, a permanent fault would effectively look like a number of transient faults, resulting in continuous autoreclosing unless additional measures were taken to overcome this such as excessive fault frequency lockout protection. It is possible to have short reclaim times by blocking the reclaim time from the protection start signals. If short reclaim times are to be used then the switchgear rating may dictate the minimum reclaim time. The advantage of a short reclaim time is that there are less lockouts of the CB, however, there will be more CB operations and so maintenance periods would be reduced.

Where motor-wound spring closed circuit breakers are used, the reclaim time must be at least as long as the spring winding time for high speed autoreclose to ensure that the breaker can perform a trip-close-trip cycle.

A typical 11/33kV reclaim time in the UK is 5-10 seconds, this prevents unnecessary lockout during thunderstorms. However, times upto 60-180 seconds may be used elsewhere in the world.

3.2 Single and three phase auto-reclosing (applicable to P543 & P545)

3.2.1 Time Delayed and High speed auto-reclosing

An analysis of faults on any overhead line network has shown that 80-90% are transient in nature.

A transient fault, such as an insulator flash-over, is a self clearing ‘non-damage’ fault. This type of fault can be cleared by the immediate tripping of one or more circuit breakers to isolate the fault, and does not recur when the line is re-energised. Lightning is the most common cause of transient faults, other possible causes being clashing conductors and wind blown debris. The remaining 10 - 20% of faults are either semi-permanent or permanent.

In the majority of fault incidents, if the faulty line is immediately tripped out, and time is allowed for the fault arc to de-ionise, reclosure of the circuit breakers will result in the line being successfully re-energised. Autoreclose schemes are employed to automatically reclose a switching device a set time after it has been opened due to operation of protection, where transient and semi-permanent faults are prevalent.

On HV/MV distribution networks, autoreclosing is applied mainly to radial feeders where system stability problems do not generally arise.

Considerations for time delayed three phase autoreclose dead times include the disconnection of the load (particularly motors), circuit breaker closing capabilities and protection reset times.

As with distribution systems, the principal benefit gained by the application of autoreclosing to overhead line feeders is improved supply continuity and possibly reduced costs since fewer personnel may be required. On some systems the application of high speed autoreclose may permit a higher level of power transfer while retaining transient stability for most faults which are likely to occur. High speed single phase autoreclosure can offer increased benefits over high speed three phase autoreclosure in terms of a higher power transfer limit and reduced stress on reclosing.

3.2.2 Relay settings

The following table shows the relay settings for the P543 & P545 auto-reclose function, including the available setting ranges and factory defaults.

MENU TEXT	DEFAULT SETTING	SETTING RANGE		STEP SIZE
		MIN	MAX	
CB CONTROL				
Single Pole A/R	Disabled	Enabled/Disabled		
Three Pole A/R	Enabled	Enabled/Disabled		
AR Status	In Service	In Service/	Indicates if Single or Three	
		Out of Service	Pole AR is enabled or not	
Total Reclosures	x	Total number of AR closures performed by the relay		
Reset Total A/R	No (Control Cell)	No/Yes		
GROUP 1 AUTORECLOSE				
Single Pole Shot	1	1	4	1
Three Pole Shot	1	1	4	1
1 Pole Dead Time	0.5s	0.2s	5s	0.01s
Dead Time 1	0.3s	0.2s	30s	0.01s
Dead Time 2	60s	1s	1800s	1s
Dead Time 3	180s	1s	3600s	1s
Dead Time 4	180s	1s	3600s	1s
CB Healthy Time	5s	1s	3600s	1s
Reclaim Time	180s	1s	600s	1s
AR Inhibit Time	5s	0.01s	600s	0.01s
Check Sync Time	5s	0.01s	9999s	0.01s
Sys Chk on Shot 1(called C/S on 3ph fast on software 13 or previous)	Disabled	Enabled/Disabled		
Phase Diff AR	Initiate AR	No Action/Initiate AR/Block AR		
Z1 AR	Initiate AR	No Action/Initiate AR/Block AR		
Z2T AR	No Action	No Action/Initiate AR/Block AR		
Z3T AR	No Action	No Action/Initiate AR/Block AR		
I>1 AR	No Action	No Action/Initiate AR/Block AR		
I>2 AR	No Action	No Action/Initiate AR/Block AR		
I>3 AR	No Action	No Action/Initiate AR/Block AR		
I>4 AR	No Action	No Action/Initiate AR/Block AR		
IN>1 AR	No Action	No Action/Initiate AR/Block AR		
IN>2 AR	No Action	No Action/Initiate AR/Block AR		
IN>3 AR	No Action	No Action/Initiate AR/Block AR		
IN>4 AR	No Action	No Action/Initiate AR/Block AR		
ISEF>1 AR	No Action	No Action/Initiate AR/Block AR		
ISEF>2 AR	No Action	No Action/Initiate AR/Block AR		
ISEF>3 AR	No Action	No Action/Initiate AR/Block AR		
ISEF>4 AR	No Action	No Action/Initiate AR/Block AR		
Multi Phase AR	BAR 3 Phase	Allow AR/BAR 2&3 Phase/BAR 3 Phase		
Dead Time Start	Protection Op	Protection Op/Protection Reset		

MENU TEXT	DEFAULT SETTING	SETTING RANGE		STEP SIZE
		MIN	MAX	
Discrim Time (software 20 and onwards)	0.1s	0.1s	5s	0.01s
CheckSync1 Close (software 20 and onwards)	Enabled	Disabled/Enabled		
CheckSync2 Close (software 20 and onwards)	Disabled	Disabled/Enabled		
LiveLine/DeadBus (software 20 and onwards)	Enabled	Disabled/Enabled		
DeadLine/LiveBus (software 20 and onwards)	Enabled	Disabled/Enabled		
DeadLine/DeadBus (software 20 and onwards)	Disabled	Disabled/Enabled		
CS AR Immediate (software 20 and onwards)	Disabled	Disabled/Enabled		

Table 20.

CB Status signals must also be available within the relay.

3.2.3 Autoreclose logic inputs

The autoreclose function uses inputs in the logic, which can be assigned and activated from any of the opto-isolated inputs on the relay via the programmable scheme logic (PSL). Contacts from external equipment may be used to influence the auto-recloser via such inputs. These logic inputs can also be assigned and activated from other sources. The function of these inputs is described below, identified by their DDB signal text.

The inputs can be selected to accept either a normally open or a normally closed contact, programmable via the PSL editor.

3.2.3.1 CB Healthy

The majority of circuit breakers are only capable of providing one trip-close-trip cycle. Following this, it is necessary to re-establish sufficient energy in the circuit breaker before the CB can be reclosed. The DDB 296: CB Healthy input is used to ensure that there is sufficient energy available to close and trip the CB before initiating a CB close command. If on completion of the dead time, sufficient energy is not detected by the relay from the DDB 296: CB Healthy input for a period given by the CB Healthy time timer, lockout will result and the CB will remain open.

This check can be disabled by not allocating an opto input to this function, and deliberate application of a logic “1” onto this DDB signal within the PSL. Assigning a PSL gate with no inputs and an inverted output will mean that the signal is always high, and the circuit breaker deemed to be “healthy”. Alternatively, it is possible to energise the CB healthy opto input from a circuit breaker open auxiliary contact (52b).

3.2.3.2 BAR

The “DDB 308: BAR” input will block autoreclose and cause a lockout if autoreclose is in progress. It can be used when protection operation without autoreclose is required. A typical example is on a transformer feeder, where autoreclosing may be initiated from the feeder protection but blocked from the transformer protection.

3.2.3.3 Reset lockout

The “DDB 306: Reset Lockout” input can be used to reset the autoreclose function following lockout and reset any autoreclose alarms, provided that the signals which initiated the lockout have been removed.

3.2.3.4 Pole discrepancy

CBs with independent mechanisms for each pole normally incorporate a ‘phases not together’ or ‘pole discrepancy’ protection device which automatically trips all three phases if they are not all in the same position i.e. all open or all closed.

During single pole autoreclosing a pole discrepancy condition is deliberately introduced and the pole discrepancy device must not operate for this condition. This may be achieved by using a delayed action pole discrepancy device with a delay longer than the single pole autoreclose dead time, ‘1 Pole Dead Time’. Alternatively, a signal can be given from the relay during the single pole autoreclose dead time, “DDB 532 AR 1 Pole In Progress”, to inhibit the pole discrepancy device

The “DDB 311: Pole Discrepancy” input is activated by a signal from an external device indicating that all three poles of the CB are not in the same position. The “DDB 311: Pole Discrepancy” input forces a 3 pole trip which will cancel any single pole autoreclose in progress and start three pole autoreclose in progress.

3.2.3.5 Enable 1 pole AR

The “DDB 309: En 1 Pole Reclose” input is used to select the single phase autoreclose operating mode.

3.2.3.6 Enable 3 pole AR

The “DDB 310: En 3 Pole Reclose” input is used to select the three phase autoreclose operating mode.

3.2.3.7 External trip

The “DDB 272: External Trip 3Ph” input and the “DDB 273: External Trip A, DDB 274: External Trip B” and “DDB 275: External Trip C” inputs can be used to initiate three or single phase autoreclose. Note, these signals are not used to trip the CB but do initiate autoreclose. To trip the CB directly they could be assigned to the trip contacts of the relay in the PSL.

3.2.4 Internal Signals

3.2.4.1 Trip Initiate signals

The “DDB 315: Any Trip A”, “DDB 316: Any Trip B” and “DDB 317: Any Trip C” signals are used to initiate signals or three phase autoreclose. Note, for single phase autoreclose these signals must be mapped in the PSL as shown in the default.

3.2.4.2 Circuit Breaker Status

The “DDB 582: CB Open 3 ph”, “DDB 583: CB Open A ph”, “DDB 584: CB Open B ph” and “DDB 585: CB Open C ph”, signals are used to indicate if a CB is open three or single phase. These are driven from the internal pole dead logic and the CB auxiliary inputs.

The “DDB 586: CB Closed 3 ph”, “DDB 587: CB Closed A ph”, “DDB 588: CB Closed B ph” and “DDB 589: CB Closed C ph”, signals are used to indicate if a CB is closed three or single phase. These are driven from the internal pole dead logic and the CB auxiliary inputs.

3.2.4.3 Check Synch OK and System Check OK

Internal signals generated from the internal system check function and external system check equipment are used by the internal autoreclose logic to permit autoreclosure. The creation of these internal signals is explained in section 3.4.

3.2.5 Autoreclose logic outputs

The following DDB signals can be masked to a relay contact in the PSL or assigned to a Monitor Bit in “Commissioning Tests”, to provide information about the status of the autoreclose cycle. These are described below, identified by their DDB signal text.

3.2.5.1 AR 1 pole in progress

The “DDB 532: AR 1 Pole in Progress” output indicates that single pole autoreclose is in progress. The output is on from protection initiation to the end of the single pole dead time, “1 Pole Dead Time”.

3.2.5.2 AR 3 pole in progress

The “DDB 531: AR 3 Pole in Progress” output indicates that three pole autoreclose is in progress. The output is on from protection initiation to the end of the three pole dead time, ‘Dead Time 1, 2, 3, 4’.

3.2.5.3 Successful close

The “DDB 539: AR Successful Reclose” output indicates that an autoreclose cycle has been successfully completed. A successful autoreclose signal is given after the CB has tripped from the protection and reclosed whereupon the fault has been cleared and the reclaim time has expired resetting the autoreclose cycle. The successful autoreclose output is reset at the next CB trip or from one of the reset lockout methods; see Section 3.2.8.5 ’Reset from lockout’.

3.2.5.4 AR status

The “DDB 544: A/R In Status 1P” output indicates that the relay is in the single phase autoreclose mode. The “DDB 543: A/R In Status 3P” output indicates that the relay is in the three phase autoreclose mode.

3.2.5.5 Auto close

The “DDB 541: Auto Close” output indicates that the autoreclose logic has issued a close signal to the CB. This output feeds a signal to the control close pulse timer and remains on until the CB has closed. This signal may be useful during relay commissioning to check the operation of the autoreclose cycle. This signal is combined with the manual close signal to produce the signal “DDB525: Control Close” which should be mapped to a relay.

3.2.6 Autoreclose alarms

The following DDB signals will produce a relay alarm. These are described below, identified by their DDB signal text.

3.2.6.1 AR No Checksync (latched)

The “DDB 165: AR No Checksync” alarm indicates that the system voltages were not in synchronism at the end of the “Check Sync Time”, leading to a lockout condition. This alarm can be reset using one of the reset lockout methods; see Section 3.2.8.5 ’Reset from lockout’.

3.2.6.2 AR CB Unhealthy (latched)

The “DDB 164: AR CB Unhealthy” alarm indicates that the “DDB168: CB Healthy” input was not energised at the end of the “CB Healthy Time”, leading to a lockout condition. The “DDB 296: CB Healthy” input is used to indicate that there is sufficient energy in the CB operating mechanism to close and trip the CB at the end of the dead time. This alarm can be reset using one of the reset lockout methods; see Section 3.2.8.5 ’Reset from lockout’.

3.2.6.3 AR lockout (self reset)

The “DDB163: AR Lockout” alarm indicates that the relay is in a lockout state and that further reclose attempts will not be made; see Section 3.2.8.4 ‘AR Lockout’ for more details. This alarm can be reset using one of the reset lockout methods; see Section 3.2.8.5 ’Reset from lockout’.

3.2.7 Autoreclose logic operating sequence

The autoreclose function provides multi-shot single and three phase autoreclose control. It can be adjusted to perform a single shot, two shot, three shot or four shot cycle, selectable via “Single Pole Shot” and “Three Pole Shot”. Dead times for all shots (reclose attempts) are independently adjustable. The number of shots is directly related to the type of faults likely to occur on the system and the voltage level of the system. Generally, on medium voltage networks where the percentage of transient and semi-permanent faults is likely to be high, a multi-shot autoreclose device will increase the possibility of the distribution line being successfully re-energised following reclosure of the circuit breaker. On high voltage networks single shot autoreclose is invariably applied. For more information, please refer to Section 0 ‘Setting guidelines’.

An autoreclose cycle can be internally initiated by operation of a protection element, provided the circuit breaker is closed until the instant of protection operation.

The user can, via a setting, determine if the autoreclose shall be initiated on the rising edge of the protection trip (Protection Op) or on the falling edge (Protection Reset), see Figure 26.

If single pole autoreclose [A/R Status 1P] only is enabled then if the first fault is a single phase fault the single pole dead time ("1 Pole Dead Time") and single pole autoreclose in progress [AR 1pole in prog] starts on the rising or falling edge (according to the setting) of the single phase trip. If the relay has been set to allow more than one single pole reclose [Single Pole Shot >1] then any subsequent single phase faults will be converted to 3 pole trips. The three pole dead times ("Dead Time 2, Dead Time 3, Dead Time 4") [Dead Time 2, 3, 4] and three pole autoreclose in progress [AR 3pole in prog] will start on the rising or falling edge (according to the setting) of the three pole trip for the 2nd, 3rd and 4th trips [shots]. For a multi-phase fault the relay will lockout on the rising or falling edge (according to the setting) of the three phase trip.

If three pole autoreclose [A/R Status 3P] only is enabled then for any fault the three pole dead time ("Dead Time 1, Dead Time 2, Dead Time 3, Dead Time 4") [Dead Time 1, 2, 3, 4] and three pole autoreclose in progress [AR 3pole in prog] starts on the rising or falling edge (according to the setting) of the three phase trip. The logic forces a 3 pole trip [Force 3 pole AR] for any single phase fault if three pole autoreclose [A/R Status 3P] only is enabled.

If single [A/R Status 1P] and three phase autoreclose [A/R Status 3P] are enabled then if the first fault is a single phase fault the single pole dead time ("1 Pole Dead Time") [1 Pole Dead Time] and single pole autoreclose in progress [AR 1pole in prog] starts on the rising or falling edge (according to the setting) of the single phase trip. If the first fault is a multi-phase fault the three pole dead time ("Dead Time 1") and three pole autoreclose in progress [AR 3pole in prog] starts on the rising or falling edge (according to the setting) of the three phase trip. If the relay has been set to allow more than one reclose [Three Pole Shot >1] then any subsequent faults will be converted to 3 pole trips [Force 3 pole AR]. The three pole dead times ("Dead Time 2, Dead Time 3, Dead Time 4") [Dead Time 2, 3, 4] and three pole autoreclose in progress [AR 3pole in prog] will start on the rising or falling edge (according to the setting) of the three pole trip for the 2nd, 3rd and 4th trips [shots]. If a single phase fault evolves to a multi-phase fault during the single pole dead time [1 Pole Dead Time] then single pole autoreclose in progress [AR 1pole in prog] is stopped and the three pole dead time [Dead Time 1] and three pole autoreclose in progress [AR 3pole in prog] is started.

At the end of the relevant dead time, the autoreclose single phase or three phase in progress signal is reset and a CB close signal is given, provided system conditions are suitable. The system conditions to be met for closing are that the system voltages are in synchronism or dead line/live bus or live line/dead bus conditions exist, indicated by the internal check synchronising element and that the circuit breaker closing spring, or other energy source, is fully charged indicated from the “DDB 296: CB Healthy” input. The CB close signal is cut-off when the circuit breaker closes. For single pole autoreclose no voltage or synchronism check is required as synchronising power is flowing in the two healthy phases. Check synchronising for the first three phase cycle is controlled by a setting.

When the CB has closed the reclaim time (“Reclaim Time”) starts. If the circuit breaker does not trip again, the autoreclose function resets at the end of the reclaim time. If the protection operates during the reclaim time the relay either advances to the next shot in the programmed autoreclose cycle, or, if all programmed reclose attempts have been made, goes to lockout.

Every time the relay trips the sequence counter is incremented by 1. The relay compares the “Single Pole Shot” and “Three Pole Shot” counter values to the sequence count. If the fault is single phase and the sequence count is greater than the “Single Pole Shot” setting then the relay will lockout. If the fault is multi-phase phase and the sequence count is greater than the “Three Pole Shot” setting then the relay will also lockout.

For example, if “Single Pole Shot” = 2 and “Three Pole Shot” = 1, after two phase-phase faults the relay will lockout because the sequence count = 2 which is greater than the “Three

Pole Shots" target of 1 and the second fault was a multi-phase fault. If there was a permanent earth fault the relay would trip and reclose twice and on the third application of earth fault current it would lockout. This is because on the third application of fault current the sequence count would be greater than the "Single Pole Shots" target of 2 and the third fault was an earth fault. There is no lockout at the second trip because the second trip was single phase and the sequence count is not greater than the "Single Pole Shots" target of 2. If there was a single phase fault which evolved to a phase-phase-ground fault then the relay would trip and reclose and on the second multi-phase fault would lockout. This is because on the second application of fault current the sequence count is greater than the "Three Pole Shots" target of 1 and the second fault was a multi-phase fault.

The total number of autoreclosures is shown in the CB Control menu under "Total Reclosures". This value can be reset to zero with the "Reset Total A/R" command.

The selection of which protection is used to initiate autoreclose phase differential, distance zones, overcurrent, earth fault and sensitive earth fault protection can be made using the settings "Initiate AR, No Action or Block AR" for the protection functions listed in the autoreclose menu. See section 3.2.8.2 'Autoreclose Initiation' for more details.

For multi-phase faults the autoreclose logic can be set to allow autoreclose block for 2 and 3 phase faults or to block autoreclose for 3 phase faults only using the setting "Multi Phase AR - Allow AR / BAR 2 & 3 Phase / BAR 3 Phase" in the Autoreclose settings.

The standard scheme logic is configured to permit control of one circuit breaker. Autoreclosure of two circuit breakers in a 1½ circuit breaker or mesh corner scheme is not supported by the standard logic.

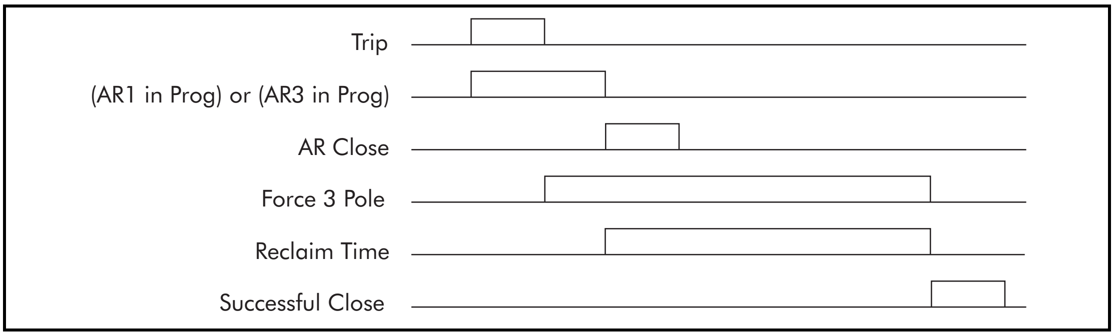


Figure 26: Autoreclose timing diagram

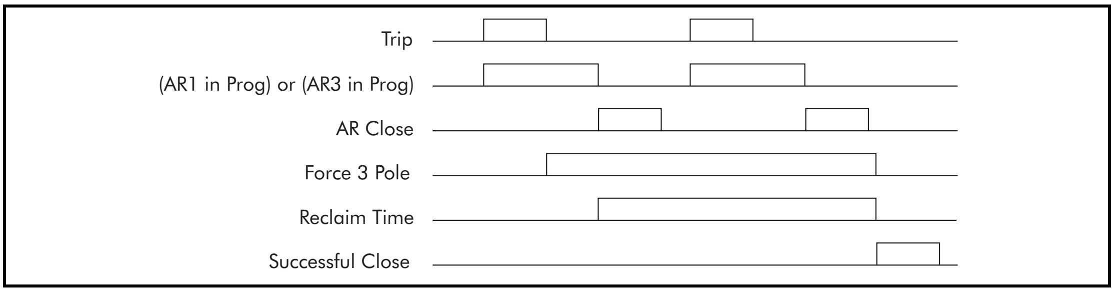


Figure 27: Autoreclose timing diagram

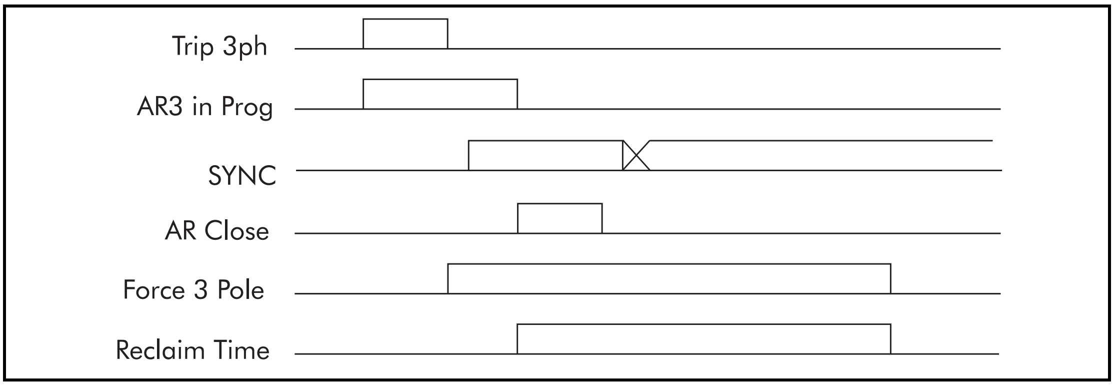


Figure 28: Autoreclose timing diagram

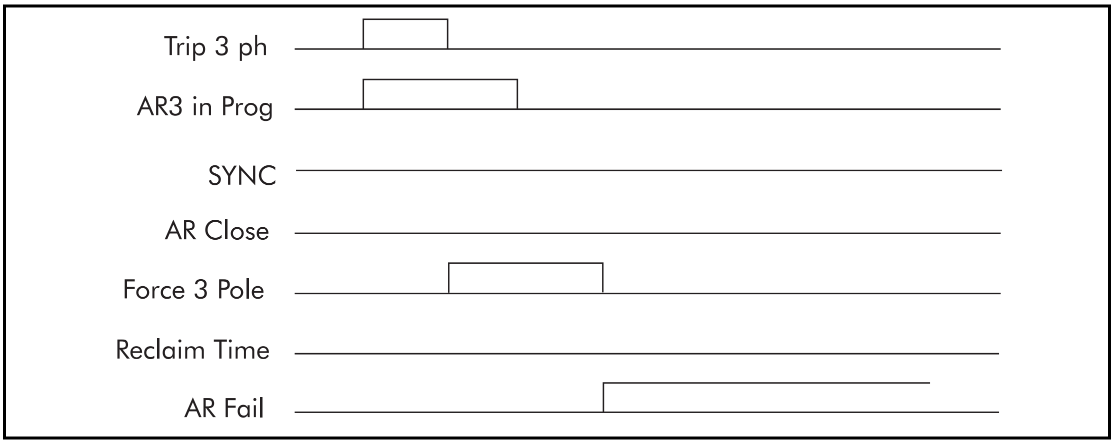


Figure 29: Autoreclose timing diagram

3.2.8 Main operating features

3.2.8.1 Autoreclose modes

The autoreclose function has three operating modes:

1. Single Pole Autoreclose
2. Three Pole Autoreclose
3. Single/Three Pole Autoreclose

Single pole and three pole autoreclose modes can be selected from opto inputs assigned for “DDB 309: En 1 Pole Reclose” and “DDB 310: En 3 Pole Reclose” respectively. Energising both opto inputs would select the single/three pole operating mode. Alternatively, the settings “Single Pole A/R - Enabled / Disabled” and “Three Pole A/R - Enabled / Disabled” in the CB Control menu can also be used to select the operating modes. How these operating modes affect the operating sequence is described above.

3.2.8.2 Autoreclose initiation

Autoreclose is initiated from the internal protection of the relay. The phase differential, distance zones, overcurrent, earth fault and sensitive earth fault protections can be selected to “Initiate AR, No Action or Block AR” in the Autoreclose settings. For high speed autoreclose only the current differential protection would normally be set to initiate autoreclose. This is because for best results when applying high speed autoreclose to improve a system stability limit, it is important that the fault should be cleared as quickly as possible from both line ends. The back-up distance protection (Zones 2 and 3) and overcurrent protection will not provide high speed clearance of all faults on the line and so are unsuitable for high speed autoreclose.

For delayed autoreclose the current differential protection would also normally be set to initiate autoreclose. If the current differential protection was out of action, because of faulty communications for example, the distance or overcurrent back-up protections could be used to initiate delayed autoreclose. This could be done by changing setting group on a signalling failure alarm in the PSL.

3.2.8.3 Autoreclose inhibit following manual close

The AR Inhibit Time setting can be used to prevent autoreclose being initiated when the CB is manually closed onto a fault. Autoreclose is disabled for the AR Inhibit Time following manual CB closure.

3.2.8.4 AR lockout

If protection operates during the reclaim time, following the final reclose attempt, the relay will be driven to lockout and the autoreclose function will be disabled until the lockout condition is reset. This will produce an alarm, “DDB 163: AR Lockout”.

The block autoreclose logic in the relay will also cause an autoreclose lockout if autoreclose is in progress. The “DDB 308: BAR” input assigned to an opto input will block autoreclose and cause a lockout if autoreclose is in progress. The autoreclose logic can also be set to block autoreclose for 2 and 3 phase faults or to block autoreclose for 3 phase faults only using the setting “Multi Phase AR - Allow AR / BAR 2&3 Phase / BAR 3 Phase” in the Autoreclose menu. Also, the phase differential, distance zones, overcurrent, earth fault and sensitive earth fault protections can be individually selected to block autoreclose using the settings, “Initiate AR, No Action or Block AR” in the Autoreclose menu.

Autoreclose lockout can also be caused by the CB failing to close because the CB springs are not charged/low gas pressure or there is no synchronism between the system voltages indicated by the “DDB 164: AR CB Unhealthy” and “DDB165: AR No Checksync” alarms.

An autoreclose lockout is also given if the CB is open at the end of the reclaim time.

Note: Lockout, can also be caused by the CB condition monitoring functions maintenance lockout, excessive fault frequency lockout, broken current lockout, CB failed to trip and CB failed to close and manual close - no check synchronism and CB unhealthy. These lockout alarms are mapped to a composite signal “DDB 546: CB Lockout Alarm”.

3.2.8.5 Reset from lockout

The “DDB 306: Reset Lockout” input assigned to an opto input can be used to reset the autoreclose function following lockout and reset any autoreclose alarms, provided that the signals which initiated the lockout have been removed. Lockout can also be reset from the clear key or the CB CONTROL command “Lockout Reset”.

The “Reset Lockout” by setting, “CB Close/ User interface” in CB CONTROL is used to enable/ disable reset of lockout automatically from a manual close after the manual close time “AR Inhibit Time”.

3.2.8.6 System check on shot 1 (called “Check Sinchronising for fast 3 phase reclose” on software 13 or previous)

The “SysChk on Shot 1” (called C/S on 3ph fast on software 13 or previous) setting is used to “Enable/Disable” system checks for the first reclose after a 3 pole trip in an autoreclose cycle. When the “SysChk on Shot 1” is set to “Disabled” no system checks are required for the first reclose which may be preferred when high speed autoreclose is applied to avoid the extra time for a system check. Subsequent reclose attempts in a multi-shot cycle will still require a system check.

3.2.8.7 Immediate Autoreclose with Check Synchronism (since software 20 and onwards)

The CS AR Immediate setting allows immediate autroreclosure without waiting for the expiry of the settable dead time, provided the check synchronism conditions are met and a fault is not detected. The intention is to allow the local end to reclose immediately if the remote end has already reclosed successfully and the synchronising conditions are met.

This feature applies when the setting is enabled. It applies to all dead times, just for three pole autoreclose and just for Live Line-Live Bus condition (plus other check synchronising conditions of phase angle, frequency etc).

When set to disabled the relay will wait for the relevant dead time.

3.2.9 Setting guidelines

3.2.9.1 Number of Shots

There are no clear-cut rules for defining the number of shots for any particular application. In order to determine the required number of shots the following factors must be taken into account:

An important consideration is the ability of the circuit breaker to perform several trip close operations in quick succession and the effect of these operations on the maintenance period.

The fact that 80 - 90% of faults are transient highlights the advantage of single shot schemes. If statistical information for the power system shows that a moderate percentage of faults are semi-permanent, further DAR shots may be used provided that system stability is not threatened. Note that DAR shots will always be three pole.

3.2.9.2 Dead Timer Setting

High speed autoreclose may be required to maintain stability on a network with two or more power sources. For high speed autoreclose the system disturbance time should be minimised by using fast protection, <50 ms, such as distance or feeder differential protection and fast circuit breakers <100 ms. For stability between two sources a system dead time of <300 ms may typically be required. The minimum system dead time considering just the CB is the trip mechanism reset time plus the CB closing time.

Minimum relay dead time settings are governed primarily by two factors:

- Time taken for de-ionisation of the fault path;
- Circuit breaker characteristics.

Also it is essential that the protection fully resets during the dead time, so that correct time discrimination will be maintained after reclosure onto a fault. For high speed autoreclose instantaneous reset of protection is required.

For highly interconnected systems synchronism is unlikely to be lost by the tripping out of a single line. Here the best policy may be to adopt longer dead times, to allow time for power swings on the system resulting from the fault to settle.

3.2.9.3 De-Ionising Time

The de-ionisation time of a fault arc depends on circuit voltage, conductor spacing, fault current and duration, wind speed and capacitive coupling from adjacent conductors. As circuit voltage is generally the most significant, minimum de-ionising times can be specified as in Table 20 below.

Note: For single pole HSAR, the capacitive current induced from the healthy phases can increase the time taken to de-ionise fault arcs.

Line Voltage (kV)	Minimum De-Energisation Time (s)
66	0.1
110	0.15
132	0.17
220	0.28
275	0.3
400	0.5

Table 21. Minimum Fault Arc De-Ionising Time (Three Pole Tripping)

3.2.9.4 Example Minimum Dead Time Calculation

The following circuit breaker and system characteristics are to be used:

CB Operating time (Trip coil energised → Arc interruption): 50ms (a);

CB Opening + Reset time (Trip coil energised → Trip mechanism reset): 200ms (b);

Protection reset time: < 80ms (c);

CB Closing time (Close command → Contacts make): 85ms (d).

De-ionising time for 220kV line:

280ms (e) for a three phase trip. (560ms for a single pole trip).

The minimum relay dead time setting is the greater of:

(a) + (c)	= 50 + 80	=	130ms, to allow protection reset;
(a) + (e) - (d)	= 50 + 280 - 85	=	<u>245ms</u>, to allow de-ionising (three pole);
	= 50 + 560 – 85	=	<u>525ms</u>, to allow de-ionising (single pole).

In practice a few additional cycles would be added to allow for tolerances, **so Dead Time 1** could be chosen as ≥ <u>300ms</u>, and **1Pole Dead Time** could be chosen as ≥ <u>600ms</u>. The overall system dead time is found by adding (d) to the chosen settings, and then subtracting (a). (This gives 335ms and 635ms respectively here).

3.2.9.5 Discrimination Timer Setting (since software 20 and onwards)

A single-phase fault can result in a single-phase trip and a single-pole autoreclose cycle will be started, however the fault may evolve during the dead time to affect another phase. For an evolving fault, the protection issues a three-phase trip.

The discrimination timer starts simultaneously with the dead time timer, and is used to discriminate from which point in time an evolving fault is identified as no longer one continued evolution of the first fault, but is now a discrete second fault condition. If the evolving fault occurs before the expiry of the discrimination time, the protection will start a three-pole autoreclose cycle if permitted. If however, the second phase fault occurs after the discrimination time, the automatic reclose function is blocked, and driven to AR Lockout.

3.2.9.6 Reclaim Timer Setting

A number of factors influence the choice of the reclaim timer, such as;

Fault incidence/Past experience - Small reclaim times may be required where there is a high incidence of recurrent lightning strikes to prevent unnecessary lockout for transient faults.

Spring charging time - For high speed autoreclose the reclaim time may be set longer than the spring charging time. A minimum reclaim time of >5s may be needed to allow the CB time to recover after a trip and close before it can perform another trip-close-trip cycle. This time will depend on the duty (rating) of the CB. For delayed autoreclose there is no need as the dead time can be extended by an extra CB healthy check **AR Inhibit Time** window time if there is insufficient energy in the CB.

Switchgear Maintenance - Excessive operation resulting from short reclaim times can mean shorter maintenance intervals.

The Reclaim Time setting is generally set greater than the tZ2 distance zone delay.

Note: The P543 reclaim time is not blocked by start signals from time delayed protection. This is because generally the main protection initiating autoreclose will be the current differential protection which is instantaneous and so blocking of the reclaim time is not required.

3.3 System Checks (applicable to P543 & P545)

3.3.1 System Checks (for version 20 and onwards)

3.3.1.1 Overview

In some situations it is possible for both “bus” and “line” sides of a circuit breaker to be live when the circuit breaker is open, for example at the ends of a feeder which has a power source at each end. Therefore, when closing the circuit breaker, it is normally necessary to check that the network conditions on both sides are suitable, before giving a CB Close command. This applies to both manual circuit breaker closing and auto-reclosure. If a circuit breaker is closed when the line and bus voltages are both live, with a large phase angle, frequency or magnitude difference between them, the system could be subjected to an unacceptable shock, resulting in loss of stability, and possible damage to connected machines.

System checks involve monitoring the voltages on both sides of a circuit breaker, and, if both sides are live, performing a synchronism check to determine whether the phase angle, frequency and voltage magnitude differences between the voltage vectors, are within permitted limits.

The pre-closing system conditions for a given circuit breaker depend on the system configuration and, for auto-reclosing, on the selected auto-reclose program. For example, on a feeder with delayed auto-reclosing, the circuit breakers at the two line ends are normally arranged to close at different times. The first line end to close usually has a live bus and a dead line immediately before reclosing, and charges the line (dead line charge) when the circuit breaker closes. The second line end circuit breaker sees live bus and live line after the first circuit breaker has reclosed. If there is a parallel connection between the ends of the tripped feeder, they are unlikely to go out of synchronism, i.e. the frequencies will be the same, but the increased impedance could cause the phase angle between the two voltages to increase. Therefore the second circuit breaker to close might need a synchronism check, to ensure that the phase angle has not increased to a level which would cause unacceptable shock to the system when the circuit breaker closes.

If there are no parallel interconnections between the ends of the tripped feeder, the two systems could lose synchronism, and the frequency at one end could “slip” relative to the other end. In this situation, the second line end would require a synchronism check comprising both phase angle and slip frequency checks.

If the second line end busbar has no power source other than the feeder which has tripped, the circuit breaker will see a live line and dead bus assuming the first circuit breaker has reclosed. When the second line end circuit breaker closes the bus will charge from the live line (dead bus charge).

3.3.1.2 VT selection

The P543 & P545 has a three phase “Main VT” input and a single phase “Check Sync VT” input. Depending on the primary system arrangement, the main three phase VT for the relay may be located on either the busbar side or the line side of the circuit breaker, with the check sync VT being located on the other side. Hence, the relay has to be programmed with the location of the main VT. This is done via the “Main VT Location” setting in the CT & VT RATIOS menu.

The Check Sync VT may be connected to either a phase to phase or phase to neutral voltage, and for correct synchronism check operation, the relay has to be programmed with the required connection. The “C/S Input” setting in the CT & VT RATIOS menu should be set to A-N, B-N, C-N, A-B, B-C or C-A as appropriate.

3.3.1.3 Basic functionality

System check logic is collectively enabled or disabled as required, by setting “System Checks” in the CONFIGURATION menu. The associated settings are available in SYSTEM CHECKS, sub-menus VOLTAGE MONITORS, CHECK SYNC and SYSTEM SPLIT. If “System Checks” is selected to Disabled, the associated SYSTEM CHECKS menu becomes invisible, and a **Sys checks Inactive** DDB signal is set.

When enabled, the P543 & P545 system check logic sets signals as listed below, according to the status of the monitored voltages.

Line Live (DDB 647) – If the Line voltage magnitude is not less than VOLTAGE MONITORS – Live Voltage setting

Line Dead (DDB 648) – If the Line voltage magnitude is less than VOLTAGE MONITORS – Dead Voltage setting

Bus Live (DDB 649) – If the Bus voltage magnitude is not less than VOLTAGE MONITORS – Live Voltage setting

Bus Dead (DDB 650) – If the Bus voltage magnitude is less than VOLTAGE MONITORS – Dead Voltage setting

Check Sync 1 OK (DDB 651) – If Check Sync 1 Status is Enabled, the Line and Bus voltages are both live, and the parameters meet the CHECK SYNC – Check Sync 1 --- settings

Check Sync 2 OK (DDB 652) – If Check Sync 2 Status is Enabled, the Line and Bus voltages are both live, and the parameters meet the CHECK SYNC – Check Sync 2 ---- settings

System Split – (DDB 186) If SS Status is Enabled, the Line and Bus voltages are both live, and the measured phase angle between the voltage vectors is greater than SYSTEM SPLIT – SS Phase Angle setting

All the above signals are available as DDB signals for mapping in Programmable Scheme Logic (PSL). In addition, the Checksync 1 & 2 signals are "hard coded" into the auto-reclose logic.

In most situations where synchronism check is required, the Check Sync 1 function alone will provide the necessary functionality, and the Check Sync 2 and System Split signals can be ignored.

The "SYSTEM CHECKS" menu contains all of the check synchronism settings for auto and manual reclosure and is shown in the table below along with the relevant default settings:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SYSTEM CHECKS				
Voltage Monitoring	Sub Heading			
Live Voltage	32V	5.5V	132V	0.5V
Dead Voltage	13V	5.5V	132V	0.5V
Check Sync	Sub Heading			
Stage 1	Enabled	Enabled or Disabled		
CS1 Phase Angle	20.00°	5°	90°	1°
CS1 Slip Control	Frequency	Frequency/Both/Timer/None		
CS1 Slip Freq	50mHz	20mHz	1Hz	10mHz
CS1 Slip Timer	1s	0s	99s	0.1s
Stage 2	Enabled	Enabled or Disabled		
CS2 Phase Angle	20.00°	5°	90°	1°
CS2 Slip Control	Frequency	Frequency/Both/Timer/None		
CS2 Slip Freq	50mHz	20mHz	1Hz	10mHz
CS2 Slip Timer	1s	0s	99s	0.1s
CS Undervoltage	54/V	10V	132V	0.5V
CS Overvoltage	130V	60V	185V	0.5V
CS Diff Voltage	6.5V	1V	132V	0.5V

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SYSTEM CHECKS				
CS Voltage Block	V<	V< / V> / Vdiff> / V< and V> / V< and Vdiff> / V> and Vdiff> / V< V> and Vdiff> / None		
System Split	Sub-heading			
SS Status	Enabled	Enabled or Disabled		
SS Phase Angle	120°	90°	175°	1°
SS Under V Block	Enabled	Enabled or Disabled		
SS Undervoltage	54V	10V	132V	0.5V
SS Timer	1s	0s	99s	0.1s

Table 22. System check settings

3.3.1.4 System Check Logic Inputs

In addition to menu activation, the following operating modes can be enabled using logic inputs:

- Check Sync 1 enabled
- Check Sync 2 enabled
- Sys split enabled

3.3.1.5 System Check Logic Outputs

When enabled, the P54x system check logic sets signals as listed below, according to the status of the monitored voltages.

Line Live – If the Line voltage magnitude is not less than VOLTAGE MONITORS – Live Voltage setting

Line Dead – If the Line voltage magnitude is less than VOLTAGE MONITORS – Dead Voltage setting

Bus Live – If the Bus voltage magnitude is not less than VOLTAGE MONITORS – Live Voltage setting

Bus Dead – If the Bus voltage magnitude is less than VOLTAGE MONITORS – Dead Voltage setting

Check Sync 1 OK – If Check Sync 1 Status is Enabled, the Line and Bus voltages are both live, and the parameters meet the CHECK SYNC – Check Sync 1 ---- settings

Check Sync 2 OK – If Check Sync 2 Status is Enabled, the Line and Bus voltages are both live, and the parameters meet the CHECK SYNC – Check Sync 2 ---- settings

System Split – If SS Status is Enabled, the Line and Bus voltages are both live, and the measured phase angle between the voltage vectors is greater than SYSTEM SPLIT – SS Phase Angle setting

All the above signals are available as DDB signals for mapping in Programmable Scheme Logic (PSL). In addition, the Checksync 1 & 2 signals are “hard coded” into the auto-reclose logic.

3.3.1.6 Check sync 2 and system split

Check Sync 2 and System Split functions are included for situations where the maximum permitted slip frequency and phase angle for synchro check can change according to actual system conditions. A typical application is on a closely interconnected system, where synchronism is normally retained when a given feeder is tripped, but under some circumstances, with parallel interconnections out of service, the feeder ends can drift out of synchronism when the feeder is tripped. Depending on the system and machine characteristics, the conditions for safe circuit breaker closing could be, for example:

Condition 1: for synchronised systems, with zero or very small slip:

slip ≦50 mHz; phase angle <30°

Condition 2: for unsynchronised systems, with significant slip:

slip ≦250 mHz; phase angle <10° and decreasing

By enabling both Check Sync 1, set for condition 1, and Check Sync 2, set for condition 2, the P543 & P545 can be configured to allow CB closure if either of the two conditions is detected.

For manual circuit breaker closing with synchro check, some utilities might prefer to arrange the logic to check initially for condition 1 only. However, if a System Split is detected before the condition 1 parameters are satisfied, the relay will switch to checking for condition 2 parameters instead, based upon the assumption that a significant degree of slip must be present when system split conditions are detected. This can be arranged by suitable PSL logic, using the system check DDB signals.

3.3.1.7 Synchronism check

Check Sync 1 and Check Sync 2 are two synchro check logic modules with similar functionality, but independent settings.

For either module to function:

the System Checks setting must be Enabled

AND

the individual Check Sync 1(2) Status setting must be Enabled

AND

the module must be individually “enabled”, by activation of DDB signal Check Sync 1(2) Enabled, mapped in PSL.

When enabled, each logic module sets its output signal when:

line volts and bus volts are both live (Line Live and Bus Live signals both set)

AND

measured phase angle is < Check Sync 1(2) Phase Angle setting

AND

(for Check Sync 2 only), the phase angle magnitude is decreasing (Check Sync 1 can operate with increasing or decreasing phase angle provided other conditions are satisfied)

AND

if Check Sync 1(2) Slip Control is set to Frequency or Frequency + Timer, the measured slip frequency is < Check Sync 1(2) Slip Freq setting

AND

if Check Sync Voltage Blocking is set to OV, UV + OV, OV + DiffV or UV + OV + DiffV, both line volts and bus volts magnitudes are < Check Sync Overvoltage setting

AND

if Check Sync Voltage Blocking is set to UV, UV + OV, UV + DiffV or UV + OV + DiffV, both line volts and bus volts magnitudes are > Check Sync Undervoltage setting

AND

if Check Sync Voltage Blocking is set to DiffV, UV + DiffV, OV + DiffV or UV + OV + DiffV, the voltage magnitude difference between line volts and bus volts is < Check Sync Diff Voltage setting

AND

if Check Sync 1(2) Slip Control is set to Timer or Frequency + Timer, the above conditions have been true for a time > or = Check Sync 1(2) Slip Timer setting

Note: Live Line / Dead Bus and Dead Bus / Line functionality is provided as part of the default PSL (see Figure 32).

3.3.1.8 Slip control by timer

If Slip Control by Timer or Frequency + Timer is selected, the combination of Phase Angle and Timer settings determines an effective maximum slip frequency, calculated as:

$$\frac{2 \text{ x } A}{T \text{ x } 360} \text{ Hz. for Check Sync 1}$$

or

$$\frac{A}{T \text{ x } 360} \text{Hz. for Check Sync 2}$$

where

A = Phase Angle setting (°)
T = Slip Timer setting (seconds)

For example, with Check Sync 1 Phase Angle setting 30° and Timer setting 3.3 sec, the “slipping” vector has to remain within ±30° of the reference vector for at least 3.3 seconds. Therefore a synchro check output will not be given if the slip is greater than 2 x 30° in 3.3 seconds. Using the formula: 2 x 30 ÷ (3.3 x 360) = 0.0505 Hz (50.5 mHz).

For Check Sync 2, with Phase Angle setting 10° and Timer setting 0.1 sec, the slipping vector has to remain within 10° of the reference vector, with the angle decreasing, for 0.1 sec. When the angle passes through zero and starts to increase, the synchro check output is blocked. Therefore an output will not be given if slip is greater than 10° in 0.1 second. Using the formula: 10 ÷ (0.1 x 360) = 0.278 Hz (278 mHz).

Slip control by Timer is not practical for “large slip / small phase angle” applications, because the timer settings required are very small, sometimes < 0.1s. For these situations, slip control by frequency is recommended.

If Slip Control by Frequency + Timer is selected, for an output to be given, the slip frequency must be less than BOTH the set Slip Freq value and the value determined by the Phase Angle and Timer settings.

3.3.1.9 System split

For the System Split module to function:-

the System Checks setting must be Enabled

AND

the SS Status setting must be Enabled

AND

the module must be individually “enabled”, by activation of DDB signal System Split Enabled, mapped in PSL

When enabled, the System Split module sets its output signal when:

line volts and bus volts are both live (Line Live and Bus Live signals both set)

AND

measured phase angle is > SS Phase Angle setting

AND

if SS Volt Blocking is set to Undervoltage, both line volts and bus volts magnitudes are > SS Undervoltage setting

The System Split output remains set for as long as the above conditions are true, or for a minimum period equal to the SS Timer setting, whichever is longer.

The "Check Synch" and "System Synch" functionality is illustrated in the Figure 30.

The overall system checks functionality is shown in Figure 31.

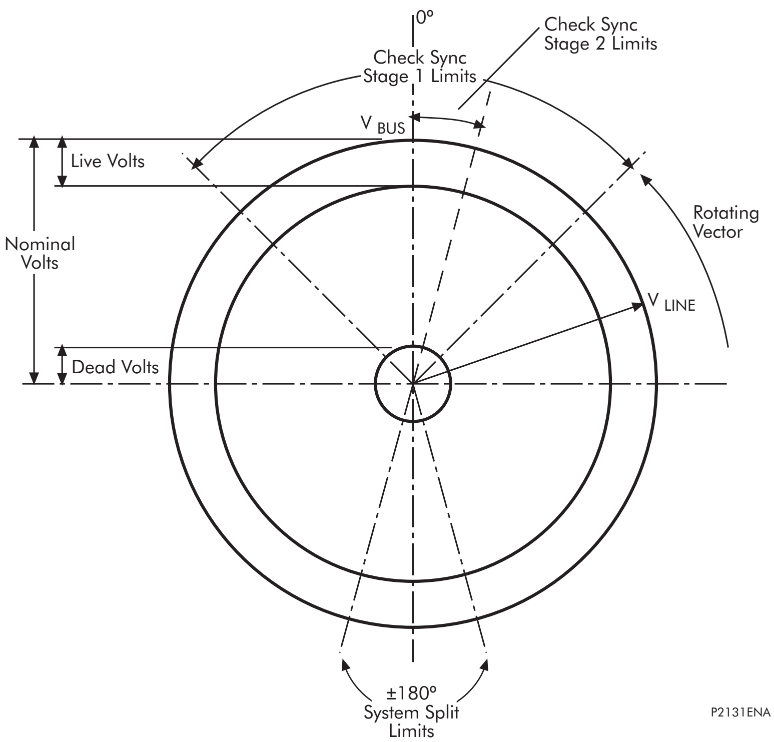


Figure 30: Synchro check and synchro split functionality

3.3.2 Check synchronisation (applicable to P543 & P545) For version 13 and previous

The check synchronism feature is used to qualify reclosure of the circuit breaker so that it can only occur when the network conditions on the busbar and line side of the open circuit breaker are acceptable. If a circuit breaker was closed when the two system voltages were out of synchronism with one another, i.e. a difference in voltage magnitudes or phase angles existed, the system would be subjected to an unacceptable 'shock', resulting in loss of stability and possible damage to connected machines.

Check synchronising therefore involves monitoring the voltage on both sides of a circuit breaker and, if both sides are 'live', the relative synchronism between the two supplies. Such checking may be required to be applied for both automatic and manual reclosing of the circuit breaker and the system conditions which are acceptable may be different in each case. For this reason, separate check synchronism settings are included within the relay for both manual and automatic reclosure of the circuit breaker. With manual closure, the CB close signal is applied into the logic as a pulse to ensure that an operator cannot simply keep the close signal applied and wait for the system to come into synchronism. This is often referred to as guard logic and requires the close signal to be released and then re-applied if the closure is unsuccessful.

The check synchronising element provides two ‘output’ signals which feed into the manual CB control and the auto reclose logic respectively. These signals allow reclosure provided that the relevant check-synch criteria are fulfilled. Note that if check-synchronising is disabled, the ‘allow closure’ signal is automatically asserted.

For an interconnected power system, tripping of one line should not cause a significant shift in the phase relationship of the busbar and line side voltages. Parallel interconnections will ensure that the two sides remain in synchronism, and that autoreclosure can proceed safely. However, if the parallel interconnection(s) is/are lost, the frequencies of the two sections of the split system will begin to slip with respect to each other during the time that the systems are disconnected. Hence, a live busbar / live line synchronism check prior to reclosing the breaker ensures that the resulting phase angle displacement, slip frequency and voltage difference between the busbar and line voltages are all within acceptable limits for the system. If they are not, closure of the breaker can be inhibited.

Note that the voltage blocking can be set to occur on either a simple undervoltage condition, on a differential voltage between bus and line or on either condition.

The ‘SYSTEM CHECKS’ menu contains all of the check synchronism settings for auto and manual reclosure and is shown in the table overleaf along with the relevant default settings:-

MENU TEXT	DEFAULT SETTING	SETTING RANGE		STEP SIZE
		MIN	MAX	
SYSTEM CHECKS				
C/S Phase Angle	20°	5°	90°	
Voltage Blocking	Undervoltage	None, Undervoltage, Differential, Both		
Undervoltage	54V	22V	132V	0.5V
Diff Voltage	6.5V	0.5V	50V	0.5V
Slip Control	Frequency	None, Timer, frequency, Both		
Slip Frequency	0.05Hz	0.02Hz	1Hz	0.01Hz
Slip Timer	1s	0	99s	0.1s
Live Voltage	32V	5.5V	132V	0.5V
Dead Voltage	13V	5.5V	132V	0.5V
MAN CLOSE CHK	Sub-heading			
Check Synch	Enabled	Enabled or Disabled		
Dead Line/Live Bus	Enabled	Enabled or Disabled		
Live Line/Dead Bus	Enabled	Enabled or Disabled		
Dead Line/Dead Bus	Disabled	Enabled or Disabled		
A/R CHECK	Sub-heading			
Check Synch	Enabled	Enabled or Disabled		
Dead Line/Live Bus	Enabled	Enabled or Disabled		
Live Line/Dead Bus	Enabled	Enabled or Disabled		
Dead Line/Dead Bus	Disabled	Enabled or Disabled		

Table 22A

The method for checking slip frequency is selected in the ‘Slip Control’ cell. When set to ‘Frequency’, the required slip frequency limit is directly set in the ‘Slip Frequency’ cell. Hence, if the measured slip frequency is less than this setting, an immediate ‘allow closure’ output will be given. When set to ‘Timer’, the phase angle difference must be maintained below the ‘C/S Phase Angle’ threshold for the set time delay before an ‘allow closure’ output is given.

Note that the combination of the ‘Slip Timer’ and ‘C/S Phase Angle’ settings can also be equated to a slip frequency, as shown below:

C/S phase Angle set to +/-20°, Slip Timer set to 1s.

The phase angle 'window' is therefore 40°, which corresponds to 40/360ths of a cycle = 0.11.

This therefore corresponds to a slip of 0.11 cycles which must be traversed in less than one second = 111 mHz. Had the timer been set to 2 seconds, the slip frequency threshold would have been halved, i.e. 55.5 mHz.

Note that if the 'Slip Control' cell is set to 'Both', the measured slip frequency must be below setting and the phase angle must be maintained below setting for the timer period before an allow closure signal is given.

The 'Live Voltage' and 'Dead Voltage' settings define the thresholds which dictate whether or not the line or bus is determined as being live or dead by the relay logic. Under conditions where either the line, bus, or both line and bus are dead, check synchronism is not applicable and closure of the breaker may or may not be acceptable. Hence, setting options are provided which allow for both manual and auto-reclosure under a variety of live/dead conditions. The following paragraphs describe where these may be used.

Live Busbar and Dead Line

Where a radial feeder is protected, tripping the circuit breaker will isolate the infeed, and the feeder will be dead. Provided that there is no local generation which can backfeed to energise the feeder, reclosure for live busbar/dead line conditions is acceptable. This setting might also be used to allow re-energisation of a faulted feeder in an interconnected power system, which had been isolated at both line ends. Live busbar/dead line reclosing allows energising from one end first, which can then be followed by live line/live busbar reclosure with voltages in synchronism at the remote end.

Dead Busbar and Live Line

If there was a circuit breaker and busbar at the remote end of the radial feeder mentioned above, the remote breaker might be reclosed for a dead busbar/live line condition.

Depending on the particular system arrangement, the main three phase VT for the relay may be located on either the busbar or the line. Hence, the relay needs to be programmed with the location of the main voltage transformer. This is done under the 'CT & VT RATIOS' column in the 'Main VT Location' cell, which should be programmed as either 'Line' or 'Bus' to allow the previously described logic to operate correctly.

Note that the check synch VT input may be driven from either a phase to phase or phase to neutral voltage. The 'C/S Input' cell in the 'CT & VT RATIOS' column has the options of A-N, B-N, C-N, A-B, B-C or C-A, which should therefore be set according to the actual VT arrangement.

If the VTS feature internal to the relay operates, the check synchronising element is inhibited from giving an 'Allow Reclosure' output. This avoids allowing reclosure in instances where voltage checks are selected and a VT fuse failure has made voltage checks unreliable.

Measurements of the magnitude and angle of the check-synch voltage, in addition to the measured phase angle and slip frequency are displayed in the 'MEASUREMENTS 1' column.

3.4 Autoreclose /Check Synchronisation Interface (Valid for software 20 and onwards)

Output signals from the internal system check function and signals from an external system check device are combined and made available as two internal inputs to the autoreclose function. One internal input permits autoreclose based on system check conditions being met. The other internal input permits immediate autoreclose based on check synchronism conditions being met, if this feature is enabled (CS AR Immediate).

If an external system check device is to be used with the internal autoreclose function then logic inputs are available for the purpose and can be assigned to opto-isolated inputs using the PSL. These logic inputs are:

- AR Check Synch OK

- AR System Check OK/SYNC

3.5 Voltage transformer supervision (VTS) (P543, P544, P545 & P546 only)

The voltage transformer supervision (VTS) feature is used to detect failure of the ac voltage inputs to the relay. This may be caused by internal voltage transformer faults, overloading, or faults on the interconnecting wiring to relays. 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 relay, which may result in maloperation.

The VTS logic in the relay is designed to detect the voltage failure, and automatically adjust the configuration of protection elements whose stability would otherwise be compromised. A time-delayed alarm output is also available.

There are three main aspects to consider regarding the failure of the VT supply. These are defined below:

1. Loss of one or two phase voltages

2. Loss of all three phase voltages under load conditions

3. Absence of three phase voltages upon line energisation

3.5.1 Loss of one or two phase voltages

The VTS feature within the relay operates on detection of negative phase sequence (nps) voltage without the presence of negative phase sequence current. This gives operation for the loss of one or two phase voltages. Stability of the VTS function is assured during system fault conditions, by the presence of nps current. The use of negative sequence quantities ensures correct operation even where three-limb or ‘V’ connected VT’s are used.

Negative Sequence VTS Element:

The negative sequence thresholds used by the element are V2 = 10V and I2 = 0.05 to 0.5In settable (defaulted to 0.05In).

3.5.2 Loss of all three phase voltages under load conditions

Under the loss of all three phase voltages to the relay, 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 VTS condition will be raised. In practice, the relay 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 current should therefore be zero. Under a fault condition a superimposed current signal will be generated which will prevent operation of the VTS.

The phase voltage level detectors are fixed and will drop off at 10V and pickup at 30V.

The sensitivity of the superimposed current elements is fixed at 0.1In.

3.5.3 Absence of three phase voltages upon line energisation

If a VT were inadvertently left isolated prior to line energisation, incorrect operation of voltage dependent elements could result. The previous VTS element detected three phase VT failure by absence of all 3 phase voltages with no corresponding change in current. On line energisation there will, however, be a change in current (as a result of load or line charging current for example). An alternative method of detecting 3 phase VT failure is therefore required on line energisation.

The absence of measured voltage on all 3 phases on line energisation can be as a result of 2 conditions. The first is a 3 phase VT failure and the second is a close up three phase fault. The first condition would require blocking of the voltage dependent function and the second would require tripping. To differentiate between these 2 conditions an overcurrent level detector (VTS I> Inhibit) is used which will prevent a VTS block from being issued if it operates. This element should be set in excess of any non-fault based currents on line energisation (load, line charging current, transformer inrush current if applicable) but below the level of current produced by a close up 3 phase fault. If the line is now closed where a 3 phase VT failure is present the overcurrent detector will not operate and a VTS block will be applied. Closing onto a three phase fault will result in operation of the overcurrent detector and prevent a VTS block being applied.

This logic will only be enabled during a live line condition (as indicated by the relays pole dead logic) to prevent operation under dead system conditions i.e. where no voltage will be present and the VTS I> Inhibit overcurrent element will not be picked up.

3.5.4 Menu settings

The VTS settings are found in the 'SUPERVISION' column of the relay menu. The relevant settings are detailed below.

SUPERVISION	Default	Min	Max	Step
VTS Status	Blocking	Blocking, Indication		
VTS Reset Mode	Manual	Manual, Auto		
VTS Time Delay	5s	1s	10s	0.1s
VTS I> Inhibit	10In	0.08In	32In	0.01In
VTS I2> Inhibit	0.05In	0.05In	0.5In	0.01In

Table 23.

The relay may respond as follows, on operation of any VTS element:

VTS set to provide alarm indication only;

Optional blocking of voltage dependent protection elements;

Optional conversion of directional overcurrent elements to non-directional protection (available when set to Blocking mode only). These settings are found in the Function Links cell of the relevant protection element columns in the menu.

The VTS I> Inhibit or VTS I2> Inhibit elements are used to overide a VTS block in event of a fault occurring on the system which could trigger the VTS logic. Once the VTS block has been established, however, then it would be undesirable for subsequent system faults to override the block. The VTS block will therefore be latched after a user settable time delay 'VTS Time Delay'. Once the signal has latched the resetting method is determined by a menu setting manual or Auto. The first is manually via the front panel interface (or remote communications) provided the VTS condition has been removed and secondly, when in 'Auto' mode, by the restoration of the 3 phase voltages above the phase level detector settings mentioned previously.

A VTS indication will be given after the VTS Time Delay has expired. In the case where the VTS is set to indicate only the relay may potentially maloperate, depending on which protection elements are enabled. In this case the VTS indication will be given prior to the VTS time delay expiring if a trip signal is given.

Where a miniature circuit breaker (MCB) is used to protect the voltage transformer ac output circuits, it is common to use MCB auxiliary contacts to indicate a three phase output disconnection. As previously described, it is possible for the VTS logic to operate correctly without this input. However, this facility has been provided for compatibility with various utilities current practices. Energising an opto-isolated input assigned to "DDB 298: MCB/VTS" on the relay will therefore provide the necessary block.

Where directional overcurrent elements are converted to non-directional protection on VTS operation, it must be ensured that the current pick-up setting of these elements is higher than full load current.

3.6 Circuit breaker state monitoring

An operator at a remote location requires a reliable indication of the state of the switchgear. Without an indication that each circuit breaker is either open or closed, the operator has insufficient information to decide on switching operations. The relay incorporates circuit breaker state monitoring, giving an indication of the position of the circuit breaker, or, if the state is unknown, an alarm is raised.

3.6.1 Circuit breaker state monitoring features

MiCOM relays can be set to monitor normally open (52a) and normally closed (52b) auxiliary contacts of the circuit breaker. Under healthy conditions, these contacts will be in opposite states. Should both sets of contacts be open, this would indicate one of the following conditions:

- Auxiliary contacts / wiring defective
- Circuit Breaker (CB) is defective
- CB is in isolated position

Should both sets of contacts be closed, only one of the following two conditions would apply:

- Auxiliary contacts / wiring defective
- Circuit Breaker (CB) is defective

If any of the above conditions exist, an alarm will be issued after a 5s time delay. A normally open / normally closed output contact can be assigned to this function via the programmable scheme logic (PSL). The time delay is set to avoid unwanted operation during normal switching duties.

In the CB CONTROL column of the relay menu there is a setting called 'CB Status Input'. This cell can be set at one of the following four options:

None 52A 52B Both 52A and 52B	P541 & P542	or	None 52A 3 pole 52B 3 pole 52A & 52B 3 pole 52A 1 pole 52B 1 pole 52A & 52B 1 pole	P543 P544 P545 & P546

Selection of the inputs used for CB status is user definable in the CB Status Input cell under the CB control menu. The inputs used to determine the circuit breakers status can be either 52a and/or 52b contacts for single or three pole and for one circuit breaker or for two circuit breakers in the case of the P544 and P546.

e.g. for single pole tripping on either the P544 or P546 utilising both 52a and 52b contacts from each breaker the following contacts are required as inputs to the relay

CB1 - 52A-a, 52A-b and 52A-c and 52B-a, 52B-b and 52B-c

CB2 - 52A-a, 52A-b and 52A-c and 52B-a, 52B-b and 52B-c

Where 'None' is selected no CB status will be available. This will directly affect any function within the relay that requires this signal, for example CB control, auto-reclose, etc. Where only 52A is used on its own then the relay will assume a 52B signal from the absence of the 52A signal. Circuit breaker status information will be available in this case but no discrepancy alarm will be available. The above is also true where only a 52B is used. If both 52A and 52B are used then status information will be available and in addition a discrepancy alarm will be possible, according to the following table. 52A and 52B inputs are assigned to relay opto-isolated inputs via the PSL.

Auxiliary Contact Position		CB State Detected	Action
52A	52B		
Open	Closed	Breaker Open	Circuit breaker healthy
Closed	Open	Breaker Closed	Circuit breaker healthy
Closed	Closed	CB Failure	Alarm raised if the condition persists for greater than 5s
Open	Open	State Unknown	Alarm raised if the condition persists for greater than 5s

Table 24.

Where single pole tripping is used (available on certain relays only) then an open breaker condition will only be given if all three phases indicate and open condition. Similarly for a closed breaker condition indication that all three phases are closed must be given. For single pole tripping applications 52A-a, 52A-b and 52A-c and/or 52B-a, 52B-b and 52B-c inputs should be used.

In the case of the P544 and P546 two circuit breakers are monitored. If inputs relevant to each of the circuit breaker's (CB1 and CB2) are available to the relay via the opto isolated inputs it will be able to determine the state of each circuit breaker.

3.7 Circuit breaker condition monitoring (P541, P542, P543 and P545)

Periodic maintenance of circuit breakers is necessary to ensure that the trip circuit and mechanism operate correctly, and also that the interrupting capability has not been compromised due to previous fault interruptions. Generally, such maintenance is based on a fixed time interval, or a fixed number of fault current interruptions. These methods of monitoring circuit breaker condition give a rough guide only and can lead to excessive maintenance.

The relays record various statistics related to each circuit breaker trip operation, allowing a more accurate assessment of the circuit breaker condition to be determined. These monitoring features are discussed in the following section.

3.7.1 Circuit breaker condition monitoring features

For each circuit breaker trip operation the relay records statistics as shown in the following table taken from the relay menu. The menu cells shown are counter values only. The Min/Max values in this case show the range of the counter values. These cells can not be set:

CB Condition	Default	Min	Max	Step
CB operations {3 pole tripping}	0	0	10000	1
CB A operations {1 & 3 pole tripping}	0	0	10000	1
CB B operations {1 & 3 pole tripping}	0	0	10000	1
CB C operations {1 & 3 pole tripping}	0	0	10000	1
Total IA Broken	0	0	25000In^	1
Total IB Broken	0	0	25000In^	1
Total IC Broken	0	0	25000In^	1In^
CB operate time	0	0	0.5s	0.001
Reset CB Data	No	Yes, No		

Table 25.

The above counters may be reset to zero, for example, following a maintenance inspection and overhaul.

The following table, detailing the options available for the CB condition monitoring, is taken from the relay menu. It includes the setup of the current broken facility and those features which can be set to raise an alarm or CB lockout.

CB Monitor Setup	Default	Min	Max	Step
Broken I^	2	1	2	0.1
I^ Maintenance	Alarm	Alarm disabled, Alarm enabled disabled		
I^ Maintenance	1000In^	1In^	25000In^	1In^

CB Monitor Setup	Default	Min	Max	Step
I^ Lockout	Alarm	Alarm disabled, Alarm enabled disabled		
I^ Lockout	2000In^	1In^	25000In^	1In^
No CB ops maint	Alarm	Alarm disabled, Alarm enabled disabled		
No CB ops maint	10	1	10000	1
No CB ops lock	Alarm	Alarm disabled, Alarm enabled disabled		
No CB ops lock	20	1	10000	1
CB time maint	Alarm	Alarm disabled, Alarm enabled disabled		
CB time maint	0.1s	0.005s	0.5s	0.001s
CB time lockout	Alarm	Alarm disabled, Alarm enabled disabled		
CB time lockout	0.2s	0.005s	0.5s	0.001s
Fault freq lock	Alarm	Alarm disabled, Alarm enabled disabled		
Fault freq count	10	0	9999	1
Fault freq time	3600s	0	9999s	1s

Table 26.

The circuit breaker condition monitoring counters will be updated every time the relay issues a trip command. In cases where the breaker is tripped by an external protection device it is also possible to update the CB condition monitoring. This is achieved by allocating one of the relays opto-isolated inputs (via the programmable scheme logic) to accept a trigger from an external device. The signal that is mapped to the opto is called ‘External Trip’.

Note: That when in Commissioning test mode the CB condition monitoring counters will not be updated.

3.7.2 Setting guidelines

3.7.2.1 Setting the Σ I^ thresholds

Where overhead lines are prone to frequent faults and are protected by oil circuit breakers (OCB’s), oil changes account for a large proportion of the life cycle cost of the switchgear. Generally, oil changes are performed at a fixed interval of circuit breaker fault operations. However, this may result in premature maintenance where fault currents tend to be low, and hence oil degradation is slower than expected. The Σ I^ counter monitors the cumulative severity of the duty placed on the interrupter allowing a more accurate assessment of the circuit breaker condition to be made.

For OCB’s, the dielectric withstand of the oil generally decreases as a function of $\Sigma I^2 t$. This is where ‘I’ is the fault current broken, and ‘t’ is the arcing time within the interrupter tank (not the interrupting time). As the arcing time cannot be determined accurately, the relay would normally be set to monitor the sum of the broken current squared, by setting ‘Broken I^’ = 2.

For other types of circuit breaker, especially those operating on higher voltage systems, practical evidence suggests that the value of ‘Broken I^’ = 2 may be inappropriate. In such applications ‘Broken I^’ may be set lower, typically 1.4 or 1.5. An alarm in this instance may be indicative of the need for gas/vacuum interrupter HV pressure testing, for example.

The setting range for ‘Broken I^’ is variable between 1.0 and 2.0 in 0.1 steps. It is imperative that any maintenance programme must be fully compliant with the switchgear manufacturer’s instructions.

3.7.2.2 Setting the number of operations thresholds

Every operation of a circuit breaker results in some degree of wear for its components. Thus, routine maintenance, such as oiling of mechanisms, may be based upon the number of operations. Suitable setting of the maintenance threshold will allow an alarm to be raised, indicating when preventative maintenance is due. Should maintenance not be carried out, the relay can be set to lockout the autoreclose function on reaching a second operations threshold. This prevents further reclosure when the circuit breaker has not been maintained to the standard demanded by the switchgear manufacturer's maintenance instructions.

Certain circuit breakers, such as oil circuit breakers (OCB's) can only perform a certain number of fault interruptions before requiring maintenance attention. This is because each fault interruption causes carbonising of the oil, degrading its dielectric properties. The maintenance alarm threshold (No CB Ops Maint) may be set to indicate the requirement for oil sampling for dielectric testing, or for more comprehensive maintenance. Again, the lockout threshold (No CB Ops Lock) may be set to disable autoreclosure when repeated further fault interruptions could not be guaranteed. This minimises the risk of oil fires or explosion.

3.7.2.3 Setting the operating time thresholds

Slow CB operation is also indicative of the need for mechanism maintenance. Therefore, alarm and lockout thresholds (CB Time Maint/CB Time Lockout) are provided and are settable in the range of 5 to 500ms. This time is set in relation to the specified interrupting time of the circuit breaker.

3.7.2.4 Setting the excessive fault frequency thresholds

A circuit breaker may be rated to break fault current a set number of times before maintenance is required. However, successive circuit breaker operations in a short period of time may result in the need for increased maintenance. For this reason it is possible to set a frequent operations counter on the relay which allows the number of operations (Fault Freq Count) over a set time period (Fault Freq Time) to be monitored. A separate alarm and lockout threshold can be set

3.8 Circuit breaker control

The relay includes the following options for control of a single circuit breaker:

- Local tripping and closing, via the relay menu
- Local tripping and closing, via relay opto-isolated inputs
- Remote tripping and closing, using the relay communications
- Local tripping via the hot keys on the user interface (Since software 20 and onwards)

It is recommended that separate relay output contacts are allocated for remote circuit breaker control and protection tripping. This enables the control outputs to be selected via a local/remote selector switch as shown in Figure 31. Where this feature is not required the same output contact(s) can be used for both protection and remote tripping.

In the case of the P544 and P546 two circuit breakers may be selectively controlled both locally and remotely if relay contacts are assigned to allow a separate control trip contact and a separate control close for each circuit breaker i.e. four output relay contacts.

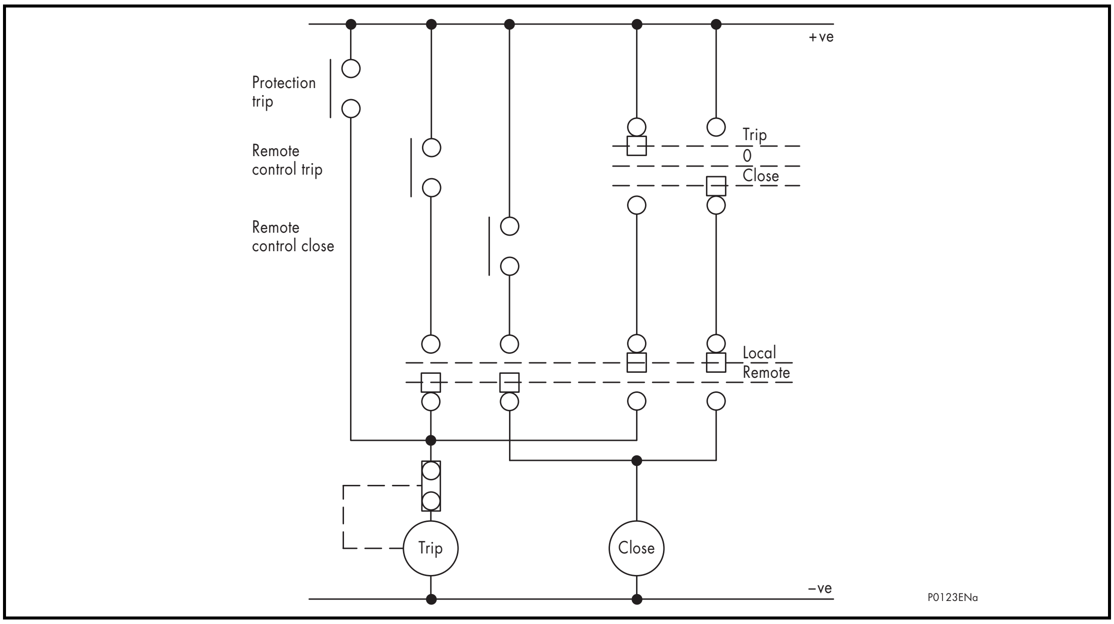


Figure 31: Remote control of circuit breaker

The following table is taken from the relay menu and shows the available settings and commands associated with circuit breaker control. Depending on the relay model some of the cells may not be visible:

CB Control	Default	Min	Max	Step
CB Control by	Disabled	Disabled, Local, Remote, Local+Remote, Opto, Opto+local, Opto+Remote, Opto+Rem+local		
Close pulse time	0.5s	0.01s	10s	0.01s
Trip pulse time	0.5s	0.01s	5s	0.01s
Man close delay	10s	0.01s	600s	0.01s
CB Healthy Time	5s	0.01s	9999s	0.01s
Check Synch Time	5s	0.01s	9999s	0.01s
Lockout reset	No	No, Yes		
Reset lockout by	CB Close	User Interface, CB Close		
Man close RstDly	5s	0.01s	600s	0.01s
A/R telecontrol	No operation	No operation, auto, non-auto {refer to autoreclose notes for further information}		
Single pole (1&3 pole A/R only)	Disabled	Disabled, enabled {refer to autoreclose notes for further information}		
Three pole (1&3 pole A/R only)	Enabled	Disabled, enabled {refer to autoreclose notes for further information}		
A/R status (Indication of current mode only)	Auto Mode	Auto mode, non-auto mode {refer to autoreclose notes for further information}		
Total reclosures	0	0	10000	1
Reset total A/R	No	No, Yes		
CB status input (P541, P542)	None	None, 52A, 52B, Both 52A and 52B		
CB status input (P543, P544)	None	None, 52A 3 pole, 52B 3 pole, 52A & 52B 3 pole, 52A 1 pole, 52B 1 pole, 52A & 52B 1 pole		

Table 27.

A manual trip will be permitted provided that the circuit breaker is initially closed. Likewise, a close command can only be issued if the CB is initially open. To confirm these states it will be necessary to use the breaker 52A and/or 52B contacts (the different selection options are given from the ‘CB Status Input’ cell above). If no CB auxiliary contacts are available then this cell should be set to None. Under these circumstances no CB control (manual or auto) will be possible.

Once a CB Close command is initiated the output contact can be set to operate following a user defined time delay (‘Man Close Delay’). This would give personnel time to move away from the circuit breaker following the close command. This time delay will apply to all manual CB Close commands.

The length of the trip or close control pulse can be set via the ‘Trip Pulse Time’ and ‘Close Pulse Time’ settings respectively. These should be set long enough to ensure the breaker has completed its open or close cycle before the pulse has elapsed.

Note that the manual trip and close commands are found in the System Data column and the hotkey of the menu.

If an attempt to close the breaker is being made, and a protection trip signal is generated, the protection trip command overrides the close command.

Where the check synchronism function is set, this can be enabled to supervise manual circuit breaker close commands. A circuit breaker close output will only be issued if the check synchronism criteria are satisfied. A user settable time delay is included (‘C/S Window’) for manual closure with check synchronising. If the checksynch criteria are not satisfied in this time period following a close command the relay will lockout and alarm.

In addition to a synchronism check before manual reclosure there is also a CB Healthy check if required. This facility accepts an input to one of the relays opto-isolators to indicate that the breaker is capable of closing (circuit breaker energy for example). A user settable time delay is included (‘Healthy Window’) for manual closure with this check. If the CB does not indicate a healthy condition in this time period following a close command then the relay will lockout and alarm.

Where auto-reclose is used it may be desirable to block its operation when performing a manual close. In general, the majority of faults following a manual closure will be permanent faults and it will be undesirable to auto-reclose. The ‘Man Close RstDly’ timer setting is the time for which auto-reclose will be disabled following a manual closure of the breaker.

If the CB fails to respond to the control command (indicated by no change in the state of CB Status inputs) a ‘CB Failed to Trip’ or ‘CB Failed to Close’ alarm will be generated after the relevant trip or close pulses have expired. These alarms can be viewed on the relay LCD display, remotely via the relay communications, or can be assigned to operate output contacts for annunciation using the relays programmable scheme logic (PSL).

Note that the ‘Healthy Window’ timer and ‘C/S Window’ timer set under this menu section are applicable to manual circuit breaker operations only. These settings are duplicated in the Auto-reclose menu for Auto-reclose applications.

The ‘Lockout Reset’ and ‘Reset Lockout by’ setting cells in the menu are applicable to CB Lockouts associated with manual circuit breaker closure, CB Condition monitoring (Number of circuit breaker operations, for example) and auto-reclose lockouts.

3.8.1 CB Control using “Hotkeys” (Since software 20 and onwards)

The hotkeys allow direct access to the manual trip and close commands without the need to enter the SYSTEM DATA column. The CB trip and close functionality via the hotkey menu is identical to that of the SYSTEM DATA menu.

If <<TRIP>> or <<CLOSE>> is selected the user is prompted to confirm the execution of the relevant command. If a trip is executed a screen with the CB status will be displayed once the command has been completed. If a close is executed a screen with a timing bar will appear while the command is being executed. This screen has the option to cancel or restart the close procedure. The timer used is taken from the manual close delay timer setting in the CB Control menu. When the command has been executed, a screen confirming the present status of the circuit breaker is displayed. The user is then prompted to select the next appropriate command or exit – this will return to the default relay screen.

If no keys are pressed for a period of 25 seconds while waiting for the command confirmation, the relay will revert to showing the CB Status. If no key presses are made for a period of 25 seconds while displaying the CB status screen, the relay will revert to the default relay screen. Figure 32 shows the hotkey menu associated with CB control functionality.

To avoid accidental operation of the trip and close functionality, the hotkey CB control commands will be disabled for 10 seconds after exiting the hotkey menu.

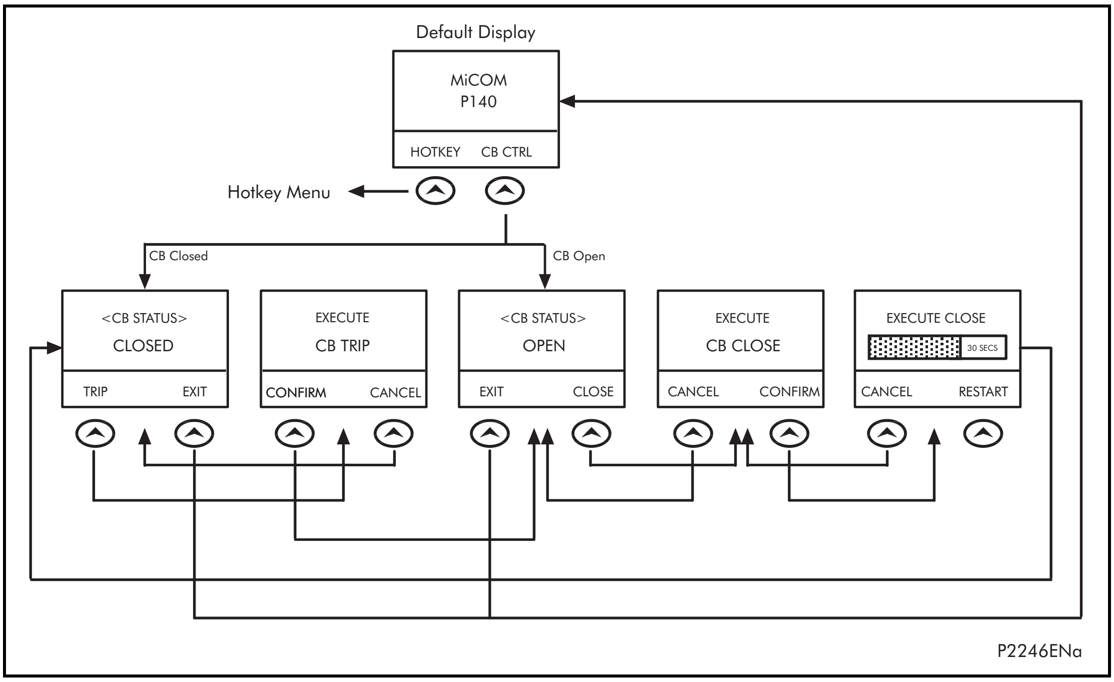


Figure 32: CB Control hotkey menu

3.9 Fault locator (P543, P544, P545 and P546)

3.9.1 Fault locator

3.9.1.1 Introduction

The relay has an integral fault locator that uses information from the current and voltage inputs to provide a distance to fault location feature. The sampled data from the analogue input circuits is written to a cyclic buffer until a fault condition is detected. The data in the input buffer is then held to allow the fault calculation to be made. When the fault calculation is complete the fault location information is available in the relay fault record.

When applied to parallel circuits mutual flux coupling can alter the impedance seen by the fault locator. The coupling will contain positive, negative and zero sequence components. In practice the positive and negative sequence coupling is insignificant. The effect on the fault locator of the zero sequence mutual coupling can be eliminated by using the mutual compensation feature provided.

3.9.1.2 Basic theory for ground faults

Figure 31 shows a two-machine equivalent circuit of a faulted power system.

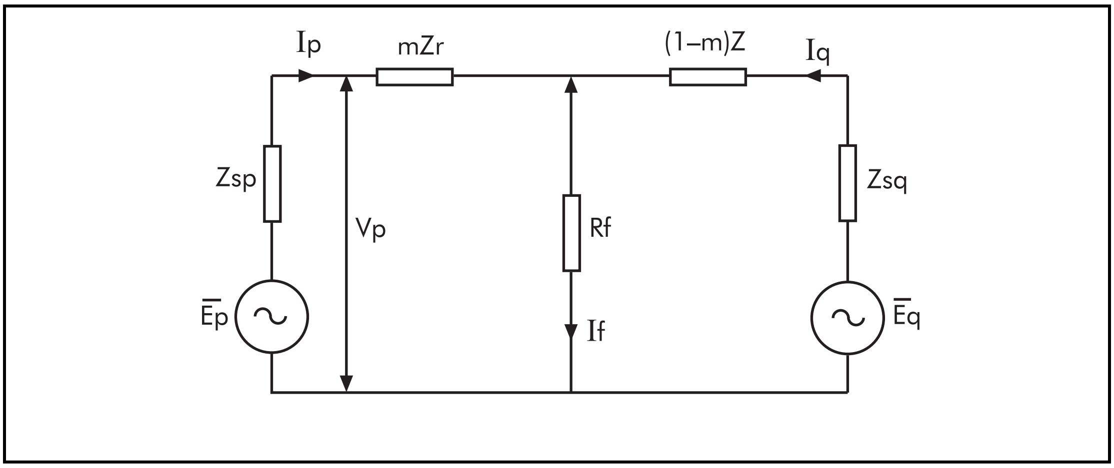


Figure 33: Two-machine equivalent circuit

From this diagram:-

Vp = mIpZr + IfRf ...(equation 1)

The fault location, m, can be found if If can be estimated allowing equation 1 to be solved.

3.9.1.3 Data acquisition and buffer processing

The fault locator stores the sampled data within a 12 cycle cyclic buffer at a resolution of 24 samples per cycle. When the fault recorder is triggered the data in the buffer is frozen such that the buffer contains 6 cycles of pre-trigger data and 6 cycles of post-trigger data. Fault calculation commences shortly after this trigger point.

The trigger for the fault recorder is user selectable via the programmable scheme logic.

The fault locator can store data for up to four faults. This ensures that fault location can be calculated for all shots on a typical multiple reclose sequence.

3.9.1.4 Faulted phase selection

Phase selection is derived from the current differential element. If the current differential does not operate, selection of the faulted phase(s) is performed by comparing the magnitude of the pre-fault and post fault values of the three phase-to-phase currents. A single phase-to-ground fault produces the same change on two of these signals and zero on the third. A phase-to-phase or double phase-to-ground fault produces one signal which is larger than the other two. A three phase fault produces the same change on all 3 currents.

Current changes are considered to be the same if they are within 20% of each other. Phase selection and fault location calculation can only be made if the current change exceeds 5% In.

3.9.1.5 The fault location calculation

The fault location calculation works by:-

a) First obtaining the vectors.

b) Selecting the faulted phase(s).

c) Estimating the phase of the fault current If for the faulted phase(s).

d) Solving equation 1 for the fault location m at the instant of time where f = 0.

3.9.1.5.1 Obtaining the vectors

Different sets of vectors are chosen depending on the type of fault identified by the phase selection algorithm. The calculation using equation 1 is applied for either a phase to ground fault or a phase to phase fault.

thus for an A phase to ground fault:-

IpZr=Ia(Zline / THETA line) + In(Zresidual / THETA residual) …..(equation 2)

and Vp=VA

and for a A phase to B phase fault:-

IpZr=Ia(Zline / THETA line) - Ib(Zresidual / THETA residual) ….(equation 3)

and Vp = VA - VB

The calculation for a ground fault (equation 4) is modified when mutual compensation is used :-

IpZr=Ia(Zline/THETA line)+In(residual/THETA residual)+

Im(mutual / THETA mutual) ....(equation 4)

3.9.1.5.2 Solving the equation for the fault location

As the sine wave of If passes through zero, the instantaneous values of the sine waves Vp and Ip can be used to solve equation (1) for the fault location m. (The term IfRf being zero.)

This is determined by shifting the calculated vectors of Vp and IpZr by the angle (90° - angle of fault current) and then dividing the real component of Vp by the real component of IpZr. (See Figure 34)

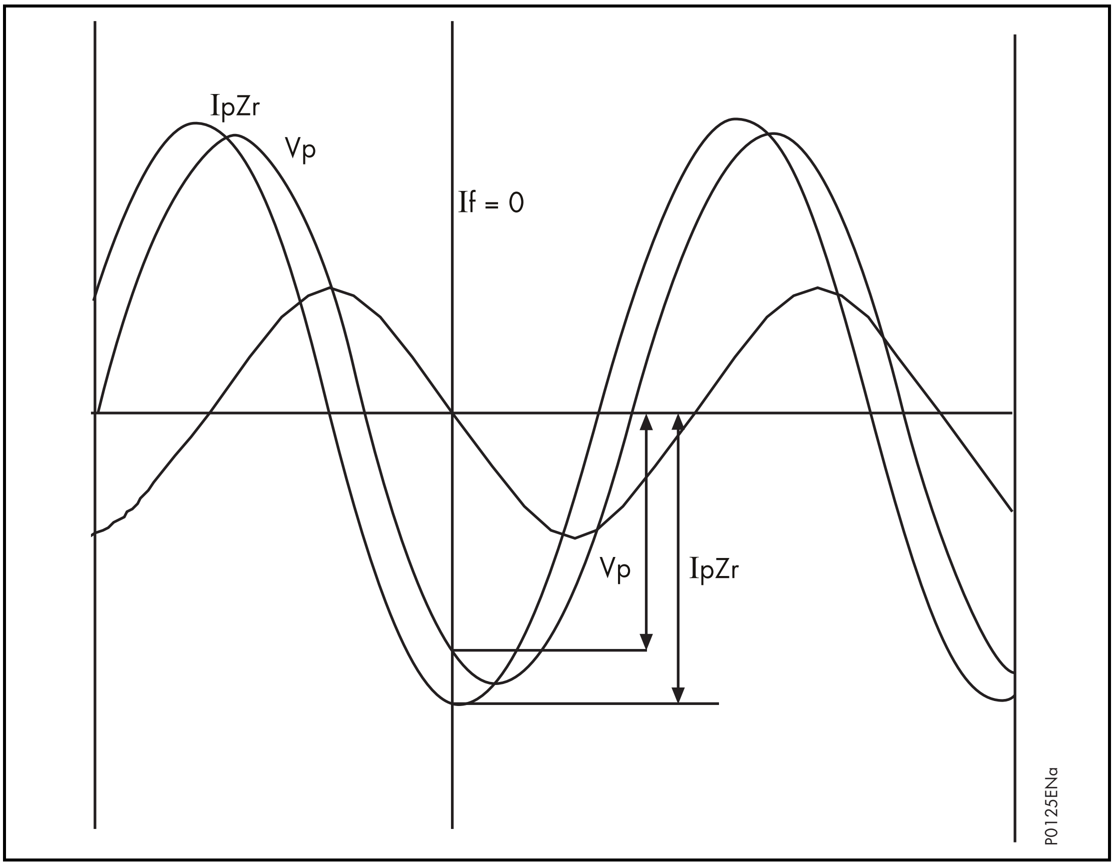


Figure 34: Fault locator selection of fault current zero

i.e.:-

Phase advanced vector Vp

$= |Vp| \, [\cos(s) + j\sin(s)] * [\sin(d) + j\cos(d)]$

$= |Vp| \, [-\sin(s-d) + j\cos(s-d)]$

Phase advanced vector IpZr

$= |IpZr| \, [\cos(e) + j\sin(e)] * [\sin(d) + j\cos(d)]$

$= |IpZr| \, [-\sin(e-d) + j\cos(e-d)]$

Therefore, from equation 1:

$m = Vp \div (Ip * Zr)$ at $If = 0$

$= Vp \sin(s-d) / (IpZr * \sin(e-d))$

where d = angle of fault current If
s = angle of Vp
e = angle of IpZr

Thus the relay evaluates m which is the fault location as a percentage of the fault locator line impedance setting and then calculates the output fault location by multiplying this by the line length setting. When calculated the fault location can be found in the fault record under the VIEW RECORDS column in the Fault Location cells. Distance to fault is available in kilometres, miles, impedance or percentage of line length.

3.9.1.6 Mutual compensation

Analysis of an earth fault on one circuit of a parallel over-head line shows that a fault locator positioned at one end of the faulty line will tend to over-reach while that at the other end will tend to under-reach. In cases of long lines with high mutual inductance, mutual zero sequence compensation can be used to improve the fault locator accuracy. The compensation is achieved by taking an input to the relay from the residual circuit of the current transformers in the parallel line.

Another problem on parallel feeders occurs when one circuit is out of service and is earthed at both ends. In this case an earth fault on the in service system can induce current in the loop of the earthed line causing a misleading mutual compensation signal to the fault locator.

It is therefore recommended that the mutual compensation is deselected when a parallel line is taken out of service.

3.9.1.7 Fault locator settings

The following table shows the relay menu for the fault locator, including the available setting ranges and factory defaults:-

MENU TEXT	DEFAULT SETTING	SETTING RANGE		STEP SIZE
		MIN	MAX	
VIEW RECORDS				
Fault Location	x metres	Distance to fault in metres		
Fault Location	x miles	Distance to fault in miles		
Fault Location	x Ω	Distance to fault in impedance		
Fault Location	x %	Distance to fault in % of line length		
GROUP 1 FAULT LOCATOR				
Line Length (metres)	16000	10	1E6	10
Line Length (miles)	10	0.005	621	0.005

MENU TEXT	DEFAULT SETTING	SETTING RANGE		STEP SIZE
		MIN	MAX	
Line Impedance	6	0.1	250	0.01
Line Angle	70	20	85	1
KZN Residual	1	0	7	0.01
KZN Res Angle	0	-90	90	1
Mutual Comp	Disabled	Enabled/Disabled		
kZm Mutual Comp	1	0	7	0.01
kZm Angle	0	-90° (software 20 or previous) -180° (software 30 or later)	90	1

Table 28.

3.9.1.8 Fault locator trigger

Fault location is part of the data included within the relay fault record and therefore the fault locator is triggered whenever a fault record is generated. This is controlled by DDB 110: Fault REC TRIG; in the default PSL this signal is energised from operation of any protection trip.

3.9.1.9 Setting example

Assuming the following data for the protected line:

230kV transmission line

CT ratio	=	1200/5
VT ratio	=	230,000/115
Line length	=	10Km
Positive sequence line impedance ZL1	=	0.089+j0.476 Ohms/Km
Zero sequence line impedance ZL0	=	0.34+j1.03 ohms/Km
Zero sequence mutual impedance ZM0	=	0.1068+j0.5712

The line length can be set in either metres or miles.

Therefore for this example set line length = 10Km.

The line impedance magnitude and angle settings are calculated as follows:

Ratio of secondary to primary impedance = CT ratio/VT ratio = 0.12

Positive sequence line impedance ZL1 = 0.12 x 10 (0.484∠79.4°)

= 0.58 ∠79.4°

Therefore set line impedance = 0.58

line angle = 79°.

The residual impedance compensation magnitude and angle are calculated using the following formula;

$$KZN = \frac{ZL0 - ZL1}{3 \times ZL1}$$

$$= \frac{(0.34 + j1.03) - (0.089 + j0.476)}{3 \times (0.484 \angle 79.4)}$$

$$= \frac{0.6 \angle 65.23}{1.45 \angle 79.4}$$

$$= 0.41 \angle -14.17$$

Therefore set kZN Residual = 0.41

kZN Res Angle = -14°

The mutual impedance compensation magnitude and angle (kZm Mutual Comp, kZm Angle) settings are calculated using the following formula;

The CT ratio for the mutual compensation may be different from the Line CT ratio. However, for this example we will assume they are identical.

$$kZm = \frac{ZM0}{3 \times ZL1}$$

$$= \frac{0.107 + j0.571}{3 \times (0.484 \angle 79.4)}$$

$$= \frac{0.581 \angle 79.4}{1.45 \angle 79.4}$$

$$= 0.4 \angle 0$$

Therefore set kZm Mutual Comp = 0.4

kZm Angle = 0°

3.10 Event & fault records

The relay records and time tags up to 512 events (since software 20 and 250 events for software 13 or previous) and stores them in non-volatile (battery backed up) memory. This enables the system operator to establish the sequence of events that occurred within the relay following a particular power system condition, switching sequence etc. When the available space is exhausted, the oldest event is automatically overwritten by the new one.

The real time clock within the relay provides the time tag to each event, to a resolution of 1ms.

The event records are available for viewing either via the frontplate LCD or remotely, via the communications ports.

Local viewing on the LCD is achieved in the menu column entitled ‘VIEW RECORDS’. This column allows viewing of event, fault and maintenance records and is shown below:-

VIEW RECORDS	
LCD Reference	Description
Select Event	Setting range from 0 to 511 (for software 20. 249 for software 13 or previous). This selects the required event record from the possible 512 (for software 20. 250 for software 13 or previous) that may be stored. A value of 0 corresponds to the latest event and so on.
Time & Date	Time & Date Stamp for the event given by the internal Real Time Clock
Event Text	Up to 16 Character description of the Event (refer to following sections)
Event Value	Up to 32 Bit Binary Flag or integer representative of the Event (refer to following sections)
Select Fault	Setting range from 0 to 4. This selects the required fault record from the possible 5 that may be stored. A value of 0 corresponds to the latest fault and so on.

VIEW RECORDS	
LCD Reference	Description
	The following cells show all the fault flags, protection starts, protection trips, fault location, measurements etc. associated with the fault, i.e. the complete fault record.
Maint Type	These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to ALSTOM GRID.
Maint Data	
Reset Indication	Either Yes or No. This serves to reset the trip LED indications provided that the relevant protection element has reset.

For extraction from a remote source via communications, refer to the SCADA Communications chapter (P54x/EN CT), where the procedure is fully explained.

Note that a full list of all the event types and the meaning of their values is given in the Relay Menu Database chapter (P54x/EN GC).

3.10.1 Types of Event

An event may be a change of state of a control input or output relay, an alarm condition, setting change etc. The following sections show the various items that constitute an event:-

3.10.1.1 Change of state of opto-isolated inputs

If one or more of the opto (logic) inputs has changed state since the last time that the protection algorithm ran, the new status is logged as an event. When this event is selected to be viewed on the LCD, three applicable cells will become visible as shown below;

Time & Date of Event
“LOGIC INPUTS”
“Event Value 0101010101010101”

The Event Value is an 8 or 16 bit word showing the status of the opto inputs, where the least significant bit (extreme right) corresponds to opto input 1 etc. The same information is present if the event is extracted and viewed via PC.

3.10.1.2 Change of state of one or more output relay contacts

If one or more of the output relay contacts has changed state since the last time that the protection algorithm ran, then the new status is logged as an event. When this event is selected to be viewed on the LCD, three applicable cells will become visible as shown overleaf;

Time & Date of Event
“OUTPUT CONTACTS”
“Event Value 010101010101010101010”

The Event Value is a 7, 14 or 21 bit word showing the status of the output contacts, where the least significant bit (extreme right) corresponds to output contact 1 etc. The same information is present if the event is extracted and viewed via PC.

3.10.1.3 Relay alarm conditions

Any alarm conditions generated by the relays will also be logged as individual events. The following table shows examples of some of the alarm conditions and how they appear in the event list over leaf:-

Alarm Condition	Resulting Event	
	Event Text	Event Value
Battery Fail	Battery Fail ON/OFF	Number from 0 to 31
Field Voltage Fail	Field V Fail ON/OFF	Number from 0 to 31
Setting group via opto invalid	Setting Grp Invalid ON/OFF	Number from 0 to 31
Protection Disabled	Prot'n Disabled ON/OFF	Number from 0 to 31
Frequency out of range	Freq out of Range ON/OFF	Number from 0 to 31
VTS Alarm	VT Fail Alarm ON/OFF	Number from 0 to 31
CB Trip Fail Protection	CB Fail ON/OFF	Number from 0 to 31
User Alarm (Self Reset) software 12 or later	SR User Alarm X* ON/OFF	Number from 47 to 54
User Alarm (Manual Reset) software 12 or later	MR User Alarm Y* ON/OFF	Number from 55 to 63
*X in range 1 to 8, Y in range 9 to 16		

Table 29.

The previous table shows the abbreviated description that is given to the various alarm conditions and also a corresponding value between 0 and 31. This value is appended to each alarm event in a similar way as for the input and output events previously described. It is used by the event extraction software, such as MiCOM S1, to identify the alarm and is therefore invisible if the event is viewed on the LCD. Either ON or OFF is shown after the description to signify whether the particular condition has become operated or has reset.

3.10.1.4 Protection element starts and trips

Any operation of protection elements, (either a start or a trip condition), will be logged as an event record, consisting of a text string indicating the operated element and an event value. Again, this value is intended for use by the event extraction software, such as MiCOM S1, rather than for the user, and is therefore invisible when the event is viewed on the LCD.

3.10.1.5 General events

A number of events come under the heading of 'General Events' - an example is shown overleaf;

Nature of Event	Displayed text in event record	Displayed value
Level 1 password modified, either from user interface, front or rear port	PW1 modified UI, F, R or R2	UI=6, F=11, R=16, R2=38

A complete list of the 'General Events' is given in the Relay Menu Database chapter (P54x/EN GC).

3.10.1.6 Fault records

Each time a fault record is generated, an event is also created. The event simply states that a fault record was generated, with a corresponding time stamp.

Note that viewing of the actual fault record is carried out in the 'Select Fault' cell further down the 'VIEW RECORDS' column, which is selectable from up to 5 records. These records consist of fault flags, fault location, fault measurements etc. Also note that the time stamp given in the fault record itself will be more accurate than the corresponding stamp given in the event record as the event is logged some time after the actual fault record is generated.

3.10.1.7 Maintenance reports

Internal failures detected by the self monitoring circuitry, such as watchdog failure, field voltage failure etc. are logged into a maintenance report. The Maintenance Report holds up to 5 such 'events' and is accessed from the 'Select Maint' cell at the bottom of the 'VIEW RECORDS' column.

Each entry consists of a self explanatory text string and a ‘Type’ and ‘Data’ cell, which are explained in the menu extract at the beginning of this section and in further detail in Relay Menu Database chapter (P54x/EN GC).

Each time a Maintenance Report is generated, an event is also created. The event simply states that a report was generated, with a corresponding time stamp.

3.10.1.8 Setting Changes

Changes to any setting within the relay are logged as an event. Two examples are shown in the following table:-

Type of Setting Change	Displayed Text in Event Record	Displayed Value
Control/Support Setting	C & S Changed	0
Group 1 Change	Group 1 Changed	1

Note: Control/Support settings are communications, measurement, CT/VT ratio settings etc, which are not duplicated within the four setting groups. When any of these settings are changed, the event record is created simultaneously. However, changes to protection or disturbance recorder settings will only generate an event once the settings have been confirmed at the ‘setting trap’.

3.10.2 Resetting of event/fault records

If it is required to delete either the event, fault or maintenance reports, this may be done from within the ‘RECORD CONTROL’ column.

3.10.3 Viewing event records via MiCOM S1 Support Software

When the event records are extracted and viewed on a PC they look slightly different than when viewed on the LCD. The following shows an example of how various events appear when displayed using MiCOM S1:-

- Monday 03 November 2000 15:32:49 GMT I>1 Start ON 2147483881

  MiCOM

  Model Number: P541

  Address: 001 Column: 00 Row: 23

  Event Type: Protection operation

- Monday 03 November 2000 15:32:52 GMT Fault Recorded 0

  MiCOM

  Model Number: P541

  Address: 001 Column: 01 Row: 00

  Event Type: Fault record

- Monday 03 November 2000 15:33:11 GMT Logic Inputs 00000000

  MiCOM

  Model Number: P541

  Address: 001 Column: 00 Row: 20

  Event Type: Logic input changed state

- Monday 03 November 2000 15:34:54 GMT Output Contacts 0010000

  MiCOM

  Model Number: P541

  Address: 001 Column: 00 Row: 21

Event Type: Relay output changed state

As can be seen, the first line gives the description and time stamp for the event, whilst the additional information that is displayed below may be collapsed via the +/- symbol.

For further information regarding events and their specific meaning, refer to the Relay Menu Database chapter (P54x/EN GC).

3.10.4 Event Filtering

It is possible to disable the reporting of events from any user interface that supports setting changes. The settings which control the various types of events are in the Record Control column.

The effect of setting each to disabled is as follows:

Alarm Event	None of the occurrences that produce an alarm will result in an event being generated. The presence of any alarms is still reported by the alarm LED flashing and the alarm bit being set in the communications status byte. Alarms can still be read using the Read key on the relay front panel.
Relay O/P Event	No event will be generated for any change in relay output state.
Opto Input Event	No event will be generated for any change in logic input state.
General Event	No General Events will be generated.
Fault Rec Event	No event will be generated for any fault that produces a fault record. The fault records can still be viewed by operating the "Select Maint" setting in column 0100.
Protection Event	Any operation of protection elements will not be logged as an event.

Note that some occurrences will result in more than one type of event, e.g. a battery failure will produce an alarm event and a maintenance record event.

If the Protection Event setting is Enabled a further set of settings is revealed which allow the event generation by individual DDB signals to be enabled or disabled.

3.11 Disturbance recorder

The integral disturbance recorder has an area of memory specifically set aside for record storage. The number of records that may be stored is dependent upon the selected recording duration but the relays typically have the capability of storing a minimum of 50 records (for software 20. 20 for software 13 or previous)., each of 0.5 (for software 20. 10.5 for software 13 or previous) seconds duration. Disturbance records continue to be recorded until the available memory is exhausted, at which time the oldest record(s) are overwritten to make space for the newest one.

The recorder stores actual samples which are taken at a rate of 24 (for software 20. 12 for software 13 or previous) samples per cycle.

Each disturbance record consists of eight analogue data channels and thirty-two digital data channels. Note that the relevant CT and VT ratios for the analogue channels are also extracted to enable scaling to primary quantities).

Note: When a 5A CT is used it must be ensured that the CT ratio entered is ≥ 5:5 to ensure correct operation of the disturbance recorder.

The 'DISTURBANCE RECORDER' menu column is shown in table 29:-

MENU TEXT	DEFAULT SETTING	SETTING RANGE		STEP SIZE
		MIN	MAX	
DISTURB RECORDER				
Duration	1.5s	0.1s	10.5s	0.01s

MENU TEXT	DEFAULT SETTING	SETTING RANGE		STEP SIZE
		MIN	MAX	
Trigger Position	33.3%	0	100%	0.1%
Trigger Mode	Single	Single or Extended		
Analog Channel 1	VAN	VAN,VBN,VCN,VCHECK SYNC,IA, IB, IC, IN, IM, IN SEF		
Analog Channel 2	VBN	As above		
Analog Channel 3	VCN	As above		
Analog Channel 4	IA	As above		
Analog Channel 5	IB	As above		
Analog Channel 6	IC	As above		
Analog Channel 7	IN	As above		
Analog Channel 8	IN SEF	As above		
Digital Inputs 1 to 32	Relays 1 to 7/14/32 and Opto's 1 to 8/16/24	Any of 7 or 14 or 32 O/P Contacts or Any of 8 /16 or 24 Opto Inputs or Internal Digital Signals		
Inputs 1 to 32 Trigger	No Trigger except Dedicated Trip Relay O/P's which are set to Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		

Table 30.

Note: The available analogue and digital signals will differ between relay types and models and so the individual Courier database in the SCADA Communications chapter (P54x/EN CT) should be referred to when determining default settings etc.

The pre and post fault recording times are set by a combination of the 'Duration' and 'Trigger Position' cells. 'Duration' sets the overall recording time and the 'Trigger Position' sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 1.5s with the trigger point being at 33.3% of this, giving 0.5s pre-fault and 1s post fault recording times.

If a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger if the 'Trigger Mode' has been set to 'Single'. However, if this has been set to 'Extended', the post trigger timer will be reset to zero, thereby extending the recording time.

As can be seen from the menu, each of the analogue channels is selectable from the available analogue inputs to the relay. The digital channels may be mapped to any of the opto isolated inputs or output contacts, in addition to a number of internal relay digital signals, such as protection starts, LED's etc. The complete list of these signals may be found by viewing the available settings in the relay menu or via a setting file in MiCOM S1. Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition, via the 'Input Trigger' cell. The default trigger settings are that any dedicated trip output contacts (e.g. relay 3) will trigger the recorder.

It is not possible to view the disturbance records locally via the LCD; they must be extracted using suitable software such as MiCOM S1. This process is fully explained in SCADA Communications chapter (P54x/EN CT). Note, however, that it is not possible to extract a disturbance record from both the front and rear communications ports simultaneously.

3.12 Measurements

The relay produces a variety of both directly measured and calculated power system quantities. These measurement values are updated on a per second basis and are summarised below:

- Phase voltages and currents, with phase angles
- Phase to phase voltage and currents, with phase angles

- Sequence voltages and currents, with phase angles
- Slip Frequency (Since software 20 and onwards)

- Power and energy quantities
- Rms. voltages and currents
- Peak, fixed and rolling demand values

There are also measured values from the protection functions, which also displayed under the measurement columns of the menu; these are described in the section on the relevant protection function.

3.12.1 Measured voltages and currents

The relay produces both phase to ground and phase to phase voltage and current values. They are produced directly from the DFT (Discrete Fourier Transform) used by the relay protection functions and present both magnitude and phase angle measurement.

3.12.2 Sequence voltages and currents

Sequence quantities are produced by the relay from the measured Fourier values; these are displayed as magnitude values.

3.12.3 Slip Frequency (Since software 20 and onwards)

The relay produces a slip frequency measurement by measuring the rate of change of phase angle, between the bus and line voltages, over a one cycle period. The slip frequency measurement assumes the bus voltage to be the reference phasor.

3.12.4 Power and energy quantities

Using the measured voltages and currents the relay calculates the apparent, real and reactive power quantities. These are produced on a phase by phase basis together with three-phase values based on the sum of the three individual phase values. The signing of the real and reactive power measurements can be controlled using the measurement mode setting. The four options are defined in the table below:

Measurement Mode	Parameter	Signing
0 (Default, P = VI*)	Export Power	+
	Import Power	–
	Lagging VArs	+
	Leading VArs	–
1	Export Power	–
	Import Power	+
	Lagging VArs	+
	Leading VArs	–
2	Export Power	+
	Import Power	–
	Lagging VArs	–
	Leading VArs	+
3	Export Power	–
	Import Power	+
	Lagging VArs	–
	Leading VArs	+

Table 31.

In addition to the measured power quantities the relay calculates the power factor on a phase by phase basis in addition to a three-phase power factor.

These power values are also used to increment the total real and reactive energy measurements. Separate energy measurements are maintained for the total exported and imported energy. The energy measurements are incremented up to maximum values of 1000GWhr or 1000GVARhr at which point they will reset to zero, it is also possible to reset these values using the menu or remote interfaces using the Reset Demand cell.

3.12.5 Rms. Voltages and Currents

Rms. Phase voltage and current values are calculated by the relay using the sum of the samples squared over a cycle of sampled data.

3.12.6 Demand Values

The relay produces fixed, rolling and peak demand values, using the Reset Demand menu cell it is possible to reset these quantities via the User Interface or the remote communications.

3.12.6.1 Fixed Demand Values

The fixed demand value is the average value of a quantity over the specified interval; values are produced for each phase current and for three phase real and reactive power. The fixed demand values displayed by the relay are those for the previous interval, the values are updated at the end of the fixed demand period.

3.12.6.2 Rolling Demand Values

The rolling demand values are similar to the fixed demand values, the difference being that a sliding window is used. The rolling demand window consists of a number of smaller sub-periods. The resolution of the sliding window is the sub-period length, with the displayed values being updated at the end of each of the sub-periods.

3.12.6.3 Peak Demand Values

Peak demand values are produced for each phase current and the real and reactive power quantities. These display the maximum value of the measured quantity since the last reset of the demand values.

3.12.7 Settings

The following settings under the heading Measurement Setup can be used to configure the relay measurement function.

Measurement Setup	Default Value	Options/Limits
Default Display	Description	Description/Plant Reference/Frequency/Access Level/3Ph + N Current/3Ph Voltage/Power/Date and time
Local Values	Primary	Primary/Secondary
Remote Values	Primary	Primary/Secondary
Measurement Ref	VA	VA/VB/VC/IA/IB/IC
Measurement Mode	0	0 to 3 Step 1
Fix Dem Period	30 minutes	1 to 99 minutes step 1 minute
Roll Sub Period	30 minutes	1 to 99 minutes step 1 minute
Num Sub Periods	1	1 to 15 step 1
Distance Unit*	Km	Km/miles
Fault Location*	Distance	Distance/Ohms/% of Line
Remote 2 Values (software 12 and onwards)	Primary	Primary/Secondary

Table 32.

* Note: These settings are available for products with integral fault location {P543, P544, P545 and P546}.

3.12.7.1 Default Display

This setting can be used to select the default display from a range of options, note that it is also possible to view the other default displays whilst at the default level using the ◁ and ▷ keys. However once the 15 minute timeout elapses the default display will revert to that selected by this setting.

3.12.7.2 Local Values

This setting controls whether measured values via the front panel user interface and the front Courier port are displayed as primary or secondary quantities.

3.12.7.3 Remote Values

This setting controls whether measured values via the rear communication port are displayed as primary or secondary quantities.

3.12.7.4 Remote2 Values (Since software 12 and onwards)

The setting applies to relays with second rear port and controls whether measured values via the second rear communication port are displayed or secondary quantities.

3.12.7.5 Measurement Ref

Using this setting the phase reference for all angular measurements by the relay can be selected.

3.12.7.6 Measurement Mode

This setting is used to control the signing of the real and reactive power quantities; the signing convention used is defined in Table 30.

3.12.7.7 Fixed Demand Period

This setting defines the length of the fixed demand window.

3.12.7.8 Rolling Sub-Period and Number of Sub-Periods

These two settings are used to set the length of the window used for the calculation of rolling demand quantities and the resolution of the slide for this window.

3.12.7.9 Distance Unit

This setting is used to select the unit of distance for fault location purposes, note that the length of the line is preserved when converting from km to miles and visa versa.

3.12.7.10 Fault Location

The calculated fault location can be displayed using one of several options selected using this setting.

3.13 Changing Setting Groups

The setting groups can be changed either by opto inputs, by a menu selection or via the hot keys (software 20 and onwards) on the user interface. In the Configuration column if ‘Setting Group – select via opts’ is selected then optos 1 and 2, which are dedicated for setting group selection, can be used to select the setting group as shown in the table below. If ‘Setting Group – select via menu’ is selected then in the Configuration column the ‘Active Settings – Group 1/2/3/4’ can be used to select the setting group. If this option is used then opto inputs 1 and 2 can be used for other functions in the programmable scheme logic.

The setting group can be changed via the hotkey menu (software 20 and onwards) providing ‘Setting Group select via menu’ is chosen.

OPTO 1	OPTO 2	Selected Setting Group
0	0	1

1	0	2
0	1	3
1	1	4

Note: Setting groups comprise both Settings and Programmable Scheme Logic. Each is independent per group – not shared as common. The settings are generated in the Settings and Records application within MiCOM S1, or can be applied directly from the relay front panel menu. The programmable scheme logic can only be set using the PSL Editor application within MiCOM S1, generating files with extension ".psl". It is essential that where the installation needs application-specific PSL, that the appropriate .psl file is downloaded (sent) to the relay, for each and every setting group that will be used. If the user fails to download the required .psl file to any setting group that may be brought into service, then factory default PSL will still be resident. This may have severe operational and safety consequences.

3.14 Control inputs (Since software 20 and onwards)

The control inputs function as software switches that can be set or reset either locally or remotely. These inputs can be used to trigger any function that they are connected to as part of the PSL. There are three setting columns associated with the control inputs which are: "CONTROL INPUTS", "CTRL I/P CONFIG" and "CTRL I/P LABELS". The function of these columns is described below:

Menu Text	Default Setting	Setting Range	Step Size
CONTROL INPUTS			
Ctrl I/P Status	00000000000000000000000000000000		
Control Input 1	No Operation	No Operation, Set, Reset	
Control Input 2 to 32	No Operation	No Operation, Set, Reset	

The Control Input commands can be found in the 'Control Input' menu. In the 'Ctrl I/P status' menu cell there is a 32 bit word which represent the 32 control input commands. The status of the 32 control inputs can be read from this 32 bit word. The 32 control inputs can also be set and reset from this cell by setting a 1 to set or 0 to reset a particular control input. Alternatively, each of the 32 Control Inputs can be set and reset using the individual menu setting cells 'Control Input 1, 2, 3' etc. The Control Inputs are available through the relay menu as described above and also via the rear communications.

In the programmable scheme logic editor 32 Control Input signals, DDB 800-831, which can be set to a logic 1 or On state, as described above, are available to perform control functions defined by the user.

Menu Text	Default Setting	Setting Range	Step Size
CTRL I/P CONFIG			
Hotkey Enabled	11111111111111111111111111111111		
Control Input 1	Latched	Latched, Pulsed	
Ctrl Command 1	SET/RESET	SET/RESET, IN/OUT, ENABLED/DISABLED, ON/OFF	
Control Input 2 to 32	Latched	Latched, Pulsed	
Ctrl Command 2 to 32	SET/RESET	SET/RESET, IN/OUT, ENABLED/DISABLED, ON/OFF	

Menu Text	Default Setting	Setting Range	Step Size
CTRL I/P LABELS			
Control Input 1	Control Input 1	16 character text	
Control Input 2 to 32	Control Input 2 to 32	16 character text	

The “CTRL I/P CONFIG” column has several functions one of which allows the user to configure the control inputs as either ‘latched’ or ‘pulsed’. A latched control input will remain in the set state until a reset command is given, either by the menu or the serial communications. A pulsed control input, however, will remain energised for 10ms after the set command is given and will then reset automatically (i.e. no reset command required).

In addition to the latched / pulsed option this column also allows the control inputs to be individually assigned to the “Hotkey” menu by setting ‘1’ in the appropriate bit in the “Hotkey Enabled” cell. The hotkey menu allows the control inputs to be set, reset or pulsed without the need to enter the “CONTROL INPUTS” column. The “Ctrl Command” cell also allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as “ON / OFF”, “IN / OUT” etc.

The “CTRL I/P LABELS” column makes it possible to change the text associated with each individual control input. This text will be displayed when a control input is accessed by the hotkey menu, or it can be displayed in the PSL.

Note: With the exception of pulsed operation, the status of the control inputs is stored in battery backed memory. In the event that the auxiliary supply is interrupted the status of all the inputs will be recorded. Following the restoration of the auxiliary supply the status of the control inputs, prior to supply failure, will be reinstated. If the battery is missing or flat the control inputs will set to logic 0 once the auxiliary supply is restored.

3.15 Real time clock synchronization via opto-inputs (Since software 20 and onwards)

In modern protective schemes it is often desirable to synchronize the relays real time clock so that events from different relays can be placed in chronological order. This can be done using the IRIG-B input, if fitted, or via the communication interface connected to the substation control system. In addition to these methods the P540 range offers the facility to synchronize via an opto-input by routing it in PSL to DDB#347 (Time Synch). Pulsing this input will result in the real time clock snapping to the nearest minute. The recommended pulse duration is 20ms to be repeated no more than once per minute. An example of the time synch function is shown below:

Time of “Synch Pulse”	Corrected Time
19:47:00 to 19:47:29	19:47:00
19:47:30 to 19:47:59	19:48:00

Note: The above assumes a time format of hh:mm:ss

To avoid the event buffer from being filled with unnecessary time synch events, it is possible to ignore any event that generated by the time synch opto input. This can be done by applying the following settings:

Menu Text	Value
RECORD CONTROL	
Opto Input Event	Enabled
Protection Event	Enabled
DDB 63 – 32 (Opto Inputs)	Set “Time Synch” associated opto to 0.

To improve the recognition time of the time synch opto input by approximately 10ms, the opto input filtering could be disabled. This is achieved by setting the appropriate bit to 0 in the “Opto Filter Cntl” cell (CONFIGURATION column). Disabling the filtering may make the opto input more susceptible to induced noise. Fortunately the effects of induced noise can be minimised by using the methods described in section 2.4.3 of the Relay Description chapter (P54x/EN HW).

4. FACTORY DEFAULT SETTINGS

The relay includes programmable scheme logic (PSL). The purpose of this logic is multi-functional and includes the following:

Enables the mapping of opto-isolated inputs, relay output contacts and the programmable LED's.

Provides relay output conditioning (delay on pick-up/drop-off, dwell time, latching or self-reset).

Fault Recorder start mapping, i.e. which internal signals initiate a fault record.

Enables customer specific scheme logic to be generated through the use of the PSL editor inbuilt into the MiCOM S1 support software.

Further information regarding editing and the use of PSL can be found in the MiCOM S1 user manual. The following section details the default settings of the PSL. Note that changes to these defaults can only be carried out using the PSL editor and not via the relay front plate.

Note: The default PSL diagrams shown in the Relay Menu Database chapter (P54x/EN GC) contain additional notes to guide the user in drawing or modifying a custom PSL for a specific application.

It is essential that where the installation needs application-specific Programmable Scheme Logic, that the appropriate .psl file is downloaded (sent) to the relay, for each and every setting group that will be used. If the user fails to download the required .psl file to any setting group that may be brought into service, then factory default PSL will still be resident. This may have severe operational and safety consequences.

4.1 Logic input mapping

	P541	P542	P543	P544	P545	P546
1	L1 Intertrip 1	L1 Intertrip 1	L1 Setting Group	L1 Setting Group	L1 Setting Group	L1 Setting Group
2	L2 PIT	L2 PIT	L2 Setting Group	L2 Setting Group	L2 Setting Group	L2 Setting Group
3	L3 Inhibit Diff	L3 Inhibit Diff	L3 Inhibit Diff	L3 Inhibit Diff	L3 Inhibit Diff	L3 Inhibit Diff
4	L4 Interlock	L4 Interlock	L4 Interlock	L4 Interlock	L4 Interlock	L4 Interlock
5	L5 Reset LEDs	L5 Reset LEDs	L5 Reset LEDs	L5 Reset LEDs	L5 Reset LEDs	L5 Reset LEDs
6	L6 External Trip	L6 External Trip	L6 Ext Trip A	L6 CB1 Ext Trip	L6 Ext Trip A	L6 CB1 Ext Trip
7	L7 CB Aux 52-A	L7 CB Aux 52-A	L7 Ext Trip B	L7 CB2 Ext Trip	L7 Ext Trip B	L7 CB2 Ext Trip
8	L8 CB Aux 52-B	L8 CB Aux 52-B	L8 Ext Trip C	L8 Stub Bus En	L8 Ext Trip C	L8 Stub Bus En
9		L9 Not Used	L9 CB AuxA 52-B	L9 CB AuxA 52-B	L9 CB AuxA 52-B	L9 CB AuxA 52-B
10		L10 Not Used	L10 CB AuxB 52-B	L10 CB AuxB 52-B	L10 CB AuxB 52-B	L10 CB AuxB 52-B
11		L11 Not Used	L11 CB AuxC 52-B	L11 CB AuxC 52-B	L11 CB AuxC 52-B	L11 CB AuxC 52-B
12		L12 Not Used	L12 Intertrip 1	L12 Intertrip 1	L12 MCB/VTS	L12 MCB/VTS
13		L13 Not Used	L13 PIT	L13 PIT	L13 PIT	L13 PIT
14		L14 Reset Lckout	L14 Reset Lckout	L14 CB2 AuxA 52-B	L14 Reset Lckout	L14 CB2 AuxA 52-B
15		L15 CB Healthy	L15 CB Healthy	L15 CB2 AuxB 52-B	L15 CB Healthy	L15 CB2 AuxB 52-B
16		L16 BAR	L16 BAR	L16 CB2 AuxC 52-B	L16 BAR	L16 CB2 AuxC 52-B
17					L17 Prop Dly Eq	L17 Prop Dly Eq
18					L18 Intertrip 1	L18 Intertrip 1
19					L19 Intertrip 2	L19 Intertrip 2
20					L20 Intertrip 3	L20 Intertrip 3
21					L21 Intertrip 4	L21 Intertrip 4
22					L22 Not Used	L22 Not Used

	P541	P542	P543	P544	P545	P546
23					L23 Not Used	L23 Not Used
24					L24 Not Used	L24 Not Used

Table 33.

4.2 Relay output mapping

	P541	P542	P543	P544	P545	P546
1	R1 Intertrip 1	R1 Intertrip 1	R1 Intertrip 1	R1 Intertrip 1	R1 Not Used	R1 Not Used
2	R2 SignalingFail	R2 SignalingFail	R2 SignalingFail	R2 SignalingFail	R2 SignalingFail	R2 SignalingFail
3	R3 Any Trip	R3 Any Trip	R3 Any Trip	R3 Any Trip	R3 Any Trip	R3 Any Trip
4	R4 General Alarm	R4 General Alarm	R4 General Alarm	R4 General Alarm	R4 General Alarm	R4 General Alarm
5	R5 CB Fail Time1	R5 CB Fail Time1	R5 CB Fail Time1	R5 CB1 Fail1Trip	R5 CB Fail Time1	R5 CB1 Fail1Trip
6	R6 Cntl CB Close	R6 Cntl CB Close	R6 Cntl CB Close	R6 Cntl CB1Close	R6 CB Fail Time2	R6 CB1 Fail2Trip
7	R7 Cntl CB Trip	R7 Cntl CB Trip	R7 Cntl CB Trip	R7 Cntl CB1Trip	R7 GPS Fail	R7 GPS Fail
8		R8 Diff Trip	R8 Trip A	R8 Trip A	R8 Not Used	R8 Not Used
9		R9 I> Trip	R9 Trip B	R9 Trip B	R9 Trip A	R9 Trip A
10		R10 IN> Trip	R10 Trip C	R10 Trip C	R10 Trip B	R10 Trip B
11		R11 AR in Prog	R11 AR in Prog	R11 Diff Trip	R11 Trip C	R11 Trip C
12		R12 SuccessClose	R12 SuccessClose	R12CB2 Fail1Trip	R12 AR in Prog	R12CB2 Fail1Trip
13		R13 AR Lockout	R13 AR Lockout	R13 CntlCB2Close	R13 SuccessClose	R13CB2 Fail2Trip
14		R14 AR InService	R14 AR InService	R14 Cntl CB2Trip	R14 AR Lockout	R14 Not Used
15					R15 AR InService	R15 Not Used
16					R16 BAR	R16 BAR
17					R17 Trip A	R17 Trip A
18					R18 Trip B	R18 Trip B
19					R19 Trip C	R19 Trip C
20					R20 Intertrip 1	R20 Intertrip 1
21					R21 Intertrip 2	R21 Intertrip 2
22					R22 Intertrip 3	R22 Intertrip 3
23					R23 Intertrip 4	R23 Intertrip 4
24					R24 Not Used	R24 Not Used
25					R25 Cntl CBClose	R25 CntlCB1Close
26					R26 Cntl CBTrip	R26 Cntl CB1Trip
27					R27 Not Used	R27 CntlCB2Close
28					R28 Not Used	R28 Cntl CB2Trip
29					R29 Diff Trip	R29 Diff Trip
30					R30 Dist Trip	R30 Dist Trip
31					R31 VTS	R31 VTS
32					R32 PSB	R32 PSB

Table 34.

4.3 Relay output conditioning

	P541	P542	P543	P544	P545	P546
1	Dwell 100ms	Dwell 100ms	Dwell 100ms	Dwell 100ms	Disabled	Disabled
2	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
3	Dwell 100ms	Dwell 100ms	Dwell 100ms	Dwell 100ms	Dwell 100ms	Dwell 100ms
4	Dwell 500ms	Dwell 500ms	Dwell 500ms	Dwell 500ms	Dwell 500ms	Dwell 500ms
5	Dwell 100ms	Dwell 100ms	Dwell 100ms	Dwell 100ms	Dwell 100ms	Dwell 100ms
6	Disabled	Disabled	Disabled	Disabled	Dwell 100ms	Dwell 100ms
7	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
8		Disabled	Dwell 100ms	Dwell 100ms	Disabled	Disabled
9		Disabled	Dwell 100ms	Dwell 100ms	Dwell 100ms	Dwell 100ms
10		Disabled	Dwell 100ms	Dwell 100ms	Dwell 100ms	Dwell 100ms
11		Disabled	Disabled	Disabled	Dwell 100ms	Dwell 100ms
12		Disabled	Disabled	Dwell 100ms	Disabled	Dwell 100ms
13		Disabled	Disabled	Disabled	Disabled	Dwell 100ms
14		Disabled	Disabled	Disabled	Disabled	Disabled
15					Disabled	Disabled
16					Disabled	Disabled
17					Dwell 100ms	Dwell 100ms
18					Dwell 100ms	Dwell 100ms
19					Dwell 100ms	Dwell 100ms
20					Dwell 100ms	Dwell 100ms
21					Dwell 100ms	Dwell 100ms
22					Dwell 100ms	Dwell 100ms
23					Dwell 100ms	Dwell 100ms
24					Disabled	Disabled
25					Disabled	Disabled
26					Disabled	Disabled
27					Disabled	Disabled
28					Disabled	Disabled
29					Disabled	Disabled
30					Disabled	Disabled
31					Disabled	Disabled
32					Disabled	Disabled

Table 35.

4.4 LED mapping

	P541	P542	P543	P544	P545	P546
1	Diff Trip	Diff Trip	Diff Trip	Diff Trip	Diff Trip	Diff Trip
2	Backup Trip	Backup Trip	Backup Trip	Backup Trip	Backup Trip	Backup Trip
3	Thermal Alarm	Thermal Alarm	Thermal Alarm	Thermal Alarm	Thermal Alarm	Thermal Alarm
4	Signaling Fail	Signaling Fail	Signaling Fail	Signaling Fail	Signaling Fail	Signaling Fail
5	Any Start	Any Start	Any Start	Any Start	Any Start	Any Start
6	Not Used	AR in Progress	AR in Progress	Not Used	AR in Progress	Not Used
7	Not Used	AR Lockout	AR Lockout	Not Used	AR Lockout	Not Used
8	Test Loopback	Test Loopback	Test Loopback	Test Loopback	Test Loopback	Test Loopback

Table 36.

4.5 LED output conditioning

	P541	P542	P543	P544	P545	P546
1	Latched	Latched	Latched	Latched	Latched	Latched
2	Latched	Latched	Latched	Latched	Latched	Latched
3	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
4	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
5	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
6	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
7	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
8	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled

Table 37.

4.6 Fault recorder start mapping

	P541	P542	P543	P544	P545	P546
	Any Trip	Any Trip	Any Trip	Any Trip	Any Trip	Any Trip

Table 38.

5. CURRENT TRANSFORMER REQUIREMENTS

5.1 Current differential protection

For accuracy, class X or class 5P current transformers (CTs) are strongly recommended. The knee point voltage of the CTs should comply with the minimum requirements of the formula shown below.

Vk ≥ K . In (Rct + 2 RL)

Where:

Vk	=	Required IEC knee point voltage
K	=	Dimensioning factor
In	=	CT nominal secondary current
Rct	=	CT resistance
RL	=	One-way lead impedance from CT to relay

K is a constant depending on:

If	=	Maximum value of through fault current for stability (multiple of In)
X/R	=	Primary system X/R ratio

K is determined as follows:

For relays set at Is1 = 20%, Is2 = 2 In, k1 = 30%, k2 = 150%:

K ≥ 40 + (0.07 x (If x X/R))

And: K ≥ 65

This is valid for (If x X/R) ≤ 1000 ”

For higher (If x X/R) up to 1600: ”

K = 107.

For relays set at Is1 = 20%, Is2 = 2 In, k1 = 30%, k2 = 100%:

K ≥ 40 + (0.35 x (If x X/R))

And: K ≥ 65

This is valid for (If x X/R) ≤ 600 ”

For higher (If x X/R) up to 1600: “

K = 256.

6. COMMISSIONING TEST MENU

To help minimise the time required to test MiCOM relays the relay provides several test facilities under the 'COMMISSION TESTS' menu heading. There are menu cells which allow the status of the opto-isolated inputs, output relay contacts, internal digital data bus (DDB) signals and user-programmable LEDs to be monitored. Additionally there are cells to test the operation of the output contacts, user-programmable LEDs and, where available, the auto-reclose cycles.

The following table shows the relay menu of commissioning tests, including the available setting ranges and factory defaults:

Menu text	Default setting	Settings
COMMISSION TESTS		
Opto I/P Status	-	-
Relay O/P Status	-	-
Test Port Status	-	-
LED Status	-	-
Monitor Bit 1	64 (LED 1)	0 to 1023 See Relay Menu Database chapter (P54x/EN GC) for details of digital data bus signals
Monitor Bit 2	65 (LED 2)	
Monitor Bit 3	66 (LED 3)	
Monitor Bit 4	67 (LED 4)	
Monitor Bit 5	68 (LED 5)	
Monitor Bit 6	69 (LED 6)	
Monitor Bit 7	70 (LED 7)	
Monitor Bit 8	71 (LED 8)	
Test Mode	Disabled	Disabled Test Mode Contacts Blocked
Test Pattern	All bits set to 0	0 = Not Operated 1 = Operated
Contact Test	No Operation	No Operation Apply Test Remove Test
Test LEDs	No Operation	No Operation Apply Test
Test Autoreclose	No Operation	No Operation Trip 3 Pole Trip Pole A Trip Pole B Trip Pole C
Test Loopback	Disabled	Disabled External Internal
DDB Status	-	-

Table 39.

6.1 Opto I/P status

This menu cell displays the status of the relay's opto-isolated inputs as a binary string, a '1' indicating an energised opto-isolated input and a '0' a de-energised one. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each logic input.

It can be used during commissioning or routine testing to monitor the status of the opto-isolated inputs whilst they are sequentially energised with a suitable dc voltage.

6.2 Relay O/P status

This menu cell displays the status of the digital data bus (DDB) signals that result in energisation of the output relays as a binary string, a ‘1’ indicating an operated state and ‘0’ a non-operated state. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each relay output.

The information displayed can be used during commissioning or routine testing to indicate the status of the output relays when the relay is ‘in service’. Additionally fault finding for output relay damage can be performed by comparing the status of the output contact under investigation with it’s associated bit.

Note: When the ‘Test Mode’ cell is set to ‘Contacts Blocked’ this cell will continue to indicate which contacts would operate if the relay was in-service, it does not show the actual status of the output relays.

6.3 Test Port status

This menu cell displays the status of the eight digital data bus (DDB) signals that have been allocated in the ‘Monitor Bit’ cells. If the cursor is moved along the binary numbers the corresponding DDB signal text string will be displayed for each monitor bit.

By using this cell with suitable monitor bit settings, the state of the DDB signals can be displayed as various operating conditions or sequences are applied to the relay. Thus the programmable scheme logic can be tested.

As an alternative to using this cell, the optional monitor/download port test box can be plugged into the monitor/download port located behind the bottom access cover. Details of the monitor/download port test box can be found in Section 6.11 of this chapter.

6.4 LED status

The ‘LED Status’ cell is an eight bit binary string that indicates which of the user-programmable LEDs on the relay are illuminated when accessing the relay from a remote location, a ‘1’ indicating a particular LED is lit and a ‘0’ not lit.

6.5 Monitor bits 1 to 8

The eight ‘Monitor Bit’ cells allow the user to select the status of which digital data bus signals can be observed in the ‘Test Port Status’ cell or via the monitor/download port.

Each ‘Monitor Bit’ is set by entering the required digital data bus (DDB) signal number (0 – 511) from the list of available DDB signals in the Relay Menu Database chapter (P54x/EN GC) of this guide. The pins of the monitor/download port used for monitor bits are given in the table overleaf. The signal ground is available on pins 18, 19, 22 and 25.

Monitor Bit	1	2	3	4	5	6	7	8
Monitor/ Download Port Pin	11	12	15	13	20	21	23	24

Table 40.

THE MONITOR/DOWNLOAD PORT DOES NOT HAVE ELECTRICAL ISOLATED AGAINST INDUCED VOLTAGES ON THE COMMUNICATIONS CHANNEL. IT SHOULD THEREFORE ONLY BE USED FOR LOCAL COMMUNICATIONS.

6.6 Test mode

This menu cell is to allow secondary injection testing to be performed on the relay. It also enables a facility to directly test the output contacts by applying menu controlled test signals. To select test mode the option ‘Test Mode’ should be selected. This takes the relay out of service causing an alarm condition to be recorded and the yellow ‘Out of Service’ LED to illuminate. This also freezes any information stored in the CB CONDITION column and in IEC60870-5-103 builds changes the Cause of Transmission, COT, to Test Mode. However the output contacts are still active in this mode. To disable the output contacts in addition to the above select ‘Blocked’. Once testing is complete the cell must be set back to ‘Disabled’ to restore the relay back to service. Test mode can also be selected by energising an opto mapped to the Test Mode signal.

WHEN THE ‘TEST MODE’ CELL IS SET TO ‘BLOCKED’ THE RELAY SCHEME LOGIC DOES NOT DRIVE THE OUTPUT RELAYS AND HENCE THE PROTECTION WILL NOT TRIP THE ASSOCIATED CIRCUIT BREAKER IF A FAULT OCCURS.

HOWEVER, THE COMMUNICATIONS CHANNELS WITH REMOTE RELAYS REMAIN ACTIVE WHICH, IF SUITABLE PRECAUTIONS ARE NOT TAKEN, COULD LEAD TO THE REMOTE ENDS TRIPPING WHEN CURRENT TRANSFORMERS ARE ISOLATED OR INJECTION TESTS ARE PERFORMED.

6.7 Test pattern

The ‘Test Pattern’ cell is used to select the output relay contacts that will be tested when the ‘Contact Test’ cell is set to ‘Apply Test’. The cell has a binary string with one bit for each user-configurable output contact which can be set to ‘1’ to operate the output under test conditions and ‘0’ to not operate it.

6.8 Contact test

When the ‘Apply Test’ command in this cell is issued the contacts set for operation (set to ‘1’) in the ‘Test Pattern’ cell change state. After the test has been applied the command text on the LCD will change to ‘No Operation’ and the contacts will remain in the Test State until reset issuing the ‘Remove Test’ command. The command text on the LCD will again revert to ‘No Operation’ after the ‘Remove Test’ command has been issued.

Note: When the ‘Test Mode’ cell is set to ‘Contacts Blocked’ the ‘Relay O/P Status’ cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.

6.9 Test LEDs

When the ‘Apply Test’ command in this cell is issued the eight user-programmable LEDs will illuminate for approximately 2 seconds before they extinguish and the command text on the LCD reverts to ‘No Operation’.

6.10 Test autoreclose

Where the relay provides an auto-reclose function, this cell will be available for testing the sequence of circuit breaker trip and auto-reclose cycles with the settings applied.

Issuing the command ‘Trip 3 Pole’ will cause the relay to perform the first three phase trip/reclose cycle so that associated output contacts can be checked for operation at the correct times during the cycle. Once the trip output has operated the command text will revert to ‘No Operation’ whilst the rest of the auto-reclose cycle is performed. To test subsequent three phase auto-reclose cycles repeat the ‘3 Pole Trip’ command.

Similarly, where single pole auto-reclosing is available, the cycles for each single pole can be checked by sequentially issuing the ‘Trip Pole A’, ‘ Trip Pole B’ or ‘Trip Pole C’, as appropriate.

Note: The factory settings for the relay’s programmable scheme logic has the ‘AR Trip Test’ signal mapped to relay 3. If the programmable scheme logic has been changed, it is essential that this signal remains mapped to relay 3 for the ‘Test Autoreclose’ facility to work.

6.11 Test Loopback

During commissioning it is necessary to connect the protection communication transmit and receive ports together. This may be done externally using optical fibre or internally. This option automatically changes the protection address to 0-0 and in the case of ‘Internal’ routes the transmitter to the receiver internally to the relay.

6.12 DDB Status

This collection of menu cells display the status of all the digital data bus (DDB) signals as a binary string, a ‘1’ indicates an operated state and ‘0’ a non-operated state. If the cursor is moved along the binary numbers the corresponding label text will be displayed.

6.13 Using a monitor/download port test box

A monitor/download port test box containing 8 LED’s and a switchable audible indicator is available from ALSTOM GRID, or one of their regional sales offices. It is housed in a small plastic box with a 25-pin male D-connector that plugs directly into the relay’s monitor/download port. There is also a 25-pin female D-connector which allows other connections to be made to the monitor/download port whilst the monitor/download port test box is in place.

Each LED corresponds to one of the monitor bit pins on the monitor/download port with ‘Monitor Bit 1’ being on the left hand side when viewing from the front of the relay. The audible indicator can either be selected to sound if a voltage appears any of the eight monitor pins or remain silent so that indication of state is by LED alone.

7. COMMUNICATIONS BETWEEN RELAYS

7.1 Communications link options

A number of communications options are available, for the communication channels between P540 system ends. The various connection options are shown below. Choosing between each of these options will depend on the type of communications equipment that is available.

Where existing suitable multiplexer communication equipment is installed for other communication between substations, the 850nm option together with an appropriate ITU-T compatible electrical interface (P590 series unit) should be selected to match the existing multiplexer equipment. For further information on the P590 optical fibre to electrical interface units, refer to section 7.3.

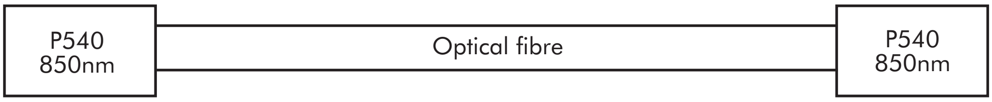
Where an IEEE C37.94 compatible multiplexer is installed the 850nm option should be configured to interface directly to the multiplexer, refer to section 7.1.5.

Where no multiplexer is installed, the direct optical fibre connection can be used, refer to sections 7.1.1 – 7.1.4. The type of fibre used (multi-mode or single-mode and wavelength) will be determined by the distance between the ends of the P540 relay system, refer to section 7.2.

In any configuration, except the IEEE C37.94, the data rate may be selected as either 64kbit/sec or 56kbit/sec, refer also to section 7.8

7.1.1 Direct optical fibre link, 850nm multi-mode fibre

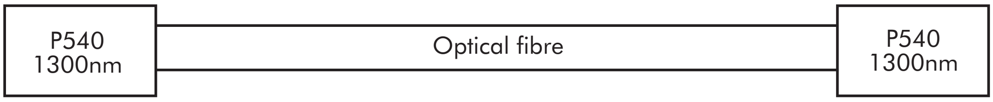
The relays are connected directly using two 850nm multi-mode optical fibres for each signalling channel. Multi-mode fibre type 50/125μm or 62.5/125μm is suitable. BFOC/2.5 type fibre optic connectors are used. These are commonly known as “ST” connectors (“ST” is a registered trademark of AT&T).



This is typically suitable for connection up to 1km.

7.1.2 Direct optical fibre link, 1300nm multi-mode fibre

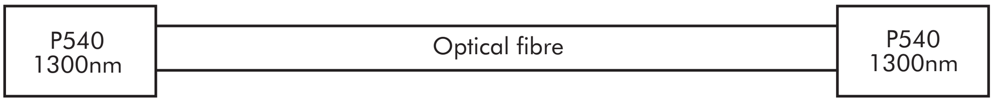
The relays are connected directly using two 1300nm multi-mode fibres for each signalling channel. Multi-mode fibre type 50/125μm or 62.5/125μm is suitable. BFOC/2.5 type fibre optic connectors are used.



This is typically suitable for connection up to 30km.

7.1.3 Direct optical fibre link, 1300nm single-mode fibre

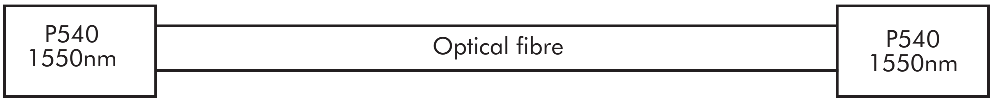
The relays are connected directly using two 1300nm single-mode fibres, type 9/125μm for each signalling channel. BFOC/2.5 type fibre optic connectors are used.



This is typically suitable for connection up to 65km.

7.1.4 Direct optical fibre link, 1550nm single-mode fibre

The relays are connected directly using two 1550nm single-mode fibres, type 9/125μm for each signalling channel. BFOC/2.5 type fibre optic connectors are used.



This is typically suitable for connection up to 90km.

7.1.5 IEEE C37.94 interface to multiplexer (since software 30)

A P540 relay with 850nm short haul optical interface is connected directly to the multiplexer by 850nm multi-mode optical fibre. Multi-mode fibre type 50/125μm or 62.5/125μm is suitable. BFOC/2.5 type fibre optic connectors are used.
The setting Comms Mode should be set to IEEE C37.94. Note the relay must be powered off and on before this setting change becomes effective.
The IEEE C37.94 standard defines an N*64kbits/s standard where N can be 1 – 12. N can be selected on the P540 or alternatively set to Auto in which case the relay will configure itself to match the multiplexer.

7.1.6 Switched communication networks

7.1.6.1 Switched communication networks (P541, P542, P543 & P544)

The P540 relays make use of digital communication signalling channels for the differential protection. For correct operation of this protection element, it is essential that the integrity of this link is continuously checked. For the P541, P542, P543 and P544 and for the P545 & P546 when GPS is not used it is also a requirement of this link that 'go' (tp1) and 'return' (tp2) times are similar (a difference of up to 1ms can be tolerated). Times greater than this can result in relay instability.

Where switched communications networks are used, it is possible that during switching, a transient time period may exist with different 'go' and 'return' times. All P540 relays include a facility to ensure protection stability during this transient period.

One of the checks performed on the communications link is a check on the calculated propagation delay for each data message. During normal operation the difference in calculated time should be minimal (possible delays being introduced by multiplexers or other intermediary communication equipment). If successive calculated propagation delay times exceed a user settable value (250 - 1000μs). The P540 raise a comm delay alarm and initiate a change in relay setting for a short time period (Char Mod Time setting) to overcome any switching delay. This change in setting is shown in Figure 36 whereby the relay bias setting, k1, is increased to 200%. This characteristic provides stability for all load conditions and will still allow tripping for most internal fault conditions.

Figure 35 shows a possible scenario for a switched network. Initially the P540 relays are communicating via path 1. The go and return times for this path are 2ms and hence the calculated propagation delay is (2 + 2)/2 = 2ms. When the channel is switched to path 2, a small time period exists where the P540's could be sending messages via path 1 and returning via path 2.

The calculated propagation delay will now be (2 + 5)/2 = 3.5ms. The resultant 1.5ms error at each line end may cause the relay to maloperate due to incorrect time alignment of current vectors (see Section 2.2.3). After a short delay, both 'go' and 'return' paths will follow route 2 and the calculated propagation delay will be (5 + 5)/2 = 5ms. The relay will now be stable, as correct current vector time alignment exists at each line end.

The Char Mod timer is started when a change in propagation delay is detected. Any subsequent change during this period will cause the timer to restart. In the above example the timer will start for the first change (2 to 3.5ms). The second change (3.5ms to 5ms) will cause the timer to restart, thus allowing for multiple switching between communication paths.

A change in propagation delay may result in a temporary failure of the protection communications channel. If this occurs, the propagation delay change may not be detected by the relay. To overcome this problem, the Char Mod Timer is re-started when the channel recovers from a protection communications channel failure if the Char Mod Timer was running when the channel failure occurred.

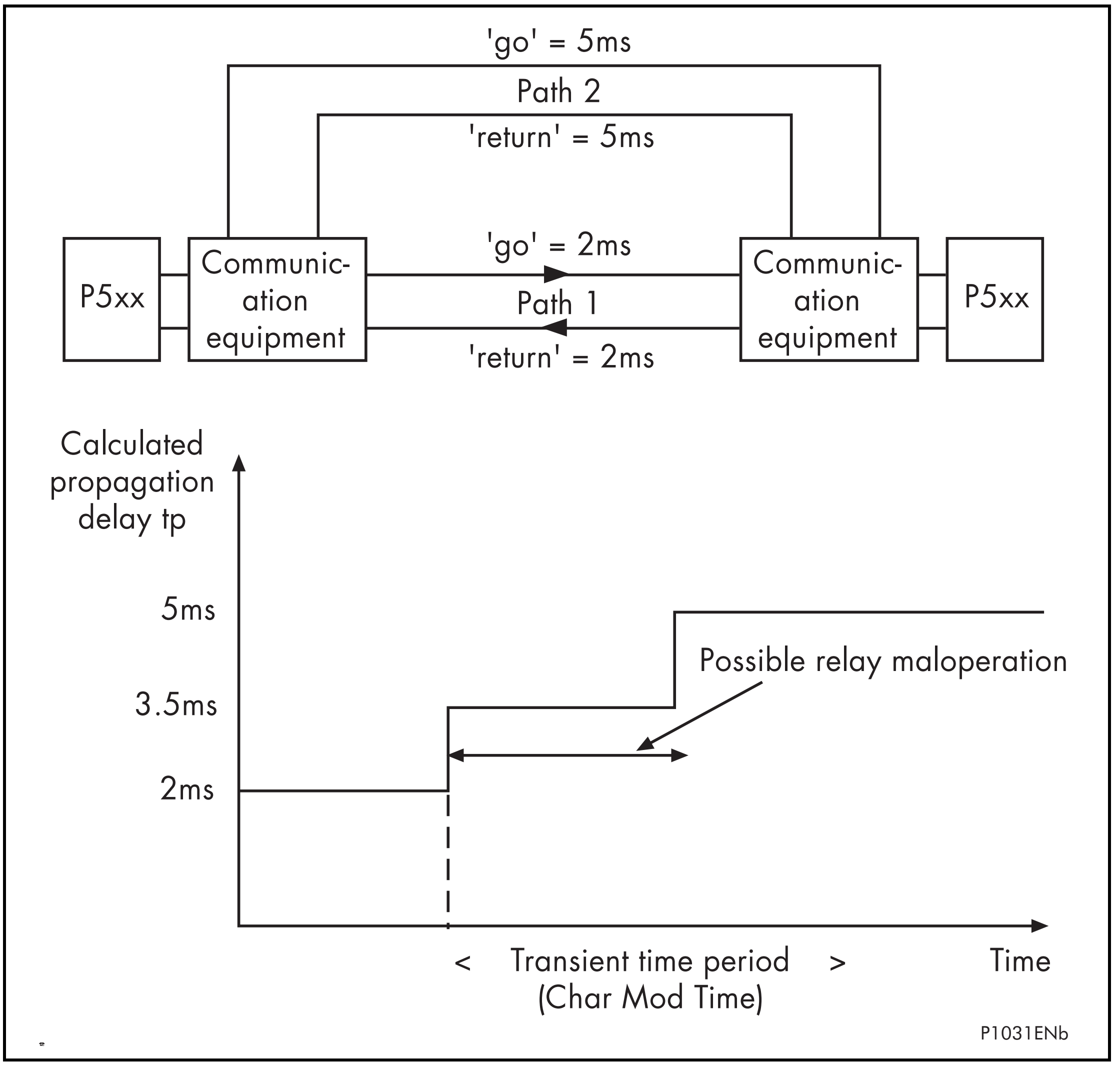


Figure 35: Switched communication network

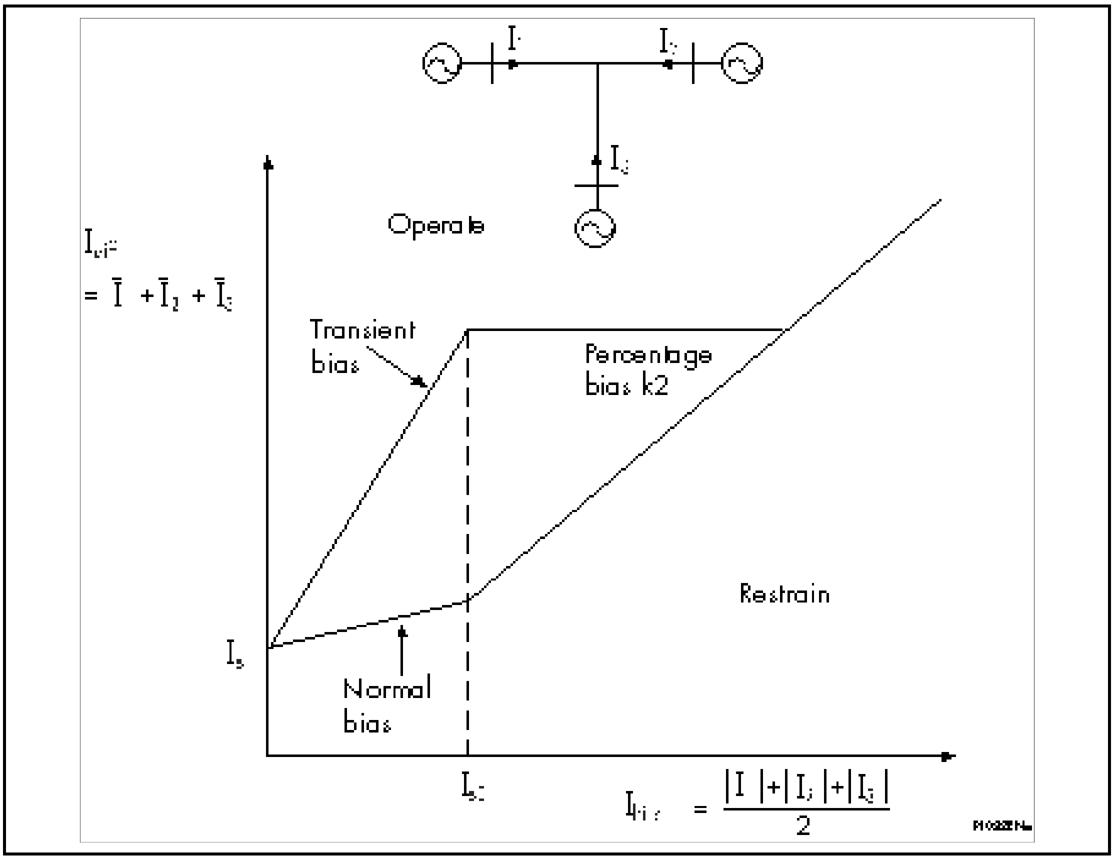


Figure 36: Transient bias characteristic

7.1.6.2 Switched communication networks with Permanent or Semi-Permanent Split Routings

The P545 and P546 relays, utilising timing information from the GPS system, are suitable for use on switched communication signalling channels for the differential protection. For correct operation of this protection element, it is essential that the integrity of this link is continuously checked. For the P545 and P546 it is not, however, a requirement that 'go' (tp1) and 'return' (tp2) times are similar if the GPS synchronisation feature is used.

7.2 Optical budgets

When applying any of the P540 range of current differential relays it is important to select the appropriate protection communications interface. This will depend on the fibre used and distance between devices. The following table shows the optical budgets of the available communications interfaces.

	850nm Multi mode	1300nm Multi mode	1300nm Single mode	1550nm Single mode
Min. transmit output level (average power)	-19.8dBm	-10dBm	-10dBm	-10dBm
Receiver sensitivity (average power)	-25.4dBm	-37dBm	-37dBm	-37dBm
Optical budget	5.6dB	27.0dB	27.0dB	27.0dB
Less safety margin (3dB)	2.6dB	24.0dB	24.0dB	24.0dB
Typical cable loss	2.6dB/km	0.8dB/km	0.4dB/km	0.3dB/km
Max. transmission distance	1km	30.0km	60.0km	80km

Table 41. Optical budgets

The total optical budget is given by transmitter output level minus the receiver sensitivity and will indicate the total allowable losses that can be tolerated between devices. A safety margin of 3dB is also included in the above table. This allows for degradation of the fibre as a result of ageing and any losses in cable joints. The remainder of the losses will come from the fibre itself. The figures given are typical only and should only be used as a guide.

In general, the 1300nm and 1550nm interfaces will be used for direct connections between relays. The 850nm would be used where multiplexing equipment is employed.

7.3 P590 Series optical fibre to electrical interface units

In order to connect the P540 relays via a pulse code modulation (PCM) multiplexer network or digital communication channel, Type P590 type interface units are required. The following interface units are available:

- P591 interface to multiplexing equipment supporting ITU-T (formerly CCITT) Recommendation G.703 co-directional electrical interface
- P592 interface to multiplexing equipment supporting ITU-T Recommendation V.35 electrical interface
- P593 interface to multiplexing or ISDN equipment supporting ITU-T Recommendation X.21 electrical interface

The data rate for each unit can be 56kbit/sec or 64kbit/sec as required for the data communications link, refer to section 7.8.

One P590 unit is required per relay data channel (i.e. for each transmit and receive signal pair). It provides optical to electrical and electrical to optical signal conversion between the P540 relay and the multiplexer. The interface unit should be located as close to the PCM multiplexer as possible, to minimise any effects on the data of electromagnetic noise or interference.

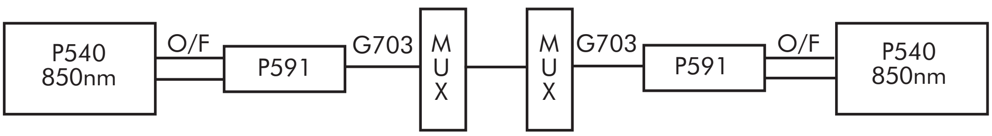
The units are housed in a 20TE MiCOM case.

Fibre optic connections to the unit are made through BFOC/2.5 type connectors, more commonly known as ‘ST’ connectors.

The optical characteristics are similar to the P540 850nm multi-mode fibre optic interface (refer to section 7.2 above).

7.3.1 Multiplexer link with G.703 electrical interface using auxiliary optical fibres and type P591 interface

A P540 relay with 850nm short haul optical interface is connected to a P591 unit by 850nm multi-mode optical fibre. Multi-mode fibre type 50/125µm or 62.5/125µm is suitable. BFOC/2.5 type fibre optic connectors are used. The P591 unit converts the data between optical fibre and ITU-T compatible G.703 co-directional electrical interface. The G.703 output must be connected to an ITU-T compatible G.703 co-directional channel on the multiplexer.



The P591 unit supports the ITU-T Recommendation G.703 co-directional interface.

The G.703 signals are isolated by pulse transformers to 1kV.

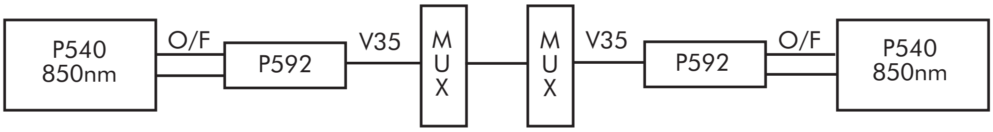
Since the G.703 signals are only of ±1V magnitude, the cable connecting the P591 unit and the multiplexer must be properly screened against electromagnetic noise and interference. The interface cable should consist of twisted pairs of 24AWG, overall shielded, and have a characteristic impedance of about 120Ω. It is generally recommended that the interface cable shield should be connected to the multiplexer frame ground only. The choice of grounding depends however on local codes and practices.

Electrical connections to the P591 unit are made via a standard 28-way Midos connector. Please refer to External Connection Diagram chapter (P54x/EN CO) for the external connection diagram.

The P540 must be set with Clock Source as ‘External’, refer to section 7.7.

7.3.2 Multiplexer link with V.35 electrical interface using auxiliary optical fibres and type P592 interface

A P540 relay with 850nm short haul optical interface is connected to a P592 unit by 850nm multi-mode optical fibre. Multi-mode fibre type 50/125μm or 62.5/125μm is suitable. BFOC/2.5 type fibre optic connectors are used. The P592 unit converts the data between optical fibre and ITU-T compatible V.35 electrical interface. The V.35 output must be connected to an ITU-T compatible V.35 channel on the multiplexer.



The P592 unit supports the ITU-T Recommendation V.35 interface.

Connections of V.35 signals to the P592 unit are made via a standard female 34 pin 'M' block connector. Since the V.35 signals are either of ±0.55V or ±12V magnitude, the cable connecting the unit to the multiplexer must be properly screened against electromagnetic noise and interference. The interface cable should consist of twisted pairs of wires which are shielded, and have a characteristic impedance of about 100Ω. It is generally recommended that the interface cable shield is connected to the multiplexer frame ground. The choice of grounding depends however on local codes and practices.

The P592 front panel consists of five indicating LEDs and six DIL (dual in line) switches.

The switch labelled 'Clockswitch' is provided to invert the V.35 transmit timing clock signal if required.

The switch labelled 'Fibre-optic Loopback' is provided to allow a test loopback of the communication signal across the fibre optic terminals. When switched on, the red LED labelled 'Fibre-optic Loopback' is illuminated.

The switch labelled 'V.35 Loopback' is provided to allow a test loopback of the communication signal across the X.21 terminals. It loops the incoming V.35 'Rx' data lines internally back to the outgoing V.35 'Tx' data lines. When switched on, the red LED labelled 'V.35 Loopback' is illuminated.

The switch labelled 'DSR' is provided to select/ignore the DSR (Data Set Ready) handshaking control signal. The red LED labelled DSR Off is extinguished either when DSR is asserted or when overridden by setting the DSR switch On.

The switch labelled 'CTS' is provided to select/ignore the CTS (Clear To Send) handshaking control signal. The red LED labelled CTS Off is extinguished either when CTS is asserted or when overridden by setting the CTS switch On.

The switch labelled 'Data Rate' is provided to allow the selection of 56 or 64k bits/s data rate, as required by the PCM multiplexing equipment.

The LED labelled 'Supply Healthy' is green and provides indication that the unit is correctly powered.

Please refer to the External Connection Diagram chapter (P54x/EN CO) for the External Connection Diagram.

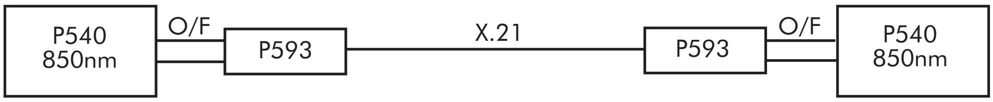
The P540 may be set either with Clock Source as 'External' for a multiplexer network which is supplying a master clock signal, or with Clock Source as 'Internal' for a multiplexer network recovering signal timing from the equipment. Refer to Section 7.7.

7.3.3 Multiplexer link with X.21 electrical interface using auxiliary optical fibres and type P593 interface

The P593 unit supports the ITU-T Recommendation X.21 interface. It is approved as line interface equipment by the British Approvals Board for Telecommunications (BABT) for connection to the services described in this section; Licence Certificate Number NS/1423/1/T/605362.

A P540 relay with 850nm short haul optical interface is connected to a P593 unit by 850nm multi-mode optical fibre. Multi-mode fibre type 50/125μm or 62.5/125μm is suitable.

BFOC/2.5 type fibre optic connectors are used. The P593 unit converts the data between optical fibre and ITU-T compatible X.21 electrical interface. The X.21 output must be connected to an ITU-T compatible X.21 channel on the multiplexer or ISDN digital data transmission link.



The P540 relays require a permanently open communications channel. Consequently, no communications handshaking is required, and it is not supported in the P593 unit. The signals supported are shown in Table 40 overleaf.

ITU-T Recommendation X.21 is closely associated with EIA specifications RS422 and RS449. The P593 can be used with RS422 or RS449 communications channels which require only the signals shown overleaf.

ITU-T designation	Description	Connector pin	Direction
-	Case earth	1	-
G	Common return	8	-
T	Transmit data A	2	From P593
T	Transmit data B	9	From P593
R	Receive data A	4	To P593
R	Receive data B	11	To P593
S	Signal element timing A	6	To P593
S	Signal element timing B	13	To P593

Table 42. X.21 circuits supported by P593 unit

Connections of X.21 signals to the P593 unit are made via a standard male 15 way D-type connector, wired as a DTE device. The interface cable should consist of twisted pairs of 24AWG, overall shielded, and have a characteristic impedance of about 100Ω. It is generally recommended that the interface cable shield is connected to the multiplexer frame ground. The choice of grounding depends however on local codes and practices.

Please refer to the External Connection Diagram chapter (P54x/EN CO) for the External Connection Diagram.

The P540 must be set with Clock Source as ‘External’, refer to section 7.7.

The P593 front panel consists of four indicating LEDs and two switches.

The LED labelled ‘Supply healthy’ is green and provides indication that the unit is correctly powered.

The LED labelled ‘Clock’ is green and provides indication that an appropriate X.21 signal element timing signal is presented to the unit.

One of the switches is labelled ‘Fibre Optic Loopback’. This is provided to allow a test loopback of the communication signal across the fibre optic terminals. When switched on, the red LED labelled ‘Fibre Optic Loopback’ is illuminated.

The second switch is labelled ‘X.21 Loopback’. This is provided to allow a test loopback of the communication signal across the X.21 terminals. It loops the incoming X.21 ‘Rx’ data lines internally back to the outgoing X.21 ‘Tx’ data lines, and also loops the incoming fibre optic ‘Rx’ data line (via the X.21 signal conversion circuitry) back to the outgoing fibre optic ‘Tx’ data line. When switched on, the red LED labelled ‘X.21 Loopback’ is illuminated.

7.4 Protection communications scheme set-up

The Scheme Set-up setting selects the connection between the system ends. A two ended system may have a single communication channel between the ends (“2 Terminal” option) or two independent communication channels to achieve dual redundancy (“Dual Redundant” option). A three ended system is selected by the option “3 Terminal”.

7.4.1 Dual redundant ("Hot Standby")

If one of the channels has failed, the communication between the relays can still be maintained by the other healthy channel.

The dual redundant model provides redundancy for communication channels by transmitting and receiving messages over both channels. Each channel is monitored continuously by the relay. The messages from both channels are used to perform the relay functions. If only one channel is available, the messages from this healthy channel are used to perform the relay functions.

The messages are transmitted over the 2 channels alternately. Every message received is validated and processed, so that both channels are continuously monitored.

7.5 Protection communications address

The protection communication messages include an address field to ensure correct scheme connection.

There are twenty one options for groups of addresses. Each group is applied to one protection system, two ended or three ended, so there are two or three addresses within a group respectively.

All the address patterns are carefully chosen so as to provide optimum noise immunity against bit corruption. There is no preference as to which address group is better than the other.

The groups of addresses available when "2 Terminal" or "Dual Redundant" scheme is selected are as follows:

	Relay A	Relay B
Universal Address	0-0	0-0
Address Group 1	1-A	1-B
Address Group 2	2-A	2-B
Address Group 3	3-A	3-B
Address Group 4	4-A	4-B
Address Group 5	5-A	5-B
Address Group 6	6-A	6-B
Address Group 7	7-A	7-B
Address Group 8	8-A	8-B
Address Group 9	9-A	9-B
Address Group 10	10-A	10-B
Address Group 11	11-A	11-B
Address Group 12	12-A	12-B
Address Group 13	13-A	13-B
Address Group 14	14-A	14-B
Address Group 15	15-A	15-B
Address Group 16	16-A	16-B
Address Group 17	17-A	17-B
Address Group 18	18-A	18-B
Address Group 19	19-A	19-B
Address Group 20	20-A	20-B

Table 43.

For two relays to communicate with one another, their addresses have to be in the same address group. One relay should be assigned with address A and the other with address B. For example, if the group 1 address is used, the one relay should be given the address 1-A, and the other relay should be given the address 1-B.

The relay with address 1-A will only accept messages with the 1-A address and will send out messages carrying address 1-B. The relay assigned with address 1-B will only accept messages with address 1-B and will send out messages carrying address 1-A.

The groups of addresses available when “3 Terminal” scheme is selected are as follows:

	Relay A	Relay B	Relay C
Address Group 1	1-A	1-B	1-C
Address Group 2	2-A	2-B	2-C
Address Group 3	3-A	3-B	3-C
Address Group 4	4-A	4-B	4-C
Address Group 5	5-A	5-B	5-C
Address Group 6	6-A	6-B	6-C
Address Group 7	7-A	7-B	7-C
Address Group 8	8-A	8-B	8-C
Address Group 9	9-A	9-B	9-C
Address Group 10	10-A	10-B	10-C
Address Group 11	11-A	11-B	11-C
Address Group 12	12-A	12-B	12-C
Address Group 13	13-A	13-B	13-C
Address Group 14	14-A	14-B	14-C
Address Group 15	15-A	15-B	15-C
Address Group 16	16-A	16-B	16-C
Address Group 17	17-A	17-B	17-C
Address Group 18	18-A	18-B	18-C
Address Group 19	19-A	19-B	19-C
Address Group 20	20-A	20-B	20-C

Table 44.

For three relays to work together as a protection system, their addresses must be in the same group and they should be assigned separately with addresses A, B and C.

They must also have a fixed connection configuration, as shown in Figure 35, in which channel 1 of one relay is connected to channel 2 of another relay.

For example, if the group 1 address is used, addresses 1-A, 1-B and 1-C should be assigned to relays A, B and C respectively. Relay A will only accept messages with address 1-A and will send messages carrying addresses 1-B and 1-C to channel 1 and channel 2 respectively. Relay B will only accept messages with address 1-B and will send messages carrying addresses 1-C and 1-A to channel 1 and to channel 2 respectively. Similarly relay C will only accept messages with address 1-C and will send messages carrying addresses 1-A and 1-B to channel 1 and to channel 2 respectively.

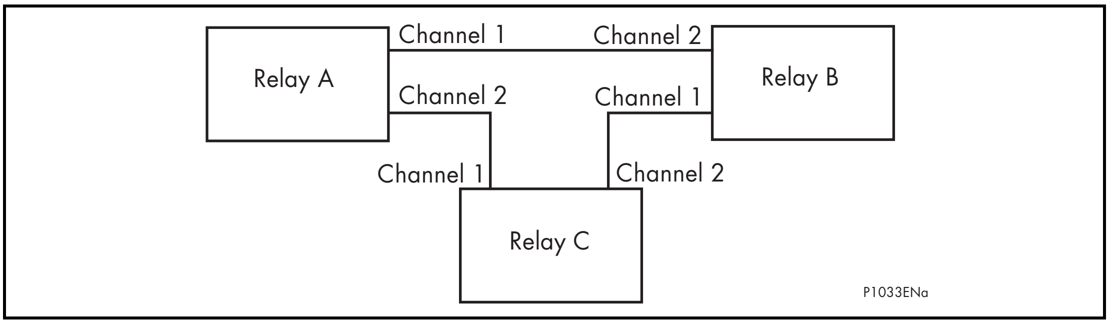


Figure 37: 3-terminal system connection

7.6 Reconfiguration of three-ended system

This function only applies to relays which are set-up for 3 Terminal operation. The operation depends on the status of the communication channels, the relays in the scheme and various time periods. There are two general areas of operation, these being the change in configuration by a user and that generated by an energisation of a relay. The various considerations applying to each of these cases are given below.

Four settings are provided as follows:

- Three Ended
- Two Ended Local and Remote 1 (L & R1)
- Two Ended Local and Remote 2 (L & R2)
- Two Ended Remote 1 and Remote 2 (R1 & R2)

Remote 1 and Remote 2 relate to protection signalling channel 1 and 2 respectively.

The operation of the reconfiguration is described in 7.6.1 and 7.6.2.

7.6.1 User reconfiguration

This covers the normal set-up of the relays into a 2-ended or 3-ended scheme depending on the state of the protected line and the relays. The facilities provided allow the user to initially use two relays to protect a two ended line and later to upgrade the scheme to three ended using a further relay. It also allows one end of a three ended scheme to be isolated and the other two ends to operate as a two ended scheme. This allows tests to be performed on the end that has been isolated and also allows for that relay to be removed altogether.

The change in configuration is enabled by two external interlocks and by the current state of the relay and its communications. If the scheme is changed from 3-ended to 2-ended, it is considered to be a reconfigure command. If the scheme is changed from 2-ended to 3-ended, it is considered to be a restore command. The checks performed for a reconfiguration are slightly different to those for a restore.

The operation of the change configuration logic is as follows.

1. The configuration setting is changed.

2. The relay detects the change in setting and attempts to implement the new setting.

3. If the relay configuration is 2-ended and the new setting is also 2-ended then the relay will block the change and issue a configuration error alarm.

4. If the relay configuration is 2-ended and the new setting is 3-ended then the relay will check that all the communications are healthy and send out the restore command to the other relays. It will then check that the scheme has stabilised at 3-ended after one second.

5. If any of the communications in the scheme were failed or if the scheme has not stabilised at 3-ended then the relay will return to its original 2-ended setting and issue a configuration error alarm.

6. If the scheme did stabilise at 3-ended then the Re-configuration setting will be updated.

7. If the relay configuration is 3-ended and the new setting is 2-ended L & R1 then the relay will first check that the two interlock opto-inputs, “Inhibit Diff” and “Interlock” are energised (note that the “Inhibit Diff” opto-input will inhibit the differential tripping, but the backup protection can still operate the trip outputs). These inputs are allocated to opto-inputs L3 and L4 in the default programmable scheme logic. The relay then checks that the communication with Remote 1 relay is healthy and sends out the command to the remote relays. It will then check that the scheme has stabilised at 2-ended L & R1after one second.

8. If the interlocks are not energised or the communication with Remote 1 relay has failed or the scheme does not stabilise at 2-ended L & R1 then the relay will return to 3-ended and will issue a configuration error alarm.

9. If the scheme did stabilise at 2-ended L & R1 then the Re-configuration setting will be updated.

10. If the relay configuration is 3-ended and the new setting is 2-ended L & R2 then the relay reacts similarly to a 2-ended L & R1 reconfiguration.

11. If the relay configuration is 3-ended and the new setting is 2-ended R1 & R2 then the relay reacts similarly to a 2-ended L & R1 reconfiguration.

7.6.2 Energisation reconfiguration

This type of configuration occurs when a relay is energised and the relay attempts to go into a configuration compatible with the other relays in the scheme. As far as possible the scheme will go to that which the user set up. There are, however, certain conditions which may prevent this from occurring.

The configuration that the relay takes up at power on is governed by the following factors:

a) the scheme currently configured on the remote relays

b) the status of the communication links

c) the configuration stored in non volatile memory before power down

Upon energisation of a relay, the following events occur:

1. The relay checks whether any messages are arriving. If so then the configuration command in the first messages to arrive will be used as the relay configuration. This is subject to certain conditions. If the relay has a choice of 2-ended and 3-ended, it will assume the 2-ended scheme unless both incoming commands are 3-ended. If all three relays are 3-ended then they will remain so.

2. If no messages arrive from either end then after one second the relay will change to the configuration that was last selected, i.e. the configuration before power down. Once messages begin to arrive again, the relay will check them for validity against the current scheme. If one relay is 3-ended and the other is 2-ended then the configuration will change to 2-ended. If both are 3-ended or the same 2-ended scheme then that will become the configuration. If two relays have different 2-ended configurations then they are unable to determine which one to use and will each generate a configuration error alarm and each relay will remain in its current configuration. This condition can be cleared by restoring the relays or by removing the supply to the relay with the incorrect configuration.

3. If all the relays in a scheme are energised simultaneously then the configuration will revert to 3-ended if all the communication channels are healthy. This occurs because all the relays are waiting to be told their configuration and all default to 3-ended. This is a very unlikely event in normal use.

4. In cases where a communication channel has only half failed i.e. the receive channel has failed but not the transmit channel, then there may be configuration errors on power up due to the fact that the relays are not communicating correctly. If the status is available via the third relay and healthy communications via its two channels then the scheme will stabilise correctly.

7.7 Clock source

A clock source is required to synchronise data transmissions between the system ends. This may be provided either by the P540 relays (internal) or may be a function of the telecommunications equipment (external). The P540 relays have a setting for each of Channel 1 and Channel 2 to set the Clock Source to either “Internal” or “External” according to the communications system configuration.

This setting is not applicable if IEEE C37.94 mode selected.

7.7.1 Internal clock source

The Clock Source should be set to “Internal” at all system ends, where they are connected by direct optical fibre, as the P540 at each end has to supply the clock.

7.7.2 External clock source

The Clock Source should be set to “External” at all system ends, where the ends are connected by multiplexer equipment which is receiving a master clock signal from the multiplexer network. It is important that there is a single master clock source on the multiplexer network and that the multiplexer equipment at each end is synchronised to this clock.

7.8 Data rate

The data rate for signalling between the two or three ends may be set to either 64kbit/sec or 56kbit/sec as appropriate.

If there is a direct fibre connection between the ends, the data rate would usually be set to 64kbit/sec, as this gives a slightly faster trip time.

If there is a multiplexer network between the ends, then this will determine the data rate to be used by the P540 system. The electrical interface to the multiplexer (G.703 co-directional, V.35, or X.21) will be provided on either a 64kbit/sec or 56kbit/sec channel, and the P540 at each end must be set to match this data rate.

Generally, North American multiplexer networks are based on 56kbit/sec (and multiples thereof) channels, whereas multiplexer networks in the rest of the world are based on 64kbit/sec (and multiples thereof) channels.

This setting is not applicable if IEEE C37.94 mode selected.

7.9 Communication alarm

A communication alarm is raised by the relay if the message error rate rises above 25% and persists over a defined period of time (refer to section 7.12 below). This is equivalent to a Bit Error Rate (BER) of 1.5×10^{-3}.

A communication alarm is also raised if the received message indicates failure of the signalling channel at the remote end.

7.10 Communication error statistics

To aid the bit error evaluation of the communication link, communication error statistics are kept by the relay. These give the number of Errored messages detected, the number of Lost Messages, and the number of Valid Messages received for each of the two channels. The number of errored messages detected complies with ITU-T G8.21 and is as follows:

Number of errored seconds	Number of seconds containing 1 or more errored or lost messages
Number of severely errored seconds	Number of seconds containing 31 or more errored or lost messages
Number of degraded minutes	Number of minutes containing 2 or more errored or lost messages
Note any severely errored seconds are ignored when working out the minute intervals	

The number of lost messages recorded is intended as an indicator for noises under normal communication conditions and not for recording long communication breaks. The lost message count is accumulated by incrementing a counter when a message is rejected by the Error code check, message length check and the sequential time tag check.

The error statistics are automatically cleared on power-up. They can also be cleared using the Clear Statistics setting in Measurements column of the menu.

7.11 Communications delay timer

The communications delay timer is the maximum difference in the measured channel propagation delay time between consecutive messages that the relay will tolerate before switching the settings, as described in section 7.1.6.

This setting is factory set to the minimum value of 250μs. It should be increased to a suitable value if the propagation delay time is expected to vary considerably such as in the case of a microwave link with multiple repeaters.

7.12 Communications fail timer

The communication fail timer is the time during which communication errors must be continuously detected before the channel is declared failed. This governs the implementation of the communication alarm and the 'Protection Scheme Inoperative' alarm. The setting is normally set to the maximum of 9.9 seconds so that the two alarms will not be affected by short bursts of noises or interruptions. The communication fail time setting however may be set to a lower value of say 200 or 300ms if the alarm contacts are to be used for enabling standby protection, or to signal a change-over to reserve communication facilities should the communication link become noisy or fail completely.

7.13 Communications fail mode

The Communications Fail Mode is used to select the channel(s) responsible for raising the communication alarm when configured for dual redundant communications. Three options are available: 'Ch 1 Fail', 'Ch 2 Fail', and 'Ch 1 and 2 Fail'. If 'Ch 1 Fail' is selected, the communication alarm will only be raised if channel 1 has failed. If 'Ch 2 Fail' is selected, the communication alarm will only be raised if channel 2 has failed. If 'Ch 1 and 2 Fail' is selected, the communication alarm will be raised if either channel has failed.

7.14 MiCOM P594 Global Positioning System (GPS) Synchronising Module

MiCOM P545 and P546 Current Differential relays can use a satellite-derived one pulse per second synchronising signal via a MiCOM P594 GPS Module. A simple diagram of the role of the GPS Timing Module within a two-ended scheme is shown in Figure 38 below.

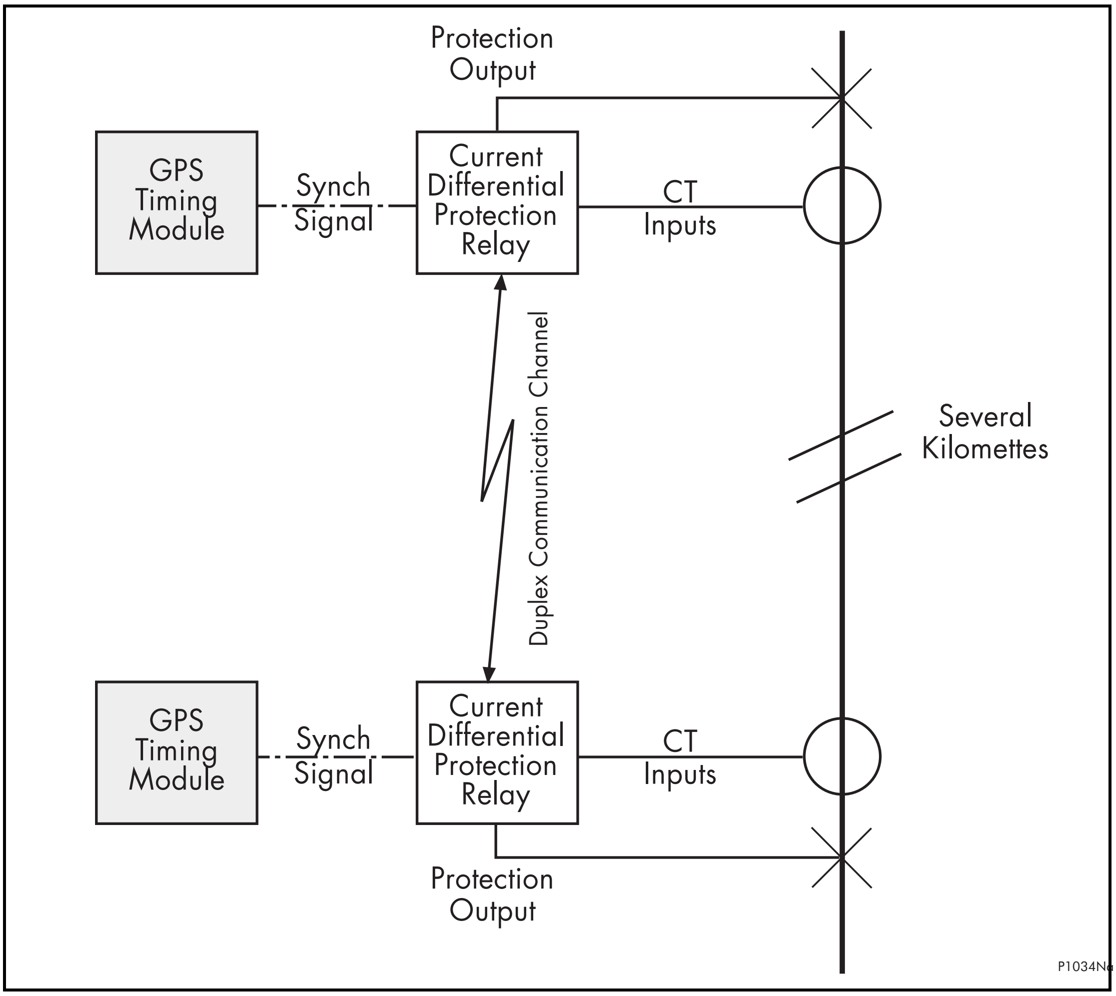


Figure 38: Network incorporating GPS synchronising module

7.14.1 Synchronising Module Output

The output to the relay from the synchronising module is via a fibre-optic link, to reduce the risk of interference, and consists of one pulse per second, with each pulse having a width of 200ms, as shown in Figures 39 and 40. One synchronising module provides outputs to synchronise up to 4 relays within a substation, using one 850nm multi mode fibre core per relay, with terminations as in section 7.1.1 and specification as in table 41.

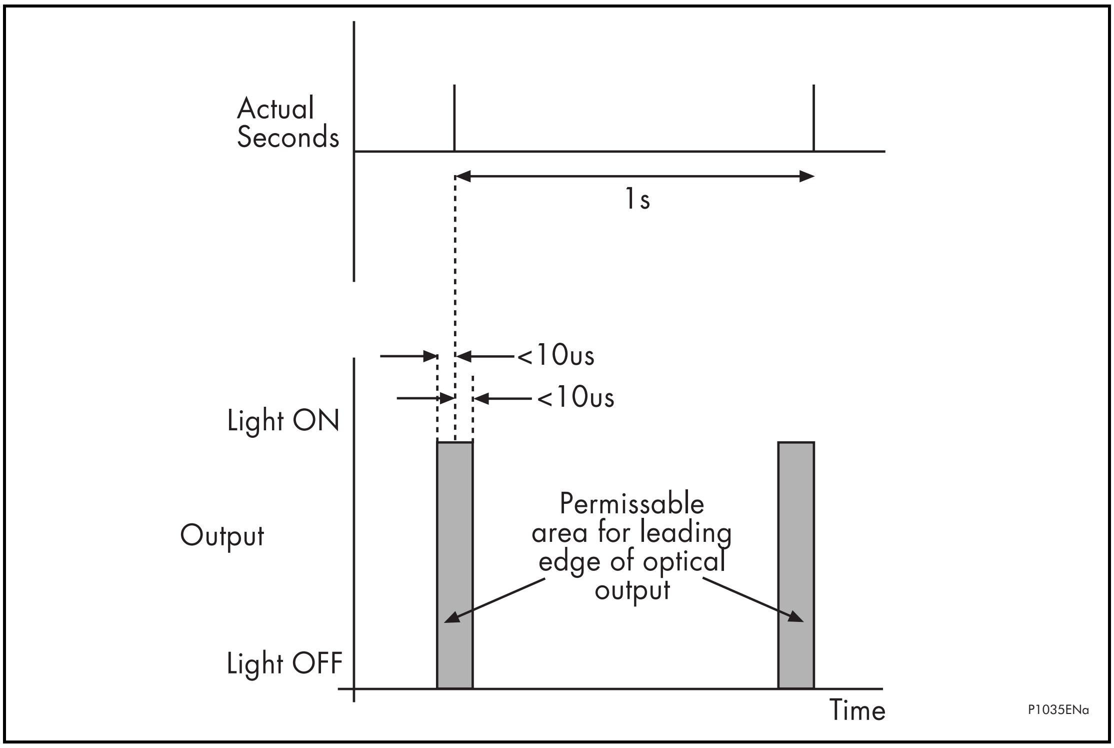


Figure 39: GPS synchronising module output local end

The relative error between any two Timing Modules (which may be several kilometres apart) is less than 1.5 microseconds, see Figure 40. This includes variations in GPS receiver accuracy and in associated circuitry, and results in a minimal error of approximately 0.1% in the overall system.

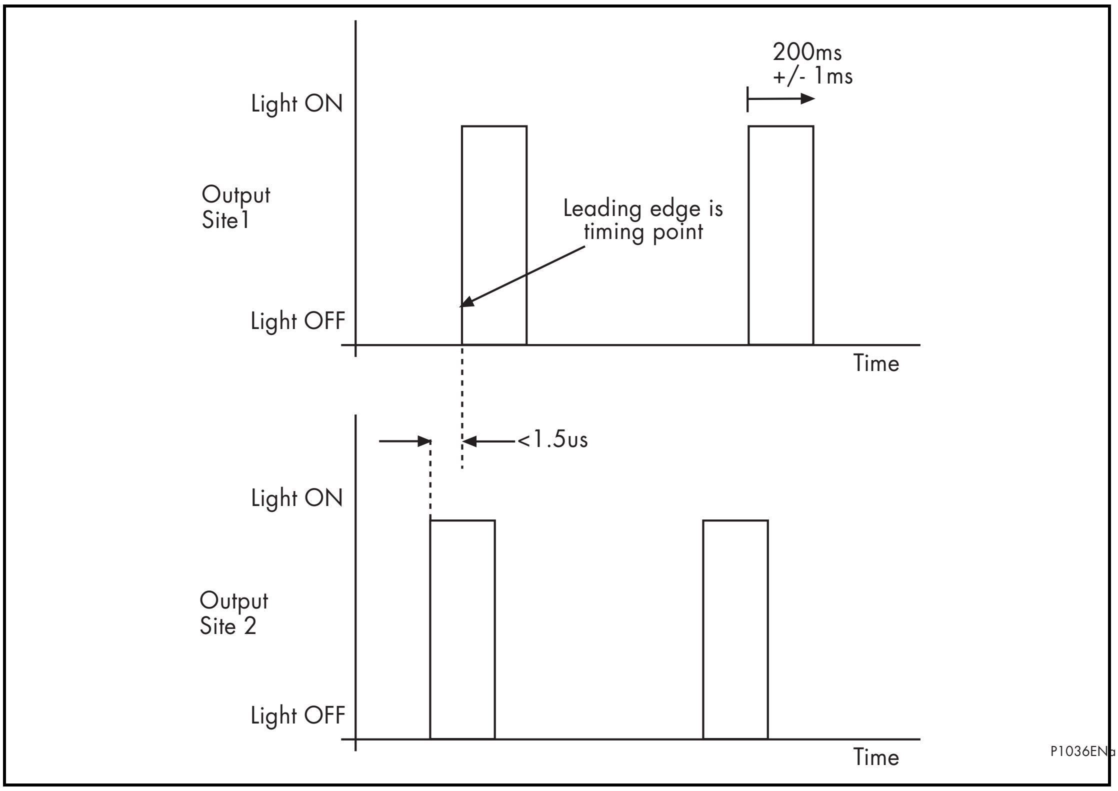


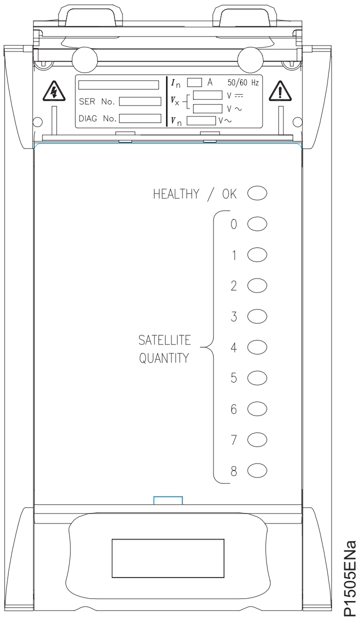
Figure 40: GPS Synchronising module output local and remote ends

Note: That the 1PPS output is only present when it is synchronised to at least four valid satellites.

7.14.2 P594 Operation

The P594 is supplied with an antenna and mounting kit as described in section 7.14.3. On power up the green 'Healthy' LED illuminates and stays on indicating that the unit is healthy. Initially the red '0' LED will be illuminated indicating the P594 has not initialised and is not outputting a signal to the P540. The remaining red LEDs '1-3' and green LEDs '4 – 8' indicate the number of satellites being seen by the P594. The P594 takes up to 3 hours to initialise after it detects four or more satellites before it starts to output a signal. This delay ensures the accuracy of the timing signal. Once initialised and provided the unit sees four or more satellites the red '0' LED is extinguished. If the number of satellites drops below four the output again turns off until the number of satellites exceeds four.

Once the initialisation is complete if the antenna is disconnected and reconnected or if the number of satellites drops below four and recovers above four the output is turned on immediately without waiting for the power on initialisation time. However, if the power to the P594 is lost it will take up to 3 hours to re-initialise.



During the commissioning it is required to measure the optical power, however most optical power meters cannot measure a signal which consists of 200ms light on and 800ms light off. To overcome this a commissioning feature has been added which is activated by disconnecting the antenna cable from the P594. This replaces the normal output signal by a 250kHz signal, which can then be measured. This condition is indicated by the green ‘healthy’ LED flashing. The P540 is immune to this signal and treats it as a loss of GPS.

7.14.3 P594 Options

The P594 requires an antenna, which is supplied as part of a kit. The basic kit contains the following:

- ONCORE™ TIMING200 antenna,
- 25m of low loss cable,
- Lighting / Surge arrestor
- Mounting pole plus brackets

For installations were the antenna must be mounted >25m from the P594 a second kit is required which contains the following:

- The basic kit,
- 25m low loss cable
- Inline amplifier

The correct mounting of the antenna is critical to the correct operation of the P594 and P540. See the installation guide for further details (P594/EN IN).

7.14.4 P594 Synchronising Module Block Diagram

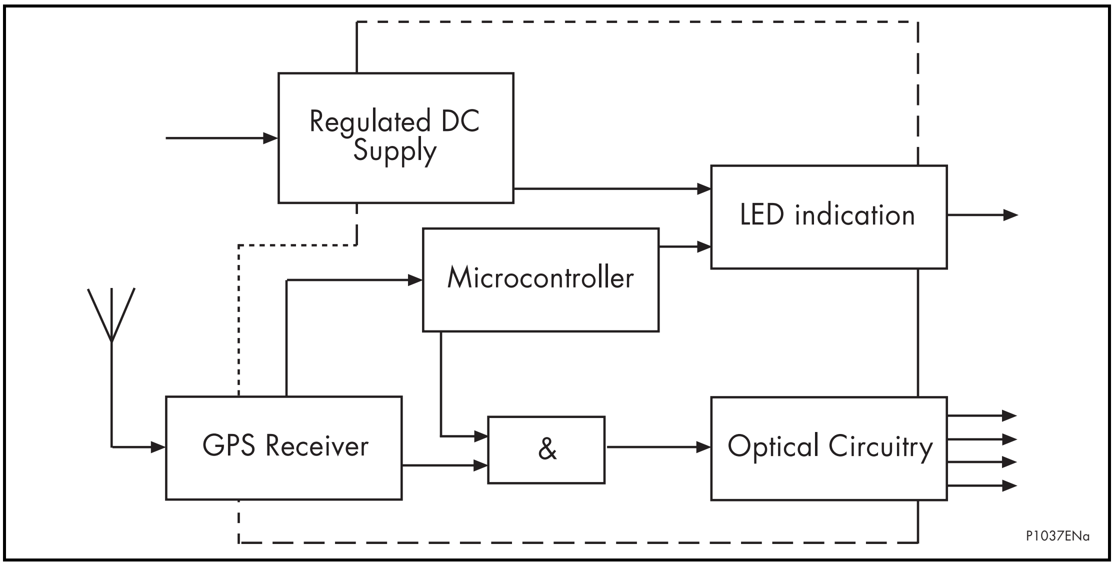


Figure 41: P594 Synchronising Module Block Diagram

RELAY DESCRIPTION

CONTENTS

1. RELAY SYSTEM OVERVIEW

1.1 Hardware overview

The relay hardware is based on a modular design whereby the relay is made up of an assemblage of several modules which are drawn from a standard range. Some modules are essential while others are optional depending on the user's requirements.

The different modules that can be present in the relay are as follows:

1.1.1 Processor board

The processor board performs all calculations for the relay and controls the operation of all other modules within the relay. The processor board also contains and controls the user interfaces (LCD, LEDs, keypad and communication interfaces).

1.1.2 Co-processor board

Used to process the current differential protection algorithms and associated communication. It contains the optical fibre transmit and receive hardware and serial data communication controller for the differential protection signalling.

1.1.3 Input module

The input module converts the information contained in the analogue and digital input signals into a format suitable for processing by the processor board. The standard input module consists of two boards: a transformer board to provide electrical isolation and a main input board which provides analogue to digital conversion and the isolated digital inputs.

1.1.4 Analogue/Digital Input module

The input module converts the information contained in the analogue and digital input signals into a format suitable for processing by the processor board. The standard input module consists of two boards. A transformer board to provide electrical isolation and a main input board which provides analogue to digital conversion (with local storage of the calibration data). The later also provides the isolated wide-ranging digital inputs, with a choice of pickup/drop-off levels, which may be used in conjunction with a range of auxiliary supply inputs.

1.1.5 Power supply module

The power supply module provides a power supply to all of the other modules in the relay, at three different voltage levels. The power supply board also provides the EIA(RS)485 electrical connection for the rear communication port. On a second board the power supply module contains the relays which provide the output contacts.

The power supply module also provides a 48V external field supply to drive the opto isolated digital inputs.

1.1.6 IRIG-B board

This board, which is optional, can be used where an IRIG-B signal is available to provide an accurate time reference for the relay. There is also an option on this board to specify a fibre optic rear communication port, for use with IEC 60870 communication only.

1.1.7 Second rear comms board

The optional second rear port is designed typically for dial-up modem access by protection engineers/operators, when the main port is reserved for SCADA traffic. Communication is via one of three physical links: K-Bus, EIA(RS)485 or EIA(RS)232. The port supports full local or remote protection and control access by MiCOM S1 software. The second rear port is also available with an on board IRIG-B input.

1.1.8 Ethernet board

This is a mandatory board for UCA2.0 enabled relays. It provides network connectivity through either copper or fibre media at rates of 10Mb/s or 100Mb/s. This board, the IRIG-B board and second rear comms board are mutually exclusive as they both utilise slot A within the relay case.

All modules are connected by a parallel data and address bus which allows the processor board to send and receive information to and from the other modules as required. There is also a separate serial data bus for conveying sample data from the input module to the processor. Figure 1 shows the modules of the relay and the flow of information between them.

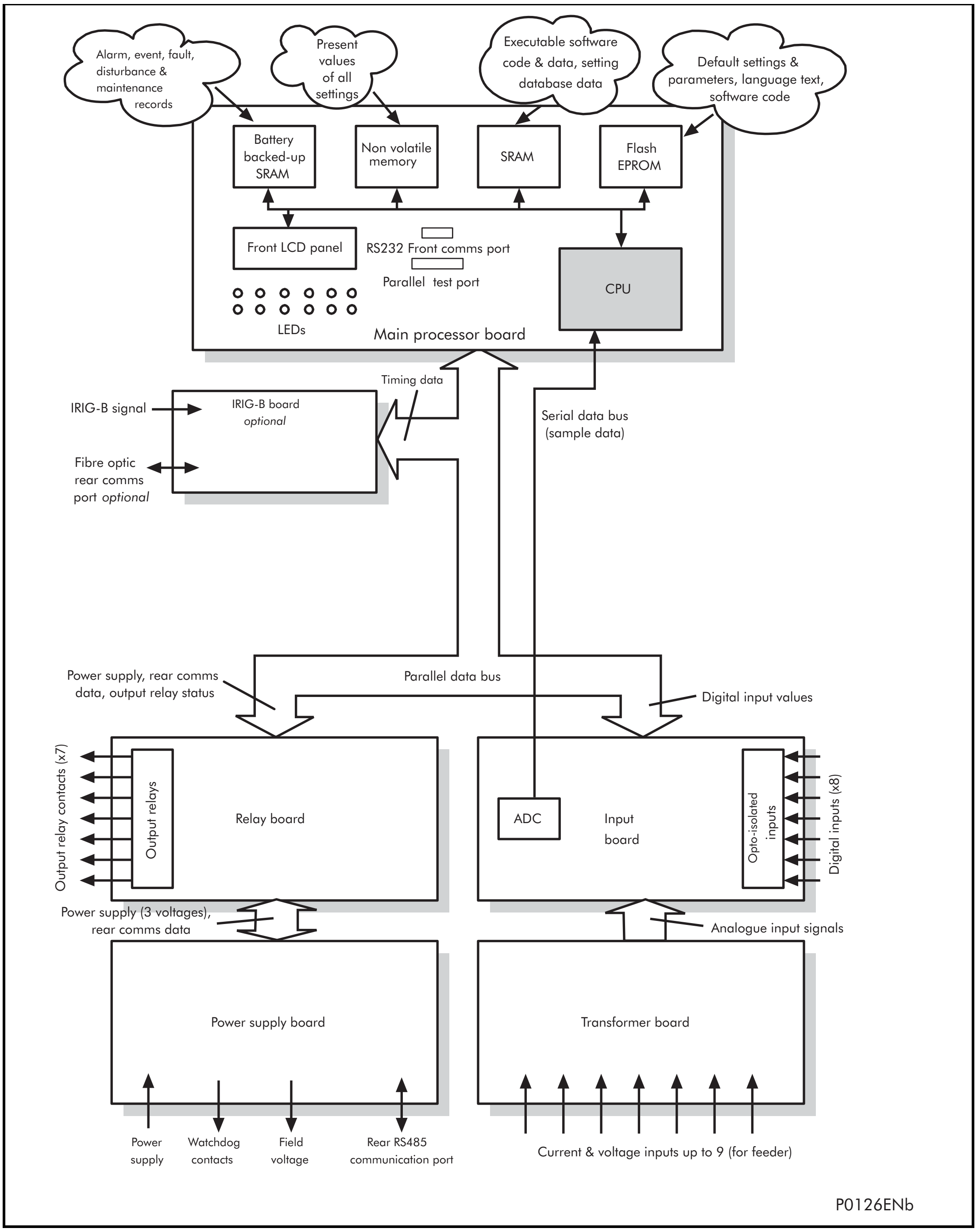


Figure 1: **Relay modules and information flow**

1.2 Software overview

The software for the relay can be conceptually split into four elements: the real-time operating system, the system services software, the platform software and the protection and control software. These four elements are not distinguishable to the user, and are all processed by the same processor board. The distinction between the four parts of the software is made purely for the purpose of explanation here.

1.2.1 Real-time operating system

The real time operating system is used to provide a framework for the different parts of the relay's software to operate within. To this end the software is split into tasks. The real-time operating system is responsible for scheduling the processing of these tasks such that they are carried out in the time available and in the desired order of priority.

The operating system is also responsible for the exchange of information between tasks, in the form of messages.

1.2.2 System services software

The system services software provides the low-level control of the relay hardware. For example, the system services software controls the boot of the relay's software from the non-volatile flash EPROM memory at power-on, and provides driver software for the user interface via the LCD and keypad, and via the serial communication ports. The system services software provides an interface layer between the control of the relay's hardware and the rest of the relay software.

1.2.3 Platform software

The platform software deals with the management of the relay settings, the user interfaces and logging of event, alarm, fault and maintenance records. All of the relay settings are stored in a database within the relay which provides direct compatibility with Courier communications. For all other interfaces (i.e. the front panel keypad and LCD interface, Modbus and IEC 60870-5-103) the platform software converts the information from the database into the format required. The platform software notifies the protection & control software of all settings changes and logs data as specified by the protection & control software.

1.2.4 Protection & control software

The protection and control software performs the calculations for all of the protection algorithms of the relay. This includes digital signal processing such as Fourier filtering and ancillary tasks such as the measurements. The protection & control software interfaces with the platform software for settings changes and logging of records, and with the system services software for acquisition of sample data and access to output relays and digital opto-isolated inputs.

1.2.5 Disturbance recorder

The analogue values and logic signals are routed from the protection and control software to the disturbance recorder software. The platform software interfaces to the disturbance recorder to allow extraction of the stored records.

2. HARDWARE MODULES

The relay is based on a modular hardware design where each module performs a separate function within the relay operation. This section describes the functional operation of the various hardware modules.

2.1 Processor board

The relay is based around a TMS320VC33-150MHz (peak speed), floating point, 32-bit digital signal processor (DSP) operating at a clock frequency of half this speed. This processor performs all of the calculations for the relay, including the protection functions, control of the data communication and user interfaces including the operation of the LCD, keypad and LEDs.

The processor board is located directly behind the relay's front panel which allows the LCD and LEDs to be mounted on the processor board along with the front panel communication ports. These comprise the 9-pin D-connector for EIA(RS)232 serial communications (e.g. using MiCOM S1 and Courier communications) and the 25-pin D-connector relay test port for parallel communication. All serial communication is handled using a field programmable gate array (FPGA).

The memory provided on the main processor board is split into two categories, volatile and non-volatile: the volatile memory is fast access SRAM which is used for the storage and execution of the processor software, and data storage as required during the processor's calculations. The non-volatile memory is sub-divided into 2 groups: 4MB of flash memory for non-volatile storage of software code, text and configuration data including the present setting values, and 2MB of battery backed-up SRAM for the storage of disturbance, event, fault and maintenance record data.

2.2 Co-processor board

A second processor board is used in the relay for the processing of the current differential protection algorithms. The processor used on the second board is the same as that used on the main processor board. The second processor board has provision for fast access (zero wait state) SRAM for use with both program and data memory storage. This memory can be accessed by the main processor board via the parallel bus, and this route is used at power-on to download the software for the second processor from the flash memory on the main processor board. Further communication between the two processor boards is achieved via interrupts and the shared SRAM. The serial bus carrying the sample data is also connected to the co-processor board, using the processor's built-in serial port, as on the main processor board.

The co-processor board also handles all communication with the remote differential relay(s). This is achieved via optical fibre communications and hence the co-processor board holds the optical modules to transmit and receive data over the fibre links.

2.3 Internal communication buses

The relay has two internal buses for the communication of data between different modules. The main bus is a parallel link which is part of a 64-way ribbon cable. The ribbon cable carries the data and address bus signals in addition to control signals and all power supply lines. Operation of the bus is driven by the main processor board which operates as a master while all other modules within the relay are slaves.

The second bus is a serial link which is used exclusively for communicating the digital sample values from the input module to the main processor board. The DSP processor has a built-in serial port which is used to read the sample data from the serial bus. The serial bus is also carried on the 64-way ribbon cable.

2.4 Input module

The input module provides the interface between the relay processor board and the analogue and digital signals coming into the relay. The input module consist of two PCBs; the main input board and a transformer board. The P541 and P542 relays provide four current inputs. The P543 and P545 relays provides four voltage inputs and five current inputs. The P544 and P546 relays provides three voltage inputs and nine current inputs.

2.4.1 Transformer board

The transformer board holds up to four voltage transformers (VTs) and up to five current transformers (CTs). The current inputs will accept either 1A or 5A nominal current (menu and wiring options) and the nominal voltage input is 110V.

The transformers are used both to step-down the currents and voltages to levels appropriate to the relay's electronic circuitry and to provide effective isolation between the relay and the power system. The connection arrangements of both the current and voltage transformer secondaries provide differential input signals to the main input board to reduce noise.

2.4.2 Input board

The main input board is shown as a block diagram in Figure 2. It provides the circuitry for the digital input signals and the analogue-to-digital conversion for the analogue signals. Hence it takes the differential analogue signals from the CTs and VTs on the transformer board(s), converts these to digital samples and transmits the samples to the processor board via the serial data bus. On the input board the analogue signals are passed through an anti-alias filter before being multiplexed into a single analogue-to-digital converter chip. The A – D converter provides 16-bit resolution and a serial data stream output. The digital input signals are opto isolated on this board to prevent excessive voltages on these inputs causing damage to the relay's internal circuitry.

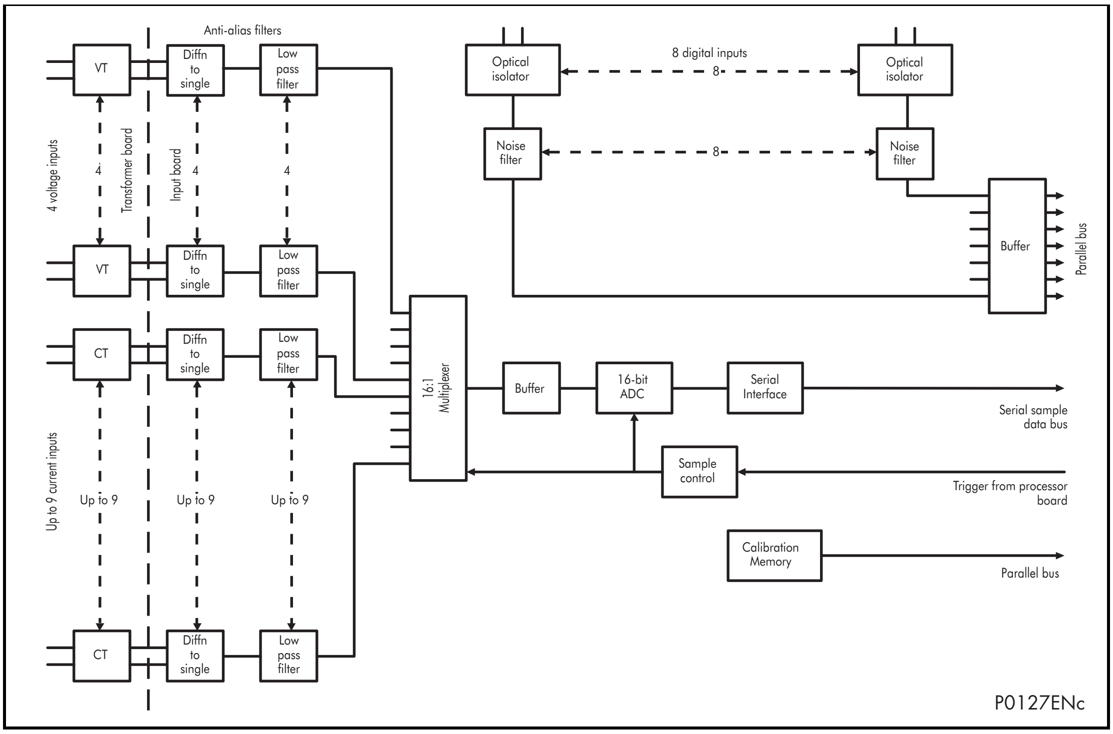


Figure 2: **Main input board**

The signal multiplexing arrangement provides for 16 analogue channels to be sampled. The P540 range of products provide up to 9 current inputs and 4 voltage inputs. Three spare channels are used to sample three different reference voltages for the purpose of continually checking the operation of the multiplexer and the accuracy of the A-D converter. The sample rate is maintained at 24 samples per cycle of the power waveform by a logic control circuit which is driven by the frequency tracking function on the main processor board.

The calibration non volatile memory holds the calibration coefficients which are used by the processor board to correct for any amplitude or phase errors introduced by the transformers and analogue circuitry.

The other function of the input board is to read the state of the signals present on the digital inputs and present this to the parallel data bus for processing. The input board holds 8 optical isolators for the connection of up to eight digital input signals. The opto-isolators are used with the digital signals for the same reason as the transformers with the analogue signals; to isolate the relay's electronics from the power system environment. A 48V 'field voltage' supply is provided at the back of the relay for use in driving the digital opto-inputs. The input board provides some hardware filtering of the digital signals to remove unwanted noise before buffering the signals for reading on the parallel data bus. Depending on the relay model, more than 8 digital input signals can be accepted by the relay. This is achieved by the use of an additional opto-board which contains the same provision for 8 isolated digital inputs as the main input board, but does not contain any of the circuits for analogue signals which are provided on the main input board.

2.4.3 Universal opto isolated logic inputs

The P540 series relays are fitted with universal opto isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part i.e. thereby allowing different voltages for different circuits e.g. signalling, tripping. From software version 30 onwards they can also be programmed as Standard 60% - 80% or 50% - 70% to satisfy different operating constraints.

Threshold levels are as follows:

Nominal Battery Voltage (Vdc)	**Standard 60% - 80%**		**50% - 70%**	
	No Operation (logic 0) Vdc	**Operation (logic 1) Vdc**	**No Operation (logic 0) Vdc**	**Operation (logic 1) Vdc**
24 / 27	<16.2	>19.2	<12.0	>16.8
30 / 34	<20.4	>24.0	<15.0	>21.0
48 / 54	<32.4	>38.4	<24.0	>33.6
110 / 125	<75.0	>88.0	<55.0	>77.0
220 / 250	<150.0	>176.0	<110	>154

This lower value eliminates fleeting pickups that may occur during a battery earth fault, when stray capacitance may present up to 50% of battery voltage across an input.
Each input also has selectable filtering which can be utilised. This allows use of a pre-set filter of ½ cycle which renders the input immune to induced noise on the wiring: although this method is secure it can be slow, particularly for intertripping. This can be improved by switching off the ½ cycle filter in which case one of the following methods to reduce ac noise should be considered. The first method is to use double pole switching on the input, the second is to use screened twisted cable on the input circuit.

2.5 Power supply module (including output relays)

The power supply module contains two PCBs, one for the power supply unit itself and the other for the output relays. The power supply board also contains the input and output hardware for the rear communication port which provides an EIA(RS)485 communication interface.

2.5.1 Power supply board (including EIA(RS)485 communication interface)

One of three different configurations of the power supply board can be fitted to the relay. This will be specified at the time of order and depends on the nature of the supply voltage that will be connected to the relay. The three options are shown in table 1 below.

Nominal dc range	Nominal ac range
24 – 48V	dc only
48 – 110V	30 – 100V rms
110 – 250V	100 – 240V rms

Table 1: Power supply options

The output from all versions of the power supply module are used to provide isolated power supply rails to all of the other modules within the relay. Three voltage levels are used within the relay, 5.1V for all of the digital circuits, ±16V for the analogue electronics, e.g. on the input board, and 22V for driving the output relay coils. All power supply voltages including the 0V earth line are distributed around the relay via the 64-way ribbon cable. One further voltage level is provided by the power supply board which is the field voltage of 48V. This is brought out to terminals on the back of the relay so that it can be used to drive the optically isolated digital inputs.

The two other functions provided by the power supply board are the EIA(RS)485 communications interface and the watchdog contacts for the relay. The EIA(RS)485 interface is used with the relay's rear communication port to provide communication using one of either Courier, Modbus, IEC 60870-5-103 or DNP3.0 protocols. The EIA(RS)485 hardware supports half-duplex communication and provides optical isolation of the serial data being transmitted and received. All internal communication of data from the power supply board is conducted via the output relay board which is connected to the parallel bus.

The watchdog facility provides two output relay contacts, one normally open and one normally closed which are driven by the processor board. These are provided to give an indication that the relay is in a healthy state.

The power supply board incorporates inrush current limiting. This limits the peak inrush current, during energisation, to approximately 10A.

2.5.2 Output relay board

The output relay board holds seven relays, three with normally open contacts and four with changeover contacts. The relays are driven from the 22V power supply line. The relays' state is written to or read from using the parallel data bus. Depending on the relay model seven additional output contacts may be provided, through the use of up to three extra relay boards.

2.6 IRIG-B board

The IRIG-B board is an order option which can be fitted to provide an accurate timing reference for the relay. This can be used wherever an IRIG-B signal is available. The IRIG-B signal is connected to the board via a BNC connector on the back of the relay. The timing information is used to synchronise the relay's internal real-time clock to an accuracy of 1ms. The internal clock is then used for the time tagging of the event, fault maintenance and disturbance records.

The IRIG-B board can also be specified with a fibre optic transmitter/receiver which can be used for the rear communication port instead of the EIA(RS)485 electrical connection (IEC 60870 only).

2.7 Second rear communications board

For relays with Courier, Modbus, IEC60870-5-103 or DNP3 protocol on the first rear communications port there is the hardware option of a second rear communications port, which will run the Courier language. This can be used over one of three physical links: twisted pair K-Bus (non polarity sensitive), twisted pair EIA(RS)485 (connection polarity sensitive) or EIA(RS)232.

The second rear comms board and IRIG-B board are mutually exclusive since they use the same hardware slot. For this reason two versions of second rear comms board are available; one with an IRIG-B input and one without. The physical layout of the second rear comms board is shown in Figure 3.

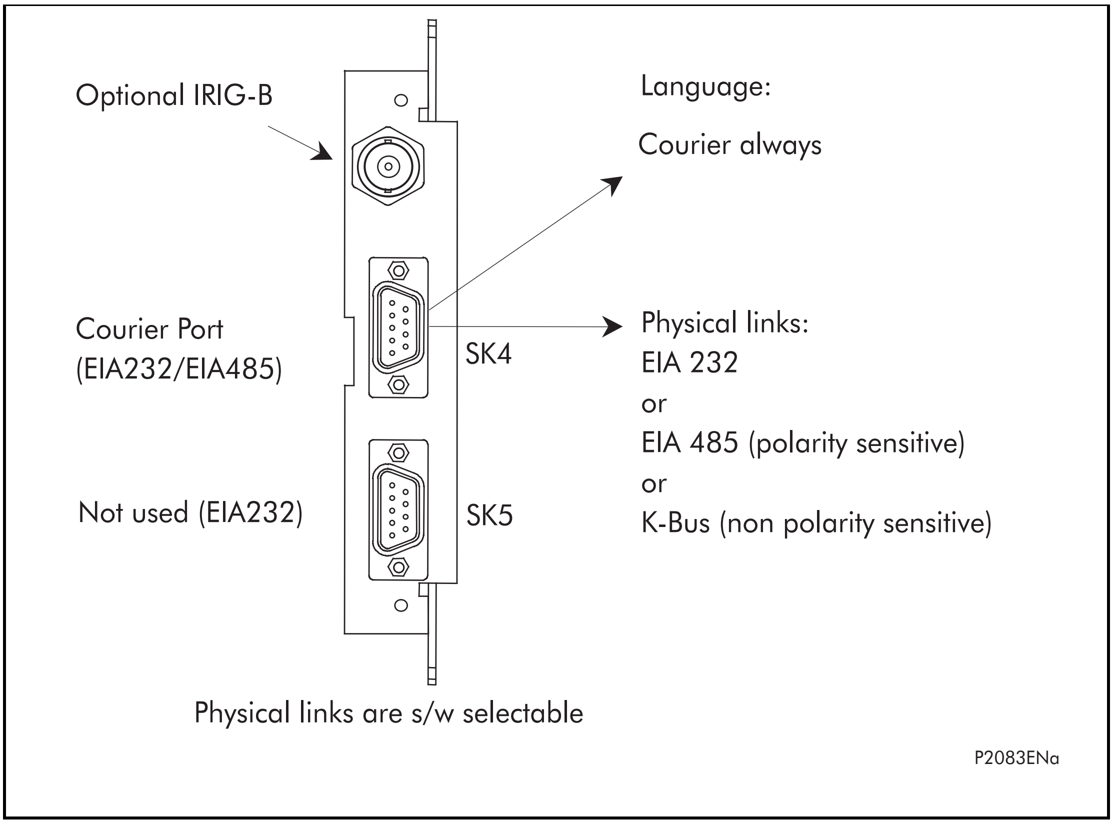


Figure 3: **Rear comms port**

2.8 Ethernet board

The ethernet board, presently only available for UCA2 communication variant relays, supports network connections of the following type:

- 10BASE-T
- 10BASE-FL
- 100BASE-TX
- 100BASE-FX

For all copper based network connections an RJ45 style connector is supported. 10Mb fibre network connections use an ST style connector while 100Mb connections use the SC style fibre connection.

An extra processor, a Motorola PPC, and memory block is fitted to the ethernet card that is responsible for running all the network related functions such as TCP/IP/OSI as supplied by VxWorks and the UCA2/MMS server as supplied by Sisco inc. The extra memory block also holds the UCA2 data model supported by the relay.

2.9 Mechanical layout

The case materials of the relay are constructed from pre-finished steel which has a conductive covering of aluminium and zinc. This provides good earthing at all joints giving a low impedance path to earth which is essential for performance in the presence of external noise. The boards and modules use a multi-point earthing strategy to improve the immunity to external noise and minimise the effect of circuit noise. Ground planes are used on boards to reduce impedance paths and spring clips are used to ground the module metalwork.

Heavy duty terminal blocks are used at the rear of the relay for the current and voltage signal connections. Medium duty terminal blocks are used for the digital logic input signals, the output relay contacts, the power supply and the rear communication port. A BNC connector is used for the optional IRIG-B signal. 9-pin and 25-pin female D-connectors are used at the front of the relay for data communication.

Inside the relay the PCBs plug into the connector blocks at the rear, and can be removed from the front of the relay only. The connector blocks to the relay's CT inputs are provided with internal shorting links inside the relay which will automatically short the current transformer circuits before they are broken when the board is removed.

The front panel consists of a membrane keypad with tactile dome keys, an LCD and 12 LEDs mounted on an aluminium backing plate.

3. RELAY SOFTWARE

The relay software was introduced in the overview of the relay at the start of this chapter. The software can be considered to be made up of four sections:

- the real-time operating system
- the system services software
- the platform software
- the protection & control software

This section describes in detail the latter two of these, the platform software and the protection & control software, which between them control the functional behaviour of the relay. Figure 4 shows the structure of the relay software.

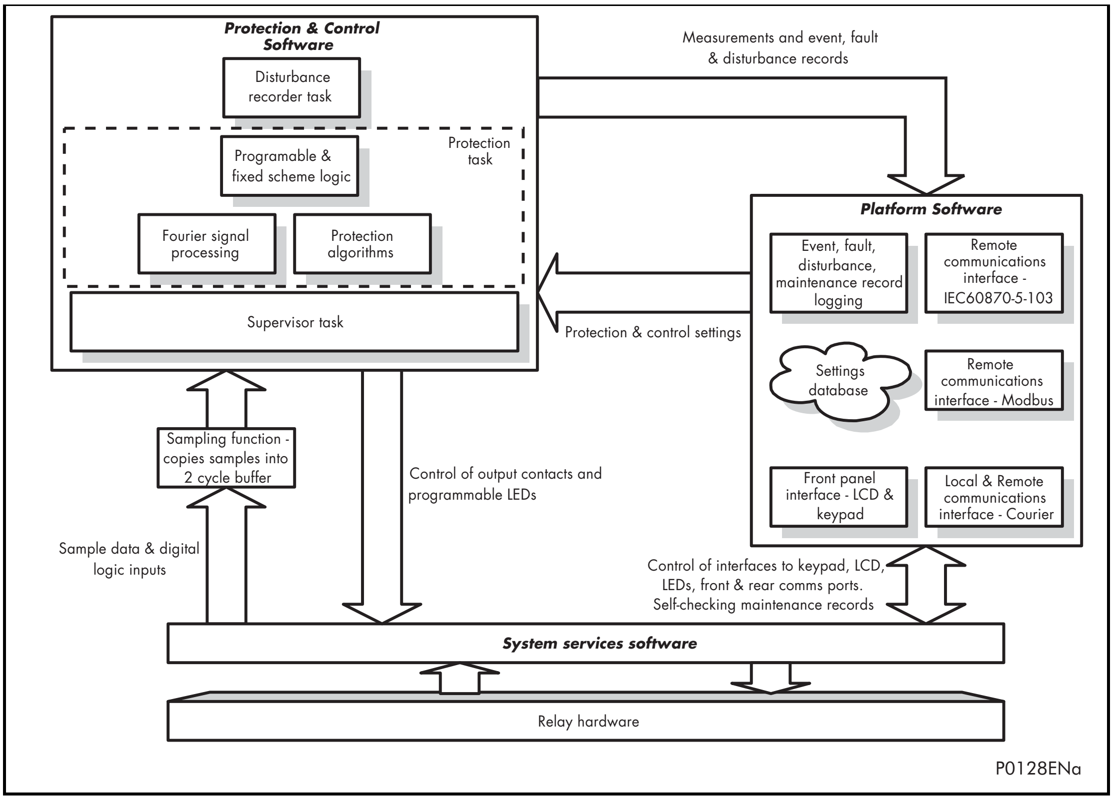


Figure 4: **Relay software structure**

3.1 Real-time operating system

The software is split into tasks; the real-time operating system is used to schedule the processing of the tasks to ensure that they are processed in the time available and in the desired order of priority. The operating system is also responsible in part for controlling the communication between the software tasks through the use of operating system messages.

3.2 System services software

As shown in Figure 3, the system services software provides the interface between the relay's hardware and the higher-level functionality of the platform software and the protection & control software. For example, the system services software provides drivers for items such as the LCD display, the keypad and the remote communication ports, and controls the boot of the processor and downloading of the processor code into SRAM from non-volatile flash EPROM at power up.

3.3 Platform software

The platform software has three main functions:

- to control the logging of records that are generated by the protection software, including alarms and event, fault, and maintenance records.
- to store and maintain a database of all of the relay's settings in non-volatile memory.
- to provide the internal interface between the settings database and each of the relay's user interfaces, i.e. the front panel interface and the front and rear communication ports, using whichever communication protocol has been specified (Courier, Modbus, IEC 60870-5-103, DNP 3.0, UCA2).

3.3.1 Record logging

The logging function is provided to store all alarms, events, faults and maintenance records. The records for all of these incidents are logged in battery backed-up SRAM in order to provide a non-volatile log of what has happened. The relay maintains four logs: one each for up to 32 alarms, 512 event records, 5 fault records and 5 maintenance records. The logs are maintained such that the oldest record is overwritten with the newest record. The logging function can be initiated from the protection software or the platform software is responsible for logging of a maintenance record in the event of a relay failure. This includes errors that have been detected by the platform software itself or error that are detected by either the system services or the protection software function. See also the section on supervision and diagnostics later in this chapter.

3.3.2 Settings database

The settings database contains all of the settings and data for the relay, including the protection, disturbance recorder and control & support settings. The settings are maintained in non-volatile memory. The platform software's management of the settings database includes the responsibility of ensuring that only one user interface modifies the settings of the database at any one time. This feature is employed to avoid conflict between different parts of the software during a setting change. For changes to protection settings and disturbance recorder settings, the platform software operates a 'scratchpad' in SRAM memory. This allows a number of setting changes to be applied to the protection elements, disturbance recorder and saved in the database in non-volatile memory. (See also chapter 1 on the user interface). If a setting change affects the protection & control task, the database advises it of the new values.

3.3.3 Database interface

The other function of the platform software is to implement the relay's internal interface between the database and each of the relay's user interfaces. The database of settings and measurements must be accessible from all of the relay's user interfaces to allow read and modify operations. The platform software presents the data in the appropriate format for each user interface.

3.4 Protection and control software

The protection and control software task is responsible for processing all of the protection elements and measurement functions of the relay. To achieve this it has to communicate with both the system services software and the platform software as well as organise its own operations. The protection software has the highest priority of any of the software tasks in the relay in order to provide the fastest possible protection response. The protection & control software has a supervisor task which controls the start-up of the task and deals with the exchange of messages between the task and the platform software.

3.4.1 Overview – protection and control scheduling

After initialisation at start-up, the protection and control task on the main processor board is suspended until the co-processor board re-starts via an interrupt. In the case were the co-processor board has failed the protection task will automatically start after six analogue samples have been received. In normal operation the task will be re-started by the co-processor four times per cycle, which corresponds to the frequency of data message transmission on the differential communication system. The acquisition of samples on the main processor board is controlled by a ‘sampling function’ which is called by the system services software and takes each set of new samples from the input module and stores them in a two-cycle buffer, these samples are also stored concurrently by the co-processor.

3.4.2 Signal processing

The sampling function provides filtering of the digital input signals from the opto-isolators and frequency tracking of the analogue signals. The digital inputs are checked against their previous value over a period of half a cycle. Hence a change in the state of one of the inputs must be maintained over at least half a cycle before it is registered with the protection and control software.

The frequency tracking of the analogue input signals is achieved by a recursive Fourier algorithm which is applied to one of the input signals, and works by detecting a change in the measured signal’s phase angle. The calculated value of the frequency is used to modify the sample rate being used by the input module so as to achieve a constant sample rate of 24 samples per cycle of the power waveform. The value of the frequency is also stored for use by the protection and control task.

When the protection and control task is re-started by the sampling function, it calculates the Fourier components for the analogue signals. The Fourier components are calculated using a one-cycle, 24-sample Discrete Fourier Transform (DFT). The DFT is always calculated using the last cycle of samples from the 2-cycle buffer, i.e. the most recent data is used. The DFT used in this way extracts the power frequency fundamental component from the signal and produces the magnitude and phase angle of the fundamental in rectangular component format. The DFT provides an accurate measurement of the fundamental frequency component, and effective filtering of harmonic frequencies and noise. This performance is achieved in conjunction with the relay input module which provides hardware anti-alias filtering to attenuate frequencies above the half sample rate, and frequency tracking to maintain a sample rate of 24 samples per cycle. The Fourier components of the input current and voltage signals are stored in memory so that they can be accessed by all of the protection elements’ algorithms. The samples from the input module are also used in an unprocessed form by the disturbance recorder for waveform recording and to calculate true rms values of current, voltage and power for metering purposes.

3.4.3 Current differential protection - co-processor board

All of the processing for the current differential protection algorithm and the communication protocol associated with it is made on the co-processor board. The differential protection is based on the relays at the line ends exchanging data messages four times per cycle. To achieve this the co-processor takes the frequency-tracked samples at 24 samples per cycle from the input board and converts these to 8 samples per cycle based on the nominal frequency (i.e. not frequency tracked). The co-processor calculates the Fourier transform of the fixed rate samples after every sample, using a one-cycle window. This generates current measurements eight times per cycle which are used for the differential protection algorithm and transmitted to the remote relay(s) using the HDLC (high-level data link control) communication protocol.

The co-processor is also responsible for managing intertripping commands via the communication link, and re-configuration instigated from the remote relay(s). Data exchange between the co-processor board and the main processor board is achieved through the use of shared memory on the co-processor board. When the main processor accesses this memory, the co-processor is temporarily halted. After the co-processor code has been copied onto the board at initialisation, the main traffic between the two boards consists of setting change information, commands from the main processor, differential protection measurements and output data.

3.4.4 Programmable scheme logic

The purpose of the programmable scheme logic (PSL) is to allow the relay user to configure an individual protection scheme to suit their own particular application. This is achieved through the use of programmable logic gates and delay timers.

The input to the PSL is any combination of the status of the digital input signals from the opto-isolators on the input board, the outputs of the protection elements, e.g. protection starts and trips, and the outputs of the fixed protection scheme logic. The fixed scheme logic provides the relay's standard protection schemes. The PSL itself consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, and/or to condition the logic outputs, e.g. to create a pulse of fixed duration on the output regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL. The protection and control software updates the logic delay timers and checks for a change in the PSL input signals every time it runs.

This system provides flexibility for the user to create their own scheme logic design. However, it also means that the PSL can be configured into a very complex system, and because of this setting of the PSL is implemented through the PC support package MiCOM S1.

3.4.5 Event and fault recording

A change in any digital input signal or protection element output signal causes an event record to be created. When this happens, the protection and control task sends a message to the supervisor task to indicate that an event is available to be processed and writes the event data to a fast buffer in SRAM which is controlled by the supervisor task. When the supervisor task receives either an event or fault record message, it instructs the platform software to create the appropriate log in battery backed-up SRAM. The operation of the record logging to battery backed-up SRAM is slower than the supervisor's buffer. This means that the protection software is not delayed waiting for the records to be logged by the platform software. However, in the rare case when a large number of records to be logged are created in a short period of time, it is possible that some will be lost if the supervisor's buffer is full before the platform software is able to create a new log in battery backed-up SRAM. If this occurs then an event is logged to indicate this loss of information.

3.4.6 Disturbance recorder

The disturbance recorder operates as a separate task from the protection and control task. It can record the waveforms for up to 8 analog channels and the values of up to 32 digital signals. The recording time is user selectable up to a maximum of 10 seconds. The disturbance recorder is supplied with data by the protection and control task once per cycle. The disturbance recorder collates the data that it receives into the required length disturbance record. The disturbance records can be extracted by MiCOM S1 which can also store the data in COMTRADE format, thus allowing the use of other packages to view the recorded data.

3.4.7 Fault locator (models P543, P544 , P545 & P546 only)

The fault locator task is also separate from the protection and control task. The fault locator is invoked by the protection and control task when a fault is detected. The fault locator uses a 12-cycle buffer of the analogue input signals and returns the calculated location of the fault to the protection and control task which includes it in the fault record for the fault. When the fault record is complete (i.e. includes the fault location), the protection and control task can send a message to the supervisor task to log the fault record.

4. SELF TESTING & DIAGNOSTICS

The relay includes a number of self-monitoring functions to check the operation of its hardware and software when it is in service. These are included so that if an error or fault occurs within the relay's hardware or software, the relay is able to detect and report the problem and attempt to resolve it by performing a re-boot. This involves the relay being out of service for a short period of time which is indicated by the 'Healthy' LED on the front of the relay being extinguished and the watchdog contact at the rear operating. If the restart fails to resolve the problem, then the relay will take itself permanently out of service. Again this will be indicated by the LED and watchdog contact.

If a problem is detected by the self-monitoring functions, the relay attempts to store a maintenance record in battery backed-up SRAM to allow the nature of the problem to be notified to the user.

The self-monitoring is implemented in two stages: firstly a thorough diagnostic check which is performed when the relay is booted-up, e.g. at power-on, and secondly a continuous self-checking operation which checks the operation of the relay's critical functions whilst it is in service.

4.1 Start-up self-testing

The self-testing which is carried out when the relay is started takes a few seconds to complete, during which time the relay's protection is unavailable. This is signalled by the 'Healthy' LED on the front of the relay which will illuminate when the relay has passed all of the tests and entered operation. If the testing detects a problem, the relay will remain out of service until it is manually restored to working order.

The operations that are performed at start-up are as follows:

4.1.1 System boot

The integrity of the flash EPROM memory is verified using a checksum before the program code and data stored in it is copied into SRAM to be used for execution by the processor. When the copy has been completed the data then held in SRAM is compared to that in the flash EPROM to ensure that the two are the same and that no errors have occurred in the transfer of data from flash EPROM to SRAM. The entry point of the software code in SRAM is then called which is the relay initialisation code.

4.1.2 Initialisation software

The initialisation process includes the operations of initialising the processor registers and interrupts, starting the watchdog timers (used by the hardware to determine whether the software is still running), starting the real-time operating system and creating and starting the supervisor task. In the course of the initialisation process the relay checks:

- the status of the battery.
- the integrity of the battery backed-up SRAM that is used to store event, fault and disturbance records.
- the voltage level of the field voltage supply which is used to drive the opto-isolated inputs.
- the operation of the LCD controller.
- the watchdog operation.

At the conclusion of the initialisation software the supervisor task begins the process of starting the platform software. The checking that is made in the process of starting the co-processor board is as follows:

- a check is made for the presence of, and a valid response from, the co-processor board.
- the SRAM on the co-processor board is checked with a test bit pattern before the co-processor code is transferred from the flash EPROM.

- the integrity of the co-processor code is checked using a checksum before and after transferring it to the co-processor
- detection of the correct number of differential signalling channels is checked.

Any of these checks which produces an error results in the co-processor board being left out of service and the relay relying on the other protection functions which are provided by the main processor board.

4.1.3 Platform software initialisation & monitoring

In starting the platform software, the relay checks the integrity of the data held in non-volatile memory with a checksum, the operation of the real-time clock, and the IRIG-B board if fitted. The final test that is made concerns the input and output of data; the presence and healthy condition of the input board is checked and the analog data acquisition system is checked through sampling the reference voltage.

At the successful conclusion of all of these tests the relay is entered into service and the protection started-up.

4.2 Continuous self-testing

When the relay is in service, it continually checks the operation of the critical parts of its hardware and software. The checking is carried out by the system services software (see section on relay software earlier in this chapter) and the results reported to the platform software. The functions that are checked are as follows:

- the flash EPROM containing all program code and language text is verified by a checksum.
- the code and constant data held in SRAM is checked against the corresponding data in flash EPROM to check for data corruption.
- the SRAM containing all data other than the code and constant data is verified with a checksum.
- the non volatile memory containing setting values is verified by a checksum, whenever its data is accessed.
- the battery status.
- the level of the field voltage.
- the integrity of the digital signal I/O data from the opto-isolated inputs and the relay contacts is checked by the data acquisition function every time it is executed. The operation of the analogue data acquisition system is continuously checked by the acquisition function every time it is executed, by means of sampling the reference voltages.
- the operation of the co-processor board is checked, including the SRAM and code, the response of the board to setting changes, incorrect received data, failure of the communication channel and general watchdog to indicate continued operation of the software on the board.
- the operation of the IRIG-B board is checked, where it is fitted, by the software that reads the time and date from the board.
- the operation of the ethernet board is checked, where it is fitted, by the software on the main processor card. If the ethernet board fails to respond an alarm is raised and the card is reset in an attempt to resolve the problem.

In the unlikely event that one of the checks detects an error within the relay's subsystems, the platform software is notified and it will attempt to log a maintenance record in battery backed-up SRAM. If the problem is with the battery status or the IRIG-B board, the relay will continue in operation. However, for problems detected in any other area the relay will initiate a shutdown and re-boot. This will result in a period of up to 5 seconds when the protection is unavailable, but the complete restart of the relay including all initialisations should clear most problems that could occur. As described above, an integral part of the start-up procedure is a thorough diagnostic self-check. If this detects the same problem that caused the relay to restart, i.e. the restart has not cleared the problem, then the relay will take itself permanently out of service. This is indicated by the 'Healthy' LED on the front of the relay, which will extinguish, and the watchdog contact which will operate.

TECHNICAL DATA

CONTENTS

1. REFERENCE CONDITIONS

The accuracy claims within this document are relevant for a relay operating under the following 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	Reference conditions	Test tolerance
Current	In	±5%
Voltage	Vn	±5%
Frequency	50 or 60Hz	±0.5%
Auxiliary supply	DC 24V, 48V or 110V AC 63.5V or 110V	±5%

Settings	Reference value
Time Multiplier Setting	1.0
Time Dial (Software 30 or later)	1
Time Dial	7

2. PROTECTION FUNCTIONS

The following functional claims are applicable to the P540 range of current differential relays.

Note however that not all the protection functions listed below are applicable to every relay.

2.1 Phase current differential protection

2.1.1 Phase current biased differential characteristic settings

Name	Range	Step Size
Is1	0.2 - 2.0In	0.05In
Is2	1.0 – 30In	0.05In
K1	30 – 150%	5%

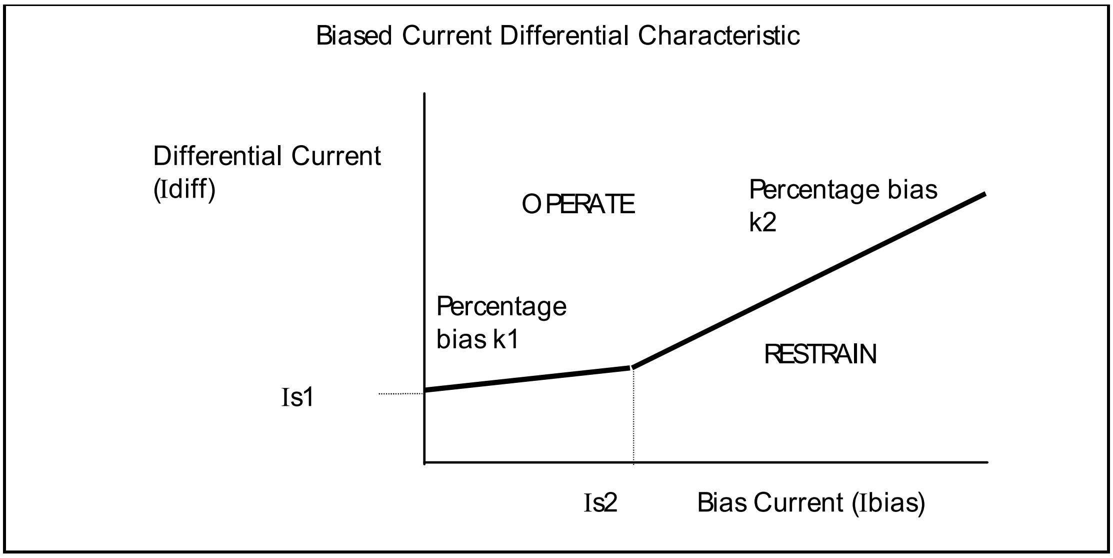
Characteristic shape determined by the following formula:

For $I_{bias} \leq I_{s2}$

$|I_{diff}| = k_1|I_{bias}| + I_{S1}$

For $I_{bias} > I_{s2}$

$|I_{diff}| = k_2|I_{bias}| - (k_2 - k_2).I_{S2} + I_{S1}$



2.1.2 Phase current differential high set characteristic settings (P541 and P542)

Name	Range	Step Size
I Diff >>	4.0 - 32.0In	0.01In

2.1.3 Differential protection operating and reset times

The time delay is user selectable as inverse time or definite time characteristics:

2.1.4 Inverse time (IDMT) characteristic

IDMT characteristics shall be selectable from a choice of four IEC/UK and five IEEE/US curves as shown in the table overleaf.

The IEC/UK IDMT curves conform to the following formula:

$$t = T \times \left(\frac{K}{(I/Is)^{\alpha} - 1} + L \right)$$

The IEEE/US IDMT curves conform to the following formula:

$$t = TD \times \left(\frac{K}{(I/Is)^{\alpha} - 1} + L \right)$$

Where t = operation time

K = constant

I = measured current

I_S = current threshold setting

α = constant

L = ANSI/IEEE constant (zero for IEC/UK curves)

T = Time Multiplier Setting for IEC/UK curves

TD = Time Dial Setting for IEEE/US curves

IDMT Curve description	Standard	K Constant	α Constant	L Constant
Standard Inverse	IEC	0.14	0.02	0
Very Inverse	IEC	13.5	1	0
Extremely Inverse	IEC	80	2	0
Long Time Inverse	UK	120	1	0
Moderately Inverse	IEEE	0.0515	0.02	0.114
Very Inverse	IEEE	19.61	2	0.491
Extremely Inverse	IEEE	28.2	2	0.1217
Inverse	US-C08	5.95	2	0.18
Short Time Inverse	US-C02	0.16758	0.02	0.11858

2.1.4.1 Required Time Multiplier Settings for IEC/UK curves

Name	Range	Step Size
TMS	0.025 to 1.2	0.025

2.1.4.2 Required Time Dial Settings for IEEE/US curves

Name	Range	Step Size
TD (software 30 or later)	0.1 - 100	0.05
TD	0.05 - 15	0.01

2.1.4.3 Definite time characteristic

Range	Step Size
0 to 100s	0.01s

The reset characteristics shall be instantaneous and shall typically be less than 60ms plus protection channel signalling time.

2.1.5 Capacitive cable charging current settings (P543, P544, P545 and P546)

Name	Range	Step Size
Susceptance	10nmho*In to 10mho*In	10nmho*In

2.1.6 Vectorial compensation settings (P541 and P542)

Setting	Phase shift	Action
Yy0	0°	Do nothing
Yd1	30° lag	Ia = (IA - IC) / $\sqrt{3}$ Ib = (IB - IA) / $\sqrt{3}$ Ic = (IC - IB) / $\sqrt{3}$
Yy2	60° lag	Ia = -IC Ib = -IA Ic = - IB
Yd3	90° lag	Ia = (IB - IC) / $\sqrt{3}$ Ib = (IC - IA) / $\sqrt{3}$ Ic = (IA - IB) / $\sqrt{3}$
Yy4	120° lag	Ia = IB Ib = IC Ic = IA
Yd5	150° lag	Yd11 and Invert
Yy6	180° lag	Invert currents
Yd7	150° lead	Yd1 and Invert
Yy8	120° lead	Ia = IC Ib = IA Ic = IB
Yd9	90° lead	Yd3 and Invert
Yy10	60° lead	Ia = -IB Ib = -IC Ic = -IA
Yd11	30° lead	Ia = (IA - IB) / $\sqrt{3}$ Ib = (IB - IC) / $\sqrt{3}$ Ic = (IC - IA) / $\sqrt{3}$
Ydy0	0°	Ia = IA - (IA + IB + IC) / 3 Ib = IB - (IA + IB + IC) / 3 Ic = IC - (IA + IB + IC) / 3
Ydy6	180° lag	Ydy0 and Invert

Where Ia, Ib and Ic are the corrected currents and

IA, IB and IC are the uncorrected phase currents

2.1.7 Current transformer ratio compensation setting

Name	Range	Step Size
Phase CT ratio correction	1 - 8	0.01

2.1.8 Accuracy

Pick-up	Formula ±10%
Drop-off	0.75 x Formula ±10%
IDMT characteristic shape	±5% or 40ms whichever is greater
DT operation	±2% or 20ms whichever is greater
Instantaneous Operation	<30ms

Reset time		<60ms
Repeatability		±2.5%
Characteristic	UK curves US curves	IEC 60255-3 – 1998 IEEE C37.112 – 1996
Vector compensation		No affect on accuracy
Current transformer ratio compensation		No affect on accuracy
High set characteristic setting		No affect on accuracy
Two ended scheme operation		No affect on accuracy
Three ended scheme operation		No affect on accuracy

2.2 Three Phase Non-Directional / Directional Overcurrent Protection

2.2.1 Setting ranges

	Stage	Range	Step size
Phase element	1st Stage	0.08 – 4.0In	0.01In
	2nd Stage	0.08 – 4.0In	0.01In
	3rd Stage	0.08 - 32In	0.01In
	4th Stage	0.08 - 32In	0.01In

Directional overcurrent settings (P543, P544, P545 and P546 only):

	Range	Step Size
Relay characteristic angle	-95° to +95°	1

2.2.2 Time delay settings

Each overcurrent element has an independent time setting and each time delay is capable of being blocked by an optically isolated input:

Element	Time delay type
1st Stage	Definite Time (DT) or IDMT
2nd Stage	DT or IDMT
3rd Stage	DT
4th Stage	DT

Curve type	Reset time delay
IEC / UK curves	DT only
All other	IDMT or DT

2.2.2.1 Inverse Time (IDMT) Characteristic

IDMT characteristics are selectable from a choice of four IEC/UK and five IEEE/US curves as shown in the table below.

The IEC/UK IDMT curves conform to the following formula:

$$t = T \times \left(\frac{K}{(I/Is)^{\alpha} - 1} + L \right)$$

The IEEE/US IDMT curves conform to the following formula:

$$t = TD \times \left(\frac{K}{(I/Is)^{\alpha} - 1} + L \right)$$

Where: t = operation time

K = constant

I = measured current

I_S = current threshold setting

α = constant

L = ANSI/IEEE constant (zero for IEC/UK curves)

T = Time Multiplier Setting for IEC/UK curves

TD = Time Dial Setting for IEEE/US curves

IDMT Curve description	Standard	K Constant	α Constant	L Constant
Standard Inverse	IEC	0.14	0.02	0
Very Inverse	IEC	13.5	1	0
Extremely Inverse	IEC	80	2	0
Long Time Inverse	UK	120	1	0
Moderately Inverse	IEEE	0.0515	0.02	0.114
Very Inverse	IEEE	19.61	2	0.491
Extremely Inverse	IEEE	28.2	2	0.1217
Inverse	US-C08	5.95	2	0.18
Short Time Inverse	US-C02	0.16758	0.02	0.11858

2.2.2.2 Time Multiplier Settings for IEC/UK curves

Name	Range	Step Size
TMS	0.025 to 1.2	0.025

2.2.2.3 Time Dial Settings for IEEE/US curves

Name	Range	Step Size
TD (Software 30 or later)	0.1 to 100	0.01
TD	0.05-15	0.05

2.2.2.4 Definite Time Characteristic

Element	Range	Step Size
All stages	0 to 100s	10ms

2.2.2.5 Reset Characteristics

For all IEC/UK curves, the reset characteristic is definite time only.

For all IEEE/US curves, the reset characteristic can be selected as either inverse curve or definite time.

The definite time can be set (as defined in IEC) to zero. Range 0 to 100 seconds in steps of 0.01 seconds.

The Inverse Reset characteristics are dependent upon the selected IEEE/US IDMT curve as shown in the table below.

All inverse reset curves conform to the following formula:

$$t_{Reset} = TD \times \left(\frac{tr}{1 - (I/Is)^{\alpha}} \right)$$

Where:	t_{Reset}	=	reset time
	tr	=	constant
	I	=	measured current
	I_S	=	current threshold setting
	α	=	constant
	TD	=	Time Dial Setting (Same setting as that employed by IDMT curve)

IEEE/US IDMT Curve description	Standard	tr Constant	α Constant
Moderately Inverse	IEEE	4.85	2
Very Inverse	IEEE	21.6	2
Extremely Inverse	IEEE	29.1	2
Inverse	US-C08	5.95	2
Short Time Inverse	US-C02	2.261	2

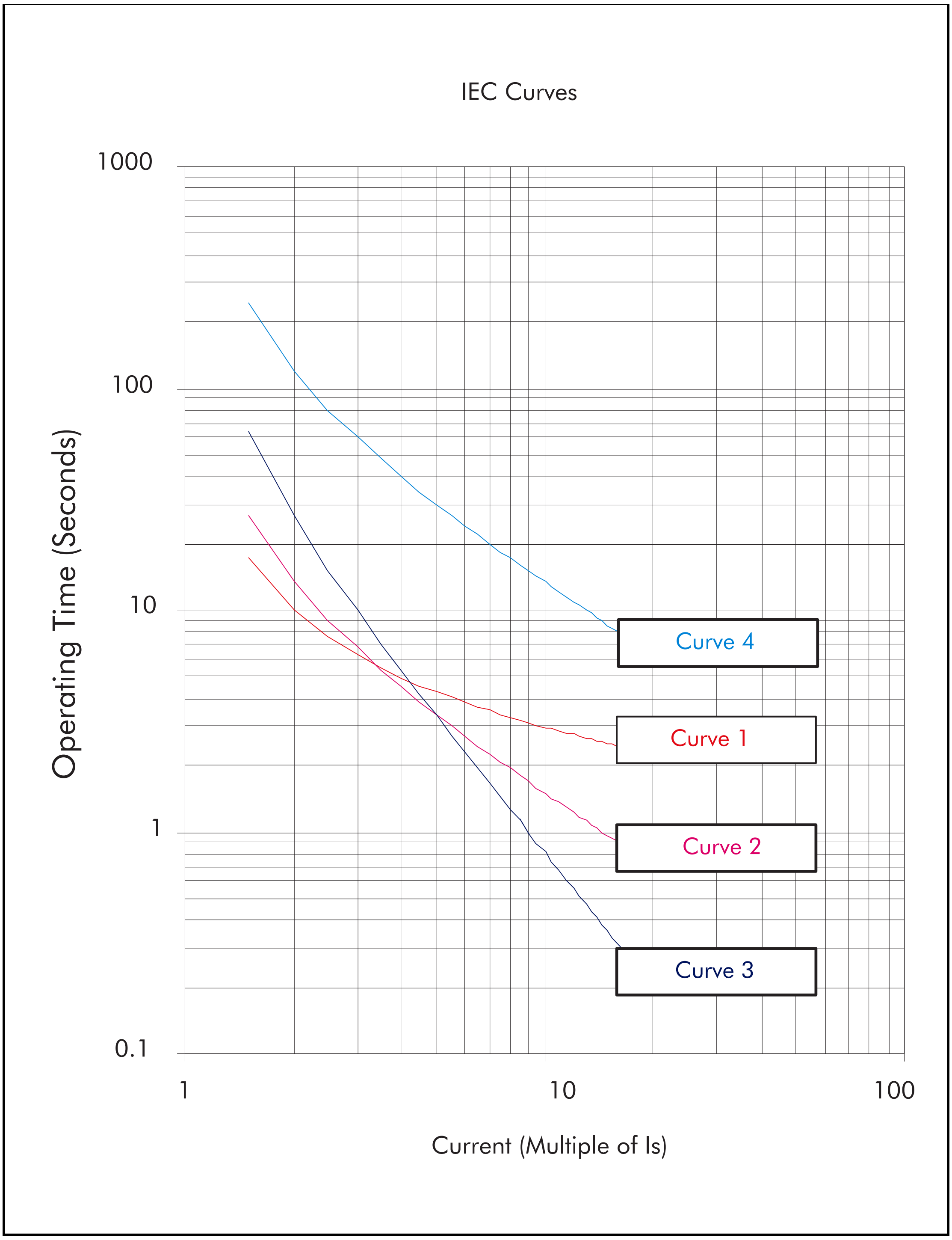
Inverse Reset Characteristics

2.2.3 Accuracy

Pick-up	Setting ±5%
Drop-off	0.95 x Setting ±5%
Minimum trip level of IDMT elements	1.05 x Setting ±5%
IDMT characteristic shape	±5% or 40ms whichever is greater (under reference conditions)*
IEEE reset	±5% or 40ms whichever is greater
DT operation	±2% or 50ms whichever is greater
DT reset	Setting ±5%
Directional boundary accuracy (RCA ±90°)	±2° hysteresis 2°
Characteristic UK curves	IEC 60255-3 – 1998
US curves	IEEE C37.112 – 1996

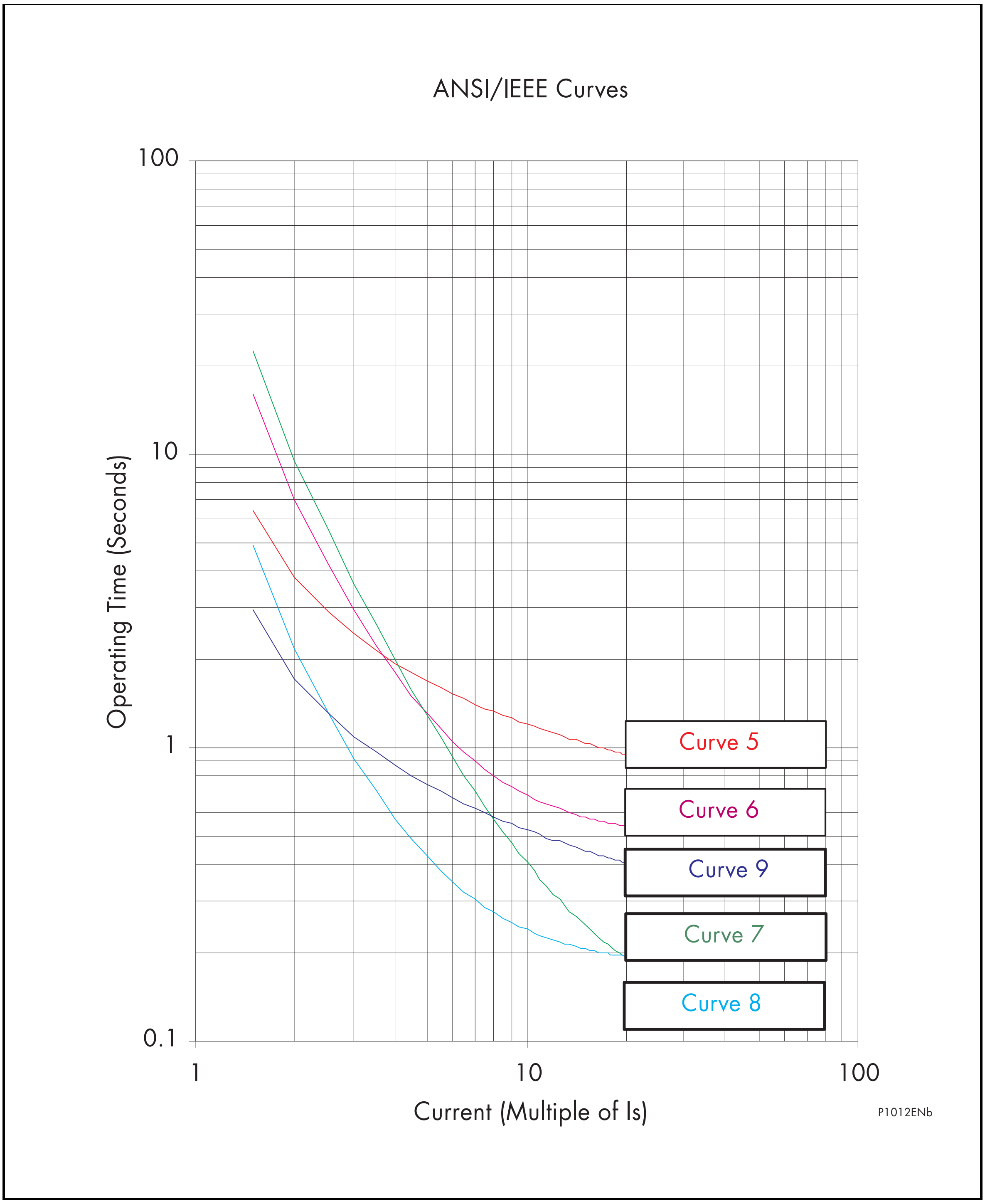
* Reference conditions TMS=1, TD=1 and I> setting of 1A, accuracy operating range 2-20Is

2.2.4 IEC IDMT Curves



Curve 1	Standard Inverse
Curve 2	Very Inverse
Curve 3	Extremely Inverse
Curve 4	UK Long Time Inverse

2.2.5 ANSI/IEEE IDMT curves



Curve 5	IEEE Moderately inverse
Curve 6	IEEE Very inverse
Curve 7	IEEE Extremely inverse
Curve 8	US Inverse
Curve 9	US Short time inverse

2.3 Earth Fault Protection

2.3.1 Setting ranges

2.3.1.1 Earth Fault, Sensitive Earth Fault

		Range	Step Size
Earth Fault	1st Stage	0.08 - 4.0In	0.01In
	2nd Stage	0.08 - 4.0In	0.01In
	3rd Stage	0.08 – 32In	0.01In
	4th Stage	0.08 – 32In	0.01In
Sensitive Earth Fault	1st Stage	0.005 – 0.1In	0.00025In
	2nd Stage	0.005 – 0.1In	0.00025In
	3rd Stage	0.005 – 0.8In	0.001In
	4th Stage	0.005 – 0.8In	0.001In

2.3.1.2 Polarising Quantities for Earth Fault Measuring Elements (Models P543, P544, P545, & P546 only)

Zero sequence voltage polarisation

	Range	Step size
Voltage threshold Vop>	0.5 – 80V	0.5V

Negative sequence polarisation

	Range	Step size
Current threshold I2p>	0.08 - 1.0In	0.01In
Voltage threshold V2p>	0.5 – 25V	0.5V
Characteristic angle	-95° to +95°	1°

2.3.2 EF and SEF time delay characteristics

The earth-fault measuring elements for EF and SEF are followed by an independently selectable time delay. These time delays are identical to those of the Phase Overcurrent time delay. The reset time delay is the same as the Phase overcurrent reset time.

2.3.3 Wattmetric SEF settings - P543, P544, P545 & P546 (Zero sequence power settings)

Name	Range	Step size
P_N>	0 - 20W (Rating = 1A, 100/120V)	0.05W
	0 - 100W (Rating = 5A, 100/120V)	0.25W

2.3.4 Accuracy

2.3.4.1 Earth fault

Pick-up	Setting ±5%
Drop-off	>0.85 x Setting
Minimum trip level of IDMT elements	1.05 x Setting ±5%
IDMT characteristic shape	±5% or 40ms whichever is greater (under reference conditions)*
IEEE reset	±10% or 40ms whichever is greater
DT operation	±2% or 50ms whichever is greater
DT reset	±5% or 50ms whichever is greater
Repeatability	7.5%

* Reference conditions TMS=1, TD=1 and IN> setting of 1A, accuracy operating range 2-20Is

2.3.4.2 SEF

Pick-up	Setting ±5%
Drop-off	0.95 x Setting ±5%
Minimum trip level of IDMT elements	1.05 x Setting ±5%
IDMT characteristic shape	±5% or 40ms whichever is greater (under reference conditions)*
IEEE reset	±17.5% or 60ms whichever is greater
DT operation	±2% or 50ms whichever is greater
DT reset	±5% or 50ms whichever is greater
Repeatability	5%

* Reference conditions TMS=1, TD=1 and IN> setting of 100mA, accuracy operating range 2-20Is

2.3.4.3 Wattmetric SEF

Pick-up	For P=0W For P>0W	ISEF> ±5% or 5mA P> ±5%
Drop-off	For P=0W For P>0W	(0.95 x I_{SEF}>) ±5% or 5mA 0.9 x P> ±5%
Boundary accuracy		±5% with 1° hysteresis
Repeatability		1%

2.3.4.4 Polarising Quantities

Zero Sequence Polarising

Operating boundary pick-up	±2°of RCA ±90°
Hysteresis	<3°
VN> Pick-up	Setting ±10%
VN> Drop-off	0.9 x Pick-up +/-10%

Negative Sequence Polarising

Operating boundary pick-up	±2°of RCA ±90°
Hysteresis	<2°
V2> Pick-up	Setting ±10%
V2> Drop-off	0.9 x Pick-up ±10%
I2> Pick-up	Setting ±10%
I2> Drop-off	0.9 x Pick-up+/-10%

2.4 Undercurrent

2.4.1 Setting ranges

Name	Range	Step size
Phase I <	0.02 - 3.2In	0.01In
Earth $I_{N\ SENSITIVE}$<	0.001 - 0.8In	0.0005In

2.4.2 Accuracy

Pick-up	±10% or 25mA whichever is the greater
Operating time	<12ms
Reset	<15ms

2.5 Broken Conductor Logic

2.5.1 Setting ranges

Settings	Range	Step size
I2/ I1	0.2 - 1.0	0.01
Time delay	0 – 100s	0.1s

2.5.2 Accuracy

Pick-up	Setting ±2.5%
Drop-off	0.95 x Setting ±2.5%
DT operation	±2% or 50ms whichever is greater
Reset	<25ms

2.6 Transient Overreach and Overshoot

2.6.1 Accuracy

Additional tolerance due to increasing X/R ratios	±5% over the X/R ratio of 1 to 90
Overshoot of overcurrent elements	<40ms

2.7 Thermal Overload

2.7.1 Setting ranges

Name	Setting Range	Step Size
Time constant	Single or Dual	-
Thermal trip current I_θ>>	0.08 - 4 I_N	0.01 I_N
Thermal alarm θ>	50 - 100% of θ>>	1% of θ>>
Time constant τ_1	1 - 200 minutes	1 minute
Time constant τ_2	1 - 200 minutes	1 minute

2.7.2 Accuracy

Pick-up	Thermal alarm	Calculated trip time ±10%*
	Thermal overload	Calculated trip time ±10%*
Repeatability		<5%

* Operating time measured with applied current of 20% above thermal setting.

2.8 Distance protection {P543, P544, P545 and P546}

2.8.1 Setting ranges

Name	Setting Range	Step Size
Zone 1 reach, Z1	0.1/In Ω - 250/In Ω	0.01/In Ω
Zone 2 reach, Z2	0.1/In Ω - 250/In Ω	0.01/In Ω
Zone 3 reach, Z3	0.1/In Ω - 250/In Ω	0.01/In Ω
Line angle	20 – 85°	1°
Zone 1 timer, tZ1	0 – 10s	0.01s
Zone 2 timer, tZ2	0 – 10s	0.01s
Zone 3 timer, tZ3	0 – 10s	0.01s
KZN Res comp	0 – 7	0.01
KZN angle	-180 - +90°	1°
RPh	0.1 – 200/In Ω	0.01/In Ω
RG	0.1 – 400/In Ω	0.01/In Ω
Delta R (PSB)	0.1 – 400/In Ω	0.01/In Ω
Delta X (PSB)	0.1 – 400/In Ω	0.01/In Ω
tZ6 (PSB)	0 – 100ms	1ms

2.8.2 Accuracy

Characteristic shape	SIR<30 SIR>30	±5% ±10%
Instantaneous operating time		<50ms
Reset time		<60ms
Time delay operation		Setting ±50ms or 5% whichever is greater
Hysteresis		±5%
Repeatability		5%
Distance sensitivity	settings <5/In Ω settings >5/In Ω	(0.05In*5/(setting* In)) ±5% 0.05In ±5%
Power swing blocking timer		±5%

2.9 Stub bus protection {P544 & P546}

2.9.1 Accuracy

See Section 2.1.8.

2.10 Direct transfer trip and inter-relay command transfer

Method	Time (plus protection signalling time)
Time for intertrip opto-input relay end A – output contact end B (opto with filter)	40ms
Time for intertrip opto-input relay end A – output contact end B (opto without filter)	30ms
Time for command transfer end A – PSL end B	15ms

2.11 Permissive intertrip

2.11.1 Setting ranges

Name	Setting Range	Step Size
Permissive intertrip timer	0 – 200 ms	5 ms

2.11.2 Accuracy

Operating level	Is1 ±5%
Drop off level	0.75 * Is1 ±10%
Instantaneous operating time	40ms + protection signalling channel time + permissive intertrip timer
Reset time	<40ms
Timer accuracy	Setting ±2% or 5ms whichever is greater

2.12 Single phase output contacts {P543, P544, P545 and P546}

2.12.1 Accuracy

Tripping	Three pole or single and three pole

2.13 Protection signalling channel, dual redundancy, channel failure, propagation time check and error statistics

2.13.1 Setting ranges

Name	Setting Range	Step Size
Data rate	56 or 64kb/s	-
Scheme setting	2 terminal, 3 terminal or dual redundant	-
Clock setting	Internal or external	-
Address	0, 1A, 1B, 1C to 20A, 20B, 20C	1
Communications failure mode (dual redundant)	Channel 1, channel 2 and channel 1 & 2	-
Comm. fail timer	0.1 – 10s	0.1s
Comms Mode (Software 30 or later)	Standard or IEEE C37.94	

2.13.2 Accuracy

Data rate setting	No affect on protection operation
Operation with internal/external clock	No affect on protection operation
Scheme setting	Relay configurable as either 2 terminal, 3 terminal or dual redundant
Addressing	Allocation of an incorrect address causes the signal channel failure alarm
Channel failure alarm	Alarm raised when appropriate channel fails
Comm. fail timer	Setting ±100ms
Model compatibility	P541 and P542 compatible P543, P544, P545 & P546 compatible Connection of a relay with a non-compatible model produces an error message

2.14 Compatibility with External interfaces

2.14.1 P590 Series optical fibre to electrical interface units – Performance

P541, P542, P543, P544, P545, P546 are compatible with following interfaces	P591, P592, P593

2.14.2 P594 GPS Synchronising Module

P594 GPS Module Output	One pulse per second Synchronising Signal

3. SUPERVISORY FUNCTIONS

The following claims for Supervisory Functions are applicable to the P540 range of current differential relays (model specific as detailed).

3.1 Voltage Transformer Supervision {P543, P544, P545 and P546}

3.1.1 Setting level

Name	Range	Step Size
Timer	1.0 - 10s	0.1s
Negative Sequence Voltage threshold (V_2)	10V (100/120V)	Fixed
Phase overvoltage	P.U. 30V, DO 10V (100/120V)	Fixed
Phase overcurrent	0.08In to 32In	0.01In
Superimposed current2	0.1In	Fixed
Negative Sequence Current threshold (I_2)	0.05In - 0.5In	0.01
VTS Time Delay	1.0 - 10s	0.1s

3.1.2 Accuracy

Fast block operation	<1 cycle
Fast block reset	<1.5 cycles
Time delay	Setting ±2% or 20ms whichever is greater

3.2 Programmable scheme logic

3.2.1 Level settings

Name	Range	Step Size
Time delay t	0-14400000ms	1ms

3.2.2 Accuracy

Output conditioner timer	Setting ±2% or 50ms whichever is greater
Dwell conditioner timer	Setting ±2% or 50ms whichever is greater
Pulse conditioner timer	Setting ±2% or 50ms whichever is greater

4. CONTROL

The following claims for Control Functions are applicable to the P540 range of current differential relays (model specific as detailed).

4.1 Autoreclose {P542, P543 and P545}

4.1.1 Level settings

Name		Range	Step Size
Number of shots {P542}		1 – 4	1
Single pole shot {P543 & P545}		1 – 4	1
Three pole shot {P543 & P545}		1 – 4	1
1 pole dead time {P543 & P545}		0.2 – 5s	0.01s
Dead time 1	{P542}	0.01s – 300s	0.01s
	{P543 & P545}	0.2s – 30s	0.01s
Dead time 2	{P542}	0.01s – 300s	0.01s
	{P543 & P545}	1s – 1800s	1s
Dead time 3	{P542}	0.01s – 9999s	0.01s
	{P543 & P545}	1s – 3600s	1s
Dead time 4	{P542}	0.01s – 9999s	0.01s
	{P543 & P545}	1s – 3600s	1s
CB healthy time		0.01s – 9999s	0.01s
Reclaim time		1s – 600s	0.01s
AR Inhibit wind		0.01s – 600s	0.01s
Close pulse {P543 & P545}		0.1s – 10s	0.01s
Check sync time		0.01s – 9999s	0.01s

4.1.2 Accuracy

Timers	Setting ±2% or 20ms whichever is greater

4.2 Display Control and Setting Groups

4.2.1 Level settings

Settings	Range	Step size
Setting groups	1 - 4	1

4.2.2 Performance

Setting groups	4 independent setting groups including independent programmable scheme logic for each group.

4.3 Differential protection re-configuration/inhibit current differential protection

4.3.1 Performance

Current differential algorithm blocked by	
Energising the opto input assigned to inhibit current differential protection	Compliant
Unhealthy communications link	Compliant
Loss of power supply to any relay	Compliant

5. MEASUREMENTS AND RECORDING FACILITIES

The following claims for Measurement & Recording facilities are applicable to the P540 range of current differential relays (model specific as detailed).

5.1 Measurements

Typically ±1%, but ±0.5% between 0.2 – 2In/Vn.

Accuracy under reference conditions.

Measurand	Range	Accuracy
Phase current	0.05 to 3 In	±1.0% of reading
Sensitive earth fault Current	0.5 to 2.5 In 0.1 to 0.5 In	±1.0% of reading ±5.0% of reading
Phase local current	0.05 to 3 In	±1.0% of reading or ±(f-fn)/fn %
Phase remote current	0.05 to 3 In	±1.0% of reading or ±(f-fn)/fn %
Phase differential current	0.05 to 3 In	±5.0%
Bias current	0.05 to 3 In	±5.0%
Voltage	0.05 to 2 Vn	±1.0% of reading
Power (W)	0.2 to 2 Vn 0.05 to 3 In	±5.0% of reading at unity power factor
Reactive Power (VArs)	0.2 to 2 Vn 0.05 to 3 In	±5.0% of reading at unity power factor
Apparent Power (VA)	0.2 to 2 Vn 0.05 to 3 In	±5.0% of reading at unity power factor
Energy (Wh)	0.2 to 2 Vn 0.2 to 3 In	±5% of reading at unity power factor
Energy (Varh)	0.2 to 2 Vn 0.2 to 3 In	±5% of reading at zero power factor
Phase accuracy	0° to 360°	±2°
Frequency	45 to 65Hz	±1%
Power frequency	0° to 120°	±5%

5.2 IRIG-B and Real Time Clock

5.2.1 Features

Real time 24 hour clock settable in hours, minutes and seconds
Calendar settable from January 1994 to December 2092
Clock and calendar maintained via battery after loss of auxiliary supply
Internal clock synchronisation using IRIG-B
Time synchronisation by energisation of opto input

5.2.2 Performance

Year 2000	Compliant
Real time clock accuracy	< ±2 seconds / day
External clock synchronisation	Conforms to IRIG standard 200-98, format B
Opto input time synchronisation	Energisation of opto causes seconds on relay clock to snap or crawl to 00 seconds (rounding up or down to nearest minute)

6. POST FAULT ANALYSIS

The following claims for Post Fault Analysis Functions are applicable to the P540 range of current differential relays (model specific as detailed).

6.1 Fault Records

6.1.1 Features

Fault record generation on protection operation indicating	Time and date Setting group Start / trip element Faulted current and voltage magnitudes Remote, bias and differential currents Frequency Fault Clearance time CB operating time Protection operating time Fault location Autoreclose shot number
Alarm events generated on the following indications	Protection disabled/test mode VTS CB alarms Autoreclose Frequency out of range Battery status Incompatible relays Differential protection inhibited Configuration / reconfiguration error Field voltage fail Loopback test Signal fail alarm Signal propagation delay alarm Differential fail alarm C Diff Comm Mode (Software 30 or later) IEEE C37.94 (Software 30 or later) Setting groups

6.1.2 Performance

Fault record display indication and information	Correct
Alarm events display indication and information	Correct
Time and date stamping	±10ms of applied fault/event
Fault Clearance time	±2%
CB operating time	±10ms
Protection operating time	±2%

6.2 Disturbance Records

6.2.1 Level settings

Settings	Range	Step size
Duration	0.1 – 10.5s	10ms
Trigger position	0 – 100%	0.1%
8 analogue channels, 32 digital channels, single or extended trigger modes		

6.2.2 Accuracy

Waveshape	Comparable with applied quantities
Magnitude and relative phases	±5% of applied quantities
Duration	±2%
Trigger position	±2% (minimum trigger 100ms)

6.3 Fault Locator Settings {P543, P544, P545 and P546}

6.3.1 Level settings

Name	Range	Step size
Line length	0.01 to 1000km **	0.01km **
Line impedance	0.1/In to 250/In Ω	0.01/In Ω
Line angle	20° to 85°	1°
Line residual	0 to 7	0.01
Residual angle (Software 30 or later)	-180° to 90°	1°
Residual angle	-90° to 90°	1°

** Or Equivalent (in miles)

6.3.2 Accuracy

Fault location	±2% of line length (Under reference conditions)*

* Reference conditions solid fault applied on line.

7. PLANT SUPERVISION

The following claims for Plant Supervision Functions are applicable to the P540 range of current differential relays (model specific as detailed).

7.1 CB State Monitoring Control and Condition Monitoring

7.1.1 Level settings

Setting	Range	Step
Trip pulse time	0.01 – 5s	0.01s
Close pulse time	0.01 – 10s	0.01s
Broken current exponent	1 – 2	0.1
Excessive fault frequency	0 – 9999	1

7.1.2 Accuracy

Timers	±2% or 20ms whichever is greater
Broken current accuracy	±5%

7.2 CB State Monitoring Control, breaker fail and backtrip, breaker fail timer

7.2.1 Level settings

Setting	Range	Step
Breaker fail timer 1	0 – 10s	0.01s
Breaker fail timer 2	0 – 10s	0.01s

7.2.2 Accuracy

Timers	±2% or 40ms whichever is greater
Reset	<30ms

8. LOCAL AND REMOTE COMMUNICATIONS

The following claims for Local & Remote Communications are applicable to the P540 range of current differential relays (model specific as detailed).

8.1 Front Port

Front port	Communication Parameters (Fixed)
Protocol	Courier
Address	1
Message format	IEC 60870FT1.2
Baud rate	19200 bits/s

8.2 Rear Port 1

Rear port settings	Setting options	Setting available for
RP1 Address	0 – 254 (step 1) 0 – 255 (step 1) 1 – 247 (step 1) 0 – 65519 (step 1)	IEC* Courier Modbus DNP3.0
RP1 Inactiv Timer	1 – 30 minutes (step 1)	All
RP1 Baud Rate	1200 bits/s 2400 bits/s 4800 bits/s 9600 bits/s 19200 bits/s 38400 bits/s	DNP3.0 DNP3.0 DNP3.0 All (not KBus) All (not KBus) All except IEC* and KBus
RP1 Parity	"Odd", "Even" or "None"	Modbus/DNP3.0
RP1 Meas Period	1 – 60 minutes (step 1)	IEC* only
RP1 Physical Link (Software 30 or later)	EIA(RS)485 Fibre optic	Courier, Modbus, IEC* and DNP3.0 Courier (except when K-Bus selected or UCA2 option fitted) Modbus IEC* DNP3.0
RP1 Physical Link	EIA(RS)485 Fibre optic	IEC* IEC*
RP1 Time Sync	Enabled / Disabled	DNP 3.0
RP1 CS103 Blocking	Disabled / Monitor Block / Command Block	IEC* Only
RP1 Port Config	K-Bus / Courier (RS485)	Courier Only
RP1 Comms Mode	IEC 60870 FT1.2 / 10 bit	Courier Only

* IEC = IEC60870-5-103

8.2.1 Performance

Front and rear ports conforming to Courier communication protocol	Compliant
Rear ports conforming to Modbus communication protocol	Compliant
Rear ports conforming to 870-5 103 communication protocol	Compliant
Rear ports conforming to DNP3.0 communication protocol	Compliant

8.3 Second Rear Communication Port

Setting	Setting Options	Setting available for
RP2 Port Config	EIA232, EIA485 or kbus	
RP2 Comms Mode	IEC60870 FT1.2, 11 bit frame or IEC60870, 10 bit frame	EIA232 and EIA485
RP2 Address	0 – 255 (step 1)	All
Rp2 InactivTimer	1 – 30 minutes (step 1)	All
RP2 Baud Rate	9600/19200/38400 bits/s	EIA232 and EIA485

Note: To avoid exceeding second rear communications port flash clearances the length of the cable, between the port and associated communications equipment should be limited to 300 metres. In situations where 300 metres may be insufficient it must be ensured that the communications cable is not laid in close proximity to high current carrying conductors. The communications cable should be screened with screen earthed at one end only.

8.4 Ethernet Communications (P543, P544, P545 and P546)

Name	Range	Step Size
IP Address	000.000.000.000 – 255.255.255.255	1
Subnet Mask	000.000.000.000 – 255.255.255.255	255
Number of Routes	0 – 4	1
Router Address 1	000.000.000.000 – 255.255.255.255	1
Target Network 1	000.000.000.000 – 255.255.255.255	1
Router Address 2	000.000.000.000 – 255.255.255.255	1
Target Network 2	000.000.000.000 – 255.255.255.255	1
Router Address 3	000.000.000.000 – 255.255.255.255	1
Target Network 3	000.000.000.000 – 255.255.255.255	1
Router Address 4	000.000.000.000 – 255.255.255.255	1
Target Network 4	000.000.000.000 – 255.255.255.255	1
NIC InactivTimer	1 – 30	1
Default Pass Lvl	0 – 2	1
GOOSE Min Cycle	1 – 50	1
GOOSE Max Cycle	1 – 60	1
GOOSE Increment	0 – 999	1
GOOSE Startup	Promiscuous / Broadcast	-
Ethernet Media	Copper / Fibre	-
Link Timeout	0.1s – 60s	0.1s

9. DIAGNOSTICS

The following claims for Diagnostic Functions are applicable to the P540 range of current differential relays (model specific as detailed).

9.1 Features

Power up self checking with watchdog indication of healthy condition
Watchdog and front display indication of a hardware or software failure occurring during power up or during normal in service operation

9.2 Performance

Power up / continuous self checks	Compliant
Watchdog operation	Compliant
Co-processor failure detection	Compliant
Time to power up	< 11s

10. RATINGS

The following claims for Ratings are applicable to the P540 range of current differential relays (model specific as detailed) and P594 GPS Receiver Module.

10.1 Nominal ratings

10.1.1 Currents (All P540 range)

In = 1A or 5A ac rms.

Separate terminals are provided for the 1A and 5A windings, with the neutral input of each winding sharing one terminal.

All current inputs will withstand the following, with any current function setting:

Withstand	Duration
4In	Continuous rating
4.5In	10 minutes
5In	5 minutes
6In	3 minutes
7In	2 minutes
30In	10 seconds
50In	3 seconds
100In	1 second

Pass Criteria — Winding temperatures <105° C

Dielectric withstand and insulation resistance unimpaired

10.1.2 Voltage inputs (All P540 range)

All voltage inputs will withstand the following, with any voltage function setting.

Nominal Voltage (Vn)	Operating range
100-120$V_{ph - ph}$ rms.	0 to 200$V_{ph - ph}$ rms.

Withstand (Vn = 100/120V)	Duration
240$V_{ph - ph}$ rms.	Continuous rating (2Vn)
312$V_{ph - ph}$ rms.	10 seconds (2.6Vn)

Pass Criteria — Winding temperatures <105° C

Dielectric withstand and insulation resistance unimpaired

10.1.3 Auxiliary voltages (All P540 range + P594 as indicated)

10.1.3.1 P540 range

Three auxiliary power supply versions are available:

Nominal Ranges	Operative dc range	Operative ac range
24-48 V dc	19 - 65 V	Not available
48-110 V dc (30/100 V ac rms.) **	37 - 150 V	24 – 110 V
110-250 V dc (100/240 V ac rms.) **	87 - 300 V	80 – 265 V

** rated for AC or DC operation.

Pass Criteria	All functions operate as specified within the operative ranges All power supplies operate continuously over their operative ranges, and environmental conditions

10.1.3.2 P594

Two auxiliary power supply versions are available:

Nominal Ranges	Operative dc range	Operative ac range
24/125 V dc (110 V ac rms.) **	19 – 150 V	50 – 133 V
48/250 V dc (110/230 V ac rms.) **	33 – 300 V	87 – 265 V

10.1.4 'Universal' Logic inputs (P540 range)

Nominal Battery Voltage (Vdc)	**Standard 60% - 80%**		**50% - 70% (Software 30 or later)**	
	No Operation (logic 0) Vdc	**Operation (logic 1) Vdc**	**No Operation (logic 0) Vdc**	**Operation (logic 1) Vdc**
24 / 27	<16.2	>19.2	<12.0	>16.8
30 / 34	<20.4	>24.0	<15.0	>21.0
48 / 54	<32.4	>38.4	<24.0	>33.6
110 / 125	<75.0	>88.0	<55.0	>77.0
220 / 250	<150.0	>176.0	<110	>154

10.1.5 Output contacts (P540 range)

Make & Carry	30A for 3s
Carry	250A for 30ms 10A continuous
Break	DC: 50W resistive DC: 62.5W inductive (L/R = 50ms) AC: 2500VA resistive AC: 2500VA inductive (P.F. = 0.7)
Maxima:	10A and 300V
Loaded contact:	10,000 operation minimum
Unloaded contact:	100,000 operations minimum
Watchdog Contact	
Break	DC: 30W resistive DC: 15W inductive (L/R = 40ms) AC: 275VA inductive (P.F. = 0.7)

10.1.6 Field voltage (P540 range)

Rated field voltage output	48V dc
Rated field voltage current limit	112mA ±20%
Operating range	40V to 60V
Alarm voltage	35 V ±5%

10.2 Burdens

10.2.1 Current (P540 range)

Reference current (In)	
Phase	<0.15VA at rated current

10.2.2 Voltage (P540 range)

Reference voltage (Vn)

Vn = 100/120V	<0.02VA at 110V

10.2.3 Auxiliary voltage

10.2.3.1 P540 range

Typical values

Type	Case size	Minimum*
P541	Size 8”/40TE	11W or 24VA
P542, P543, P544	Size 12”/60TE	11W or 24VA
P545, P546	Size 16”/80TE	11W or 24VA

* no output contacts or optos energised

For each energised Opto powered from the Field Voltage or each energised Output Relay:

Each additional energised opto input	0.09W (24/27, 30/34, 48/54V)
Each additional energised opto input	0.12W (110/125V)
Each additional energised opto input	0.19W (220/250V)
Each additional energised output relay	0.13W

10.2.3.2 P594 GPS Module

Type	Case size	Nominal
P594	20TE	4W

10.2.4 Logic inputs (P540 range)

Typically 10mVA at 48v (field voltage)

10.2.5 Optically isolated inputs

Peak current of opto inputs when energised is 3.5mA (0-300V)

Maximum input voltage 300V dc (any setting).

11. CT REQUIREMENTS (P540 RANGE)

11.1 Current differential protection

For accuracy, class X or class 5P current transformers (CTs) are strongly recommended. The knee point voltage of the CTs should comply with the minimum requirements of the formula shown below.

Vk ≥ K . In (Rct + 2 RL)

Where:

Vk	=	Required IEC knee point voltage
K	=	Dimensioning factor
In	=	CT nominal secondary current
Rct	=	CT resistance
RL	=	One-way lead impedance from CT to relay

K is a constant depending on:

If	=	Maximum value of through fault current for stability (multiple of In)
X/R	=	Primary system X/R ratio

K is determined as follows:

For relays set at Is1 = 20%, Is2 = 2 In, k1 = 30%, k2 = 150%:

K ≥ 40 + (0.07 x (If x X/R))

And: K ≥ 65

This is valid for (If x X/R) ≤ 1000

For higher (If x X/R) up to 1600 :

K = 107.

For relays set at Is1 = 20%, Is2 = 2 In, k1 = 30%, k2 = 100%:

K ≥ 40 + (0.35 x (If x X/R))

And: K ≥ 65

This is valid for (If x X/R) ≤ 600

For higher (If x X/R) up to 1600 :

K = 256.

11.2 Earth fault protection

Using core balance CT.

$$Vk > 6 (N) (In)(R_{CT} + 2R_L)$$

where maximum X/R ratio =5 and the maximum earth fault current =2 x In

where

Vk, Rct, RL	= (See above)
N	= Max. earth fault current/core balance CT rated primary current

Note: N should not be greater than 2. The core balance CT must be selected accordingly.

12. HIGH VOLTAGE WITHSTAND (P540 RANGE & P594)

12.1 Dielectric withstand, impulse, insulation resistance and ANSI test requirements insulation test voltage

12.1.1 Impulse

IEC 60255-5:2000

5kV 1.2/50μs impulse, common and differential mode - input, power supply, & terminal block communications connections.

12.1.2 Dielectric withstand

IEC 60255-5:2000

2kV rms. for 1 minute between all terminals connected together and case earth.

2kV rms. for 1 minute between all terminals of independent circuits with terminals on each independent circuit connected together.

1kV rms. for 1 minute across watchdog contacts.

12.1.3 ANSI dielectric withstand

ANSI/IEEE C37.90. (1989) (Reaff. 1994)

1kV rms. for 1 minute across open contacts of the watchdog contacts.

1kV rms. for 1 minute across open contacts of changeover output contacts.

1.5kV rms. for 1 minute across normally open output contacts.

12.1.4 Insulation resistance

IEC 60255-5:2000

100 MΩ minimum.

13. ELECTRICAL ENVIRONMENT

13.1 Performance criteria

The following three classes of performance criteria are used within sections 13.2 to 13.12 (where applicable) to specify the performance of the MiCOM relay when subjected to the electrical interference. The performance criteria are based on the performance criteria specified in EN50263: 2000.

13.1.1 Class A

During the testing the relay shall not maloperate, upon completion of the testing the relay shall function as specified. A maloperation shall include a transient operation of the output contacts, operation of the watchdog contacts, reset of any of the relays microprocessors, an alarm indication, degradation of measurements or human-machine interface.

Communications must continue uncorrupted via the communications ports during the tests, however communications may continue with a higher bit error rate during the tests, provided that it recovers with no external intervention and does not allow data to be lost.

If the above performance criteria are satisfied, MiCOM Px40 Platform has passed the test for this performance criteria level.

13.1.2 Class B

During the testing the relay shall not maloperate, upon completion of the testing the relay shall function as specified. A maloperation shall include a transient operation of the output contacts, operation of the watchdog contacts, reset of any of the relays microprocessors, an alarm indication. Temporary degradation of measurements or human-machine interface is acceptable provided it self recovers and there is no loss of stored data.

Communications must continue uncorrupted via the communications ports during the tests, however communications may continue with a higher bit error rate during the tests, provided that it recovers with no external intervention and does not allow data to be lost.

If the above performance criteria are satisfied, MiCOM Px40 Platform has passed the test for this performance criteria level.

13.1.3 Class C

The MiCOM Px40 Platform relay shall power down and power up again in a controlled manner. The output relays are permitted to change state during the test as long as they reset once the relay powers up.

Communications to MiCOM Px40 Platform may be suspended during the testing as long as communications recovers with no external intervention after testing.

13.2 Auxilary supply tests, dc interruption, etc.

13.2.1 DC voltage interruptions

13.2.1.1 P540 RANGE

IEC 60255-11:1979.

DC Auxiliary Supply Interruptions 2, 5, 10, 20ms. Performance criteria - Class A.

DC Auxiliary Supply Interruptions 50, 100, 200ms, 40s. Performance criteria - Class C.

P594 GPS Receiver Module

IEC 60255-11:1979.

DC Auxiliary Supply Interruptions 2, 5, 10, 20ms. Performance criteria - Class A.

DC Auxiliary Supply Interruptions 50, 100, 200ms, 40s. Performance criteria - Class C.

13.2.2 DC voltage fluctuations

13.2.2.1 P540 range

IEC 60255-11:1979.

AC 100Hz ripple superimposed on DC max. and min. auxiliary supply at 12% of highest rated DC.

Performance criteria - Class A.

13.2.2.2 P594 GPS Receiver Module

IEC 60255-11:1979.

AC 100Hz ripple superimposed on DC max. and min. auxiliary supply at 12% of highest rated DC.

Performance criteria - Class A.

13.3 AC voltage dips and short interruptions

13.3.1 AC Voltage short interruptions

13.3.1.1 P540 range

IEC 61000-4-11:1994.

AC Auxiliary Supply Interruptions 2, 5, 10, 20ms. Performance criteria - Class A. AC Auxiliary Supply Interruptions 50, 100, 200ms, 1s, 40s. Performance criteria - Class C.

13.3.2 AC voltage dips

13.3.2.1 P540 range

IEC 61000-4-11:1994

AC Auxiliary Supply 100% Voltage Dips 2, 5, 10, 20ms. Performance criteria - Class A. AC Auxiliary Supply 100% Voltage Dips 50, 100, 200ms, 1s, 40s. Performance criteria - Class C.

AC Auxiliary Supply 60% Voltage Dips 2, 5, 10, 20ms. Performance criteria - Class A. AC Auxiliary Supply 60% Voltage Dips 50, 100, 200ms, 1s, 40s. Performance criteria - Class C.

AC Auxiliary Supply 30% Voltage Dips 2, 5, 10, 20ms. Performance criteria - Class A. AC Auxiliary Supply 30% Voltage Dips 50, 100, 200ms, 1s, 40s. Performance criteria - Class C.

13.4 High Frequency Disturbance IEC 60255-22-1:1988 Class III. (P540 range & P594 GPS Receiver)

1MHz burst disturbance test.

2.5kV common mode.

Power supply, field voltage, CTs, VTs, opto inputs, output contacts, IRIG-B and terminal block communications connections.

1kV differential mode.

Power supply, field voltage, CTs, VTs, opto inputs and output contacts.

Performance criteria Class A.

Fast Transients (P540 range & P594 GPS Receiver)

EN 61000-4-4:1995 (IEC 60255-22-4:2002), Level 3 and Level 4.

2kV 5kHz (Level 3) and 4kV 2.5kHz (Level 4) direct coupling.

Power supply, field voltage, opto inputs, output contacts, CTs, VTs.

2kV 5kHz (Level 3) and 4kV 2.5kHz (Level 4) capacitive clamp.

IRIG-B and terminal block communications connections.

Performance criteria Class A.

13.5 Conducted / Radiated emissions (P540 range & P594 GPS Receiver)

13.5.1 Conducted emissions

EN55022:1998 (EN60255-25:2000).

0.15 - 0.5MHz, 79dBμV (quasi peak) 66dBμV (average).

0.5 - 30MHz, 73dBμV (quasi peak) 60dBμV (average).

Radiated emissions

EN55022:1998 (EN60255-25:2000).

30 - 230MHz, 40dBμV/m at 10m measurement distance.

230 - 1000MHz, 47dBμV/m at 10m measurement distance.

13.6 Conducted / Radiated Immunity (P540 range & P594 GPS Receiver)

13.6.1 Conducted immunity

EN 61000-4-6:1996 Level 3 (EN60255-22-6:2001).

10V emf @ 1kHz 80% am, 150kHz to 80MHz.
Spot tests at 27MHz, 68MHz.

Performance criteria Class A.

13.6.2 Radiated immunity

EN 61000-4-3: 2002 Level 3 (IEC 60255-22-3:2000 Class III)

10 V/m 80MHz - 1GHz @ 1kHz 80% am.

Spot tests at 80MHz, 160MHz, 450MHz, 900MHz and 900MHz (200Hz rep. freq., 50% duty cycle pulse modulated).

Performance criteria Class A.

13.6.3 Radiated immunity from digital radio telephones

EN 61000-4-3: 2002 Level 4

30 V/m 800MHz – 960MHz and 1.4GHz – 2GHz @ 1kHz 80% am.

Performance criteria Class A.

13.7 Electrostatic Discharge (P540 range & P594 GPS Receiver)

EN61000-4-2:1995 Level 3 and Level 4 (EN60255-22-2:1996).

Level 4: 15kV air discharge.
Level 4: 8kV contact discharge.
Tests carried out both with and without cover fitted.

Performance criteria Class A.

13.8 Surge Immunity (P540 range & P594 GPS Receiver)

EN61000-4-5:1995 Level 4 (EN60255-22-5:2002).

4kV common mode 12Ω source impedance, 2kV differential mode 2Ω source impedance, level 4.

Power supply.

4kV common mode 42Ω source impedance, 2kV differential mode 42Ω source impedance, Level 4.

Opto inputs, relays, field voltage, CT, VT.

4kV common mode 2Ω source impedance applied to cable screen.

Terminal block communications connections and IRIG-B.

2kV common mode 42Ω source impedance applied each line to earth.

RJ45 ethernet communications.

Performance criteria Class A.

13.9 Power Frequency Interference (P540 range & P594 GPS Receiver)

NGTS* 2.13 Issue 3 April 1998, section 5.5.6.9.

500V rms. common mode.
250V rms. differential mode.

Voltage applied to all non-mains frequency inputs. Interference applied to all permanently connected communications circuits via the induced voltage method.

Performance criteria Class A.

* National Grid Technical Specification

13.10 Surge Withstand Capability (SWC) - (P540 range & P594 GPS Receiver)

ANSI/IEEE C37.90.1 2002

Oscillatory SWC Test.
2.5kV, 1MHz - common and differential mode – applied to all circuits except for IRIG-B and terminal block communications, which are tested using a capacitor clamp.

Fast Transient SWC Tests

4kV crest voltage - common and differential mode - applied to all circuits except for IRIG-B and terminal block communications, which are tested using a capacitor clamp.

Performance criteria Class A.

13.11 Radiated Immunity (P540 range & P594 GPS Receiver)

ANSI/IEEE C37.90.2 1995

35 V/m 25MHz - 1GHz, no modulation applied to all sides.

35 V/m 25MHz - 1GHz, 100% pulse modulated, front only.

Performance criteria Class A.

13.12 Power Frequency Magnetic Field IMMUNITY (P540 range & P594 GPS Receiver)

EN61000-4-8:1993 Level 5.

100A/m field applied continuously in all planes for the EUT in a quiescent and tripping state

1000A/m field applied for 3s in all planes for the EUT in a quiescent and tripping state

Performance criteria Class A.

13.13 Pulse Magnetic Field IMMUNITY (P540 range & P594 GPS Receiver)

EN 61000-4-9:1993 Level 5.

1000A/m field applied in all planes for the EUT in a quiescent state

Performance criteria Class A.

13.14 Damped oscillatory Magnetic Field IMMUNITY (P540 range & P594 GPS Receiver)

EN61000-4-10:1993 Level 5.

100A/m field applied in all planes at 100kHz / 1MHz with a burst duration of 2 seconds

Performance criteria Class A.

13.15 Oscillatory waves immunity test (P540 range)

EN61000-4-12:1995 Level 3.

2.5kV peak between indpendent circuits and case earth.

1.0kV peak across terminals of the same circuit.

Performance criteria Class A.

14. ATMOSPHERIC ENVIRONMENT

14.1 Temperature (P540 range & P594 GPS Receiver)

IEC 60068-2-1:1990/A2:1994 - Cold

IEC 60068-2-2:1974/A2:1994 - Dry heat

IEC 60255-6:1988.

Operating temperature range °C		Storage temperature range °C	
Cold Temperature	Dry heat Temperature	Cold Temperature	Dry heat Temperature
-25	55	-25	70

14.2 Humidity (P540 range & P594 GPS Receiver)

IEC 60068-2-3:1969

Damp heat, steady state, 40° C ± 2° C and 93% relative humidity (RH) +2% -3%, duration 56 days.

IEC 60068-2-30:1980.

Damp heat cyclic, six (12 + 12 hour cycles) of 55°C ±2°C 93% ±3% RH and 25°C ±3°C 93% ±3% RH.

14.3 Enclosure protection (P540 range & P594 GPS Receiver)

IEC 60529:1989.

IP52 front face

IP30 sides of case

IP10 rear of case

IP5x – Protected against dust, limited ingress permitted.

IP3x – Protected against solid foreign objects of 25mm diameter and greater.

IP1x – Protected against solid foreign objects of 50mm diameter and greater.

IPx2 – Protected against vertically falling drops of water with the product in 4 fixed positions of 15° tilt with a flow rate of 3mm/minute for 2.5 minutes.

Ipx0 – No protection against water ingress.

15. MECHANICAL ENVIRONMENT (P540 RANGE & P594 GPS RECEIVER)

15.1 Performance criteria

The following severity classes are used, where applicable, to specify the performance to specify the performance of the MiCOM relay, when subjected to mechanical testing.

15.1.1 Severity Classes

The following table details the Class and Typical Applications of the vibration, shock bump and seismic tests detailed previously

Class	Typical Application
1	Measuring relays and protection equipment for normal use in power plants, substations and industrial plants and for normal transportation conditions
2	Measuring relays and protection equipment for which a very high security margin is required or where the vibration (shock and bump) (seismic shock) levels are very high, e.g. shipboard application and for severe transportation conditions.

15.1.2 Vibration (sinusoidal)

IEC 60255-21-1:1988

Cross over frequency - 58 to 60 Hz

Vibration Response

Severity Class	Peak displacement below cross over frequency (mm)	Peak acceleration above cross over frequency (gn)	Number of sweeps in each axis	Frequency range (Hz)
2	0.075	1	1	10 – 150

Vibration Endurance

Severity Class	Peak acceleration (gn)	Number of sweeps in each axis	Frequency range (Hz)
2	2.0	20	10 – 150

15.1.3 Shock and bump

IEC 60255-21-2:1988

Type of test	Severity Class	Peak acceleration (gn)	Duration of pulse (ms)	Number of Pulses in each direction
Shock response	2	10	11	3
Shock withstand	1	15	11	3
Bump	1	10	16	1000

15.1.4 Seismic

IEC 60255-21-3:1993

Cross over frequency - 8 to 9Hz

x = horizontal axis, y = vertical axis

Severity Class	Peak displacement below cross over frequency (mm)		Peak acceleration above cross over frequency (gn)		Number of sweep cycles in each axis	Frequency range (Hz)
	x	y	x	y		
2	7.5	3.5	2.0	1.0	1	1- 35

16. INFLUENCING QUANTITIES

16.1 Harmonics (P540 range)

Tolerances quoted are an additional tolerance with respect to measured accuracy without harmonics.

Harmonics applied 2nd – 17th	10% harmonics
Measurements / filtered relay inputs	Unaffected by harmonics
Fault locator	±2% of line length

16.2 Frequency (P540 Range)

Operating frequency 45Hz – 65Hz		Affect
Overcurrent protection		Unaffected by frequency
Earth fault protection		Unaffected by frequency
Sensitive earth fault protection		Unaffected by frequency
Disturbance recorder		Unaffected by frequency
Check sync slip frequency		Unaffected by frequency
Differential protection	single end fed	± (f-fn)/fn %
	double end fed	± 2*(f-fn)/fn %

17. APPLICATION SPECIFIC

17.1 Magnetising Inrush Current {P541 and P542}

17.1.1 Level settings

Setting	Range	Step
Id High set	4 – 32A	0.01A

17.1.2 Accuracy

Minimum Id setting for stability (60MVA)	>40% of max. peak inrush current
Operating times	<40ms

17.2 Stability tests during current reversal conditions (P540 range)

17.2.1 Features

Relay to remain stable for current reversals within the protected feeder

17.3 Performance

Stability during current reversals	Compliant

17.4 Capacitive charging current compensation {P543, P544, P545 and P546}

17.4.1 Level settings

Setting	Range	Step
Susceptance	0.01μS – 10S	0.01μS

17.4.2 Performance

Capacitive current compensation disabled	Is1 to be set at least 2.5 times the steady state charging current for stability
Capacitive current compensation enabled	Is1 settable below the steady state charging current without maloperating

17.5 Transient bias characteristic for switched communication channels (P540 range – GPS Disable for P545/P546)

17.5.1 Level settings

Setting	Range	Step
Comm delay tol.	250 - 1000μs	50μs
Char mod time	0 – 2s	100μs

17.5.2 Performance

Propagation delay exceeding setting	Bias characteristic modified for set time delay
Timers	±2% or 20ms whichever is greater

18. MISCELLANEOUS

18.1 Analogue inputs, Logic inputs, Outputs relays (P540 range)

Relay	1A/5A dual rated CTs	100 / 120V VTs	Logic inputs	Output relays	Output LEDs	Test port
P541	4	0	8	7	8	TTL logic output
P542	4	0	16	14	8	TTL logic output
P543	5	4	16	14	8	TTL logic output
P544	9	3	16	14	8	TTL logic output
P545	5	4	24	32	8	TTL logic output
P546	9	3	24	32	8	TTL logic output
			status displayed on LCD	status displayed on LCD	test pattern available on front user interface	DDB* signals mapped to front port for test purposes

*Digital Data Bus

18.2 Front user interface (P540 range)

All relay settings configurable from front user interface with the exception of programmable scheme logic, GOOSE logic and DNP.	Compliant
Back light inactivity timer	15 min. ±1min.
Two levels of password protection. Protection critical cells have high level password protection with other cells requiring a lower or no password	Compliant
Password protection removable	Compliant

18.3 Battery life (P540 range)

Battery life (assuming relay energised for 90% of time)	> 10 years
1/2 AA size 3.6 V lithium thionyl chloride battery (SAFT advanced battery reference LS14250)	
Low battery voltage, failure or absence of battery will be indicated	Compliant
The relay is protected against incorrect insertion of battery	Compliant
Removal of the battery with the relay energised will no affect records, events or real time clock	Compliant

18.4 Frequency tracking (P540 range)

Relay will frequency track over its entire operating range	45 – 65Hz
The relay will frequency track off any voltage or current inputs	Compliant
The relay will frequency track down to the following Levels: Voltage Current	
Effect of harmonic	None, relay tracks off fundamental frequency

18.5 K-Bus compatibility (P540 range)

Relay K-Bus interface compatible with other relays of different product families using K-Bus.	Compliant
Relay K-Bus port operates over 1km range with loading at either end of transmission line.	Compliant

19. EC EMC COMPLIANCE (P540 RANGE, P594 GPS RECEIVER)

Compliance to the European Community Directive 89/336/EEC amended by 93/68/EEC is claimed via the Technical Construction File route.

The Competent Body has issued a Technical Certificate and a Declaration of Conformity has been completed.

The following standard shall be used for reference and to establish conformity:

EN 50263:2000 Electromagnetic compatibilty (EMC) Product Standard for measuring relays and protection equipment.

20. EC LVD COMPLIANCE (P540 RANGE, P594 GPS RECEIVER)

Compliance with European Community Directive on Low Voltage 73/23/EEC is demonstrated by reference to generic safety standards:

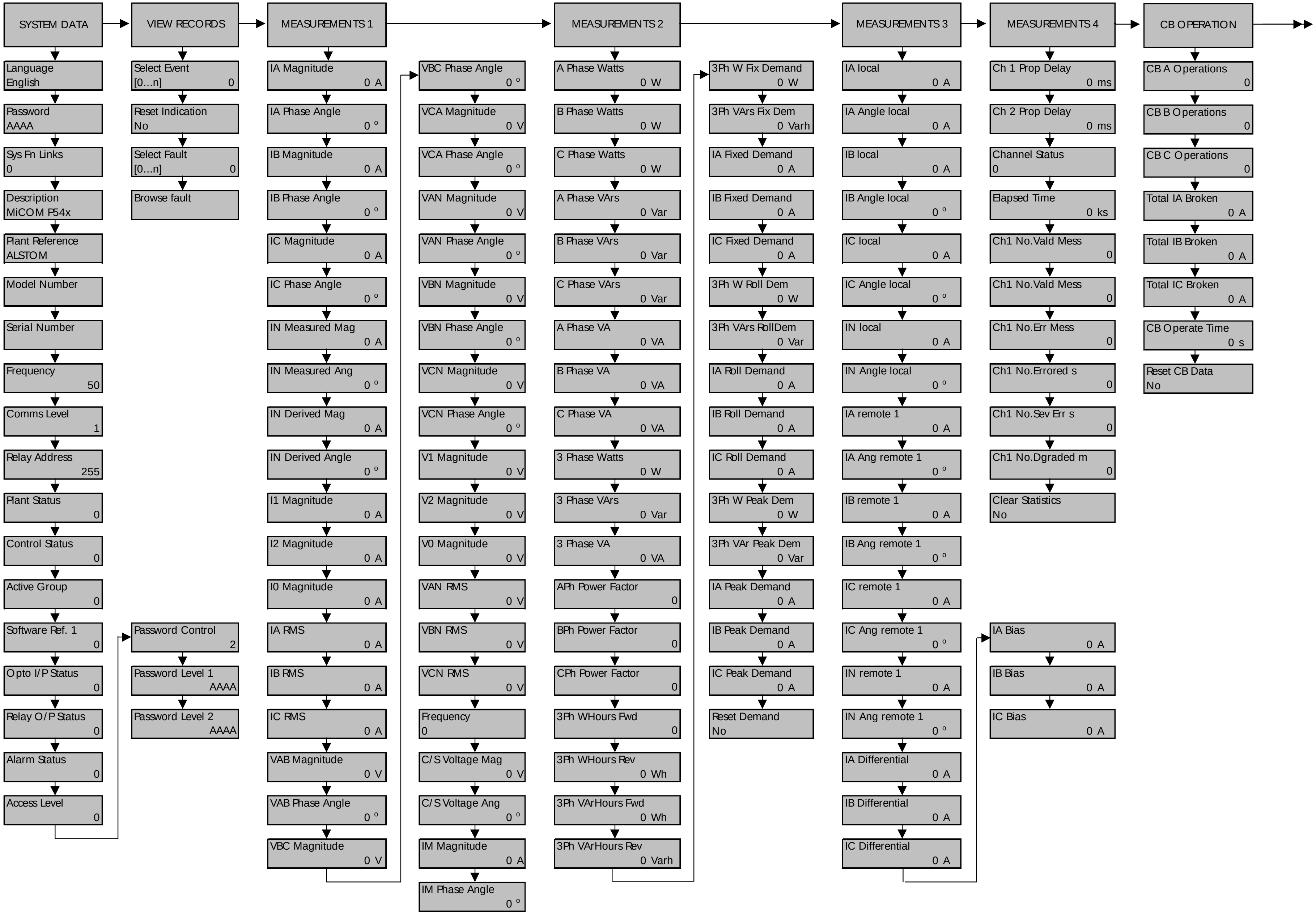
EN 61010-1:2001

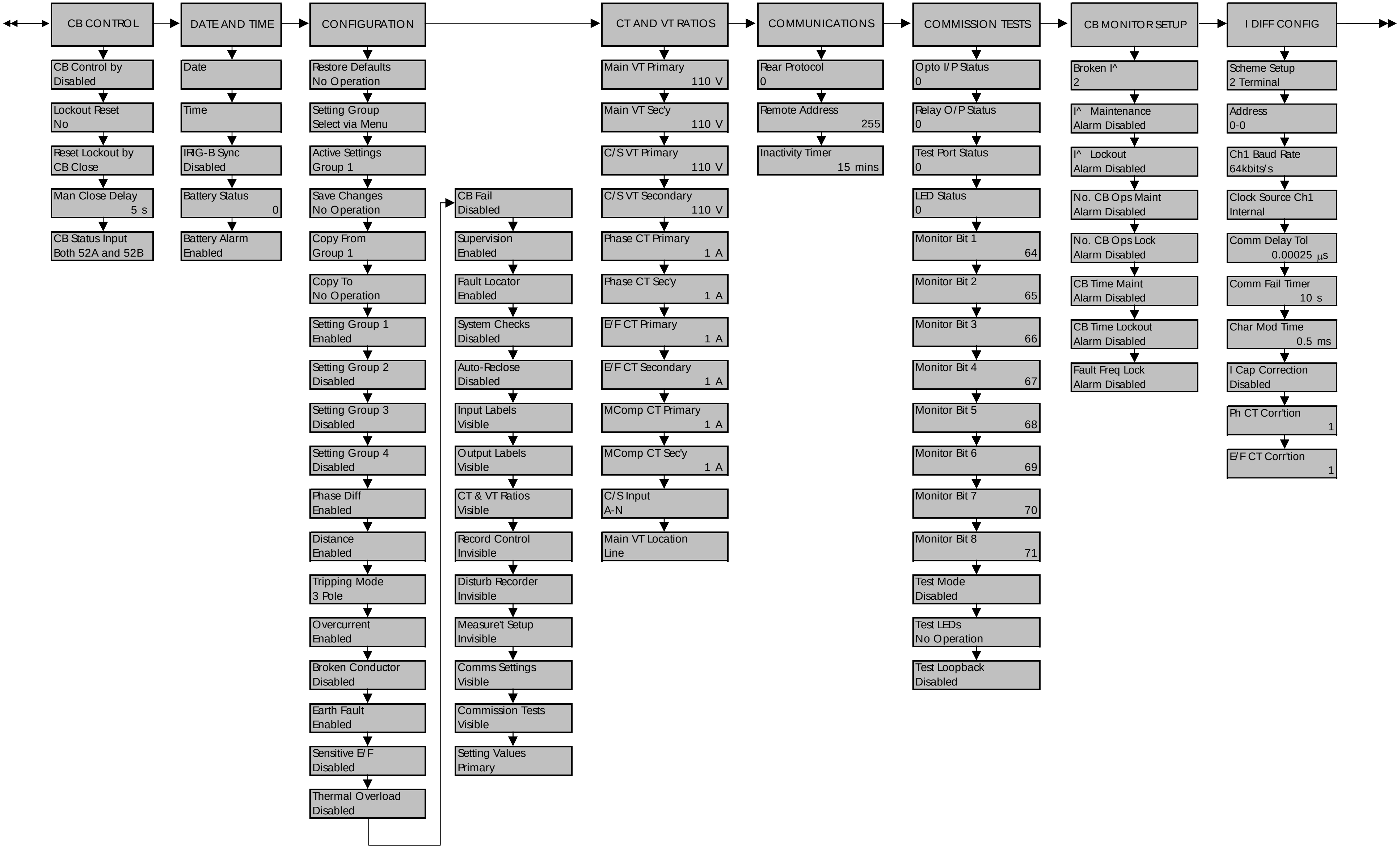
EN 60950-1:2001

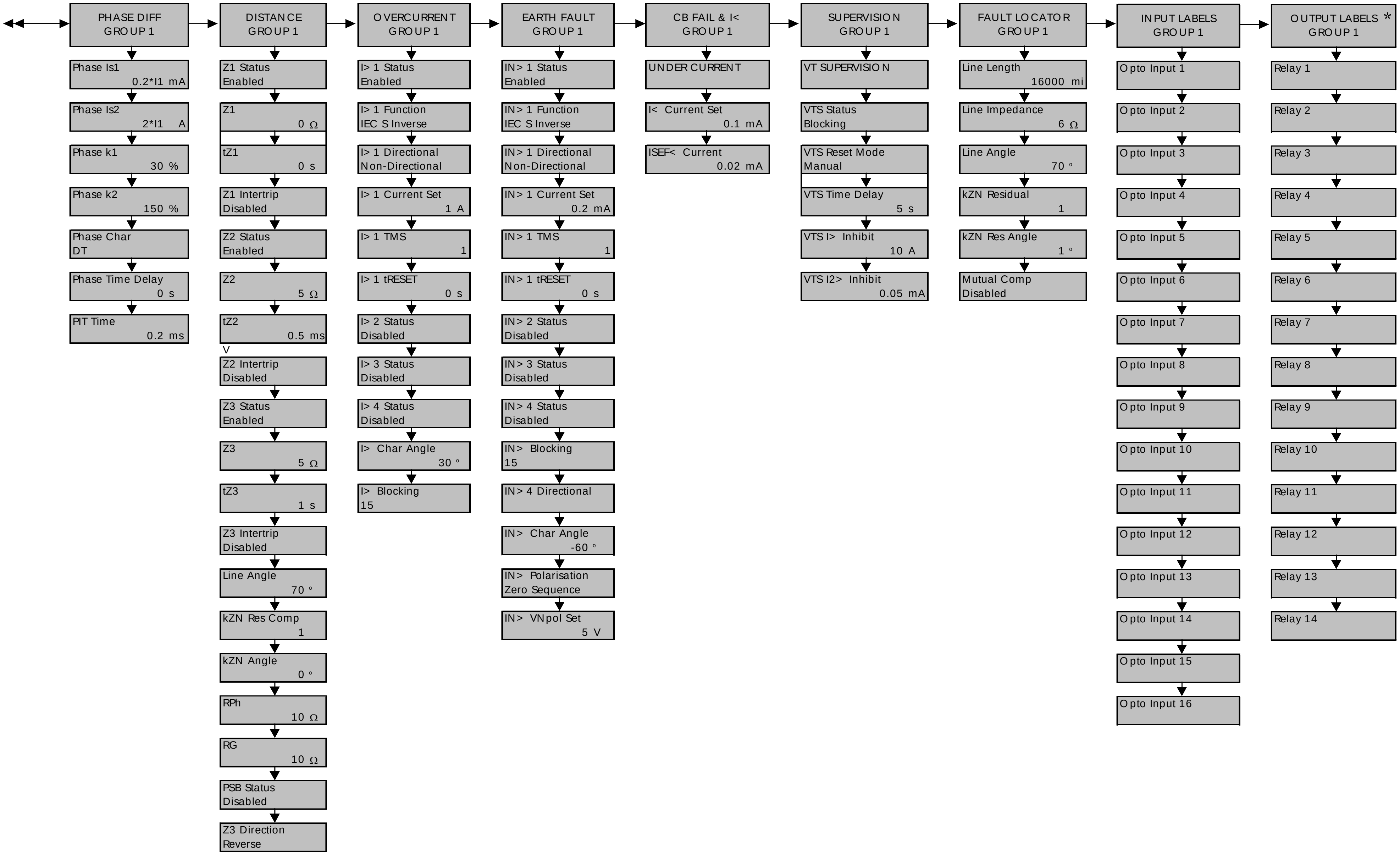
MENU CONTENT TABLES

Note 1: This specific menu map relates to the MiCOM P543, for other versions please make reference to the Courier Database (P54x/EN GC).

Note 2: * Group 1 is shown on the menu map, Groups 2, 3 and 4 are identical to Group 1 and therefore omitted.


SYSTEM DATA
Language English
Password AAAA
Sys Fn Links 0
Description MiCOM P54x
Plant Reference ALSTOM
Model Number
Serial Number
Frequency 50
Comms Level 1
Relay Address 255
Plant Status 0
Control Status 0
Active Group 0
Software Ref. 1 0
Opto I/P Status 0
Relay O/P Status 0
Alarm Status 0
Access Level 0
VIEW RECORDS
Select Event [0...n] 0
Reset Indication No
Select Fault [0...n] 0
Browse fault
Password Control 2
Password Level 1 AAAA
Password Level 2 AAAA
MEASUREMENTS 1
IA Magnitude 0 A
IA Phase Angle 0 °
IB Magnitude 0 A
IB Phase Angle 0 °
IC Magnitude 0 A
IC Phase Angle 0 °
IN Measured Mag 0 A
IN Measured Ang 0 °
IN Derived Mag 0 A
IN Derived Angle 0 °
I1 Magnitude 0 A
I2 Magnitude 0 A
I0 Magnitude 0 A
IA RMS 0 A
IB RMS 0 A
IC RMS 0 A
VAB Magnitude 0 V
VAB Phase Angle 0 °
VBC Magnitude 0 V
VBC Phase Angle 0 °
VCA Magnitude 0 V
VCA Phase Angle 0 °
VAN Magnitude 0 V
VAN Phase Angle 0 °
VBN Magnitude 0 V
VBN Phase Angle 0 °
VCN Magnitude 0 V
VCN Phase Angle 0 °
V1 Magnitude 0 V
V2 Magnitude 0 V
V0 Magnitude 0 V
VAN RMS 0 V
VBN RMS 0 V
VCN RMS 0 V
Frequency 0
C/S Voltage Mag 0 V
C/S Voltage Ang 0 °
IM Magnitude 0 A
IM Phase Angle 0 °
MEASUREMENTS 2
A Phase Watts 0 W
B Phase Watts 0 W
C Phase Watts 0 W
A Phase VArs 0 Var
B Phase VArs 0 Var
C Phase VArs 0 Var
A Phase VA 0 VA
B Phase VA 0 VA
C Phase VA 0 VA
3 Phase Watts 0 W
3 Phase VArs 0 Var
3 Phase VA 0 VA
APh Power Factor 0
BPh Power Factor 0
CPh Power Factor 0
3Ph WHours Fwd 0
3Ph WHours Rev 0 Wh
3Ph VArHours Fwd 0 Wh
3Ph VArHours Rev 0 Varh
3Ph W Fix Demand 0 W
3Ph VArs Fix Dem 0 Varh
IA Fixed Demand 0 A
IB Fixed Demand 0 A
IC Fixed Demand 0 A
3Ph W Roll Dem 0 W
3Ph VArs RollDem 0 Var
IA Roll Demand 0 A
IB Roll Demand 0 A
IC Roll Demand 0 A
3Ph W Peak Dem 0 W
3Ph VAr Peak Dem 0 Var
IA Peak Demand 0 A
IB Peak Demand 0 A
IC Peak Demand 0 A
Reset Demand No
MEASUREMENTS 3
IA local 0 A
IA Angle local 0 A
IB local 0 A
IB Angle local 0 °
IC local 0 A
IC Angle local 0 °
IN local 0 A
IN Angle local 0 °
IA remote 1 0 A
IA Ang remote 1 0 °
IB remote 1 0 A
IB Ang remote 1 0 °
IC remote 1 0 A
IC Ang remote 1 0 °
IN remote 1 0 A
IN Ang remote 1 0 °
IA Differential 0 A
IB Differential 0 A
IC Differential 0 A
MEASUREMENTS 4
Ch 1 Prop Delay 0 ms
Ch 2 Prop Delay 0 ms
Channel Status 0
Elapsed Time 0 ks
Ch1 No.Vald Mess 0
Ch1 No.Vald Mess 0
Ch1 No.Err Mess 0
Ch1 No.Errored s 0
Ch1 No.Sev Err s 0
Ch1 No.Dgraded m 0
Clear Statistics No
IA Bias 0 A
IB Bias 0 A
IC Bias 0 A
CB OPERATION
CB A Operations 0
CB B Operations 0
CB C Operations 0
Total IA Broken 0 A
Total IB Broken 0 A
Total IC Broken 0 A
CB Operate Time 0 s
Reset CB Data No


CB CONTROL
CB Control by
Disabled
Lockout Reset
No
Reset Lockout by
CB Close
Man Close Delay
5 s
CB Status Input
Both 52A and 52B
DATE AND TIME
Date
Time
IRIG-B Sync
Disabled
Battery Status
0
Battery Alarm
Enabled
CONFIGURATION
Restore Defaults
No Operation
Setting Group
Select via Menu
Active Settings
Group 1
Save Changes
No Operation
Copy From
Group 1
Copy To
No Operation
Setting Group 1
Enabled
Setting Group 2
Disabled
Setting Group 3
Disabled
Setting Group 4
Disabled
Phase Diff
Enabled
Distance
Enabled
Tripping Mode
3 Pole
Overcurrent
Enabled
Broken Conductor
Disabled
Earth Fault
Enabled
Sensitive E/F
Disabled
Thermal Overload
Disabled
CB Fail
Disabled
Supervision
Enabled
Fault Locator
Enabled
System Checks
Disabled
Auto-Reclose
Disabled
Input Labels
Visible
Output Labels
Visible
CT & VT Ratios
Visible
Record Control
Invisible
Disturb Recorder
Invisible
Measure't Setup
Invisible
Comms Settings
Visible
Commission Tests
Visible
Setting Values
Primary
CT AND VT RATIOS
Main VT Primary
110 V
Main VT Sec'y
110 V
C/S VT Primary
110 V
C/S VT Secondary
110 V
Phase CT Primary
1 A
Phase CT Sec'y
1 A
E/F CT Primary
1 A
E/F CT Secondary
1 A
MComp CT Primary
1 A
MComp CT Sec'y
1 A
C/S Input
A-N
Main VT Location
Line
COMMUNICATIONS
Rear Protocol
0
Remote Address
255
Inactivity Timer
15 mins
COMMISSION TESTS
Opto I/P Status
0
Relay O/P Status
0
Test Port Status
0
LED Status
0
Monitor Bit 1
64
Monitor Bit 2
65
Monitor Bit 3
66
Monitor Bit 4
67
Monitor Bit 5
68
Monitor Bit 6
69
Monitor Bit 7
70
Monitor Bit 8
71
Test Mode
Disabled
Test LEDs
No Operation
Test Loopback
Disabled
CB MONITOR SETUP
Broken I^
2
I^ Maintenance
Alarm Disabled
I^ Lockout
Alarm Disabled
No. CB Ops Maint
Alarm Disabled
No. CB Ops Lock
Alarm Disabled
CB Time Maint
Alarm Disabled
CB Time Lockout
Alarm Disabled
Fault Freq Lock
Alarm Disabled
I DIFF CONFIG
Scheme Setup
2 Terminal
Address
0-0
Ch1 Baud Rate
64kbits/s
Clock Source Ch1
Internal
Comm Delay Tol
0.00025 µs
Comm Fail Timer
10 s
Char Mod Time
0.5 ms
I Cap Correction
Disabled
Ph CT Corr'tion
1
E/F CT Corr'tion
1


PHASE DIFF GROUP 1
Phase Is1 0.2*I1 mA
Phase Is2 2*I1 A
Phase k1 30 %
Phase k2 150 %
Phase Char DT
Phase Time Delay 0 s
PIT Time 0.2 ms
DISTANCE GROUP 1
Z1 Status Enabled
Z1 0 Ω
tZ1 0 s
Z1 Intertrip Disabled
Z2 Status Enabled
Z2 5 Ω
tZ2 0.5 ms
Z2 Intertrip Disabled
Z3 Status Enabled
Z3 5 Ω
tZ3 1 s
Z3 Intertrip Disabled
Line Angle 70 °
kZN Res Comp 1
kZN Angle 0 °
RPh 10 Ω
RG 10 Ω
PSB Status Disabled
Z3 Direction Reverse
OVERCURRENT GROUP 1
I> 1 Status Enabled
I> 1 Function IEC S Inverse
I> 1 Directional Non-Directional
I> 1 Current Set 1 A
I> 1 TMS 1
I> 1 tRESET 0 s
I> 2 Status Disabled
I> 3 Status Disabled
I> 4 Status Disabled
I> Char Angle 30 °
I> Blocking 15
EARTH FAULT GROUP 1
IN> 1 Status Enabled
IN> 1 Function IEC S Inverse
IN> 1 Directional Non-Directional
IN> 1 Current Set 0.2 mA
IN> 1 TMS 1
IN> 1 tRESET 0 s
IN> 2 Status Disabled
IN> 3 Status Disabled
IN> 4 Status Disabled
IN> Blocking 15
IN> 4 Directional
IN> Char Angle -60 °
IN> Polarisation Zero Sequence
IN> VNpol Set 5 V
CB FAIL & I< GROUP 1
UNDER CURRENT
I< Current Set 0.1 mA
ISEF< Current 0.02 mA
SUPERVISION GROUP 1
VT SUPERVISION
VTS Status Blocking
VTS Reset Mode Manual
VTS Time Delay 5 s
VTS I> Inhibit 10 A
VTS I2> Inhibit 0.05 mA
FAULT LOCATOR GROUP 1
Line Length 16000 mi
Line Impedance 6 Ω
Line Angle 70 °
kZN Residual 1
kZN Res Angle 1 °
Mutual Comp Disabled
INPUT LABELS GROUP 1
Opto Input 1
Opto Input 2
Opto Input 3
Opto Input 4
Opto Input 5
Opto Input 6
Opto Input 7
Opto Input 8
Opto Input 9
Opto Input 10
Opto Input 11
Opto Input 12
Opto Input 13
Opto Input 14
Opto Input 15
Opto Input 16
OUTPUT LABELS * GROUP 1
Relay 1
Relay 2
Relay 3
Relay 4
Relay 5
Relay 6
Relay 7
Relay 8
Relay 9
Relay 10
Relay 11
Relay 12
Relay 13
Relay 14

SCADA COMMUNICATIONS

CONTENTS

1. INTRODUCTION

This chapter describes the remote interfaces of the MiCOM relay in enough detail to allow integration within a substation communication network. As has been outlined in earlier chapters, the relay supports a choice of one of four protocols via the rear communication interface. This is in addition to the front serial interface and 2nd rear communications port, which supports the Courier protocol only.

The rear EIA485 (RS485) interface is isolated and is suitable for permanent connection whichever protocol is selected. The advantage of this type of connection is that up to 32 relays can be 'daisy chained' together using a simple twisted pair electrical connection.

For each of the protocol options, the supported functions/commands will be listed together with the database definition. The operation of standard procedures such as extraction of event, fault and disturbance records, or setting changes, will also be described.

It should be noted that the descriptions contained within this chapter do not aim to fully detail the protocol itself. The relevant documentation for the protocol should be referred to for this information. This chapter serves to describe the specific implementation of the protocol in the relay.

1.1 Physical connection

Two connection options are available for 1st rear communications port, either the rear EIA485 (RS485) port or an optional rear fibre optic port.

The Technical Data section details the communication protocols that are supported on each interface.

2. COURIER INTERFACE

2.1 Courier protocol

Courier is an ALSTOM Grid communication protocol. The concept of the protocol is that a standard set of commands are used to access a database of settings and data within the relay. This allows a generic master to be able to communicate with different slave devices. The application specific aspects are contained within the database itself rather than the commands used to interrogate it, i.e. the master station does not need to be pre-configured.

The same protocol can be used via four physical links K-Bus, EIA485 (RS485), an optional fibre optic port (Version 30 software or later) and EIA232 (RS232).

K-Bus is based on EIA485 (RS485) voltage levels with HDLC FM0 encoded synchronous signalling and its own frame format. The K-Bus twisted pair connection is unpolarised, whereas the EIA485 and EIA232 interfaces are polarised.

The EIA232 interface uses the IEC60870-5 FT1.2 frame format.

The relay supports an IEC60870-5 FT1.2 connection on the front-port. This is intended for temporary local connection and is not suitable for permanent connection. This interface uses a fixed baud rate, 11-bit frame, and a fixed device address.

The rear interface is used to provide a permanent connection for K-Bus and allows multi-drop connection. It should be noted that although K-Bus is based on EIA485 voltage levels it is a synchronous HDLC protocol using FM0 encoding. It is not possible to use a standard EIA232 to EIA485 converter to convert IEC60870-5 FT1.2 frames to K-Bus. Nor is it possible to connect K-Bus to an EIA485 computer port. A protocol converter, such as the KITZ101, should be employed for this purpose.

The following documentation should be referred to for a detailed description of the Courier protocol, command-set and link description.

R6509	K-Bus Interface Guide
R6510	IEC60870 Interface Guide
R6511	Courier Protocol

R6512 Courier User Guide

2.2 Front courier port

The front EIA232[1] (RS232) 9 pin port supports the Courier protocol for one to one communication. It is designed for use during installation and commissioning/maintenance and is not suitable for permanent connection. Since this interface will not be used to link the relay to a substation communication system, some of the features of Courier are not implemented. These are as follows:

Automatic extraction of Event Records:

- Courier Status byte does not support the Event flag
- Send Event/Accept Event commands are not implemented

Automatic extraction of Disturbance records:

- Courier Status byte does not support the Disturbance flag

Busy Response Layer:

- Courier Status byte does not support the Busy flag, the only response to a request will be the final data

Fixed Address:

- The address of the front Courier port is always 1, the Change Device address command is not supported.

Fixed Baud rate:

- 19200 bps

It should be noted that although automatic extraction of event and disturbance records is not supported it is possible to manually access this data via the front port.

2.3 Supported command set

The following Courier commands are supported by the relay:

Protocol Layer

Reset Remote Link

Poll Status

Poll Buffer*

Low Level Commands

Send Event*

Accept Event*

Send Block

Store Block Identifier

Store Block Footer

Menu Browsing

Get Column Headings

Get Column Text

Get Column Values

Get Strings

[1] This port is actually compliant to EIA574; the 9-pin version of EIA232, see www.tiaonline.org.

Get Text

Get Value

Get Column Setting Limits

Setting Changes

Enter Setting Mode

Preload Setting

Abort Setting

Execute Setting

Reset Menu Cell

Set Value

Control Commands

Select Setting Group

Change Device Address*

Set Real Time

Note: Commands indicated with a * are not supported via the front Courier port.

2.4 Relay courier database

The Courier database is a two dimensional structure with each cell in the database being referenced by a row and column address. Both the column and the row can take a range from 0 to 255. Addresses in the database are specified as hexadecimal values, e.g. 0A02 is column 0A (10 decimal) row 02. Associated settings/data will be part of the same column, row zero of the column contains a text string to identify the contents of the column, i.e. a column heading.

P54x/EN GC contains the complete database definition for the relay. For each cell location the following information is stated:

- Cell Text
- Cell Datatype
- Cell value
- Whether the cell is settable, if so
- Minimum value
- Maximum value
- Step size
- Password Level required to allow setting changes
- String information (for Indexed String or Binary flag cells)

2.5 Setting changes

(See R6512, Courier User Guide - Chapter 9)

Courier provides two mechanisms for making setting changes, both of these are supported by the relay. Either method can be used for editing any of the settings within the relay database.

2.5.1 Method 1

This uses a combination of three commands to perform a settings change:

Enter Setting Mode - checks that the cell is settable and returns the limits

Preload Setting - Places a new value to the cell, this value is echoed to ensure that setting corruption has not taken place, the validity of the setting is not checked by this action.

Execute Setting - Confirms the setting change, if the change is valid then a positive response will be returned, if the setting change fails then an error response will be returned.

Abort Setting - This command can be used to abandon the setting change.

This is the most secure method and is ideally suited to on-line editors as the setting limits are taken from the relay before the setting change is made. However this method can be slow if many settings are being changed as three commands are required for each change.

2.5.2 Method 2

The Set Value command can be used to directly change a setting, the response to this command will be either a positive confirm or an error code to indicate the nature of a failure. This command can be used to implement a setting more rapidly then the previous method, however the limits are not extracted from the relay. This method is most suitable for off-line setting editors such as MiCOM S1, or for the issuing of pre-configured (SCADA) control commands.

2.5.3 Relay settings

There are three categories of settings within the relay database

- Control and Support
- Disturbance Recorder
- Protection Settings Group

Setting changes made to the control and support settings are implemented immediately and stored in non-volatile memory. Changes made to either the Disturbance recorder settings or the Protection Settings Groups are stored in a 'scratchpad' memory and are not immediately implemented by the relay.

To action setting changes stored in the scratchpad the Save Changes cell in the Configuration column must be written to. This allows the changes to either be confirmed and stored in non-volatile memory, or the setting changes to be aborted.

2.5.4 Setting transfer mode

If it is necessary to transfer all of the relay settings to or from the relay a cell within the Communication System Data column can be used. This cell (location BF03) when set to 1 makes all of the relay settings visible. Any setting changes made, with the relay set in this mode, are stored in scratchpad memory (including control and support settings). When the value of BF03 is set back to 0 any setting changes are verified and stored in non-volatile memory.

2.6 Event extraction

Events can be extracted either automatically (rear port only) or manually (either Courier port). For automatic extraction all events are extracted in sequential order using the standard Courier event mechanism, this includes fault/maintenance data if appropriate. The manual approach allows the user to select events, faults, or maintenance data at random from the stored records.

2.6.1 Automatic event extraction

(See Chapter 7 Courier User Guide, publication R6512)

This method is intended for continuous extraction of event and fault information as it is produced. It is only supported via the rear Courier port.

When new event information is created the Event bit is set within the Status byte, this indicates to the Master device that event information is available. The oldest, unextracted event can be extracted from the relay using the Send Event command. The relay will respond with the event data, which will be either a Courier Type 0 or Type 3 event. The Type 3 event is used for fault records and maintenance records.

Once an event has been extracted from the relay, the Accept Event can be used to confirm that the event has been successfully extracted. If all events have been extracted then the event bit will reset, if there are more events still to be extracted the next event can be accessed using the Send Event command as before.

2.6.2 Event types

Events will be created by the relay under the following circumstances:

- Change of state of output contact
- Change of state of opto input
- Protection element operation
- Alarm condition
- Setting Change
- Password entered/timed-out
- Fault Record (Type 3 Courier Event)
- Maintenance record (Type 3 Courier Event)

2.6.3 Event format

The Send Event command results in the following fields being returned by the relay:

- Cell Reference
- Timestamp
- Cell Text
- Cell Value

The menu database, P34x/EN GC, contains a table of the events created by the relay and indicates how the contents of the above fields are interpreted. Fault records and Maintenance records will return a Courier Type 3 event, which contains the above fields together with two additional fields:

- Event extraction column
- Event number

These events contain additional information that is extracted from the relay using the referenced extraction column. Row 01 of the extraction column contains a setting that allows the fault/maintenance record to be selected. This setting should be set to the event number value returned within the record, the extended data can be extracted from the relay by uploading the text and data from the column.

2.6.4 Manual event record extraction

Column 01 of the database can be used for manual viewing of event, fault, and maintenance records. The contents of this column will depend on the nature of the record selected. It is possible to select events by event number and to directly select a fault record or maintenance record by number.

Event Record selection (Row 01) - This cell can be set to a value between 0 to 249 to select which of the 250 stored events is selected, 0 will select the most recent record; 249 the oldest stored record. For simple event records, (Type 0) cells 0102 to 0105 contain the event details. A single cell is used to represent each of the event fields. If the event selected is a fault or maintenance record (Type 3) then the remainder of the column will contain the additional information.

Fault Record Selection (Row 05) – This cell can be used to directly select a fault record using a value between 0 and 4 to select one of up to five stored fault records. (0 will be the most recent fault and 4 will be the oldest). The column will then contain the details of the fault record selected.

Maintenance Record Selection (Row F0) – This cell can be used to select a maintenance record using a value between 0 and 4 and operates in a similar way to the fault record selection.

It should be noted that if this column is used to extract event information from the relay the number associated with a particular record will change when a new event or fault occurs.

2.7 Disturbance record extraction

The disturbance records are stored in uncompressed format and can be extracted either manually or automatically using the standard Courier mechanism defined in Chapter 8 of the Courier User Guide.
The front Courier port does not support automatic extraction although disturbance record data can be extracted manually from this port.

2.8 Programmable scheme logic settings

The programmable scheme logic (PSL) settings can be uploaded from and downloaded to the relay using the block transfer mechanism defined in Chapter 12 of the Courier User Guide.

The following cells are used to perform the extraction:

- B204 Domain: Used to select either PSL settings (Upload or download) or PSL configuration data (Upload only)

- B208 Sub-Domain: Used to select the Protection Setting Group to be uploaded/downloaded.

- B20C Version: Used on a download to check the compatibility of the file to be downloaded with the relay.

- B21C Transfer Mode: Used to set-up the transfer process.

- B120 Data Transfer Cell: Used to perform upload/download.

The Programmable scheme-logic settings can be uploaded and downloaded to and from the relay using this mechanism. If it is necessary to edit the settings MiCOM S1 must be used as the data format is compressed. MiCOM S1 also performs checks on the validity of the settings before they are downloaded to the relay.

3. MODBUS INTERFACE

The Modbus interface is a master/slave protocol and it is defined by Modbus.org: See

www.modbus.org

Modbus Serial Protocol Reference Guide PI-MBUS-300 Rev. E

3.1 Communication link

This interface uses the rear EIA485 (RS485) port (or for software version 30 or later an optional rear fibre optic port) for communication using 'RTU' mode communication rather than 'ASCII' mode as this provides more efficient use of the communication bandwidth. This mode of communication is defined by the Modbus standard.

In summary, the character framing is 1 start bit, 8 bit data, either 1 parity bit and 1 stop bit, or two stop bits. This gives 11 bits per character.

The following parameters can be configured for this port using either the front panel interface or the front Courier port:

- Baud Rate
- Device Address
- Parity
- Inactivity Time

3.2 Modbus functions

The following Modbus function codes are supported by the relay:

01 Read Coil Status

02 Read Input Status

03 Read Holding Registers

04 Read Input Registers

06 Preset Single Register

08 Diagnostics

11 Fetch Communication Event Counter

12 Fetch Communication Event Log

16 Preset Multiple Registers 127 max

These are interpreted by the MiCOM relay in the following way:

01 Read status of output contacts (0xxxx addresses)

02 Read status of opto inputs (1xxxx addresses)

03 Read Setting values (4xxxx addresses)

04 Read Measured values (3xxxx addresses

06 Write single setting value (4xxxx addresses)

16 Write multiple setting values (4xxxx addresses)

3.3 Response codes

Code	Modbus Description	MiCOM Interpretation
01	Illegal Function Code	The function code transmitted is not supported by the slave
02	Illegal Data Address	The start data address in the request is not an allowable value. If any of the addresses in the range cannot be accessed due to password protection then all changes within the request are discarded and this error response will be returned. Note: If the start address is correct but the range includes non – implemented addresses this response is not produced
03	Illegal Value	A value referenced in the data field transmitted by the master is not within range. Other values transmitted within the same packet will be executed if inside range.
06	Slave Device Busy	The write command cannot be implemented due to the database being locked by another interface. This response is also produced if the relay software is busy executing a previous request.

3.4 Register mapping

The relay supports the following memory page references:

Memory Page	Interpretation
0xxxx	Read and write access of the Output Relays.
1xxxx	Read only access of the Opto Inputs.
3xxxx	Read only access of Data.
4xxxx	Read and write access of Settings.

Where xxxx represents the addresses available in the page (0 to 9999)

Note that the “extended memory file” (6xxxx) is not supported.

A complete map of the Modbus addresses supported by the relay is contained in menu database, P54x/EN GC, of this service manual.

Note that Modbus convention is to document register addresses as ordinal values whereas the actual protocol addresses are literal values. The Micom relays begin their register addresses at zero. Thus, the first register in a memory page is register address zero. The second register is register address 1 and so on. Note that the page number notation is not part of the address.

3.5 Event extraction

The relay supports two methods of event extraction providing either automatic or manual extraction of the stored event, fault, and maintenance records.

3.5.1 Manual selection

There are three registers available to manually select stored records, there are also three read only registers allowing the number of stored records to be determined.

40100 - Select Event, 0 to 249

40101 - Select Fault, 0 to 4

40102 - Select Maintenance Record, 0 to 4

For each of the above registers a value of 0 represents the most recent stored record. The following registers can be read to indicate the numbers of the various types of record stored.

30100 - Number of stored records

30101 - Number of stored fault records

30102 - Number of stored maintenance records

Each fault or maintenance record logged causes an event record to be created by the relay. If this event record is selected the additional registers allowing the fault or maintenance record details will also become populated.

3.5.2 Automatic extraction

The automatic extraction facilities allow all types of record to be extracted as they occur. Event records are extracted in sequential order including any fault or maintenance data that may be associated with the event.

The Modbus master can determine whether the relay has any events stored that have not yet been extracted. This is performed by reading the relay status register 30001 (G26 data type). If the event bit of this register is set then the relay has unextracted events available. To select the next event for sequential extraction the master station writes a value of 1 to the record selection register 40400 (G18 data type). The event data together with any fault/maintenance data can be read from the registers specified below. Once the data has been read the event record can be marked as having been read by writing a value of 2 to register 40400.

3.5.3 Record data

The location and format of the registers used to access the record data is the same whether they have been selected using either of the two mechanisms detailed above.

Event Description	Modbus Address	Length	Comments
Time and Date	30103	4	See G12 data type description in section 3.8.
Event Type	30107	1	See G13 data type. Indicates type of event
Event Value	30108	2	Nature of Value depends on Event Type. This will contain the status as a binary flag for Contact, Opto, Alarm, and protection events.
Modbus Address	30110	1	This indicates the Modbus Register address where the change occurred. Alarm 30011 Relays 30723 Optos 30725 Protection events – Like the Relay and Opto addresses this will map onto the Modbus address of the appropriate DDB status register depending on which bit of the DDB the change occurred. These will range from 30727 to 30785. For Platform events, Fault events and Maintenance events the default is 0.
Event Index	30111	1	This register will contain the DDB ordinal for protection events or the bit number for alarm events. The direction of the change will be indicated by the most significant bit; 1 for 0 – 1change and 0 for 1 – 0 change.

Event Description	Modbus Address	Length	Comments
Additional Data Present	30112	1	0 means that there is no additional data 1 means fault record data can be read from 30113 to 30199 (number of registers depends on the product) 2 means maintenance record data can be read from 30036 to 30039

If a fault record or maintenance record is directly selected using the manual mechanism then the data can be read from the register ranges specified above. The event record data in registers 30103 to 30111 will not be available.

It is possible using register 40401(G6 data type) to clear independently the stored relay event/fault and maintenance records. This register also provides an option to reset the relay indications which has the same effect on the relay as pressing the clear key within the alarm viewer using the front panel menu.

3.6 Disturbance record extraction

The relay provides facilities for both manual and automatic extraction of disturbance records. The extraction mechanisms are explained below.

3.6.1 Extraction mechanism

Records extracted over MODBUS from Px40 platform relays will be presented in COMTRADE format. This involves extracting an ASCII text configuration file and then extracting a binary data file.

Each file is extracted by reading a series of data pages from the relay. The data page is made up of 127 registers, giving a maximum transfer of 254 bytes per page.

3.6.1.1 Interface registers

The following set of registers is presented to the master station to support the extraction of uncompressed disturbance records:

MODBUS Register	Name	Description
3x00001	Status Register	Provides the status of the relay as bit flags: b0 – Out of service b1 – Minor Self Test Failure b2 – Event b3 – Time Synchronization b4 – Disturbance b5 – Fault b6 – Trip b7 – Alarm b8 to b15 – Unused A ‘1’ on b4 indicates the presence of a disturbance.
3x00800	N^o of stored disturbances	Indicates the total number of disturbance records currently stored in the relay, both extracted and unextracted.
3x00801	Unique identifier of the oldest disturbance record.	Indicates the unique identifier value for the oldest disturbance record stored in the relay. This is an integer value used in conjunction with the ‘N^o of stored disturbances’ value to calculate a value for manually selecting records.

MODBUS Register	Name	Description
4x00250	Manual disturbance record selection register	This register is used to manually select disturbance records. The values written to this cell are an offset of the unique identifier value for the oldest record. The offset value, which ranges from 0 to the N^o of stored disturbances – 1, is added to the identifier of the oldest record to generate the identifier of the required record.
4x00400	Record selection command register.	This register is used during the extraction process and has a number of commands. These are: b0 – Select next event b1 – accept event b2 – Select next disturbance record b3 – Accept disturbance record b4 – Select next page of disturbance data b5 – Select data file
3x00930 – 3x00933	Record time stamp	These registers return the timestamp of the disturbance record.
3x00802	N^o of registers in data page.	This register informs the master station of the number of registers in the data page that are populated.
3x00803 – 3x00929	Data page registers	These 127 registers are used to transfer data from the relay to the master station. They are 16-bit unsigned integers.
3x00934	Disturbance record status register	The disturbance record status register is used during the extraction process to indicate to the master station when data is ready for extraction. See next table.
4x00251	Data file format selection	This is used to select the required data file format. This is reserved for future use.

Note: Register addresses are provided in reference code + address format. E.g. 4x00001 is reference code 4x, address 1 (which is specified as function code 03, address 0x0000 in the MODBUS specification).

The Disturbance Record status register will report one of the following values:

State	Description
Idle	This will be the state reported when no record is selected, such as after power on or after a record has been marked as extracted.
Busy	The relay is currently processing data.
Page Ready	The data page has been populated and the master station can now safely read the data.
Configuration Complete	All of the configuration data has been read without error.
Record Complete	All of the disturbance data has been extracted.
Disturbance Overwritten	An error occurred during the extraction process where the disturbance being extracted was overwritten by a new record.
No unextracted Disturbances	An attempt was made by the master station to automatically select the next oldest unextracted disturbance when all records have been extracted.
Not a valid Disturbance	An attempt was made by the master station to manually select a record that did not exist in the relay.
Command Out Of Sequence	The master station issued a command to the relay that was not expected during the extraction process.

3.6.2 Extraction procedure

The following procedure will be used to extract disturbances from the relay. The procedure is split into four sections:

Selection of a disturbance – Either manually or automatically

Extraction of the configuration file

Extraction of the data file

Accepting the extracted record (automatic extraction only)

3.6.2.1 Manual Extraction procedure

The procedure used to extract a disturbance manually is shown in the diagram below (Figure 2). The manual method of extraction does not allow for the acceptance of disturbance records.

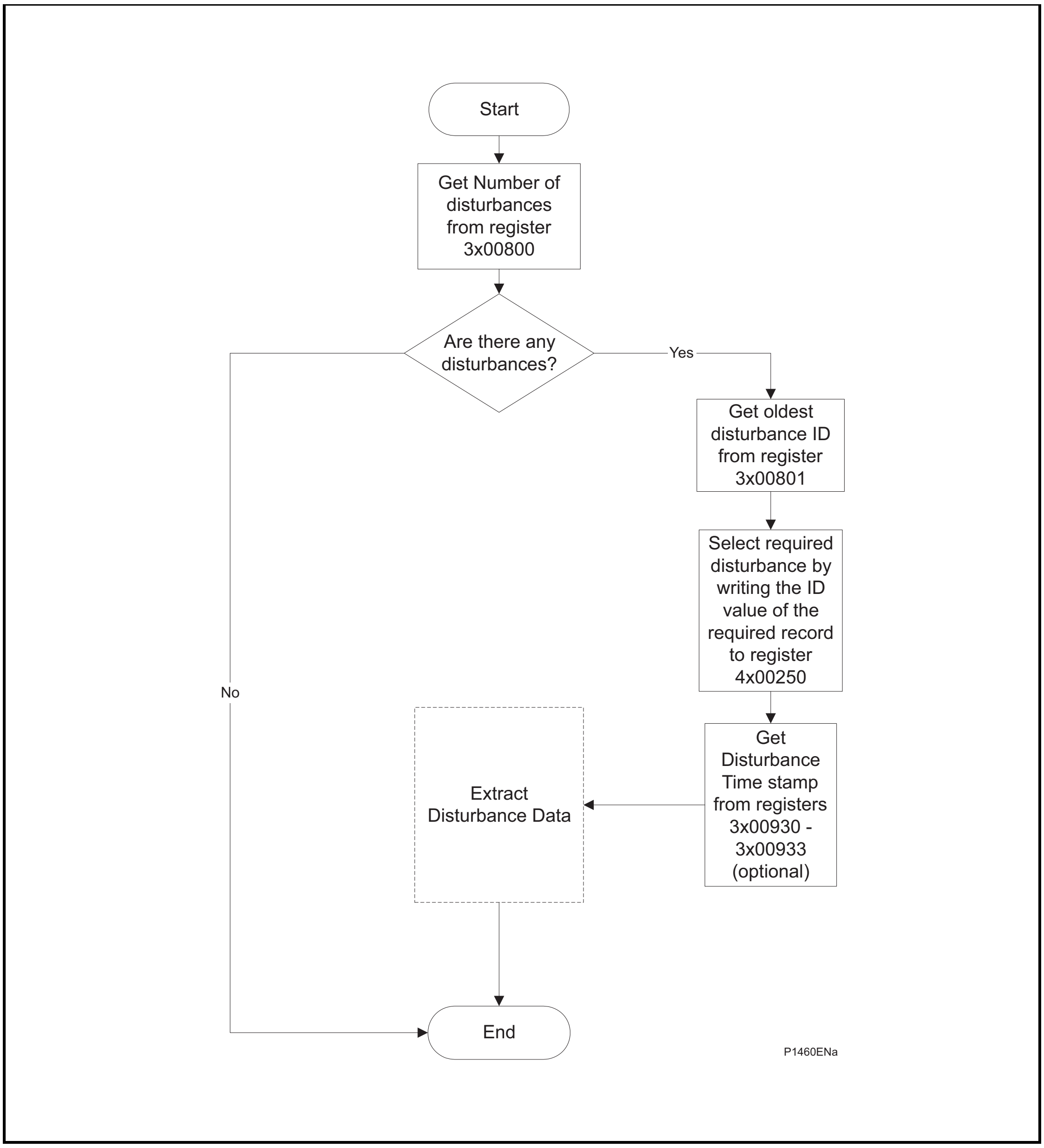


Figure 1: Manual selection of a disturbance record

3.6.2.2 Automatic extraction procedure

There are two methods that can be used for automatically extracting disturbances. Option 1 is simpler and is better at extracting single disturbance records, i.e. when the disturbance recorder is polled regularly. Option 2, however, is more complex to implement but is more efficient at extracting large quantities of disturbance records. This may be useful when the disturbance recorder is polled only occasionally and hence may have many stored records.

3.6.2.3 Automatic extraction procedure – option 1

The procedure for the first method is shown below (Figure 2). This also shows the acceptance of the disturbance record once the extraction is complete.

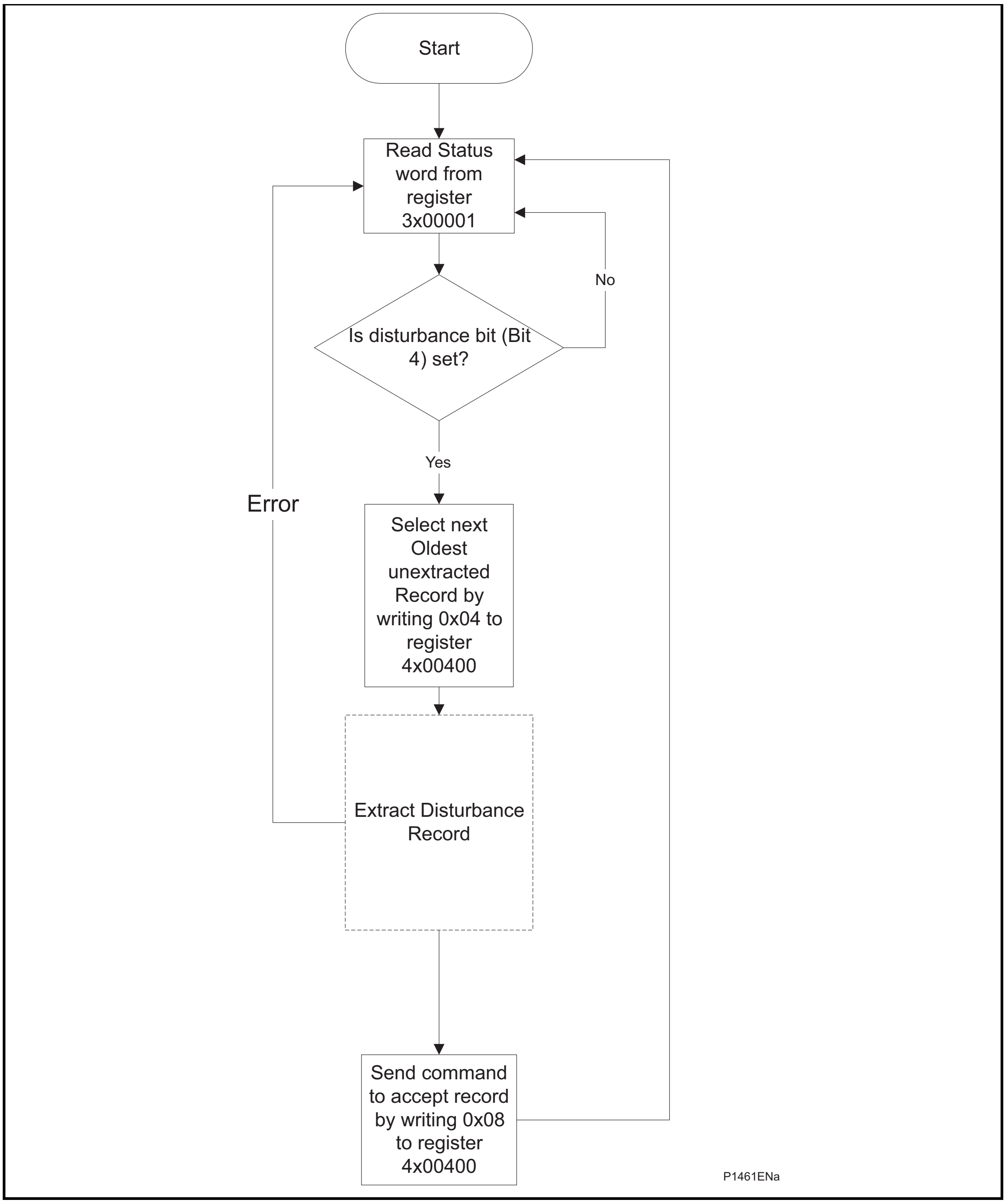


Figure 2: Automatic selection of a disturbance – option 1

3.6.2.4 Automatic extraction procedure – option 2

The second method that can be used for automatic extraction is shown in the diagram below (Figure 3). This also shows the acceptance of the disturbance record once the extraction is complete:

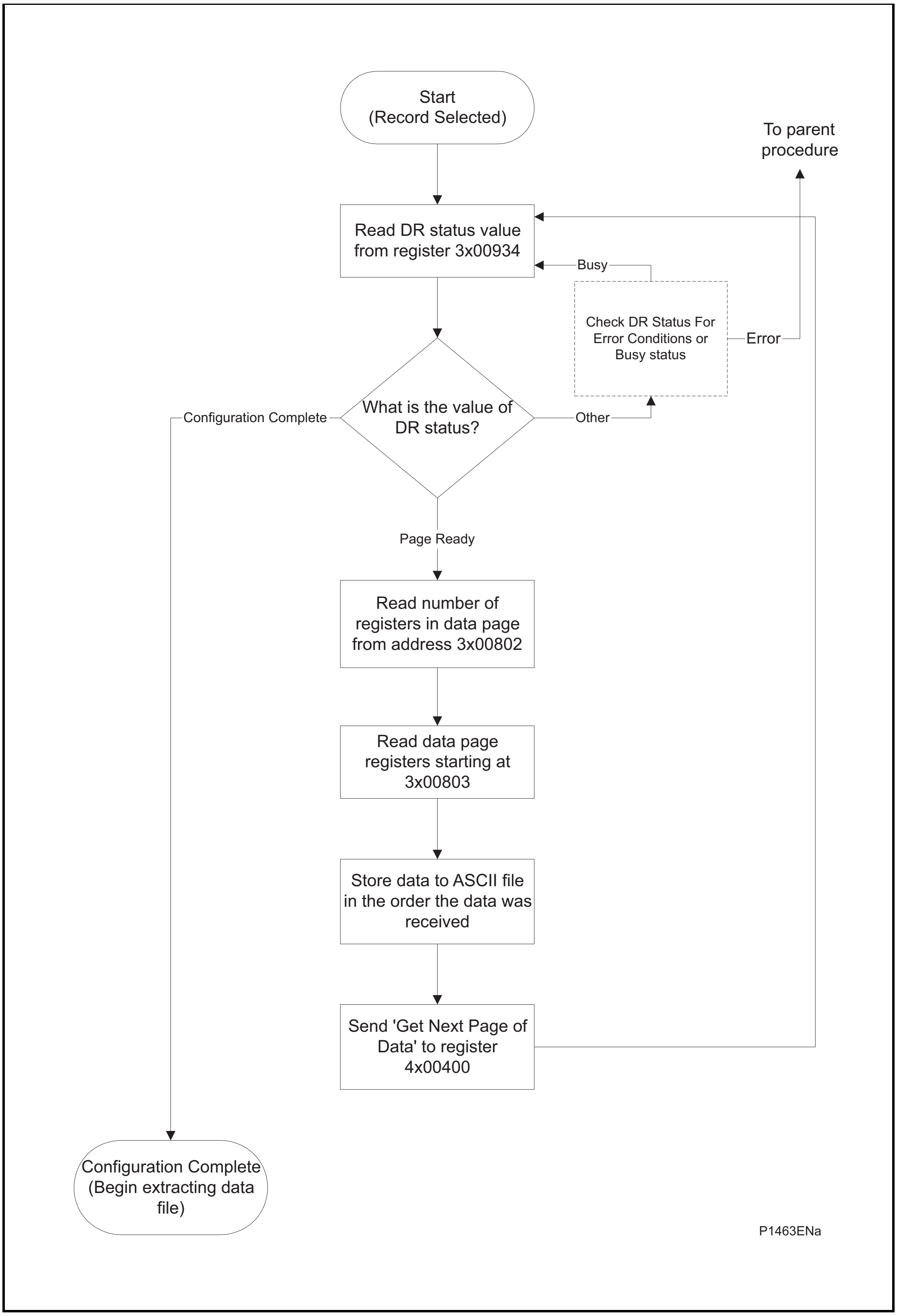


Figure 3: Automatic selection of a disturbance – option 2

3.6.3 Extracting the disturbance data

The extraction of the disturbance record, as shown in the three diagrams above, is a two-stage process that involves extracting the configuration file first and then the data file.

The following diagram (Figure 4) shows how the configuration file is extracted from the relay:

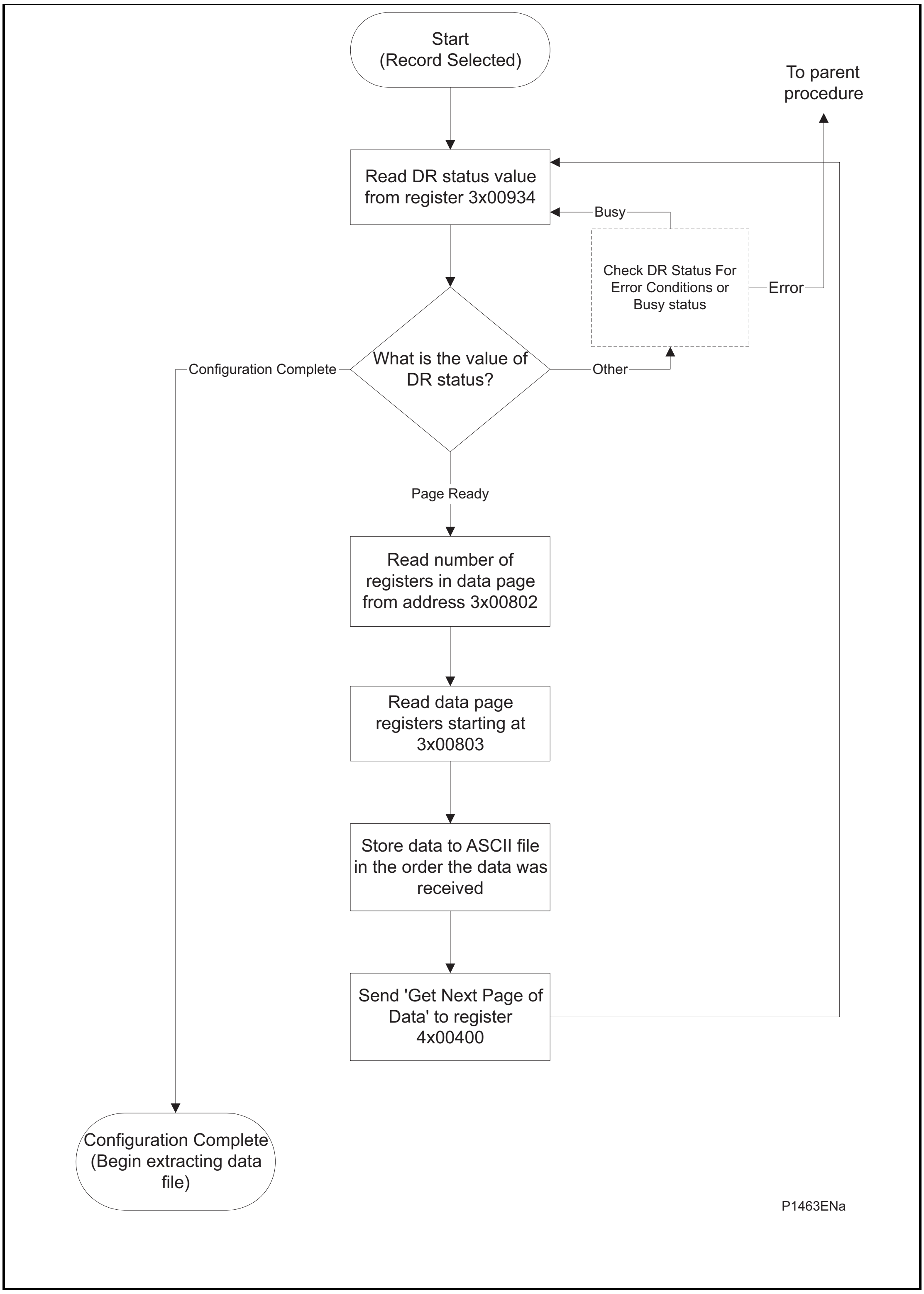


Figure 4: Extracting the COMTRADE configuration file

The following diagram (Figure 5) shows how the data file is extracted:

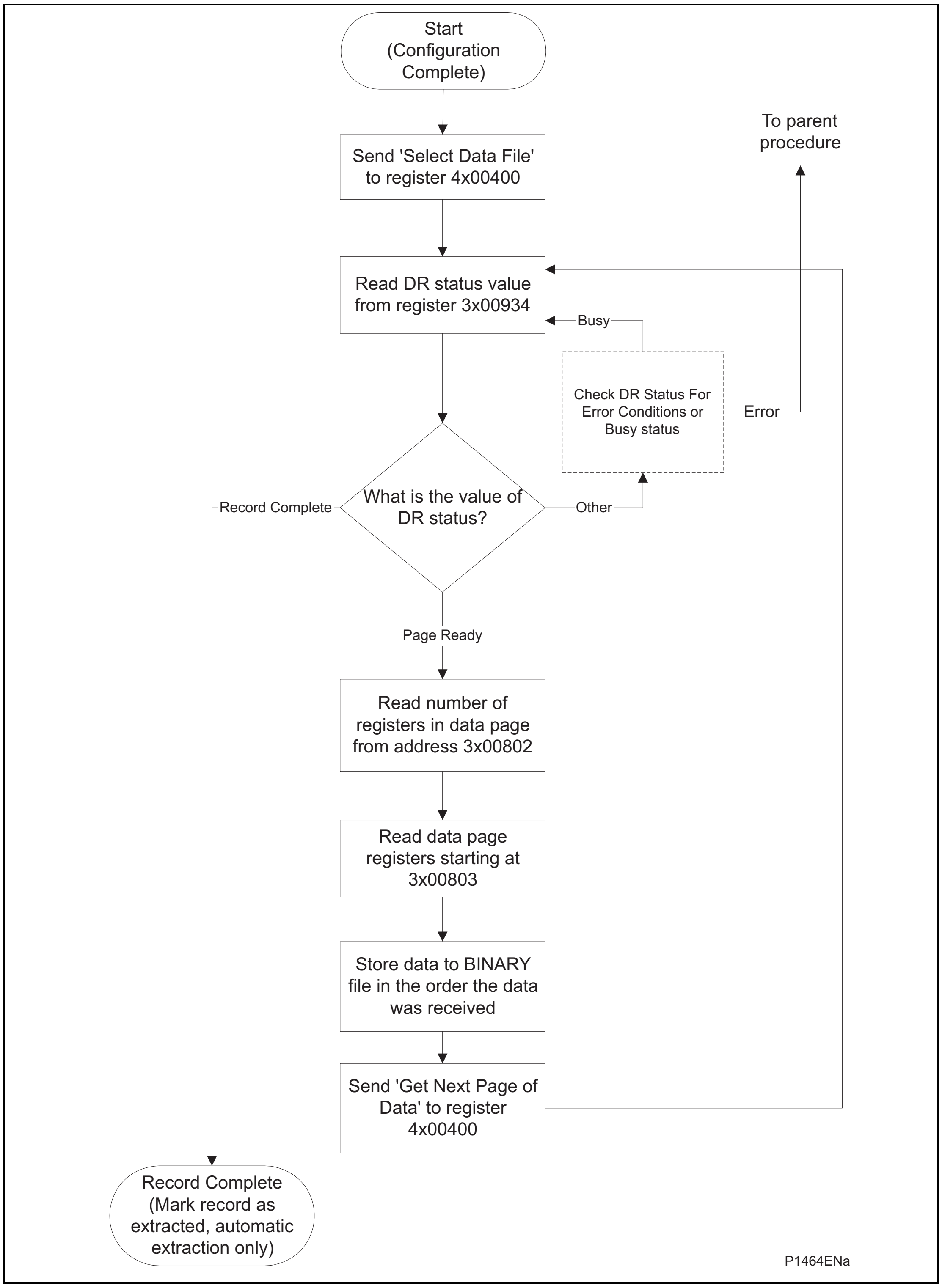


Figure 5: Extracting the COMTRADE binary data file

During the extraction of the COMTRADE files, an error may occur that will be reported on the DR Status register 3x00934. This can be caused by the relay overwriting the record being extracted or due to the master station issuing a command that is not within the bounds of the extraction procedure.

3.6.4 Manual selection

Each disturbance record has a unique identifier which increments for each stored record and resets at a value of 65535. The following registers can be used to determine the identifiers for the stored records

30800 - The number of stored disturbance records

30801 - The identifier for the oldest stored record

A record can be selected by writing the required record identifier to register 40250. It is possible to read the timestamp of the selected record and in this way produce a chronological list of all the stored records.

3.6.5 Automatic extraction

The Modbus master station can determine the presence of unread disturbance records by polling register 30001 (G26 data type). When the disturbance bit of this register is set, disturbance records are available for extraction. To select the next disturbance record, write a value of 4 to register 40400 (G18 data type). Once the disturbance record data has been read by the master station this record can be marked as having been read by writing a value of 8 to register 40400.

3.6.6 Record data

The timestamp for a record selected using either of the above means can be read from registers 30390 to 30393.

The number of pages required to extract a record will depend on the configured size of the record.

When a record is first selected, the first page of data will be available in registers 30803 to 30929. (The number of registers required for the current page can be read from register 30802. It will have a value of 127 for all but the last page in the record). Once the first page has been read, the next page can be selected by writing a value of 5 to register 40400. If this action is performed after the last page for the disturbance record has been selected an illegal value error response will be returned. This error response can be used by the Modbus master to indicate that the last page of the disturbance record has been read.

3.7 Setting changes

The relay settings can be split into two categories:

control and support settings

disturbance record settings and protection setting groups

Changes to settings within the control and support area are executed immediately. Changes to the protection setting groups or the disturbance recorder settings are stored in a temporary ‘scratchpad’ area and must be confirmed before they are implemented. All the relay settings are 4xxxx page addresses. The following points should be noted when changing settings:

Settings implemented using multiple registers must be written to using a multi-register write operation.

The first address for a multi-register write must be a valid address, if there are unmapped addresses within the range being written to then the data associated with these addresses will be discarded.

If a write operation is performed with values that are out of range then the illegal data response will be produced. Valid setting values within the same write operation will be executed.

If a write operation is performed attempting to change registers that require a higher level of password access than is currently enabled then all setting changes in the write operation will be discarded.

3.7.1 Password protection

As described in the introduction to this service manual, the relay settings can be subject to Password protection. The level of password protection required to change a setting is indicated in the relay setting database (P54x/EN GC). Level 2 is the highest level of password access, level 0 indicates that no password is required.

The following registers are available to control Password protection:

40001&40002	Password Entry
40022	Default Password Level
40023&40024	Setting to Change password level 1
40025&40026	Setting to Change password level 2
30010	Can be read to indicate current access level

Control and support settings

Control and support settings are executed immediately on the write operation.

3.7.2 Protection and disturbance recorder settings

Setting changes to either of these areas are stored in a scratchpad area and will not be used by the relay unless a confirm or an abort operation is performed. Register 40405 can be used either to confirm or abort the setting changes within the scratchpad area. It should be noted that the relay supports four groups of protection settings. The Modbus addresses for each of the four groups are repeated within the following address ranges:

Group 1	41000-42999
Group 2	43000-44999
Group 3	45000-46999
Group 4	47000-48999

In addition to the basic editing of the protection setting groups, the following functions are provided:

Default values can be restored to a setting group or to all of the relay settings by writing to register 40402.

It is possible to copy the contents of one setting group to another by writing the source group to register 40406 and the target group to 40407.

It should be noted that the setting changes performed by either of the two operations defined above are made to the scratchpad area. These changes must be confirmed by writing to register 40405.

The active protection setting groups can be selected by writing to register 40404. An illegal data response will be returned if an attempt is made to set the active group to one that has been disabled.

3.8 Date and Time Format (Data Type G12)

The date-time data type G12 allows *real* date and time information to be conveyed down to a resolution of 1ms. The data-type is used for record time-stamps and for time-synchronisation

The structure of the data type is shown in Table 3.1 and is compliant with the IEC60870-5-4 “Binary Time 2a” format.

	Bit position							
Byte	7	6	5	4	3	2	1	0
1	m^7	m^6	m^5	m^4	m^3	m^2	m^1	m^0
2	m^{15}	m^{14}	m^{13}	m^{12}	m^{11}	m^{10}	m^9	m^8
3	IV	R	I^5	I^4	I^3	I^2	I^1	I^0
4	SU	R	R	H^4	H^3	H^2	H^1	H^0
5	W^2	W^1	W^0	D^4	D^3	D^2	D^1	D^0
6	R	R	R	R	M^3	M^2	M^1	M^0
7	R	Y^6	Y^5	Y^4	Y^3	Y^2	Y^1	Y^0

Where:

- m = 0…59,999ms
- I = 0…59 minutes
- H = 0…23 Hours
- W = 1…7 Day of week; Monday to Sunday, 0 for not calculated
- D = 1…31 Day of Month
- M = 1…12 Month of year; January to December
- Y = 0…99 Years (year of century)
- R = Reserved bit = 0
- SU = summertime: 0=standard time, 1=summer time
- IV = invalid value: 0=valid, 1=invalid
- Range = 0ms…99 Years

Table 3-1 G12 Date & time data type structure.

The seven bytes of the structure are packed into four 16-bit registers. Two packing formats are provided: *standard* and *reverse*. The prevailing format is selected by register 4x306 or for software 30 onwards via the G238 setting in the “Date and Time” menu column.

The *standard* packing-format is the default and complies with the IEC60870-5-4 requirement that byte 1 is transmitted first, followed by byte 2 through to byte 7, followed by a null (zero) byte to make eight bytes in total. Since register data is usually transmitted in big-endian format (high order byte followed by low order byte), byte 1 will be in the high-order byte position followed by byte 2 in the low-order position for the first register. The last register will contain just byte 7 in the high order position and the low order byte will have a value of zero.

The *reverse* packing-format is the exact byte transmission order reverse of the *standard* format. That is, the null (zero) byte is sent as the high-order byte of the first register and byte 7 as the register’s low-order byte. The second register’s high-order byte contains byte 6 and byte 5 in it’s low order byte.

The principal application of the *reverse* format is for date-time packet-format consistency when a mixture of MiCOM Px40 series products are being used. This is especially true when there is a requirement for broadcast time synchronisation with a mixture of such MiCOM products.

The data type provides only the year of century value; the century must be deduced. Simplistically the century could be imposed as 20 for applications not dealing with dates stored in this format from the previous (20th) century. Alternatively, the century can be calculated as the one that will produce the nearest time value to the current date. For example: 30-12-99 is 30-12-1999 when received in 1999 & 2000, but is 30-12-2099 when received in 2050. This technique allows 2 digit years to be accurately converted to 4 digits in a ±50 year window around the current datum.

The invalid bit has two applications:

1. It can indicate that the date-time information is considered inaccurate, but is the best information available.

2. Date-time information is not available.

3.

The summertime bit is used to indicate that summertime (day light saving) is being used and, more importantly, to resolve the alias and time discontinuity which occurs when summertime starts and ends. This is important for the correct time correlation of time stamped records. (Note that the value of the summertime bit does not affect the time displayed by the product.)

The day of the week field is optional and if not calculated will be set to zero.

The concept of time zone is not catered for by this data type and hence by the product. It is up to the end user to determine the time zone utilised by the product. Normal practise is to use UTC (universal co-ordinated time), which avoids the complications with day light saving time-stamp correlation's.

3.9 Power & Energy Measurement Data Formats (G29 & G125)

The power and energy measurements are available in two data formats; G29 integer format and G125 IEEE754 floating point format. For historical reasons the registers listed in the main part of the "Measurements 2" column of the menu database (see P54x/EN GC) are of the G29 format. The floating point, G125, versions appear at the end of the column.

3.9.1 Data Type G29

Data type G29 consists of three registers. The first register is the per unit power or energy measurement and is of type G28, which is a signed 16 bit quantity. The second and third registers contain a multiplier to convert the per unit value to a real value. The multiplier is of type G27, which is an unsigned 32-bit quantity. Thus, the overall value conveyed by the G29 data type must be calculated as G29=G28×G27.

The relay calculates the G28 per unit power or energy value as G28=((measured secondary quantity) / (CT secondary) × (110V / (VT secondary)). Since data type G28 is a signed 16-bit integer, its dynamic range is constrained to ±32768. This limitation should be borne in mind for the energy measurements, as the G29 value will saturate a long time before the equivalent G125 does.

The associated G27 multiplier is calculated as G27=(CT primary) × (VT primary / 110V) when primary value measurements are selected, and as G27=(CT secondary) × (VT secondary / 110V) when secondary value measurements are selected.

Due to the required truncations from floating point values to integer values in the calculations of the G29 component parts and its limited dynamic range, the use of the G29 values is only recommended when the Modbus master cannot deal with the G125 IEEE754 floating point equivalents.

Note that the G29 values must be read in whole multiples of three registers. It is not possible to read the G28 and G27 parts with separate read commands.

Example:

For A-Phase Power (Watts) (registers 30300 - 30302) for a 110V relay, In = 1A, VT ratio = 110V: 110V and CT ratio = 1A:1A.

Applying A-phase 1A @ 63.51V

A-phase Watts = ((63.51V × 1A) / In=1A) × (110/Vn=110V) = 63.51 Watts

The G28 part of the value is the truncated per unit quantity, which will be equal to 64 (40h).

The multiplier is derived from the VT and CT ratios set in the relay, with the equation ((CT Primary) × (VT Primary) / 110V). Thus, the G27 part of the value will equal 1. Hence the overall value of the G29 register set is 64×1 = 64W

The registers would contain:

30300 - 0040h

30301 - 0000h

30302 - 0001h

Using the previous example with a VT ratio = 110,000V:110V and CT ratio = 10,000A:1A the G27 multiplier would be 10,000A×110,000V/110 = 10,000,000. The overall value of the G29 register set is 64 × 10,000,000 = 640MW. (Note that there is an actual error of 49MW in this calculation due to loss of resolution.)

The registers would contain:

30300 - 0040h

30301 - 0098h

30302 - 9680h

3.9.2 Data Type G125

Data type G125 is a *short float* IEEE754 floating point format, which occupies 32 bits in two consecutive registers. The high order byte of the format is in the first (low order) register and the low order byte in the second register.

The value of the G125 measurement is as accurate as the relay's ability to resolve the measurement after it has applied the secondary or primary scaling factors as require. It does not suffer from the truncation errors or dynamic range limitations associated with the G29 data format.

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4. IEC60870-5-103 Interface

The IEC60870-5-103 interface is a master/slave interface with the relay as the slave device. The relay conforms to compatibility level 2, compatibility level 3 is not supported.

The following IEC60870-5-103 facilities are supported by this interface:

- Initialisation (Reset)
- Time Synchronisation
- Event Record Extraction
- General Interrogation
- Cyclic Measurements
- General Commands
- Disturbance Record Extraction
- Private Codes

4.1 Physical connection and link layer

Two connection options are available for IEC60870-5-103, either the rear EIA485 (RS485) port or an optional rear fibre optic port. Should the fibre optic port be fitted the selection of the active port can be made via the front panel menu or the front Courier port.

For either of the two modes of connection it is possible to select both the relay address and baud rate using the front panel menu/front Courier. Following a change to either of these two settings a reset command is required to re-establish communications, see reset command description below.

4.2 Initialisation

Whenever the relay has been powered up, or if the communication parameters have been changed a reset command is required to initialise the communications. The relay will respond to either of the two reset commands (Reset CU or Reset FCB), the difference being that the Reset CU will clear any unsent messages in the relay's transmit buffer.

The relay will respond to the reset command with an identification message ASDU 5, the Cause Of Transmission COT of this response will be either Reset CU or Reset FCB depending on the nature of the reset command. The content of ASDU 5 is described in the IEC60870-5-103 section of the menu database, P54x/EN GC.

In addition to the above identification message, if the relay has been powered up it will also produce a power up event.

4.3 Time synchronisation

The relay time and date can be set using the time synchronisation feature of the IEC60870-5-103 protocol. The relay will correct for the transmission delay as specified in IEC60870-5-103. If the time synchronisation message is sent as a send/confirm message then the relay will respond with a confirm. Whether the time-synchronisation message is sent as a send confirm or a broadcast (send/no reply) message, a time synchronisation Class 1 event will be generated/produced.

If the relay clock is being synchronised using the IRIG-B input then it will not be possible to set the relay time using the IEC60870-5-103 interface. An attempt to set the time via the interface will cause the relay to create an event with the current date and time taken from the IRIG-B synchronised internal clock.

4.4 Spontaneous events

Events are categorised using the following information:

- Function Type
- Information number

The IEC60870-5-103 profile in the menu database, P54x/EN GC, contains a complete listing of all events produced by the relay.

4.5 General interrogation

The GI request can be used to read the status of the relay, the function numbers, and information numbers that will be returned during the GI cycle are indicated in the IEC60870-5-103 profile in the menu database, P54x/EN GC.

4.6 Cyclic measurements

The relay will produce measured values using ASDU 9 on a cyclical basis, this can be read from the relay using a Class 2 poll (note ADSU 3 is not used). The rate at which the relay produces new measured values can be controlled using the Measurement Period setting. This setting can be edited from the front panel menu/front Courier port and is active immediately following a change.

It should be noted that the measurands transmitted by the relay are sent as a proportion of 2.4 times the rated value of the analogue value.

4.7 Commands

A list of the supported commands is contained in the menu database, P54x/EN GC. The relay will respond to other commands with an ASDU 1, with a cause of transmission (COT) indicating 'negative acknowledgement'.

4.8 Test mode

It is possible using either the front panel menu or the front Courier port to disable the relay output contacts to allow secondary injection testing to be performed. This is interpreted as 'test mode' by the IEC60870-5-103 standard. An event will be produced to indicate both entry to and exit from test mode. Spontaneous events and cyclic measured data transmitted whilst the relay is in test mode will have a COT of ‘test mode’.

4.9 Disturbance records

The disturbance records are stored in uncompressed format and can be extracted using the standard mechanisms described in IEC60870-5-103. Note, IEC60870-5-103 only supports up to 8 records.

4.10 Blocking of monitor direction

The relay supports a facility to block messages in the Monitor direction and also in the Command direction. Messages can be blocked in the Monitor and Command directions using the menu commands, Communications – CS103 Blocking – Disabled / Monitor Blocking / Command Blocking or DDB signals Monitor Blocked and Command Blocked.

5. DNP3 INTERFACE

5.1 DNP3 Protocol

The DNP3 protocol is defined and administered by the DNP Users Group. Information about the user group, DNP3 in general and the protocol specifications can be found on their Internet site:

www.dnp.org

The descriptions given here are intended to accompany the device profile document which is included in the menu database, P54x/EN GC. The DNP3 protocol is not described here, please refer to the documentation available from the user group. The device profile document specifies the full details of the DNP3 implementation for the relay. This is the standard format DNP3 document that specifies which objects, variations and qualifiers are supported. The device profile document also specifies what data is available from the relay via DNP3. The relay operates as a DNP3 slave and supports subset level 2 of the protocol, plus some of the features from level 3.

DNP3 communication uses the EIA485 (RS485) rear communication port or for software 30 onwards an optional fibre optic port at the rear of the relay. The data format is 1 start bit, 8 data bits, an optional parity bit and 1 stop bit. Parity is configurable (see menu settings below).

5.2 DNP3 Menu Setting

The settings shown below are available in the menu for DNP3 in the ‘Communications’ column.

Setting	Range	Description
Remote Address	0 – 65534	DNP3 address of relay (decimal)
Baud Rate	1200, 2400, 4800, 9600, 19200, 38400	Selectable baud rate for DNP3 communication
Parity	None, Odd, Even	Parity setting
Time Sync	Enabled, Disabled	Enables or disables the relay requesting time sync from the master via IIN bit 4 word 1

5.3 Object 1 Binary Inputs

Object 1, binary inputs, contains information describing the state of signals within the relay which mostly form part of the digital data bus (DDB). In general these include the state of the output contacts and input optos, alarm signals and protection start and trip signals. The ‘DDB number’ column in the device profile document provides the DDB numbers for the DNP3 point data. These can be used to cross-reference to the DDB definition list which is also found in the menu database, P54x/EN GC. The binary input points can also be read as change events via object 2 and object 60 for class 1-3 event data.

5.4 Object 10 Binary Outputs

Object 10, binary outputs, contains commands which can be operated via DNP3. As such the points accept commands of type pulse on [null, trip, close] and latch on/off as detailed in the device profile in the menu database, P54x/EN GC and execute the command once for either command. The other fields are ignored (queue, clear, trip/close, in time and off time).

Due to that fact that many of the relay’s functions are configurable, it may be the case that some of the object 10 commands described below are not available for operation. In the case of a read from object 10 this will result in the point being reported as off-line and an operate command to object 12 will generate an error response.

Examples of object 10 points that maybe reported as off-line are:

- Activate setting groups	-	Ensure setting groups are enabled
- CB trip/close	-	Ensure remote CB control is enabled
- Reset NPS thermal	-	Ensure NPS thermal protection is enabled
Reset thermal O/L	-	Ensure thermal overload protection is enabled
Reset RTD flags	-	Ensure RTD Inputs is enabled
Control Inputs	-	Ensure control inputs are enabled

5.5 Object 20 Binary Counters

Object 20, binary counters, contains cumulative counters and measurements. The binary counters can be read as their present 'running' value from object 20, or as a 'frozen' value from object 21. The running counters of object 20 accept the read, freeze and clear functions. The freeze function takes the current value of the object 20 running counter and stores it in the corresponding object 21 frozen counter. The freeze and clear function resets the object 20 running counter to zero after freezing its value.

5.6 Object 30 Analogue Input

Object 30, analogue inputs, contains information from the relay's measurements columns in the menu. All object 30 points are reported as fixed-point values although they are stored inside the relay in a floating point format. The conversion to fixed point format requires the use of a scaling factor, which differs for the various types of data within the relay e.g. current, voltage, phase angle etc. The data types supported are listed at the end of the device profile document with each type allocated a 'D number', i.e. D1, D2, etc. In the object 30 point list each data point has a D number data type assigned to it which defines the scaling factor, default deadband setting and the range and resolution of the deadband setting. The deadband is the setting used to determine whether a change event should be generated for each point. The change events can be read via object 32 or object 60 and will be generated for any point whose value has changed by more than the deadband setting since the last time the data value was reported.

Any analogue measurement that is unavailable at the time it is read will be reported as offline, e.g. the frequency when the current and voltage frequency is outside the tracking range of the relay or the thermal state when the thermal protection is disabled in the configuration column. Note that all object 30 points are reported as secondary values in DNP3 (with respect to CT and VT ratios).

5.7 DNP3 Configuration Using MiCOM S1

A PC support package for DNP3 is available as part of the Settings and Records module of MiCOM S1. The S1 module allows configuration of the relay's DNP3 response. The PC is connected to the relay via a serial cable to the 9-pin front part of the relay – see chapter 1, Introduction. The configuration data is uploaded from the relay to the PC in a block of compressed format data and downloaded to the relay in a similar manner after modification. The new DNP3 configuration takes effect in the relay after the download is complete. The default configuration can be restored at any time by choosing 'All Settings' from the 'Restore Defaults' cell in the menu 'Configuration' column. In S1, the DNP3 data is displayed on a three tabbed screen, one screen each for object1, 20 and 30. Object 10 is not configurable.

5.7.1 Object 1

For every point included in the device profile document there is a check box for membership of class 0 and radio buttons for class 1, 2 or 3 membership. Any point that is in class 0 must be a member of one of the change event classes, 1, 2 or 3.

Points that are configured out of class 0 are by default not capable of generating change events. Furthermore, points that are not part of class 0 are effectively removed from the DNP3 response by renumbering the points that are in class 0 into a contiguous list starting at point number 0. The renumbered point numbers are shown at the left hand side of the screen in S1 and can be printed out to form a revised device profile for the relay. This mechanism allows best use of available bandwidth by only reporting the data points required by the user when a poll for all points is made.

5.7.2 Object 20

The running counter value of object 20 points can be configured to be in or out of class 0. Any running counter that is in class 0 can have its frozen value selected to be in or out of the DNP3 response, but a frozen counter cannot be included without the corresponding running counter. As with object 1, the class 0 response will be renumbered into a contiguous list of points based on the selection of running counters. The frozen counters will also be renumbered based on the selection; note that if some of the counters that are selected as running are not also selected as frozen then the renumbering will result in the frozen counters having different point numbers to their running counterparts. For example, object 20 point 3 (running counter) might have its frozen value reported as object 21 point 1.

5.7.3 Object 30

For the analogue inputs, object 30, the same selection options for classes 0, 1, 2 and 3 are available as for object 1. In addition to these options, which behave in exactly the same way as for object 1, it is possible to change the deadband setting for each point. The minimum and maximum values and the resolution of the deadband settings are defined in the device profile document; MiCOM S1 will allow the deadband to be set to any value within these constraints.

6. SECOND REAR COMMUNICATIONS PORT (COURIER)

Relays with Courier, Modbus, IEC60870-5-103 or DNP3 protocol on the first rear communications port have the option of a second rear port, running the Courier language. The second port is designed typically for dial-up modem access by protection engineers/operators, when the main port is reserved for SCADA communication traffic. Communication is via one of three physical links: K-Bus, EIA485(RS485) or EIA232(RS232)[1]. The port supports full local or remote protection and control access by MiCOM S1 software.

When changing the port configuration between K-Bus, EIA485 & EIA232 it is necessary to reboot the relay to update the hardware configuration of the second rear port.

There is also provision for the EIA485 & EIA232 protocols to be configured to operate with a modem, using an IEC60870 10 bit frame.

Port Configuration	Valid communication protocol
K-Bus	K-Bus
EIA232	IEC60870 FT1.2, 11bit frame IEC60870,10 bit frame
EIA485	IEC60870 FT1.2, 11bit frame IEC60870, 10 bit frame

If both rear communications ports are connected to the same bus, care should be taken to ensure their address settings are not the same, to avoid message conflicts.

6.1 Courier protocol

The following documentation should be referred to for a detailed description of the Courier protocol, command set and link description.

- R6509 K-Bus Interface Guide
- R6510 IEC60870 Interface Guide
- R6511 Courier Protocol
- R6512 Courier User Guide

The second rear communications port is functionally the same as detailed in section 2 for a Courier rear communications port, with the following exceptions:

6.2 Event extraction

Automatic event extraction is not supported when the first rear port protocol is Courier, Modbus or CS103. It is supported when the first rear port protocol is DNP3.

6.3 Disturbance record extraction

Automatic disturbance record extraction is not supported when the first rear port protocol is Courier, Modbus or CS103. It is supported when the first rear port protocol is DNP3.

6.4 Connection to the Second Rear Port

The second rear Courier port connects via the 9-way female D-type connector (SK4) in the middle of the card end plate (in between IRIG-B connector and lower D-type). The connection is compliant to EIA574.

For IEC60870-5-2 over EIA232

Pin	Connection
1	No Connection
2	RxD
3	TxD
4	DTR#
5	Ground
6	No Connection
7	RTS#
8	CTS#
9	No Connection

For K-bus or IEC60870-5-2 over EIA485

Pin*	Connection
4	EIA485 – 1 (+ ve)
7	EIA485 – 2 (- ve)

* - All other pins unconnected.

- These pins are control lines for use with a modem

NOTES:

1) Connector pins 4 and 7 are used by both the EIA232and EIA485 physical layers, but for different purposes. Therefore, the cables should be removed during configuration switches.

2) For the EIA485 protocol an EIA485 to EIA232 converter will be required to connect a modem or PC running MiCOM S1, to the relay. A CK222 is recommended.

3) EIA485 is polarity sensitive, with pin 4 positive (+) and pin 7 negative (-).

4) The K-Bus protocol can be connected to a PC via a KITZ101 or 102.

7. SK5 PORT CONNECTION

The lower 9-way D-type connector (SK5) is currently unsupported. Do not connect to this port.

UCA2.0 COMMUNICATIONS

Note: UCA2.0 is supported in P543, P544, P545 and P546

CONTENTS

1. WHAT IS UCA2.0?

UCA2.0 is a communication architecture that was created by the Electric Power Research Institute (EPRI) as a generic means of representing information for use across the electric and other utility industries.

In the late 1980's, the evolving presence of numerical technology, digital processing and computing brought a much greater efficiency and operational potential to the electric utilities. Products were utilising communication protocols best suited to the Protection & Control industry; little thought was given to the ease of integration of these products with other vendors' products and systems. The result of which was costly and confusing for Engineers to integrate.

In response to this problem, and foreseeing the advantages to both utilities and vendors, EPRI began the Integrated Utility Communications (IUC) program. The goal was the creation of a set of industry standards applicable to all utility industries. One of the first projects, UCA2.0 was concerned with defining the methods and language that would allow devices from different vendors to understand each other, or interoperate.

It is important to note that UCA2.0 is an architecture, rather than a simple protocol, UCA2.0 incorporates a family of basic communications protocols. The selection and organisation of these protocols has been designed to provide great flexibility, and to reduce integration and vendor product costs.

1.1 Why Interoperability

UCA2.0 responds to the utilities' desire of having easier integration for different vendors' products. Traditionally, one vendor's implementation of Modbus, for example, could place the A phase amps at register 40002. Other devices on the network, such as a Remote Terminal Unit (RTU), would then be programmed with the location of this information. When a new vendor's product, using register 30028 to represent Phase A current is added to the network, the RTU's must be re-programmed to accept this new register. While making extensive changes to your existing system for each new device, you create several dialects of the original protocol and true interoperability can not be realised.

UCA2.0 takes a lot of these integration problems out of the picture. A UCA2.0 compliant device, such as a MiCOM relay, is built using these integration-friendly concepts. Meaning that instead of 40002 being a register containing Phase A current (which varies from vendor to vendor), a variable with the GOMSFE naming: **'MMXU.MX.A.PhsAf'** exists in one or many places as defined by the wrappers.

1.2 What is GOMSFE?

The Generic Object Models for Substation and Feeder Equipment (GOMSFE) document acts as the "dictionary" which defines:

- Categories of information within a device
- Hierarchy in which this information is organised
- Standard naming conventions through which others communicate with the device

UCA2.0 compliant devices will have all data and functions available to respond to these "names" defined in GOMFSE. For example, the standard measurement data from the protection device, is given using these "names" as below:

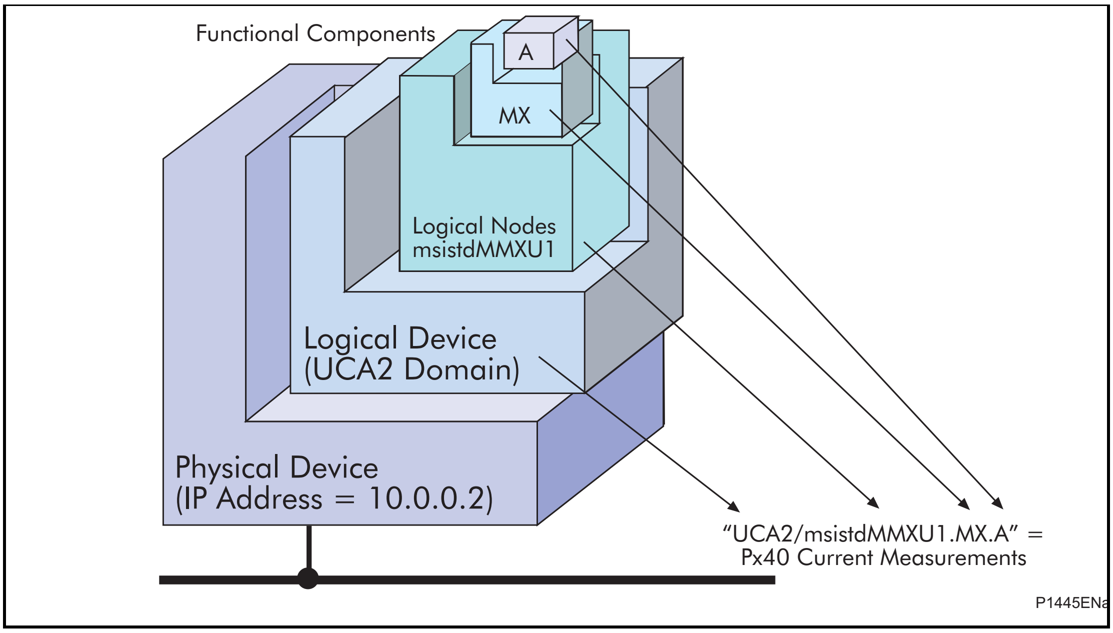


Figure 1: Data representation over UCA2.0

In UCA2.0, data is set up in a directory structure of a series of larger to smaller folders. To view Phase A amps or any other piece of data, you must know the location of the data within the informational hierarchy of GOMSFE.

1.3 How is UCA2.0 built up?

The information presented over UCA2.0 can be broken down into the following more understandable layers:

- Physical Address – Identifies the actual device within a system. Typically the devices name or IP address can be used (for example Feeder_1 or 10.0.0.2)

- Logical Device – Identifies an 'area' within the physical device. This is the upper level of the UCA2.0 data model. For the MiCOM relays, only 1 logical device exists; UCA2, which contains the actual relay data model.

- Wrapper/Brick Instance – Identifies the major functional areas within the UCA2.0 data model. 6 characters are used to define the functional group (wrapper) while the actual functionality (brick name) is identified by a 5 character name. For example brick name MMXU1 represents Polyphase measurements. By preceding this brick name with a wrapper 'msistd' the brick instance can be identified as containing standard polyphase measurements. In MiCOM Px40, wrappers are split into internal and external wrappers to allow better and simpler identification. In this example, external wrapper 'msi' = measurements, internal wrapper 'std' = standard. Please see the data model overview section and wrapper glossary for details of the wrappers used in each product and their meanings.

- Functional Component – This next layer is used to identify the type of data you will be presented with. Taking the MMXU1 brick, choices at this level could be a functional component called MX (measurement values) or DC (descriptions).

- A Data Element/Data Leaf – This is the actual data. If data leaf 'A' is read under the MX Functional Component, a measurement value will be returned. If the same data leaf is read under the DC Functional Component then a description will be returned.

Combining all this information together, a typical request may be seen to be:

Feeder_1 → UCA2\msistdMMXU1.MX.A.

1.4 Summary

A UCA2.0 compliant device does not mean it is interchangeable, but does mean interoperable. You cannot simply replace one product with another, however the terminology is pre-defined and anyone with prior knowledge of UCA2.0 should be able very quickly integrate a new device without the need for mapping of all of the new data. UCA2.0 will inevitably bring improved substation communications and interoperability, at a lower cost to the end user.

1.5 Example of a Functional Component

Each brick within the data model has defined parts called object names, these are then split into standard Functional Components.

These Functional Components are:

Functional Component	Description
CF	Configuration parameter(s)
CO	Control point(s)
DC	Descriptive (Menu) text
MX	Measurement value(s)
RP	Report control block
SG	Settings that belong to a setting group
SP	Settings that do not belong to a setting group (global to all setting groups)
ST	Status point(s)

Table 1: List of Functional Component symbols and their descriptions.

For below example, the Admittance protection brick contains the 'Status Report Control Block' object (BrcbST). This belongs in the Functional Component RP and contains different Class Items such as BufTim, DatSet etc. These class items are where the actual data is stored.

Object Name	FC	Class Item	Description
BrcbST	Status Report Control Block		
	RP	BufTim	Buffer Time
	RP	DatSet	Data Set

Elements under all Functional Components except CF and RP have a description (DC [menu text]). Elements belonging to the SP, SG, CO and MX Functional Components also have configuration parameters (CF).

The configuration parameter (CF) Functional Component may contain the following components. Depending upon the brick and object it is associated with. Some may have only deadbands, some may have increments, max/min values and units.

- Incr/Incri – Setting Increment*
- Max/maxi – Maximum setting value*
- Min/mini – Minimum setting value*
- Db/dbf – Deadband value Integer, (f) indicates floating point deadband
- Ondur/offdur – On and Off duration for controls/commands
- U – Setting/Measurement units.

Note: * Components Incri/Maxi/Mini represents integer values instead of floating point.

2. INTRODUCTION TO UCA2.0 GOOSE

The implementation of UCA2.0 Generic Object Orientated Substation Events (GOOSE) sets the way for cheaper and faster inter-relay communications. UCA2.0 GOOSE is based upon the principle of reporting the state of a selection of binary (i.e. ON or OFF) signals to other devices. In the case of Px40 relays, these binary signals are derived from the Programmable Scheme Logic Digital Data Bus signals.

UCA2.0 GOOSE messages are event-driven. When a monitored point changes state, e.g. from logic 0 to logic 1, a new message is sent. The device will wait for a pre-calculated time and then re-send the message. The calculation of this delay time is defined by GOMFSE. It increases with each re-transmission until the maximum delay time is reached (defined by the GOOSE Max Cycle setting).

To ensure the fastest possible transfer of information, UCA2.0 GOOSE messages are sent as multicast packets over the network. An advantage to this method is the fact that all devices connected to the same network* will see the message.

Note: * Multicast messages cannot be routed across networks without specialised equipment.

The use of multicast messaging means that UCA2.0 GOOSE uses a publisher-subscriber system to transfer information around the network. When a device detects a change in one of it's monitored status points it publishes (i.e. sends) a message. Any device that is interested in the information subscribes (i.e. listens) to the data it contains.

2.1 UCA2.0 GOOSE Message Structure

The structure of information transmitted via UCA2.0 GOOSE is defined by the 'Protection Action' (PACT) common class template, defined by GOMFSE.

A UCA2.0 GOOSE message transmitted by a Px40 relay can carry up to 96 Digital Data Bus signals, where the monitored signals are characterised by a two-bit status value, or "bit-pair". The value transmitted in the bit-pair is customisable although GOMFSE recommends the following assignments:

Bit Pair value	Represents
00	A transitional or unknown state
01	A logical 0 or OFF state
10	A logical 1 or ON state
11	An invalid state

Table 2: UCA2.0 GOOSE message bit-pair assignment values.

The PACT common class splits the contents of a UCA2.0 GOOSE message into two main parts; 32 DNA bit-pairs and 64 User Status bit-pairs.

The DNA bit-pairs are intended to carry GOMSFE defined protection scheme information, where supported by the device. MiCOM Px40 implementation provides full end-user flexibility, as it is possible to assign any Digital Data Bus signal to any of the 32 DNA bit-pairs. The User Status bit pairs are intended to carry all 'user-defined' state and control information. As with the DNA, it is possible to assign any Digital Data Bus signal to these bit-pairs.

To ensure full compatibility with third party UCA2.0 GOOSE enabled products, it is recommended that the DNA bit-pair assignments are as per the definition given in GOMFSE.

2.2 UCA2.0 GOOSE Message Configuration

A new UCA2.0 GOOSE message is transmitted whenever a monitored signal changes state (e.g. from logic 0 to logic 1). The reception of these messages in the presence of noise must be considered. Subscribing devices are reliant on the message reception in order to track the state of the device. Following a change of state, the bit-pairs being transmitted must be acquired dependably.

To ensure reliable reception of a device's state, a message retransmission strategy is used. This strategy works very well in the presence of burst noise. The probability of a single corrupted or missed message is greater than the probability of two successive corrupted or missed messages. This reduces rapidly as more messages are transmitted. It therefore seem sensible to rapidly transmit many UCA2.0 GOOSE messages in the hope that at least some will be received in the order of 10ms. However, rapidly transmitting many UCA2.0 GOOSE messages consumes available network bandwidth and increases the probability of collision delays. Network availability for other devices and protocols also decreases. Thus, the design of a UCA2.0 GOOSE scheme must allow sufficient network access time to all devices and other protocols, in order for the scheme to work reliably.

The reliability of a UCA2.0 GOOSE scheme relates to the maximum time that can elapse between message retransmissions, before the validity period expires. Each message has a validity period, if this is reached, the message is deemed to have expired. This is unacceptable, as you will no longer be sure of the device's state. When a message expires in this way, the subscribing device will revert to a set of safe default values. In order to prevent a message from expiring, a new (or retransmitted) message must be received within the expiry period.

Reliable schemes use a low message rate, which leads to the opposing demands of scheme dependability, which requires a high message rate. Reliable schemes achieve good network utilisation, while the increased message rate of a dependable scheme increases the probability that the message is received in the order of 10 milliseconds. To make matters worse, these attributes are affected by many other parameters, some of which are:

- number of transmitting devices on the network
- responsiveness of the scheme to new events
- probability of simultaneous event message transmission
- probability of event avalanches
- probability of message corruption on the network
- ability of the network infrastructure to manage simultaneous broadcast/multicast messages

In practise, these parameters, which control the message transmission curves, cannot be calculated. Time must be allocated to the testing of schemes in just the same way a hardwired scheme must be tested.

As devices are added to the network, the number of possible interactions increases and the scope for error widens. Scheme availability can be decreased if interactions have not been adequately tested (in a realistic commissioning time). However, it should be noted that the message retransmission parameters would not affect the basic operation of UCA2.0 GOOSE, only its performance, especially under high event levels.

The parameters that control the message transmission curve are the Minimum Cycle time, Maximum Cycle time, and GOOSE Increment settings.

The Minimum Cycle time is the time between the first event driven message being transmitted and the first re-transmission. GOMFSE states that the minimum retransmission time will be in the order of 10ms.

The Maximum Cycle time is the maximum time between message retransmissions.

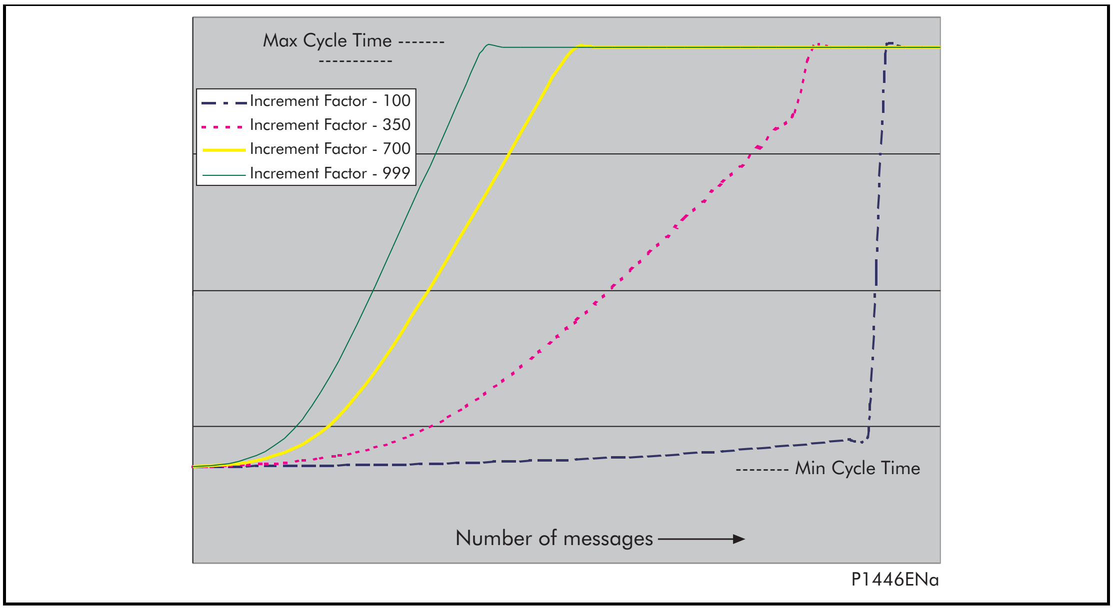


Figure 2: GOOSE message transmission rates

The Increment determines the rate at which the message 'steps-up' from Min cycle time to max cycle time, as shown in figure 2.

The validity of a message before it expires is double the maximum cycle time plus the minimum cycle time.

The general guidelines for establishing these parameters can be summarised as:

- Determine the minimum cycle time. GOMSFE recommends a value in the order of 10ms. However, if multiple devices can be triggered to transmit a new message simultaneously then the minimum cycle time values applied to each device should be different. This reduces the probability of experiencing message collisions, and increases reliability. The use of similar values may not produce sufficient time differentiation on the network to be of significant use. This limits the number of practical values that may be used whilst remaining close to the 10ms objective set by GOMSFE.

- Determine the maximum duration that a sending device's messages are valid. Given each device's minimum cycle time, the maximum cycle time will be half the message valid time, minus the minimum cycle time. A typical message valid time value for an inter-tripping scheme is 2s, which gives a typical maximum cycle time of 1s. Blocking schemes are typically more tolerant and message validity times can be extended.

- The increment value should be chosen such that it is as small as possible but different for each device sharing a common (or similar) minimum cycle time value. This will provide a degree of time differentiation as retransmissions occur. Small increment values cause the retransmission delay to slowly increase to the maximum value (increasing dependability), whereas a large increment value will cause it to rapidly increase (increasing reliability). See figure 2.

- Analysing which devices in the scheme are likely to respond simultaneously may require the subdivision of a scheme into smaller clusters of devices. This may also help in determining the retransmission parameters. Splitting large networks into smaller segments using routers etc. will help limit the effects of GOOSE message avalanches, but will require specialist equipment to pass (route) GOOSE messages between isolated segments.

3. UCA2.0 IN MiCOM PX40

UCA2.0 is implemented in MiCOM Px40 relays by use of a separate Ethernet Card. This card manages the majority of the UCA2.0 implementation and data transfer to avoid any impact on the performance of the protection.

3.1 Capability

The UCA2.0 interface provides the following capabilities:

1. Read and Write access to relay settings and controls.

   Setting cells associated with Control & Support functions (settings that do not belong to a protection group) are available in the Set Point (SP) Functional Component of a UCA2.0 brick.

   Setting cells associated with Protection & Control functions (settings that belong to a protection group) are available in the Setting Group (SG) Functional Component of a UCA2.0 brick.

2. Read access to measurements.

   All measurands are presented under the Measurement (MX) Functional Component of any supporting UCA2.0 brick.

3. Generation of reports on changes of measurements.

   Measurement reports can be generated when user-defined criteria have been met. This will usually be in the form of a setting such as percentage change of a measurement (deadband). Reports are available for configuration under the Reporting (RP) Functional Component of a UCA2.0 brick.

4. Generation of reports when an event record is created.

   Status reports can be generated by Protection events when user-defined reporting criteria have been met. This will usually be as a result of a protection element, such as Phase Overcurrent, starting or tripping. Reports are available for configuration under the Reporting (RP) Functional Component of a UCA2.0 brick.

5. Support for time synchronisation over an Ethernet link.

   Time synchronisation is supported using SMP (Station Management Protocol); this protocol is used to synchronise the internal real time clock of the relays. For further information on this protocol, please visit www.sisconet.com

6. GOOSE Peer-to-Peer Communication

   GOOSE communications are included as part of the UCA2.0 implementation. Please see sections 2 and 4 for more details.

7. Disturbance Record Extraction

   Extraction of disturbance records is supported by the MiCOM Px40 relays. The record is extracted as an ASCII format COMTRADE file.

3.2 Network Connectivity

Note: This section presumes a prior knowledge of IP addressing and related topics. Further details on this topic may be found on the Internet (search for IP Configuration) and in numerous relevant books.

When configuring the relay for operation on a network, a unique IP address must be set on the relay. If the assigned IP address is duplicated elsewhere on the same network, the remote communications will operate in an indeterminate way. However, the relay will check for a conflict on every IP configuration change and at power up. An alarm will be raised if an IP conflict is detected. Similarly, a relay set with an invalid IP configuration (or factory default) will also cause an alarm to be displayed (Bad TCP/IP Cfg.).

The relay can be configured to accept data from networks other than the local network by using the 'Router Address' and 'Target Network' settings. The Router Address is the IP address of the router that is providing the sub-network interconnectivity. The Target Network is the base IP address of the remote network. Setting the Target Network to 000.000.000.000 will force the relay to use the specified router as the 'default gateway' for all data other than that produced on the local network.

3.3 Access to Measurements

All the relay measurements are presented over UCA2.0 using the 'Measurement' functional component (MX) or parts of it. Reported measurement values are refreshed by the relay once per second, inline with the relay User Interface. All measurements supported are listed in the product data model.

3.4 Settings

3.4.1 Remote Setting Management

The UCA2.0 interface provides access to all setting groups within the relay. The visible setting group can be changed by the control 'EditSG' within the 'GLOBE' brick (write to this control).

The active setting group is changed by the control 'ActSG' within the 'GLOBE' brick, with the value of the corresponding setting group (Group2 = 2 etc) to make active. If the specified setting group is disabled, an error response will be generated. Changing the active setting group does not affect the setting group visible for editing over the UCA2.0 interface.

Setting groups can be enabled or disabled, however it is possible to view any setting group regardless if disabled. It is not possible to set a disabled setting group as the active group, equally, it is not possible to disable the active setting group.

To confirm changes made within a setting group, the control 'SaveSG' in the GLOBE brick must be used. Writing a value (1, 2, 3 or 4) to 'SaveSG' will save any changes made to the corresponding setting group number.

3.4.2 Accessing Settings and Controls

The UCA2.0 interface is able to read and write to both control and support settings (through the 'Set Point', SP functional component). The protection settings use the 'Group Set Point', SG functional component.

The limits for settings are presented using the 'Configuration' (CF) functional component. Cell menu text is included through the use of the 'Description' (DC) functional component as UCA2.0 is not capable of transmitting settings as text strings. Such settings are enumerated, meaning simply that the choice is represented by a number instead of text. This enumeration is shown in the product data model.

Command cells are interpreted as UCA2.0 controls and are available for write access in the 'Control' (CO) functional component.

3.4.3 UCA2.0 Settings & Statistics

The following settings and data allow support for the UCA2.0 implementation. Settings are detailed and explained in the following section. GOOSE statistics shown are used to monitor the GOOSE activity between relays.

Col	Row	Description
0E	1F	Ethernet Comms
0E	20	IP Address
0E	21	Subnet Mask
0E	22	MAC Address
0E	23	GOOSE IED Name
0E	24	Number of Routes
0E	25	Router Address 1

Col	Row	Name
0E	34	GOOSE VIP Status
0E	3D	Ethernet Media
0E	3F	GOOSE STATISTICS
0E	40	Enrolled Flags
0E	41	Tx Msg Count.
0E	42	Rx Msg Count.
0E	43	DDB Changes

Col	Row	Description
0E	26	Target Network 1
0E	27	Router Address 2
0E	28	Target Network 2
0E	29	Router Address 3
0E	2A	Target Network 3
0E	2B	Router Address 4
0E	2C	Target Address 4
0E	2D	Inactivity Timer
0E	2E	Default Pass Level
0E	2F	GOOSE Min Cycle
0E	30	GOOSE Max Cycle
0E	31	GOOSE Increment
0E	32	GOOSE Startup

Col	Row	Name
0E	44	Last Seq Tx
0E	45	Last Msg Tx
0E	46	Msg Reject Count
0E	50	IED View Select
0E	51	IED Recvd Msgs
0E	52	IED Last Seq Rx
0E	53	IED Last Msg Rx
0E	54	IED Missed msgs
0E	55	IED Missed chngs
0E	56	IED Timeouts
0E	5F	IED Stats Reset
0E	6A	Report Link Test
0E	6B	Link Time-Out

3.4.4 UCA2.0 Connection Settings

The settings shown are those configurable to allow the UCA2.0 interface to operate. These are available in the menu ‘Communications’ column.

Setting	Range	Description
IP Address*	000.000.000.000 to 255.255.255.255	Unique network IP address that identifies the relay.
Subnet Mask*	000.000.000.000 to 255.255.255.255	Identifies the sub-network that the relay is connected to.
Number of Routes	0 to 4	The number of routers/target networks that the relay will recognise.
Router Address 1*	000.000.000.000 to 255.255.255.255	Address of a router on the same network as the relay.
Target Network 1*	000.000.000.000 to 255.255.255.255	Address of the network that router1 will connect. If IP address 000.000.000.000, the above router acts as the default router.
Router Address 2*	000.000.000.000 to 255.255.255.255	As Router Address 1.
Target Network 2*	000.000.000.000 to 255.255.255.255	As Target Network 1.
Router Address 3*	000.000.000.000 to 255.255.255.255	As Router Address 1.
Target Network 3*	000.000.000.000 to 255.255.255.255	As Target Network 1.
Router Address 4*	000.000.000.000 to 255.255.255.255	As Router Address 1.
Target Network 4*	000.000.000.000 to 255.255.255.255	As Target Network 1.
Inactivity Timer	1 to 30	Minutes of inactivity before the relay releases a client’s database lock.
Default Pass Lvl	0 to 2	Default password level assigned to new client connections. The connected client can change password level at any time.
Ethernet Media*	Copper or Fibre	The media type that the relay will communicate on.

Note: * Changing Ethernet Media setting forces all client connections to close and the Ethernet card to reboot.

4. UCA2.0 GOOSE IN PX40

Enrolling a UCA2.0 GOOSE device is done through the Px40's GOOSE Scheme Logic. Each UCA2.0 GOOSE enabled device on the network transmits messages using a unique "Sending IED" name. If a relay is interested in receiving data from this device, the "Sending IED" name is simply added to the relay's list of 'interested devices'.

UCA 2.0 GOOSE is normally disabled in the MiCOM Px40 products and is enabled by downloading a GOOSE Scheme Logic file that is customised.

4.1 UCA2.0 GOOSE Configuration

4.1.1 Configuration Overview

The GOOSE Scheme Logic editor is used to enrol devices and also to provide support for mapping the Digital Data Bus signals (from the Programmable Scheme Logic) onto the UCA2.0 GOOSE bit-pairs.

If the relay is interested in data from other UCA2.0 GOOSE devices, their "Sending IED" names are added as '*enrolled*' devices within the GOOSE Scheme Logic. The GOOSE Scheme Logic editor then allows the mapping of incoming UCA2.0 GOOSE message bit-pairs onto Digital Data Bus signals for use within the Programmable Scheme Logic.

The UCA2.0 GOOSE messaging is configured by way of the min cycle time, max cycle time, Increment and message life period. Due to the risk of incorrect operation, specific care should be taken to ensure that the configuration is correct. For further details on configuring the messaging, please see section 2.2 above.

4.1.2 Virtual Inputs

The GOOSE Scheme Logic interfaces with the Programmable Scheme Logic by means of 32 Virtual Inputs. The Virtual Inputs are then used in much the same way as the Opto Status Inputs.

The logic that drives each of the Virtual Inputs is contained within the relay's GOOSE Scheme Logic file. It is possible to map any number of bit-pairs, from any enrolled device, using logic gates onto a Virtual Input.

The following gate types are supported within the GOOSE Scheme Logic:

Gate Type	Operation
AND	The GOOSE Virtual Input will only be logic 1 (i.e. ON) when all bit-pairs match the desired state.
OR	The GOOSE Virtual Input will be logic 1 (i.e. ON) when any bit-pair matches its desired state.
PROGRAMMABLE	The GOOSE Virtual Input will only be logic 1 (i.e. ON) when the majority of the bit-pairs match their desired state.

Table 3: Supported GOOSE Scheme Logic gates

In terms of Programmable Scheme Logic, GOOSE Virtual Inputs are used in the same way as the Opto Input signals. They can be used for anything from inputs to complex logic implementations or directly mapped onto a programmable LED or relay contact output.

4.1.3 Virtual Outputs

The Programmable Scheme Logic provides 32 Virtual Output signals that can be connected to incoming signals or outputs of logic gates. The Virtual Outputs are used in much the same way as contact output signals and their use can simplify otherwise complex logic assignments between Programmable Scheme Logic and GOOSE Scheme Logic bit-pairs. Any Digital Data Bus signal can be assigned to GOOSE Scheme Logic bit-pairs, not just the Virtual Outputs.

4.2 UCA2.0 GOOSE Processing & Pre-sets

Under certain circumstances, it may be necessary to force a bit-pair to be a pre-set value. This could be used for testing or when certain operating conditions exist.

4.2.1 Pre-processing

Prior to a UCA2.0 GOOSE message being transmitted, the DNA and User Status bit-pairs can be forced to pre-set values as required. This is accomplished on a 'per bit-pair' basis either off-line using the GOOSE Scheme Logic editor or on-line using the following components of the GLOBE UCA2 data model brick:

- SelOutDNA

  Output selection for DNA bit pairs (pass through or preset)

- SelOutUserSt

  Output selection for UserSt bit pairs (pass through or preset)

  - PresetDNA *
  - Preset values for DNA bit pairs
  - PresetUserSt *
  - Preset values for UserSt bit pairs

Note: * Not used when SelOutDNA and SelOutUserSt are pass through.

4.2.2 Post-processing

Immediately after receiving a UCA2.0 GOOSE message, the DNA and User Status bit-pairs are processed and can be set to one of three possible values; Pass through, default or forced. The selection is controlled off-line using the GOOSE Scheme editor or on-line using the following components of the GLOBE UCA2 data model brick:

- SelinDNA

  Input selection for DNA bit pairs (pass though, default or forced)

- SelinUserSt

  Input selection for UserSt bit pairs (pass though, default or forced)

  - DefDNA *

    Default values for DNA bit pairs

    - ForDNA *

      Forced values for DNA bit pairs

    - DefUserSt *

      Default values for UserSt bit pairs

    - ForUserSt *

      Forced values for UserSt bit pairs

Note: * Not used when SelinDNA and SelinUserSt are pass through.

The input selection is accomplished on a 'per bit-pair' basis where; 'Pass through' uses the data received in the message. 'Default' uses a set of scheme safe values suitable if a device is unable to transmit messages. ' Forced' uses a set of overriding values for exercising required scheme functionality.

4.3 UCA2.0 GOOSE Start-up modes

The MiCOM implementation supports two UCA2.0 GOOSE start-up modes. Promiscuous start-up is compatible with all UCA2.0 GOOSE devices. Broadcast start-up is specific to MiCOM devices and may not be compatible with other UCA2.0 GOOSE devices.

Within a single scheme, the start-up mode across all devices must be consistent to guarantee scheme operation.

4.3.1 Promiscuous Start-up

When a MiCOM relay switches on, the UCA2.0 GOOSE processes will be initiated. At this point, the relay knows its own configuration and from which other devices UCA2.0 GOOSE messages will be received.

The Ethernet hardware will be set into a promiscuous mode of operation, whereby it will receive all Ethernet messages regardless of their target address. When in promiscuous mode, unwanted messages will be filtered by examining the destination MAC address. It will accept messages under the following conditions:

- Those addressed to the relay.
- All multicast messages.
- All broadcast messages

All received UCA2.0 GOOSE messages will be checked against the scheme configuration. If the relay has subscribed to the received message, the transmitting device's MAC address is recorded (enrolled).

When all subscribed devices have been enrolled, the relay will revert from promiscuous mode and enter normal mode to receive messages from the specified multicast MAC addresses of the enrolled devices.

When starting, the relay will transmit a message as soon as the DNA and User status bit-pairs are in a valid state. This allows subscribing devices to enrol this relay's MAC address.

If a received message is timed out, a network problem is deemed to exist and the Ethernet hardware will be placed in promiscuous mode. All messages will be monitored until the failed device(s) re-appear.

The promiscuous method places extra load on the relay when one or more subscribed devices are not operational and transmitting messages. This may be a problem in systems where there is much network traffic as there is chance that schemes may start experiencing problems.

4.3.2 Broadcast Start-up

When a MiCOM relay switches on, the UCA2.0 GOOSE process is initiated. At this point the relay knows its own configuration and from which other devices messages will be received.

The starting relay will broadcast (rather than multicast) a set of messages as soon as the DNA and User status bit-pairs are in a valid state. Other MiCOM devices on the network will recognise this broadcast message. If subscribed to the starting device, its MAC address is recorded and a message is transmitted back to the device (addressed not broadcast or multicast). This allows the starting device to configure its own GOOSE management. If the starting relay has subscribed to the received message, the transmitting device's MAC address is (enrolled).

This broadcast mechanism allows the starting device to construct a list of transmitting devices (from the returned messages), and allows other devices on the network to enrol the starting device. This approach achieves a known scheme state in a faster time when compared to the promiscuous start-up.

4.4 Ethernet Hardware

The optional Ethernet card (ZN0012) has 2 variants which supports the UCA2.0 implementation, one card with RJ45 and ST (10Mb card), the other with RJ45 and SC (100Mb card). This allows the following connection media:

- 10BASE-T – 10Mb Copper Connection (RJ45 type)
- 10BASE-FL – 10Mb Fibre Optic Connection (ST type)
- 100BASE-TX – 100Mb Copper Connection (RJ45 type)

- 100BASE-FX – 100Mb Fibre Optic Connection (SC type)

This card is fitted into Slot A of the relay, which is the optional communications slot

When using UCA2.0 communications through the Ethernet Card, the rear RS485 and front RS232 ports are also available for simultaneous use, using the Courier Protocol.

Each Ethernet card has a unique ‘Mac address’ used for Ethernet communications, this is also printed on the rear of the card, alongside the Ethernet sockets.

4.4.1 Ethernet Disconnection

UCA2.0 ‘Associations’ are unique and made to the relay between the client (master) and server (UCA2.0 device). In the event that the Ethernet is disconnected, such associations cannot be remade. Since there is no more interaction via the old association, the relay cancels it making it available for other clients.

4.4.2 Loss Of Power

The relay allows the re-establishment of associations without a negative impact on the relays operation after having its power removed. As the relay acts as a server in this process, the client must request the association. Uncommitted setting are cancelled when power is lost, and reports requested by connected clients are reset and must be re-enabled by the client when it next creates the new association to the relay.

5. P540 UCA2.0 DATA MODEL DESCRIPTION

The P54x Current Differential Protection relay data model presented in this document covers four models (P543 to P546) and relates to Version 20 software release only. This document is designed to contain an overview of the data model. The full data model is available alongside all other product documentation from www.alstom.com, your local sales representative or our 24 hour customer contact centre on +44 (0)1785 250070.

The reader of this document is expected to be conversant with UCA2.0 and GOMSFE V0.92 terminology and have read the other UCA2.0 documentation in this chapter of the service manual.

5.1 Data Model Overview

The “UCA2” logical device data model consists of many bricks and wrappers. UCA2.0 specifies a 6 character string for a wrapper. To ensure ease of identification in MiCOM Px40 products, these wrappers are split into Internal and External Wrappers, each with 3 characters as below. These are listed in the following table along with the bricks used in this product range and their description.

External Wrapper	Internal Wrapper	Brick	Index	Description
		GLOBE	0	The globe instance
alm		GALM	1	Generic Alarms
asc		RFGP	0	System Checks - Function Configuration
		RSYN	0	System Checks - Common Configuration
asc	spl	RSYN	1	System Checks - System Split (Stage 1)
asc	syn	RSYN	0	System Checks - Check Sync Common Configuration
		RSYN	1	System Checks - Check Sync (Stage 1)
		RSYN	2	System Checks - Check Sync (Stage 2)
bkc		PBKC	1	Broken Conductor (I2/I1) Protection
cbf		RCBF	1	Circuit Breaker Failure Protection
cbr		XCBR	0	Circuit Breaker Control / Monitoring - Common Settings
		XCBR	1	Circuit Breaker 1 Control / Monitoring
		XCBR	2	Circuit Breaker 2 Control / Monitoring
ctl	inp	GCTL	1	Control inputs to relay logic (PSL)
ctl	lbl	RLBL	1	Labels for Control inputs (ctlinpGCTL1)
ctl	mod	GESP	1	Operation Mode (Pulsed/Latched) for Control inputs (ctlinpGCTL)
dif		PDIF	0	Current Differential Protection - Common Settings
		RCOM	0	Current Differential Protection - Common Communications Configuration
		RFGP	0	Current Differential Protection - Configuration
dif	cap	PDIF	0	Current Differential Protection - Capacitive charging current susceptance setting
dif	chn	RCOM	1	Current Differential Protection Channel 1 - Communications Configuration
		RCOM	2	Current Differential Protection Channel 2 - Communications Configuration

External Wrapper	Internal Wrapper	Brick	Index	Description
dif	end	PDIF	2	Current Differential Protection Two-ended System - Differential Settings
		PDIF	3	Current Differential Protection Three-ended System - Differential Settings
		RCOM	2	Current Differential Protection Two-ended System - Communications Configuration
		RCOM	3	Current Differential Protection Three-ended System - Communications Configuration
dif	gps	RFGP	1	Current Differential Protection GPS - Common Configuration
dis		PDIS	0	Distance Protection - Common Settings
dis	psb	PDIS	1	Distance Protection Power Swing / Blocking - Settings
dis	zon	PDIS	1	Distance Protection Zone 1 - Settings
		PDIS	2	Distance Protection Zone 2 - Settings
		PDIS	3	Distance Protection Zone 3 - Settings
efd		POCP	0	(Derived) Earth Fault Common Settings
efd	stg	PTOC	1	Earth Fault Stage 1 (Derived)
		PTOC	2	Earth Fault Stage 2 (Derived)
		PTOC	3	Earth Fault Stage 3 (Derived)
		PTOC	4	Earth Fault Stage 4 (Derived)
frc		FRCF	1	Fault Recorder Configuration
grp	cfg	RFGP	1	Setting Group 1 Control
		RFGP	2	Setting Group 2 Control
		RFGP	3	Setting Group 3 Control
		RFGP	4	Setting Group 4 Control
log		ILOG	1	Record Control
mcd	chn	MPCM	0	Current Differential Protection Communications Common Measurements
		MPCM	1	Current Differential Protection Communications Channel 1 Measurements
		MPCM	2	Current Differential Protection Communications Channel 2 Measurements
mcd	loc	MMXU	1	Local Current Differential Protection Measurements
mcd	rem	MMXU	1	Remote End 1 Current Differential Protection Measurements
		MMXU	2	Remote End 2 Current Differential Protection Measurements
mcd	std	MDIF	1	Current Differential Standard Measurements
msi		MCFG	0	Measurements Configuration
msi	dvd	MMXU	1	Derived Measurements
msi	fxd	MDMD	1	Fixed Demand Measurements
msi	mut	MSQI	1	Mutual Compensation Zero Sequence Measurements
msi	pek	MDMD	1	Peak Demand Measurements
msi	rms	MMXU	1	RMS Based Measurements

External Wrapper	Internal Wrapper	Brick	Index	Description
msi	rol	MDMD	1	Rolling Demand Measurements
msi	std	MFLO	1	Energy Flow Measurements
		MMXU	1	Standard Measurements
		MSQI	1	Sequence Measurements
		SYNC	1	Synchronism Check Measurements
opt	cfg	GESP	1	Opto-Isolated Status Inputs - Configuration
opt	fil	RFGP	1	Opto-Isolated Status Inputs - Power system frequency filter configuration
opt	lbl	RLBL	1	Opto-Isolated Status Inputs - Labels
opt	sts	GIND	1	Opto-Isolated Status Inputs - Status indicators
poc		POCP	0	Phase Overcurrent Common Settings
poc	stg	PTOC	1	Phase Overcurrent Stage 1
		PTOC	2	Phase Overcurrent Stage 2
		PTOC	3	Phase Overcurrent Stage 3
		PTOC	4	Phase Overcurrent Stage 4
rdr		RDRA	1	Disturbance Recorder Analogue Configuration
		RDRB	1	Disturbance Recorder Digital Configuration
		RDRE	1	Disturbance Record Extraction
rly	lbl	RLBL	1	Output contact - Labels
rly	sts	GIND	1	Output contact - Status
sen		RFGP	1	Sensitive Earth Fault (SEF) - Common settings
sen	sef	POCP	0	Sensitive Earth Fault Common Settings
		PTOC	1	Sensitive Earth Fault Stage 1
		PTOC	2	Sensitive Earth Fault stage 2
		PTOC	3	Sensitive Earth Fault Stage 3
		PTOC	4	Sensitive Earth Fault Stage 4
thm		PTHM	1	Thermal Protection
trp	mod	RFGP	1	Protection Tripping Mode Configuration (1 and 3-phase or 3-phase only)
tst		RTST	1	Commissioning Tests
txf	eft	RCTR	1	Neutral (Earth Fault) CT Ratio
txf	mut	RCTR	1	Mutual Compensation CT Ratio
txf	phs	RCTR	1	Phase CT Ratios
		RVTR	1	Phase VT Ratios
txf	syn	RVTR	1	Synchronisation Check VT Ratio
txs		RFGP	0	Transformer Supervision - Configuration
txs	vts	RTXS	1	Transformer Supervision - VT/PT

5.2 Device Identity

The Device Identify element provides a unique identity that describes the relay, its location, its classification etc. The Device Identity (DI) in the relay is defined as below:

Item	Supported	Description	Default Value	Access
Name	✓	Name of device	"P540"	read & write
Class	✓	Product classification	"Protective Relay"	read & write
d	✓	Description of device	"Line Differential"	read & write
Own	✓	Owner of device	""	read & write
Loc	✓	Location	""	read & write
VndID.Vnd	✓	The manufacturers name	"ALSTOM"	read & write
VndID.Mdl	✓	Device model number	device dependent	read
VndID. DevMdls	✓	Device model name	device dependent	read & write
VndID.SerNum	✓	The unique serial number	device dependent	read
VndID.SftRev	✓	The software version	device dependent	read
CommID. CommAdr	✓	Comm address on gateway side	device dependent	read
CommID. CommRev	✓	The revision of the transport	device dependent	read
CommID.Pro	✓	Protocol used on gateway side	device dependent	read
CommID.Med	✓	Medium used on gateway side	device dependent	read

Table 4: Device identity (DI) implementation.

5.3 Wrapper Glossary

External Wrapper	Description
alm	Alarm indications
asc	System Checks
bkc	Broken Conductor
cbf	Circuit breaker failure protection
cbr	Circuit Breaker Control / Monitoring
ctl	Control
dif	Current Differential Protection
dis	Distance Protection
efd	Earth Fault (Derived)
frc	Fault Recorder Configuration
grp	Setting group
log	Record Control
mcd	Measurements (Current Differential)
msi	Measurements (measured input quantity)

External Wrapper	Description
opt	Opto-isolated status input
poc	Phase Overcurrent protection
rdr	Disturbance Recorder Configuration
rly	Output contacts
sen	Sensitive Input related
thm	Thermal Protection
trp	Tripping
tst	Commissioning Tests
txf	Transformer
txs	Transformer supervision

Internal Wrapper	Description
cap	Capacitance
cfg	Configuration
chn	Channel (Communications)
dvd	Derived values
eft	Earth fault protection
end	end
fil	Filter
fxd	Fixed demand metering
gps	Global Positioning System
inp	Input(s)
lbl	Label
loc	Local
mod	Mode
mut	Mutual
pek	Peak demand metering
phs	3-phase
psb	Power swing / Blocking
rem	Remote
rms	RMS metering values
rol	Rolling demand metering
sef	Sensitive Earth Fault
spl	Split
std	Standard
stg	Stage
sts1	Status
syn	Synchronisation
vts	VT/PT supervision
zon	Zone

RELAY MENU DATABASE

MiCOM P541, P542, P543, P544, P545, P546 Guides

Current Differential Relays

Relay Menu Database

This version of the Relay Menu Database is specific to the following models

Model number	Software number
P541------0300J	P541------0300-A
P542------0300J	P542------0300-A
P543------0300J	P543------0300-A
P544------0300J	P544------0300-A
P545------0300J	P545------0300-A
P546------0300J	P546------0300-A

Details for model number P54x------0200G, Software number P54x------0200-E can be found in P54x/EN GC/G42

For other models / software versions, please contact
ALSTOM Grid - for the relevant information.

This chapter is split into several sections, these are as follows:

- Menu Database for Courier, User Interface and Modbus
- Menu Datatype Definition
- IEC60870-5-103 Interoperability Guide
- Event Data for Courier, User Interface and Modbus
- Internal Digital Signals
- DNP 3.0 Device Profile
- Default Programmable Logic

Menu database

This database defines the structure of the relay menu for the courier interface, the front panel user interface and the Modbus interface. This includes all of the relay settings and measurements. Datatypes for Modbus and indexed strings for Courier and the user interface are cross-referenced to the Menu Datatype Definition section (using a G Number). For all settable cells the setting limits and default value are also defined within this database.

Note: The following labels are used within the database

Label	Description	Value
V1	Main VT Rating	1 (100/110V)
V2	Checksynch VT Rating	1 (100/110V)
V3	NVD VT Rating	1 (100/110V)
I1	Phase CT Rating	1 or 5 (Setting 0A08)
I2	Earth Fault CT Rating	1 or 5 (Setting 0A0A)
I3	Sensitive CT Rating	1 or 5 (Setting 0A0C)
I4	Mutual CT Rating	1 or 5 (Setting 0A0E)

Menu datatype definition

This table defines the datatypes used for Modbus (the datatypes for the Courier and user interface are defined within the Menu Database itself using the standard Courier Datatypes). This section also defines the indexed string setting options for all interfaces. The datatypes defined within this section are cross-referenced to from the menu Database using a G number.

IEC60870-5-103 Interoperability guide

This table fully defines the operation of the IEC60870-5-103 (VDEW) interface for the relay it should be read in conjunction with the relevant section of the SCADA Communications chapter of this manual (P54x/EN CT).

Event data

This section of the appendix specifies all the event information that can be produced by the relay. It details exactly how each event will be presented via the Courier, User and Modbus interfaces.

Internal digital signals

This table defines all of the relay internal digital signals (opto inputs, output contacts and protection inputs and outputs). A relay may have up to 512 internal signals each referenced by a numeric index as shown in this table. This numeric index is used to select a signal for the commissioning monitor port. It is also used to explicitly define protection events produced by the relay (see the Event Data section of this Appendix).

DNP 3.0 Device Profile

This table fully defines the operation of the DNP 3.0 interface for the relay it should be read in conjunction with the relevant section of the SCADA Communications Chapter of this Manual (P54x/EN CT).

UCA2.0

Protocol Implementation & Conformance Statement (PICS).

The table gives the PICS for models P543 to P546.

Default programmable logic

This section documents the default programmable logic for the various models of the relay. This default logic for each model of the relay is supplied with the MiCOM S1 Scheme Logic Editor PC support software.

References

P54x/EN IT - Introduction: User Interface operation and connections to the relay

P54x/EN CT - Communications: Overview of communication interfaces

Courier User Guide R6512

Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev E

IEC60870-5-103 Telecontrol Equipment and Systems – Transmission Protocols – Companion Standard for the informative interface of Protection Equipment.

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
SYSTEM DATA		00	00												*	*	*	*	*	*	
Language			01	Indexed String	G19			G19	English	Setting	0	3	1	2	*	*	*	*	*	*	Sets only for interface being used
Password			02	ASCII Password (4)	G20	40001	40002	G20	AAAA	Setting	65	90	1	0	*	*	*	*	*	*	Sets only for interface being used
Sys Fn Links			03	Binary Flag (1) Indexed String	G95	40003		G95	0	Setting	1	1	1	2	*	*	*	*	*	*	
Description			04	ASCII Text (16)		40004	40011	G3	MiCOM P54x	Setting	32	163	1	2	*	*	*	*	*	*	
Plant Reference			05	ASCII Text (16)		40012	40019	G3	ALSTOM	Setting	32	163	1	2	*	*	*	*	*	*	
Model Number			06	ASCII Text (32)		30020	30035	G3	Model Number	Data					*	*	*	*	*	*	
Firmware Number			07	ASCII Text (16)				G3	Firmware Number	Data											
Serial Number			08	ASCII Text (7)		30044	30051	G3	Serial Number	Data					*	*	*	*	*	*	
Frequency			09	Unsigned Integer (16 bits)		40020		G1	50	Setting	50	60	10	2	*	*	*	*	*	*	
Comms Level			0A	Unsigned Integer (16 bits)					1	Data					*	*	*	*	*	*	
Relay Address			0B	Unsigned Integer (16 bits)					255	Setting	0	255	1	1	*	*	*	*	*	*	Address of interface Rear Courier Address available via LCD
				Binary Flag (16)		30001		G26		Data					*	*	*	*	*	*	Modbus only (Relay status)
Plant Status			0C	Binary Flag (16)		30002	30003	G4		Data					*	*	*	*	*	*	
Control Status			0D	Binary Flag (16)		30004	30005	G5		Data					*	*	*	*	*	*	
Active Group			0E	Unsigned Integer (16 bits)		30006		G1		Data					*	*	*	*	*	*	
UNUSED			0F																		
CB Trip/Close			10	Indexed String	G55				No Operation	Command	0	2	1	1	*	*	*		*		Visible to LCD+Front Port
CB Trip/Close			10					G55	No Operation	Command	0	10	1	1				*		*	Visible to LCD + Front Port
CB Trip/Close	N/A		10	Indexed String	G55	40021		G55	No Operation	Command	0	2	1	1	*	*	*		*		Visible to Rear Port
CB Trip/Close			10	Indexed String	G55	40021		G55	No Operation	Command	0	10	1	1				*		*	Visible to Rear Port
Software Ref. 1			11	ASCII Text (16)		30052	30059	G3		Data					*	*	*	*	*	*	
Software Ref. 2			12	ASCII Text (16)		30060	30067	G3		Data											
Software Ref. 3			13	ASCII Text (16)		30068	30075	G3		Data											
Software Ref. 4			14	ASCII Text (16)		30076	30083	G3		Data											
UNUSED			15-1F																		
Opto I/P Status			20	Binary Flag (16) Indexed String		30007		G8		Data					*	*	*	*			
Opto I/P Status			20	Binary Flag (24) Indexed String		30725	30726	G27		Data					*	*	*	*	*	*	
Relay O/P Status			21	Binary Flag (32) Indexed String		30008	30009	G9		Data					*	*	*	*	*	*	
Alarm Status 1			22	Binary Flag (32) Indexed String		30011	30012	G96		Data					*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
UNUSED			23																		
Alarm Status 1 (Copy of 0022)			50	Binary Flag (32) Indexed String						Data					*	*	*	*	*	*	
Alarm Status 2			51	Binary Flag (32) Indexed String		30013	30014	G128		Data					*	*	*	*	*	*	
Alarm Status 3			52	Binary Flag (32) Indexed String		30015	30016	G228		Data					*	*	*	*	*	*	
Access Level			D0	Unsigned Integer (16 bits)	G1	30010		G1		Data					*	*	*	*	*	*	
Password Control			D1	Unsigned Integer (16 bits)	G22	40022		G22	2	Setting	0	2	1	2	*	*	*	*	*	*	Sets only for interface being used
Password Level 1			D2	ASCII Password (4)	G20	40023	40024	G20	AAAA	Setting	65	90	1	1	*	*	*	*	*	*	Sets only for interface being used
Password Level 2			D3	ASCII Password (4)	G20	40025	40026	G20	AAAA	Setting	65	90	1	2	*	*	*	*	*	*	Sets only for interface being used
Reserved for levels > 2			D4-D8																		
VIEW RECORDS		01	00												*	*	*	*	*	*	
						30100 30101 30102		G1 G1 G1							* * *	* * *	* * *	* * *	* * *	* * *	No of event records stored Number of Fault records stored No of Maintenance Records stored
Select Event [0...n]			01	Unsigned Integer (16 bits)		40112			0	Setting	0	249	1	0	*	*	*	*	*	*	Max value is oldest record n is last event record.
Menu Cell Ref	N/A		02	Cell Reference		30107		G13	(From Record)	Data					*	*	*	*	*	*	Indicates type of event See Event sheet
Time & Date			03	IEC870 Time & Date		30103	30106	G12	(From Record)	Data					*	*	*	*	*	*	
Event Text			04	ASCII Text (32)						Data					*	*	*	*	*	*	See Event sheet
Event Value			05	Binary Flag (32)/UINT32		30108	30109	G27		Data					*	*	*	*	*	*	Note DTL depends on event type See Event sheet
Select Fault [0...n]			06	Unsigned Integer (16 bits)		40101		G1	0	Setting	0	4	1	0	*	*	*	*	*	*	Allows Fault Record to be selected n is last fault record
						30110		G1							*	*	*	*	*	*	Modbus address where change occurred Alarm 30011; Relay 30723, Opto 30725
						30111		G1							*	*	*	*	*	*	State of current 16 ddb elements
						30112		G1							*	*	*	*	*	*	Additional data present
Started Phase A B C N		N/A								Data					*	*	*	*	*	*	A/B/C/N Visible if Start A/B/C/N
Tripped Phase A B C N		N/A								Data					*	*	*	*	*	*	A/B/C/N Visible if Trip A/B/C/N
Current Diff Start		N/A								Data					*	*	*	*	*	*	
Current Diff Trip InterTrip / Stub Bus		N/A								Data					*	*	*	 *	*	 *	InterTrip & Stub Bus mutually exclusive Stub Bus only present in Model 4
Intertrips PIT DIT Dist I>3		N/A								Data					*	*	*	*	*	*	
Distance Start Z1 Z2 Z3		N/A								Data							*	*	*	*	Z1/Z2/Z3 if Start Z1/Z2/Z3
Distance Trip Z1 Z2 Z3		N/A								Data							*	*	*	*	Z1/Z2/Z3 if Trip Z1/Z2/Z3
Overcurrent Start I> 1234		N/A								Data					*	*	*	*	*	*	1/2/3/4 Visible if Start I>1/2/3/4
Overcurrent Trip I> 1234		N/A								Data					*	*	*	*	*	*	1/2/3/4 Visible if Trip I>1/2/3/4
Broken Conductor Trip		N/A								Data					*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Earth Fault Start IN> 1234		N/A								Data					*	*	*	*	*	*	1/2/3/4 visible if Start IN>1/2/3/4
Earth Fault Trip IN> 1234		N/A								Data					*	*	*	*	*	*	1/2/3/4 visible if Trip IN>1/2/3/4
Sensitive E/F Start ISEF> 1234		N/A								Data							*	*	*	*	1/2/3/4 visible if Start ISEF>1/2/3/4
Sensitive E/F Trip ISEF> 1234		N/A								Data							*	*	*	*	1/2/3/4 visible if Trip ISEF>1/2/3/4
Thermal Overload Alarm Trip		N/A								Data					*	*	*	*	*	*	
Breaker Fail CB Fail		N/A								Data					*	*	*	*	*	*	1/2 visible if CB Fail 1/2
Supervision VTS PSB		N/A								Data							*	*	*	*	VTS/PSB visible if AlarmVTS/PSB
A/R State Trip 1 2 3 4 5		N/A								Data						*	*		*		1/2/3/4/5 visible if SC:Count 1/2/3/4/5
Faulted Phase	N/A		07	Binary Flag (8)	G16	30113		G16		Data					*	*	*	*	*	*	Started phases + tripped phases
Start Elements	N/A		08	Binary Flag (32) Indexed String	G84	30114	30115	G84		Data					*	*	*	*	*	*	Started Elements
Start Elements 2	N/A		09	Binary Flag (32) Indexed String	G84			G84		Data											Started Elements 2
Trip Elements(1)	N/A		0A	Binary Flag (32) Indexed String	G85	30116	30117	G85		Data					*	*	*	*	*	*	Tripped main elements
Trip Elements(2)	N/A		0B	Binary Flag (32) Indexed String	G86	30118	30119	G86		Data											Tripped secondary elements
Fault Alarms	N/A		0C	Binary Flag (32) Indexed String	G87	30120	30121	G87		Data					*	*	*	*	*	*	Faullt Alarms/Warnings
Fault Time			0D	IEC870 Time & Date		30122	30125	G12		Data					*	*	*	*	*	*	Fault Record Time Stamp
Active Group			0E	Unsigned Integer (16 bits)		30126		G1		Data					*	*	*	*	*	*	
System Frequency			0F	Courier Number (frequency)		30127		G30		Data					*	*	*	*	*	*	
Fault Duration			10	Courier Number (time)		30128	30129	G24		Data					*	*	*	*	*	*	
CB Operate Time			11	Courier Number (time)		30130		G25		Data					*	*	*	*	*	*	
Relay Trip Time			12	Courier Number (time)		30131	30132	G24		Data					*	*	*	*	*	*	
Fault Location			13	Courier Number (metres)		30133	30134	G125		Data							*	*	*	*	OD0A=0 AND 0D09=0, can be invalid
Fault Location			14	Courier Number (miles)		30135	30136	G125		Data							*	*	*	*	OD0A=0 AND 0D09=1, can be invalid
Fault Location			15	Courier Number (ohms)		30137	30138	G125		Data							*	*	*	*	Can be Invalid
Fault Location			16	Courier Number (percentage)		30139	30140	G125		Data							*	*	*	*	Can be Invalid
IA			17	Courier Number (current)		30141	30142	G24		Data					*	*	*	*	*	*	
IB			18	Courier Number (current)		30143	30144	G24		Data					*	*	*	*	*	*	
IC			19	Courier Number (current)		30145	30146	G24		Data					*	*	*	*	*	*	
VAB			1A	Courier Number (voltage)		30147	30148	G24		Data							*	*	*	*	
VBC			1B	Courier Number (voltage)		30149	30150	G24		Data							*	*	*	*	
VCA			1C	Courier Number (voltage)		30151	30152	G24		Data							*	*	*	*	

Add product specific fault record items from this row onwards, do not redefine any of the above Courier cells.
Additional product specific targetting information can be added for the front panel menu

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
IA local			1D	Courier Number (current)		30153	30154	G24		Data					*	*	*	*	*	*	
IB local			1E	Courier Number (current)		30155	30156	G24		Data					*	*	*	*	*	*	
IC local			1F	Courier Number (current)		30157	30158	G24		Data					*	*	*	*	*	*	
IA remote 1			20	Courier Number (current)		30159	30160	G24		Data					*	*	*	*	*	*	
IB remote 1			21	Courier Number (current)		30161	30162	G24		Data					*	*	*	*	*	*	
IC remote 1			22	Courier Number (current)		30163	30164	G24		Data					*	*	*	*	*	*	
IA remote 2			23	Courier Number (current)		30165	30166	G24		Data					*	*	*	*	*	*	
IB remote 2			24	Courier Number (current)		30167	30168	G24		Data					*	*	*	*	*	*	
IC remote 2			25	Courier Number (current)		30169	30170	G24		Data					*	*	*	*	*	*	
IA Differential			26	Courier Number (current)		30171	30172	G24		Data					*	*	*	*	*	*	
IB Differential			27	Courier Number (current)		30173	30174	G24		Data					*	*	*	*	*	*	
IC Differential			28	Courier Number (current)		30175	30176	G24		Data					*	*	*	*	*	*	
IN Differential			29	Courier Number (current)		30177	30178	G24		Data											
IA Bias			2A	Courier Number (current)		30179	30180	G24		Data					*	*	*	*	*	*	
IB Bias			2B	Courier Number (current)		30181	30182	G24		Data					*	*	*	*	*	*	
IC Bias			2C	Courier Number (current)		30183	30184	G24		Data					*	*	*	*	*	*	
Select Maint [0...n]			F0	Unsigned Integer (16 bits)		40102		G1	0	Setting	0	4	1	0	*	*	*	*	*	*	Allows Self Test Report to be selected n is last maintenance record.
Maint Text			F1	ASCII Text (32)						Data					*	*	*	*	*	*	
Maint Type			F2	UINT32		30036	30037	G27		Data					*	*	*	*	*	*	
Maint Data			F3	UINT32		30038	30039	G27		Data					*	*	*	*	*	*	
Reset Indication			FF	Indexed String	G11				No	Command	0	1	1	1	*	*	*	*	*	*	
MEASUREMENTS 1		02	00												*	*	*	*	*	*	
IA Magnitude			01	Courier Number (current)		30200	30201	G24		Data					*	*	*	*	*	*	
IA Phase Angle			02	Courier Number (angle)		30202		G30		Data					*	*	*	*	*	*	
IB Magnitude			03	Courier Number (current)		30203	30204	G24		Data					*	*	*	*	*	*	
IB Phase Angle			04	Courier Number (angle)		30205		G30		Data					*	*	*	*	*	*	
IC Magnitude			05	Courier Number (current)		30206	30207	G24		Data					*	*	*	*	*	*	
IC Phase Angle			06	Courier Number (angle)		30208		G30		Data					*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
IN Measured Mag			07	Courier Number (current)		30209	30210	G24		Data					*	*	*	*	*	*	
IN Measured Ang			08	Courier Number (angle)		30211		G30		Data					*	*	*	*	*	*	
IN Derived Mag			09	Courier Number (current)		30212	30213	G24		Data					*	*	*	*	*	*	
IN Derived Angle			0A	Courier Number (angle)		30214		G30		Data					*	*	*	*	*	*	
ISEF Magnitude			0B	Courier Number (current)		30215	30216	G24		Data											
ISEF Angle			0C	Courier Number (angle)		30217		G30		Data											
I1 Magnitude			0D	Courier Number (current)		30218	30219	G24		Data					*	*	*	*	*	*	
I2 Magnitude			0E	Courier Number (current)		30220	30221	G24		Data					*	*	*	*	*	*	
I0 Magnitude			0F	Courier Number (current)		30222	30223	G24		Data					*	*	*	*	*	*	
IA RMS			10	Courier Number (current)		30224	30225	G24		Data					*	*	*	*	*	*	
IB RMS			11	Courier Number (current)		30226	30227	G24		Data					*	*	*	*	*	*	
IC RMS			12	Courier Number (current)		30228	30229	G24		Data					*	*	*	*	*	*	
IN RMS			13	Courier Number (current)				G24		Data											
VAB Magnitude			14	Courier Number (voltage)		30230	30231	G24		Data							*	*	*	*	
VAB Phase Angle			15	Courier Number (angle)		30232		G30		Data							*	*	*	*	
VBC Magnitude			16	Courier Number (voltage)		30233	30234	G24		Data							*	*	*	*	
VBC Phase Angle			17	Courier Number (angle)		30235		G30		Data							*	*	*	*	
VCA Magnitude			18	Courier Number (voltage)		30236	30237	G24		Data							*	*	*	*	
VCA Phase Angle			19	Courier Number (angle)		30238		G30		Data							*	*	*	*	
VAN Magnitude			1A	Courier Number (voltage)		30239	30240	G24		Data							*	*	*	*	
VAN Phase Angle			1B	Courier Number (angle)		30241		G30		Data							*	*	*	*	
VBN Magnitude			1C	Courier Number (voltage)		30242	30243	G24		Data							*	*	*	*	
VBN Phase Angle			1D	Courier Number (angle)		30244		G30		Data							*	*	*	*	
VCN Magnitude			1E	Courier Number (voltage)		30245	30246	G24		Data							*	*	*	*	
VCN Phase Angle			1F	Courier Number (angle)		30247		G30		Data							*	*	*	*	
VN Measured Mag			20	Courier Number (voltage)		30248	30249	G24		Data											
VN Measured Ang			21	Courier Number (angle)		30250		G30		Data											
VN Derived Mag			22	Courier Number (voltage)		30251	30252	G24		Data											
VN Derived Ang			23	Courier Number (angle)		30253		G30		Data											
V1 Magnitude			24	Courier Number (voltage)		30254	30255	G24		Data							*	*	*	*	
V2 Magnitude			25	Courier Number (voltage)		30256	30257	G24		Data							*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
V0 Magnitude			26	Courier Number (voltage)		30258	30259	G24		Data							*	*	*	*	
VAN RMS			27	Courier Number (voltage)		30260	30261	G24		Data							*	*	*	*	
VBN RMS			28	Courier Number (voltage)		30262	30263	G24		Data							*	*	*	*	
VCN RMS			29	Courier Number (voltage)		30264	30265	G24		Data							*	*	*	*	
VAB RMS			2A	Courier Number (voltage)		30266	30267	G24		Data											
VBC RMS			2B	Courier Number (voltage)		30268	30269	G24		Data											
VCA RMS			2C	Courier Number (voltage)		30270	30271	G24		Data											
Frequency			2D	Courier Number (frequency)		30272		G30		Data					*	*	*	*	*	*	
C/S Voltage Mag			2E	Courier Number (voltage)		30273	30274	G24		Data							*		*		Visible if System Checks enabled
C/S Voltage Ang			2F	Courier Number (angle)		30275		G30		Data							*		*		Visible if System Checks enabled
C/S Bus-Line Ang			30	Courier Number (angle)		30276		G30		Data							*		*		Visible if System Checks enabled
Slip Frequency			31	Courier Number (frequency)		30277		G30		Data							*		*		Visible if System Checks enabled
IM Magnitude			32	Courier Number (current)		30278	30279	G24		Data							*	*	*	*	
IM Phase Angle			33	Courier Number (angle)		30280		G30		Data							*	*	*	*	
MEASUREMENTS 2		03	00												*	*	*	*	*	*	
A Phase Watts			01	Courier Number (power)		30300	30302	G29		Data							*	*	*	*	
B Phase Watts			02	Courier Number (power)		30303	30305	G29		Data							*	*	*	*	
C Phase Watts			03	Courier Number (power)		30306	30308	G29		Data							*	*	*	*	
A Phase VArs			04	Courier Number (VAr)		30309	30311	G29		Data							*	*	*	*	
B Phase VArs			05	Courier Number (VAr)		30312	30314	G29		Data							*	*	*	*	
C Phase VArs			06	Courier Number (VAr)		30315	30317	G29		Data							*	*	*	*	
A Phase VA			07	Courier Number (VA)		30318	30320	G29		Data							*	*	*	*	
B Phase VA			08	Courier Number (VA)		30321	30323	G29		Data							*	*	*	*	
C Phase VA			09	Courier Number (VA)		30324	30326	G29		Data							*	*	*	*	
3 Phase Watts			0A	Courier Number (power)		30327	30329	G29		Data							*	*	*	*	
3 Phase VArs			0B	Courier Number (VAr)		30330	30332	G29		Data							*	*	*	*	
3 Phase VA			0C	Courier Number (VA)		30333	30335	G29		Data							*	*	*	*	
Zero Seq Power			0D	Courier Number (VA)				G29		Data											
3Ph Power Factor			0E	Courier Number (decimal)		30336		G30		Data							*	*	*	*	
APh Power Factor			0F	Courier Number (decimal)		30337		G30		Data							*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
BPh Power Factor			10	Courier Number (decimal)		30338		G30		Data							*	*	*	*	
CPh Power Factor			11	Courier Number (decimal)		30339		G30		Data							*	*	*	*	
3Ph WHours Fwd			12	Courier Number (Wh)		30340	30342	G29		Data							*	*	*	*	3 Phase Watt - Hours (Forward)
3Ph WHours Rev			13	Courier Number (Wh)		30343	30345	G29		Data							*	*	*	*	3 Phase Watts - Hours (Reverse)
3Ph VArHours Fwd			14	Courier Number (VArh)		30346	30348	G29		Data							*	*	*	*	3 Phase VAr - Hours (Forward)
3Ph VArHours Rev			15	Courier Number (VArh)		30349	30351	G29		Data							*	*	*	*	3 Phase VAr - Hours (Reverse)
3Ph W Fix Demand			16	Courier Number (power)		30352	30354	G29		Data							*	*	*	*	3 Phase Watts - Fixed Demand
3Ph VArs Fix Dem			17	Courier Number (VAr)		30355	30357	G29		Data							*	*	*	*	3 Phase VArs - Fixed Demand
IA Fixed Demand			18	Courier Number (current)		30358	30359	G24		Data					*	*	*	*	*	*	
IB Fixed Demand			19	Courier Number (current)		30360	30361	G24		Data					*	*	*	*	*	*	
IC Fixed Demand			1A	Courier Number (current)		30362	30363	G24		Data					*	*	*	*	*	*	
3Ph W Roll Dem			1B	Courier Number (power)		30364	30366	G29		Data							*	*	*	*	3 Phase Watts - Rolling Demand
3Ph VArs RollDem			1C	Courier Number (VAr)		30367	30369	G29		Data							*	*	*	*	3 Phase VArs - Rolling Demand
IA Roll Demand			1D	Courier Number (current)		30370	30371	G24		Data					*	*	*	*	*	*	
IB Roll Demand			1E	Courier Number (current)		30372	30373	G24		Data					*	*	*	*	*	*	
IC Roll Demand			1F	Courier Number (current)		30374	30375	G24		Data					*	*	*	*	*	*	
3Ph W Peak Dem			20	Courier Number (power)		30376	30378	G29		Data							*	*	*	*	3 Phase Watts - Peak Demand
3Ph VAr Peak Dem			21	Courier Number (VAr)		30379	30381	G29		Data							*	*	*	*	3 Phase VArs - Peak Demand
IA Peak Demand			22	Courier Number (current)		30382	30383	G24		Data					*	*	*	*	*	*	
IB Peak Demand			23	Courier Number (current)		30384	30385	G24		Data					*	*	*	*	*	*	
IC Peak Demand			24	Courier Number (current)		30386	30387	G24		Data					*	*	*	*	*	*	
Reset Demand			25	Indexed String	G11	40103		G11	No	Command	0	1	1	1	*	*	*	*	*	*	
	N/A					30388	30389	G125		Data							*	*	*	*	A Phase Watts (see [0301])
	N/A					30390	30391	G125		Data							*	*	*	*	B Phase Watts (see [0302])
	N/A					30392	30393	G125		Data							*	*	*	*	C Phase Watts (see [0303])
	N/A					30394	30395	G125		Data							*	*	*	*	A Phase VArs (see [0304])
	N/A					30396	30397	G125		Data							*	*	*	*	B Phase VArs (see [0305])
	N/A					30398	30399	G125		Data							*	*	*	*	C Phase VArs (see [0306])
	N/A					30400	30401	G125		Data							*	*	*	*	A Phase VA (see [0307])
	N/A					30402	30403	G125		Data							*	*	*	*	B Phase VA (see [0308])
	N/A					30404	30405	G125		Data							*	*	*	*	C Phase VA (see [0309])
	N/A					30406	30407	G125		Data							*	*	*	*	3 Phase Watts (see [030A])

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
	N/A					30408	30409	G125		Data							*	*	*	*	3 Phase VArs (see [030B])
	N/A					30410	30411	G125		Data							*	*	*	*	3 Phase VA (see [030C])
	N/A					30412	30413	G125		Data							*	*	*	*	3 Phase WHours Fwd (see [0312])
	N/A					30414	30415	G125		Data							*	*	*	*	3 Phase WHours Rev (see [0313])
	N/A					30416	30417	G125		Data							*	*	*	*	3 Phase VArHours Fwd (see [0314])
	N/A					30418	30419	G125		Data							*	*	*	*	3 Phase VArHours Rev (see [0315])
	N/A					30420	30421	G125		Data							*	*	*	*	3 Phase W Fix Demand (see [0316])
	N/A					30422	30423	G125		Data							*	*	*	*	3 Phase VArs Fix Demand (see [0317])
	N/A					30424	30425	G125		Data							*	*	*	*	3 Phase W Roll Demand (see [031B])
	N/A					30426	30427	G125		Data							*	*	*	*	3 Phase VArs Roll Demand (see [031C])
	N/A					30428	30429	G125		Data							*	*	*	*	3 Phase W Peak Demand (see [0320])
	N/A					30430	30431	G125		Data							*	*	*	*	3 Phase VArs Peak Demand (see [0321])
Do not add any more rows to this column																					
MEASUREMENTS 3		04	00												*	*	*	*	*	*	
IA local			01	Courier Number (current)		30440	30441	G24		Data					*	*	*	*	*	*	
IA Angle local			02	Courier Number (angle)		30442		G30		Data					*	*	*	*	*	*	
IB local			03	Courier Number (current)		30443	30444	G24		Data					*	*	*	*	*	*	
IB Angle local			04	Courier Number (angle)		30445		G30		Data					*	*	*	*	*	*	
IC local			05	Courier Number (current)		30446	30447	G24		Data					*	*	*	*	*	*	
IC Angle local			06	Courier Number (angle)		30448		G30		Data					*	*	*	*	*	*	
IN local			07	Courier Number (current)		30449	30450	G24		Data											
IN Angle local			08	Courier Number (angle)		30451		G30		Data											
IA remote 1			09	Courier Number (current)		30452	30453	G24		Data					*	*	*	*	*	*	
IA Ang remote 1			0A	Courier Number (angle)		30454		G30		Data					*	*	*	*	*	*	
IB remote 1			0B	Courier Number (current)		30455	30456	G24		Data					*	*	*	*	*	*	
IB Ang remote 1			0C	Courier Number (angle)		30457		G30		Data					*	*	*	*	*	*	
IC remote 1			0D	Courier Number (current)		30458	30459	G24		Data					*	*	*	*	*	*	
IC Ang remote 1			0E	Courier Number (angle)		30460		G30		Data					*	*	*	*	*	*	
IN remote 1			0F	Courier Number (current)		30461	30462	G24		Data											
IN Ang remote 1			10	Courier Number (angle)		30463		G30		Data											
IA remote 2			11	Courier Number (current)		30464	30465	G24		Data					*	*	*	*	*	*	
IA Ang remote 2			12	Courier Number (angle)		30466		G30		Data					*	*	*	*	*	*	
IB remote 2			13	Courier Number (current)		30467	30468	G24		Data					*	*	*	*	*	*	
IB Ang remote 2			14	Courier Number (angle)		30469		G30		Data					*	*	*	*	*	*	
IC remote 2			15	Courier Number (current)		30470	30471	G24		Data					*	*	*	*	*	*	
IC Ang remote 2			16	Courier Number (angle)		30472		G30		Data					*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
IN remote 2			17	Courier Number (current)		30473	30474	G24		Data											
IN Ang remote 2			18	Courier Number (angle)		30475		G30		Data											
IA Differential			19	Courier Number (current)		30476	30477	G24		Data					*	*	*	*	*	*	
IB Differential			1A	Courier Number (current)		30478	30479	G24		Data					*	*	*	*	*	*	
IC Differential			1B	Courier Number (current)		30480	30481	G24		Data					*	*	*	*	*	*	
IN Differential			1C	Courier Number (current)		30482	30483	G24		Data											
IA Bias			1D	Courier Number (current)		30484	30485	G24		Data					*	*	*	*	*	*	
IB Bias			1E	Courier Number (current)		30486	30487	G24		Data					*	*	*	*	*	*	
IC Bias			1F	Courier Number (current)		30488	30489	G24		Data					*	*	*	*	*	*	
Thermal State			20	Courier Number (percentage)		30490		G30		Data					*	*	*	*	*	*	(0917 =1) && (3C01>=1)
Reset Thermal			21	Indexed String	G11	40104		G11	No	Command	0	1	1	1	*	*	*	*	*	*	(0917 =1) && (3C01>=1)
MEASUREMENTS 4		05	00												*	*	*	*	*	*	
Ch 1 Prop Delay			01	Courier Number (time)		30500		G25		Data					*	*	*	*	*	*	Propagation time delay Ch1
Ch 2 Prop Delay			02	Courier Number (time)		30501		G25		Data					*	*	*	*	*	*	2001 = 0 OR 2001 = 2 Propagation time delay Ch2
Channel Status			03	Binary Flag (10) & Indexed String	G113	30502		G113		Data					*	*	*	*			Channel status
Channel Status			03	Binary Flag (13) & Indexed String	G113	30502		G113		Data									*	*	Channel Status
Elapsed Time			04	Courier Number (time)		30503	30504	G24		Data					*	*	*	*	*	*	Seconds since power up or statistics reset
Ch1 No.Vald Mess			05	Unsigned Integer (32 bits)		30505		G1		Data					*	*	*	*	*	*	No. of valid messages Ch1
Ch1 No.Err Mess			06	Unsigned Integer (32 bits)		30506		G1		Data					*	*	*	*	*	*	No. of errored messages Ch1
Ch1 No.Errored s			07	Unsigned Integer (32 bits)		30507		G1		Data					*	*	*	*	*	*	No. of errored seconds Ch1
Ch1 No.Sev Err s			08	Unsigned Integer (32 bits)		30508		G1		Data					*	*	*	*	*	*	No. of severely errored seconds Ch1
Ch1 No.Dgraded m			09	Unsigned Integer (32 bits)		30509		G1		Data					*	*	*	*	*	*	No. of degraded minutes Ch1
Ch2 No.Vald Mess			0A	Unsigned Integer (32 bits)		30510		G1		Data					*	*	*	*	*	*	2001 = 0 OR 2001 = 2 No. of valid messages Ch2
Ch2 No.Err Mess			0B	Unsigned Integer (32 bits)		30511		G1		Data					*	*	*	*	*	*	2001 = 0 OR 2001 = 2 No. of errored messages Ch2
Ch2 No.Errored s			0C	Unsigned Integer (32 bits)		30512		G1		Data					*	*	*	*	*	*	2001 = 0 OR 2001 = 2 No. of errored seconds Ch2
Ch2 No.Sev Err s			0D	Unsigned Integer (32 bits)		30513		G1		Data					*	*	*	*	*	*	2001 = 0 OR 2001 = 2 No. of severely errored seconds Ch2
Ch2 No.Dgraded m			0E	Unsigned Integer (32 bits)		30514		G1		Data					*	*	*	*	*	*	2001 = 0 OR 2001 = 2 No. of degraded minutes Ch2
Clear Statistics			0F	Indexed String	G11	40105		G11	No	Command	0	1	1	1	*	*	*	*	*	*	Reset All Values
Ch1 Rx Prop Delay			11	Courier Number (time)		30515		G25		Data									*	*	Propagation Delay Ch1 Rx

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Ch1 Tx Prop Delay			12	Courier Number (time)		30516		G25		Data									*	*	Propagation Delay Ch1 Tx
Ch2 Rx Prop Delay			13	Courier Number (time)		30517		G25		Data									*	*	(2001 = 0 OR 2001 = 2)&2013=Enabled Propagation Delay Ch2 Rx
Ch2 Tx Prop Delay			14	Courier Number (time)		30518		G25		Data									*	*	(2001 = 0 OR 2001 = 2 &2013=Enabled Propagation Delay Ch2 Tx
	N/A					30519	30520	G27		Data					*	*	*	*	*	*	Ch1 No.Vald Mess (see [0505])
	N/A					30521	30522	G27		Data					*	*	*	*	*	*	Ch1 No.Err Mess (see [0506])
	N/A					30523	30524	G27		Data					*	*	*	*	*	*	Ch2 No.Vald Mess (see [050A])
	N/A					30525	30526	G27		Data					*	*	*	*	*	*	Ch2 No.Err Mess (see [050B])
CB OPERATION		06	00												*	*	*		*		CB CONDITION MONITORING
CB Operations			01	Unsigned Integer (16 bits)		30600		G1		Data					*	*					Number of Circuit Breaker Operations
CB A Operations			02	Unsigned Integer (16 bits)		30601		G1		Data							*		*		Number of Circuit Breaker Operations
CB B Operations			03	Unsigned Integer (16 bits)		30602		G1		Data							*		*		Number of Circuit Breaker Operations
CB C Operations			04	Unsigned Integer (16 bits)		30603		G1		Data							*		*		Number of Circuit Breaker Operations
Total IA Broken			05	Courier Number (current)		30604	30605	G24		Data							*		*		Broken Current A Phase
Total IB Broken			06	Courier Number (current)		30606	30607	G24		Data					*	*	*		*		Broken Current B Phase
Total IC Broken			07	Courier Number (current)		30608	30609	G24		Data					*	*	*		*		Broken Current C Phase
CB Operate Time			08	Courier Number (time)		30610		G25		Data					*	*	*		*		Circuit Breaker operating time
Reset CB Data			09	Indexed String	G11	40150		G11	No	Command					*	*	*		*		Reset All Values
CB CONTROL		07	00												*	*	*	*	*	*	
CB Control by			01	Indexed String	G99	40200		G99	Disabled	Setting	0	7	1	2	*	*	*	*	*	*	
Close Pulse Time			02	Courier Number (time)		40201		G2	0.5	Setting	0.1	10	0.01	2	*	*	*	*	*	*	
Trip Pulse Time			03	Courier Number (time)		40202		G2	0.5	Setting	0.1	5	0.01	2	*	*	*	*	*	*	
Man Close t max			04	Courier Number (time)				G35	1	Setting	0.01	9999	0.01	2							
Man Close Delay			05	Courier Number (time)		40203		G2	10	Setting	0.01	600	0.01	2	*	*	*	*	*	*	Manual Close Delay
CB Healthy Time			06	Courier Number (time)		40204	40205	G35	5	Setting	0.01	9999	0.01	2	*	*	*	*	*	*	CB Healthy Window
Check Sync Time			07	Courier Number (time)		40206	40207	G35	5	Setting	0.01	9999	0.01	2			*		*		System Checks OK Window
Lockout Reset			08	Indexed String	G11	40208		G11	No	Command	0	1	1	2		*	*		*		
Reset Lockout by			09	Indexed String	G81	40209		G81	CB Close	Setting	0	1	1	2	*	*	*		*		
Man Close RstDly			0A	Courier Number (time)		40210		G2	5	Setting	0.1	600	0.01	2	*	*	*		*		Manual Close Reset Delay
AR TeleControl			0B	Indexed String	G78	40211		G78	No Operation	Command	0	2	1	2		*					
Single Pole A/R			0C	Indexed String	G37	40212		G37	Disabled	Setting	0	1	1	2			*		*		Single Pole Autoreclose
Three Pole A/R			0D	Indexed String	G37	40213		G37	Enabled	Setting	0	1	1	2			*		*		Three Pole Autoclose

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
A/R Status			0E	Indexed String		30611		G83		Data						*					Auto mode / non auto mode
Total Reclosures			0F	Unsigned Integer (16 bits)				G1		Data						*	*		*		No of Autoreclosures
Reset Total A/R			10	Indexed String		40214		G11	No	Command	0	1	1	2		*	*		*		Reset No of Autoreclosures
CB Status Input			11	Indexed String	G118	40215		G118	Both 52A and 52B	Setting	0	3	1	2	*	*					52A and 52B Logic Input
CB Status Input			11	Indexed String	G118	405215		G118	52B 1 pole	Setting	0	6	1	2			*	*	*	*	52A and 52B Logic Input
DATE AND TIME		08	00												*	*	*	*	*	*	
Date/Time	N/A		01	IEC870 Time & Date		40300	40303	G12		Setting				0	*	*	*	*	*	*	
Date/Time	N/A		N/A	IEC870 Time & Date		42049	42052	G12		Setting				0	*	*	*	*	*	*	Modbus only
Date 12-Jan-98			N/A												*	*	*	*	*	*	Front Panel Menu only
Time 12:00			N/A												*	*	*	*	*	*	Front Panel Menu only
IRIG-B Sync			04	Indexed String	G37	40304		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
IRIG-B Status			05	Indexed String	G17	30090		G17		Data					*	*	*	*	*	*	
Battery Status			06	Indexed String	G59	30091		G59		Data					*	*	*	*	*	*	
Battery Alarm			07	Indexed String	G37	40305		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
CONFIGURATION		09	00												*	*	*	*	*	*	
Restore Defaults			01	Indexed String	G53	40402		G53	No Operation	Command	0	5	1	2	*	*	*	*	*	*	
Setting Group			02	Indexed String	G61	40403		G61	Select via Menu	Setting	0	1	1	2	*	*	*	*	*	*	
Active Settings			03	Indexed String	G90	40404		G90	Group 1	Setting	0	3	1	1	*	*	*	*	*	*	
Save Changes			04	Indexed String	G62	40405		G62	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Copy From			05	Indexed String	G90	40406		G90	Group 1	Setting	0	3	1	2	*	*	*	*	*	*	
Copy To			06	Indexed String	G98	40407		G98	No Operation	Command	0	3	1	2	*	*	*	*	*	*	
Setting Group 1			07	Indexed String	G37	40408		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
Setting Group 2			08	Indexed String	G37	40409		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
Setting Group 3			09	Indexed String	G37	40410		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
Setting Group 4			0A	Indexed String	G37	40411		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
Phase Diff			0B	Indexed String	G37	40412		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
Neutral Diff			0C	Indexed String	G37	40413		G37	Disabled	Setting	0	1	1	2							
Distance			0D	Indexed String	G37	40414		G37	Enabled	Setting	0	1	1	2			*	*	*	*	
Tripping Mode			0E	Indexed String	G102	40415		G102	3 Pole	Setting	0	1	1	2			*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Opto Filter Cntl			0F	Binary Flag (8 Bit)	G8	40438	40439	G8	0xFF	Setting	0xFF	8	1	2	*						
Opto Filter Cntl			0F	Binary Flag (16 Bit)	G8	40438	40439	G8	0xFFFF	Setting	0xFFFF	16	1	2		*	*	*			
Opto Filter Cntl			0F	Binary Flag (32 Bit)	G8	40438	40439	G8	0xFFFFFF	Setting	0xFFFFFF	32	1	2					*	*	
Overcurrent			10	Indexed String	G37	40417		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
Neg Sequence O/C			11	Indexed String	G37	40418		G37		Setting	0	1	1	2							
Broken Conductor			12	Indexed String	G37	40419		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
Earth Fault			13	Indexed String	G37	40420		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
Product Specific			14	Indexed String		40421				Setting	0	1	1	2							
Sensitive E/F			15	Indexed String	G37	40422		G37	Disabled	Setting	0	1	1	2			*	*	*	*	
Residual O/V NVD			16	Indexed String	G37	40423		G37		Setting	0	1	1	2							Residual Overvoltage
Thermal Overload			17	Indexed String	G37	40424		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
Product Specific			18	Indexed String		40425								2							
Product Specific			19	Indexed String		40426								2							
Product Specific			1A	Indexed String		40427								2							
Product Specific			1B	Indexed String		40428								2							
Product Specific			1C	Indexed String		40429								2							
Volt Protection			1D	Indexed String	G37	40430		G37		Setting	0	1	1	2							
Freq Protection			1E	Indexed String	G37	40431		G37		Setting	0	1	1	2							
RTD Inputs			1F	Indexed String	G37	40432		G37		Setting	0	1	1	2							
CB Fail			20	Indexed String	G37	40433		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
Supervision			21	Indexed String	G37	40434		G37	Enabled	Setting	0	1	1	2			*	*	*	*	
Fault Locator			22	Indexed String	G37	40435		G37	Enabled	Setting	0	1	1	2			*	*	*	*	
System Checks			23	Indexed String	G37	40436		G37	Disabled	Setting	0	1	1	2			*		*		
Auto-Reclose			24	Indexed String	G37	40437		G37	Disabled	Setting	0	1	1	2		*	*		*		
Input Labels			25	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	*	*	*	
Output Labels			26	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	*	*	*	
RTD Labels			27	Indexed String	G80					Setting	0	1	1	1							
CT & VT Ratios			28	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	*	*	*	
Record Control			29	Indexed String	G80				Invisible	Setting	0	1	1	1	*	*	*	*	*	*	
Disturb Recorder			2A	Indexed String	G80				Invisible	Setting	0	1	1	1	*	*	*	*	*	*	Disturbance recorder
Measure't Setup			2B	Indexed String	G80				Invisible	Setting	0	1	1	1	*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	2	3	4	5	6	Comment
Comms Settings			2C	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	*	*	*	
Commission Tests			2D	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	*	*	*	
Setting Values			2E	Indexed String	G54				Primary	Setting	0	1	1	1	*	*	*	*	*	*	
Control Inputs			2F	Indexed String	G80				Visible	Setting	0	1	1	2	*	*	*	*	*	*	
Ctrl I/P Config			35	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	*	*	*	
Ctrl I/P Labels			36	Indexed String	G80				Visible	Setting	0	1	1	1	*	*	*	*	*	*	
Direct Access			39	Indexed String	G231				Enabled	Setting	0	1	1	1	*	*	*	*	*	*	
LCD Contrast			FF	Unsigned Integer (16 bits)					11	Setting	0	31	1	1	*	*	*	*	*	*	
						40400		G18							*	*	*	*	*	*	Record Selection command Register
						40401		G6							*	*	*	*	*	*	Record Control Command Register
																					Ratios used for display of primary
CT AND VT RATIOS		0A	00												*	*	*	*	*	*	values for multiplier see mult column
Main VT Primary			01	Courier Number (voltage)		40500	40501	G35	110	Setting	100	1000000	1	2			*	*	*	*	Label V1=Main VT Rating/110
Main VT Sec'y			02	Courier Number (voltage)		40502		G2	110	Setting	80*V1	140*V1	1*V1	2			*	*	*	*	Label M1=0A01/0A02
C/S VT Primary			03	Courier Number (voltage)		40503	40504	G35	110	Setting	100	1000000	1	2			*		*		Label V2=C/S VT Rating/110
C/S VT Secondary			04	Courier Number (voltage)		40505		G2	110	Setting	80*V2	140*V2	1*V2	2			*		*		Check Sync VT Secondary Label M2=0A03/0A04
NVD VT Primary			05	Courier Number (voltage)		40506	40507	G35		Setting	100	1000000	1	2							Neutral Displacement VT Primary Label V3=Neutral Disp VT Rating/110
NVD VT Secondary			06	Courier Number (voltage)		40508		G2		Setting	100	440	1	2							Neutral Displacement VT Secondary Label M3=0A05/0A06
Phase CT Primary			07	Courier Number (current)		40509		G2	1	Setting	1	30000	1	2	*	*	*	*	*	*	I1=Phase CT secondary rating
Phase CT Sec'y			08	Courier Number (current)		40510		G2	1	Setting	1	5	4	2	*	*	*	*	*	*	Label M4=0A07/0A08
E/F CT Primary			09	Courier Number (current)		40511		G2	1	Setting	1	30000	1	2	*	*	*	*	*	*	Label I2=E/F CT secondary rating
E/F CT Secondary			0A	Courier Number (current)		40512		G2	1	Setting	1	5	4	2	*	*	*	*	*	*	Label M5=0A09/0A0A
SEF CT Primary			0B	Courier Number (current)		40513		G2		Setting	1	30000	1	2							Label I3=SEF CT secondary rating
SEF CT Secondary			0C	Courier Number (current)		40514		G2		Setting	1	5	4	2							Label M6=0A0B/0A0C
MComp CT Primary			0D	Courier Number (current)		40515		G2	1	Setting	1	30000	1	2			*	*	*	*	Mutual Compensation CT Primary Label I4=Mutual Comp CT Rating
MComp CT Sec'y			0E	Courier Number (current)		40516		G2	1	Setting	1	5	4	2			*	*	*	*	Mutual Compensation CT Secondary Label M7=0A0D/0A0E
C/S Input			0F	Indexed String	G40	40517		G40	A-N	Setting	0	5	1	2			*		*		
Main VT Location			10	Indexed String	G89	40518		G89	Line	Setting	0	1	1	2			*		*		
RECORD CONTROL		0B	00												*	*	*	*	*	*	
Clear Events			01	Indexed String	G11				No	Command	0	1	1	1	*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Clear Faults			02	Indexed String	G11				No	Command	0	1	1	1	*	*	*	*	*	*	
Clear Maint			03	Indexed String	G11				No	Command	0	1	1	1	*	*	*	*	*	*	
Alarm Event			04	Indexed String	G37	40520		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
Relay O/P Event			05	Indexed String	G37	40521		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
Opto Input Event			06	Indexed String	G37	40522		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
General Event			07	Indexed String	G37	40523		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
Fault Rec Event			08	Indexed String	G37	40524		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
Maint Rec Event			09	Indexed String	G37	40525		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
Protection Event			0A	Indexed String	G37	40526		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
DDB 31 - 0			0B	Binary Flag (32 Bit)	G27	40527	40528	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 63 - 32			0C	Binary Flag (32 Bit)	G27	40529	40530	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 95 - 64			0D	Binary Flag (32 Bit)	G27	40531	40532	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 127 - 96			0E	Binary Flag (32 Bit)	G27	40533	40534	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 159 - 128			0F	Binary Flag (32 Bit)	G27	40535	40536	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 191 - 160			10	Binary Flag (32 Bit)	G27	40537	40538	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 223 - 192			11	Binary Flag (32 Bit)	G27	40539	40540	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 255 - 224			12	Binary Flag (32 Bit)	G27	40541	40542	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 287 - 256			13	Binary Flag (32 Bit)	G27	40543	40544	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 319 - 288			14	Binary Flag (32 Bit)	G27	40545	40546	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 351 - 320			15	Binary Flag (32 Bit)	G27	40547	40548	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 383 - 352			16	Binary Flag (32 Bit)	G27	40549	40550	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 415 - 384			17	Binary Flag (32 Bit)	G27	40551	40552	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 447 - 416			18	Binary Flag (32 Bit)	G27	40553	40554	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 479 - 448			19	Binary Flag (32 Bit)	G27	40555	40556	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 511 - 480			1A	Binary Flag (32 Bit)	G27	40557	40558	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 543 - 512			1B	Binary Flag (32 Bit)	G27	40559	40560	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 575 - 544			1C	Binary Flag (32 Bit)	G27	40561	40562	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 607 - 576			1D	Binary Flag (32 Bit)	G27	40563	40564	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 639 - 608			1E	Binary Flag (32 Bit)	G27	40565	40566	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 671 - 640			1F	Binary Flag (32 Bit)	G27	40567	40568	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 703 - 672			20	Binary Flag (32 Bit)	G27	40569	40570	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
DDB 735 - 704			21	Binary Flag (32 Bit)	G27	40571	40572	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 767 - 736			22	Binary Flag (32 Bit)	G27	40573	40574	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 799 - 768			23	Binary Flag (32 Bit)	G27	40575	40576	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 831 - 800			24	Binary Flag (32 Bit)	G27	40577	40578	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 863 - 832			25	Binary Flag (32 Bit)	G27	40579	40580	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 895 - 864			26	Binary Flag (32 Bit)	G27	40581	40582	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 927 - 896			27	Binary Flag (32 Bit)	G27	40583	40584	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 959 - 928			28	Binary Flag (32 Bit)	G27	40585	40586	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 991 - 960			29	Binary Flag (32 Bit)	G27	40587	40588	G27	0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	
DDB 1022 - 992			2A	Binary Flag (32 Bit)	G27	40589	40590	G27	0xFFFFFFFF	Setting	0x7FFFFFFF	32	1	2	*	*	*	*	*	*	
Clear Dist Recs			30	Indexed String	G11				No	Command	0	1	1	1	*	*	*	*	*	*	
DISTURB RECORDER		0C	00												*	*	*	*	*	*	DISTURBANCE RECORDER
Duration			01	Courier Number (time)		40600		G2	1.5	Setting	0.1	10.5	0.01	2	*	*	*	*	*	*	
Trigger Position			02	Courier Number (percentage)		40601		G2	33.3	Setting	0	100	0.1	2	*	*	*	*	*	*	
Trigger Mode			03	Indexed String	G34	40602		G34	Single		0	1	1	2	*	*	*	*	*	*	
Analog Channel 1			04	Indexed String	G31	40603		G31	VA	Setting	0	3/3/8/11	1	2	*	*	*	*	*	*	
Analog Channel 2			05	Indexed String	G31	40604		G31	VB	Setting	0	3/3/8/11	1	2	*	*	*	*	*	*	
Analog Channel 3			06	Indexed String	G31	40605		G31	VC	Setting	0	3/3/8/11	1	2	*	*	*	*	*	*	
Analog Channel 4			07	Indexed String	G31	40606		G31	IA	Setting	0	3/3/8/11	1	2	*	*	*	*	*	*	
Analog Channel 5			08	Indexed String	G31	40607		G31	IB	Setting	0	3/3/8/11	1	2	*	*	*	*	*	*	
Analog Channel 6			09	Indexed String	G31	40608		G31	IC	Setting	0	3/3/8/11	1	2	*	*	*	*	*	*	
Analog Channel 7			0A	Indexed String	G31	40609		G31	IN	Setting	0	3/3/8/11	1	2	*	*	*	*	*	*	
Analog Channel 8			0B	Indexed String	G31	40610		G31	IN2	Setting	0	3/3/8/11	1	2	*	*	*	*	*	*	
Digital Input 1			0C	Indexed String	G32	40611		G32	Relay 1	Setting	0	DDB Size	1	2	*	*	*	*	*	*	Note: Number of Signals model dependant
Input 1 Trigger			0D	Indexed String	G66	40612		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 2			0E	Indexed String	G32	40613		G32	Relay 2	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 2 Trigger			0F	Indexed String	G66	40614		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 3			10	Indexed String	G32	40615		G32	Relay 3	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 3 Trigger			11	Indexed String	G66	40616		G66	Trigger L/H	Setting	0	2	1	2	*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Row	Data Type	Data Group Courier	Modbus Address Start	End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	2	3	4	5	6	Comment
Digital Input 4			12	Indexed String	G32	40617		G32	Relay 4	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 4 Trigger			13	Indexed String	G66	40618		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 5			14	Indexed String	G32	40619		G32	Relay 5	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 5 Trigger			15	Indexed String	G66	40620		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 6			16	Indexed String	G32	40621		G32	Relay 6	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 6 Trigger			17	Indexed String	G66	40622		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 7			18	Indexed String	G32	40623		G32	Relay 7	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 7 Trigger			19	Indexed String	G66	40624		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 8			1A	Indexed String	G32	40625		G32	Relay 8 Opto Input 1	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 8 Trigger			1B	Indexed String	G66	40626		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 9			1C	Indexed String	G32	40627		G32	Relay 9 Opto Input 2	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 9 Trigger			1D	Indexed String	G66	40628		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 10			1E	Indexed String	G32	40629		G32	Relay 10 Opto Input 3	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 10 Trigger			1F	Indexed String	G66	40630		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 11			20	Indexed String	G32	40631		G32	Relay 11 Opto Input 4	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 11 Trigger			21	Indexed String	G66	40632		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 12			22	Indexed String	G32	40633		G32	Relay 12 Opto Input 5	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 12 Trigger			23	Indexed String	G66	40634		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 13			24	Indexed String	G32	40635		G32	Relay 13 Opto Input 6	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 13 Trigger			25	Indexed String	G66	40636		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 14			26	Indexed String	G32	40637		G32	Relay 14 Opto Input 7	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 14 Trigger			27	Indexed String	G66	40638		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 15			28	Indexed String	G32	40639		G32	Opto Input 1 Opto Input 8	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 15 Trigger			29	Indexed String	G66	40640		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 16			2A	Indexed String	G32	40641		G32	Opto Input 2 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 16 Trigger			2B	Indexed String	G66	40642		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 17			2C	Indexed String	G32	40643		G32	Opto Input 3 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 17 Trigger			2D	Indexed String	G66	40644		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 18			2E	Indexed String	G32	40645		G32	Opto Input 4 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 18 Trigger			2F	Indexed String	G66	40646		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 19			30	Indexed String	G32	40647		G32	Opto Input 5 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Input 19 Trigger			31	Indexed String	G66	40648		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 20			32	Indexed String	G32	40649		G32	Opto Input 6 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 20 Trigger			33	Indexed String	G66	40650		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 21			34	Indexed String	G32	40651		G32	Opto Input 7 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 21 Trigger			35	Indexed String	G66	40652		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 22			36	Indexed String	G32	40653		G32	Opto Input 8 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 22 Trigger			37	Indexed String	G66	40654		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 23			38	Indexed String	G32	40655		G32	Opto Input 9 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 23 Trigger			39	Indexed String	G66	40656		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 24			3A	Indexed String	G32	40657		G32	Opto Input 10 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 24 Trigger			3B	Indexed String	G66	40658		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 25			3C	Indexed String	G32	40659		G32	Opto Input 11 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 25 Trigger			3D	Indexed String	G66	40660		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 26			3E	Indexed String	G32	40661		G32	Opto Input 12 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 26 Trigger			3F	Indexed String	G66	40662		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 27			40	Indexed String	G32	40663		G32	Opto Input 13 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 27 Trigger			41	Indexed String	G66	40664		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 28			42	Indexed String	G32	40665		G32	Opto Input 14 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 28 Trigger			43	Indexed String	G66	40666		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 29			44	Indexed String	G32	40667		G32	Opto Input 15 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 29 Trigger			45	Indexed String	G66	40668		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 30			46	Indexed String	G32	40669		G32	Opto Input 16 Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 30 Trigger			47	Indexed String	G66	40670		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 31			48	Indexed String	G32	40671		G32	Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 31 Trigger			49	Indexed String	G66	40672		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
Digital Input 32			4A	Indexed String	G32	40673		G32	Not Used	Setting	0	DDB Size	1	2	*	*	*	*	*	*	
Input 32 Trigger			4B	Indexed String	G66	40674		G66	No Trigger	Setting	0	2	1	2	*	*	*	*	*	*	
MEASURE'T SETUP		0D	00												*	*	*	*	*	*	MEASUREMENT SETTINGS
Default Display			01	Indexed String	G52 G110	40700		G52	Description	Setting	0	7	1	2			*	*	*	*	
Default Display			01	Indexed String	G110	40700		G110	Description	Setting	0	5	1	2	*	*					

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Local Values			02	Indexed String	G54	40701		G54	Primary	Setting	0	1	1	1	*	*	*	*	*	*	Local Measurement Values
Remote Values			03	Indexed String	G54	40702		G54	Primary	Setting	0	1	1	1	*	*	*	*	*	*	Remote Measurement Values
Measurement Ref			04	Indexed String	G56	40703		G56	VA	Setting	0	5	1	1			*	*	*	*	Measurement Phase Reference
Measurement Ref			04	Indexed String	G56	40703		G56	IA	Setting	0	2	1	1	*	*					Measurement Phase Reference
Fix Dem Period			06	Courier Number (time-minutes)		40706		G2	30	Setting	1	99	1	2	*	*	*	*	*	*	Fixed Demand Interval
Roll Sub Period			07	Courier Number (time-minutes)		40707		G2	30	Setting	1	99	1	2	*	*	*	*	*	*	Rolling demand sub period
Num Sub Periods			08	Unsigned Integer (16 bits)		40708		G1	1	Setting	1	15	1	2	*	*	*	*	*	*	Number of rolling sub-periods
Distance Unit			09	Indexed String	G97	40709		G97	Miles	Setting	0	1	1	2			*	*	*	*	
Fault Location			0A	Indexed String	G51	40710		G51	Distance	Setting	0	2	1	2			*	*	*	*	
Remote 2 Values			0B	Indexed String	G54	40711		G54	Primary	Setting	0	1	1	1	*	*	*	*	*	*	Remote 2 Measurement Values
COMMUNICATIONS		0E	00												*	*	*	*	*	*	
RP1 Protocol			01	Indexed String	G71					Data					*	*	*	*	*	*	
RP1 Address			02	Unsigned Integer (16 bits)					255	Setting	0	255	1	1	*	*	*	*	*	*	Rear Port = Courier or IEC60870-5-103
RP1 Address			02	Unsigned Integer (16 bits)					1	Setting	1	247	1	2	*	*	*	*	*	*	Rear Port = Modbus
RP1 Address			02	Unsigned Integer (16 bits)					1	Setting	0	65519	1	1	*	*	*	*	*	*	Build = DNP 3.0
RP1 InactivTimer			03	Courier Number (time-minutes)					15	Setting	1	30	1	2	*	*	*	*	*	*	
RP1 Baud Rate			04	Indexed String	G38v				19200 bits/s	Setting	0	1	1	2	*	*	*	*	*	*	Rear Port = IEC60870-5-103
RP1 Baud Rate			04	Indexed String	G38m				19200 bits/s	Setting	0	2	1	2	*	*	*	*	*	*	Build = Modbus
RP1 Baud Rate			04	Indexed String	G38d				19200 bits/s	Setting	0	5	1	2	*	*	*	*	*	*	Build = DNP3
RP1 Meas Period			05	Indexed String	G39				None	Setting	0	2	1	2	*	*	*	*	*	*	Build = Modbus or DNP3
RP1 Meas Period			06	Courier Number (time)					10	Setting	1	60	1	2	*	*	*	*	*	*	Build = IEC60870-5-103
RP1 PhysicalLink			07	Indexed String	G21				Copper	Setting	0	1	1	1	*	*	*	*	*	*	Fibre Optic board fitted
RP1 Time Sync			08	Indexed String	G37				Disabled	Setting	0	1	1	2	*	*	*	*	*	*	Build=DNP 3.0
Modbus IEC Time			09	Indexed String	G238	40306		G1	Standard	Setting	0	1	1	2	*	*	*	*	*	*	Build = Modbus
RP1 CS103Blcking			0A	Indexed String	G210				Disabled	Setting	0	2	1	2	*	*	*	*	*	*	Build=IEC60870-5-103
RP1 Card Status			0B	Indexed String	G208			G1		Data					*	*	*	*	*	*	Build = K Bus
RP1 Port Config			0C	Indexed String	G207			G1	K Bus	Setting	0	1	1	2	*	*	*	*	*	*	When 0E0B ? 2 (RP1 Port status shows K-Bus OK or EIA485 OK)
RP1 Comms Mode			0D	Indexed String	G206			G1	IEC60870 FT1.2	Setting	0	1	1	2	*	*	*	*	*	*	When 0E0B ? 0 (RP1 Port status shows EIA485 OK or Fibre-Optic OK)
RP1 Baud Rate			0E	Indexed String	G38m			G1	19200 bits/s	Setting	0	1	1	2	*	*	*	*	*	*	When 0E0B ? 0 (RP1 Port status shows EIA485 OK or Fibre-Optic OK)
Ethernet Comms			1F	Indexed String						Data							*	*	*	*	Build=UCA2

Courier Text	LCD ref	Courier Ref Col	Row	Data Type	Data Group Courier	Modbus Address Start	End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	2	3	4	5	6	Comment
IP Address			20	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
Subnet Mask			21	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
MAC Address			22							Data							*	*	*	*	
GOOSE IED Name			23							Data							*	*	*	*	
Number of Routes			24	Unsigned Integer (16 bits)					0	Setting	0	4	1	2			*	*	*	*	Build=UCA2
Router Address 1			25	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
Target Network 1			26	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
Router Address 2			27	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
Target Network 2			28	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
Router Address 3			29	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
Target Network 3			2A	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
Router Address 4			2B	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
Target Network 4			2C	ASCII Text (16 chars)					000.000.000.000	Setting	48	57	1	2			*	*	*	*	Build=UCA2
NIC InactivTimer			2D	Unsigned Integer (16 bits)					15	Setting	1	30	1	2			*	*	*	*	Build=UCA2
Default Pass Lvl			2E	Unsigned Integer (16 bits)					2	Setting	0	2	1	2			*	*	*	*	Build=UCA2
GOOSE Min Cycle			2F	Unsigned Integer (16 bits)					10	Setting	1	50	1	2			*	*	*	*	Build=UCA2
GOOSE Max Cycle			30	Unsigned Integer (16 bits)					1	Setting	1	60	1	2			*	*	*	*	Build=UCA2
GOOSE Increment			31	Unsigned Integer (16 bits)					900	Setting	0	999	1	2			*	*	*	*	Build=UCA2
GOOSE Startup			32	Indexed String					Promiscuous	Setting	0	1	1	2			*	*	*	*	Build=UCA2
GOOSE VIP Status			34	Binary Flag (32 bits)					0x00000000h	Data							*	*	*	*	Build=UCA2
NSAP Address			36	ASCII Text					0x00000000h	Setting											Build=UCA2
Transport Select			37	ASCII Text					00.00.00.00	Setting											Build=UCA2
Session Select			38	ASCII Text					00.00	Setting											Build=UCA2
Present. Select			39	ASCII Text					00.00	Setting											Build=UCA2
AP Title			3A	ASCII Text					000.000.000.000	Setting											Build=UCA2
AE Qual. Used			3B	Indexed String					Not Used	Setting											Build=UCA2
AE Qualifier			3C	Unsigned Integer (16 bits)					0	Setting											Build=UCA2
Ethernet Media			3D	Indexed String	G220				Copper	Setting	0	1	1	2			*	*	*	*	Build=UCA2
GOOSE STATISTICS			3F	(Sub Heading)													*	*	*	*	Build=UCA2
Enrolled Flags			40	Binary Flag (32 bits)					0x00000000h	Data							*	*	*	*	Build=UCA2
Tx Msg Count			41	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Rx Msg Count			42	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
DDB Changes			43	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
Last Seq Tx			44	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
Last Msg Tx			45	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
Msg Reject Count			46	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
IED View Select			50	Unsigned Integer (16 bits)					0	Setting	0	32	1	0			*	*	*	*	Build=UCA2
IED Rx Msgs			51	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
IED Last Seq Rx			52	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
IED Last Msg Rx			53	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
IED Missed Msgs			54	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
IED Missed Chngs			55	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
IED Timeouts			56	Unsigned Integer (16 bits)					0	Data							*	*	*	*	Build=UCA2
IED Stats Reset			5F	Indexed String					None	Setting	0	4	1	2			*	*	*	*	Build=UCA2
Loopback Mode			60	Indexed String					Loopback Off	Setting	0	2	1	2			*	*	*	*	Build=UCA2
Reload Mode			61	Indexed String					No Action	Setting	0	1	1	2			*	*	*	*	Build=UCA2
Report Link Test			6A	Indexed String	G226				Alarm	Data	0	2	1	2			*	*	*	*	Build=UCA2
Link Timeout			6B	Courier Number (time)					60	Setting	0.1	60	0.1	2			*	*	*	*	Build=UCA2
COMMUNICATIONS				extensions											*	*	*	*	*	*	
REAR PORT2 (RP2)			80	(Sub Heading)											*	*	*	*	*	*	RearCommsCardState != UNSUPPORTED
RP2 Protocol			81	Indexed String	G71			G1	Fixed at 'Courier'	Data					*	*	*	*	*	*	RearCommsCardState != UNSUPPORTED
RP2 Card Status			84	Indexed String	G204			G1		Data					*	*	*	*	*	*	RearCommsCardState != UNSUPPORTED
RP2 Port Config			88	Indexed String	G205			G1	RS232/60870-5-2	Setting	0	1	1	2	*	*	*	*	*	*	RearCommsCardState= OK
RP2 Comms Mode			8A	Indexed String	G206			G1	IEC60870 FT1.2	Setting	0	1	1	2	*	*	*	*	*	*	RearCommsCardState= OK AND OE18=0
RP2 Address			90	Unsigned Integer (16 bits)				G1	255	Setting	0	255	1	1	*	*	*	*	*	*	RearCommsCardState= OK
RP2 InactivTimer			92	Courier Number (time-minutes)				G2	15	Setting	1	30	1	2	*	*	*	*	*	*	RearCommsCardState= OK
RP2 Baud Rate			94	Indexed String	G38m			G1	19200 bits/s	Setting	0	1	1	2	*	*	*	*	*	*	RearCommsCardState= OK AND OE18=0
COMMISSION TESTS		0F	00												*	*	*	*	*	*	
Opto I/P Status			01	Binary Flag (24) Indexed String				G8		Data					*	*	*	*	*	*	
Relay O/P Status			02	Binary Flag (14) Indexed String				G9		Data					*	*	*	*	*	*	
Test Port Status			03	Binary Flag (8) Indexed String				0-7		Data					*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
LED Status			04	Binary Flag (8)	0-7			0-7		Data					*	*	*	*	*	*	
Monitor Bit 1			05	Unsigned Integer (16 bits)		40850		G1	64	Setting	0	1022	1	1	*	*	*	*	*	*	Default LED 1
Monitor Bit 2			06	Unsigned Integer (16 bits)		40851		G1	65	Setting	0	1022	1	1	*	*	*	*	*	*	Default LED 2
Monitor Bit 3			07	Unsigned Integer (16 bits)		40852		G1	66	Setting	0	1022	1	1	*	*	*	*	*	*	Default LED 3
Monitor Bit 4			08	Unsigned Integer (16 bits)		40853		G1	67	Setting	0	1022	1	1	*	*	*	*	*	*	Default LED 4
Monitor Bit 5			09	Unsigned Integer (16 bits)		40854		G1	68	Setting	0	1022	1	1	*	*	*	*	*	*	Default LED 5
Monitor Bit 6			0A	Unsigned Integer (16 bits)		40855		G1	69	Setting	0	1022	1	1	*	*	*	*	*	*	Default LED 6
Monitor Bit 7			0B	Unsigned Integer (16 bits)		40856		G1	70	Setting	0	1022	1	1	*	*	*	*	*	*	Default LED 7
Monitor Bit 8			0C	Unsigned Integer (16 bits)		40857		G1	71	Setting	0	1022	1	1	*	*	*	*	*	*	Default LED 8
Test Mode			0D	Indexed String	G119	40858		G119	Disabled	Setting	0	2	1	2	*	*	*	*	*	*	
Test Pattern			0E	Binary Flag (21) Indexed String	G9	40859	40860	G9	0	Setting	127	7	1	2	*						
Test Pattern			0E	Binary Flag (21) Indexed String	G9	40859	40860	G9	0	Setting	16383	14	1	2		*	*	*			
Test Pattern			0E	Binary Flag (21) Indexed String	G9	40859	40860	G9	0	Setting	4294967295	32	1	2					*	*	
Contact Test			0F	Indexed String	G93	40861		G93	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Test LEDs			10	Indexed String	G94	40862		G94	No Operation	Command	0	1	1	2	*	*	*	*	*	*	
Test Autoreclose			11	Indexed String	G36	40863		G36	No Operation	Command	0	1	1	2		*			*		
Test Autoreclose			11	Indexed String	G36	40836		G36	No Operation	Command	0	4	1	2			*		*		
Test Loopback			12	Indexed String	G121	40864		G121	Disabled	Setting	0	2	1	2	*	*	*	*	*	*	
DDB 31 - 0	N/A		20	Binary Flag (32)		30723	30724	G27		Data					*	*	*	*	*	*	
DDB 63 - 32	N/A		21	Binary Flag (32)		30725	30726	G27		Data					*	*	*	*	*	*	
DDB 95 - 64	N/A		22	Binary Flag (32)		30727	30728	G27		Data					*	*	*	*	*	*	
DDB 127 - 96	N/A		23	Binary Flag (32)		30729	30730	G27		Data					*	*	*	*	*	*	
DDB 159 - 128	N/A		24	Binary Flag (32)		30731	30732	G27		Data					*	*	*	*	*	*	
DDB 191 - 160	N/A		25	Binary Flag (32)		30733	30734	G27		Data					*	*	*	*	*	*	
DDB 223 - 192	N/A		26	Binary Flag (32)		30735	30736	G27		Data					*	*	*	*	*	*	
DDB 255 - 224	N/A		27	Binary Flag (32)		30737	30738	G27		Data					*	*	*	*	*	*	
DDB 287 - 256	N/A		28	Binary Flag (32)		30739	30740	G27		Data					*	*	*	*	*	*	
DDB 319 - 288	N/A		29	Binary Flag (32)		30741	30742	G27		Data					*	*	*	*	*	*	
DDB 351 - 320	N/A		2A	Binary Flag (32)		30743	30744	G27		Data					*	*	*	*	*	*	
DDB 383 - 352	N/A		2B	Binary Flag (32)		30745	30746	G27		Data					*	*	*	*	*	*	
DDB 415 - 384	N/A		2C	Binary Flag (32)		30747	30748	G27		Data					*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
DDB 447 - 416	N/A		2D	Binary Flag (32)		30749	30750	G27		Data					*	*	*	*	*	*	
DDB 479 - 448	N/A		2E	Binary Flag (32)		30751	30752	G27		Data					*	*	*	*	*	*	
DDB 511 - 480	N/A		2F	Binary Flag (32)		30753	30754	G27		Data					*	*	*	*	*	*	
DDB 543 - 512	N/A		30	Binary Flag (32)		30755	30756	G27		Data					*	*	*	*	*	*	
DDB 575 - 544	N/A		31	Binary Flag (32)		30757	30758	G27		Data					*	*	*	*	*	*	
DDB 607 - 576	N/A		32	Binary Flag (32)		30759	30760	G27		Data					*	*	*	*	*	*	
DDB 639 - 608	N/A		33	Binary Flag (32)		30761	30762	G27		Data					*	*	*	*	*	*	
DDB 671 - 640	N/A		34	Binary Flag (32)		30763	30764	G27		Data					*	*	*	*	*	*	
DDB 703 - 672	N/A		35	Binary Flag (32)		30765	30766	G27		Data					*	*	*	*	*	*	
DDB 735 - 704	N/A		36	Binary Flag (32)		30767	30768	G27		Data					*	*	*	*	*	*	
DDB 767 - 736	N/A		37	Binary Flag (32)		30769	30770	G27		Data					*	*	*	*	*	*	
DDB 799 - 768	N/A		38	Binary Flag (32)		30771	30772	G27		Data					*	*	*	*	*	*	
DDB 831 - 800	N/A		39	Binary Flag (32)		30773	30774	G27		Data					*	*	*	*	*	*	
DDB 863 - 832	N/A		3A	Binary Flag (32)		30775	30776	G27		Data					*	*	*	*	*	*	
DDB 895 - 864	N/A		3B	Binary Flag (32)		30777	30778	G27		Data					*	*	*	*	*	*	
DDB 927 - 896	N/A		3C	Binary Flag (32)		30779	30780	G27		Data					*	*	*	*	*	*	
DDB 959 - 928	N/A		3D	Binary Flag (32)		30781	30782	G27		Data					*	*	*	*	*	*	
DDB 991 - 960	N/A		3E	Binary Flag (32)		30783	30784	G27		Data					*	*	*	*	*	*	
DDB 1022 - 992	N/A		3F	Binary Flag (32)		30785	30786	G27		Data					*	*	*	*	*	*	
N.B. South Pars Extensions	N/A			Binary Flag (16)		30701		G1		Data					*	*	*	*	*	*	Relay status (repeat of Courier Status)
	N/A			Courier Number (current)		30702		G24		Data					*	*	*	*	*	*	IA Magnitude
	N/A			Courier Number (current)		30704		G24		Data					*	*	*	*	*	*	IB Magnitude
	N/A			Courier Number (current)		30706		G24		Data					*	*	*	*	*	*	IC Magnitude
	N/A			Courier Number (voltage)		30708		G24		Data							*	*	*	*	VAB Magnitude
	N/A			Courier Number (voltage)		30710		G24		Data							*	*	*	*	VBC Magnitude
	N/A			Courier Number (voltage)		30712		G24		Data							*	*	*	*	VCA Magnitude
	N/A			Courier Number (power)		30714		G29		Data							*	*	*	*	3 Phase Watts
	N/A			Courier Number (power)		30717		G29		Data							*	*	*	*	3 Phase VArs
	N/A			Courier Number (decimal)		30720		G30		Data							*	*	*	*	3 Phase Power Factor
	N/A			Courier Number (frequency)		30721		G30		Data					*	*	*	*	*	*	Frequency
	N/A			Binary Flag (8)		30722		G1		Data					*	*	*	*	*	*	Relay Test Port Status
CB MONITOR SETUP		10	00												*	*	*		*		
Broken I^			01	Courier Number (decimal)		40151		G2	2	Setting	1	2	0.1	2	*	*	*		*		Broken Current Index Note: NM1 = 0A08^1001
I^ Maintenance			02	Indexed String	G88	40152		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*		*		Broken Current maintenance alarm
I^ Maintenance			03	Courier Number (current)		40153	40154	G35	1000	Setting	1	25000	1	2	*	*	*		*		IX Maintenance Alarm
I^ Lockout			04	Indexed String	G88	40155		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*		*		Broken Current lockout alarm

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
I^ Lockout			05	Courier Number (current)		40156	40157	G35	2000	Setting	1	25000	1	2	*	*	*		*		Broken Current lockout threshold
No. CB Ops Maint			06	Indexed String	G88	40158		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*		*		Circuit Breaker Trips maintenance alarm
No. CB Ops Maint			07	Unsigned Integer (16 bits)		40159		G1	10	Setting	1	10000	1	2	*	*	*		*		CB Trips maintenance threshold
No. CB Ops Lock			08	Indexed String	G88	40160		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*		*		Circuit Breaker Trips lockout alarm
No. CB Ops Lock			09	Unsigned Integer (16 bits)		40161		G1	20	Setting	1	10000	1	2	*	*	*		*		CB Trips lockout threshold
CB Time Maint			0A	Indexed String	G88	40162		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*		*		CB Operating Time maintenance alarm
CB Time Maint			0B	Courier Number (time)		40163	40164	G35	0.1	Setting	0.005	0.5	0.001	2	*	*	*		*		CB Operating Time maintenance threshold
CB Time Lockout			0C	Indexed String	G88	40165		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*		*		CB Operating Time lockout alarm
CB Time Lockout			0D	Courier Number (time)		40166	40167	G35	0.2	Setting	0.005	0.5	0.001	2	*	*	*		*		CB Operating Time lockout threshold
Fault Freq Lock			0E	Indexed String	G88	40168		G88	Alarm Disabled	Setting	0	1	1	2	*	*	*		*		Excessive fault frequency alarm
Fault Freq Count			0F	Unsigned Integer (16 bits)		40169		G1	10	Setting	1	9999	1	2	*	*	*		*		Excessive Fault Frequency Counter
Fault Freq Time			10	Courier Number (time)		40170	40171	G35	3600	Setting	0	9999	1	2	*	*	*		*		Excessive Fault Frequency Time
OPTO CONFIG		11	00												*	*	*	*	*	*	Only visible if Universal Optos fitted
Global Nominal V			01	Indexed String	G200	40900		G200	24-27V	Setting	0	5	1	2	*	*	*	*	*	*	
Opto Input 1			02	Indexed String	G201	40901		G201	24-27V	Setting	0	4	1	2	*	*	*	*	*	*	
Opto Input 2			03	Indexed String	G201	40902		G201	24-27V	Setting	0	4	1	2	*	*	*	*	*	*	
Opto Input 3			04	Indexed String	G201	40903		G201	24-27V	Setting	0	4	1	2	*	*	*	*	*	*	
Opto Input 4			05	Indexed String	G201	40904		G201	24-27V	Setting	0	4	1	2	*	*	*	*	*	*	
Opto Input 5			06	Indexed String	G201	40905		G201	24-27V	Setting	0	4	1	2	*	*	*	*	*	*	
Opto Input 6			07	Indexed String	G201	40906		G201	24-27V	Setting	0	4	1	2	*	*	*	*	*	*	
Opto Input 7			08	Indexed String	G201	40907		G201	24-27V	Setting	0	4	1	2	*	*	*	*	*	*	
Opto Input 8			09	Indexed String	G201	40908		G201	24-27V	Setting	0	4	1	2	*	*	*	*	*	*	
Opto Input 9			0A	Indexed String	G201	40909		G201	24-27V	Setting	0	4	1	2		*	*	*	*	*	
Opto Input 10			0B	Indexed String	G201	40910		G201	24-27V	Setting	0	4	1	2		*	*	*	*	*	
Opto Input 11			0C	Indexed String	G201	40911		G201	24-27V	Setting	0	4	1	2		*	*	*	*	*	
Opto Input 12			0D	Indexed String	G201	40912		G201	24-27V	Setting	0	4	1	2		*	*	*	*	*	
Opto Input 13			0E	Indexed String	G201	40913		G201	24-27V	Setting	0	4	1	2		*	*	*	*	*	
Opto Input 14			0F	Indexed String	G201	40914		G201	24-27V	Setting	0	4	1	2		*	*	*	*	*	
Opto Input 15			10	Indexed String	G201	40915		G201	24-27V	Setting	0	4	1	2		*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Opto Input 16			11	Indexed String	G201	40916		G201	24-27V	Setting	0	4	1	2		*	*	*	*	*	
Opto Input 17			12	Indexed String	G201	40917		G201	24-27V	Setting	0	4	1	2					*	*	
Opto Input 18			13	Indexed String	G201	40918		G201	24-27V	Setting	0	4	1	2					*	*	
Opto Input 19			14	Indexed String	G201	40919		G201	24-27V	Setting	0	4	1	2					*	*	
Opto Input 20			15	Indexed String	G201	40920		G201	24-27V	Setting	0	4	1	2					*	*	
Opto Input 21			16	Indexed String	G201	40921		G201	24-27V	Setting	0	4	1	2					*	*	
Opto Input 22			17	Indexed String	G201	40922		G201	24-27V	Setting	0	4	1	2					*	*	
Opto Input 23			18	Indexed String	G201	40923		G201	24-27V	Setting	0	4	1	2					*	*	
Opto Input 24			19	Indexed String	G201	40924		G201	24-27V	Setting	0	4	1	2					*	*	
Opto Input 25			1A	Indexed String	G201	40925		G201	24-27V	Setting	0	4	1	2							
Opto Input 26			1B	Indexed String	G201	40926		G201	24-27V	Setting	0	4	1	2							
Opto Input 27			1C	Indexed String	G201	40927		G201	24-27V	Setting	0	4	1	2							
Opto Input 28			1D	Indexed String	G201	40928		G201	24-27V	Setting	0	4	1	2							
Opto Input 29			1E	Indexed String	G201	40929		G201	24-27V	Setting	0	4	1	2							
Opto Input 30			1F	Indexed String	G201	40930		G201	24-27V	Setting	0	4	1	2							
Opto Input 31			20	Indexed String	G201	40931		G201	24-27V	Setting	0	4	1	2							
Opto Input 32			21	Indexed String	G201	40932		G201	24-27V	Setting	0	4	1	2							
Opto Input 32			21	Indexed String	G201	40932		G201	24-27V	Setting	0	4	1	2							
Characteristic			80	Indexed String	G237	40935		G1	Standard 60%-80%	Setting	0	1	1	2	*	*	*	*	*	*	
CONTROL INPUTS		12	00												*	*	*	*	*	*	
Ctrl I/P Status			01	Binary Flag (32 bits) Indexed String	G202	40800	40801	G202		Data				2	*	*	*	*	*	*	
Control Input 1			02	Indexed String	G203	40802		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 2			03	Indexed String	G203	40803		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 3			04	Indexed String	G203	40804		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 4			05	Indexed String	G203	40805		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 5			06	Indexed String	G203	40806		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 6			07	Indexed String	G203	40807		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 7			08	Indexed String	G203	40808		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 8			09	Indexed String	G203	40809		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 9			0A	Indexed String	G203	40810		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 10			0B	Indexed String	G203	40811		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Control Input 11			0C	Indexed String	G203	40812		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 12			0D	Indexed String	G203	40813		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 13			0E	Indexed String	G203	40814		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 14			0F	Indexed String	G203	40815		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 15			10	Indexed String	G203	40816		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 16			11	Indexed String	G203	40817		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 17			12	Indexed String	G203	40818		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 18			13	Indexed String	G203	40819		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 19			14	Indexed String	G203	40820		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 20			15	Indexed String	G203	40821		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 21			16	Indexed String	G203	40822		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 22			17	Indexed String	G203	40823		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 23			18	Indexed String	G203	40824		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 24			19	Indexed String	G203	40825		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 25			1A	Indexed String	G203	40826		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 26			1B	Indexed String	G203	40827		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 27			1C	Indexed String	G203	40828		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 28			1D	Indexed String	G203	40829		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 29			1E	Indexed String	G203	40830		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 30			1F	Indexed String	G203	40831		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 31			20	Indexed String	G203	40832		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
Control Input 32			21	Indexed String	G203	40833		G203	No Operation	Command	0	2	1	2	*	*	*	*	*	*	
CTRL I/P CONFIG		13	00												*	*	*	*	*	*	
Hotkey Enabled			01	Binary Flag (32 bits) Indexed String	G233				0xFFFFFFFF	Setting	0xFFFFFFFF	32	1	2	*	*	*	*	*	*	Hotkey Menu - Control Input availability
Control Input 1			10	Indexed String	G234	410,002		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 1			11	Indexed String	G234	410,003		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 2			14	Indexed String	G234	410,004		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 2			15	Indexed String	G232	410,005		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 3			18	Indexed String	G234	410,006		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 3			19	Indexed String	G232	410,007		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	2	3	4	5	6	Comment
Control Input 4			1C	Indexed String	G234	410,008		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 4			1D	Indexed String	G232	410,009		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 5			20	Indexed String	G234	410,010		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 5			21	Indexed String	G232	410,011		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 6			24	Indexed String	G234	410,012		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 6			25	Indexed String	G232	410,013		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 7			28	Indexed String	G234	410,014		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 7			29	Indexed String	G232	410,015		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 8			2C	Indexed String	G234	410,016		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 8			2D	Indexed String	G232	410,017		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 9			30	Indexed String	G234	410,018		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 9			31	Indexed String	G232	410,019		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 10			34	Indexed String	G234	410,020		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 10			35	Indexed String	G232	410,021		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 11			38	Indexed String	G234	410,022		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 11			39	Indexed String	G232	410,023		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 12			3C	Indexed String	G234	410,024		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 12			3D	Indexed String	G232	410,025		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 13			40	Indexed String	G234	410,026		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 13			41	Indexed String	G232	410,027		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 14			44	Indexed String	G234	410,028		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 14			45	Indexed String	G232	410,029		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 15			48	Indexed String	G234	410,030		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 15			49	Indexed String	G232	410,031		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 16			4C	Indexed String	G234	410,032		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 16			4D	Indexed String	G232	410,033		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 17			50	Indexed String	G234	410,034		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 17			51	Indexed String	G232	410,035		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 18			54	Indexed String	G234	410,036		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 18			55	Indexed String	G232	410,037		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 19			58	Indexed String	G234	410,038		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	2	3	4	5	6	Comment
Ctrl Command 19			59	Indexed String	G232	410,039		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 20			5C	Indexed String	G234	410,040		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 20			5D	Indexed String	G232	410,041		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 21			60	Indexed String	G234	410,042		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 21			61	Indexed String	G232	410,043		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 22			64	Indexed String	G234	410,044		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 22			65	Indexed String	G232	410,045		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 23			68	Indexed String	G234	410,046		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 23			69	Indexed String	G232	410,047		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 24			6C	Indexed String	G234	410,048		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 24			6D	Indexed String	G232	410,049		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 25			70	Indexed String	G234	410,050		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 25			71	Indexed String	G232	410,051		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 26			74	Indexed String	G234	410,052		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 26			75	Indexed String	G232	410,053		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 27			78	Indexed String	G234	410,054		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 27			79	Indexed String	G232	410,055		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 28			7C	Indexed String	G234	410,056		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 28			7D	Indexed String	G232	410,057		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 29			80	Indexed String	G234	410,058		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 29			81	Indexed String	G232	410,059		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 30			84	Indexed String	G234	410,060		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 30			85	Indexed String	G232	410,061		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 31			88	Indexed String	G234	410,062		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 31			89	Indexed String	G232	410,063		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
Control Input 32			8C	Indexed String	G234	410,064		G234	Latched	Setting	0	1	1	2	*	*	*	*	*	*	Individual Control Input Type
Ctrl Command 32			8D	Indexed String	G232	410,065		G232	SET/RESET	Setting	0	3	1	2	*	*	*	*	*	*	Individual Control Input Command Text
I DIFF CONFIG		20	00												*	*	*	*	*	*	
Scheme Setup			01	Indexed String	G101	40950		G101	2 Terminal	Setting	0	2	1	2	*	*	*	*	*	*	
Address			02	Indexed String	G103	40951		G103	0-0	Setting	0	60	1	2	*	*	*	*	*	*	Protection Signalling Address 3 Terminal

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Address			03	Indexed String	G103	40952		G103	0-0	Setting	0	40	1	2	*	*	*	*	*	*	Protection Signalling Address 2 Terminal + Dual Redundant
Baud Rate Ch1			04	Indexed String	G104	40953		G104	64kbits/s	Setting	0	1	1	2	*	*	*	*	*	*	
Clock Source Ch1			05	Indexed String	G105	40954		G105	Internal	Setting	0	1	1	2	*	*	*	*	*	*	
Clock Source Ch2			06	Indexed String	G105	40955		G105	Internal	Setting	0	1	1	2	*	*	*	*	*	*	2001 = 0 OR 2001 = 2 AND 2020 =0
Comm Delay Tol			07	Courier Number (time)		40956		G2	0.00025	Setting	0.00025	0.001	0.00005	2	*	*	*	*	*	*	Signalling Delay Tolerance
Comm Fail Timer			08	Courier Number (time)		40957		G2	10	Setting	0.1	10	0.1	2	*	*	*	*	*	*	Signalling Fail Alarm Timer
Comm Fail Mode			09	Indexed String	G106	40958		G106	Ch 1 and 2 Fail	Setting	0	2	1	2	*	*	*	*	*	*	Report Signalling Failure Mode
Char Mod Time			0A	Courier Number (time)		40959		G2	0.5	Setting	0	2	0.0001	2	*	*	*	*	*	*	Change in Td Modification Timer
I Cap Correction			0B	Indexed String	G37	40960		G37	Disabled	Setting	0	1	1	2			*	*	*	*	Capacitive Current Correction Status
Susceptance			0C	Courier Number (Inverse ohms)		40961	40962	G35	0.00000001*I1	Setting	0.00000001*I1	10*I1	.00000001*I	2			*	*	*	*	
Inrush Restraint			0D	Indexed String	G37	40963		G37	Disabled	Setting	0	1	1	2	*	*					
Vectorial Comp			0E	Indexed String	G108	40964		G108	Yy0 (0 deg)	Setting	0	13	1	2	*	*					
Ph CT Corr'tion			0F	Courier Number (decimal)		40965		G2	1	Setting	1	8	0.01	2	*	*	*	*	*	*	Phase CT Correction
E/F CT Corr'tion			10	Courier Number (decimal)		40966		G2	1	Setting	1	8	0.01	2							
Re-Configuration			11	Indexed String	G109	40967		G109	Three Ended	Command	0	3	1	2	*	*	*	*	*	*	
Kr (Temporary)			12	Courier Number (decimal)				G2	4	Setting	1	40	0.1	2	*	*					Tempory setting durring Development
GPS Sync			13	Indexed String	G37	40968		G37	Disabled	Setting	0	1	1	2					*	*	
Baud Rate Ch2			14	Indexed String	G104	40969		G104	64kbits/s	Setting	0	1	1	2	*	*	*	*	*	*	2001 = 0 OR 2001 = 2 AND 2020 =0
Prop Delay Equal			15	Indexed String	G11	40970		G126	No Operation	Command	0	1	1	1					*	*	Enable protection
Comms Mode			20	Indexed String	G130	40971		G1	Standard	Setting	0	1	1	2	*	*	*	*	*	*	
Ch1 N*64kbits/s			21	Indexed String	G131	40972		G1	1	Setting	0	12	1	2	*	*	*	*	*	*	
Ch2 N*64kbits/s			22	Indexed String	G131	40973		G1	1	Setting	0	12	1	2	*	*	*	*	*	*	2001 = 0 OR 2001 = 2 AND 2020 = 1
CTRL I/P LABELS		29	00																		
Control Input 1			01	ASCII Text (16 chars)		410,100	410,107	G3	Control Input 1	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 2			02	ASCII Text (16 chars)		410,108	410,115	G3	Control Input 2	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 3			03	ASCII Text (16 chars)		410,116	410,123	G3	Control Input 3	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 4			04	ASCII Text (16 chars)		410,124	410,131	G3	Control Input 4	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 5			05	ASCII Text (16 chars)		410,132	410,139	G3	Control Input 5	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 6			06	ASCII Text (16 chars)		410,140	410,147	G3	Control Input 6	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 7			07	ASCII Text (16 chars)		410,148	410,155	G3	Control Input 7	Setting	32	163	1	2	*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Control Input 8			08	ASCII Text (16 chars)		410,156	410,163	G3	Control Input 8	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 9			09	ASCII Text (16 chars)		410,164	410,171	G3	Control Input 9	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 10			0A	ASCII Text (16 chars)		410,172	410,179	G3	Control Input 10	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 11			0B	ASCII Text (16 chars)		410,180	410,187	G3	Control Input 11	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 12			0C	ASCII Text (16 chars)		410,188	410,195	G3	Control Input 12	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 13			0D	ASCII Text (16 chars)		410,196	410,203	G3	Control Input 13	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 14			0E	ASCII Text (16 chars)		410,204	410,211	G3	Control Input 14	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 15			0F	ASCII Text (16 chars)		410,212	410,219	G3	Control Input 15	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 16			10	ASCII Text (16 chars)		410,220	410,227	G3	Control Input 16	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 17			11	ASCII Text (16 chars)		410,228	410,235	G3	Control Input 17	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 18			12	ASCII Text (16 chars)		410,236	410,243	G3	Control Input 18	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 19			13	ASCII Text (16 chars)		410,244	410,251	G3	Control Input 19	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 20			14	ASCII Text (16 chars)		410,252	410,259	G3	Control Input 20	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 21			15	ASCII Text (16 chars)		410,260	410,267	G3	Control Input 21	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 22			16	ASCII Text (16 chars)		410,268	410,275	G3	Control Input 22	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 23			17	ASCII Text (16 chars)		410,276	410,283	G3	Control Input 23	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 24			18	ASCII Text (16 chars)		410,284	410,291	G3	Control Input 24	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 25			19	ASCII Text (16 chars)		410,292	410,299	G3	Control Input 25	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 26			1A	ASCII Text (16 chars)		410,300	410,307	G3	Control Input 26	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 27			1B	ASCII Text (16 chars)		410,308	410,315	G3	Control Input 27	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 28			1C	ASCII Text (16 chars)		410,316	410,323	G3	Control Input 28	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 29			1D	ASCII Text (16 chars)		410,324	410,331	G3	Control Input 29	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 30			1E	ASCII Text (16 chars)		410,332	410,339	G3	Control Input 30	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 31			1F	ASCII Text (16 chars)		410,340	410,347	G3	Control Input 31	Setting	32	163	1	2	*	*	*	*	*	*	
Control Input 32			20	ASCII Text (16 chars)		410,348	410,355	G3	Control Input 32	Setting	32	163	1	2	*	*	*	*	*	*	
PRODUCT SPECIFIC		30	00			41000															
GROUP 1 PHASE DIFF		31	00												*	*	*	*	*	*	
Phase Is1			01	Courier Number (current)		41050		G2	0.2*I1	Setting	0.2*I1	2*I1	0.05*I1	2	*	*	*	*	*	*	3 Terminal
Phase Is2			02	Courier Number (current)		41051		G2	2*I1	Setting	1*I1	30*I1	0.05*I1	2	*	*	*	*	*	*	3 Terminal
Phase k1			03	Courier Number (percentage)		41052		G2	30	Setting	30	150	5	2	*	*	*	*	*	*	3 Terminal

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Phase k2			04	Courier Number (percentage)		41053		G2	100	Setting	30	150	5	2	*	*	*	*	*	*	3 Terminal
Phase Is1			05	Courier Number (current)		41054		G2	0.2*I1	Setting	0.2*I1	2*I1	0.05*I1	2	*	*	*	*	*	*	2 Terminal + Dual Redundant
Phase Is2			06	Courier Number (current)		41055		G2	2*I1	Setting	1*I1	30*I1	0.05*I1	2	*	*	*	*	*	*	2 Terminal + Dual Redundant
Phase k1			07	Courier Number (percentage)		41056		G2	30	Setting	30	150	5	2	*	*	*	*	*	*	2 Terminal + Dual Redundant
Phase k2			08	Courier Number (percentage)		41057		G2	150	Setting	30	150	5	2	*	*	*	*	*	*	2 Terminal + Dual Redundant
Phase Char			09	Indexed String	G112	41058		G112	DT	Setting	0	9	1	2	*	*	*	*	*	*	
Phase Time Delay			0A	Courier Number (time)		41059		G2	0	Setting	0	100	0.01	2	*	*	*	*	*	*	
Phase TMS			0B	Courier Number (decimal)		41060		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	*	*	*	4>=3109>=1
Phase Time Dial			0C	Courier Number (decimal)		41061		G2	1	Setting	0.01	100	0.01	2	*	*	*	*	*	*	
PIT Time			0D	Courier Number (time)		41062		G2	0.2	Setting	0	0.2	0.005	2	*	*	*	*	*	*	
Id High Set			0E	Courier Number (current)		41063		G2	4.0*I1	Setting	4*I1	32*I1	0.01*I1	2	*	*					
GROUP 1 DISTANCE		33	00														*	*	*	*	
Z1 Status			01	Indexed String	G100	41150		G100	Enabled	Setting	0	2	1	2			*	*	*	*	
Z1			02	Courier Number (impedance)		41151		G2	5	Setting	0.1/I1	250/I1	0.01/I1	2			*	*	*	*	pos seq
tZ1			03	Courier Number (time)		41152		G2	0	Setting	0	10	0.01	2			*	*	*	*	
Z1 Intertrip			04	Indexed String	G37	41153		G37	Disabled	Setting	0	1	1	2			*	*	*	*	
Z2 Status			05	Indexed String	G100	41154		G100	Enabled	Setting	0	2	1	2			*	*	*	*	
Z2			06	Courier Number (impedance)		41155		G2	5	Setting	0.1/I1	250/I1	0.01/I1	2			*	*	*	*	
tZ2			07	Courier Number (time)		41156		G2	0.5	Setting	0	10	0.01	2			*	*	*	*	
Z2 Intertrip			08	Indexed String	G37	41157		G37	Disabled	Setting	0	1	1	2			*	*	*	*	
Z3 Status			09	Indexed String	G100	41158		G100	Enabled	Setting	0	2	1	2			*	*	*	*	
Z3			0A	Courier Number (impedance)		41159		G2	5	Setting	0.1/I1	250/I1	0.01/I1	2			*	*	*	*	
tZ3			0B	Courier Number (time)		41160		G2	1	Setting	0	10	0.01	2			*	*	*	*	
Z3 Intertrip			0C	Indexed String	G37	41161		G37	Disabled	Setting	0	1	1	2			*	*	*	*	
Line Angle			0D	Courier Number (angle)		41162		G2	70	Setting	20	85	1	2			*	*	*	*	
kZN Res Comp			0E	Courier Number (decimal)		41163		G2	1	Setting	0	7	0.01	2			*	*	*	*	
kZN Angle			0F	Courier Number (angle)		41164		G2	0	Setting	-180	90	1	2			*	*	*	*	
RPh			10	Courier Number (impedance)		41165		G2	10	Setting	0.1/I1	400/I1	0.01/I1	2			*	*	*	*	Loop
RG			11	Courier Number (impedance)		41166		G2	10	Setting	0.1/I1	400/I1	0.01/I1	2			*	*	*	*	Loop
PSB Status			12	Indexed String	G37	41167		G37	Disabled	Setting	0	1	1	2			*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Delta R			13	Courier Number (impedance)		41168		G2	0.5	Setting	0	400/I1	0.01/I1	2			*	*	*	*	Loop
Delta X			14	Courier Number (impedance)		41169		G2	0.5	Setting	0	400/I1	0.01/I1	2			*	*	*	*	Loop
tZ6			15	Courier Number (time)		41170		G2	0.05	Setting	0	0.1	0.001	2			*	*	*	*	
Z3 Direction			16	Indexed String	G120	41171		G120	Reverse	Setting	0	1	1	2			*	*	*	*	
Direction			17	Indexed String	G120	41172		G120	Fordward	Setting	0	1	1	2			*	*	*	*	
GROUP 1 PRODUCT SPECIFIC		34	00			41200															
GROUP 1 OVERCURRENT		35	00												*	*	*	*	*	*	
I>1 Status			01	Indexed String	G100	41250		G100	Enabled	Setting	0	2	1	2	*	*	*	*	*	*	
I>1 Function			02	Indexed String	G112	41251		G112	IEC S Inverse	Setting	0	9	1	2	*	*	*	*	*	*	
I>1 Directional			03	Indexed String	G44	41252		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	
I>1 Current Set			04	Courier Number (current)		41253		G2	1	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	*	*	*	I>1 Current Setting
I>1 Time Delay			05	Courier Number (time)		41254		G2	1	Setting	0	100	0.01	2	*	*	*	*	*	*	I>1 Definite Time
I>1 TMS			06	Courier Number (decimal)		41255		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	*	*	*	4>=3502>=1
I>1 Time Dial			07	Courier Number (decimal)		41256		G2	1	Setting	0.01	100	0.01	2	*	*	*	*	*	*	
I>1 Reset Char			08	Indexed String	G60	41257		G60	DT	Setting	0	1	1	2	*	*	*	*	*	*	
I>1 tRESET			09	Courier Number (time)		41258		G2	0	Setting	0	100	0.01	2	*	*	*	*	*	*	4>=3502>=0 OR 3508=0
I>2 Status			0A	Indexed String	G100	41259		G100	Disabled	Setting	0	2	1	2	*	*	*	*	*	*	
I>2 Function			0B	Indexed String	G112	41260		G112	IEC S Inverse	Setting	0	9	1	2	*	*	*	*	*	*	I>2 Overcurrent Status
I>2 Directional			0C	Indexed String	G44	41261		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	
I>2 Current Set			0D	Courier Number (current)		41262		G2	1	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	*	*	*	
I>2 Time Delay			0E	Courier Number (time)		41263		G2	1	Setting	0	100	0.01	2	*	*	*	*	*	*	
I>2 TMS			0F	Courier Number (decimal)		41264		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	*	*	*	4>=350B>=1
I>2 Time Dial			10	Courier Number (decimal)		41265		G2	1	Setting	0.01	100	0.01	2	*	*	*	*	*	*	
I>2 Reset Char			11	Indexed String	G60	41266		G60	DT	Setting	0	1	1	2	*	*	*	*	*	*	
I>2 tRESET			12	Courier Number (time)		41267		G2	0	Setting	0	100	0.01	2	*	*	*	*	*	*	4>=350B>=0 OR 3511=0
I>3 Status			13	Indexed String	G100	41268		G100	Disabled	Setting	0	2	1	2	*	*	*	*	*	*	
I>3 Directional			14	Indexed String	G44	41269		G44	Directional Fwd	Setting	0	2	1	2			*	*	*	*	
I>3 Current Set			15	Courier Number (current)		41270		G2	10	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	*	*	*	
I>3 Time Delay			16	Courier Number (time)		41271		G2	0	Setting	0	100	0.01	2	*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
I>3 Intertrip			17	Indexed String	G37	41272		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
I>4 Status			18	Indexed String	G100	41273		G100	Disabled	Setting	0	2	1	2	*	*	*	*	*	*	
I>4 Directional			19	Indexed String	G44	41274		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	
I>4 Current Set			1A	Courier Number (current)		41275		G2	10	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	*	*	*	
I>4 Time Delay			1B	Courier Number (time)		41276		G2	0	Setting	0	100	0.01	2	*	*	*	*	*	*	
I> Char Angle			1C	Courier Number (angle)		41277		G2	30	Setting	-95	95	1	2			*	*	*	*	I> Characteristic Angle
I> Blocking			1D	Binary Flag (6) Indexed String	G14	41278		G14	15	Setting	63	6	1	2		*	*	*	*	*	VTS Block/Autoreclose block per stage
reserved for voltage controlled overcurrent			1E	(Sub-heading)																	
reserved for voltage controlled overcurrent			1F																		
reserved for voltage controlled overcurrent			20																		
reserved for voltage controlled overcurrent			21																		
GROUP 1 NEG SEQ O/C		36	00											2							
GROUP 1 BROKEN CONDUCTOR		37	00												*	*	*	*	*	*	
Broken Conductor			01	Indexed String	G37	41350		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
I2/I1 Setting			02	Courier Number (decimal)		41351		G2	0.2	Setting	0.2	1	0.01	2	*	*	*	*	*	*	
I2/I1 Time Delay			03	Courier Number (time)		41352		G2	60	Setting	0	100	0.1	2	*	*	*	*	*	*	
GROUP 1 EARTH FAULT		38	00												*	*	*	*	*	*	
IN>1 Status			01	Indexed String	G100	41400		G100	Enabled	Setting	0	2	1	2	*	*	*	*	*	*	
IN>1 Function			02	Indexed String	G112	41401		G112	IEC S Inverse	Setting	0	9	1	2	*	*	*	*	*	*	
IN>1 Directional			03	Indexed String	G44	41402		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	
IN>1 Current Set			04	Courier Number (current)		41403		G2	0.2	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	*	*	*	I>1 Current Setting
IN>1 Time Delay			05	Courier Number (time)		41404		G2	1	Setting	0	200	0.01	2	*	*	*	*	*	*	I>1 Definite Time
IN>1 TMS			06	Courier Number (decimal)		41405		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	*	*	*	4>=3802>=1
IN>1 Time Dial			07	Courier Number (decimal)		41406		G2	1	Setting	0.01	100	0.01	2	*	*	*	*	*	*	
IN>1 Reset Char			08	Indexed String	G60	41407		G60	DT	Setting	0	1	1	2	*	*	*	*	*	*	
IN>1 tRESET			09	Courier Number (time)		41408		G2	0	Setting	0	100	0.01	2	*	*	*	*	*	*	4>=3802>=0 OR 3808=0
IN>2 Status			0A	Indexed String	G100	41409		G100	Disabled	Setting	0	2	1	2	*	*	*	*	*	*	
IN>2 Function			0B	Indexed String	G112	41410		G112	IEC S Inverse	Setting	0	9	1	2	*	*	*	*	*	*	I>2 Overcurrent Status

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
IN>2 Directional			0C	Indexed String	G44	41411		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	
IN>2 Current Set			0D	Courier Number (current)		41412		G2	0.2	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	*	*	*	
IN>2 Time Delay			0E	Courier Number (time)		41413		G2	1	Setting	0	200	0.01	2	*	*	*	*	*	*	
IN>2 TMS			0F	Courier Number (decimal)		41414		G2	1	Setting	0.025	1.2	0.025	2	*	*	*	*	*	*	4>=380B>=1
IN>2 Time Dial			10	Courier Number (decimal)		41415		G2	1	Setting	0.01	100	0.1	2	*	*	*	*	*	*	
IN>2 Reset Char			11	Indexed String	G60	41416		G60	DT	Setting	0	1	1	2	*	*	*	*	*	*	
IN>2 tRESET			12	Courier Number (time)		41417		G2	0	Setting	0	100	0.01	2	*	*	*	*	*	*	4>=380B>=0 OR 3811=0
IN>3 Status			13	Indexed String	G100	41418		G100	Disabled	Setting	0	2	1	2	*	*	*	*	*	*	
IN>3 Directional			14	Indexed String	G44	41419		G44	Directional Fwd	Setting	0	2	1	2			*	*	*	*	
IN>3 Current Set			15	Courier Number (current)		41420		G2	10	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	*	*	*	
IN>3 Time Delay			16	Courier Number (time)		41421		G2	0	Setting	0	200	0.01	2	*	*	*	*	*	*	
IN>4 Status			17	Indexed String	G100	41422		G100	Disabled	Setting	0	2	1	2	*	*	*	*	*	*	
IN>4 Directional			18	Indexed String	G44	41423		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	
IN>4 Current Set			19	Courier Number (current)		41424		G2	10	Setting	0.08*I1	32*I1	0.01*I1	2	*	*	*	*	*	*	
IN>4 Time Delay			1A	Courier Number (time)		41425		G2	0	Setting	0	200	0.01	2	*	*	*	*	*	*	
IN> Blocking			1B	Binary Flag (6) Indexed String	G63	41426		G63	15	Setting	63	6	1	2		*	*	*	*	*	
IN> DIRECTIONAL			1C	(Sub Heading)		41427								2			*	*	*	*	
IN> Char Angle			1D	Courier Number (angle)		41428		G2	-60	Setting	-95	95	1	2			*	*	*	*	
IN> Polarisation			1E	Indexed String	G46	41429		G46	Zero Sequence	Setting	0	1	1	2			*	*	*	*	
IN> Voltage Pol			1F	Indexed String	G49			G49	Derived	Setting	0	1	1	2							
IN> VNpol Set			20	Courier Number (voltage)		41430		G2	5	Setting	0.5*V1	80*V1	0.5*V1	2			*	*	*	*	IN> VN Polarising Setting
IN> V2pol Set			21	Courier Number (voltage)		41431		G2	5	Setting	0.5*V1	25*V1	0.5*V1	2			*	*	*	*	IN> V2 Polarising Setting
IN> I2pol Set			22	Courier Number (current)		41432		G2	0.08	Setting	0.08*I1	1.0*I1	0.01*I1	2			*	*	*	*	IN> I2 Polarising Setting
GROUP 1 PRODUCT SPECIFIC		39	00			41450															
GROUP 1 SENSITIVE E/F		3A	00														*	*	*	*	GROUP 1 - SENSITIVE EARTH FAULT
Sens E/F Options			01	Indexed String	G58	41500		G58	SEF Enabled	Setting	0	1	1	2			*	*	*	*	Sensitive Earth Fault Options
ISEF>1 Function			02	Indexed String	G43	41501		G43	DT	Setting	0	10	1	2			*	*	*	*	
ISEF>1 Direction			03	Indexed String	G44	41502		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	ISEF>1 Directionality
ISEF>1 Current			04	Courier Number (current)		41503		G2	0.05	Setting	0.005*I3	0.1*I3	0.00025*I3	2			*	*	*	*	ISEF>1 Current Setting

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
ISEF>1 Delay			05	Courier Number (time)		41504		G2	1	Setting	0	200	0.01	2			*	*	*	*	ISEF>1 Definite Time
ISEF>1 TMS			06	Courier Number (decimal)		41505		G2	1	Setting	0.025	1.2	0.025	2			*	*	*	*	5>=3A02>=2
ISEF>1 Time Dial			07	Courier Number (decimal)		41506		G2	1	Setting	0.01	100	0.01	2			*	*	*	*	ISEF>1 TMS
ISEF>1 Reset Chr			08	Indexed String	G60	41507		G60	DT	Setting	0	1	1	2			*	*	*	*	
ISEF>1 tRESET			09	Courier Number (time)		41508		G2	0	Setting	0	100	0.01	2			*	*	*	*	5>=3A02>=1 OR 3A08=0
ISEF>2 Function			0A	Indexed String	G43	41509		G43	Disabled	Setting	0	10	1	2			*	*	*	*	
ISEF>2 Direction			0B	Indexed String	G44	41510		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	
ISEF>2 Current			0C	Courier Number (current)		41511		G2	0.05	Setting	0.005*I3	0.1*I3	0.00025*I3	2			*	*	*	*	
ISEF>2 Delay			0D	Courier Number (time)		41512		G2	1	Setting	0	200	0.01	2			*	*	*	*	
ISEF>2 TMS			0E	Courier Number (decimal)		41513		G2	1	Setting	0.025	1.2	0.025	2			*	*	*	*	5>=3A0A>=2
ISEF>2 Time Dial			0F	Courier Number (decimal)		41514		G2	1	Setting	0.01	100	0.01	2			*	*	*	*	
ISEF>2 Reset Chr			10	Indexed String	G60	41515		G60	DT	Setting	0	1	1	2			*	*	*	*	
ISEF>2 tRESET			11	Courier Number (time)		41516		G2	0	Setting	0	100	0.01	2			*	*	*	*	5>=3A0A>=1 OR 3A10=0
ISEF>3 Status			12	Indexed String	G37	41517		G37	Disabled	Setting	0	1	1	2			*	*	*	*	ISEF>3 Sensitive Earth Fault Status
ISEF>3 Direction			13	Indexed String	G44	41518		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	ISEF>3 Directionality
ISEF>3 Current			14	Courier Number (current)		41519		G2	0.4	Setting	0.005*I3	0.8*I3	0.001*I3	2			*	*	*	*	ISEF>3 Current Setting
ISEF>3 Delay			15	Courier Number (time)		41520		G2	0.5	Setting	0	200	0.01	2			*	*	*	*	ISEF>3 Definite Time
ISEF>4 Status			16	Indexed String	G37	41521		G37	Disabled	Setting	0	1	1	2			*	*	*	*	ISEF>4 Sensitive Earth Fault Status
ISEF>4 Direction			17	Indexed String	G44	41522		G44	Non-Directional	Setting	0	2	1	2			*	*	*	*	ISEF>4 Directionality
ISEF>4 Current			18	Courier Number (current)		41523		G2	0.6	Setting	0.005*I3	0.8*I3	0.001*I3	2			*	*	*	*	ISEF>4 Current Setting
ISEF>4 Delay			19	Courier Number (time)		41524		G2	0.25	Setting	0	200	0.01	2			*	*	*	*	ISEF>4 Definite Time
ISEF> Blocking			1A	Binary Flag (6) Indexed String	G64	41525		G64	15	Setting	63	6	1	2			*	*	*	*	
ISEF DIRECTIONAL			1B	(Sub Heading)										2			*	*	*	*	ISEF Directional Element
ISEF> Char Angle			1C	Courier Number (angle)		41526		G2	90	Setting	-95	95	1	2			*	*	*	*	Characteristic Angle
ISEF> Vpol Input			1D	Indexed String	G49			G49	Derived	Setting	0	1	1	2							Polarising Neutral Voltage Input
ISEF> VN pol Set			1E	Courier Number (voltage)		41527		G2	5	Setting	0.5*V1	88*V1	0.5*V1	2			*	*	*	*	Polarisation voltage Vop>
Wattmetric SEF			1F	(Sub Heading)													*	*	*	*	Wattmetric Earth Fault
PN> Setting			20	Courier Number (power)		41528		G2	9	Setting	0.0*V1*I2	20*V1*I2	0.05*V1*I2	2			*	*	*	*	Po> Power Setting
Restricted E/F			21	(Sub Heading)																	Restricted Earth Fault
IREF> K1			22	Courier Number (percentage)				G2		Setting	0	20	1	2							REF K1
IREF> K2			23	Courier Number (percentage)				G2		Setting	0	150	1	2							REF K2

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
IREF> Is1			24	Courier Number (current)				G2		Setting	0.05*I3	1.0*I3	0.01*I3	2							REF Is1
IREF> Is2			25	Courier Number (current)				G2		Setting	0.1*I3	1.5*I3	0.01*I3	2							REF Is2
GROUP 1 RESIDUAL O/V NVD		3B	00																		
GROUP 1 THERMAL OVERLOAD		3C	00												*	*	*	*	*	*	
Characteristic			01	Indexed String	G67	41600		G67	Single	Setting	0	2	1	2	*	*	*	*	*	*	
Thermal Trip			02	Courier Number (current)		41601		G2	1	Setting	0.08*I1	4.0*I1	0.01*I1	2	*	*	*	*	*	*	
Thermal Alarm			03	Courier Number (percentage)		41602		G2	70	Setting	50	100	1	2	*	*	*	*	*	*	
Time Constant 1			04	Courier Number (time-minutes)		41603		G2	10	Setting	1	200	1	2	*	*	*	*	*	*	
Time Constant 2			05	Courier Number (time-minutes)		41604		G2	5	Setting	1	200	1	2	*	*	*	*	*	*	
GROUP 1 PRODUCT SPECIFIC		3D	00			41650															
GROUP 1 PRODUCT SPECIFIC		3E	00			41700															
GROUP 1 PRODUCT SPECIFIC		3F	00			41750															
GROUP 1 PRODUCT SPECIFIC		40	00			41800															
GROUP 1 PRODUCT SPECIFIC		41	00			41850															
GROUP 1 VOLT PROTECTION		42	00																		
GROUP 1 FREQ PROTECTION		43	00																		
GROUP 1 RTD PROTECTION		44	00																		
GROUP 1 CB FAIL & I<		45	00												*	*	*	*	*	*	
BREAKER FAIL			01	(Sub Heading)											*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
CB Fail 1 Status			02	Indexed String	G37	42100		G37	Enabled	Setting	0	1	1	2	*	*	*	*	*	*	
CB Fail 1 Timer			03	Courier Number (time)		42101		G2	0.2	Setting	0	10	0.01	2	*	*	*	*	*	*	
CB Fail 2 Status			04	Indexed String	G37	42102		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
CB Fail 2 Timer			05	Courier Number (time)		42103		G2	0.4	Setting	0	10	0.01	2	*	*	*	*	*	*	
Volt Prot Reset			06	Indexed String	G68	42104		G68		Setting	0	2	1	2							
Ext Prot Reset			07	Indexed String	G68	42105		G68	Prot Reset & I<	Setting	0	2	1	2	*	*	*	*	*	*	
UNDER CURRENT			08	(Sub Heading)											*	*	*	*	*	*	
I< Current Set			09	Courier Number (current)		42106		G2	0.1	Setting	0.02*I1	3.2*I1	0.01*I1	2	*	*	*	*	*	*	
IN< Current Set			0A	Courier Number (current)		42107		G2	0.1	Setting	0.02*I2	3.2*I2	0.01*I2	2							
ISEF< Current			0B	Courier Number (current)		42108		G2	0.02	Setting	0.001*I3	0.8*I3	0.0005*I3	2	*	*	*	*	*	*	
BLOCKED O/C			0C	(Sub Heading)											*	*	*	*	*	*	Blocked Overcurrent Schemes
Remove I> Start			0D	Indexed String	G37	42109		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
Remove IN> Start			0E	Indexed String	G37	42110		G37	Disabled	Setting	0	1	1	2	*	*	*	*	*	*	
GROUP 1 SUPERVISION		46	00														*	*	*	*	
VT SUPERVISION			01	(Sub Heading)													*	*	*	*	
VTS Status			02	Indexed String	G7	42150		G7	Blocking	Setting	0	1	1	2			*	*	*	*	
VTS Reset Mode			03	Indexed String	G69	42151		G69	Manual	Setting	0	1	1	2			*	*	*	*	
VTS Time Delay			04	Courier Number (time)		42152		G2	5	Setting	1	10	0.1	2			*	*	*	*	
VTS I> Inhibit			05	Courier Number (current)		42153		G2	10	Setting	0.08*I1	32*I1	0.01*I1	2			*	*	*	*	
VTS I2> Inhibit			06	Courier Number (current)		42154		G2	0.05	Setting	0.05*I1	0.5*I1	0.01*I1	2			*	*	*	*	
CT SUPERVISION			07	(Sub Heading)																	
CTS Status			08	Courier Number (voltage)	G37	42155		G37		Setting	0	1	1	2							
CTS VN< Inhibit			09	Courier Number (voltage)		42156		G2		Setting	0.5*V1	22*V1	0.5*V1	2							
CTS IN> Set			0A	Courier Number (current)		42157		G2		Setting	0.08*I1	4*I1	0.01*I1	2							
CTS Time Delay			0B	Courier Number (time)		42158		G2		Setting	0	10	1	2							
GROUP 1 FAULT LOCATOR		47	00														*	*	*	*	
Line Length			01	Courier Number (metres)		42200	42201	G35	16000	Setting	10	1E6	1	2			*	*	*	*	Length in km
Line Length			02	Courier Number (miles)		42202	42203	G35	10	Setting	0.005	621	0.005	2			*	*	*	*	Setting stored in km, displayed using miles
Line Impedance			03	Courier Number (impedance)		42204		G2	6	Setting	0.1*V1/I1	250*V1/I1	0.01*V1/I1	2			*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Line Angle			04	Courier Number (angle)		42205		G2	70	Setting	20	85	1	2			*	*	*	*	
kZN Residual			05	Courier Number (decimal)		42206		G2	1	Setting	0	7	0.01	2			*	*	*	*	Multiplier
kZN Res Angle			06	Courier Number (angle)		42207		G2	0	Setting	-180	90	1	2			*	*	*	*	
Mutual Comp			07	Indexed String	G37	42208		G37	Disabled	Setting	0	1	1	2			*	*	*	*	
kZm Mutual Comp			08	Courier Number (decimal)		42209		G2	1	Setting	0	7	0.01	2			*	*	*	*	
kZm Angle			09	Courier Number (angle)		42210		G2	0	Setting	-90	90	1	2			*	*	*	*	
GROUP 1 SYSTEM CHECKS		48	00														*		*		
C/S Phase Angle			01	Courier Number (angle)		42250		G2	20	Setting	5	90	1	2							
Voltage Blocking			02	Indexed String	G41	42251		G41	Undervoltage	Setting	0	3	1	2							
Undervoltage			03	Courier Number (voltage)		42252		G2	54	Setting	22*V1	132*V1	0.5*V1	2							(4802 = 1) OR (4802 = 3)
Diff Voltage			04	Courier Number (voltage)		42253		G2	6.5	Setting	0.5*V1	50*V1	0.5*V1	2							(4802 = 2) OR (4802 = 3)
Slip Control			05	Indexed String	G42	42254		G42	Frequency	Setting	0	3	1	2							
Slip Frequency			06	Courier Number (frequency)		42255		G2	0.05	Setting	0.02	1	0.01	2							(4805 = 2) OR (4805 = 3)
Slip Timer			07	Courier Number (time)		42256		G2	1	Setting	0	99	0.1	2							(4805 = 1) OR (4805 = 3)
Live Voltage			08	Courier Number (voltage)		42257		G2	32	Setting	5.5*V1	132*V1	0.5*V1	2							
Dead Voltage			09	Courier Number (voltage)		42258		G2	13	Setting	5.5*V1	132*V1	0.5*V1	2							
MAN CLOSE CHK			0A	(Sub Heading)																	
Check Synch			0B	Indexed String	G37	42259		G37	Enabled	Setting	0	1	1	2							
DeadLine/LiveBus			0C	Indexed String	G37	42260		G37	Enabled	Setting	0	1	1	2							Dead Line/Live Bus
LiveLine/DeadBus			0D	Indexed String	G37	42261		G37	Enabled	Setting	0	1	1	2							Live Line/Dead Bus
DeadLine/DeadBus			0E	Indexed String	G37	42262		G37	Disabled	Setting	0	1	1	2							Dead Line/Dead Bus
A/R CHECK			0F	(Sub Heading)																	
Check Synch			10	Indexed String	G37	42263		G37	Enabled	Setting	0	1	1	2							
DeadLine/LiveBus			11	Indexed String	G37	42264		G37	Enabled	Setting	0	1	1	2							Dead Line/Live Bus
LiveLine/DeadBus			12	Indexed String	G37	42265		G37	Enabled	Setting	0	1	1	2							Live Line/Dead Bus
DeadLine/DeadBus			13	Indexed String	G37	42266		G37	Disabled	Setting	0	1	1	2							Dead Line/Dead Bus
VOLTAGE MONITORS			14	(Sub Heading)													*		*		
Live Voltage			15	Courier Number (voltage)		42270		G2	32	Setting	1*V1	132*V1	0.5*V1	2			*		*		
Dead Voltage			16	Courier Number (voltage)		42271		G2	13	Setting	1*V1	132*V1	0.5*V1	2			*		*		
CHECK SYNCH			17	(Sub Heading)													*		*		

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
CS1 Status			18	Indexed String		42272		G1	Enabled	Setting	0	1	1	2			*		*		
CS1 Phase Angle			19	Courier Number (angle)		42273		G2	20	Setting	5	90	1	2			*		*		
CS1 Slip Control			1A	Indexed String		42274		G1	Frequency	Setting	0	3	1	2			*		*		
CS1 Slip Freq			1B	Courier Number (frequency)		42275		G2	0.05	Setting	0.01	1	0.01	2			*		*		4818=1 AND (481A=2 OR 481A=3)
CS1 Slip Timer			1C	Courier Number (time)		42276		G2	1	Setting	0	99	0.01	2			*		*		4818=1 AND (481A=1 OR 481A=3)
CS2 Status			1D	Indexed String		42277		G1	Enabled	Setting	0	1	1	2			*		*		
CS2 Phase Angle			1E	Courier Number (angle)		42278		G2	20	Setting	5	90	1	2			*		*		
CS2 Slip Control			1F	Indexed String		42279		G1	Frequency	Setting	0	3	1	2			*		*		
CS2 Slip Freq			20	Courier Number (frequency)		42280		G2	0.05	Setting	0.01	1	0.01	2			*		*		481D=1 AND (481F=2 OR 481F=3)
CS2 Slip Timer			21	Courier Number (time)		42281		G2	1	Setting	0	99	0.01	2			*		*		481D=1 AND (481F=1 OR 481F=3)
CS Undervoltage			22	Courier Number (voltage)		42282		G2	54	Setting	10*V1	132*V1	0.5*V1	2			*		*		4818=1 OR 481D=1
CS Overvoltage			23	Courier Number (voltage)		42283		G2	130	Setting	60*V1	185*V1	0.5*V1	2			*		*		4818=1 OR 481D=1
CS Diff Voltage			24	Courier Number (voltage)		42284		G2	6.5	Setting	1*V1	132*V1	0.5*V1	2			*		*		4818=1 OR 481D=1
CS Voltage Block			25	Indexed String		42285		G1	V<	Setting	0	7	1	2			*		*		4818=1 OR 481D=1
SYSTEM SPLIT			26	(Sub Heading)													*		*		
SS Status			27	Indexed String		42286		G1	Enabled	Setting	0	1	1	2			*		*		
SS Phase Angle			28	Courier Number (angle)		42287		G2	120	Setting	90	175	1	2			*		*		
SS Under V Block			29	Indexed String		42288		G1	Enabled	Setting	0	1	1	2			*		*		
SS Undervoltage			2A	Courier Number (voltage)		42289		G2	54	Setting	10*V1	132*V1	0.5*V1	2			*		*		
SS Timer			2B	Courier Number (time)		42290		G2	1	Setting	0	99	0.01	2			*		*		
GROUP 1 AUTORECLOSE		49	00													*	*		*		
A/R Mode Select			01	Indexed String	G70			G70		Setting	0	3	1	2							
Number of Shots			02	Unsigned Integer (16 bits)		42300		G1	1	Setting	1	4	1	2		*					
Number SEF Shots			03	Unsigned Integer (16 bits)				G1	0	Setting	0	4	1	2							
Sequence Co-ord			04	Indexed String	G37			G37	Disabled	Setting	0	1	1	2							
Single Pole Shot			05	Unsigned Integer (16 bits)		42301		G1	1	Setting	1	4	1	2			*		*		AR on 1 pole
Three Pole Shot			06	Unsigned Integer (16 bits)		42302		G1	1	Setting	1	4	1	2			*		*		AR on 3 pole
1 Pole Dead Time			07	Courier Number (time)		42303		G2	0.5	Setting	0.2	5	0.01	2			*		*		1PDTIME
Dead Time 1			08	Courier Number (time)		42304		G2	10	Setting	0.01	300	0.01	2		*					DTime1
Dead Time 1			08	Courier Number (time)		42304		G2	0.3	Setting	0.2	30	0.01	2			*		*		DTime1

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Dead Time 2			09	Courier Number (time)		42305		G2	60	Setting	0.01	300	0.01	2		*					DTime2
Dead Time 2			09	Courier Number (time)		42305		G2	60	Setting	1	1800	1	2			*		*		DTime2
Dead Time 3			0A	Courier Number (time)		42306	42307	G35	180	Setting	0.01 1	9999	0.01	2		*					DTime3
Dead Time 3			0A	Courier Number (time)		42306	42307	G35	180	Setting	0.01 1	9999 3600	0.01 1	2		*	*		*		DTime3
Dead Time 4			0B	Courier Number (time)		42308	42309	G35	180	Setting	0.01 1	9999	0.01	2		*					DTime4
Dead Time 4			0B	Courier Number (time)		42308	42309	G35	180	Setting	0.01 1	3600	1	2			*		*		DTime4
CB Healthy Time			0C	Courier Number (time)		42310	42311	G35	5	Setting	0.01	9999	0.01	2		*					
CB Healthy Time			0C	Courier Number (time)		42310	42311	G35	5	Setting	1	3600	1	2			*		*		
Start Dead t On			0D	Indexed String	G72			G72	Protection Resets	Setting	0	1	1	2							
tReclaim Extend			0E	Indexed String	G73	42312		G73	No operation	Setting	0	1	1	2		*					
Reclaim Time			0F	Courier Number (time)		42313		G2	180	Setting	1	600	0.01	2		*					Reclaim time
Reclaim Time			0F	Courier Number (time)		42313		G2	180	Setting	1	600	1	2			*		*		Reclaim time
AR Inhibit Time			10	Courier Number (time)		42314		G2	5	Setting	0.01	600	0.01	2		*	*		*		AR Inhibit Time Delay
Close pulse			11	Courier Number (time)		42315		G2	1	Setting	0.1	10	0.01	2							Successful Close pulse ARTime
A/R Lockout			12	Indexed String	G91			G91	Allow Tripping	Setting	0	1	1	2							Block Trips on Lockout
EFF Maint Lock			13	Indexed String	G91	42316		G91	Allow Tripping	Setting	0	1	1	2		*					Block Protection Trips when Maint/EFF Locked Out
A/R Deselected			14	Indexed String	G91			G91	Allow Tripping	Setting	0	1	1	2							Block Protection Trips if Auto Mode Deselected
Manual Close			15	Indexed String	G91			G91	Allow Tripping	Setting	0	1	1	2							Block Protection Trips after Control Close
Trip 1 Main			16	Indexed String	G82	42317		G82	No Block	Setting	0	1	1	2		*					Block Main Prot for 1st Trip
Trip 2 Main			17	Indexed String	G82	42318		G82	Block Inst Prot	Setting	0	1	1	2		*					Block Main Prot for 2nd Trip
Trip 3 Main			18	Indexed String	G82	42319		G82	Block Inst Prot	Setting	0	1	1	2		*					Block Main Prot for 3rd Trip
Trip 4 Main			19	Indexed String	G82	42320		G82	Block Inst Prot	Setting	0	1	1	2		*					Block Main Prot for 4th Trip
Trip 5 Main			1A	Indexed String	G82	42321		G82	Block Inst Prot	Setting	0	1	1	2		*					Block Main Prot for 5th Trip
Trip 1 SEF			1B	Indexed String	G82			G82	Block Inst Prot	Setting	0	1	1	2							Block SEF Protection Trips
Trip 2 SEF			1C	Indexed String	G82			G82	Block Inst Prot	Setting	0	1	1	2							Reinstate Protection Trips
Trip 3 SEF			1D	Indexed String	G82			G82	Block Inst Prot	Setting	0	1	1	2							Reinstate SEF Protection Trips
Trip 4 SEF			1E	Indexed String	G82			G82	Block Inst Prot	Setting	0	1	1	2							Reinstate Protection Trips
Trip 5 SEF			1F	Indexed String	G82			G82	Block Inst Prot	Setting	0	1	1	2							Reinstate SEF Protection Trips
Man Close on Flt			20	Indexed String	G92			G92	Lockout	Setting	0	1	1	2							Lockout for Control Close onto Fault
Trip in Non-auto			21	Indexed String	G92			G92	No Lockout	Setting	0	1	1	2							Lockout if Protection Operates in Non Auto or Liveline modes
Reset Lockout by			22	Indexed String	G74	42322		G74	User Interface	Setting	0	1	1	2							Reset Lockout

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Man Close BlkDly			23	Courier Number (time)				G2	5	Setting	0.01	300	0.01	2							Control Close Inhibit Time
A/R on Man Close			24	Indexed String	G75			G75	Disabled	Setting	0	1	1	2							Auto-Reclose after Control Close
Check Sync Time			25	Courier Number (time)		42323		G35	5	Setting	0.01	9999	0.01	2			*		*		Check Sync Window
C/S on 1st Shot			26	Indexed String	G37			G37	Enabled	Setting	0	1	1	2							System Check on First Shot
SysChk on Shot 1			27	Indexed String	G37	42325		G37	Disabled	Setting	0	1	1	2			*		*		SYNC AR3 Fast
Phase Diff AR			28	Indexed String	G114	42326		G114	Initiate AR	Setting	0	2	1	2		*	*		*		
Neutral Diff AR			29	Indexed String	G114	42327		G114	No Action	Setting	0	2	1	2							
Z1 AR			2A	Indexed String	G114	42328		G114	Initiate AR	Setting	0	2	1	2			*		*		(090D = 1) && (3301 <> 0)
Z2T AR			2B	Indexed String	G114	42329		G114	Block AR	Setting	0	2	1	2			*		*		(090D =1) && (3305 <> 0)
Z3T AR			2C	Indexed String	G114	42330		G114	Block AR	Setting	0	2	1	2			*		*		(090D = 1) && (3309 <>0)
I>1 AR			2D	Indexed String	G114	42331		G114	No Action	Setting	0	2	1	2		*	*		*		(0910 = 1) && (3501 <> 0)
I>2 AR			2E	Indexed String	G114	42332		G114	No Action	Setting	0	2	1	2		*	*		*		(0910 = 1) && (350A <> 0)
I>3 AR			2F	Indexed String	G114	42333		G114	No Action	Setting	0	2	1	2		*	*		*		(0910 = 1) && (3513 <> 0)
I>4 AR			30	Indexed String	G114	42334		G114	No Action	Setting	0	2	1	2		*	*		*		(0910 = 1) && (3518 <> 0)
IN>1 AR			31	Indexed String	G114	42335		G114	No Action	Setting	0	2	1	2		*	*		*		(0913 = 1) && (3801 <> 0)
IN>2 AR			32	Indexed String	G114	42336		G114	No Action	Setting	0	2	1	2		*	*		*		(0913 = 1) && (380A <> 0)
IN>3 AR			33	Indexed String	G114	42337		G114	No Action	Setting	0	2	1	2		*	*		*		(0913 = 1) && (3813 <> 0)
IN>4 AR			34	Indexed String	G114	42338		G114	No Action	Setting	0	2	1	2		*	*		*		(0913 = 1) && (3817 <> 0)
ISEF>1 AR			35	Indexed String	G114	42339		G114	No Action	Setting	0	2	1	2			*		*		(0915 = 1) && (3A02 <> 0)
ISEF>2 AR			36	Indexed String	G114	42340		G114	No Action	Setting	0	2	1	2			*		*		(0915 = 1) && (3A0A <> 0)
ISEF>3 AR			37	Indexed String	G114	42341		G114	No Action	Setting	0	2	1	2			*		*		(0915 = 1) && (3A12 <> 0)
ISEF>4 AR			38	Indexed String	G114	42342		G114	No Action	Setting	0	2	1	2			*		*		(0915 = 1) && (3A16 <> 0)
Mult Phase AR			39	Indexed String	G115	42343		G115	BAR 3 Phase	Setting	0	2	1	2			*		*		
Dead Time Start			3A		G127	42344		G127	Protection Op	Setting	0	1	1	2			*		*		
Discrim Time			3B	Courier Number (time)		42345		G2	0.1	Setting	0.1	5	0.01	2			*		*		
SYSTEM CHECKS			40	(Sub Heading)																	SYSTEM CHECKS
CheckSync1 Close			41	Indexed String	G37	42346		G37	Enabled	Setting	0	1	1	2			*		*		
CheckSync2 Close			42	Indexed String	G37	42347		G37	Disabled	Setting	0	1	1	2			*		*		
LiveLine/DeadBus			43	Indexed String	G37	42348		G37	Enabled	Setting	0	1	1	2			*		*		
DeadLine/LiveBus			44	Indexed String	G37	42349		G37	Enabled	Setting	0	1	1	2			*		*		
DeadLine/DeadBus			45	Indexed String	G37	42350		G37	Disabled	Setting	0	1	1	2			*		*		

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
CS AR Immediate			46	Indexed String	G37	42351		G37	Disabled	Setting	0	1	1	2			*		*		
GROUP 1 INPUT LABELS		4A	00												*	*	*	*	*	*	
Opto Input 1			01	ASCII Text (16)		42400	42407	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Opto Input 2			02	ASCII Text (16)		42408	42415	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Opto Input 3			03	ASCII Text (16)		42416	42423	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Opto Input 4			04	ASCII Text (16)		42424	42431	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Opto Input 5			05	ASCII Text (16)		42432	42439	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Opto Input 6			06	ASCII Text (16)		42440	42447	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Opto Input 7			07	ASCII Text (16)		42448	42455	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Opto Input 8			08	ASCII Text (16)		42456	42463	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Opto Input 9			09	ASCII Text (16)		42464	42471	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Opto Input 10			0A	ASCII Text (16)		42472	42479	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Opto Input 11			0B	ASCII Text (16)		42480	42487	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Opto Input 12			0C	ASCII Text (16)		42488	42495	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Opto Input 13			0D	ASCII Text (16)		42496	42503	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Opto Input 14			0E	ASCII Text (16)		42504	42511	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Opto Input 15			0F	ASCII Text (16)		42512	42519	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Opto Input 16			10	ASCII Text (16)		42520	42527	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Opto Input 17			11	ASCII Text (16 chars)		42870	42877	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Opto Input 18			12	ASCII Text (16 chars)		42878	42885	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Opto Input 19			13	ASCII Text (16 chars)		42886	42893	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Opto Input 20			14	ASCII Text (16 chars)		42894	42901	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Opto Input 21			15	ASCII Text (16 chars)		42902	42909	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Opto Input 22			16	ASCII Text (16 chars)		42910	42917	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Opto Input 23			17	ASCII Text (16 chars)		42918	42925	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Opto Input 24			18	ASCII Text (16 chars)		42926	42933	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
GROUP 1 OUTPUT LABELS		4B	00												*	*	*	*	*	*	
Relay 1			01	ASCII Text (16)		42550	42557	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Relay 2			02	ASCII Text (16)		42558	42565	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	2	3	4	5	6	Comment
Relay 3			03	ASCII Text (16)		42566	42573	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Relay 4			04	ASCII Text (16)		42574	42581	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Relay 5			05	ASCII Text (16)		42582	42589	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Relay 6			06	ASCII Text (16)		42590	42597	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Relay 7			07	ASCII Text (16)		42598	42605	G3	see 50315.3110.012	Setting	32	163	1	2	*	*	*	*	*	*	
Relay 8			08	ASCII Text (16)		42606	42613	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Relay 9			09	ASCII Text (16)		42614	42621	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Relay 10			0A	ASCII Text (16)		42622	42629	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Relay 11			0B	ASCII Text (16)		42630	42637	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Relay 12			0C	ASCII Text (16)		42638	42645	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Relay 13			0D	ASCII Text (16)		42646	42653	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Relay 14			0E	ASCII Text (16)		42654	42661	G3	see 50315.3110.012	Setting	32	163	1	2		*	*	*	*	*	
Relay 15			0F	ASCII Text (16)		42662	42669	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 16			10	ASCII Text (16)		42670	42677	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 17			11	ASCII Text (16)		42678	42685	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 18			12	ASCII Text (16)		42686	42693	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 19			13	ASCII Text (16)		42694	42701	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 20			14	ASCII Text (16)		42702	42709	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 21			15	ASCII Text (16)		42710	42717	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 22			16	ASCII Text (16)		42718	42725	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 23			17	ASCII Text (16)		42726	42733	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 24			18	ASCII Text (16)		42734	42741	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 25			19	ASCII Text (16)		42742	42749	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 26			1A	ASCII Text (16)		42750	42757	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 27			1B	ASCII Text (16)		42758	42765	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 28			1C	ASCII Text (16)		42766	42773	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 29			1D	ASCII Text (16)		42774	42781	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 30			1E	ASCII Text (16)		42782	42789	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 31			1F	ASCII Text (16)		42790	42797	G3	see 50315.3110.012	Setting	32	163	1	2					*	*	
Relay 32			20	ASCII Text (16)		42798	42805	G3	see 50315.3110.012										*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
GROUP 1 RTD LABELS		4C	00																		
GROUP 2 PROTECTION SETTINGS																					
Repeat of Group 1 columns/rows		50	00			*43000	44999								*	*	*	*	*	*	
GROUP 3 PROTECTION SETTINGS																					
Repeat of Group 1 columns/rows		70	00			*45000	46999								*	*	*	*	*	*	
GROUP 4 PROTECTION SETTINGS																					
Repeat of Group 1 columns/rows		90	00			*47000	48999								*	*	*	*	*	*	
This is an invisible column for auto extraction of event records, do not redefine any of its rows but keep it consistent with column [01]																					
(No Header)	N/A	B0	00	Auto extraction Event Record Column											*	*	*	*	*	*	
Select Record			01	Unsigned Integer(2)						Setting	0	65535	1		*	*	*	*	*	*	Unique cyclical fault number(from event)
Faulted Phases			04	Binary Flag (8) Indexed String						Data					*	*	*	*	*	*	Product Specific Bit Flags Targetting
Started Elements			05	Binary Flag (32)Indexed String	0..31			0..31	1 bit per elementLSB String..MSB String	Data					*	*	*	*	*	*	Product Specific Bit Flags Targetting
Started Elements 2			06	Binary Flag (32)Indexed String	0..31			0..31	1 bit per elementLSB String..MSB String	Data											Product Specific Bit Flags Targetting
Tripped Elements (1)			07	Binary Flag (32)Indexed String	0..31			0..31	1 bit per elementLSB String..MSB String	Data					*	*	*	*	*	*	Product Specific Bit Flags Targetting
Tripped Elements (2)			08	Binary Flag (32)Indexed String	0..31			0..31	1 bit per elementLSB String..MSB String	Data											Product Specific Bit Flags Targetting
Fault Alarms			09	Binary Flag (32)Indexed String	0..31			0..31	1 bit per elementLSB String..MSB String	Data					*	*	*	*	*	*	Product Specific Bit Flags Targetting
Fault Time			0A	IEC870 Time & Date						Data					*	*	*	*	*	*	
Active Setting Group			0B	Unsigned Integer						Data					*	*	*	*	*	*	
System Frequency			0C	Courier Number (frequency)						Data					*	*	*	*	*	*	
Fault Duration			0D	Courier Number (time)						Data					*	*	*	*	*	*	
CB Operate Time			0E	Courier Number (time)						Data					*	*	*	*	*	*	
Relay Trip Time			0F	Courier Number (time)						Data					*	*	*	*	*	*	
Fault Location			10	Courier Number (metres)						Data							*	*	*	*	
Fault Location			11	Courier Number (miles)						Data							*	*	*	*	
Fault Location			12	Courier Number (ohms)						Data							*	*	*	*	
Fault Location			13	Courier Number (percentage)						Data							*	*	*	*	
IA			14	Courier Number (current)						Data					*	*	*	*	*	*	
IB			15	Courier Number (current)						Data					*	*	*	*	*	*	
IC			16	Courier Number (current)						Data					*	*	*	*	*	*	
VAB			17	Courier Number (voltage)						Data							*	*	*	*	
VBC			18	Courier Number (voltage)						Data							*	*	*	*	
VCA			19	Courier Number (voltage)						Data							*	*	*	*	
IA local			1A	Courier Number (current)						Data					*	*	*	*	*	*	
IB local			1B	Courier Number (current)						Data					*	*	*	*	*	*	
IC local			1C	Courier Number (current)						Data					*	*	*	*	*	*	
IA remote 1			1D	Courier Number (current)						Data					*	*	*	*	*	*	
IB remote 1			1E	Courier Number (current)						Data					*	*	*	*	*	*	
IC remote 1			1F	Courier Number (current)						Data					*	*	*	*	*	*	
IA remote 2			20	Courier Number (current)						Data					*	*	*	*	*	*	
IB remote 2			21	Courier Number (current)						Data					*	*	*	*	*	*	
IC remote 2			22	Courier Number (current)						Data					*	*	*	*	*	*	
IA Diff			23	Courier Number (current)						Data					*	*	*	*	*	*	
IB Diff			24	Courier Number (current)						Data					*	*	*	*	*	*	
IC Diff			25	Courier Number (current)						Data					*	*	*	*	*	*	
IN Diff			26	Courier Number (current)						Data					*	*	*	*	*	*	
IA Bias			27	Courier Number (current)						Data					*	*	*	*	*	*	
IB Bias			28	Courier Number (current)						Data					*	*	*	*	*	*	
IC Bias			29	Courier Number (current)						Data					*	*	*	*	*	*	
Add product specific fault record items from this row onwards, do not redefine any of the above cells.																					

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	2	3	4	5	6	Comment
This is an invisible column for auto extraction of event records, do not redefine any of its rows but keep it consistent with column [01]																					
No Header	N/A	B1	00												*	*	*	*	*	*	
Select Record			01	UINT16						Setting	0	65535	1		*	*	*	*	*	*	
Time and Date			02	IEC Date and Time						Data					*	*	*	*	*	*	
Record Text			03	ASCII Text						Data					*	*	*	*	*	*	Text Description of Error
Type			04	UINT32						Data					*	*	*	*	*	*	Error Code
Data			05	UINT32						Data					*	*	*	*	*	*	Error Code
DATA TRANSFER (No Header)	N/A	B2	00												*	*	*	*	*	*	
Domain			04	Indexed String				G57	PSL Settings	Setting	0	1	1	2	*	*	*	*	*	*	
Sub-Domain			08	Indexed String				G90	Group 1	Setting	0	3	1	2	*	*	*	*	*	*	
Version			0C	Unsigned Integer (2 Bytes)					256	Setting	0	65535	1	2	*	*	*	*	*	*	
Start			10	Not Used											*	*	*	*	*	*	
Length			14	Not Used											*	*	*	*	*	*	
Reference			18	Not Used											*	*	*	*	*	*	
Transfer Mode			1C	Unsigned Integer Indexed String	G76			G76	6	Setting	0	7	1	2	*	*	*	*	*	*	
Data Transfer			20	Repeated groups of Unsigned Integers						Setting					*	*	*	*	*	*	Only settable if Domain = PSL Settings
RECORDER CONTROL (No Head	N/A	B3	00												*	*	*	*	*	*	
UNUSED			01																		
Recorder Source			02	Indexed String	0			0	Samples	Data					*	*	*	*	*	*	
Reserved for future use			03-1F																		
RECORDER EXTRACTION COLUMN (No Header)	N/A	B4	00												*	*	*	*	*	*	
Select Record			01	Unsigned Integer					0	Setting	-199	199	1	0	*	*	*	*	*	*	
Trigger Time			02	IEC870 Time & Date						Data					*	*	*	*	*	*	
Active Channels			03	Binary Flag						Data					*	*	*	*	*	*	CS103 only
Channel Types			04	Binary Flag						Data					*	*	*	*	*	*	CS103 only
Channels Offsets			05	Courier Number (decimal)						Data					*	*	*	*	*	*	CS103 only
Channel Scaling			06	Courier Number (decimal)						Data					*	*	*	*	*	*	CS103 only
Channel SkewVal			07	Integer						Data					*	*	*	*	*	*	CS103 only
Channel MinVal			08	Integer						Data					*	*	*	*	*	*	CS103 only
Channel MaxVal			09	Integer						Data					*	*	*	*	*	*	CS103 only
Format			0A	Unsigned Integer						Data					*	*	*	*	*	*	0 = incompressed, 1 = compressed
Upload			0B	Unsigned Integer						Data					*	*	*	*	*	*	
UNUSED			0C-0F																		
No. of Samples			10	Unsigned Integer						Data					*	*	*	*	*	*	CS103 only
Trig Position			11	Unsigned Integer						Data					*	*	*	*	*	*	CS103 only
Time Base			12	Courier Number (time)						Data					*	*	*	*	*	*	CS103 only
UNUSED			13																		
Sample Timer			14	Unsigned Integer						Data					*	*	*	*	*	*	CS103 only
UNUSED			15-1F																		
Dist Channel 1			20	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 2			21	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 3			22	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 3			23	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 4			24	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 5			25	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 6			26	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 7			27	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 8			28	Integer						Data					*	*	*	*	*	*	CS103 only

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Dist Channel 9			29	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 10			2A	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 11			2B	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 12			2C	Integer						Data					*	*	*	*	*	*	CS103 only
Dist Channel 31			3D	Bginary Flag						Data					*	*	*	*	*	*	CS103 only
Dist Channel 32			3E	Binary Flag						Data					*	*	*	*	*	*	CS103 only
						30800		G1		Data											Number of Disturbance Records (0 to 200)
						30801		G1		Data											Oldest Stored Disturbance Record(1 to 65535)
						30802		G1		Data					*	*	*	*	*	*	Number of Registers in Current Page
						30803	30929	G1		Data					*	*	*	*	*	*	Disturbance Record Page (0 to 65535)
						40250		G1		Setting	1	65535	1	2	*	*	*	*	*	*	Select Disturbance Record
						30930	30933	G12		Data					*	*	*	*	*	*	Timestamp of selected record
						30934		G1		Data					*	*	*	*	*	*	
						40251		G1		Setting	1	65535	1	2	*	*	*	*	*	*	
Calibration Coefficients (Hidder	N/A	B5													*	*	*	*	*	*	
Cal Soft Version			01	ASCII Text (16)											*	*	*	*	*	*	
Cal Date and Time			02	IEC Date and time											*	*	*	*	*	*	
Channel Types			03	Repeated Group 16 * Binary Flag 8 bits											*	*	*	*	*	*	
Cal Coeffs			04	Block transfer Repeated Group of UINT32 (4 coeffs voltage channel, 8 coeffs current channel)											*	*	*	*	*	*	
Comms Diagnostics (Hidden)	N/A	B6	00	Note: No text in column text																	
Err Count F			01	UINT32											*	*	*	*	*	*	
Msg Count F			02	UINT32											*	*	*	*	*	*	
Prot Count F			03	UINT32											*	*	*	*	*	*	
Slave Count F			04	UINT32											*	*	*	*	*	*	
Reset Count F			05	(Reset Menu Cell cmd only)											*	*	*	*	*	*	
Err Count R			06	UINT32											*	*	*	*	*	*	
Prot Count R			07	UINT32											*	*	*	*	*	*	
Slave Count R			08	UINT32											*	*	*	*	*	*	
Busy Count R			09	UINT32											*	*	*	*	*	*	
Reset Count R			0A	(Reset Menu Cell cmd only)											*	*	*	*	*	*	
PSL DATA		B7	00												*	*	*	*	*	*	
Grp1 PSL Ref		B7	01	ASCII Text (32 chars)		31000	31015	G3	Default PSL "model number"	Data					*	*	*	*	*	*	
Date/Time		B7	02	IEC870 Date & Time		31016	31019	G12		Data					*	*	*	*	*	*	when downloaded
Grp1 PSL ID		B7	03	Unsigned Integer (32 bits)		31020	31021	G27	0	Data					*	*	*	*	*	*	
Grp2 PSL Ref		B7	11	ASCII Text (32 chars)		31022	31037	G3	Default PSL "model number"	Data					*	*	*	*	*	*	
Date/Time		B7	12	IEC870 Date & Time		31038	31041	G12		Data					*	*	*	*	*	*	when downloaded
Grp2 PSL ID		B7	13	Unsigned Integer (32 bits)		31042	31043	G27	0	Data					*	*	*	*	*	*	
Grp3 PSL Ref		B7	21	ASCII Text (32 chars)		31044	31059	G3	Default PSL "model number"	Data					*	*	*	*	*	*	
Date/Time		B7	22	IEC870 Date & Time		31060	31063	G12		Data					*	*	*	*	*	*	when downloaded
Grp3 PSL ID		B7	23	Unsigned Integer (32 bits)		31064	31065	G27	0	Data					*	*	*	*	*	*	

Courier Text	LCD ref	Courier Ref Col	Courier Ref Row	Data Type	Data Group Courier	Modbus Address Start	Modbus Address End	Data Group Modbus	Default Setting	Cell Type	Min	Max	Step	Password Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Comment
Grp4 PSL Ref		B7	31	ASCII Text (32 chars)		31066	31079	G3	Default PSL "model number"	Data					*	*	*	*	*	*	
Date/Time		B7	32	IEC870 Date & Time		31082	31085	G12		Data					*	*	*	*	*	*	when downloaded
Grp4 PSL ID		B7	33	Unsigned Integer (32 bits)		31086	31087	G27	0	Data					*	*	*	*	*	*	
COMMS SYS DATA	N/A	BF	00																		
Dist Record Cntrl Ref			01	Menu Cell(2)					B300	Data					*	*	*	*	*	*	Disturbance Record Control Reference
Dist Record Extract Ref			02	Menu Cell(2)					B400	Data					*	*	*	*	*	*	Disturbance Record Extraction Reference
Setting Transfer			03	Unsigned Integer						Setting					*	*	*	*	*	*	
Reset Demand			04	None (Reset Menu Cell)						Data (but supports Reset Menu)					*	*	*	*	*	*	Rest Measurements Demand Values
UNUSED			05																		
Block Xfer Ref			06	Menu Cell(2)					B200	Data					*	*	*	*	*	*	Block Transfer Reference

Data Types

Type	Value / Bit Mask	Description	Notes
G1		UNSIGNED INTEGER	eg. 5678 stored as 5678
G2		NUMERIC SETTING	See 50300.3110.004
G3		ASCII TEXT CHARACTERS	
	0x00FF	2nd character	
	0xFF00	1st character	
G4		PLANT STATUS (2 REGISTERS)	(0 = Off, 1 = On)
	(Second reg, First Reg)		
	0x0000,0x0001	Plant Status 1	
	0x0000,0x0002	Plant Status 2	
	0x0000,0x0004	Plant Status 3	
	0x0000,0x0008	Plant Status 4	
	0x0000,0x0010	Plant Status 5	
	0x0000,0x0020	Plant Status 6	
	0x0000,0x0040	Plant Status 7	
	0x0000,0x0080	Plant Status 8	
	0x0000,0x0100	Plant Status 9	
	0x0000,0x0200	Plant Status 10	
	0x0000,0x0400	Plant Status 11	
	0x0000,0x0800	Plant Status 12	
	0x0000,0x1000	Plant Status 13	
	0x0000,0x2000	Plant Status 14	
	0x0000,0x4000	Plant Status 15	
	0x0000,0x8000	Plant Status 16	
	0x0001,0x0000	Plant Status 17	
	0x0002,0x0000	Plant Status 18	
	0x0004,0x0000	Plant Status 19	
	0x0008,0x0000	Plant Status 20	
	0x0010,0x0000	Plant Status 21	
	0x0020,0x0000	Plant Status 22	
	0x0040,0x0000	Plant Status 23	
	0x0080,0x0000	Plant Status 24	
	0x0100,0x0000	Plant Status 25	
	0x0200,0x0000	Plant Status 26	
	0x0400,0x0000	Plant Status 27	
	0x0800,0x0000	Plant Status 28	
	0x1000,0x0000	Plant Status 29	
	0x2000,0x0000	Plant Status 30	
	0x4000,0x0000	Plant Status 31	
	0x8000,0x0000	Plant Status 32	
G5		CONTROL STATUS (2 REGISTERS)	(0 = Off, 1 = On)
	(Second reg, First Reg)		
	0x0000,0x0001	Control Status 1	
	0x0000,0x0002	Control Status 2	

Type	Value / Bit Mask	Description	Notes
	0x0000,0x0004	Control Status 3	
	0x0000,0x0008	Control Status 4	
	0x0000,0x0010	Control Status 5	
	0x0000,0x0020	Control Status 6	
	0x0000,0x0040	Control Status 7	
	0x0000,0x0080	Control Status 8	
	0x0000,0x0100	Control Status 9	
	0x0000,0x0200	Control Status 10	
	0x0000,0x0400	Control Status 11	
	0x0000,0x0800	Control Status 12	
	0x0000,0x1000	Control Status 13	
	0x0000,0x2000	Control Status 14	
	0x0000,0x4000	Control Status 15	
	0x0000,0x8000	Control Status 16	
	0x0001,0x0000	Control Status 17	
	0x0002,0x0000	Control Status 18	
	0x0004,0x0000	Control Status 19	
	0x0008,0x0000	Control Status 20	
	0x0010,0x0000	Control Status 21	
	0x0020,0x0000	Control Status 22	
	0x0040,0x0000	Control Status 23	
	0x0080,0x0000	Control Status 24	
	0x0100,0x0000	Control Status 25	
	0x0200,0x0000	Control Status 26	
	0x0400,0x0000	Control Status 27	
	0x0800,0x0000	Control Status 28	
	0x1000,0x0000	Control Status 29	
	0x2000,0x0000	Control Status 30	
	0x4000,0x0000	Control Status 31	
	0x8000,0x0000	Control Status 32	
G6		Record Control Command Register	
	0	No operation	
	1	Clear Event records	
	2	Clear Fault Record	
	3	Clear Maintenance Records	
	4	Reset Indications	
	5	Clear Disturbances	
G7		VTS Indicate/Block	
	0	Blocking	
	1	Indication	
G8	(Second reg, First Reg)	LOGIC INPUT STATUS	(0 = Off, 1 = Energised)
	0x0000,0x0001	Opto 1 Input State	
	0x0000,0x0002	Opto 2 Input State	
	0x0000,0x0004	Opto 3 Input State	
	0x0000,0x0008	Opto 4 Input State	

Type	Value / Bit Mask	Description	Notes
	0x0000,0x0010	Opto 5 Input State	
	0x0000,0x0020	Opto 6 Input State	
	0x0000,0x0040	Opto 7 Input State	
	0x0000,0x0080	Opto 8 Input State	
	0x0000,0x0100	Opto 9 Input State	
	0x0000,0x0200	Opto 10 Input State	
	0x0000,0x0400	Opto 11 Input State	
	0x0000,0x0800	Opto 12 Input State	
	0x0000,0x1000	Opto 13 Input State	
	0x0000,0x2000	Opto 14 Input State	
	0x0000,0x4000	Opto 15 Input State	
	0x0000,0x8000	Opto 16 Input State	
	0x0001,0x0000	Opto 17 Input State	
	0x0002,0x0000	Opto 18 Input State	
	0x0004,0x0000	Opto 19 Input State	
	0x0008,0x0000	Opto 20 Input State	
	0x0010,0x0000	Opto 21 Input State	
	0x0020,0x0000	Opto 22 Input State	
	0x0040,0x0000	Opto 23 Input State	
	0x0080,0x0000	Opto 24 Input State	
	0x0100,0x0000	Opto 25 Input State	
	0x0200,0x0000	Opto 26 Input State	
	0x0400,0x0000	Opto 27 Input State	
	0x0800,0x0000	Opto 28 Input State	
	0x1000,0x0000	Opto 29 Input State	
	0x2000,0x0000	Opto 30 Input State	
	0x4000,0x0000	Opto 31 Input State	
	0x8000,0x0000	Opto 32 Input State	
G9		RELAY OUTPUT STATUS	(0=Not Operated, 1=Operated)
	(Second reg, First Reg)		
	0x0000,0x0001	Relay 1	
	0x0000,0x0002	Relay 2	
	0x0000,0x0004	Relay 3	
	0x0000,0x0008	Relay 4	
	0x0000,0x0010	Relay 5	
	0x0000,0x0020	Relay 6	
	0x0000,0x0040	Relay 7	
	0x0000,0x0080	Relay 8	
	0x0000,0x0100	Relay 9	
	0x0000,0x0200	Relay 10	
	0x0000,0x0400	Relay 11	
	0x0000,0x0800	Relay 12	
	0x0000,0x1000	Relay 13	
	0x0000,0x2000	Relay 14	
	0x0000,0x4000	Relay 15	
	0x0000,0x8000	Relay 16	

Type	Value / Bit Mask	Description	Notes
	0x0001,0x0000	Relay 17	
	0x0002,0x0000	Relay 18	
	0x0004,0x0000	Relay 19	
	0x0008,0x0000	Relay 20	
	0x0010,0x0000	Relay 21	
	0x0020,0x0000	Relay 22	
	0x0040,0x0000	Relay 23	
	0x0080,0x0000	Relay 24	
	0x0100,0x0000	Relay 25	
	0x0200,0x0000	Relay 26	
	0x0400,0x0000	Relay 27	
	0x0800,0x0000	Relay 28	
	0x1000,0x0000	Relay 29	
	0x2000,0x0000	Relay 30	
	0x4000,0x0000	Relay 31	
	0x8000,0x0000	Relay 32	
G11		YES/NO	
	0	No	
	1	Yes	
G12		TIME AND DATE (4 REGISTERS)	This will take the IEC 870 format as shown in ref (J) section 5.1.16
	0xFFFF	1st register - Milli-seconds	
	0x9FBF	2nd register - Summertime & hours / Validity & minutes	
	0x0FFF	3rd Register - Month of year / Day of month / Day of week	
	0x007F	4th Register - Years	
G13		EVENT RECORD TYPE	
	0	Latched alarm active	
	1	Latched alarm inactive	
	2	Self reset alarm active	
	3	Self reset alarm inactive	
	4	Relay event	
	5	Opto event	
	6	Protection event	
	7	Platform event	
	8	Fault logged event	
	9	Maintenance record logged event	
G14		I> Blocking	
	Bit 0	VTS Blocks I>1	
	Bit 1	VTS Blocks I>2	
	Bit 2	VTS Blocks I>3	
	Bit 3	VTS Blocks I>4	
	Bit 4	A/R Blocks I>3	
	Bit 5	A/R Blocks I>4	
	Bit 6	Not Used	
	Bit 7	Not Used	
G15		DISTURBANCE RECORD INDEX STATUS	
	0	No Record	

Type	Value / Bit Mask	Description	Notes
	1	Unextracted	
	2	Extracted	
G16		FAULTED PHASE	
	0x0001	Start A	
	0x0002	Start B	
	0x0004	Start C	
	0x0008	Start N	
	0x0010	Trip A	
	0x0020	Trip B	
	0x0040	Trip C	
	0x0080	Trip N	
G17		IRIG-B Status	
	0	Card Not Fitted	
	1	Card Failed	
	2	Signal Healthy	
	3	No Signal	
G18		Record Selection Command Register	
	0x0000	No Operation	
	0x0001	Select next event	
	0x0002	Accept Event	
	0x0004	Select next Disurbance Record	
	0x0008	Accept disturbance record	
	0x0010	Select Next Disturbance record page	
G19		LANGUAGE	
	0	English	
	1	Francais	
	2	Deutsch	
	3	Espanol	
G20	(Second reg, First Reg)	PASSWORD (2 REGISTERS)	When registers of this type are read this slave will always indicate an "*" in each character poisition te preserve the password security.
	0x0000, 0x00FF	First password character	
	0x0000, 0xFF00	Second password character	
	0x00FF, 0x0000	Third password character	
	0xFF00, 0x0000	Fourth password character	
G21		IEC870 Interface	
	0	Copper	
	1	Fibre Optic	
G22		PASSWORD CONTROL ACCESS LEVEL	
	0	Level 0 - Passwords required for levels 1 & 2.	
	1	Level 1 - Password required for level 2.	
	2	Level 2 - No passwords required.	
G23		Voltage Curve selection	
	0	Disabled	
	1	DT	
	2	IDMT	

Type	Value / Bit Mask	Description	Notes
G24	2 REGISTERS	UNSIGNED LONG VALUE, 3 DECIMAL PLACES	
		High order word of long stored in 1st register	
		Low order word of long stored in 2nd register	
		Example 123456.789 stored as 123456789	
G25	1 REGISTER	UNSIGNED VALUE, 3 DECIMAL PLACES	
		Example 50.050 stored as 50050	
G26		RELAY STATUS	
	0x0001	In Service Status (1 = In service, 0 = out of service)	
	0x0002	Minor Self Test Failure (=1, 0 otherwise)	
	0x0004	New auto-extraction event available (=1, 0 otherwise)	
	0x0008	Time Synchronised (=1 after Modbus time synch. Resets to 0 after 5	
	0x0010	New auto-extraction disturbance record available (=1, 0 otherwise)	
	0x0020	Fault (not used always 0)	
	0x0040	Trip LED status (1 = LED on, 0 = LED off)	
	0x0080	Alarm status summary (logical OR of all alarm status bits)	
	0x0100	Unused	
	0x0200	Unused	
	0x0400	Unused	
	0x0800	Unused	
	0x1000	Unused	
	0x2000	Unused	
	0x4000	Unused	
	0x8000	Unused	
G27	2 REGISTERS	UNSIGNED LONG VALUE	Example 123456 stored as 123456
		High order word of long stored in 1st register	
		Low order word of long stored in 2nd register	
G28	1 REGISTER	SIGNED VALUE POWER & WATT-HOURS	
		Power = (Secondary power/CT secondary) *(100/VT secondary)	
G29	3 REGISTER	POWER MULTIPLER	
		All power measurments use a signed value of type G28 and a 2 unsigned long multiplier of type G27 Value = Real Value *110/(CTsecondary*VTsecondary).	
		For Primary Power Multipler = CTprimary *VTprimary/110	
		For Secondary Power Multipler = CTsecondary *VTsecondary/110	
G30	1 REGISTER	SIGNED VALUE, 2 DECIMAL PLACES	
G31		ANALOGUE CHANNEL ASSIGNMENT SELECTOR	(Models 1 & 2)
	0	IA	
	1	IB	
	2	IC	
	3	IN	

Type	Value / Bit Mask	Description	Notes
G31		ANALOGUE CHANNEL ASSIGNMENT SELECTOR	(Model 3 & 5)
	0	IA	
	1	IB	
	2	IC	
	3	IN	
	4	VA	
	5	VB	
	6	VC	
	7	IM	
	8	V Checksync	
G31		ANALOGUE CHANNEL ASSIGNMENT SELECTOR	(Model 4 & 6)
	0	IA	
	1	IB	
	2	IC	
	3	IN	
	4	VA	
	5	VB	
	6	VC	
	7	IM	
	8	IA2	
	9	IB2	
	10	IC2	
	11	IN2	
G32	***Please refer to table on page 71***		
G33		RECORDER TRIGGERING (2 REGISTERS, 32 BINARY FLAGS)	(0 = No Trigger, 1= Trigger)
	(Second reg, First Reg)		
	0x0000,0x0001	Digital Channel 1 Bit 0	
	0x0000,0x0002	Digital Channel 1 Bit 1	
	0x0000,0x0004	Digital Channel 1 Bit 2	
	0x0000,0x0008	Digital Channel 1 Bit 3	
	0x0000,0x0010	Digital Channel 1 Bit 4	
	0x0000,0x0020	Digital Channel 1 Bit 5	
	0x0000,0x0040	Digital Channel 1 Bit 6	
	0x0000,0x0080	Digital Channel 1 Bit 7	
	0x0000,0x0100	Digital Channel 1 Bit 8	
	0x0000,0x0200	Digital Channel 1 Bit 9	
	0x0000,0x0400	Digital Channel 1 Bit 10	
	0x0000,0x0800	Digital Channel 1 Bit 11	
	0x0000,0x1000	Digital Channel 1 Bit 12	
	0x0000,0x2000	Digital Channel 1 Bit 13	
	0x0000,0x4000	Digital Channel 1 Bit 14	
	0x0000,0x8000	Digital Channel 1 Bit 15	
	0x0001,0x0000	Digital Channel 2 Bit 0	
	0x0002,0x0000	Digital Channel 2 Bit 1	
	0x0004,0x0000	Digital Channel 2 Bit 2	
	0x0008,0x0000	Digital Channel 2 Bit 3	
	0x0010,0x0000	Digital Channel 2 Bit 4	
	0x0020,0x0000	Digital Channel 2 Bit 5	

Type	Value / Bit Mask	Description	Notes
	0x0040,0x0000	Digital Channel 2 Bit 6	
	0x0080,0x0000	Digital Channel 2 Bit 7	
	0x0100,0x0000	Digital Channel 2 Bit 8	
	0x0200,0x0000	Digital Channel 2 Bit 9	
	0x0400,0x0000	Digital Channel 2 Bit 10	
	0x0800,0x0000	Digital Channel 2 Bit 11	
	0x1000,0x0000	Digital Channel 2 Bit 12	
	0x2000,0x0000	Digital Channel 2 Bit 13	
	0x4000,0x0000	Digital Channel 2 Bit 14	
	0x8000,0x0000	Digital Channel 2 Bit 15	
G34		TRIGGER MODE	
	0	Single	
	1	Extended	
G35		Numeric Setting (as G2 but 2 registers)	Number of steps from minimum value expressed as 2 register 32 bit unsigned int
G36		TEST AUTORECLOSE	
	0	No Operation	
	1	Trip 3 Pole	
	2	Trip Pole A	
	3	Trip Pole B	
	4	Trip Pole C	
G37		ENABLED / DISABLED	
	0	Disabled	
	1	Enabled	
G38m		COMMUNICATION BAUD RATE (MODBUS)	
	0	9600 bits/s	
	1	19200 bits/s	
	2	38400 bits/s	
G38v		COMMUNICATION BAUD RATE (IEC 60870)	
	0	9600 bits/s	
	1	19200 bits/s	
G38d		COMMUNICATION BAUD RATE (DNP 3.0)	
	0	1200 bits/s	
	1	2400 bits/s	
	2	4800 bits/s	
	3	9600 bits/s	
	4	19200 bits/s	
	5	38400 bits/s	
G39		COMMUNICATIONS PARITY	
	0	Odd	
	1	Even	
	2	None	
G40		CHECK SYNC INPUT SELECTION	
	0	A-N	
	1	B-N	
	2	C-N	

Type	Value / Bit Mask	Description	Notes
	3	A-B	
	4	B-C	
	5	C-A	
G41		CHECK SYNC VOLTAGE BLOCKING	
	0	None	
	1	V<	
	2	V>	
	3	Vdiff>	
	4	V< and V>	
	5	V< and Vdiff>	
	6	V> and Vdiff>	
	7	V< V> and Vdiff>	
G42		CHECK SYNC SLIP CONTROL	
	0	None	
	1	Timer	
	2	Frequency	
	3	Both	
G43		IDMT CURVE TYPE	
	0	Disabled	
	1	DT	
	2	IEC S Inverse	
	3	IEC V Inverse	
	4	IEC E Inverse	
	5	UK LT Inverse	
	6	IEEE M Inverse	
	7	IEEE V Inverse	
	8	IEEE E Inverse	
	9	US Inverse	
	10	US ST Inverse	
G44		DIRECTION	
	0	Non-Directional	
	1	Directional Fwd	
	2	Directional Rev	
G45		VTS BLOCK	
	0	Block	
	1	Non-Directional	
G46		POLARISATION	
	0	Zero Sequence	
	1	Neg Sequence	
G47		MEASURING MODE	
	0	Phase-Phase	
	1	Phase-Neutral	
G48		OPERATION MODE	
	0	Any Phase	
	1	Three Phase	

Type	Value / Bit Mask	Description	Notes
G49		V0 INPUT	
	0	Measured	
	1	Derived	
G50		RTD SELECT	
	0x0001	RTD Input #1	
	0x0002	RTD Input #2	
	0x0004	RTD Input #3	
	0x0008	RTD Input #4	
	0x0010	RTD Input #5	
	0x0020	RTD Input #6	
	0x0040	RTD Input #7	
	0x0080	RTD Input #8	
	0x0100	RTD Input #9	
	0x0200	RTD Input #10	
G51		FAULT LOCATION	
	0	Distance	
	1	Ohms	
	2	% of Line	
G52		DEFAULT DISPLAY	
	0	3Ph + N Current	
	1	3Ph Voltage	
	2	Power	
	3	Date and Time	
	4	Description	
	5	Plant Reference	
	6	Frequency	
	7	Access Level	
G53		SELECT FACTORY DEFAULTS	
	0	No Operation	
	1	All Settings	
	2	Setting Group 1	
	3	Setting Group 2	
	4	Setting Group 3	
	5	Setting Group 4	
G54		SELECT PRIMARY SECONDARY MEASUREMENTS	
	0	Primary	
	1	Secondary	
G55		CIRCUIT BREAKER CONTROL	
	0	No Operation	
	1	Trip	
	2	Close	
	3	No Operation	
	4	No Operation	
	5	No Operation	
	6	No Operation	
	7	No Operation	

Type	Value / Bit Mask	Description	Notes
	8	No Operation	
	9	Trip CB2	
	10	Close CB2	
G56		PHASE MEASUREMENT REFERENCE	Models 3, 4, 5 & 6
	0	VA	
	1	VB	
	2	VC	
	3	IA	
	4	IB	
	5	IC	
G56		PHASE MEASUREMENT REFERENCE	Models 1 & 2
	0	IA	
	1	IB	
	2	IC	
G57		Data Transfer Domain	
	0	PSL Settings	
	1	PSL Configuration	
G58		SEF SELECTION	
	0	SEF Enabled	
	1	Wattmetric SEF	
	2	REF	
G59		BATTERY STATUS	
	0	Dead	
	1	Healthy	
G60		IDMT CURVE TYPE	
	0	DT	
	1	Inverse	
G61		ACTIVE GROUP CONTROL	
	0	Select via Menu	
	1	Select via Opto	
G62		SAVE AS	
	0	No Operation	
	1	Save	
	2	Abort	
G63		IN> Blocking	
	Bit 0	VTS Blocks IN>1	
	Bit 1	VTS Blocks IN>2	
	Bit 2	VTS Blocks IN>3	
	Bit 3	VTS Blocks IN>4	
	Bit 4	A/R Blocks IN>3	
	Bit 5	A/R Blocks IN>4	
	Bit 6	Not Used	
	Bit 7	Not Used	
G64		ISEF> Blocking	
	Bit 0	VTS Blks ISEF>1	
	Bit 1	VTS Blks ISEF>2	

Type	Value / Bit Mask	Description	Notes
	Bit 2	VTS Blks ISEF>3	
	Bit 3	VTS Blks ISEF>4	
	Bit 4	A/R Blks ISEF>3	
	Bit 5	A/R Blks ISEF>4	
	Bit 6	Not Used	
	Bit 7	Not Used	
G65		F< Function Link	
	Bit 0	F<1 U/V Block	
	Bit 1	F<2 U/V Block	
	Bit 2	F<3 U/V Block	
	Bit 3	F<4 U/V Block	
	Bit 4	Not Used	
	Bit 5	Not Used	
	Bit 6	Not Used	
	Bit 7	Not Used	
G66		MESSAGE FORMAT	
	0	No Trigger	
	1 2	Trigger L/H Trigger H/L	
G67		THERMAL OVERLOAD	
	0	Disabled	
	1	Single	
	2	Dual	
G68		CB Fail Reset Options	
	0	I< Only	
	1	CB Open & I<	
	2	Prot Reset & I<	
G69		VTS RESET MODE	
	0	Manual	
	1	Auto	
G70		AUTORECLOSE MODE	
	0	Opto Set	
	1	Auto	
	2	User Set	
	3	Pulse Set	
G71		PROTOCOL	
	0	Courier	
	1	IEC870-5-103	
	2	Modbus	
	3	DNP 3.0	
G72		START DEAD TIME	
	0	Protection Reset	
	1	CB Trips	
G73		RECLAIM TIME if PROTECTION START	
	0	On Prot Start	
	1	No operation	
G74		RESET LOCKOUT	

Type	Value / Bit Mask	Description	Notes
	0	User Interface	
	1	Select NonAuto	
G75		Auto-Reclose after Control Close	
	0	Enabled	
	1	Inhibited	
G76		TRANSFER MODE	
	0	Prepare Rx	
	1	Complete Rx	
	2	Prepare Tx	
	3	Complete Tx	
	4	Rx Prepared	
	5	Tx Prepared	
	6	OK	
	7	Error	
G77		Auto-Reclose	
	0	Out of Service	
	1	In Service	
G78		AR Telecontrol	
	0	No Operation	
	1	Auto	
	2	Non-auto	
G79		Custom Settings	
	0	Disabled	
	1	Basic	
	2	Complete	
G80		Visible/Invisible	
	0	Invisible	
	1	Visible	
G81		Reset Lockout by	
	0	User Interface	
	1	CB Close	
G82		A/R Protection blocking	
	0 1	No Block Block Inst Prot	
G83		A/R Status	
	0	Auto Mode	
	1	Non-auto Mode	
	2	Live Line	
G84	Modbus value+bit pos (Second reg, First Reg)	Started Elements(Product Specific)	
	0x0000,0x0001	General Start	
	0x0000,0x0002	Start I Diff	
	0x0000,0x0004	Start Z1	
	0x0000,0x0008	Start Z2	
	0x0000,0x0010	Start Z3	
	0x0000,0x0020	Start I>1	

Type	Value / Bit Mask	Description	Notes
	0x0000,0x0040	Start I>2	
	0x0000,0x0080	Start I>3	
	0x0000,0x0100	Start I>4	
	0x0000,0x0200	Start IN>1	
	0x0000,0x0400	Start IN>2	
	0x0000,0x0800	Start IN>3	
	0x0000,0x1000	Start IN>4	
	0x0000,0x2000	Start ISEF>1	
	0x0000,0x4000	Start ISEF>2	
	0x0000,0x8000	Start ISEF>3	
	0x0001,0x0000	Start ISEF>4	
	0x0002,0x0000	Start Thermal	
	0x0004,0x0000		
	0x0008,0x0000		
	0x0010,0x0000		
	0x0020,0x0000		
	0x0040,0x0000		
	0x0080,0x0000		
	0x0100,0x0000		
	0x0200,0x0000		
	0x0400,0x0000		
	0x0800,0x0000		
	0x1000,0x0000		
	0x2000,0x0000		
	0x4000,0x0000		
	0x8000,0x0000		
G85	Modbus value+bit pos (Second reg, First Reg)	Tripped Elements(1)(Product Specific)	
	0x0000,0x0001	Any Trip	
	0x0000,0x0002	Trip I Diff	
	0x0000,0x0004	InterTrip I Diff	
	0x0000,0x0008	PIT	
	0x0000,0x0010	DIT	
	0x0000,0x0020	Trip Z1	
	0x0000,0x0040	Trip Z2	
	0x0000,0x0080	Trip Z3	
	0x0000,0x0100	InterTrip Backup	
	0x0000,0x0200	Trip I>1	
	0x0000,0x0400	Trip I>2	
	0x0000,0x0800	Trip I>3	
	0x0000,0x1000	Trip I>4	
	0x0000,0x2000	Trip Broken line	
	0x0000,0x4000	Trip IN>1	
	0x0000,0x8000	Trip IN>2	
	0x0001,0x0000	Trip IN>3	
	0x0002,0x0000	Trip IN>4	

Type	Value / Bit Mask	Description	Notes
	0x0004,0x0000	Trip ISEF>1	
	0x0008,0x0000	Trip ISEF>2	
	0x0010,0x0000	Trip ISEF>3	
	0x0020,0x0000	Trip ISEF>4	
	0x0040,0x0000	Trip Thermal	
	0x0080,0x0000	Stub Bus Trip	
	0x0100,0x0000		
	0x0200,0x0000		
	0x0400,0x0000		
	0x0800,0x0000		
	0x1000,0x0000		
	0x2000,0x0000		
	0x4000,0x0000		
	0x8000,0x0000		
G86	Bit Description	Tripped Elements(2) (Product Specific)	
	(Second reg, First Reg)		
	(Courier and IEC870 Bit Position)		
	0x0000,0x0001	Trip V<1	
	0x0000,0x0002	Trip V<2	
	0x0000,0x0004	Trip V>1	
	0x0000,0x0008	Trip V>2	
	0x0000,0x0010	Trip F<1	
	0x0000,0x0020	Trip F<2	
	0x0000,0x0040	Trip F<3	
	0x0000,0x0080	Trip F<4	
	0x0000,0x0100	Trip F>1	
	0x0000,0x0200	Trip F>2	
	0x0000,0x0400		
	0x0000,0x0800		
	0x0000,0x1000		
	0x0000,0x2000		
	0x0000,0x4000		
	0x0000,0x8000		
	0x0001,0x0000	Trip RTD 1	
	0x0002,0x0000	Trip RTD 2	
	0x0004,0x0000	Trip RTD 3	
	0x0008,0x0000	Trip RTD 4	
	0x0010,0x0000	Trip RTD 5	
	0x0020,0x0000	Trip RTD 6	
	0x0040,0x0000	Trip RTD 7	
	0x0080,0x0000	Trip RTD 8	
	0x0100,0x0000	Trip RTD 9	
	0x0200,0x0000	Trip RTD 10	
	0x0400,0x0000		
	0x0800,0x0000		
	0x1000,0x0000		

Type	Value / Bit Mask	Description	Notes
	0x2000,0x0000		
	0x4000,0x0000		
	0x8000,0x0000		
G87	Bit Description	Fault Alarms (Product Specific)	
	(Second reg, First Reg)		
	(Courier and IEC870 Bit Position)		
	0x0000,0x0001	CB Fail 1	
	0x0000,0x0002	CB Fail 2	
	0x0000,0x0004	A/R Trip 1	
	0x0000,0x0008	A/R Trip 2	
	0x0000,0x0010	A/R Trip 3	
	0x0000,0x0020	A/R Trip 4	
	0x0000,0x0040	A/R Trip 5	
	0x0000,0x0080	VTS	
	0x0000,0x0100	PSB	
	0x0000,0x0200	CB2 Fail 1	
	0x0000,0x0400	CB2 Fail 2	
	0x0000,0x0800		
	0x0000,0x1000		
	0x0000,0x2000		
	0x0000,0x4000		
	0x0000,0x8000		
	0x0001,0x0000		
	0x0002,0x0000		
	0x0004,0x0000		
	0x0008,0x0000		
	0x0010,0x0000		
	0x0020,0x0000		
	0x0040,0x0000		
	0x0080,0x0000		
	0x0100,0x0000		
	0x0200,0x0000		
	0x0400,0x0000		
	0x0800,0x0000		
	0x1000,0x0000		
	0x2000,0x0000		
	0x4000,0x0000		
	0x8000,0x0000		
G88		Alarms	
	0	Alarm Disabled	
	1	Alarm Enabled	
G89		Main VT Location	
	0	Line	
	1	Bus	

Type	Value / Bit Mask	Description	Notes
G90		Group Selection	
	0	Group 1	
	1	Group 2	
	2	Group 3	
	3	Group 4	
G91		A/R Protection Blocking	
	0	Allow Tripping	
	1	Block Tripping	
G92		Lockout	
	0	No Lockout	
	1	Lockout	
G93		Commission Test	
	0	No Operation	
	1	Apply Test	
	2	Remove Test	
G94		Commission Test	
	0	No Operation	
	1	Apply Test	
G95		System Fn Links	
	Bit 0	Trip led self reset	(1 = enable self reset)
	Bit 1	Not Used	
	Bit 2	Not Used	
	Bit 3	Not used	
	Bit 4	Not Used	
	Bit 5	Not Used	
	Bit 6	Not Used	
	Bit 7	Not Used	
G96	Bit Position	Indexed Strings	
	0	Unused	
	1	Unused	
	2	SG-opto Invalid	
	3	Protection OFF	
	4	VT Fail Alarm	
	5	Power Swing	
	6	CB Fail	
	7	I^ Maint Alarm	
	8	I^ Maint Lockout	
	9	CB OPs Maint	
	10	CB OPs Lock	
	11	CB Time Maint	
	12	CB Time Lockout	
	13	Fault Freq Lock	
	14	CB Status Alarm	
	15	GPS Alarm	
	16	CB Trip Fail	
	17	CB Close Fail	
	18	Man CB Unhealthy	

Type	Value / Bit Mask	Description	Notes
	19	No C/S Man Close	
	20	A/R Lockout / CB2 Fail Alarm	
	21	A/R CB Unhealthy	
	22	A/R No Checksync	
	23	Incompatible Rly	
	24	Test Loopback	
	25	Signalling Fail	
	26	Change in TD	
	27	C Diff Failure	
	28	C Diff Inhibited	
	29	Config Error	
	30	Re-Config Error	
	31	F out of range	
G97		Distance Unit	
	0	Kilometres	
	1	Miles	
G98		Copy to	
	0	No Operation	
	1	Group 1	
	2	Group 2	
	3	Group 3	
	4	Group 4	
G99		CB Control	
	0	Disabled	
	1	Local	
	2	Remote	
	3	Local+Remote	
	4	Opto	
	5	Opto+local	
	6	Opto+Remote	
	7	Opto+Rem+local	
G100		ENABLE/DISABLE	
	0	Disabled	
	1	Enabled	
	2	Enabled Ch Fail	
G101		SET-UP	
	0	3 Terminal	
	1	2 Terminal	
	2	Dual Redundant	
G102		TRIPPING MODE	
	0	3 Pole	
	1	1 and 3 Pole	
G103		SIGNALLING ADDRESS	
	0	0-0	
	1	1-A	
	2	2-A	

Type	Value / Bit Mask	Description	Notes
	3	3-A	
	4	4-A	
	5	5-A	
	6	6-A	
	7	7-A	
	8	8-A	
	9	9-A	
	10	10-A	
	11	11-A	
	12	12-A	
	13	13-A	
	14	14-A	
	15	15-A	
	16	16-A	
	17	17-A	
	18	18-A	
	19	19-A	
	20	20-A	
	21	1-B	
	22	2-B	
	23	3-B	
	24	4-B	
	25	5-B	
	26	6-B	
	27	7-B	
	28	8-B	
	29	9-B	
	30	10-B	
	31	11-B	
	32	12-B	
	33	13-B	
	34	14-B	
	35	15-B	
	36	16-B	
	37	17-B	
	38	18-B	
	39	19-B	
	40	20-B	
	41	1-C	
	42	2-C	
	43	3-C	
	44	4-C	
	45	5-C	
	46	6-C	
	47	7-C	
	48	8-C	

Type	Value / Bit Mask	Description	Notes
	49	9-C	
	50	10-C	
	51	11-C	
	52	12-C	
	53	13-C	
	54	14-C	
	55	15-C	
	56	16-C	
	57	17-C	
	58	18-C	
	59	19-C	
	60	20-C	
G104		SIGNALLING BAUD RATE	
	0	64kbits/s	
	1	56kbits/s	
G105		SIGNALLING CLOCK SOURCE	
	0	Internal	
	1	External	
G106		REPORT CHANNEL FAILURE	
	0	Ch 1 Failure	
	1	Ch 2 Failure	
	2	Ch 1 and 2 Fail	
G107		NEUTRAL STATUS	
	0	Biased	
	1	Power	
G108		VECTORIAL COMPENSATION	
	0	Yy0 (0 deg)	
	1	Yd1 (-30 deg)	
	2	Yy2 (-60 deg)	
	3	Yd3 (-90 deg)	
	4	Yy4 (-120 deg)	
	5	Yd5 (-150 deg)	
	6	Yy6 (180 deg)	
	7	Yd7 (+150 deg)	
	8	Yy8 (+120 deg)	
	9	Yd9 (+90 deg)	
	10	Yy10 (+60 deg)	
	11	Yd11 (+30 deg)	
	12	Ydy0 (0 deg)	
	13	Ydy6 (180 deg)	
G109		RE-CONFIGURATION	
	0	Three Ended	
	1	Two Ended	(L&R1)
	2	Two Ended	(L&R2)
	3	Two Ended	(R1&R2)

Type	Value / Bit Mask	Description	Notes
G110		DEFAULT DISPLAY	(Models 1 & 2)
	0	3Ph + N Current	
	1	Date and Time	
	2	Description	
	3	Plant Reference	
	4	Frequency	
	5	Access Level	
G112		IDMT CURVE TYPE	
	0	DT	
	1	IEC S Inverse	
	2	IEC V Inverse	
	3	IEC E Inverse	
	4	UK LT Inverse	
	5	IEEE M Inverse	
	6	IEEE V Inverse	
	7	IEEE E Inverse	
	8	US Inverse	
	9	US ST Inverse	
G113		Channel Fn Links	(note logic 1 is healthy)
	Bit 0	Ch1 Rx	
	Bit 1	Ch1 Tx	
	Bit 2	Ch2 Rx	
	Bit 3	Ch2 Tx	
	Bit 4	Local GPS	
	Bit 5	Ch1 GPS	
	Bit 6	Ch2 GPS	
	Bit 7	Ch1 Signal Lost	
	Bit 8	Ch2 Signal Lost	
	Bit 9	Ch1 Path Yellow	
	Bit 10	Ch2 Path Yellow	
	Bit 11	Ch1 Mismatch RxN	
	Bit 12	Ch2 Mismatch RxN	
G114		AR STATUS	
	0	No Action	
	1	Initiate AR	
	2	Block AR	
G115		AR STATUS	
	0	Allow Autoclose	
	1	BAR 2 and 3 Phase	
	2	BAR 3 Phase	
G118		CB Control Logic Input Assignment	Models 1 & 2
	0	None	
	1	52A	
	2	52B	
	3	Both 52A and 52B	

Type	Value / Bit Mask	Description	Notes
G118		CB Control Logic Input Assignment	Models 3, 4, 5 & 6
	0	None	
	1	52A 3 pole	
	2	52B 3 pole	
	3	52A & 52B 3 pole	
	4	52A 1 pole	
	5	52B 1 pole	
	6	52A & 52B 1 pole	
G119		Test Mode	
	0	Disabled	
	1	Test Mode	
	2	Blocked contacts	
G120		Forward/Reverse	
		Forward	
		Reverse	
G121		Loopback Mode	
	0	Disabled	
	1	External	
	2	Internal	
G125	2 REGISTERS	IEEE FLOATING POINT FORMAT	
		Bit 31 = sign	
		Bits 30-23 = e7 - e0	
		Implicit 1.	
		Bits 22-0 = f22 - f0	
G126		Prop Relay Equal Command	
	0	No operation	
	1	Restore C Diff	
G127		Autoreclose Dead Time Start	
	0	Protection Op	
	1	Protection Reset	
G128	Bit Position	Indexed Strings	
	0	Rear Comms fail	
	1	Unused	
	2	Unused	
	3	Unused	
	4	Not Used	
	5	Not Used	
	6	Not Used	
	7	Not Used	
	8	Not Used	
	9	Not Used	
	10	Not Used	
	11	Not Used	
	12	Not Used	
	13	C Diff Comm Mode	
	14	IEEE C37.94	

Type	Value / Bit Mask	Description	Notes
	15	Not Used	
	16	SR User Alarm 1	
	17	SR User Alarm 2	
	18	SR User Alarm 3	
	19	SR User Alarm 4	
	20	SR User Alarm 5	
	21	SR User Alarm 6	
	22	SR User Alarm 7	
	23	SR User Alarm 8	
	24	MR User Alarm 9	
	25	MR User Alarm 10	
	26	MR User Alarm 11	
	27	MR User Alarm 12	
	28	MR User Alarm 13	
	29	MR User Alarm 14	
	30	MR User Alarm 15	
	31	MR User Alarm 16	
G130		Protection Comms Mode	
	0	Standard	
	1	IEEE C37.94	
G131		Protection Comms N*64kbits/s Slots	
	0	Auto	
	1	1	
	2	2	
	3	3	
	4	4	
	5	5	
	6	6	
	7	7	
	8	8	
	9	9	
	10	10	
	11	11	
	12	12	
G200		Threshold Voltages	
	0	24-27V	
	1	30-34V	
	2	48-54V	
	3	110-125V	
	4	220-250V	
	5	Custom	
G201		Universal Optos	
	0	24-27V	
	1	30-34V	
	2	48-54V	
	3	110-125V	
	4	220-250V	

Type	Value / Bit Mask	Description	Notes
G202	(2nd Reg, 1st Reg)	Controll Input Status (2 REGISTERS)	(0 = Reset, 1 = Set)
	0x0000,0x0001	Control Input 1	
	0x0000,0x0002	Control Input 2	
	0x0000,0x0004	Control Input 3	
	0x0000,0x0008	Control Input 4	
	0x0000,0x0010	Control Input 5	
	0x0000,0x0020	Control Input 6	
	0x0000,0x0040	Control Input 7	
	0x0000,0x0080	Control Input 8	
	0x0000,0x0100	Control Input 9	
	0x0000,0x0200	Control Input 10	
	0x0000,0x0400	Control Input 11	
	0x0000,0x0800	Control Input 12	
	0x0000,0x1000	Control Input 13	
	0x0000,0x2000	Control Input 14	
	0x0000,0x4000	Control Input 15	
	0x0000,0x8000	Control Input 16	
	0x0001,0x0000	Control Input 17	
	0x0002,0x0000	Control Input 18	
	0x0004,0x0000	Control Input 19	
	0x0008,0x0000	Control Input 20	
	0x0010,0x0000	Control Input 21	
	0x0020,0x0000	Control Input 22	
	0x0040,0x0000	Control Input 23	
	0x0080,0x0000	Control Input 24	
	0x0100,0x0000	Control Input 25	
	0x0200,0x0000	Control Input 26	
	0x0400,0x0000	Control Input 27	
	0x0800,0x0000	Control Input 28	
	0x1000,0x0000	Control Input 29	
	0x2000,0x0000	Control Input 30	
	0x4000,0x0000	Control Input 31	
	0x8000,0x0000	Control Input 32	
G203		Virtual Input	
	0	No Operation	
	1	Set	
	2	Reset	
G204		Second Rear Comms Card Status	
	0	Unsupported	
	1	Card Not Fitted	
	2	EAI232 OK	
	3	EAI485 OK	
	4	K Bus OK	

Type	Value / Bit Mask	Description	Notes
G205		Port Config (Second Rear Port)	
	0	EAI232 (RS232)	
	1	EAI485 (RS485)	
	2	K Bus	
G206		Comms Mode	
	0	IEC60870 FT1.2 Frame	
	1	10-bit no parity	
G207		Port Config	
	0	K Bus	
	1	EIA485 (RS485)	
G208		Port Status	
	0	K Bus OK	
	1	EIA485 OK	
	1	Fibre Optic OK	
G210		CS103 Blocking	
	0	Disabled	
	1	Monitor Blocking	
	2	Command Blocking	
G220		Ethernet Media	
	0	Copper	
	1	Fibre	
G221		GOOSE STARTUP MODE (Reserved)	
	0	Promiscuous	
	1	Broadcast	
G222		AE QUALIFIER SELECTOR (Reserved)	
	0	Not Used	
	1	Used	
G223		IED STATISTICS RESET (Reserved)	
	0	Our IED	
	1	Viewed IED	
	2	All Enrolled	
	3	All Enrolled + Ours	
G224		ETHERNET LOOPBACK MODE (Reserved)	
	0	Loopback Off	
	1	Internal Loop	
	2	External Loop	
G225		SOFTWARE RELOAD MODE (Reserved)	
	0	No Action	
	1	Reload Software	
G226		Link Status	
	0	Alarm	
	1	Event	
	2	None	

Type	Value / Bit Mask	Description	Notes
G100		ADD PRODUCT SPECIFIC DATA GROUPS HERE	
to			
G500			
G228		Alarm Status 3	
	0	Battery Fail	
	1	Field Volt Fail	
	2	Rear Comm 2 Fail	
	3	GOOSE IED Absent	
	4	NIC Not Fitted	
	5	NIC No Response	
	6	NIC Fatal Error	
	7	NIC Soft. Reload	
	8	Bad TCP/IP Cfg.	
	9	Bad OSI Config.	
	10	NIC Link Fail	
	11	NIC SW Mis-Match	
	12	IP Addr Conflict	
	13	Unused	
	14	Unused	
	15	Unused	
	16	Backup Setting	
	17	Unused	
	18	Unused	
	19	Unused	
	20	Unused	
	21	Unused	
	22	Unused	
	23	Unused	
	24	Unused	
	25	Unused	
	26	Unused	
	27	Unused	
	28	Unused	
	29	Unused	
	30	Unused	
	31	Unused	
G231		DIRECT ACCESS KEYS	
	0	Disabled	
	1	Enabled	
G232		CONTROL INPUT COMMAND TEXT	
	0	ON/OFF	
	1	SET/RESET	
	2	IN/OUT	
	3	ENABLED/DISABLED	

Type	Value / Bit Mask	Description	Notes
G233		HOTKEY ENABLED CONTROL INPUTS	
	0x00000001	Control Input 1	
	0x00000002	Control Input 2	
	0x00000004	Control Input 3	
	0x00000008	Control Input 4	
	0x00000010	Control Input 5	
	0x00000020	Control Input 6	
	0x00000040	Control Input 7	
	0x00000080	Control Input 8	
	0x00000100	Control Input 9	
	0x00000200	Control Input 10	
	0x00000400	Control Input 11	
	0x00000800	Control Input 12	
	0x00001000	Control Input 13	
	0x00002000	Control Input 14	
	0x00004000	Control Input 15	
	0x00008000	Control Input 16	
	0x00010000	Control Input 17	
	0x00020000	Control Input 18	
	0x00040000	Control Input 19	
	0x00080000	Control Input 20	
	0x00100000	Control Input 21	
	0x00200000	Control Input 22	
	0x00400000	Control Input 23	
	0x00800000	Control Input 24	
	0x01000000	Control Input 25	
	0x02000000	Control Input 26	
	0x04000000	Control Input 27	
	0x08000000	Control Input 28	
	0x10000000	Control Input 29	
	0x20000000	Control Input 30	
	0x40000000	Control Input 31	
	0x80000000	Control Input 32	
G234		CONTROL INPUT SIGNAL TYPE	
	0	Latched	
	1	Pulsed	
G235		ETHERNET PROTOCOL	
	0	UCA 2.0	
	1	UCA 2.0 GOOSE	

Type	Value / Bit Mask	Description	Notes
G237		Port Config	
	0	Standard 60%-80%	
	1	50% - 70%	
G238		Modbus IEC Time	
	0	Standard	
	1	Reverse	

Data Types

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	0	Unused	Unused	Unused	Unused	Unused	Unused
	1	Output R1	Output R1	Output R1	Output R1	Output R1	Output R1
	2	Output R2	Output R2	Output R2	Output R2	Output R2	Output R2
	3	Output R3	Output R3	Output R3	Output R3	Output R3	Output R3
	4	Output R4	Output R4	Output R4	Output R4	Output R4	Output R4
	5	Output R5	Output R5	Output R5	Output R5	Output R5	Output R5
	6	Output R6	Output R6	Output R6	Output R6	Output R6	Output R6
	7	Output R7	Output R7	Output R7	Output R7	Output R7	Output R7
	8	Input L1	Output R8	Output R8	Output R8	Output R8	Output R8
	9	Input L2	Output R9	Output R9	Output R9	Output R9	Output R9
	10	Input L3	Output R10	Output R10	Output R10	Output R10	Output R10
	11	Input L4	Output R11	Output R11	Output R11	Output R11	Output R11
	12	Input L5	Output R12	Output R12	Output R12	Output R12	Output R12
	13	Input L6	Output R13	Output R13	Output R13	Output R13	Output R13
	14	Input L7	Output R14	Output R14	Output R14	Output R14	Output R14
	15	Input L8	Input L1	Input L1	Input L1	Output R15	Output R15
	16	Programmable LED 1	Input L2	Input L2	Input L2	Output R16	Output R16
	17	Programmable LED 2	Input L3	Input L3	Input L3	Output R17	Output R17
	18	Programmable LED 3	Input L4	Input L4	Input L4	Output R18	Output R18
	19	Programmable LED 4	Input L5	Input L5	Input L5	Output R19	Output R19
	20	Programmable LED 5	Input L6	Input L6	Input L6	Output R20	Output R20
	21	Programmable LED 6	Input L7	Input L7	Input L7	Output R21	Output R21
	22	Programmable LED 7	Input L8	Input L8	Input L8	Output R22	Output R22
	23	Programmable LED 8	Input L9	Input L9	Input L9	Output R23	Output R23
	24	SG-opto Invalid	Input L10	Input L10	Input L10	Output R24	Output R24
	25	Prot'n Disabled	Input L11	Input L11	Input L11	Output R25	Output R25
	26	CB Fail Alarm	Input L12	Input L12	Input L12	Output R26	Output R26
	27	I^ Maint Alarm	Input L13	Input L13	Input L13	Output R27	Output R27
	28	I^ Lockout Alarm	Input L14	Input L14	Input L14	Output R28	Output R28
	29	CB OPs Maint	Input L15	Input L15	Input L15	Output R29	Output R29

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	30	CB OPs Lock	Input L16	Input L16	Input L16	Output R30	Output R30
	31	CB Time Maint	Programmable LED 1	Programmable LED 1	Programmable LED 1	Output R31	Output R31
	32	CB Time Lockout	Programmable LED 2	Programmable LED 2	Programmable LED 2	Output R32	Output R32
	33	Fault Freq Lock	Programmable LED 3	Programmable LED 3	Programmable LED 3	Input L1	Input L1
	34	CB Status Alarm	Programmable LED 4	Programmable LED 4	Programmable LED 4	Input L2	Input L2
	35	CB Trip Fail	Programmable LED 5	Programmable LED 5	Programmable LED 5	Input L3	Input L3
	36	CB Close Fail	Programmable LED 6	Programmable LED 6	Programmable LED 6	Input L4	Input L4
	37	Man CB Unhealthy	Programmable LED 7	Programmable LED 7	Programmable LED 7	Input L5	Input L5
	38	InCompatible Rly	Programmable LED 8	Programmable LED 8	Programmable LED 8	Input L6	Input L6
	39	Test Loopback	SG-opto Invalid	SG-opto Invalid	SG-opto Invalid	Input L7	Input L7
	40	Signalling Fail	Prot'n Disabled	Prot'n Disabled	Prot'n Disabled	Input L8	Input L8
	41	Comm Delay Alarm	CB Fail Alarm	VT Fail Alarm	VT Fail Alarm	Input L9	Input L9
	42	C Diff Failure	I^ Maint Alarm	Power Swing	Power Swing	Input L10	Input L10
	43	C Diff Inhibited	I^ Lockout Alarm	CB Fail Alarm	CB1 Fail Alarm	Input L11	Input L11
	44	Config Error	CB OPs Maint	I^ Maint Alarm	CB Status Alarm	Input L12	Input L12
	45	Re-Config Error	CB OPs Lock	I^ Lockout Alarm	CB Trip Fail	Input L13	Input L13
	46	F out of Range	CB Time Maint	CB OPs Maint	CB Close Fail	Input L14	Input L14
	47	Unused	CB Time Lockout	CB OPs Lock	Man CB Unhealthy	Input L15	Input L15
	48	Unused	Fault Freq Lock	CB Time Maint	CB2 Fail Alarm	Input L16	Input L16
	49	Unused	CB Status Alarm	CB Time Lockout	InCompatible Rly	Input L17	Input L17
	50	Unused	CB Trip Fail	Fault Freq Lock	Test Loopback	Input L18	Input L18
	51	Unused	CB Close Fail	CB Status Alarm	Signalling Fail	Input L19	Input L19
	52	Unused	Man CB Unhealthy	CB Trip Fail	Comm Delay Alarm	Input L20	Input L20
	53	Unused	A/R Lockout	CB Close Fail	C Diff Failure	Input L21	Input L21
	54	Unused	A/R CB Unhealthy	Man CB Unhealthy	C Diff Inhibited	Input L22	Input L22
	55	Unused	InCompatible Rly	No C/S Man Close	Config Error	Input L23	Input L23
	56	C Diff Comm Mode	Test Loopback	A/R Lockout	Re-Config Error	Input L24	Input L24
	57	IEEE C37.94	Signalling Fail	A/R CB Unhealthy	F out of Range	Programmable LED 1	Programmable LED 1
	58	Unused	Comm Delay Alarm	A/R No Checksync	Unused	Programmable LED 2	Programmable LED 2
	59	SR User Alarm 1	C Diff Failure	InCompatible Rly	Unused	Programmable LED 3	Programmable LED 3
	60	SR User Alarm 2	C Diff Inhibited	Test Loopback	Unused	Programmable LED 4	Programmable LED 4
	61	SR User Alarm 3	Config Error	Signalling Fail	Unused	Programmable LED 5	Programmable LED 5

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	62	SR User Alarm 4	Re-Config Error	Comm Delay Alarm	Unused	Programmable LED 6	Programmable LED 6
	63	SR User Alarm 5	F out of Range	C Diff Failure	Unused	Programmable LED 7	Programmable LED 7
	64	SR User Alarm 6	Unused	C Diff Inhibited	Unused	Programmable LED 8	Programmable LED 8
	65	SR User Alarm 7	Unused	Config Error	Unused	SG-opto Invalid	SG-opto Invalid
	66	SR User Alarm 8	Unused	Re-Config Error	Unused	Prot'n Disabled	Prot'n Disabled
	67	MR User Alarm 9	Unused	F out of Range	C Diff Comm Mode	VT Fail Alarm	VT Fail Alarm
	68	MR User Alarm 10	Unused	Unused	IEEE C37.94	Power Swing	Power Swing
	69	MR User Alarm 11	Unused	Unused	Unused	CB Fail Alarm	CB1 Fail Alarm
	70	MR User Alarm 12	Unused	Unused	SR User Alarm 1	I^ Maint Alarm	CB Status Alarm
	71	MR User Alarm 13	Unused	Unused	SR User Alarm 2	I^ Lockout Alarm	GPS Alarm
	72	MR User Alarm 14	Unused	Unused	SR User Alarm 3	CB OPs Maint	CB Trip Fail
	73	MR User Alarm 15	C Diff Comm Mode	Unused	SR User Alarm 4	CB OPs Lock	CB Close Fail
	74	MR User Alarm 16	IEEE C37.94	Unused	SR User Alarm 5	CB Time Maint	Man CB Unhealthy
	75	Control Input 1	Unused	Unused	SR User Alarm 6	CB Time Lockout	CB2 Fail Alarm
	76	Control Input 2	SR User Alarm 1	Unused	SR User Alarm 7	Fault Freq Lock	InCompatible Rly
	77	Control Input 3	SR User Alarm 2	C Diff Comm Mode	SR User Alarm 8	CB Status Alarm	Test Loopback
	78	Control Input 4	SR User Alarm 3	IEEE C37.94	MR User Alarm 9	GPS Alarm	Signalling Fail
	79	Control Input 5	SR User Alarm 4	System Split alarm	MR User Alarm 10	CB Trip Fail	Comm Delay Alarm
	80	Control Input 6	SR User Alarm 5	SR User Alarm 1	MR User Alarm 11	CB Close Fail	C Diff Failure
	81	Control Input 7	SR User Alarm 6	SR User Alarm 2	MR User Alarm 12	Man CB Unhealthy	C Diff Inhibited
	82	Control Input 8	SR User Alarm 7	SR User Alarm 3	MR User Alarm 13	No C/S Man Close	Config Error
	83	Control Input 9	SR User Alarm 8	SR User Alarm 4	MR User Alarm 14	A/R Lockout	Re-Config Error
	84	Control Input 10	MR User Alarm 9	SR User Alarm 5	MR User Alarm 15	A/R CB Unhealthy	F out of Range
	85	Control Input 11	MR User Alarm 10	SR User Alarm 6	MR User Alarm 16	A/R No Checksync	Unused
	86	Control Input 12	MR User Alarm 11	SR User Alarm 7	Control Input 1	InCompatible Rly	Unused
	87	Control Input 13	MR User Alarm 12	SR User Alarm 8	Control Input 2	Test Loopback	Unused
	88	Control Input 14	MR User Alarm 13	MR User Alarm 9	Control Input 3	Signalling Fail	Unused
	89	Control Input 15	MR User Alarm 14	MR User Alarm 10	Control Input 4	Comm Delay Alarm	Unused
	90	Control Input 16	MR User Alarm 15	MR User Alarm 11	Control Input 5	C Diff Failure	Unused
	91	Control Input 17	MR User Alarm 16	MR User Alarm 12	Control Input 6	C Diff Inhibited	Unused
	92	Control Input 18	Control Input 1	MR User Alarm 13	Control Input 7	Config Error	Unused
	93	Control Input 19	Control Input 2	MR User Alarm 14	Control Input 8	Re-Config Error	Unused

Type	**Value / Bit Mask**						
G32		P541	P542	P543	P544	P545	P546
	94	Control Input 20	Control Input 3	MR User Alarm 15	Control Input 9	F out of Range	C Diff Comm Mode
	95	Control Input 21	Control Input 4	MR User Alarm 16	Control Input 10	Unused	IEEE C37.94
	96	Control Input 22	Control Input 5	Control Input 1	Control Input 11	Unused	Unused
	97	Control Input 23	Control Input 6	Control Input 2	Control Input 12	Unused	SR User Alarm 1
	98	Control Input 24	Control Input 7	Control Input 3	Control Input 13	Unused	SR User Alarm 2
	99	Control Input 25	Control Input 8	Control Input 4	Control Input 14	Unused	SR User Alarm 3
	100	Control Input 26	Control Input 9	Control Input 5	Control Input 15	Unused	SR User Alarm 4
	101	Control Input 27	Control Input 10	Control Input 6	Control Input 16	Unused	SR User Alarm 5
	102	Control Input 28	Control Input 11	Control Input 7	Control Input 17	Unused	SR User Alarm 6
	103	Control Input 29	Control Input 12	Control Input 8	Control Input 18	Unused	SR User Alarm 7
	104	Control Input 30	Control Input 13	Control Input 9	Control Input 19	C Diff Comm Mode	SR User Alarm 8
	105	Control Input 31	Control Input 14	Control Input 10	Control Input 20	IEEE C37.94	MR User Alarm 9
	106	Control Input 32	Control Input 15	Control Input 11	Control Input 21	System Split alarm	MR User Alarm 10
	107	Any Trip	Control Input 16	Control Input 12	Control Input 22	SR User Alarm 1	MR User Alarm 11
	108	Diff Trip	Control Input 17	Control Input 13	Control Input 23	SR User Alarm 2	MR User Alarm 12
	109	Diff Trip A	Control Input 18	Control Input 14	Control Input 24	SR User Alarm 3	MR User Alarm 13
	110	Diff Trip B	Control Input 19	Control Input 15	Control Input 25	SR User Alarm 4	MR User Alarm 14
	111	Diff Trip C	Control Input 20	Control Input 16	Control Input 26	SR User Alarm 5	MR User Alarm 15
	112	Diff InterTrip	Control Input 21	Control Input 17	Control Input 27	SR User Alarm 6	MR User Alarm 16
	113	Diff InterTrip A	Control Input 22	Control Input 18	Control Input 28	SR User Alarm 7	Control Input 1
	114	Diff InterTrip B	Control Input 23	Control Input 19	Control Input 29	SR User Alarm 8	Control Input 2
	115	Diff InterTrip C	Control Input 24	Control Input 20	Control Input 30	MR User Alarm 9	Control Input 3
	116	Perm InterTrip	Control Input 25	Control Input 21	Control Input 31	MR User Alarm 10	Control Input 4
	117	BU Intertrip	Control Input 26	Control Input 22	Control Input 32	MR User Alarm 11	Control Input 5
	118	BU InterTrip A	Control Input 27	Control Input 23	Any Trip	MR User Alarm 12	Control Input 6
	119	BU InterTrip B	Control Input 28	Control Input 24	Diff Trip	MR User Alarm 13	Control Input 7
	120	BU InterTrip C	Control Input 29	Control Input 25	Diff Trip A	MR User Alarm 14	Control Input 8
	121	I>1 Trip	Control Input 30	Control Input 26	Diff Trip B	MR User Alarm 15	Control Input 9
	122	I>1 Trip A	Control Input 31	Control Input 27	Diff Trip C	MR User Alarm 16	Control Input 10
	123	I>1 Trip B	Control Input 32	Control Input 28	Diff InterTrip	Control Input 1	Control Input 11
	124	I>1 Trip C	Any Trip	Control Input 29	Diff InterTrip A	Control Input 2	Control Input 12
	125	I>2 Trip	Diff Trip	Control Input 30	Diff InterTrip B	Control Input 3	Control Input 13

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	126	I>2 Trip A	Diff Trip A	Control Input 31	Diff InterTrip C	Control Input 4	Control Input 14
	127	I>2 Trip B	Diff Trip B	Control Input 32	Perm InterTrip	Control Input 5	Control Input 15
	128	I>2 Trip C	Diff Trip C	Any Trip	Zone 1 Trip	Control Input 6	Control Input 16
	129	I>3 Trip	Diff InterTrip	Diff Trip	Zone 1 A Trip	Control Input 7	Control Input 17
	130	I>3 Trip A	Diff InterTrip A	Diff Trip A	Zone 1 B Trip	Control Input 8	Control Input 18
	131	I>3 Trip B	Diff InterTrip B	Diff Trip B	Zone 1 C Trip	Control Input 9	Control Input 19
	132	I>3 Trip C	Diff InterTrip C	Diff Trip C	Zone 1 N Trip	Control Input 10	Control Input 20
	133	I>4 Trip	Perm InterTrip	Diff InterTrip	Zone 2 Trip	Control Input 11	Control Input 21
	134	I>4 Trip A	BU Intertrip	Diff InterTrip A	Zone 2 A Trip	Control Input 12	Control Input 22
	135	I>4 Trip B	BU InterTrip A	Diff InterTrip B	Zone 2 B Trip	Control Input 13	Control Input 23
	136	I>4 Trip C	BU InterTrip B	Diff InterTrip C	Zone 2 C Trip	Control Input 14	Control Input 24
	137	IN>1 Trip	BU InterTrip C	Perm InterTrip	Zone 2 N Trip	Control Input 15	Control Input 25
	138	IN>2 Trip	I>1 Trip	Zone 1 Trip	Zone 3 Trip	Control Input 16	Control Input 26
	139	IN>3 Trip	I>1 Trip A	Zone 1 A Trip	Zone 3 A Trip	Control Input 17	Control Input 27
	140	IN>4 Trip	I>1 Trip B	Zone 1 B Trip	Zone 3 B Trip	Control Input 18	Control Input 28
	141	Broken Wire Trip	I>1 Trip C	Zone 1 C Trip	Zone 3 C Trip	Control Input 19	Control Input 29
	142	Thermal Trip	I>2 Trip	Zone 1 N Trip	Zone 3 N Trip	Control Input 20	Control Input 30
	143	Diff Start	I>2 Trip A	Zone 2 Trip	BU Intertrip	Control Input 21	Control Input 31
	144	Any Start	I>2 Trip B	Zone 2 A Trip	BU InterTrip A	Control Input 22	Control Input 32
	145	Diff Start A	I>2 Trip C	Zone 2 B Trip	BU InterTrip B	Control Input 23	Any Trip
	146	Diff Start B	I>3 Trip	Zone 2 C Trip	BU InterTrip C	Control Input 24	Diff Trip
	147	Diff Start C	I>3 Trip A	Zone 2 N Trip	Force 3pole BU	Control Input 25	Diff Trip A
	148	I>1 Start	I>3 Trip B	Zone 3 Trip	I>1 Trip	Control Input 26	Diff Trip B
	149	I>1 Start A	I>3 Trip C	Zone 3 A Trip	I>1 Trip A	Control Input 27	Diff Trip C
	150	I>1 Start B	I>4 Trip	Zone 3 B Trip	I>1 Trip B	Control Input 28	Diff InterTrip
	151	I>1 Start C	I>4 Trip A	Zone 3 C Trip	I>1 Trip C	Control Input 29	Diff InterTrip A
	152	I>2 Start	I>4 Trip B	Zone 3 N Trip	I>2 Trip	Control Input 30	Diff InterTrip B
	153	I>2 Start A	I>4 Trip C	Pole Discrepancy	I>2 Trip A	Control Input 31	Diff InterTrip C
	154	I>2 Start B	IN>1 Trip	BU Intertrip	I>2 Trip B	Control Input 32	Perm InterTrip
	155	I>2 Start C	IN>2 Trip	BU InterTrip A	I>2 Trip C	Any Trip	Zone 1 Trip
	156	I>3 Start	IN>3 Trip	BU InterTrip B	I>3 Trip	Diff Trip	Zone 1 A Trip
	157	I>3 Start A	IN>4 Trip	BU InterTrip C	I>3 Trip A	Diff Trip A	Zone 1 B Trip

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	158	I>3 Start B	Broken Wire Trip	Force 3pole BU	I>3 Trip B	Diff Trip B	Zone 1 C Trip
	159	I>3 Start C	Thermal Trip	I>1 Trip	I>3 Trip C	Diff Trip C	Zone 1 N Trip
	160	I>4 Start	AR Trip Test	I>1 Trip A	I>4 Trip	Diff InterTrip	Zone 2 Trip
	161	I>4 Start A	Diff Start	I>1 Trip B	I>4 Trip A	Diff InterTrip A	Zone 2 A Trip
	162	I>4 Start B	Any Start	I>1 Trip C	I>4 Trip B	Diff InterTrip B	Zone 2 B Trip
	163	I>4 Start C	Diff Start A	I>2 Trip	I>4 Trip C	Diff InterTrip C	Zone 2 C Trip
	164	IN>1 Start	Diff Start B	I>2 Trip A	IN>1 Trip	Perm InterTrip	Zone 2 N Trip
	165	IN>2 Start	Diff Start C	I>2 Trip B	IN>2 Trip	Zone 1 Trip	Zone 3 Trip
	166	IN>3 Start	I>1 Start	I>2 Trip C	IN>3 Trip	Zone 1 A Trip	Zone 3 A Trip
	167	IN>4 Start	I>1 Start A	I>3 Trip	IN>4 Trip	Zone 1 B Trip	Zone 3 B Trip
	168	Thermal Alarm	I>1 Start B	I>3 Trip A	ISEF>1 Trip	Zone 1 C Trip	Zone 3 C Trip
	169	I> BlockStart	I>1 Start C	I>3 Trip B	ISEF>2 Trip	Zone 1 N Trip	Zone 3 N Trip
	170	IN/SEF>Blk Start	I>2 Start	I>3 Trip C	ISEF>3 Trip	Zone 2 Trip	BU Intertrip
	171	Platform Alarm 0	I>2 Start A	I>4 Trip	ISEF>4 Trip	Zone 2 A Trip	BU InterTrip A
	172	Platform Alarm 2	I>2 Start B	I>4 Trip A	Broken Wire Trip	Zone 2 B Trip	BU InterTrip B
	173	Platform Alarm 3	I>2 Start C	I>4 Trip B	Thermal Trip	Zone 2 C Trip	BU InterTrip C
	174	Platform Alarm 4	I>3 Start	I>4 Trip C	Stub Bus Trip	Zone 2 N Trip	Force 3pole BU
	175	Platform Alarm 5	I>3 Start A	IN>1 Trip	Zone 1 Start	Zone 3 Trip	I>1 Trip
	176	Platform Alarm 6	I>3 Start B	IN>2 Trip	Zone 2 Start	Zone 3 A Trip	I>1 Trip A
	177	Platform Alarm 7	I>3 Start C	IN>3 Trip	Zone 3 Start	Zone 3 B Trip	I>1 Trip B
	178	Platform Alarm 8	I>4 Start	IN>4 Trip	Diff Start	Zone 3 C Trip	I>1 Trip C
	179	Platform Alarm 9	I>4 Start A	ISEF>1 Trip	Any Start	Zone 3 N Trip	I>2 Trip
	180	Platform Alarm 10	I>4 Start B	ISEF>2 Trip	Diff Start A	Pole Discrepancy	I>2 Trip A
	181	Platform Alarm 11	I>4 Start C	ISEF>3 Trip	Diff Start B	BU Intertrip	I>2 Trip B
	182	Platform Alarm 12	IN>1 Start	ISEF>4 Trip	Diff Start C	BU InterTrip A	I>2 Trip C
	183	Platform Alarm 13	IN>2 Start	Broken Wire Trip	Zone 1 A Start	BU InterTrip B	I>3 Trip
	184	Platform Alarm 14	IN>3 Start	Thermal Trip	Zone 1 B Start	BU InterTrip C	I>3 Trip A
	185	Platform Alarm 15	IN>4 Start	AR Trip Test	Zone 1 C Start	Force 3pole BU	I>3 Trip B
	186	Platform Alarm 16	Thermal Alarm	AR Trip Test A	Zone 1 N Start	I>1 Trip	I>3 Trip C
	187	Platform Alarm 17	I> BlockStart	AR Trip Test B	Zone 2 A Start	I>1 Trip A	I>4 Trip
	188	Platform Alarm 18	IN/SEF>Blk Start	AR Trip Test C	Zone 2 B Start	I>1 Trip B	I>4 Trip A
	189	Platform Alarm 19	Platform Alarm 0	Zone 1 Start	Zone 2 C Start	I>1 Trip C	I>4 Trip B

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	190	Platform Alarm 20	Platform Alarm 2	Zone 2 Start	Zone 2 N Start	I>2 Trip	I>4 Trip C
	191	Platform Alarm 21	Platform Alarm 3	Zone 3 Start	Zone 3 A Start	I>2 Trip A	IN>1 Trip
	192	Platform Alarm 22	Platform Alarm 4	Diff Start	Zone 3 B Start	I>2 Trip B	IN>2 Trip
	193	Platform Alarm 23	Platform Alarm 5	Any Start	Zone 3 C Start	I>2 Trip C	IN>3 Trip
	194	Platform Alarm 24	Platform Alarm 6	Diff Start A	Zone 3 N Start	I>3 Trip	IN>4 Trip
	195	Platform Alarm 25	Platform Alarm 7	Diff Start B	Zone 6 Start	I>3 Trip A	ISEF>1 Trip
	196	Platform Alarm 26	Platform Alarm 8	Diff Start C	I>1 Start	I>3 Trip B	ISEF>2 Trip
	197	Platform Alarm 27	Platform Alarm 9	Zone 1 A Start	I>1 Start A	I>3 Trip C	ISEF>3 Trip
	198	Platform Alarm 28	Platform Alarm 10	Zone 1 B Start	I>1 Start B	I>4 Trip	ISEF>4 Trip
	199	Platform Alarm 29	Platform Alarm 11	Zone 1 C Start	I>1 Start C	I>4 Trip A	Broken Wire Trip
	200	Platform Alarm 30	Platform Alarm 12	Zone 1 N Start	I>2 Start	I>4 Trip B	Thermal Trip
	201	Platform Alarm 31	Platform Alarm 13	Zone 2 A Start	I>2 Start A	I>4 Trip C	Stub Bus Trip
	202	Bfail1 Trip 3ph	Platform Alarm 14	Zone 2 B Start	I>2 Start B	IN>1 Trip	Zone 1 Start
	203	Bfail2 Trip 3ph	Platform Alarm 15	Zone 2 C Start	I>2 Start C	IN>2 Trip	Zone 2 Start
	204	Control Trip	Platform Alarm 16	Zone 2 N Start	I>3 Start	IN>3 Trip	Zone 3 Start
	205	Control Close	Platform Alarm 17	Zone 3 A Start	I>3 Start A	IN>4 Trip	Diff Start
	206	Close in Prog	Platform Alarm 18	Zone 3 B Start	I>3 Start B	ISEF>1 Trip	Any Start
	207	Lockout Alarm	Platform Alarm 19	Zone 3 C Start	I>3 Start C	ISEF>2 Trip	Diff Start A
	208	Field Volt Fail	Platform Alarm 20	Zone 3 N Start	I>4 Start	ISEF>3 Trip	Diff Start B
	209	IA< Start	Platform Alarm 21	Zone 6 Start	I>4 Start A	ISEF>4 Trip	Diff Start C
	210	IB< Start	Platform Alarm 22	I>1 Start	I>4 Start B	Broken Wire Trip	Zone 1 A Start
	211	IC< Start	Platform Alarm 23	I>1 Start A	I>4 Start C	Thermal Trip	Zone 1 B Start
	212	ISEF< Start	Platform Alarm 24	I>1 Start B	IN>1 Start	AR Trip Test	Zone 1 C Start
	213	All Poles Dead	Platform Alarm 25	I>1 Start C	IN>2 Start	AR Trip Test A	Zone 1 N Start
	214	Any Pole Dead	Platform Alarm 26	I>2 Start	IN>3 Start	AR Trip Test B	Zone 2 A Start
	215	CB Open 3 ph	Platform Alarm 27	I>2 Start A	IN>4 Start	AR Trip Test C	Zone 2 B Start
	216	CB Closed 3 ph	Platform Alarm 28	I>2 Start B	ISEF>1 Start	Zone 1 Start	Zone 2 C Start
	217	SignalFail Ch1Rx	Platform Alarm 29	I>2 Start C	ISEF>2 Start	Zone 2 Start	Zone 2 N Start
	218	SignalFail Ch1Tx	Platform Alarm 30	I>3 Start	ISEF>3 Start	Zone 3 Start	Zone 3 A Start
	219	SignalFail Ch2Rx	Platform Alarm 31	I>3 Start A	ISEF>4 Start	Diff Start	Zone 3 B Start
	220	SignalFail Ch2Tx	Bfail1 Trip 3ph	I>3 Start B	Thermal Alarm	Any Start	Zone 3 C Start
	221	CB Status Alarm	Bfail2 Trip 3ph	I>3 Start C	I> BlockStart	Diff Start A	Zone 3 N Start

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	222	Ch1 Intertrip 1	Control Trip	I>4 Start	IN/SEF>Blk Start	Diff Start B	Zone 6 Start
	223	Ch1 Intertrip 2	Control Close	I>4 Start A	Platform Alarm 0	Diff Start C	I>1 Start
	224	Ch1 Intertrip 3	Close in Prog	I>4 Start B	Platform Alarm 2	Zone 1 A Start	I>1 Start A
	225	Ch1 Intertrip 4	Block Main Prot	I>4 Start C	Platform Alarm 3	Zone 1 B Start	I>1 Start B
	226	Ch1 Intertrip 5	AR 3pole in prog	IN>1 Start	Platform Alarm 4	Zone 1 C Start	I>1 Start C
	227	Ch1 Intertrip 6	Seq Counter = 0	IN>2 Start	Platform Alarm 5	Zone 1 N Start	I>2 Start
	228	Ch1 Intertrip 7	Seq Counter = 1	IN>3 Start	Platform Alarm 6	Zone 2 A Start	I>2 Start A
	229	Ch1 Intertrip 8	Seq Counter = 2	IN>4 Start	Platform Alarm 7	Zone 2 B Start	I>2 Start B
	230	Ch2 Intertrip 1	Seq Counter = 3	ISEF>1 Start	Platform Alarm 8	Zone 2 C Start	I>2 Start C
	231	Ch2 Intertrip 2	Seq Counter = 4	ISEF>2 Start	Platform Alarm 9	Zone 2 N Start	I>3 Start
	232	Ch2 Intertrip 3	Successful Close	ISEF>3 Start	Platform Alarm 10	Zone 3 A Start	I>3 Start A
	233	Ch2 Intertrip 4	Dead T in Prog	ISEF>4 Start	Platform Alarm 11	Zone 3 B Start	I>3 Start B
	234	Ch2 Intertrip 5	Auto Close	Thermal Alarm	Platform Alarm 12	Zone 3 C Start	I>3 Start C
	235	Ch2 Intertrip 6	A/R Status	I> BlockStart	Platform Alarm 13	Zone 3 N Start	I>4 Start
	236	Ch2 Intertrip 7	Lockout Alarm	IN/SEF>Blk Start	Platform Alarm 14	Zone 6 Start	I>4 Start A
	237	Ch2 Intertrip 8	Field Volt Fail	Platform Alarm 0	Platform Alarm 15	I>1 Start	I>4 Start B
	238	HMI Access Lvl 1	IA< Start	Platform Alarm 2	Platform Alarm 16	I>1 Start A	I>4 Start C
	239	HMI Access Lvl 2	IB< Start	Platform Alarm 3	Platform Alarm 17	I>1 Start B	IN>1 Start
	240	FPort AccessLvl1	IC< Start	Platform Alarm 4	Platform Alarm 18	I>1 Start C	IN>2 Start
	241	FPort AccessLvl2	ISEF< Start	Platform Alarm 5	Platform Alarm 19	I>2 Start	IN>3 Start
	242	RPrt1 AccessLvl1	All Poles Dead	Platform Alarm 6	Platform Alarm 20	I>2 Start A	IN>4 Start
	243	RPrt1 AccessLvl2	Any Pole Dead	Platform Alarm 7	Platform Alarm 21	I>2 Start B	ISEF>1 Start
	244	RPrt2 AccessLvl1	CB Open 3 ph	Platform Alarm 8	Platform Alarm 22	I>2 Start C	ISEF>2 Start
	245	RPrt2 AccessLvl2	CB Closed 3 ph	Platform Alarm 9	Platform Alarm 23	I>3 Start	ISEF>3 Start
	246	Ch1 Signal Lost	SignalFail Ch1Rx	Platform Alarm 10	Platform Alarm 24	I>3 Start A	ISEF>4 Start
	247	Ch1 Path Yellow	SignalFail Ch1Tx	Platform Alarm 11	Platform Alarm 25	I>3 Start B	Thermal Alarm
	248	Ch1 Mismatch RxN	SignalFail Ch2Rx	Platform Alarm 12	Platform Alarm 26	I>3 Start C	I> BlockStart
	249	Ch2 Signal Lost	SignalFail Ch2Tx	Platform Alarm 13	Platform Alarm 27	I>4 Start	IN/SEF>Blk Start
	250	Ch2 Path Yellow	CB Status Alarm	Platform Alarm 14	Platform Alarm 28	I>4 Start A	Platform Alarm 0
	251	Ch2 Mismatch RxN	Ch1 Intertrip 1	Platform Alarm 15	Platform Alarm 29	I>4 Start B	Platform Alarm 2
	252	Virtual Input 1	Ch1 Intertrip 2	Platform Alarm 16	Platform Alarm 30	I>4 Start C	Platform Alarm 3
	253	Virtual Input 2	Ch1 Intertrip 3	Platform Alarm 17	Platform Alarm 31	IN>1 Start	Platform Alarm 4

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	254	Virtual Input 3	Ch1 Intertrip 4	Platform Alarm 18	VTS Fast Block	IN>2 Start	Platform Alarm 5
	255	Virtual Input 4	Ch1 Intertrip 5	Platform Alarm 19	VTS Slow Block	IN>3 Start	Platform Alarm 6
	256	Virtual Input 5	Ch1 Intertrip 6	Platform Alarm 20	CB1 Fail1 Trip	IN>4 Start	Platform Alarm 7
	257	Virtual Input 6	Ch1 Intertrip 7	Platform Alarm 21	CB1 Fail2 Trip	ISEF>1 Start	Platform Alarm 8
	258	Virtual Input 7	Ch1 Intertrip 8	Platform Alarm 22	CB2 Fail1 Trip	ISEF>2 Start	Platform Alarm 9
	259	Virtual Input 8	Ch2 Intertrip 1	Platform Alarm 23	CB2 Fail2 Trip	ISEF>3 Start	Platform Alarm 10
	260	Virtual Input 9	Ch2 Intertrip 2	Platform Alarm 24	Control Trip 1	ISEF>4 Start	Platform Alarm 11
	261	Virtual Input 10	Ch2 Intertrip 3	Platform Alarm 25	Control Close 1	Thermal Alarm	Platform Alarm 12
	262	Virtual Input 11	Ch2 Intertrip 4	Platform Alarm 26	Control Trip 2	I> BlockStart	Platform Alarm 13
	263	Virtual Input 12	Ch2 Intertrip 5	Platform Alarm 27	Control Close 2	IN/SEF>Blk Start	Platform Alarm 14
	264	Virtual Input 13	Ch2 Intertrip 6	Platform Alarm 28	Close in Prog	Platform Alarm 0	Platform Alarm 15
	265	Virtual Input 14	Ch2 Intertrip 7	Platform Alarm 29	Field Volt Fail	Platform Alarm 2	Platform Alarm 16
	266	Virtual Input 15	Ch2 Intertrip 8	Platform Alarm 30	IA< Start	Platform Alarm 3	Platform Alarm 17
	267	Virtual Input 16	HMI Access Lvl 1	Platform Alarm 31	IB< Start	Platform Alarm 4	Platform Alarm 18
	268	Virtual Input 17	HMI Access Lvl 2	VTS Fast Block	IC< Start	Platform Alarm 5	Platform Alarm 19
	269	Virtual Input 18	FPort AccessLvl1	VTS Slow Block	ISEF< Start	Platform Alarm 6	Platform Alarm 20
	270	Virtual Input 19	FPort AccessLvl2	Bfail1 Trip 3ph	CB1 IA< Start	Platform Alarm 7	Platform Alarm 21
	271	Virtual Input 20	RPrt1 AccessLvl1	Bfail2 Trip 3ph	CB1 IB< Start	Platform Alarm 8	Platform Alarm 22
	272	Virtual Input 21	RPrt1 AccessLvl2	Control Trip	CB1 IC< Start	Platform Alarm 9	Platform Alarm 23
	273	Virtual Input 22	RPrt2 AccessLvl1	Control Close	CB1 ISEF< Start	Platform Alarm 10	Platform Alarm 24
	274	Virtual Input 23	RPrt2 AccessLvl2	Close in Prog	CB2 IA< Start	Platform Alarm 11	Platform Alarm 25
	275	Virtual Input 24	Ch1 Signal Lost	AR 3pole in prog	CB2 IB< Start	Platform Alarm 12	Platform Alarm 26
	276	Virtual Input 25	Ch1 Path Yellow	AR 1pole in prog	CB2 IC< Start	Platform Alarm 13	Platform Alarm 27
	277	Virtual Input 26	Ch1 Mismatch RxN	Seq Counter = 0	CB2 ISEF< Start	Platform Alarm 14	Platform Alarm 28
	278	Virtual Input 27	Ch2 Signal Lost	Seq Counter = 1	All Poles Dead	Platform Alarm 15	Platform Alarm 29
	279	Virtual Input 28	Ch2 Path Yellow	Seq Counter = 2	Any Pole Dead	Platform Alarm 16	Platform Alarm 30
	280	Virtual Input 29	Ch2 Mismatch RxN	Seq Counter = 3	Pole Dead A	Platform Alarm 17	Platform Alarm 31
	281	Virtual Input 30	Virtual Input 1	Seq Counter = 4	Pole Dead B	Platform Alarm 18	VTS Fast Block
	282	Virtual Input 31	Virtual Input 2	Seq Counter = 5	Pole Dead C	Platform Alarm 19	VTS Slow Block
	283	Virtual Input 32	Virtual Input 3	Successful Close	CB1 Open 3 ph	Platform Alarm 20	CB1 Fail1 Trip
	284	Virtual Output 1	Virtual Input 4	Auto Close	CB1 Open A ph	Platform Alarm 21	CB1 Fail2 Trip
	285	Virtual Output 2	Virtual Input 5	A/R Status 3P	CB1 Open B ph	Platform Alarm 22	CB2 Fail1 Trip

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	286	Virtual Output 3	Virtual Input 6	A/R Status 1P	CB1 Open C ph	Platform Alarm 23	CB2 Fail2 Trip
	287	Virtual Output 4	Virtual Input 7	Force 3 pole AR	CB1 Closed 3 ph	Platform Alarm 24	Control Trip 1
	288	Virtual Output 5	Virtual Input 8	Lockout Alarm	CB1 Closed A ph	Platform Alarm 25	Control Close 1
	289	Virtual Output 6	Virtual Input 9	Field Volt Fail	CB1 Closed B ph	Platform Alarm 26	Control Trip 2
	290	Virtual Output 7	Virtual Input 10	IA< Start	CB1 Closed C ph	Platform Alarm 27	Control Close 2
	291	Virtual Output 8	Virtual Input 11	IB< Start	CB2 Open 3 ph	Platform Alarm 28	Close in Prog
	292	Virtual Output 9	Virtual Input 12	IC< Start	CB2 Open A ph	Platform Alarm 29	Field Volt Fail
	293	Virtual Output10	Virtual Input 13	ISEF< Start	CB2 Open B ph	Platform Alarm 30	IA< Start
	294	Virtual Output11	Virtual Input 14	All Poles Dead	CB2 Open C ph	Platform Alarm 31	IB< Start
	295	Virtual Output12	Virtual Input 15	Any Pole Dead	CB2 Closed 3 ph	VTS Fast Block	IC< Start
	296	Virtual Output13	Virtual Input 16	Pole Dead A	CB2 Closed A ph	VTS Slow Block	ISEF< Start
	297	Virtual Output14	Virtual Input 17	Pole Dead B	CB2 Closed B ph	Bfail1 Trip 3ph	CB1 IA< Start
	298	Virtual Output15	Virtual Input 18	Pole Dead C	CB2 Closed C ph	Bfail2 Trip 3ph	CB1 IB< Start
	299	Virtual Output16	Virtual Input 19	Ctl Check Sync	SignalFail Ch1Rx	Control Trip	CB1 IC< Start
	300	Virtual Output17	Virtual Input 20	A/R Check Synch	SignalFail Ch1Tx	Control Close	CB1 ISEF< Start
	301	Virtual Output18	Virtual Input 21	CB Open 3 ph	SignalFail Ch2Rx	Close in Prog	CB2 IA< Start
	302	Virtual Output19	Virtual Input 22	CB Open A ph	SignalFail Ch2Tx	AR 3pole in prog	CB2 IB< Start
	303	Virtual Output20	Virtual Input 23	CB Open B ph	1 Pole Trip En	AR 1pole in prog	CB2 IC< Start
	304	Virtual Output21	Virtual Input 24	CB Open C ph	CB1 Status Alarm	Seq Counter = 0	CB2 ISEF< Start
	305	Virtual Output22	Virtual Input 25	CB Closed 3 ph	CB2 Status Alarm	Seq Counter = 1	All Poles Dead
	306	Virtual Output23	Virtual Input 26	CB Closed A ph	Ch1 Intertrip 1	Seq Counter = 2	Any Pole Dead
	307	Virtual Output24	Virtual Input 27	CB Closed B ph	Ch1 Intertrip 2	Seq Counter = 3	Pole Dead A
	308	Virtual Output25	Virtual Input 28	CB Closed C ph	Ch1 Intertrip 3	Seq Counter = 4	Pole Dead B
	309	Virtual Output26	Virtual Input 29	SignalFail Ch1Rx	Ch1 Intertrip 4	Seq Counter = 5	Pole Dead C
	310	Virtual Output27	Virtual Input 30	SignalFail Ch1Tx	Ch1 Intertrip 5	Successful Close	CB1 Open 3 ph
	311	Virtual Output28	Virtual Input 31	SignalFail Ch2Rx	Ch1 Intertrip 6	Auto Close	CB1 Open A ph
	312	Virtual Output29	Virtual Input 32	SignalFail Ch2Tx	Ch1 Intertrip 7	A/R Status 3P	CB1 Open B ph
	313	Virtual Output30	Virtual Output 1	1 Pole Trip En	Ch1 Intertrip 8	A/R Status 1P	CB1 Open C ph
	314	Virtual Output31	Virtual Output 2	CB Status Alarm	Ch2 Intertrip 1	Force 3 pole AR	CB1 Closed 3 ph
	315	Virtual Output32	Virtual Output 3	Ch1 Intertrip 1	Ch2 Intertrip 2	Lockout Alarm	CB1 Closed A ph
	316		Virtual Output 4	Ch1 Intertrip 2	Ch2 Intertrip 3	Field Volt Fail	CB1 Closed B ph
	317		Virtual Output 5	Ch1 Intertrip 3	Ch2 Intertrip 4	IA< Start	CB1 Closed C ph

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	318		Virtual Output 6	Ch1 Intertrip 4	Ch2 Intertrip 5	IB< Start	CB2 Open 3 ph
	319		Virtual Output 7	Ch1 Intertrip 5	Ch2 Intertrip 6	IC< Start	CB2 Open A ph
	320		Virtual Output 8	Ch1 Intertrip 6	Ch2 Intertrip 7	ISEF< Start	CB2 Open B ph
	321		Virtual Output 9	Ch1 Intertrip 7	Ch2 Intertrip 8	All Poles Dead	CB2 Open C ph
	322		Virtual Output10	Ch1 Intertrip 8	I2>	Any Pole Dead	CB2 Closed 3 ph
	323		Virtual Output11	Ch2 Intertrip 1	HMI Access Lvl 1	Pole Dead A	CB2 Closed A ph
	324		Virtual Output12	Ch2 Intertrip 2	HMI Access Lvl 2	Pole Dead B	CB2 Closed B ph
	325		Virtual Output13	Ch2 Intertrip 3	FPort AccessLvl1	Pole Dead C	CB2 Closed C ph
	326		Virtual Output14	Ch2 Intertrip 4	FPort AccessLvl2	Ctl Check Sync	SignalFail Ch1Rx
	327		Virtual Output15	Ch2 Intertrip 5	RPrt1 AccessLvl1	A/R Check Synch	SignalFail Ch1Tx
	328		Virtual Output16	Ch2 Intertrip 6	RPrt1 AccessLvl2	CB Open 3 ph	SignalFail Ch2Rx
	329		Virtual Output17	Ch2 Intertrip 7	RPrt2 AccessLvl1	CB Open A ph	SignalFail Ch2Tx
	330		Virtual Output18	Ch2 Intertrip 8	RPrt2 AccessLvl2	CB Open B ph	Ch 1 GPS Fail
	331		Virtual Output19	I2>	Ch1 Signal Lost	CB Open C ph	Ch 2 GPS Fail
	332		Virtual Output20	HMI Access Lvl 1	Ch1 Path Yellow	CB Closed 3 ph	1 Pole Trip En
	333		Virtual Output21	HMI Access Lvl 2	Ch1 Mismatch RxN	CB Closed A ph	CB1 Status Alarm
	334		Virtual Output22	FPort AccessLvl1	Ch2 Signal Lost	CB Closed B ph	CB2 Status Alarm
	335		Virtual Output23	FPort AccessLvl2	Ch2 Path Yellow	CB Closed C ph	Ch1 Intertrip 1
	336		Virtual Output24	RPrt1 AccessLvl1	Ch2 Mismatch RxN	SignalFail Ch1Rx	Ch1 Intertrip 2
	337		Virtual Output25	RPrt1 AccessLvl2	Virtual Input 1	SignalFail Ch1Tx	Ch1 Intertrip 3
	338		Virtual Output26	RPrt2 AccessLvl1	Virtual Input 2	SignalFail Ch2Rx	Ch1 Intertrip 4
	339		Virtual Output27	RPrt2 AccessLvl2	Virtual Input 3	SignalFail Ch2Tx	Ch1 Intertrip 5
	340		Virtual Output28	Live Line	Virtual Input 4	Ch 1 GPS Fail	Ch1 Intertrip 6
	341		Virtual Output29	Dead Line	Virtual Input 5	Ch 2 GPS Fail	Ch1 Intertrip 7
	342		Virtual Output30	Live Bus	Virtual Input 6	1 Pole Trip En	Ch1 Intertrip 8
	343		Virtual Output31	Dead Bus	Virtual Input 7	CB Status Alarm	Ch2 Intertrip 1
	344		Virtual Output32	Check Sync 1 OK	Virtual Input 8	Ch1 Intertrip 1	Ch2 Intertrip 2
	345			Check Sync 2 OK	Virtual Input 9	Ch1 Intertrip 2	Ch2 Intertrip 3
	346			SysChks Inactive	Virtual Input 10	Ch1 Intertrip 3	Ch2 Intertrip 4
	347			Ch1 Signal Lost	Virtual Input 11	Ch1 Intertrip 4	Ch2 Intertrip 5
	348			Ch1 Path Yellow	Virtual Input 12	Ch1 Intertrip 5	Ch2 Intertrip 6
	349			Ch1 Mismatch RxN	Virtual Input 13	Ch1 Intertrip 6	Ch2 Intertrip 7

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	350			Ch2 Signal Lost	Virtual Input 14	Ch1 Intertrip 7	Ch2 Intertrip 8
	351			Ch2 Path Yellow	Virtual Input 15	Ch1 Intertrip 8	I2>
	352			Ch2 Mismatch RxN	Virtual Input 16	Ch2 Intertrip 1	HMI Access Lvl 1
	353			Virtual Input 1	Virtual Input 17	Ch2 Intertrip 2	HMI Access Lvl 2
	354			Virtual Input 2	Virtual Input 18	Ch2 Intertrip 3	FPort AccessLvl1
	355			Virtual Input 3	Virtual Input 19	Ch2 Intertrip 4	FPort AccessLvl2
	356			Virtual Input 4	Virtual Input 20	Ch2 Intertrip 5	RPrt1 AccessLvl1
	357			Virtual Input 5	Virtual Input 21	Ch2 Intertrip 6	RPrt1 AccessLvl2
	358			Virtual Input 6	Virtual Input 22	Ch2 Intertrip 7	RPrt2 AccessLvl1
	359			Virtual Input 7	Virtual Input 23	Ch2 Intertrip 8	RPrt2 AccessLvl2
	360			Virtual Input 8	Virtual Input 24	I2>	Ch1 Signal Lost
	361			Virtual Input 9	Virtual Input 25	HMI Access Lvl 1	Ch1 Path Yellow
	362			Virtual Input 10	Virtual Input 26	HMI Access Lvl 2	Ch1 Mismatch RxN
	363			Virtual Input 11	Virtual Input 27	FPort AccessLvl1	Ch2 Signal Lost
	364			Virtual Input 12	Virtual Input 28	FPort AccessLvl2	Ch2 Path Yellow
	365			Virtual Input 13	Virtual Input 29	RPrt1 AccessLvl1	Ch2 Mismatch RxN
	366			Virtual Input 14	Virtual Input 30	RPrt1 AccessLvl2	Virtual Input 1
	367			Virtual Input 15	Virtual Input 31	RPrt2 AccessLvl1	Virtual Input 2
	368			Virtual Input 16	Virtual Input 32	RPrt2 AccessLvl2	Virtual Input 3
	369			Virtual Input 17	Virtual Output 1	Live Line	Virtual Input 4
	370			Virtual Input 18	Virtual Output 2	Dead Line	Virtual Input 5
	371			Virtual Input 19	Virtual Output 3	Live Bus	Virtual Input 6
	372			Virtual Input 20	Virtual Output 4	Dead Bus	Virtual Input 7
	373			Virtual Input 21	Virtual Output 5	Check Sync 1 OK	Virtual Input 8
	374			Virtual Input 22	Virtual Output 6	Check Sync 2 OK	Virtual Input 9
	375			Virtual Input 23	Virtual Output 7	SysChks Inactive	Virtual Input 10
	376			Virtual Input 24	Virtual Output 8	Ch1 Signal Lost	Virtual Input 11
	377			Virtual Input 25	Virtual Output 9	Ch1 Path Yellow	Virtual Input 12
	378			Virtual Input 26	Virtual Output10	Ch1 Mismatch RxN	Virtual Input 13
	379			Virtual Input 27	Virtual Output11	Ch2 Signal Lost	Virtual Input 14
	380			Virtual Input 28	Virtual Output12	Ch2 Path Yellow	Virtual Input 15
	381			Virtual Input 29	Virtual Output13	Ch2 Mismatch RxN	Virtual Input 16

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	382			Virtual Input 30	Virtual Output14	Virtual Input 1	Virtual Input 17
	383			Virtual Input 31	Virtual Output15	Virtual Input 2	Virtual Input 18
	384			Virtual Input 32	Virtual Output16	Virtual Input 3	Virtual Input 19
	385			Virtual Output 1	Virtual Output17	Virtual Input 4	Virtual Input 20
	386			Virtual Output 2	Virtual Output18	Virtual Input 5	Virtual Input 21
	387			Virtual Output 3	Virtual Output19	Virtual Input 6	Virtual Input 22
	388			Virtual Output 4	Virtual Output20	Virtual Input 7	Virtual Input 23
	389			Virtual Output 5	Virtual Output21	Virtual Input 8	Virtual Input 24
	390			Virtual Output 6	Virtual Output22	Virtual Input 9	Virtual Input 25
	391			Virtual Output 7	Virtual Output23	Virtual Input 10	Virtual Input 26
	392			Virtual Output 8	Virtual Output24	Virtual Input 11	Virtual Input 27
	393			Virtual Output 9	Virtual Output25	Virtual Input 12	Virtual Input 28
	394			Virtual Output10	Virtual Output26	Virtual Input 13	Virtual Input 29
	395			Virtual Output11	Virtual Output27	Virtual Input 14	Virtual Input 30
	396			Virtual Output12	Virtual Output28	Virtual Input 15	Virtual Input 31
	397			Virtual Output13	Virtual Output29	Virtual Input 16	Virtual Input 32
	398			Virtual Output14	Virtual Output30	Virtual Input 17	Virtual Output 1
	399			Virtual Output15	Virtual Output31	Virtual Input 18	Virtual Output 2
	400			Virtual Output16	Virtual Output32	Virtual Input 19	Virtual Output 3
	401			Virtual Output17		Virtual Input 20	Virtual Output 4
	402			Virtual Output18		Virtual Input 21	Virtual Output 5
	403			Virtual Output19		Virtual Input 22	Virtual Output 6
	404			Virtual Output20		Virtual Input 23	Virtual Output 7
	405			Virtual Output21		Virtual Input 24	Virtual Output 8
	406			Virtual Output22		Virtual Input 25	Virtual Output 9
	407			Virtual Output23		Virtual Input 26	Virtual Output10
	408			Virtual Output24		Virtual Input 27	Virtual Output11
	409			Virtual Output25		Virtual Input 28	Virtual Output12
	410			Virtual Output26		Virtual Input 29	Virtual Output13
	411			Virtual Output27		Virtual Input 30	Virtual Output14
	412			Virtual Output28		Virtual Input 31	Virtual Output15
	413			Virtual Output29		Virtual Input 32	Virtual Output16

Type	Value / Bit Mask						
G32		P541	P542	P543	P544	P545	P546
	414			Virtual Output30		Virtual Output 1	Virtual Output17
	415			Virtual Output31		Virtual Output 2	Virtual Output18
	416			Virtual Output32		Virtual Output 3	Virtual Output19
	417					Virtual Output 4	Virtual Output20
	418					Virtual Output 5	Virtual Output21
	419					Virtual Output 6	Virtual Output22
	420					Virtual Output 7	Virtual Output23
	421					Virtual Output 8	Virtual Output24
	422					Virtual Output 9	Virtual Output25
	423					Virtual Output10	Virtual Output26
	424					Virtual Output11	Virtual Output27
	425					Virtual Output12	Virtual Output28
	426					Virtual Output13	Virtual Output29
	427					Virtual Output14	Virtual Output30
	428					Virtual Output15	Virtual Output31
	429					Virtual Output16	Virtual Output32
	430					Virtual Output17	
	431					Virtual Output18	
	432					Virtual Output19	
	433					Virtual Output20	
	434					Virtual Output21	
	435					Virtual Output22	
	436					Virtual Output23	
	437					Virtual Output24	
	438					Virtual Output25	
	439					Virtual Output26	
	440					Virtual Output27	
	441					Virtual Output28	
	442					Virtual Output29	
	443					Virtual Output30	
	444					Virtual Output31	
	445					Virtual Output32	

IEC870-5-103: Compatibility Level					Compatability Level 2							
Physical Layer Electrical Interface EIA RS-485												
Number of loads 1 for one protection equipment												
Optical Interface (Order option)												
Plastic fibre BFOC/2.5 type connector												
Transmission speed												
User Setting : 9600 or 19200												
Application Layer												
One COMMON ADDRESS OF ASDU = LINK ADDRESS												
Standard Information numbers in monitor direction												
ASDU TYPE	**COT**	**FUN**	**Inf No.**	**Description**	**GI**	**Model Number**						**Interpretation**
						1	**2**	**3**	**4**	**5**	**6**	
System Functions(Monitor)												
8	10	255	0	End of General Interrogration		*	*	*	*	*	*	
6	8	255	0	Time Synchronisation		*	*	*	*	*	*	
5	3	192	2	Reset FCB		*	*	*	*	*	*	
5	4	192	3	Reset CU		*	*	*	*	*	*	
5	5	192	4	Start/Restart		*	*	*	*	*	*	
5	6	192	5	Power On		*	*	*	*	*	*	
Note: Indentification message in ASDU 5: "AREVA P"+ 16bit model + 8bit major version +1character minor version e.g. "AREVA P" + 543 + 21 + 'A'												
Status Indications												
1	1,7,9,11,12,20,21	192	16	A/R Status	*		*					Autoreclose in Service
1	1,7,9,11,12,20,21	192	16	A/R Status 3P	*			*		*		Autoreclose in Service 1 pole
1	1,7,9,11,12,20,21	192	17	Tele-protection active								
1	1,7,9,11,12,20,21	192	18	Protection active								
1	1,7,9,11,12,20,21	192	19	LED Reset		*	*	*	*	*	*	RESET_INDICATIONS
1	9,11	192	20	Monitor direction blocked	*	*	*	*	*	*	*	
1	9,11	192	21	Test mode	*	*	*	*	*	*	*	Prot'n Disabled
1	9,11	192	22	Local parameter setting								
1	1,7,9,11,12,20,21	192	23	Characteristic 1	*	*	*	*	*	*	*	PG1 Changed
1	1,7,9,11,12,20,21	192	24	Characteristic 2	*	*	*	*	*	*	*	PG2 Changed
1	1,7,9,11,12,20,21	192	25	Characteristic 3	*	*	*	*	*	*	*	PG3 Changed

ASDU TYPE	COT	FUN	Inf No.	Description	GI	Model Number 1	2	3	4	5	6	Interpretation
1	1,7,9,11,12,20,21	192	26	Characteristic 4	*	*	*	*	*	*	*	PG4 Changed
1	1,7,9,11	192	27	Opto 1	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_1
1	1,7,9,11	192	28	Opto 2	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_2
1	1,7,9,11	192	29	Opto 3	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_3
1	1,7,9,11	192	30	Opto 4	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_4
Supervision Indications												
1	1,7,9	192	32	Measurand supervision I								
1	1,7,9	192	33	Measurand supervision V								
1	1,7,9	192	35	Phase sequence supervision								
1	1,7,9	192	36	Trip circuit supervision								
1	1,7,9	192	37	I>> back-up supervision								
1	1,7,9	192	38	VT fuse failure	*			*	*	*	*	VT Supervision Indication
1	1,7,9	192	39	Teleprotection disturbed								
1	1,7,9	192	46	Group warning								
1	1,7,9	192	47	Group alarm								
Earth Fault Indications												
1	1,7,9	192	48	Earth Fault L1								
1	1,7,9	192	49	Earth Fault L2								
1	1,7,9	192	50	Earth Fault L3								
1	1,7,9	192	51	Earth Fault Fwd								
1	1,7,9	192	52	Earth Fault Rev								
Fault Indications												
2	1,7,9	192	64	Start /pickup L1	*	*	*	*	*	*	*	Differential Start A
2	1,7,9	192	65	Start /pickup L2	*	*	*	*	*	*	*	Differential Start B
2	1,7,9	192	66	Start /pickup L3	*	*	*	*	*	*	*	Differential Start C
2	1,7,9	192	67	Start /pickup N								
2	1,7	192	68	General Trip		*	*	*	*	*	*	Any Trip
2	1,7	192	69	Trip L1		*	*	*	*	*	*	Differential Trip A
2	1,7	192	70	Trip L2		*	*	*	*	*	*	Differential Trip B
2	1,7	192	71	Trip L3		*	*	*	*	*	*	Differential Trip C
2	1,7	192	72	Trip I>>								
4	1,7	192	73	Fault Location in ohms				*	*	*	*	

ASDU TYPE	COT	FUN	Inf No.	Description	GI	Model Number 1	2	3	4	5	6	Interpretation
2	1,7	192	74	Fault forward								
2	1,7	192	75	Fault reverse								
2	1,7	192	76	Teleprotection signal sent								
2	1,7	192	77	Teleprotection signal received								
2	1,7	192	78	Zone 1				*	*	*	*	Zone 1 Trip
2	1,7	192	79	Zone 2				*	*	*	*	Zone 2 Trip
2	1,7	192	80	Zone 3				*	*	*	*	Zone 3 Trip
2	1,7	192	81	Zone 4								
2	1,7	192	82	Zone 5								
2	1,7	192	83	Zone 6								
2	1,7,9	192	84	General Start	*	*	*	*	*	*	*	Any Start
2	1,7	192	85	Breaker Failure		*	*	*	*	*	*	CB Fail Alarm
2	1,7	192	86	Trip measuring system L1								
2	1,7	192	87	Trip measuring system L2								
2	1,7	192	88	Trip measuring system L3								
2	1,7	192	89	Trip measuring system E								
2	1,7	192	90	Trip I>		*	*	*	*	*	*	I>1 Trip
2	1,7	192	91	Trip I>>		*	*	*	*	*	*	I>3 Trip
2	1,7	192	92	Trip IN>		*	*	*	*	*	*	IN1>1 Trip
2	1,7	192	93	Trip IN>>		*	*	*	*	*	*	IN1>3 Trip
Auto-Reclose Indications (Monitor)												
1	1,7	192	128	CB 'on' by A/R			*	*		*		Autoreclose Close Signal
1	1,7	192	129	CB 'on' by long time A/R								
1	1,7,9	192	130	AR blocked	*		*	*		*		Autoreclose Lockout
Measurands (Monitor)												
3.1	2,7	192	144	Measurand I								
3.2	2,7	192	145	Measurands I,V								
3.3	2,7	192	146	Measurands I,V,P,Q								
3.4	2,7	192	147	Measurands IN,VEN								
9	2,7	192	148	Measurands IL1,2,3,VL1,2,3,P,Q,f		*	*	*	*	*	*	Note unavailable measurands sent as invalid
Generic Functions(Monitor)												
10	42,43	192	240	Read Headings								

ASDU TYPE	COT	FUN	Inf No.	Description	GI	Model Number 1	2	3	4	5	6	Interpretation
10	42,43	192	241	Read attributes of all entries of a group								
10	42,43	192	243	Read directory of entry								
10	1,2,7,9,11,12,42,43	192	244	Real attribute of entry								
10	10	192	245	End of GGI								
10	41,44	192	249	Write entry with confirm								
10	40,41	192	250	Write entry with execute								
10	40	192	251	Write entry aborted								
Standard information numbers in control direction												
System Functions (Control)												
7	9	192	0	Init General Interrogation		*	*	*	*	*	*	
6	8			Time Synchronisation		*	*	*	*	*	*	
General Commands												
20	20	192	16	Auto-recloser on/off			*					Autoreclose in Service
20	20	192	16	Auto-recloser on/off				*		*		Autoreclose in Service 3 pole
20	20	192	17	Teleprotection on/off								
20	20	192	18	Protection on/off								
20	20	192	19	LED Reset		*	*	*	*	*	*	Reset Indications and Latches
20	20	192	23	Activate characteristic 1		*	*	*	*	*	*	Group 1 Active
20	20	192	24	Activate characteristic 2		*	*	*	*	*	*	Group 2 Active
20	20	192	25	Activate characteristic 3		*	*	*	*	*	*	Group 3 Active
20	20	192	26	Activate characteristic 4		*	*	*	*	*	*	Group 4 Active
Generic Functions												
21	42	192	240	Read headings of all defined groups								
21	42	192	241	Read single attribute of all entries of a group								
21	42	192	243	Read directory of single entry								
21	42	192	244	Read attribute of sngle entry								
21	9	192	245	Generic General Interrogation (GGI)								
10	40	192	248	Write entry								

ASDU TYPE	COT	FUN	Inf No.	Description	GI	Model Number 1	2	3	4	5	6	Interpretation
10	40	192	249	Write with confirm								
10	40	192	250	Write with execute								
10	40	192	251	Write entry abort								
Basic Application Functions												
Test Mode						*	*	*	*	*	*	
Blocking of monitor direction						*	*	*	*	*	*	
Disturbance data						*	*	*	*	*	*	
Generic services												
Private data						*	*	*	*	*	*	
Miscellaneous												
					Max.MVAL = times rated value							
Measurands							1.2			2.4		
Current L1										*		
Current L2										*		
Current L3										*		
Voltage L1-E										*		
Voltage L2-E										*		
Voltage L3-E										*		
Active Power P										*		
Reactive Power Q										*		
Frequency f										*		
Voltage L1-L2												

Non Standard Information numbers in monitor direction

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
1	1,7,9	194	0	Contact 1	*	*	*	*	*	*	*	DDB_OUTPUT_RELAY_1	0
1	1,7,9	194	1	Contact 2	*	*	*	*	*	*	*	DDB_OUTPUT_RELAY_2	1
1	1,7,9	194	2	Contact 3	*	*	*	*	*	*	*	DDB_OUTPUT_RELAY_3	2
1	1,7,9	194	3	Contact 4	*	*	*	*	*	*	*	DDB_OUTPUT_RELAY_4	3
1	1,7,9	194	4	Contact 5	*	*	*	*	*	*	*	DDB_OUTPUT_RELAY_5	4
1	1,7,9	194	5	Contact 6	*	*	*	*	*	*	*	DDB_OUTPUT_RELAY_6	5
1	1,7,9	194	6	Contact 7	*	*	*	*	*	*	*	DDB_OUTPUT_RELAY_7	6
1	1,7,9	194	7	Contact 8	*		*	*	*	*	*	DDB_OUTPUT_RELAY_8	7
1	1,7,9	194	8	Contact 9	*		*	*	*	*	*	DDB_OUTPUT_RELAY_9	8
1	1,7,9	194	9	Contact 10	*		*	*	*	*	*	DDB_OUTPUT_RELAY_10	9
1	1,7,9	194	10	Contact 11	*		*	*	*	*	*	DDB_OUTPUT_RELAY_11	10
1	1,7,9	194	11	Contact 12	*		*	*	*	*	*	DDB_OUTPUT_RELAY_12	11
1	1,7,9	194	12	Contact 13	*		*	*	*	*	*	DDB_OUTPUT_RELAY_13	12
1	1,7,9	194	13	Contact 14	*		*	*	*	*	*	DDB_OUTPUT_RELAY_14	13
1	1,7,9	194	14	Contact 15	*					*	*	DDB_OUTPUT_RELAY_15	14
1	1,7,9	194	15	Contact 16	*					*	*	DDB_OUTPUT_RELAY_16	15
1	1,7,9	194	16	Contact 17	*					*	*	DDB_OUTPUT_RELAY_17	16
1	1,7,9	194	17	Contact 18	*					*	*	DDB_OUTPUT_RELAY_18	17
1	1,7,9	194	18	Contact 19	*					*	*	DDB_OUTPUT_RELAY_19	18
1	1,7,9	194	19	Contact 20	*					*	*	DDB_OUTPUT_RELAY_20	19
1	1,7,9	194	20	Contact 21	*					*	*	DDB_OUTPUT_RELAY_21	20
1	1,7,9	194	21	Contact 22	*					*	*	DDB_OUTPUT_RELAY_22	21
1	1,7,9	194	22	Contact 23	*					*	*	DDB_OUTPUT_RELAY_23	22
1	1,7,9	194	23	Contact 24	*					*	*	DDB_OUTPUT_RELAY_24	23
1	1,7,9	194	24	Contact 25	*					*	*	DDB_OUTPUT_RELAY_25	24
1	1,7,9	194	25	Contact 26	*					*	*	DDB_OUTPUT_RELAY_26	25
1	1,7,9	194	26	Contact 27	*					*	*	DDB_OUTPUT_RELAY_27	26
1	1,7,9	194	27	Contact 28	*					*	*	DDB_OUTPUT_RELAY_28	27
1	1,7,9	194	28	Contact 29	*					*	*	DDB_OUTPUT_RELAY_29	28
1	1,7,9	194	29	Contact 30	*					*	*	DDB_OUTPUT_RELAY_30	29
1	1,7,9	194	30	Contact 31	*					*	*	DDB_OUTPUT_RELAY_31	30
1	1,7,9	194	31	Contact 32	*					*	*	DDB_OUTPUT_RELAY_32	31
1	1,7,9,11	192	27	Opto 1	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_1	32
1	1,7,9,11	192	28	Opto 2	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_2	33
1	1,7,9,11	192	29	Opto 3	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_3	34
1	1,7,9,11	192	30	Opto 4	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_4	35

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
1	1,7,9,11	194	36	Opto 5	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_5	36
1	1,7,9,11	194	37	Opto 6	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_6	37
1	1,7,9,11	194	38	Opto 7	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_7	38
1	1,7,9,11	194	39	Opto 8	*	*	*	*	*	*	*	DDB_OPTO_ISOLATOR_8	39
1	1,7,9,11	194	40	Opto 9	*		*	*	*	*	*	DDB_OPTO_ISOLATOR_9	40
1	1,7,9,11	194	41	Opto 10	*		*	*	*	*	*	DDB_OPTO_ISOLATOR_10	41
1	1,7,9,11	194	42	Opto 11	*		*	*	*	*	*	DDB_OPTO_ISOLATOR_11	42
1	1,7,9,11	194	43	Opto 12	*		*	*	*	*	*	DDB_OPTO_ISOLATOR_12	43
1	1,7,9,11	194	44	Opto 13	*		*	*	*	*	*	DDB_OPTO_ISOLATOR_13	44
1	1,7,9,11	194	45	Opto 14	*		*	*	*	*	*	DDB_OPTO_ISOLATOR_14	45
1	1,7,9,11	194	46	Opto 15	*		*	*	*	*	*	DDB_OPTO_ISOLATOR_15	46
1	1,7,9,11	194	47	Opto 16	*		*	*	*	*	*	DDB_OPTO_ISOLATOR_16	47
1	1,7,9,11	194	48	Opto 17	*					*	*	DDB_OPTO_ISOLATOR_17	48
1	1,7,9,11	194	49	Opto 18	*					*	*	DDB_OPTO_ISOLATOR_18	49
1	1,7,9,11	194	50	Opto 19	*					*	*	DDB_OPTO_ISOLATOR_19	50
1	1,7,9,11	194	51	Opto 20	*					*	*	DDB_OPTO_ISOLATOR_20	51
1	1,7,9,11	194	52	Opto 21	*					*	*	DDB_OPTO_ISOLATOR_21	52
1	1,7,9,11	194	53	Opto 22	*					*	*	DDB_OPTO_ISOLATOR_22	53
1	1,7,9,11	194	54	Opto 23	*					*	*	DDB_OPTO_ISOLATOR_23	54
1	1,7,9,11	194	55	Opto 24	*					*	*	DDB_OPTO_ISOLATOR_24	55
		194	56									DDB_UNUSED_56	56
		194	57									DDB_UNUSED_57	57
		194	58									DDB_UNUSED_58	58
		194	59									DDB_UNUSED_59	59
		194	60									DDB_UNUSED_60	60
		194	61									DDB_UNUSED_61	61
		194	62									DDB_UNUSED_62	62
		194	63									DDB_UNUSED_63	63
		194	64	LED 1								DDB_OUTPUT_LED_1	64
		194	65	LED 2								DDB_OUTPUT_LED_2	65
		194	66	LED 3								DDB_OUTPUT_LED_3	66
		194	67	LED 4								DDB_OUTPUT_LED_4	67
		194	68	LED 5								DDB_OUTPUT_LED_5	68
		194	69	LED 6								DDB_OUTPUT_LED_6	69
		194	70	LED 7								DDB_OUTPUT_LED_7	70
		194	71	LED 8								DDB_OUTPUT_LED_8	71
		194	72	Relay Cond 1								DDB_OUTPUT_CON_1	72

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		194	73	Relay Cond 2								DDB_OUTPUT_CON_2	73
		194	74	Relay Cond 3								DDB_OUTPUT_CON_3	74
		194	75	Relay Cond 4								DDB_OUTPUT_CON_4	75
		194	76	Relay Cond 5								DDB_OUTPUT_CON_5	76
		194	77	Relay Cond 6								DDB_OUTPUT_CON_6	77
		194	78	Relay Cond 7								DDB_OUTPUT_CON_7	78
		194	79	Relay Cond 8								DDB_OUTPUT_CON_8	79
		194	80	Relay Cond 9								DDB_OUTPUT_CON_9	80
		194	81	Relay Cond 10								DDB_OUTPUT_CON_10	81
		194	82	Relay Cond 11								DDB_OUTPUT_CON_11	82
		194	83	Relay Cond 12								DDB_OUTPUT_CON_12	83
		194	84	Relay Cond 13								DDB_OUTPUT_CON_13	84
		194	85	Relay Cond 14								DDB_OUTPUT_CON_14	85
		194	86	Relay Cond 15								DDB_OUTPUT_CON_15	86
		194	87	Relay Cond 16								DDB_OUTPUT_CON_16	87
		194	88	Relay Cond 17								DDB_OUTPUT_CON_17	88
		194	89	Relay Cond 18								DDB_OUTPUT_CON_18	89
		194	90	Relay Cond 19								DDB_OUTPUT_CON_19	90
		194	91	Relay Cond 20								DDB_OUTPUT_CON_20	91
		194	92	Relay Cond 21								DDB_OUTPUT_CON_21	92
		194	93	Relay Cond 22								DDB_OUTPUT_CON_22	93
		194	94	Relay Cond 23								DDB_OUTPUT_CON_23	94
		194	95	Relay Cond 24								DDB_OUTPUT_CON_24	95
		194	96	Relay Cond 25								DDB_OUTPUT_CON_25	96
		194	97	Relay Cond 26								DDB_OUTPUT_CON_26	97
		194	98	Relay Cond 27								DDB_OUTPUT_CON_27	98
		194	99	Relay Cond 28								DDB_OUTPUT_CON_28	99
		194	100	Relay Cond 29								DDB_OUTPUT_CON_29	100
		194	101	Relay Cond 30								DDB_OUTPUT_CON_30	101
		194	102	Relay Cond 31								DDB_OUTPUT_CON_31	102
		194	103	Relay Cond 32								DDB_OUTPUT_CON_32	103
		194	104	LED Cond IN 1								DDB_LED_CON_1	104
		194	105	LED Cond IN 2								DDB_LED_CON_2	105
		194	106	LED Cond IN 3								DDB_LED_CON_3	106
		194	107	LED Cond IN 4								DDB_LED_CON_4	107
		194	108	LED Cond IN 5								DDB_LED_CON_5	108
		194	109	LED Cond IN 6								DDB_LED_CON_6	109

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		194	110	LED Cond IN 7								DDB_LED_CON_7	110
		194	111	LED Cond IN 8								DDB_LED_CON_8	111
		194	112	Timer in 1								DDB_TIMERIN_1	112
		194	113	Timer in 2								DDB_TIMERIN_2	113
		194	114	Timer in 3								DDB_TIMERIN_3	114
		194	115	Timer in 4								DDB_TIMERIN_4	115
		194	116	Timer in 5								DDB_TIMERIN_5	116
		194	117	Timer in 6								DDB_TIMERIN_6	117
		194	118	Timer in 7								DDB_TIMERIN_7	118
		194	119	Timer in 8								DDB_TIMERIN_8	119
		194	120	Timer in 9								DDB_TIMERIN_9	120
		194	121	Timer in 10								DDB_TIMERIN_10	121
		194	122	Timer in 11								DDB_TIMERIN_11	122
		194	123	Timer in 12								DDB_TIMERIN_12	123
		194	124	Timer in 13								DDB_TIMERIN_13	124
		194	125	Timer in 14								DDB_TIMERIN_14	125
		194	126	Timer in 15								DDB_TIMERIN_15	126
		194	127	Timer in 16								DDB_TIMERIN_16	127
		194	128	Timer out 1								DDB_TIMEROUT_1	128
		194	129	Timer out 2								DDB_TIMEROUT_2	129
		194	130	Timer out 3								DDB_TIMEROUT_3	130
		194	131	Timer out 4								DDB_TIMEROUT_4	131
		194	132	Timer out 5								DDB_TIMEROUT_5	132
		194	133	Timer out 6								DDB_TIMEROUT_6	133
		194	134	Timer out 7								DDB_TIMEROUT_7	134
		194	135	Timer out 8								DDB_TIMEROUT_8	135
		194	136	Timer out 9								DDB_TIMEROUT_9	136
		194	137	Timer out 10								DDB_TIMEROUT_10	137
		194	138	Timer out 11								DDB_TIMEROUT_11	138
		194	139	Timer out 12								DDB_TIMEROUT_12	139
		194	140	Timer out 13								DDB_TIMEROUT_13	140
		194	141	Timer out 14								DDB_TIMEROUT_14	141
		194	142	Timer out 15								DDB_TIMEROUT_15	142
		194	143	Timer out 16								DDB_TIMEROUT_16	143
		194	144	Fault REC TRIG								DDB_FAULT_RECORDER_START	144
1	1,7,9	194	145	SG-opto Invalid	*	*	*	*	*	*	*	DDB_ILLEGAL_OPTO_SETTINGS_GROUP	145
1	9,11	192	21	Prot'n Disabled	*	*	*	*	*	*	*	DDB_OOS_ALARM	146

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
1	1,7,9	192	38	VT Fail Alarm	*			*	*	*	*	DDB_VTS_INDICATION	147
1	1,7,9	194	148	Power Swing	*			*	*	*	*	DDB_PSB_ALARM	148
2	1,7	192	85	CB Fail Alarm		*	*	*	*	*	*	DDB_BREAKER_FAIL_ALARM	149
1	1,7,9	194	150	I^ Maint Alarm	*	*	*	*		*		DDB_BROKEN_CURRENT_ALARM	150
1	1,7,9	194	151	I^ Lockout Alarm	*	*	*	*		*		DDB_BROKEN_CURRENT_LOCKOUT	151
1	1,7,9	194	152	CB OPs Maint	*	*	*	*		*		DDB_MAINTENANCE_ALARM	152
1	1,7,9	194	153	CB OPs Lock	*	*	*	*		*		DDB_MAINTENANCE_LOCKOUT	153
1	1,7,9	194	154	CB Time Maint	*	*	*	*		*		DDB_EXCESSIVE_OP_TIME_ALARM	154
1	1,7,9	194	155	CB Time Lockout	*	*	*	*		*		DDB_EXCESSIVE_OP_TIME_LOCKOUT	155
1	1,7,9	194	156	Fault Freq Lock	*	*	*	*		*		DDB_EFF_LOCKOUT	156
1	1,7,9	194	157	CB Status Alarm	*	*	*	*	*	*	*	DDB_COMBINED_CB_STATUS_ALARM	157
1	1,7,9	194	158	GPS Alarm	*					*	*	DDB_LOCAL_GPS_FAIL	158
1	1,7,9	194	159	CB Trip Fail	*	*	*	*	*	*	*	DDB_CB_FAILED_TO_TRIP	159
1	1,7,9	194	160	CB Close Fail	*	*	*	*	*	*	*	DDB_CB_FAILED_TO_CLOSE	160
1	1,7,9	194	161	Man CB Unhealthy	*	*	*	*	*	*	*	DDB_CONTROL_CB_UNHEALTHY	161
1	1,7,9	194	162	No C/S Man Close	*			*		*		DDB_CONTROL_NO_CHECK_SYNC	162
1	1,7,9	192	130	A/R Lockout	*		*	*		*		DDB_AR_LOCKOUT	163
2	1,7	194	163	CB2 Fail Alarm					*		*	DDB_BREAKER_FAIL_ALARM_2	163
1	1,7,9	194	164	A/R CB Unhealthy	*		*	*		*		DDB_AR_CB_UNHEALTHY	164
1	1,7,9	194	165	A/R No Checksync	*			*		*		DDB_AR_NO_CHECK_SYNC	165
1	1,7,9	194	166	Incompatible Rly	*	*	*	*	*	*	*	DDB_IN_COMPATABLE_RELAYS	166
1	1,7,9	194	167	Test Loopback	*	*	*	*	*	*	*	DDB_LOOPBACK_TEST	167
1	1,7,9	194	168	Signalling Fail	*	*	*	*	*	*	*	DDB_SIGNALLING_FAILURE	168
1	1,7,9	194	169	Comm Delay Alarm	*	*	*	*	*	*	*	DDB_PROPAGATION_DELAY_FAILURE	169
1	1,7,9	194	170	C Diff Failure	*	*	*	*	*	*	*	DDB_PROTECTION_FAILURE	170
1	1,7,9	194	171	C Diff Inhibited	*	*	*	*	*	*	*	DDB_INHIBIT_CD_PROTECTION	171
1	1,7,9	194	172	Config Error	*	*	*	*	*	*	*	DDB_CONFIGURATION_ERROR	172
1	1,7,9	194	173	Re-Config Error	*	*	*	*	*	*	*	DDB_RE_CONFIGURATION_ERROR	173
1	1,7,9	194	174	F out of range	*	*	*	*	*	*	*	DDB_FREQ_ALARM	174
		194	175	Future Product Alarms								DDB_ALARM_36	175
		194	176	Future Product Alarms								DDB_ALARM_37	176
		194	177	Future Product Alarms								DDB_ALARM_38	177
		194	178	Future Product Alarms								DDB_ALARM_39	178
		194	179	Future Product Alarms								DDB_ALARM_40	179
		194	180	Future Product Alarms								DDB_ALARM_41	180
		194	181	Future Product Alarms								DDB_ALARM_42	181
		194	182	Future Product Alarms								DDB_ALARM_43	182

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		194	183	Future Product Alarms								DDB_ALARM_44	183
		194	184	Future Product Alarms								DDB_ALARM_45	184
		194	185	Future Product Alarms								DDB_ALARM_46	185
1	1,7,9	194	184	C Diff Comm Mode	*	*	*	*	*	*	*	DDB_CD_PROT_COMMS_MODE	184
1	1,7,9	194	185	IEEE C37.94	*	*	*	*	*	*	*	DDB_CD_IEEE_37_94	185
1	1,7,9	194	186	System Split	*		*		*			DDB_SYSTEM_SPLIT_ALARM	186
1	1,7,9	194	187	SR User Alarm 1	*	*	*	*	*	*	*	DDB_ALARM_48	187
1	1,7,9	194	188	SR User Alarm 2	*	*	*	*	*	*	*	DDB_ALARM_49	188
1	1,7,9	194	189	SR User Alarm 3	*	*	*	*	*	*	*	DDB_ALARM_50	189
1	1,7,9	194	190	SR User Alarm 4	*	*	*	*	*	*	*	DDB_ALARM_51	190
1	1,7,9	194	191	SR User Alarm 5	*	*	*	*	*	*	*	DDB_ALARM_52	191
1	1,7,9	194	192	SR User Alarm 6	*	*	*	*	*	*	*	DDB_ALARM_53	192
1	1,7,9	194	193	SR User Alarm 7	*	*	*	*	*	*	*	DDB_ALARM_54	193
1	1,7,9	194	194	SR User Alarm 8	*	*	*	*	*	*	*	DDB_ALARM_55	194
1	1,7,9	194	195	MR User Alarm 9	*	*	*	*	*	*	*	DDB_ALARM_56	195
1	1,7,9	194	196	MR User Alarm 10	*	*	*	*	*	*	*	DDB_ALARM_57	196
1	1,7,9	194	197	MR User Alarm 11	*	*	*	*	*	*	*	DDB_ALARM_58	197
1	1,7,9	194	198	MR User Alarm 12	*	*	*	*	*	*	*	DDB_ALARM_59	198
1	1,7,9	194	199	MR User Alarm 13	*	*	*	*	*	*	*	DDB_ALARM_60	199
1	1,7,9	194	200	MR User Alarm 14	*	*	*	*	*	*	*	DDB_ALARM_61	200
1	1,7,9	194	201	MR User Alarm 15	*	*	*	*	*	*	*	DDB_ALARM_62	201
1	1,7,9	194	202	MR User Alarm 16	*	*	*	*	*	*	*	DDB_ALARM_63	202
		194	203	Unused								DDB_UNUSED_203	203
		194	204	Unused								DDB_UNUSED_204	204
		194	205	Unused								DDB_UNUSED_205	205
		194	206	Unused								DDB_UNUSED_206	206
		194	207									DDB_UNUSED_207	207
		194	208									DDB_UNUSED_208	208
		194	209									DDB_UNUSED_209	209
		194	210									DDB_UNUSED_210	210
		194	211									DDB_UNUSED_211	211
		194	212									DDB_UNUSED_212	212
		194	213									DDB_UNUSED_213	213
		194	214									DDB_UNUSED_214	214
		194	215									DDB_UNUSED_215	215
		194	216									DDB_DIRECT_1	216
		194	217									DDB_DIRECT_2	217

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		194	218									DDB_DIRECT_3	218
		194	219									DDB_DIRECT_4	219
		194	220									DDB_DIRECT_5	220
		194	221									DDB_DIRECT_6	221
		194	222									DDB_DIRECT_7	222
		194	223									DDB_DIRECT_8	223
1	9,11,12,20,21	194	224	Control Input 1	*	*	*	*	*	*	*	DDB_CONTROL_1	224
1	9,11,12,20,21	194	225	Control Input 2	*	*	*	*	*	*	*	DDB_CONTROL_2	225
1	9,11,12,20,21	194	226	Control Input 3	*	*	*	*	*	*	*	DDB_CONTROL_3	226
1	9,11,12,20,21	194	227	Control Input 4	*	*	*	*	*	*	*	DDB_CONTROL_4	227
1	9,11,12,20,21	194	228	Control Input 5	*	*	*	*	*	*	*	DDB_CONTROL_5	228
1	9,11,12,20,21	194	229	Control Input 6	*	*	*	*	*	*	*	DDB_CONTROL_6	229
1	9,11,12,20,21	194	230	Control Input 7	*	*	*	*	*	*	*	DDB_CONTROL_7	230
1	9,11,12,20,21	194	231	Control Input 8	*	*	*	*	*	*	*	DDB_CONTROL_8	231
1	9,11,12,20,21	194	232	Control Input 9	*	*	*	*	*	*	*	DDB_CONTROL_9	232
1	9,11,12,20,21	194	233	Control Input 10	*	*	*	*	*	*	*	DDB_CONTROL_10	233
1	9,11,12,20,21	194	234	Control Input 11	*	*	*	*	*	*	*	DDB_CONTROL_11	234
1	9,11,12,20,21	194	235	Control Input 12	*	*	*	*	*	*	*	DDB_CONTROL_12	235
1	9,11,12,20,21	194	236	Control Input 13	*	*	*	*	*	*	*	DDB_CONTROL_13	236
1	9,11,12,20,21	194	237	Control Input 14	*	*	*	*	*	*	*	DDB_CONTROL_14	237
1	9,11,12,20,21	194	238	Control Input 15	*	*	*	*	*	*	*	DDB_CONTROL_15	238
1	9,11,12,20,21	194	239	Control Input 16	*	*	*	*	*	*	*	DDB_CONTROL_16	239
1	9,11,12,20,21	194	240	Control Input 17	*	*	*	*	*	*	*	DDB_CONTROL_17	240
1	9,11,12,20,21	194	241	Control Input 18	*	*	*	*	*	*	*	DDB_CONTROL_18	241
1	9,11,12,20,21	194	242	Control Input 19	*	*	*	*	*	*	*	DDB_CONTROL_19	242
1	9,11,12,20,21	194	243	Control Input 20	*	*	*	*	*	*	*	DDB_CONTROL_20	243
1	9,11,12,20,21	194	244	Control Input 21	*	*	*	*	*	*	*	DDB_CONTROL_21	244
1	9,11,12,20,21	194	245	Control Input 22	*	*	*	*	*	*	*	DDB_CONTROL_22	245
1	9,11,12,20,21	194	246	Control Input 23	*	*	*	*	*	*	*	DDB_CONTROL_23	246
1	9,11,12,20,21	194	247	Control Input 24	*	*	*	*	*	*	*	DDB_CONTROL_24	247
1	9,11,12,20,21	194	248	Control Input 25	*	*	*	*	*	*	*	DDB_CONTROL_25	248
1	9,11,12,20,21	194	249	Control Input 26	*	*	*	*	*	*	*	DDB_CONTROL_26	249
1	9,11,12,20,21	194	250	Control Input 27	*	*	*	*	*	*	*	DDB_CONTROL_27	250
1	9,11,12,20,21	194	251	Control Input 28	*	*	*	*	*	*	*	DDB_CONTROL_28	251
1	9,11,12,20,21	194	252	Control Input 29	*	*	*	*	*	*	*	DDB_CONTROL_29	252
1	9,11,12,20,21	194	253	Control Input 30	*	*	*	*	*	*	*	DDB_CONTROL_30	253
1	9,11,12,20,21	194	254	Control Input 31	*	*	*	*	*	*	*	DDB_CONTROL_31	254

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
1	9,11,12,20,21	194	255	Control Input 32	*	*	*	*	*	*	*	DDB_CONTROL_32	255
		195	0	Perm Intertrip								DDB_PERMISSIVE_INTERTRIP_OPTO	256
		195	1	Stub Bus Enabled								DDB_STUB_BUS_ENABLED	257
		195	2	Inhibit C Diff								DDB_INHIBIT_CURRENT_DIFF_OPTO	258
		195	3	Recon Interlock								DDB_RECONFIGURATION_INTERLOCK	259
		195	4	I>1 Timer Block								DDB_POC_1_TIMER_BLOCK	260
		195	5	I>2 Timer Block								DDB_POC_2_TIMER_BLOCK	261
		195	6	I>3 Timer Block								DDB_POC_3_TIMER_BLOCK	262
		195	7	I>4 Timer Block								DDB_POC_4_TIMER_BLOCK	263
		195	8	IN>1 Timer Block								DDB_EF1_1_TIMER_BLOCK	264
		195	9	IN>2 Timer Block								DDB_EF1_2_TIMER_BLOCK	265
		195	10	IN>3 Timer Block								DDB_EF1_3_TIMER_BLOCK	266
		195	11	IN>4 Timer Block								DDB_EF1_4_TIMER_BLOCK	267
		195	12	ISEF>1 Timer Blk								DDB_SEF_1_TIMER_BLOCK	268
		195	13	ISEF>2 Timer Blk								DDB_SEF_2_TIMER_BLOCK	269
		195	14	ISEF>3 Timer Blk								DDB_SEF_3_TIMER_BLOCK	270
		195	15	ISEF>4 Timer Blk								DDB_SEF_4_TIMER_BLOCK	271
		195	16	External Trip3ph								DDB_EXTERNAL_TRIP_3PH	272
		195	17	External Trip A								DDB_EXTERNAL_TRIP_A	273
		195	18	External Trip B								DDB_EXTERNAL_TRIP_B	274
		195	19	External Trip C								DDB_EXTERNAL_TRIP_C	275
		195	20	CB2 Ext Trip3ph								DDB_CB2_EXTERNAL_TRIP_3PH	276
		195	21	CB2 Ext Trip A								DDB_CB2_EXTERNAL_TRIP_A	277
		195	22	CB2 Ext Trip B								DDB_CB2_EXTERNAL_TRIP_B	278
		195	23	CB2 Ext Trip C								DDB_CB2_EXTERNAL_TRIP_C	279
		195	24	CB Aux 3ph(52-A)								DDB_CB_THREE_PHASE_52A	280
		195	25	CB Aux A(52-A)								DDB_CB_PHASE_A_52A	281
		195	26	CB Aux B(52-A)								DDB_CB_PHASE_B_52A	282
		195	27	CB Aux C(52-A)								DDB_CB_PHASE_C_52A	283
		195	28	CB Aux 3ph(52-B)								DDB_CB_THREE_PHASE_52B	284
		195	29	CB Aux A(52-B)								DDB_CB_PHASE_A_52B	285
		195	30	CB Aux B(52-B)								DDB_CB_PHASE_B_52B	286
		195	31	CB Aux C(52-B)								DDB_CB_PHASE_C_52B	287
		195	32	CB2Aux 3ph(52-A)								DDB_CB2_THREE_PHASE_52A	288
		195	33	CB2Aux A(52-A)								DDB_CB2_PHASE_A_52A	289
		195	34	CB2Aux B(52-A)								DDB_CB2_PHASE_B_52A	290
		195	35	CB2Aux C(52-A)								DDB_CB2_PHASE_C_52A	291

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		195	36	CB2Aux 3ph(52-B)								DDB_CB2_THREE_PHASE_52B	292
		195	37	CB2Aux A(52-B)								DDB_CB2_PHASE_A_52B	293
		195	38	CB2Aux B(52-B)								DDB_CB2_PHASE_B_52B	294
		195	39	CB2Aux C(52-B)								DDB_CB2_PHASE_C_52B	295
		195	40	CB Healthy								DDB_CB_HEALTHY	296
		195	41	CB2 Healthy								DDB_CB2_HEALTHY	297
		195	42	MCB/VTS								DDB_VTS_MCB_OPTO	298
		195	43	Trip CB								DDB_LOGIC_INPUT_TRIP	299
		195	44	Close CB								DDB_LOGIC_INPUT_CLOSE	300
		195	45	Trip CB2								DDB_LOGIC_INPUT_TRIP_2	301
		195	46	Close CB2								DDB_LOGIC_INPUT_CLOSE_2	302
		195	47	Reset Close Dly								DDB_RESET_CB_CLOSE_DELAY	303
		195	48	Reset Relays/LED								DDB_RESET_RELAYS_LEDS	304
		195	49	Reset Thermal								DDB_RESET_THERMAL	305
		195	50	Reset Lockout								DDB_RESET_LOCKOUT	306
		195	51	Reset CB Data								DDB_RESET_ALL_VALUES	307
		195	52	BAR								DDB_BLOCK_AR	308
		195	53	En 1pole reclose								DDB_INP_SPAR	309
		195	54	En 3pole reclose								DDB_INP_TPAR	310
		195	55	Pole Discrepancy								DDB_INP_TR2P	311
		195	56									DDB_UNUSED_312	312
		195	57	Inhibit PSB								DDB_INHIBIT_PSB	313
		195	58	Any 3 Pole Trip								DDB_TR_3_PHASE	314
		195	59	Any Trip A								DDB_TR_A_PHASE	315
		195	60	Any Trip B								DDB_TR_B_PHASE	316
		195	61	Any Trip C								DDB_TR_C_PHASE	317
		195	62	Test Mode								DDB_TEST_MODE	318
		195	63	Prop Delay Eq								DDB_OVERRIDE_INHIBIT	319
		195	64	Ch 1 Intertrip 1								DDB_USER_DEF_INTERTRIP_CH1_1_IN	320
		195	65	Ch 1 Intertrip 2								DDB_USER_DEF_INTERTRIP_CH1_2_IN	321
		195	66	Ch 1 Intertrip 3								DDB_USER_DEF_INTERTRIP_CH1_3_IN	322
		195	67	Ch 1 Intertrip 4								DDB_USER_DEF_INTERTRIP_CH1_4_IN	323
		195	68	Ch 1 Intertrip 5								DDB_USER_DEF_INTERTRIP_CH1_5_IN	324
		195	69	Ch 1 Intertrip 6								DDB_USER_DEF_INTERTRIP_CH1_6_IN	325
		195	70	Ch 1 Intertrip 7								DDB_USER_DEF_INTERTRIP_CH1_7_IN	326
		195	71	Ch 1 Intertrip 8								DDB_USER_DEF_INTERTRIP_CH1_8_IN	327
		195	72	Ch 2 Intertrip 1								DDB_USER_DEF_INTERTRIP_CH2_1_IN	328

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		195	73	Ch 2 Intertrip 2								DDB_USER_DEF_INTERTRIP_CH2_2_IN	329
		195	74	Ch 2 Intertrip 3								DDB_USER_DEF_INTERTRIP_CH2_3_IN	330
		195	75	Ch 2 Intertrip 4								DDB_USER_DEF_INTERTRIP_CH2_4_IN	331
		195	76	Ch 2 Intertrip 5								DDB_USER_DEF_INTERTRIP_CH2_5_IN	332
		195	77	Ch 2 Intertrip 6								DDB_USER_DEF_INTERTRIP_CH2_6_IN	333
		195	78	Ch 2 Intertrip 7								DDB_USER_DEF_INTERTRIP_CH2_7_IN	334
		195	79	Ch 2 Intertrip 8								DDB_USER_DEF_INTERTRIP_CH2_8_IN	335
		195	80	Loopback Mode								DDB_INTERNAL_LOOPBACK	336
		195	81	Z1 Block								DDB_BLOCK_Z1	337
		195	82	Z2 Block								DDB_BLOCK_Z2	338
		195	83	Z3 Block								DDB_BLOCK_Z3	339
1	9,11	195	84	Command Blocking	*	*	*	*	*	*	*	DDB_COMMAND_BLOCKING	340
1	9,11	192	20	Monitor direction blocked	*	*	*	*	*	*	*	DDB_MONITOR_BLOCKING	341
		195	86									DDB_PSB_UNBLOCK	342
		195	87									DDB_CHECKSYNC_1_ENABLED	343
		195	88									DDB_CHECKSYNC_2_ENABLED	344
		195	89									DDB_SYSTEM_SPLIT_ENABLED	345
		195	90									DDB_SYNC_AR_CS_CHECK_OK	346
		195	91									DDB_TIME_SYNCH	347
		195	92									DDB_UNUSED_348	348
		195	93									DDB_UNUSED_349	349
2	1,7	192	68	Any Trip		*	*	*	*	*	*	DDB_ANY_TRIP	350
2	1,7	195	95	Diff Trip		*	*	*	*	*	*	DDB_DIFFERENTIAL_TRIP	351
2	1,7	192	69	Diff Trip A		*	*	*	*	*	*	DDB_DIFFERENTIAL_TRIP_A	352
2	1,7	192	70	Diff Trip B		*	*	*	*	*	*	DDB_DIFFERENTIAL_TRIP_B	353
2	1,7	192	71	Diff Trip C		*	*	*	*	*	*	DDB_DIFFERENTIAL_TRIP_C	354
2	1,7	195	99	Diff Intertrip		*	*	*	*	*	*	DDB_DIFFERENTIAL_INTERTRIP	355
2	1,7	195	100	Diff Intertrip A		*	*	*	*	*	*	DDB_DIFFERENTIAL_INTERTRIP_A	356
2	1,7	195	101	Diff Intertrip B		*	*	*	*	*	*	DDB_DIFFERENTIAL_INTERTRIP_B	357
2	1,7	195	102	Diff Intertrip C		*	*	*	*	*	*	DDB_DIFFERENTIAL_INTERTRIP_C	358
2	1,7	195	103	Direct Intertrip								DDB_DIRECT_INTERTRIP	359
2	1,7	195	104	Perm Intertrip		*	*	*	*	*	*	DDB_PERMISSIVE_INTERTRIP	360
2	1,7	192	78	Zone 1 Trip				*	*	*	*	DDB_ZONE_1_TRIP	361
2	1,7	195	106	Zone 1 A Trip				*	*	*	*	DDB_ZONE_1_TRIP_A	362
2	1,7	195	107	Zone 1 B Trip				*	*	*	*	DDB_ZONE_1_TRIP_B	363
2	1,7	195	108	Zone 1 C Trip				*	*	*	*	DDB_ZONE_1_TRIP_C	364
2	1,7	195	109	Zone 1 N Trip				*	*	*	*	DDB_ZONE_1_TRIP_N	365

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
2	1,7	192	79	Zone 2 Trip				*	*	*	*	DDB_ZONE_2_TRIP	366
2	1,7	195	111	Zone 2 A Trip				*	*	*	*	DDB_ZONE_2_TRIP_A	367
2	1,7	195	112	Zone 2 B Trip				*	*	*	*	DDB_ZONE_2_TRIP_B	368
2	1,7	195	113	Zone 2 C Trip				*	*	*	*	DDB_ZONE_2_TRIP_C	369
2	1,7	195	114	Zone 2 N Trip				*	*	*	*	DDB_ZONE_2_TRIP_N	370
2	1,7	192	80	Zone 3 Trip				*	*	*	*	DDB_ZONE_3_TRIP	371
2	1,7	195	116	Zone 3 A Trip				*	*	*	*	DDB_ZONE_3_TRIP_A	372
2	1,7	195	117	Zone 3 B Trip				*	*	*	*	DDB_ZONE_3_TRIP_B	373
2	1,7	195	118	Zone 3 C Trip				*	*	*	*	DDB_ZONE_3_TRIP_C	374
2	1,7	195	119	Zone 3 N Trip				*	*	*	*	DDB_ZONE_3_TRIP_N	375
2	1,7	195	120	Pole Discrepancy				*		*		DDB_POLE_DISCREPENCE_TRIP	376
2	1,7	195	121	BU Intertrip		*	*	*	*	*	*	DDB_BACKUP_INTERTRIP	377
2	1,7	195	122	BU Intertrip A		*	*	*	*	*	*	DDB_BACKUP_INTERTRIP_A	378
2	1,7	195	123	BU Intertrip B		*	*	*	*	*	*	DDB_BACKUP_INTERTRIP_B	379
2	1,7	195	124	BU Intertrip C		*	*	*	*	*	*	DDB_BACKUP_INTERTRIP_C	380
2	1,7	195	125	Force 3pole BU				*	*	*	*	DDB_FORCE_3POLE_INTERTRIP	381
2	1,7	192	90	I>1 Trip		*	*	*	*	*	*	DDB_POC_1_3PH_TRIP	382
2	1,7	195	127	I>1 Trip A		*	*	*	*	*	*	DDB_POC_1_PH_A_TRIP	383
2	1,7	195	128	I>1 Trip B		*	*	*	*	*	*	DDB_POC_1_PH_B_TRIP	384
2	1,7	195	129	I>1 Trip C		*	*	*	*	*	*	DDB_POC_1_PH_C_TRIP	385
2	1,7	192	91	I>2 Trip		*	*	*	*	*	*	DDB_POC_2_3PH_TRIP	386
2	1,7	195	131	I>2 Trip A		*	*	*	*	*	*	DDB_POC_2_PH_A_TRIP	387
2	1,7	195	132	I>2 Trip B		*	*	*	*	*	*	DDB_POC_2_PH_B_TRIP	388
2	1,7	195	133	I>2 Trip C		*	*	*	*	*	*	DDB_POC_2_PH_C_TRIP	389
2	1,7	195	134	I>3 Trip		*	*	*	*	*	*	DDB_POC_3_3PH_TRIP	390
2	1,7	195	135	I>3 Trip A		*	*	*	*	*	*	DDB_POC_3_PH_A_TRIP	391
2	1,7	195	136	I>3 Trip B		*	*	*	*	*	*	DDB_POC_3_PH_B_TRIP	392
2	1,7	195	137	I>3 Trip C		*	*	*	*	*	*	DDB_POC_3_PH_C_TRIP	393
2	1,7	195	138	I>4 Trip		*	*	*	*	*	*	DDB_POC_4_3PH_TRIP	394
2	1,7	195	139	I>4 Trip A		*	*	*	*	*	*	DDB_POC_4_PH_A_TRIP	395
2	1,7	195	140	I>4 Trip B		*	*	*	*	*	*	DDB_POC_4_PH_B_TRIP	396
2	1,7	195	141	I>4 Trip C		*	*	*	*	*	*	DDB_POC_4_PH_C_TRIP	397
2	1,7	192	92	IN>1 Trip		*	*	*	*	*	*	DDB_EF1_1_TRIP	398
2	1,7	192	93	IN>2 Trip		*	*	*	*	*	*	DDB_EF1_2_TRIP	399
2	1,7	195	144	IN>3 Trip		*	*	*	*	*	*	DDB_EF1_3_TRIP	400
2	1,7	195	145	IN>4 Trip		*	*	*	*	*	*	DDB_EF1_4_TRIP	401
2	1,7	195	146	ISEF>1 Trip				*	*	*	*	DDB_SEF_1_TRIP	402

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
2	1,7	195	147	ISEF>2 Trip				*	*	*	*	DDB_SEF_2_TRIP	403
2	1,7	195	148	ISEF>3 Trip				*	*	*	*	DDB_SEF_3_TRIP	404
2	1,7	195	149	ISEF>4 Trip				*	*	*	*	DDB_SEF_4_TRIP	405
2	1,7	195	150	Broken Wire Trip		*	*	*	*	*	*	DDB_BROKEN_CONDUCTOR_TRIP	406
2	1,7	195	151	Thermal Trip		*	*	*	*	*	*	DDB_THERMAL_TRIP	407
2	1,7	195	152	Stub Bus Trip					*		*	DDB_STUB_BUS_TRIP	408
2	1,7	195	153	AR Trip Test			*	*		*		DDB_AR_TRIP_TEST	409
2	1,7	195	154	AR Trip Test A				*		*		DDB_AR_TRIP_TEST_A	410
2	1,7	195	155	AR Trip Test B				*		*		DDB_AR_TRIP_TEST_B	411
2	1,7	195	156	AR Trip Test C				*		*		DDB_AR_TRIP_TEST_C	412
		195	157									DDB_UNUSED_413	413
		195	158									DDB_UNUSED_414	414
		195	159									DDB_UNUSED_415	415
		195	160									DDB_UNUSED_416	416
		195	161									DDB_UNUSED_417	417
		195	162									DDB_UNUSED_418	418
		195	163									DDB_UNUSED_419	419
		195	164									DDB_UNUSED_420	420
		195	165									DDB_UNUSED_421	421
		195	166									DDB_UNUSED_422	422
		195	167									DDB_UNUSED_423	423
		195	168									DDB_UNUSED_424	424
		195	169									DDB_UNUSED_425	425
		195	170									DDB_UNUSED_426	426
		195	171									DDB_UNUSED_427	427
		195	172									DDB_UNUSED_428	428
		195	173									DDB_UNUSED_429	429
2	1,7,9	195	174	Zone 1 Start	*			*	*	*	*	DDB_ZONE_1_START	430
2	1,7,9	195	175	Zone 2 Start	*			*	*	*	*	DDB_ZONE_2_START	431
2	1,7,9	195	176	Zone 3 Start	*			*	*	*	*	DDB_ZONE_3_START	432
2	1,7,9	195	177	Diff Start	*	*	*	*	*	*	*	DDB_DIFFERENTIAL_START	433
2	1,7,9	192	84	Any Start	*	*	*	*	*	*	*	DDB_ANY_START	434
2	1,7,9	192	64	Diff Start A	*	*	*	*	*	*	*	DDB_DIFFERENTIAL_START_A	435
2	1,7,9	192	65	Diff Start B	*	*	*	*	*	*	*	DDB_DIFFERENTIAL_START_B	436
2	1,7,9	192	66	Diff Start C	*	*	*	*	*	*	*	DDB_DIFFERENTIAL_START_C	437
2	1,7,9	195	182	Zone 1 A Start	*			*	*	*	*	DDB_ZONE_1_START_A	438
2	1,7,9	195	183	Zone 1 B Start	*			*	*	*	*	DDB_ZONE_1_START_B	439

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
2	1,7,9	195	184	Zone 1 C Start	*			*	*	*	*	DDB_ZONE_1_START_C	440
2	1,7,9	195	185	Zone 1 N Start	*			*	*	*	*	DDB_ZONE_1_START_N	441
2	1,7,9	195	186	Zone 2 A Start	*			*	*	*	*	DDB_ZONE_2_START_A	442
2	1,7,9	195	187	Zone 2 B Start	*			*	*	*	*	DDB_ZONE_2_START_B	443
2	1,7,9	195	188	Zone 2 C Start	*			*	*	*	*	DDB_ZONE_2_START_C	444
2	1,7,9	195	189	Zone 2 N Start	*			*	*	*	*	DDB_ZONE_2_START_N	445
2	1,7,9	195	190	Zone 3 A Start	*			*	*	*	*	DDB_ZONE_3_START_A	446
2	1,7,9	195	191	Zone 3 B Start	*			*	*	*	*	DDB_ZONE_3_START_B	447
2	1,7,9	195	192	Zone 3 C Start	*			*	*	*	*	DDB_ZONE_3_START_C	448
2	1,7,9	195	193	Zone 3 N Start	*			*	*	*	*	DDB_ZONE_3_START_N	449
2	1,7,9	195	194	Zone 6 Start	*			*	*	*	*	DDB_ZONE_6_START	450
2	1,7,9	195	195	I>1 Start	*	*	*	*	*	*	*	DDB_POC_1_3PH_START	451
2	1,7,9	195	196	I>1 Start A	*	*	*	*	*	*	*	DDB_POC_1_PH_A_START	452
2	1,7,9	195	197	I>1 Start B	*	*	*	*	*	*	*	DDB_POC_1_PH_B_START	453
2	1,7,9	195	198	I>1 Start C	*	*	*	*	*	*	*	DDB_POC_1_PH_C_START	454
2	1,7,9	195	199	I>2 Start	*	*	*	*	*	*	*	DDB_POC_2_3PH_START	455
2	1,7,9	195	200	I>2 Start A	*	*	*	*	*	*	*	DDB_POC_2_PH_A_START	456
2	1,7,9	195	201	I>2 Start B	*	*	*	*	*	*	*	DDB_POC_2_PH_B_START	457
2	1,7,9	195	202	I>2 Start C	*	*	*	*	*	*	*	DDB_POC_2_PH_C_START	458
2	1,7,9	195	203	I>3 Start	*	*	*	*	*	*	*	DDB_POC_3_3PH_START	459
2	1,7,9	195	204	I>3 Start A	*	*	*	*	*	*	*	DDB_POC_3_PH_A_START	460
2	1,7,9	195	205	I>3 Start B	*	*	*	*	*	*	*	DDB_POC_3_PH_B_START	461
2	1,7,9	195	206	I>3 Start C	*	*	*	*	*	*	*	DDB_POC_3_PH_C_START	462
2	1,7,9	195	207	I>4 Start	*	*	*	*	*	*	*	DDB_POC_4_3PH_START	463
2	1,7,9	195	208	I>4 Start A	*	*	*	*	*	*	*	DDB_POC_4_PH_A_START	464
2	1,7,9	195	209	I>4 Start B	*	*	*	*	*	*	*	DDB_POC_4_PH_B_START	465
2	1,7,9	195	210	I>4 Start C	*	*	*	*	*	*	*	DDB_POC_4_PH_C_START	466
2	1,7,9	195	211	IN>1 Start	*	*	*	*	*	*	*	DDB_EF1_1_START	467
2	1,7,9	195	212	IN>2 Start	*	*	*	*	*	*	*	DDB_EF1_2_START	468
2	1,7,9	195	213	IN>3 Start	*	*	*	*	*	*	*	DDB_EF1_3_START	469
2	1,7,9	195	214	IN>4 Start	*	*	*	*	*	*	*	DDB_EF1_4_START	470
2	1,7,9	195	215	ISEF>1 Start	*			*	*	*	*	DDB_SEF_1_START	471
2	1,7,9	195	216	ISEF>2 Start	*			*	*	*	*	DDB_SEF_2_START	472
2	1,7,9	195	217	ISEF>3 Start	*			*	*	*	*	DDB_SEF_3_START	473
2	1,7,9	195	218	ISEF>4 Start	*			*	*	*	*	DDB_SEF_4_START	474
2	1,7,9	195	219	Thermal Alarm	*	*	*	*	*	*	*	DDB_THERMAL_ALARM	475
2	1,7,9	195	220	I> BlockStart	*	*	*	*	*	*	*	DDB_PH_BLOCKED_OC_START	476

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
2	1,7,9	195	221	IN/SEF>Blk Start	*	*	*	*	*	*	*	DDB_N_BLOCKED_OC_START	477
		195	222									DDB_UNUSED_478	478
		195	223									DDB_UNUSED_479	479
		195	224									DDB_UNUSED_480	480
		195	225									DDB_UNUSED_481	481
		195	226									DDB_UNUSED_482	482
		195	227									DDB_UNUSED_483	483
		195	228									DDB_UNUSED_484	484
		195	229									DDB_UNUSED_485	485
		195	230									DDB_UNUSED_486	486
		195	231									DDB_BATTERY_FAIL_ALARM	487
		195	232									DDB_UNUSED_488	488
		195	233									DDB_GOOSE_MISSING_IED_ALARM	489
		195	234									DDB_ECARD_NOT_FITTED_ALARM	490
		195	235									DDB_NIC_NOT_RESPONDING_ALARM	491
		195	236									DDB_NIC_FATAL_ERROR_ALARM	492
		195	237									DDB_NIC_SOFTWARE_RELOAD_ALARM	493
		195	238									DDB_INVALID_TCP_IP_CONFIG_ALARM	494
		195	239									DDB_INVALID_OSI_CONFIG_ALARM	495
		195	240									DDB_NIC_LINK_FAIL_ALARM	496
		195	241									DDB_SW_MISMATCH_ALARM	497
		195	242									DDB_IP_ADDRESS_CONFLICT_ALARM	498
		195	243									DDB_UNUSED_499	499
		195	244									DDB_UNUSED_500	500
		195	245									DDB_UNUSED_501	501
		195	246									DDB_UNUSED_502	502
		195	247									DDB_BACKUP_DATA_IN_USE	503
		195	248									DDB_UNUSED_504	504
		195	249									DDB_UNUSED_505	505
		195	250									DDB_UNUSED_506	506
		195	251									DDB_UNUSED_507	507
		195	252									DDB_UNUSED_508	508
		195	253									DDB_UNUSED_509	509
		195	254									DDB_UNUSED_510	510
		195	255									DDB_UNUSED_511	511
		196	0									DDB_UNUSED_512	512
		196	1									DDB_UNUSED_513	513

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		196	2									DDB_UNUSED_514	514
		196	3									DDB_UNUSED_515	515
		196	4									DDB_UNUSED_516	516
		196	5									DDB_UNUSED_517	517
1	1,7	196	6	VTS Fast Block				*	*	*	*	DDB_VTS_FAST_BLOCK	518
1	1,7	196	7	VTS Slow Block				*	*	*	*	DDB_VTS_SLOW_BLOCK	519
1	1,7	196	8	Bfail1 Trip 3ph		*	*	*	*	*	*	DDB_CBF1_TRIP_3PH	520
1	1,7	196	9	Bfail2 Trip 3ph		*	*	*	*	*	*	DDB_CBF2_TRIP_3PH	521
1	1,7	196	10	CB2 Fail1 Trip					*		*	DDB_CB2F1_TRIP_3PH	522
1	1,7	196	11	CB2 Fail2 Trip					*		*	DDB_CB2F2_TRIP_3PH	523
1	1,7	196	12	Control Trip		*	*	*	*	*	*	DDB_CONTROL_TRIP	524
1	1,7	196	13	Control Close		*	*	*	*	*	*	DDB_CONTROL_CLOSE	525
1	1,7	196	14	Control Trip 2					*		*	DDB_CONTROL_TRIP_2	526
1	1,7	196	15	Control Close 2					*		*	DDB_CONTROL_CLOSE_2	527
1	1,7	196	16	Close in Prog		*	*	*	*	*	*	DDB_CONTROL_CLOSE_IN_PROGRESS	528
1	1,7	196	17	Block Main Prot			*					DDB_AR_BLOCK_MAIN_PROTECTION	529
1	1,7	196	18	Block SEF Prot			*					DDB_AR_BLOCK_SEF_PROTECTION	530
1	1,7	196	19	AR 3pole in prog			*	*		*		DDB_AR_3_POLE_IN_PROGRESS	531
1	1,7	196	20	AR 1pole in prog				*		*		DDB_AR_1_POLE_IN_PROGRESS	532
1	1,7	196	21	Seq Counter = 0			*	*		*		DDB_SEQ_COUNT_0	533
1	1,7	196	22	Seq Counter = 1			*	*		*		DDB_SEQ_COUNT_1	534
1	1,7	196	23	Seq Counter = 2			*	*		*		DDB_SEQ_COUNT_2	535
1	1,7	196	24	Seq Counter = 3			*	*		*		DDB_SEQ_COUNT_3	536
1	1,7	196	25	Seq Counter = 4			*	*		*		DDB_SEQ_COUNT_4	537
1	1,7	196	26	Seq Counter = 5				*		*		DDB_SEQ_COUNT_5	538
1	1,7,9	196	27	Successful Close	*		*	*		*		DDB_AR_SUCCESSFUL_RECLOSE	539
1	1,7	196	28	Dead T in Prog			*					DDB_DEAD_TIME_IN_PROGRESS	540
1	1,7	192	128	Auto Close			*	*		*		DDB_AUTO_CLOSE	541
1	1,7,9,11,12,20,21	192	16	A/R Status	*		*					DDB_AR_IN_SERVICE	542
1	1,7,9,11,12,20,21	192	16	A/R Status 3P	*			*		*		DDB_AR_IN_SERVICE_3P	543
1	1,7,9,11,12,20,21	196	32	AR Status 1P	*			*		*		DDB_AR_IN_SERVICE_1P	544
1	1,7	196	33	Force 3 pole				*		*		DDB_AR_FORCE_3_POLE_TRIPS	545
1	9	196	34	Lockout Alarm	*	*	*	*		*		DDB_CB_LOCKOUT_ALARM	546
1	1,7,9	196	35	Field Volts Fail	*	*	*	*	*	*	*	DDB_FIELD_VOLTS_FAIL	547
1	1,7	196	36	IA< Start		*	*	*	*	*	*	DDB_PHASE_A_UNDERCURRENT	548
1	1,7	196	37	IB< Start		*	*	*	*	*	*	DDB_PHASE_B_UNDERCURRENT	549
1	1,7	196	38	IC< Start		*	*	*	*	*	*	DDB_PHASE_C_UNDERCURRENT	550

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
1	1,7	196	39	ISEF< Start		*	*	*	*	*	*	DDB_SEF_UNDERCURRENT	551
1	1,7	196	40	CB1 IA< Start					*		*	DDB_PHASE_A_UNDERCURRENT_CB1	552
1	1,7	196	41	CB1 IB< Start					*		*	DDB_PHASE_B_UNDERCURRENT_CB1	553
1	1,7	196	42	CB1 IC< Start					*		*	DDB_PHASE_C_UNDERCURRENT_CB1	554
1	1,7	196	43	CB1 ISEF< Start					*		*	DDB_SEF_UNDERCURRENT_CB1	555
1	1,7	196	44	CB2 IA< Start					*		*	DDB_PHASE_A_UNDERCURRENT_CB2	556
1	1,7	196	45	CB2 IB< Start					*		*	DDB_PHASE_B_UNDERCURRENT_CB2	557
1	1,7	196	46	CB2 IC< Start					*		*	DDB_PHASE_C_UNDERCURRENT_CB2	558
1	1,7	196	47	CB2 ISEF< Start					*		*	DDB_SEF_UNDERCURRENT_CB2	559
1	1,7	196	48	All Poles Dead		*	*	*	*	*	*	DDB_ALL_POLEDEAD	560
1	1,7	196	49	Any Pole Dead		*	*	*	*	*	*	DDB_ANY_POLEDEAD	561
1	1,7	196	50	Pole Dead A				*	*	*	*	DDB_PHASE_A_POLEDEAD	562
1	1,7	196	51	Pole Dead B				*	*	*	*	DDB_PHASE_B_POLEDEAD	563
1	1,7	196	52	Pole Dead C				*	*	*	*	DDB_PHASE_C_POLEDEAD	564
1	1,7	196	53	VTS Acc Ind				*	*	*	*	DDB_VTS_ACCELERATE_INPUT	565
1	1,7	196	54	VTS Volt Dep				*	*	*	*	DDB_VTS_ANY_VOLTAGE_DEP_FN	566
1	1,7	196	55	VTS Ia>				*	*	*	*	DDB_VTS_IA_OPERATED	567
1	1,7	196	56	VTS Ib>				*	*	*	*	DDB_VTS_IB_OPERATED	568
1	1,7	196	57	VTS Ic>				*	*	*	*	DDB_VTS_IC_OPERATED	569
1	1,7	196	58	VTS Va>				*	*	*	*	DDB_VTS_VA_OPERATED	570
1	1,7	196	59	VTS Vb>				*	*	*	*	DDB_VTS_VB_OPERATED	571
1	1,7	196	60	VTS Vc>				*	*	*	*	DDB_VTS_VC_OPERATED	572
1	1,7	196	61	VTS I2>				*	*	*	*	DDB_VTS_I2_OPERATED	573
1	1,7	196	62	VTS V2>				*	*	*	*	DDB_VTS_V2_OPERATED	574
1	1,7	196	63	VTS Ia delta>				*	*	*	*	DDB_VTS_DELTA_IA_OPERATED	575
1	1,7	196	64	VTS Ib delta>				*	*	*	*	DDB_VTS_DELTA_IB_OPERATED	576
1	1,7	196	65	VTS Ic delta >				*	*	*	*	DDB_VTS_DELTA_IC_OPERATED	577
1	1,7	196	66	B Fail SEF Trip				*	*	*	*	DDB_CURRENT_PROT_SEF_TRIP	578
1	1,7	196	67	Ctl Check Synch				*		*		DDB_SYNC_CTRL_SYS_CHECK_OK	579
1	1,7	196	68	AR Check Synch				*		*		DDB_SYNC_AR_SYS_CHECK_OK	580
1	1,7	196	69	Pre-Lockout			*					DDB_CB_PRE_LOCKOUT	581
1	1,7,9	196	70	CB Open 3 ph	*	*	*	*	*	*	*	DDB_CB_OPEN	582
1	1,7,9	196	71	CB Open A ph	*			*	*	*	*	DDB_CB_PHASE_A_OPEN	583
1	1,7,9	196	72	CB Open B ph	*			*	*	*	*	DDB_CB_PHASE_B_OPEN	584
1	1,7,9	196	73	CB Open C ph	*			*	*	*	*	DDB_CB_PHASE_C_OPEN	585
1	1,7,9	196	74	CB Closed 3 ph	*	*	*	*	*	*	*	DDB_CB_CLOSED	586
1	1,7,9	196	75	CB Closed A ph	*			*	*	*	*	DDB_CB_PHASE_A_CLOSED	587

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
1	1,7,9	196	76	CB Closed B ph	*			*	*	*	*	DDB_CB_PHASE_B_CLOSED	588
1	1,7,9	196	77	CB Closed C ph	*			*	*	*	*	DDB_CB_PHASE_C_CLOSED	589
1	1,7,9	196	78	CB2 Open 3 ph	*				*		*	DDB_CB2_OPEN	590
1	1,7,9	196	79	CB2 Open A ph	*				*		*	DDB_CB2_PHASE_A_OPEN	591
1	1,7,9	196	80	CB2 Open B ph	*				*		*	DDB_CB2_PHASE_B_OPEN	592
1	1,7,9	196	81	CB2 Open C ph	*				*		*	DDB_CB2_PHASE_C_OPEN	593
1	1,7,9	196	82	CB2 Closed 3 ph	*				*		*	DDB_CB2_CLOSED	594
1	1,7,9	196	83	CB2 Closed A ph	*				*		*	DDB_CB2_PHASE_A_CLOSED	595
1	1,7,9	196	84	CB2 Closed B ph	*				*		*	DDB_CB2_PHASE_B_CLOSED	596
1	1,7,9	196	85	CB2 Closed C ph	*				*		*	DDB_CB2_PHASE_C_CLOSED	597
1	1,7	196	86	Freq High		*	*	*	*	*	*	DDB_FREQ_ABOVE_RANGE_LIMIT	598
1	1,7	196	87	Freq Low		*	*	*	*	*	*	DDB_FREQ_BELOW_RANGE_LIMIT	599
1	1,7	196	88	Freq Not found		*	*	*	*	*	*	DDB_FREQ_NOT_FOUND	600
1	1,7	196	89	Stop Freq Track		*	*	*	*	*	*	DDB_FREQ_STOP_TRACK	601
1	1,7,9	196	90	SignalFail Ch1Rx	*	*	*	*	*	*	*	DDB_SIGNALLING_FAIL_CH1_RX	602
1	1,7,9	196	91	SignalFail Ch1Tx	*	*	*	*	*	*	*	DDB_SIGNALLING_FAIL_CH1_TX	603
1	1,7,9	196	92	SignalFail Ch2Rx	*	*	*	*	*	*	*	DDB_SIGNALLING_FAIL_CH2_RX	604
1	1,7,9	196	93	SignalFail Ch2Tx	*	*	*	*	*	*	*	DDB_SIGNALLING_FAIL_CH2_TX	605
1	1,7,9	196	94	Ch 1 GPS Fail	*					*	*	DDB_REMOTE_1_GPS_FAIL	606
1	1,7,9	196	95	Ch 2 GPS Fail	*					*	*	DDB_REMOTE_2_GPS_FAIL	607
1	1,7	196	96	Config Same		*	*	*	*	*	*	DDB_CONFIGURED	608
1	1,7	196	97	Reconfig Pass		*	*	*	*	*	*	DDB_RECONFIGURE_OK	609
1	1,7	196	98	Reconfig Fail		*	*	*	*	*	*	DDB_RECONFIGURE_FAIL	610
1	1,7	196	99	Restore Pass		*	*	*	*	*	*	DDB_RESTORE_OK	611
1	1,7	196	100	Restore Fail		*	*	*	*	*	*	DDB_RESTORE_FAIL	612
1	1,7	196	101	Inhibit C Diff		*	*	*	*	*	*	DDB_INHIBIT_CURRENT_DIFF	613
1	1,7	196	102	I>3 Intertrip		*	*	*	*	*	*	DDB_OVER_CURRENT_INTERTRIP_EN	614
1	1,7	196	103	Z1 Intertrip				*	*	*	*	DDB_ZONE_1_INTERTRIP_EN	615
1	1,7	196	104	Z2 Intertrip				*	*	*	*	DDB_ZONE_2_INTERTRIP_EN	616
1	1,7	196	105	Z3 Intertrip				*	*	*	*	DDB_ZONE_3_INTERTRIP_EN	617
1	1,7	196	106	1 Pole Trip En				*	*	*	*	DDB_SINGLE_POLE_TRIP_EN	618
1	1,7,9	196	107	CB Status Alarm	*	*	*	*	*	*	*	DDB_CB_STATUS_ALARM	619
1	1,7,9	196	108	CB2 Status Alarm	*				*		*	DDB_CB2_STATUS_ALARM	620
1	1,7	196	109	Ch 1 Intertrip 1		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH1_1_OUT	621
1	1,7	196	110	Ch 1 Intertrip 2		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH1_2_OUT	622
1	1,7	196	111	Ch 1 Intertrip 3		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH1_3_OUT	623
1	1,7	196	112	Ch 1 Intertrip 4		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH1_4_OUT	624

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
1	1,7	196	113	Ch 1 Intertrip 5		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH1_5_OUT	625
1	1,7	196	114	Ch 1 Intertrip 6		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH1_6_OUT	626
1	1,7	196	115	Ch 1 Intertrip 7		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH1_7_OUT	627
1	1,7	196	116	Ch 1 Intertrip 8		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH1_8_OUT	628
1	1,7	196	117	Ch 2 Intertrip 1		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH2_1_OUT	629
1	1,7	196	118	Ch 2 Intertrip 2		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH2_2_OUT	630
1	1,7	196	119	Ch 2 Intertrip 3		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH2_3_OUT	631
1	1,7	196	120	Ch 2 Intertrip 4		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH2_4_OUT	632
1	1,7	196	121	Ch 2 Intertrip 5		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH2_5_OUT	633
1	1,7	196	122	Ch 2 Intertrip 6		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH2_6_OUT	634
1	1,7	196	123	Ch 2 Intertrip 7		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH2_7_OUT	635
1	1,7	196	124	Ch 2 Intertrip 8		*	*	*	*	*	*	DDB_USER_DEF_INTERTRIP_CH2_8_OUT	636
1	1,7	196	125	I2>				*	*	*	*	DDB_NEG_SEQ	637
		196	126									DDB_UIPASSWORD_ONE	638
		196	127									DDB_UIPASSWORD_TWO	639
		196	128									DDB_FCURPASSWORD_ONE	640
		196	129									DDB_FCURPASSWORD_TWO	641
		196	130									DDB_REMOTEPASSWORD_ONE	642
		196	131									DDB_REMOTEPASSWORD_TWO	643
		196	132									DDB_REMOTE2PASSWORD_ONE	644
		196	133									DDB_REMOTE2PASSWORD_TWO	645
		196	134									DDB_RESET_Z1_EXT	646
		196	135									DDB_SYSCHECKS_LINE_LIVE	647
		196	136									DDB_SYSCHECKS_LINE_DEAD	648
		196	137									DDB_SYSCHECKS_BUS_LIVE	649
		196	138									DDB_SYSCHECKS_BUS_DEAD	650
		196	139									DDB_CHECKSYNC_1_OK	651
		196	140									DDB_CHECKSYNC_2_OK	652
		196	141									DDB_SYSCHECKS_INACTIVE	653
1	1,7,9	196	142		*	*	*	*	*	*	*	DDB_IEEE37_94_CH1_LOSS_OF_SIG	654
1	1,7,9	196	143		*	*	*	*	*	*	*	DDB_IEEE37_94_CH1_PATH_YELLOW	655
1	1,7,9	196	144		*	*	*	*	*	*	*	DDB_IEEE37_94_CH1_BAD_RX_N	656
1	1,7,9	196	145		*	*	*	*	*	*	*	DDB_IEEE37_94_CH2_LOSS_OF_SIG	657
1	1,7,9	196	146		*	*	*	*	*	*	*	DDB_IEEE37_94_CH2_PATH_YELLOW	658
1	1,7,9	196	147		*	*	*	*	*	*	*	DDB_IEEE37_94_CH2_BAD_RX_N	659
		196	148									DDB_UNUSED_660	660
		196	149									DDB_UNUSED_661	661

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		196	150									DDB_UNUSED_662	662
		196	151									DDB_UNUSED_663	663
		196	152									DDB_UNUSED_664	664
		196	153									DDB_UNUSED_665	665
		196	154									DDB_UNUSED_666	666
		196	155									DDB_UNUSED_667	667
		196	156									DDB_UNUSED_668	668
		196	157									DDB_UNUSED_669	669
		196	158									DDB_UNUSED_670	670
		196	159									DDB_UNUSED_671	671
1	1,7,9	196	160		*	*	*	*	*	*	*	DDB_GOOSEIN_1	672
1	1,7,9	196	161		*	*	*	*	*	*	*	DDB_GOOSEIN_2	673
1	1,7,9	196	162		*	*	*	*	*	*	*	DDB_GOOSEIN_3	674
1	1,7,9	196	163		*	*	*	*	*	*	*	DDB_GOOSEIN_4	675
1	1,7,9	196	164		*	*	*	*	*	*	*	DDB_GOOSEIN_5	676
1	1,7,9	196	165		*	*	*	*	*	*	*	DDB_GOOSEIN_6	677
1	1,7,9	196	166		*	*	*	*	*	*	*	DDB_GOOSEIN_7	678
1	1,7,9	196	167		*	*	*	*	*	*	*	DDB_GOOSEIN_8	679
1	1,7,9	196	168		*	*	*	*	*	*	*	DDB_GOOSEIN_9	680
1	1,7,9	196	169		*	*	*	*	*	*	*	DDB_GOOSEIN_10	681
1	1,7,9	196	170		*	*	*	*	*	*	*	DDB_GOOSEIN_11	682
1	1,7,9	196	171		*	*	*	*	*	*	*	DDB_GOOSEIN_12	683
1	1,7,9	196	172		*	*	*	*	*	*	*	DDB_GOOSEIN_13	684
1	1,7,9	196	173		*	*	*	*	*	*	*	DDB_GOOSEIN_14	685
1	1,7,9	196	174		*	*	*	*	*	*	*	DDB_GOOSEIN_15	686
1	1,7,9	196	175		*	*	*	*	*	*	*	DDB_GOOSEIN_16	687
1	1,7,9	196	176		*	*	*	*	*	*	*	DDB_GOOSEIN_17	688
1	1,7,9	196	177		*	*	*	*	*	*	*	DDB_GOOSEIN_18	689
1	1,7,9	196	178		*	*	*	*	*	*	*	DDB_GOOSEIN_19	690
1	1,7,9	196	179		*	*	*	*	*	*	*	DDB_GOOSEIN_20	691
1	1,7,9	196	180		*	*	*	*	*	*	*	DDB_GOOSEIN_21	692
1	1,7,9	196	181		*	*	*	*	*	*	*	DDB_GOOSEIN_22	693
1	1,7,9	196	182		*	*	*	*	*	*	*	DDB_GOOSEIN_23	694
1	1,7,9	196	183		*	*	*	*	*	*	*	DDB_GOOSEIN_24	695
1	1,7,9	196	184		*	*	*	*	*	*	*	DDB_GOOSEIN_25	696
1	1,7,9	196	185		*	*	*	*	*	*	*	DDB_GOOSEIN_26	697
1	1,7,9	196	186		*	*	*	*	*	*	*	DDB_GOOSEIN_27	698

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
1	1,7,9	196	187		*	*	*	*	*	*	*	DDB_GOOSEIN_28	699
1	1,7,9	196	188		*	*	*	*	*	*	*	DDB_GOOSEIN_29	700
1	1,7,9	196	189		*	*	*	*	*	*	*	DDB_GOOSEIN_30	701
1	1,7,9	196	190		*	*	*	*	*	*	*	DDB_GOOSEIN_31	702
1	1,7,9	196	191		*	*	*	*	*	*	*	DDB_GOOSEIN_32	703
1	1,7,9	196	192		*	*	*	*	*	*	*	DDB_GOOSEOUT_1	704
1	1,7,9	196	193		*	*	*	*	*	*	*	DDB_GOOSEOUT_2	705
1	1,7,9	196	194		*	*	*	*	*	*	*	DDB_GOOSEOUT_3	706
1	1,7,9	196	195		*	*	*	*	*	*	*	DDB_GOOSEOUT_4	707
1	1,7,9	196	196		*	*	*	*	*	*	*	DDB_GOOSEOUT_5	708
1	1,7,9	196	197		*	*	*	*	*	*	*	DDB_GOOSEOUT_6	709
1	1,7,9	196	198		*	*	*	*	*	*	*	DDB_GOOSEOUT_7	710
1	1,7,9	196	199		*	*	*	*	*	*	*	DDB_GOOSEOUT_8	711
1	1,7,9	196	200		*	*	*	*	*	*	*	DDB_GOOSEOUT_9	712
1	1,7,9	196	201		*	*	*	*	*	*	*	DDB_GOOSEOUT_10	713
1	1,7,9	196	202		*	*	*	*	*	*	*	DDB_GOOSEOUT_11	714
1	1,7,9	196	203		*	*	*	*	*	*	*	DDB_GOOSEOUT_12	715
1	1,7,9	196	204		*	*	*	*	*	*	*	DDB_GOOSEOUT_13	716
1	1,7,9	196	205		*	*	*	*	*	*	*	DDB_GOOSEOUT_14	717
1	1,7,9	196	206		*	*	*	*	*	*	*	DDB_GOOSEOUT_15	718
1	1,7,9	196	207		*	*	*	*	*	*	*	DDB_GOOSEOUT_16	719
1	1,7,9	196	208		*	*	*	*	*	*	*	DDB_GOOSEOUT_17	720
1	1,7,9	196	209		*	*	*	*	*	*	*	DDB_GOOSEOUT_18	721
1	1,7,9	196	210		*	*	*	*	*	*	*	DDB_GOOSEOUT_19	722
1	1,7,9	196	211		*	*	*	*	*	*	*	DDB_GOOSEOUT_20	723
1	1,7,9	196	212		*	*	*	*	*	*	*	DDB_GOOSEOUT_21	724
1	1,7,9	196	213		*	*	*	*	*	*	*	DDB_GOOSEOUT_22	725
1	1,7,9	196	214		*	*	*	*	*	*	*	DDB_GOOSEOUT_23	726
1	1,7,9	196	215		*	*	*	*	*	*	*	DDB_GOOSEOUT_24	727
1	1,7,9	196	216		*	*	*	*	*	*	*	DDB_GOOSEOUT_25	728
1	1,7,9	196	217		*	*	*	*	*	*	*	DDB_GOOSEOUT_26	729
1	1,7,9	196	218		*	*	*	*	*	*	*	DDB_GOOSEOUT_27	730
1	1,7,9	196	219		*	*	*	*	*	*	*	DDB_GOOSEOUT_28	731
1	1,7,9	196	220		*	*	*	*	*	*	*	DDB_GOOSEOUT_29	732
1	1,7,9	196	221		*	*	*	*	*	*	*	DDB_GOOSEOUT_30	733
1	1,7,9	196	222		*	*	*	*	*	*	*	DDB_GOOSEOUT_31	734
1	1,7,9	196	223		*	*	*	*	*	*	*	DDB_GOOSEOUT_32	735

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		196	224									DDB_UNUSED_736	736
		196	225									DDB_UNUSED_737	737
		196	226									DDB_UNUSED_738	738
		196	227									DDB_UNUSED_739	739
		196	228									DDB_UNUSED_740	740
		196	229									DDB_UNUSED_741	741
		196	230									DDB_UNUSED_742	742
		196	231									DDB_UNUSED_743	743
		196	232									DDB_UNUSED_744	744
		196	233									DDB_UNUSED_745	745
		196	234									DDB_UNUSED_746	746
		196	235									DDB_UNUSED_747	747
		196	236									DDB_UNUSED_748	748
		196	237									DDB_UNUSED_749	749
		196	238									DDB_FL_OC_SEND_A	750
		196	239									DDB_FL_OC_SEND_B	751
		196	240									DDB_FL_OC_SEND_C	752
		196	241									DDB_FL_Z1_INTERTRIP_SEND_A	753
		196	242									DDB_FL_Z1_INTERTRIP_SEND_B	754
		196	243									DDB_FL_Z1_INTERTRIP_SEND_C	755
		196	244									DDB_FL_Z2_INTERTRIP_SEND_A	756
		196	245									DDB_FL_Z2_INTERTRIP_SEND_B	757
		196	246									DDB_FL_Z2_INTERTRIP_SEND_C	758
		196	247									DDB_FL_Z3_INTERTRIP_SEND_A	759
		196	248									DDB_FL_Z3_INTERTRIP_SEND_B	760
		196	249									DDB_FL_Z3_INTERTRIP_SEND_C	761
		196	250									DDB_FL_CURRENT_PROT_SEF_TRIP	762
		196	251									DDB_BACKUP_INTERTRIP_SEND_A	763
		196	252									DDB_BACKUP_INTERTRIP_SEND_B	764
		196	253									DDB_BACKUP_INTERTRIP_SEND_C	765
		196	254									DDB_BACKUP_IN	766
		196	255									DDB_UNUSED_767	767
		197	0									DDB_UNUSED_768	768
		197	1									DDB_UNUSED_769	769
		197	2									DDB_UNUSED_770	770
		197	3									DDB_UNUSED_771	771
		197	4									DDB_UNUSED_772	772

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		197	5									DDB_UNUSED_773	773
		197	6									DDB_UNUSED_774	774
		197	7									DDB_UNUSED_775	775
		197	8									DDB_UNUSED_776	776
		197	9									DDB_UNUSED_777	777
		197	10									DDB_UNUSED_778	778
		197	11									DDB_UNUSED_779	779
		197	12									DDB_UNUSED_780	780
		197	13									DDB_UNUSED_781	781
		197	14									DDB_UNUSED_782	782
		197	15									DDB_UNUSED_783	783
		197	16									DDB_UNUSED_784	784
		197	17									DDB_UNUSED_785	785
		197	18									DDB_UNUSED_786	786
		197	19									DDB_UNUSED_787	787
		197	20									DDB_UNUSED_788	788
		197	21									DDB_UNUSED_789	789
		197	22									DDB_UNUSED_790	790
		197	23									DDB_UNUSED_791	791
		197	24									DDB_UNUSED_792	792
		197	25									DDB_UNUSED_793	793
		197	26									DDB_UNUSED_794	794
		197	27									DDB_UNUSED_795	795
		197	28									DDB_UNUSED_796	796
		197	29									DDB_UNUSED_797	797
		197	30									DDB_UNUSED_798	798
		197	31									DDB_UNUSED_799	799
		197	32									DDB_UNUSED_800	800
		197	33									DDB_UNUSED_801	801
		197	34									DDB_UNUSED_802	802
		197	35									DDB_UNUSED_803	803
		197	36									DDB_UNUSED_804	804
		197	37									DDB_UNUSED_805	805
		197	38									DDB_UNUSED_806	806
		197	39									DDB_UNUSED_807	807
		197	40									DDB_UNUSED_808	808
		197	41									DDB_UNUSED_809	809

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		197	42									DDB_UNUSED_810	810
		197	43									DDB_UNUSED_811	811
		197	44									DDB_UNUSED_812	812
		197	45									DDB_UNUSED_813	813
		197	46									DDB_UNUSED_814	814
		197	47									DDB_UNUSED_815	815
		197	48									DDB_UNUSED_816	816
		197	49									DDB_UNUSED_817	817
		197	50									DDB_UNUSED_818	818
		197	51									DDB_UNUSED_819	819
		197	52									DDB_UNUSED_820	820
		197	53									DDB_UNUSED_821	821
		197	54									DDB_UNUSED_822	822
		197	55									DDB_UNUSED_823	823
		197	56									DDB_PSLINT_1	824
		197	57									DDB_PSLINT_2	825
		197	58									DDB_PSLINT_3	826
		197	59									DDB_PSLINT_4	827
		197	60									DDB_PSLINT_5	828
		197	61									DDB_PSLINT_6	829
		197	62									DDB_PSLINT_7	830
		197	63									DDB_PSLINT_8	831
		197	64									DDB_PSLINT_9	832
		197	65									DDB_PSLINT_10	833
		197	66									DDB_PSLINT_11	834
		197	67									DDB_PSLINT_12	835
		197	68									DDB_PSLINT_13	836
		197	69									DDB_PSLINT_14	837
		197	70									DDB_PSLINT_15	838
		197	71									DDB_PSLINT_16	839
		197	72									DDB_PSLINT_17	840
		197	73									DDB_PSLINT_18	841
		197	74									DDB_PSLINT_19	842
		197	75									DDB_PSLINT_20	843
		197	76									DDB_PSLINT_21	844
		197	77									DDB_PSLINT_22	845
		197	78									DDB_PSLINT_23	846

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		197	79									DDB_PSLINT_24	847
		197	80									DDB_PSLINT_25	848
		197	81									DDB_PSLINT_26	849
		197	82									DDB_PSLINT_27	850
		197	83									DDB_PSLINT_28	851
		197	84									DDB_PSLINT_29	852
		197	85									DDB_PSLINT_30	853
		197	86									DDB_PSLINT_31	854
		197	87									DDB_PSLINT_32	855
		197	88									DDB_PSLINT_33	856
		197	89									DDB_PSLINT_34	857
		197	90									DDB_PSLINT_35	858
		197	91									DDB_PSLINT_36	859
		197	92									DDB_PSLINT_37	860
		197	93									DDB_PSLINT_38	861
		197	94									DDB_PSLINT_39	862
		197	95									DDB_PSLINT_40	863
		197	96									DDB_PSLINT_41	864
		197	97									DDB_PSLINT_42	865
		197	98									DDB_PSLINT_43	866
		197	99									DDB_PSLINT_44	867
		197	100									DDB_PSLINT_45	868
		197	101									DDB_PSLINT_46	869
		197	102									DDB_PSLINT_47	870
		197	103									DDB_PSLINT_48	871
		197	104									DDB_PSLINT_49	872
		197	105									DDB_PSLINT_50	873
		197	106									DDB_PSLINT_51	874
		197	107									DDB_PSLINT_52	875
		197	108									DDB_PSLINT_53	876
		197	109									DDB_PSLINT_54	877
		197	110									DDB_PSLINT_55	878
		197	111									DDB_PSLINT_56	879
		197	112									DDB_PSLINT_57	880
		197	113									DDB_PSLINT_58	881
		197	114									DDB_PSLINT_59	882
		197	115									DDB_PSLINT_60	883

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		197	116									DDB_PSLINT_61	884
		197	117									DDB_PSLINT_62	885
		197	118									DDB_PSLINT_63	886
		197	119									DDB_PSLINT_64	887
		197	120									DDB_PSLINT_65	888
		197	121									DDB_PSLINT_66	889
		197	122									DDB_PSLINT_67	890
		197	123									DDB_PSLINT_68	891
		197	124									DDB_PSLINT_69	892
		197	125									DDB_PSLINT_70	893
		197	126									DDB_PSLINT_71	894
		197	127									DDB_PSLINT_72	895
		197	128									DDB_PSLINT_73	896
		197	129									DDB_PSLINT_74	897
		197	130									DDB_PSLINT_75	898
		197	131									DDB_PSLINT_76	899
		197	132									DDB_PSLINT_77	900
		197	133									DDB_PSLINT_78	901
		197	134									DDB_PSLINT_79	902
		197	135									DDB_PSLINT_80	903
		197	136									DDB_PSLINT_81	904
		197	137									DDB_PSLINT_82	905
		197	138									DDB_PSLINT_83	906
		197	139									DDB_PSLINT_84	907
		197	140									DDB_PSLINT_85	908
		197	141									DDB_PSLINT_86	909
		197	142									DDB_PSLINT_87	910
		197	143									DDB_PSLINT_88	911
		197	144									DDB_PSLINT_89	912
		197	145									DDB_PSLINT_90	913
		197	146									DDB_PSLINT_91	914
		197	147									DDB_PSLINT_92	915
		197	148									DDB_PSLINT_93	916
		197	149									DDB_PSLINT_94	917
		197	150									DDB_PSLINT_95	918
		197	151									DDB_PSLINT_96	919
		197	152									DDB_PSLINT_97	920

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		197	153									DDB_PSLINT_98	921
		197	154									DDB_PSLINT_99	922
		197	155									DDB_PSLINT_100	923
		197	156									DDB_PSLINT_101	924
		197	157									DDB_PSLINT_102	925
		197	158									DDB_PSLINT_103	926
		197	159									DDB_PSLINT_104	927
		197	160									DDB_PSLINT_105	928
		197	161									DDB_PSLINT_106	929
		197	162									DDB_PSLINT_107	930
		197	163									DDB_PSLINT_108	931
		197	164									DDB_PSLINT_109	932
		197	165									DDB_PSLINT_110	933
		197	166									DDB_PSLINT_111	934
		197	167									DDB_PSLINT_112	935
		197	168									DDB_PSLINT_113	936
		197	169									DDB_PSLINT_114	937
		197	170									DDB_PSLINT_115	938
		197	171									DDB_PSLINT_116	939
		197	172									DDB_PSLINT_117	940
		197	173									DDB_PSLINT_118	941
		197	174									DDB_PSLINT_119	942
		197	175									DDB_PSLINT_120	943
		197	176									DDB_PSLINT_121	944
		197	177									DDB_PSLINT_122	945
		197	178									DDB_PSLINT_123	946
		197	179									DDB_PSLINT_124	947
		197	180									DDB_PSLINT_125	948
		197	181									DDB_PSLINT_126	949
		197	182									DDB_PSLINT_127	950
		197	183									DDB_PSLINT_128	951
		197	184									DDB_PSLINT_129	952
		197	185									DDB_PSLINT_130	953
		197	186									DDB_PSLINT_131	954
		197	187									DDB_PSLINT_132	955
		197	188									DDB_PSLINT_133	956
		197	189									DDB_PSLINT_134	957

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		197	190									DDB_PSLINT_135	958
		197	191									DDB_PSLINT_136	959
		197	192									DDB_PSLINT_137	960
		197	193									DDB_PSLINT_138	961
		197	194									DDB_PSLINT_139	962
		197	195									DDB_PSLINT_140	963
		197	196									DDB_PSLINT_141	964
		197	197									DDB_PSLINT_142	965
		197	198									DDB_PSLINT_143	966
		197	199									DDB_PSLINT_144	967
		197	200									DDB_PSLINT_145	968
		197	201									DDB_PSLINT_146	969
		197	202									DDB_PSLINT_147	970
		197	203									DDB_PSLINT_148	971
		197	204									DDB_PSLINT_149	972
		197	205									DDB_PSLINT_150	973
		197	206									DDB_UNUSED_974	974
		197	207									DDB_UNUSED_975	975
		197	208									DDB_UNUSED_976	976
		197	209									DDB_UNUSED_977	977
		197	210									DDB_UNUSED_978	978
		197	211									DDB_UNUSED_979	979
		197	212									DDB_UNUSED_980	980
		197	213									DDB_UNUSED_981	981
		197	214									DDB_UNUSED_982	982
		197	215									DDB_UNUSED_983	983
		197	216									DDB_UNUSED_984	984
		197	217									DDB_UNUSED_985	985
		197	218									DDB_UNUSED_986	986
		197	219									DDB_UNUSED_987	987
		197	220									DDB_UNUSED_988	988
		197	221									DDB_UNUSED_989	989
		197	222									DDB_UNUSED_990	990
		197	223									DDB_UNUSED_991	991
		197	224									DDB_UNUSED_992	992
		197	225									DDB_UNUSED_993	993
		197	226									DDB_UNUSED_994	994

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
		197	227									DDB_UNUSED_995	995
		197	228									DDB_UNUSED_996	996
		197	229									DDB_UNUSED_997	997
		197	230									DDB_UNUSED_998	998
		197	231									DDB_UNUSED_999	999
		197	232									DDB_UNUSED_1000	1000
		197	233									DDB_UNUSED_1001	1001
		197	234									DDB_UNUSED_1002	1002
		197	235									DDB_UNUSED_1003	1003
		197	236									DDB_UNUSED_1004	1004
		197	237									DDB_UNUSED_1005	1005
		197	238									DDB_UNUSED_1006	1006
		197	239									DDB_UNUSED_1007	1007
		197	240									DDB_UNUSED_1008	1008
		197	241									DDB_UNUSED_1009	1009
		197	242									DDB_UNUSED_1010	1010
		197	243									DDB_UNUSED_1011	1011
		197	244									DDB_UNUSED_1012	1012
		197	245									DDB_UNUSED_1013	1013
		197	246									DDB_UNUSED_1014	1014
		197	247									DDB_UNUSED_1015	1015
		197	248									DDB_UNUSED_1016	1016
		197	249									DDB_UNUSED_1017	1017
		197	250									DDB_UNUSED_1018	1018
		197	251									DDB_UNUSED_1019	1019
		197	252									DDB_UNUSED_1020	1020
		197	253									DDB_UNUSED_1021	1021
		197	254									DDB_UNUSED_1022	1022
1	1,7	197	255	Battery Fail		*	*	*	*	*	*		
1	1,7	198	0	Rear Comm 2 Fail		*	*	*	*	*	*		
1	1,7	198	1	GOOSE IED Absent									
1	1,7	198	2	NIC Not Fitted									
1	1,7	198	3	NIC No Response									
1	1,7	198	4	NIC Fatal Error									
1	1,7	198	5	NIC Soft. Reload									
1	1,7	198	6	Bad TCP/IP Cfg.									
1	1,7	198	7	Bad OSI Config.									

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
1	1,7	198	8	NIC Link Fail									
1	1,7	198	9	NIC SW Mis-Match									
1	1,7	198	10	IP Addr Conflict									
		198	11	Unused									
		198	12	Unused									
		198	13	Unused									
1	1,7	198	14	Backup Setting	*	*	*	*	*	*	*		
		198	15	Unused									
		198	16	Unused									
		198	17	Unused									
		198	18	Unused									
		198	19	Unused									
		198	20	Unused									
		198	21	Unused									
		198	22	Unused									
		198	23	Unused									
		198	24	Unused									
		198	25	Unused									
		198	26	Unused									
		198	27	Unused									
		198	28	Unused									
		198	29	Unused									

Non Standard Information numbers in control direction

20	20	196	32	Auto-recloser on/off				*		*		Autoreclose in Service 1 pole	
20	20	194	224	Control Input 1		*	*	*	*	*	*		
20	20	194	225	Control Input 2		*	*	*	*	*	*		
20	20	194	226	Control Input 3		*	*	*	*	*	*		
20	20	194	227	Control Input 4		*	*	*	*	*	*		
20	20	194	228	Control Input 5		*	*	*	*	*	*		
20	20	194	229	Control Input 6		*	*	*	*	*	*		
20	20	194	230	Control Input 7		*	*	*	*	*	*		
20	20	194	231	Control Input 8		*	*	*	*	*	*		
20	20	194	232	Control Input 9		*	*	*	*	*	*		
20	20	194	233	Control Input 10		*	*	*	*	*	*		
20	20	194	234	Control Input 11		*	*	*	*	*	*		
20	20	194	235	Control Input 12		*	*	*	*	*	*		

ASDU TYPE	COT	FUN	INF	English Text	GI	1	2	3	4	5	6	DDB Element Name	Ordinal
20	20	194	236	Control Input 13		*	*	*	*	*	*		
20	20	194	237	Control Input 14		*	*	*	*	*	*		
20	20	194	238	Control Input 15		*	*	*	*	*	*		
20	20	194	239	Control Input 16		*	*	*	*	*	*		
20	20	194	240	Control Input 17		*	*	*	*	*	*		
20	20	194	241	Control Input 18		*	*	*	*	*	*		
20	20	194	242	Control Input 19		*	*	*	*	*	*		
20	20	194	243	Control Input 20		*	*	*	*	*	*		
20	20	194	244	Control Input 21		*	*	*	*	*	*		
20	20	194	245	Control Input 22		*	*	*	*	*	*		
20	20	194	246	Control Input 23		*	*	*	*	*	*		
20	20	194	247	Control Input 24		*	*	*	*	*	*		
20	20	194	248	Control Input 25		*	*	*	*	*	*		
20	20	194	249	Control Input 26		*	*	*	*	*	*		
20	20	194	250	Control Input 27		*	*	*	*	*	*		
20	20	194	251	Control Input 28		*	*	*	*	*	*		
20	20	194	252	Control Input 29		*	*	*	*	*	*		
20	20	194	253	Control Input 30		*	*	*	*	*	*		
20	20	194	254	Control Input 31		*	*	*	*	*	*		
20	20	194	255	Control Input 32		*	*	*	*	*	*		

Disturbance Data Actual Channel Identifiers

ACC	Standard	Interpretation
0	Global	Null Channel
1	IL1	IA
2	IL2	IB
3	IL3	IC
4	IN	IN
5	VL1E	VAN
6	VL2E	VBN
7	VL3E	VCN
8	VEN	VN
100	-	IA-2
101	-	IB-2
102	-	IC-2
103	-	IN-2
104	-	VChkSyn
105	-	IM

Event record data format

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	P541	P542	P543	P544	P545	P546
Logic Inputs		**Change in Opto Input**	5	0020	Binary Flag (8 bits)	*					
					Binary Flag (16 bits)		*	*	*		
				0F21	Binary Flag (24 bits)					*	*
					Value contains new opto input status						
Output Contacts		**Change in output contact status**	4	0021	Binary Flag (7 bits)	*					
					Binary Flag (14 bits)		*	*	*		
				0F20	Binary Flag (32 bits)					*	*
					Value contains new output contact status						
		Alarm Events:									
					Binary Flag (32 bits) Bit Number						
Battery Fail	ON/OFF	Battery Fail	2/3	0022	0	*	*	*	*	*	*
Field Volt Fail	ON/OFF	Field Voltage Fail	2/3	0022	1	*	*	*	*	*	*
SG-opto Invalid	ON/OFF	Setting group via opto invalid (Self Reset)	2/3	0022	2	*	*	*	*	*	*
Prot'n Disabled	ON/OFF	Protection Disabled (Self Reset)	2/3	0022	3	*	*	*	*	*	*
VT Fail Alarm	ON/OFF	VT Fail Alarm (Self Reset)	2/3	0022	4			*	*	*	*
Power Swing	ON/OFF	Power Swingl Alarm (Latched)	0/1	0022	5			*	*	*	*
CB Fail Alarm	ON/OFF	CB Fail Alarm (Latched)	0/1	0022	6	*	*	*	*	*	*
I^ Maint Alarm	ON/OFF	Broken current Maintenance Alarm (Self Reset)	2/3	0022	7	*	*	*		*	
I^ Lockout Alarm	ON/OFF	Broken current Lockout Alarm (Self Reset)	2/3	0022	8	*	*	*		*	
CB Ops Maint	ON/OFF	No of CB Ops Maintenance Alarm (Self Reset)	2/3	0022	9	*	*	*		*	
CB Ops Lock	ON/OFF	No of CB Ops Lockout Alarm (Self Reset)	2/3	0022	10	*	*	*		*	
CB Time Maint	ON/OFF	CB Op Time Maintenance Alarm (Self Reset)	2/3	0022	11	*	*	*		*	
CB Time Lockout	ON/OFF	CB Op Time Lockout Alarm (Self Reset)	2/3	0022	12	*	*	*		*	
Fault Freq Lock	ON/OFF	Excessive Fault Frequency Lockout (Self Reset)	2/3	0022	13	*	*	*		*	
CB Status Alarm	ON/OFF	CB Status Alarm (Latched)	0/1	0022	14	*	*	*	*	*	*
GPS Alarm	ON/OFF	GPS Alarm (Latched)	0/1	0022	15					*	*
CB Trip Fail	ON/OFF	CB Fail Trip Control (Latched)	0/1	0022	16	*	*	*	*	*	*
CB Close Fail	ON/OFF	CB Fail Close Control (Latched)	0/1	0022	17	*	*	*	*	*	*
Man CB Unhealthy	ON/OFF	No Healthy Control Close (Latched)	0/1	0022	18	*	*	*	*	*	*
No C/S Man Close	ON/OFF	No C/S control close (Latched)	0/1	0022	19			*		*	
AR Lockout	ON/OFF	A/R Lockout (Self Reset)	2/3	0022	20		*	*		*	

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	P541	P542	P543	P544	P545	P546
CB2 Fail Alarm	ON/OFF	CB2 Fail Alarm (Latched)	0/1	0022	20				*		*
AR CB Unhealthy	ON/OFF	A/R CB Not healthy (Latched)	0/1	0022	21		*	*		*	
A/R No Check Sync	ON/OFF	A/R No Checksync (Latched)	0/1	0022	22			*		*	
InCompatible Rly	ON/OFF	Incompatible Relay Alarm (Self Reset)	2/3	0022	23	*	*	*	*	*	*
Test Loopback	ON/OFF	Test Loopback Alarm (Self Reset)	2/3	0022	24	*	*	*	*	*	*
Signalling Fail	ON/OFF	Signalling Fail Alarm (Latched)	0/1	0022	25	*	*	*	*	*	*
Comm Delay Alarm	ON/OFF	Communications Delay Alarm (Latched)	0/1	0022	26	*	*	*	*	*	*
C Diff Failure	ON/OFF	Current Differential Failure Alarm (Latched)	0/1	0022	27	*	*	*	*	*	*
C Diff Inhibited	ON/OFF	Current Diff Protection Inhibited (Self Reset)	2/3	0022	28	*	*	*	*	*	*
Config Error	ON/OFF	Configuration Error Alarm (Latched)	0/1	0022	29	*	*	*	*	*	*
Re-Config Error	ON/OFF	Re-Configuration Alarm (Latched)	0/1	0022	30	*	*	*	*	*	*
F out of Range	ON/OFF	Frequency out of Range Alarm (Self Reset)	2/3	0022	31	*	*	*	*	*	*
C Diff Comm Mode	ON/OFF	C Diff Protection Comms Mode (Self Reset)	2/3	0051	13	*	*	*	*	*	*
IEEE C37.94	ON/OFF	IEEE C37.94 Communications Alarms (Self Reset)	2/3	0051	14	*	*	*	*	*	*
System Split	ON/OFF	System Split Latched)	2/3	0051	15	.	.	*	.	*	.
SR User Alarm 1	ON/OFF	User Alarm 1 (Self Reset)	2/3	0051	16	*	*	*	*	*	*
SR User Alarm 2	ON/OFF	User Alarm 2 (Self Reset)	2/3	0051	17	*	*	*	*	*	*
SR User Alarm 3	ON/OFF	User Alarm 3 (Self Reset)	2/3	0051	18	*	*	*	*	*	*
SR User Alarm 4	ON/OFF	User Alarm 4 (Self Reset)	2/3	0051	19	*	*	*	*	*	*
SR User Alarm 5	ON/OFF	User Alarm 5 (Self Reset)	2/3	0051	20	*	*	*	*	*	*
SR User Alarm 6	ON/OFF	User Alarm 6 (Self Reset)	2/3	0051	21	*	*	*	*	*	*
SR User Alarm 7	ON/OFF	User Alarm 7 (Self Reset)	2/3	0051	22	*	*	*	*	*	*
SR User Alarm 8	ON/OFF	User Alarm 8 (Self Reset)	2/3	0051	23	*	*	*	*	*	*
MR User Alarm 9	ON/OFF	User Alarm 9 (Latched)	0/1	0051	24	*	*	*	*	*	*
MR User Alarm 10	ON/OFF	User Alarm 10 (Latched)	0/1	0051	25	*	*	*	*	*	*
MR User Alarm 11	ON/OFF	User Alarm 11 (Latched)	0/1	0051	26	*	*	*	*	*	*
MR User Alarm 12	ON/OFF	User Alarm 12 (Latched)	0/1	0051	27	*	*	*	*	*	*
MR User Alarm 13	ON/OFF	User Alarm 13 (Latched)	0/1	0051	28	*	*	*	*	*	*
MR User Alarm 14	ON/OFF	User Alarm 14 (Latched)	0/1	0051	29	*	*	*	*	*	*
MR User Alarm 15	ON/OFF	User Alarm 15 (Latched)	0/1	0051	30	*	*	*	*	*	*
MR User Alarm 16	ON/OFF	User Alarm 16 (Latched)	0/1	0051	31	*	*	*	*	*	*
Battery Fail	ON/OFF	Battery Fail	2/3	0052	0	*	*	*	*	*	*
Field Volt Fail	ON/OFF	Field Voltage Fail	2/3	0052	1	*	*	*	*	*	*
Rear Comm 2 Fail	ON/OFF	Rear Comm 2 Fail		0052	2	*	*	*	*	*	*
GOOSE IED Absent	ON/OFF			0052	3	*	*	*	*	*	*
NIC Not Fitted	ON/OFF			0052	4	*	*	*	*	*	*

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	P541	P542	P543	P544	P545	P546
NIC No Response	ON/OFF			0052	5	*	*	*	*	*	*
NIC Fatal Error	ON/OFF			0052	6	*	*	*	*	*	*
NIC Soft. Reload	ON/OFF			0052	7	*	*	*	*	*	*
Bad TCP/IP Cfg.	ON/OFF			0052	8	*	*	*	*	*	*
Bad OSI Config.	ON/OFF			0052	9	*	*	*	*	*	*
NIC Link Fail	ON/OFF			0052	10	*	*	*	*	*	*
NIC SW Mis-Match	ON/OFF			0052	11	*	*	*	*	*	*
IP Addr Conflict	ON/OFF			0052	12	*	*	*	*	*	*
unused	ON/OFF			0052	13	*	*	*	*	*	*
unused	ON/OFF			0052	14	*	*	*	*	*	*
unused	ON/OFF			0052	15	*	*	*	*	*	*
unused	ON/OFF			0052	16	*	*	*	*	*	*
Backup Setting	ON/OFF			0052	17	*	*	*	*	*	*
		Protection Events:			Binary Flag (32 bits) Bit Number						
Control Input 1	ON/OFF		6	0F27	0	*	*	*	*	*	*
Control Input 2	ON/OFF		6	0F27	1	*	*	*	*	*	*
Control Input 3	ON/OFF		6	0F27	2	*	*	*	*	*	*
Control Input 4	ON/OFF		6	0F27	3	*	*	*	*	*	*
Control Input 5	ON/OFF		6	0F27	4	*	*	*	*	*	*
Control Input 6	ON/OFF		6	0F27	5	*	*	*	*	*	*
Control Input 7	ON/OFF		6	0F27	6	*	*	*	*	*	*
Control Input 8	ON/OFF		6	0F27	7	*	*	*	*	*	*
Control Input 9	ON/OFF		6	0F27	8	*	*	*	*	*	*
Control Input 10	ON/OFF		6	0F27	9	*	*	*	*	*	*
Control Input 11	ON/OFF		6	0F27	10	*	*	*	*	*	*
Control Input 12	ON/OFF		6	0F27	11	*	*	*	*	*	*
Control Input 13	ON/OFF		6	0F27	12	*	*	*	*	*	*
Control Input 14	ON/OFF		6	0F27	13	*	*	*	*	*	*
Control Input 15	ON/OFF		6	0F27	14	*	*	*	*	*	*
Control Input 16	ON/OFF		6	0F27	15	*	*	*	*	*	*
Control Input 17	ON/OFF		6	0F27	16	*	*	*	*	*	*
Control Input 18	ON/OFF		6	0F27	17	*	*	*	*	*	*
Control Input 19	ON/OFF		6	0F27	18	*	*	*	*	*	*
Control Input 20	ON/OFF		6	0F27	19	*	*	*	*	*	*
Control Input 21	ON/OFF		6	0F27	20	*	*	*	*	*	*

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	P541	P542	P543	P544	P545	P546
Control Input 22	ON/OFF		6	0F27	21	*	*	*	*	*	*
Control Input 23	ON/OFF		6	0F27	22	*	*	*	*	*	*
Control Input 24	ON/OFF		6	0F27	23	*	*	*	*	*	*
Control Input 25	ON/OFF		6	0F27	24	*	*	*	*	*	*
Control Input 26	ON/OFF		6	0F27	25	*	*	*	*	*	*
Control Input 27	ON/OFF		6	0F27	26	*	*	*	*	*	*
Control Input 28	ON/OFF		6	0F27	27	*	*	*	*	*	*
Control Input 29	ON/OFF		6	0F27	28	*	*	*	*	*	*
Control Input 30	ON/OFF		6	0F27	29	*	*	*	*	*	*
Control Input 31	ON/OFF		6	0F27	30	*	*	*	*	*	*
Control Input 32	ON/OFF		6	0F27	31	*	*	*	*	*	*
Reset Relays/LED	ON/OFF	Reset Latched Relays & LED's	6	0F29	16	*	*	*	*	*	*
Any Trip	ON/OFF	Any Trip	6	0F2A	30	*	*	*	*	*	*
Diff Trip	ON/OFF	Differential Trip	6	0F2A	31	*	*	*	*	*	*
Diff Trip A	ON/OFF	Differential Trip A	6	0F2B	0	*	*	*	*	*	*
Diff Trip B	ON/OFF	Differential Trip B	6	0F2B	1	*	*	*	*	*	*
Diff Trip C	ON/OFF	Differential Trip C	6	0F2B	2	*	*	*	*	*	*
Diff Intertrip	ON/OFF	Differential Intertrip	6	0F2B	3	*	*	*	*	*	*
Diff Intertrip A	ON/OFF	Differential Intertrip A	6	0F2B	4	*	*	*	*	*	*
Diff Intertrip B	ON/OFF	Differential Intertrip B	6	0F2B	5	*	*	*	*	*	*
Diff Intertrip C	ON/OFF	Differential Intertrip C	6	0F2B	6	*	*	*	*	*	*
Direct Intertrip	ON/OFF	Direct Intertrip	6	0F2B	7						
Perm Intertrip	ON/OFF	Permissive Intertrip	6	0F2B	8	*	*	*	*	*	*
Zone 1 Trip	ON/OFF	Any Zone 1 Trip	6	0F2B	9			*	*	*	*
Zone 1 A Trip	ON/OFF	Zone 1 A Phase Trip	6	0F2B	10			*	*	*	*
Zone 1 B Trip	ON/OFF	Zone 1 B Phase Trip	6	0F2B	11			*	*	*	*
Zone 1 C Trip	ON/OFF	Zone 1 C Phase Trip	6	0F2B	12			*	*	*	*
Zone 1 N Trip	ON/OFF	Zone 1 N Trip	6	0F2B	13			*	*	*	*
Zone 2 Trip	ON/OFF	Any Zone 2 Trip	6	0F2B	14			*	*	*	*
Zone 2 A Trip	ON/OFF	Zone 2 A Phase Trip	6	0F2B	15			*	*	*	*
Zone 2 B Trip	ON/OFF	Zone 2 B Phase Trip	6	0F2B	16			*	*	*	*
Zone 2 C Trip	ON/OFF	Zone 2 C Phase Trip	6	0F2B	17			*	*	*	*
Zone 2 N Trip	ON/OFF	Zone 2 N Trip	6	0F2B	18			*	*	*	*
Zone 3 Trip	ON/OFF	Any Zone 3 Trip	6	0F2B	19			*	*	*	*
Zone 3 A Trip	ON/OFF	Zone 3 A Phase Trip	6	0F2B	20			*	*	*	*
Zone 3 B Trip	ON/OFF	Zone 3 B Phase Trip	6	0F2B	21			*	*	*	*
Zone 3 C Trip	ON/OFF	Zone 3 C Phase Trip	6	0F2B	22			*	*	*	*

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	P541	P542	P543	P544	P545	P546
Zone 3 N Trip	ON/OFF	Zone 3 N Trip	6	0F2B	23			*	*	*	*
Pole Discrepancy	ON/OFF	Pole Discrepancy	6	0F2B	24			*		*	
BU Intertrip	ON/OFF	Pole Discrepancy	6	0F2B	25	*	*	*	*	*	*
BU Intertrip A	ON/OFF	Differential Intertrip A	6	0F2B	26	*	*	*	*	*	*
BU Intertrip B	ON/OFF	Differential Intertrip B	6	0F2B	27	*	*	*	*	*	*
BU Intertrip C	ON/OFF	Differential Intertrip C	6	0F2B	28	*	*	*	*	*	*
Force 3pole BU	ON/OFF	Force 3 pole backup Intertrip	6	0F2B	29			*	*	*	*
I>1 Trip	ON/OFF	1st Stage O/C Trip 3ph	6	0F2B	30	*	*	*	*	*	*
I>1 Trip A	ON/OFF	1st Stage O/C Trip A	6	0F2B	31	*	*	*	*	*	*
I>1 Trip B	ON/OFF	1st Stage O/C Trip B	6	0F2C	0	*	*	*	*	*	*
I>1 Trip C	ON/OFF	1st Stage O/C Trip C	6	0F2C	1	*	*	*	*	*	*
I>2 Trip	ON/OFF	2nd Stage O/C Trip 3ph	6	0F2C	2	*	*	*	*	*	*
I>2 Trip A	ON/OFF	2nd Stage O/C Trip A	6	0F2C	3	*	*	*	*	*	*
I>2 Trip B	ON/OFF	2nd Stage O/C Trip B	6	0F2C	4	*	*	*	*	*	*
I>2 Trip C	ON/OFF	2nd Stage O/C Trip C	6	0F2C	5	*	*	*	*	*	*
I>3 Trip	ON/OFF	3rd Stage O/C Trip 3ph	6	0F2C	6	*	*	*	*	*	*
I>3 Trip A	ON/OFF	3rd Stage O/C Trip A	6	0F2C	7	*	*	*	*	*	*
I>3 Trip B	ON/OFF	3rd Stage O/C Trip B	6	0F2C	8	*	*	*	*	*	*
I>3 Trip C	ON/OFF	3rd Stage O/C Trip C	6	0F2C	9	*	*	*	*	*	*
I>4 Trip	ON/OFF	4th Stage O/C Trip 3ph	6	0F2C	10	*	*	*	*	*	*
I>4 Trip A	ON/OFF	4th Stage O/C Trip A	6	0F2C	11	*	*	*	*	*	*
I>4 Trip B	ON/OFF	4th Stage O/C Trip B	6	0F2C	12	*	*	*	*	*	*
I>4 Trip C	ON/OFF	4th Stage O/C Trip C	6	0F2C	13	*	*	*	*	*	*
IN>1 Trip	ON/OFF	1st Stage SBEF Trip	6	0F2C	14	*	*	*	*	*	*
IN>2 Trip	ON/OFF	2nd Stage SBEF Trip	6	0F2C	15	*	*	*	*	*	*
IN>3 Trip	ON/OFF	3rd Stage SBEF Trip	6	0F2C	16	*	*	*	*	*	*
IN>4 Trip	ON/OFF	4th Stage SBEF Trip	6	0F2C	17	*	*	*	*	*	*
ISEF>1 Trip	ON/OFF	1st Stage SEF Trip	6	0F2C	18			*	*	*	*
ISEF>2 Trip	ON/OFF	2nd Stage SEF Trip	6	0F2C	19			*	*	*	*
ISEF>3 Trip	ON/OFF	3rd Stage SEF Trip	6	0F2C	20			*	*	*	*
ISEF>4 Trip	ON/OFF	4th Stage SEF Trip	6	0F2C	21			*	*	*	*
Broken Wire Trip	ON/OFF	Broken Conductor Trip	6	0F2C	22	*	*	*	*	*	*
Thermal Trip	ON/OFF	Thermal Overload Trip	6	0F2C	23	*	*	*	*	*	*
Stub Bus Trip	ON/OFF	Stub Bus Trip	6	0F2C	24				*		*
AR Trip Test	ON/OFF	Autoreclose trip test	6	0F2C	25		*	*		*	
AR Trip Test A	ON/OFF	Autoreclose trip test A phase	6	0F2C	26			*		*	
AR Trip Test B	ON/OFF	Autoreclose trip test B phase	6	0F2C	27			*		*	

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	P541	P542	P543	P544	P545	P546
AR Trip Test C	ON/OFF	Autoreclose trip test C Phase	6	0F2C	28			*		*	
Zone 1 Start	ON/OFF	Zone 1 Start	6	0F2D	14			*	*	*	*
Zone 2 Start	ON/OFF	Zone 2 Start	6	0F2D	15			*	*	*	*
Zone 3 Start	ON/OFF	Zone 3 Start	6	0F2D	16			*	*	*	*
Diff Start	ON/OFF	Differential Start	6	0F2D	17	*	*	*	*	*	*
Any Start	ON/OFF	Any Start	6	0F2D	18	*	*	*	*	*	*
Diff Start A	ON/OFF	Differential Start A	6	0F2D	19	*	*	*	*	*	*
Diff Start B	ON/OFF	Differential Start B	6	0F2D	20	*	*	*	*	*	*
Diff Start C	ON/OFF	Differential Start C	6	0F2D	21	*	*	*	*	*	*
Zone 1 A Start	ON/OFF	Zone 1 A Phase Start	6	0F2D	22			*	*	*	*
Zone 1 B Start	ON/OFF	Zone 1 B Phase Start	6	0F2D	23			*	*	*	*
Zone 1 C Start	ON/OFF	Zone 1 C Phase Start	6	0F2D	24			*	*	*	*
Zone 1 N Start	ON/OFF	Zone 1 N Start	6	0F2D	25			*	*	*	*
Zone 2 A Start	ON/OFF	Zone 2 A Phase Start	6	0F2D	26			*	*	*	*
Zone 2 B Start	ON/OFF	Zone 2 B Phase Start	6	0F2D	27			*	*	*	*
Zone 2 C Start	ON/OFF	Zone 2 C Phase Start	6	0F2D	28			*	*	*	*
Zone 2 N Start	ON/OFF	Zone 2 N Start	6	0F2D	29			*	*	*	*
Zone 3 A Start	ON/OFF	Zone 3 A Phase Start	6	0F2D	30			*	*	*	*
Zone 3 B Start	ON/OFF	Zone 3 B Phase Start	6	0F2D	31			*	*	*	*
Zone 3 C Start	ON/OFF	Zone 3 C Phase Start	6	0F2E	0			*	*	*	*
Zone 3 N Start	ON/OFF	Zone 3 N Start	6	0F2E	1			*	*	*	*
Zone 6 Start	ON/OFF	Zone 6 Start (PSB Start)	6	0F2E	2			*	*	*	*
I>1 Start	ON/OFF	1st Stage O/C Start 3ph	6	0F2E	3	*	*	*	*	*	*
I>1 Start A	ON/OFF	1st Stage O/C Start A	6	0F2E	4	*	*	*	*	*	*
I>1 Start B	ON/OFF	1st Stage O/C Start B	6	0F2E	5	*	*	*	*	*	*
I>1 Start C	ON/OFF	1st Stage O/C Start C	6	0F2E	6	*	*	*	*	*	*
I>2 Start	ON/OFF	2nd Stage O/C Start 3ph	6	0F2E	7	*	*	*	*	*	*
I>2 Start A	ON/OFF	2nd Stage O/C Start A	6	0F2E	8	*	*	*	*	*	*
I>2 Start B	ON/OFF	2nd Stage O/C Start B	6	0F2E	9	*	*	*	*	*	*
I>2 Start C	ON/OFF	2nd Stage O/C Start C	6	0F2E	10	*	*	*	*	*	*
I>3 Start	ON/OFF	3rd Stage O/C Start 3ph	6	0F2E	11	*	*	*	*	*	*
I>3 Start A	ON/OFF	3rd Stage O/C Start A	6	0F2E	12	*	*	*	*	*	*
I>3 Start B	ON/OFF	3rd Stage O/C Start B	6	0F2E	13	*	*	*	*	*	*
I>3 Start C	ON/OFF	3rd Stage O/C Start C	6	0F2E	14	*	*	*	*	*	*
I>4 Start	ON/OFF	4th Stage O/C Start 3ph	6	0F2E	15	*	*	*	*	*	*
I>4 Start A	ON/OFF	4th Stage O/C Start A	6	0F2E	16	*	*	*	*	*	*
I>4 Start B	ON/OFF	4th Stage O/C Start B	6	0F2E	17	*	*	*	*	*	*

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	P541	P542	P543	P544	P545	P546
I>4 Start C	ON/OFF	4th Stage O/C Start C	6	0F2E	18	*	*	*	*	*	*
IN>1 Start	ON/OFF	1st Stage SBEF Start	6	0F2E	19	*	*	*	*	*	*
IN>2 Start	ON/OFF	2nd Stage SBEF Start	6	0F2E	20	*	*	*	*	*	*
IN>3 Start	ON/OFF	3rd Stage SBEF Start	6	0F2E	21	*	*	*	*	*	*
IN>4 Start	ON/OFF	4th Stage SBEF Start	6	0F2E	22	*	*	*	*	*	*
ISEF>1 Start	ON/OFF	1st Stage SEF Start	6	0F2E	23			*	*	*	*
ISEF>2 Start	ON/OFF	2nd Stage SEF Start	6	0F2E	24			*	*	*	*
ISEF>3 Start	ON/OFF	3rd Stage SEF Start	6	0F2E	25			*	*	*	*
ISEF>4 Start	ON/OFF	4th Stage SEF Start	6	0F2E	26			*	*	*	*
Thermal Alarm	ON/OFF	Thermal Overload Alarm	6	0F2E	27	*	*	*	*	*	*
I> BlockStart	ON/OFF	I> Blocked O/C Start	6	0F2E	28	*	*	*	*	*	*
IN/SEF>Blk Start	ON/OFF	IN/ISEF> Blocked O/C Start	6	0F2E	29	*	*	*	*	*	*
Bfail1 Trip 3ph	ON/OFF	tBF1 Trip 3Ph	6	0F30	8	*	*	*	*	*	*
Bfail2 Trip 3ph	ON/OFF	tBF2 Trip 3Ph	6	0F30	9	*	*	*	*	*	*
CB2 Fail1 Trip	ON/OFF	Autoreclose Block Main Protection	6	0F30	10				*		*
CB2 Fail2 Trip	ON/OFF	Autoreclose Block SEF Protection	6	0F30	11				*		*
Control Trip	ON/OFF	Control Trip	6	0F30	12	*	*	*	*	*	*
Control Close	ON/OFF	Control Close	6	0F30	13	*	*	*	*	*	*
Control Trip 2	ON/OFF	Control Trip 2	6	0F30	14				*		*
Control Close 2	ON/OFF	Control Close 2	6	0F30	15				*		*
Close in Prog	ON/OFF	Control Close in Progress	6	0F30	16	*	*	*	*	*	*
Block Main Prot	ON/OFF	AR Block Main Protection	6	0F30	17		*				
AR 3pole in prog	ON/OFF	Auto Reclose/(AR 3 pole) in Progress	6	0F30	19		*	*		*	
AR 1pole in prog	ON/OFF	AR 1pole in progress	6	0F30	20			*		*	
Seq Counter = 1	ON/OFF	Seq Counter = 1	6	0F30	22		*	*		*	
Seq Counter = 2	ON/OFF	Seq Counter = 2	6	0F30	23		*	*		*	
Seq Counter = 3	ON/OFF	Seq Counter = 3	6	0F30	24		*	*		*	
Seq Counter = 4	ON/OFF	Seq Counter = 4	6	0F30	25		*	*		*	
Successful Close	ON/OFF	Successful Reclosure	6	0F30	27		*	*		*	
Dead T in Prog	ON/OFF	Dead Time in Progress	6	0F30	28		*				
Auto Close	ON/OFF	Auto Close/ AR Close	6	0F30	29		*	*		*	
A/R Status	ON/OFF	Autoreclose In/Out of service	6	0F30	30		*				
A/R Status 3P	ON/OFF	Autoreclose In/Out of service	6	0F30	31			*		*	
AR Status 1P	ON/OFF	Autoreclose In/Out of service	6	0F31	0			*		*	
Force 3 pole	ON/OFF	AR Force 3 pole trips	6	0F31	1			*		*	
CB Open 3 ph	ON/OFF	3 ph CB Open	6	0F32	6	*	*	*	*	*	*
CB Open A ph	ON/OFF	Ph A CB Open	6	0F32	7			*	*	*	*

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value		P541	P542	P543	P544	P545	P546
CB Open B ph	ON/OFF	Ph B CB Open	6	0F32	8				*	*	*	*
CB Open C ph	ON/OFF	Ph C CB Open	6	0F32	9				*	*	*	*
CB Closed 3 ph	ON/OFF	3 ph CB Closed	6	0F32	10		*	*	*	*	*	*
CB Closed A ph	ON/OFF	Ph A CB Closed	6	0F32	11				*	*	*	*
CB Closed B ph	ON/OFF	Ph B CB Closed	6	0F32	12				*	*	*	*
CB Closed C ph	ON/OFF	Ph C CB Closed	6	0F32	13				*	*	*	*
CB2 Open 3 ph	ON/OFF	3 ph CB2 Open	6	0F32	14					*		*
CB2 Open A ph	ON/OFF	Ph A CB2 Open	6	0F32	15					*		*
CB2 Open B ph	ON/OFF	Ph B CB2 Open	6	0F32	16					*		*
CB2 Open C ph	ON/OFF	Ph C CB2 Open	6	0F32	17					*		*
CB2 Closed 3 ph	ON/OFF	3 ph CB2 Closed	6	0F32	18					*		*
CB2 Closed A ph	ON/OFF	Ph A CB2 Closed	6	0F32	19					*		*
CB2 Closed B ph	ON/OFF	Ph B CB2 Closed	6	0F32	20					*		*
CB2 Closed C ph	ON/OFF	Ph C CB2 Closed	6	0F32	21					*		*
SignalFail Ch1Rx	ON/OFF	Protection Signaling Failure Alarm - Ch1 Rx	6	0F32	26		*	*	*	*	*	*
SignalFail Ch1Tx	ON/OFF	Protection Signaling Failure Alarm - Ch1 Tx	6	0F32	27		*	*	*	*	*	*
SignalFail Ch2Rx	ON/OFF	Protection Signaling Failure Alarm - Ch2 Rx	6	0F32	28		*	*	*	*	*	*
SignalFail Ch2Tx	ON/OFF	Protection Signaling Failure Alarm - Ch2 Tx	6	0F32	29		*	*	*	*	*	*
Ch 1 GPS Fail	ON/OFF	Remote 1 GPS Fail	6	0F32	30						*	*
Ch 2 GPS Fail	ON/OFF	Remote 2 GPS Fail	6	0F32	31						*	*
Config Same	ON/OFF	relay is already configured	6	0F33	0		*	*	*	*	*	*
Reconfig Pass	ON/OFF	reconfigure was successful	6	0F33	1		*	*	*	*	*	*
Reconfig Fail	ON/OFF	reconfigure was unsuccessful	6	0F33	2		*	*	*	*	*	*
Restore Pass	ON/OFF	restore was successful	6	0F33	3		*	*	*	*	*	*
Restore Fail	ON/OFF	restore was unsuccessful	6	0F33	4		*	*	*	*	*	*
CB Status Alarm	ON/OFF	CB Status Alarm	6	0F33	11		*	*	*	*	*	*
CB2 Status Alarm	ON/OFF	CB Status Alarm 2	6	0F33	12					*		*
Ch 1 Intertrip 1	ON/OFF	User Defined Intertrip	6	0F33	13		*	*	*	*	*	*
Ch 1 Intertrip 2	ON/OFF	User Defined Intertrip	6	0F33	14		*	*	*	*	*	*
Ch 1 Intertrip 3	ON/OFF	User Defined Intertrip	6	0F33	15		*	*	*	*	*	*
Ch 1 Intertrip 4	ON/OFF	User Defined Intertrip	6	0F33	16		*	*	*	*	*	*
Ch 1 Intertrip 5	ON/OFF	User Defined Intertrip	6	0F33	17		*	*	*	*	*	*
Ch 1 Intertrip 6	ON/OFF	User Defined Intertrip	6	0F33	18		*	*	*	*	*	*
Ch 1 Intertrip 7	ON/OFF	User Defined Intertrip	6	0F33	19		*	*	*	*	*	*
Ch 1 Intertrip 8	ON/OFF	User Defined Intertrip	6	0F33	20		*	*	*	*	*	*
Ch 2 Intertrip 1	ON/OFF	User Defined Intertrip	6	0F33	21		*	*	*	*	*	*
Ch 2 Intertrip 2	ON/OFF	User Defined Intertrip	6	0F33	22		*	*	*	*	*	*

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value		P541	P542	P543	P544	P545	P546
Ch 2 Intertrip 3	ON/OFF	User Defined Intertrip	6	0F33	23		*	*	*	*	*	*
Ch 2 Intertrip 4	ON/OFF	User Defined Intertrip	6	0F33	24		*	*	*	*	*	*
Ch 2 Intertrip 5	ON/OFF	User Defined Intertrip	6	0F33	25		*	*	*	*	*	*
Ch 2 Intertrip 6	ON/OFF	User Defined Intertrip	6	0F33	26		*	*	*	*	*	*
Ch 2 Intertrip 7	ON/OFF	User Defined Intertrip	6	0F33	27		*	*	*	*	*	*
Ch 2 Intertrip 8	ON/OFF	User Defined Intertrip	6	0F33	28		*	*	*	*	*	*
Ch1 Signal Lost	ON/OFF	Ch1 Loss Of Signal	6	0F34	14		*	*	*	*	*	*
Ch1 Path Yellow	ON/OFF	Ch1 Path "Yellow"	6	0F34	15		*	*	*	*	*	*
Ch1 Mismatch RxN	ON/OFF	Ch1 Mismatch Received N	6	0F34	16		*	*	*	*	*	*
Ch2 Signal Lost	ON/OFF	Ch2 Loss Of Signal	6	0F34	17		*	*	*	*	*	*
Ch2 Path Yellow	ON/OFF	Ch2 Path "Yellow"	6	0F34	18		*	*	*	*	*	*
Ch2 Mismatch RxN	ON/OFF	Ch2 Mismatch Received N	6	0F34	19		*	*	*	*	*	*
GOOSE VIP 1	ON/OFF	GOOSE Input 1	6	0F35	0		*	*	*	*	*	*
GOOSE VIP 2	ON/OFF	GOOSE Input 2	6	0F35	1		*	*	*	*	*	*
GOOSE VIP 3	ON/OFF	GOOSE Input 3	6	0F35	2		*	*	*	*	*	*
GOOSE VIP 4	ON/OFF	GOOSE Input 4	6	0F35	3		*	*	*	*	*	*
GOOSE VIP 5	ON/OFF	GOOSE Input 5	6	0F35	4		*	*	*	*	*	*
GOOSE VIP 6	ON/OFF	GOOSE Input 6	6	0F35	5		*	*	*	*	*	*
GOOSE VIP 7	ON/OFF	GOOSE Input 7	6	0F35	6		*	*	*	*	*	*
GOOSE VIP 8	ON/OFF	GOOSE Input 8	6	0F35	7		*	*	*	*	*	*
GOOSE VIP 9	ON/OFF	GOOSE Input 9	6	0F35	8		*	*	*	*	*	*
GOOSE VIP 10	ON/OFF	GOOSE Input 10	6	0F35	9		*	*	*	*	*	*
GOOSE VIP 11	ON/OFF	GOOSE Input 11	6	0F35	10		*	*	*	*	*	*
GOOSE VIP 12	ON/OFF	GOOSE Input 12	6	0F35	11		*	*	*	*	*	*
GOOSE VIP 13	ON/OFF	GOOSE Input 13	6	0F35	12		*	*	*	*	*	*
GOOSE VIP 14	ON/OFF	GOOSE Input 14	6	0F35	13		*	*	*	*	*	*
GOOSE VIP 15	ON/OFF	GOOSE Input 15	6	0F35	14		*	*	*	*	*	*
GOOSE VIP 16	ON/OFF	GOOSE Input 16	6	0F35	15		*	*	*	*	*	*
GOOSE VIP 17	ON/OFF	GOOSE Input 17	6	0F35	16		*	*	*	*	*	*
GOOSE VIP 18	ON/OFF	GOOSE Input 18	6	0F35	17		*	*	*	*	*	*
GOOSE VIP 19	ON/OFF	GOOSE Input 19	6	0F35	18		*	*	*	*	*	*
GOOSE VIP 20	ON/OFF	GOOSE Input 20	6	0F35	19		*	*	*	*	*	*
GOOSE VIP 21	ON/OFF	GOOSE Input 21	6	0F35	20		*	*	*	*	*	*
GOOSE VIP 22	ON/OFF	GOOSE Input 22	6	0F35	21		*	*	*	*	*	*
GOOSE VIP 23	ON/OFF	GOOSE Input 23	6	0F35	22		*	*	*	*	*	*
GOOSE VIP 24	ON/OFF	GOOSE Input 24	6	0F35	23		*	*	*	*	*	*
GOOSE VIP 25	ON/OFF	GOOSE Input 25	6	0F35	24		*	*	*	*	*	*

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value		P541	P542	P543	P544	P545	P546
GOOSE VIP 26	ON/OFF	GOOSE Input 26	6	0F35	25		*	*	*	*	*	*
GOOSE VIP 27	ON/OFF	GOOSE Input 27	6	0F35	26		*	*	*	*	*	*
GOOSE VIP 28	ON/OFF	GOOSE Input 28	6	0F35	27		*	*	*	*	*	*
GOOSE VIP 29	ON/OFF	GOOSE Input 29	6	0F35	28		*	*	*	*	*	*
GOOSE VIP 30	ON/OFF	GOOSE Input 30	6	0F35	29		*	*	*	*	*	*
GOOSE VIP 31	ON/OFF	GOOSE Input 31	6	0F35	30		*	*	*	*	*	*
GOOSE VIP 32	ON/OFF	GOOSE Input 32	6	0F35	31		*	*	*	*	*	*
GOOSE Out 1	ON/OFF	GOOSE Output 1	6	0F36	0		*	*	*	*	*	*
GOOSE Out 1	ON/OFF	GOOSE Output 2	6	0F36	1		*	*	*	*	*	*
GOOSE Out 2	ON/OFF	GOOSE Output 3	6	0F36	2		*	*	*	*	*	*
GOOSE Out 3	ON/OFF	GOOSE Output 4	6	0F36	3		*	*	*	*	*	*
GOOSE Out 4	ON/OFF	GOOSE Output 5	6	0F36	4		*	*	*	*	*	*
GOOSE Out 5	ON/OFF	GOOSE Output 6	6	0F36	5		*	*	*	*	*	*
GOOSE Out 6	ON/OFF	GOOSE Output 7	6	0F36	6		*	*	*	*	*	*
GOOSE Out 7	ON/OFF	GOOSE Output 8	6	0F36	7		*	*	*	*	*	*
GOOSE Out 8	ON/OFF	GOOSE Output 9	6	0F36	8		*	*	*	*	*	*
GOOSE Out 9	ON/OFF	GOOSE Output 10	6	0F36	9		*	*	*	*	*	*
GOOSE Out 10	ON/OFF	GOOSE Output 11	6	0F36	10		*	*	*	*	*	*
GOOSE Out 11	ON/OFF	GOOSE Output 12	6	0F36	11		*	*	*	*	*	*
GOOSE Out 12	ON/OFF	GOOSE Output 13	6	0F36	12		*	*	*	*	*	*
GOOSE Out 13	ON/OFF	GOOSE Output 14	6	0F36	13		*	*	*	*	*	*
GOOSE Out 14	ON/OFF	GOOSE Output 15	6	0F36	14		*	*	*	*	*	*
GOOSE Out 15	ON/OFF	GOOSE Output 16	6	0F36	15		*	*	*	*	*	*
GOOSE Out 16	ON/OFF	GOOSE Output 17	6	0F36	16		*	*	*	*	*	*
GOOSE Out 17	ON/OFF	GOOSE Output 18	6	0F36	17		*	*	*	*	*	*
GOOSE Out 18	ON/OFF	GOOSE Output 19	6	0F36	18		*	*	*	*	*	*
GOOSE Out 19	ON/OFF	GOOSE Output 20	6	0F36	19		*	*	*	*	*	*
GOOSE Out 20	ON/OFF	GOOSE Output 21	6	0F36	20		*	*	*	*	*	*
GOOSE Out 21	ON/OFF	GOOSE Output 22	6	0F36	21		*	*	*	*	*	*
GOOSE Out 22	ON/OFF	GOOSE Output 23	6	0F36	22		*	*	*	*	*	*
GOOSE Out 23	ON/OFF	GOOSE Output 24	6	0F36	23		*	*	*	*	*	*
GOOSE Out 24	ON/OFF	GOOSE Output 25	6	0F36	24		*	*	*	*	*	*
GOOSE Out 25	ON/OFF	GOOSE Output 26	6	0F36	25		*	*	*	*	*	*
GOOSE Out 26	ON/OFF	GOOSE Output 27	6	0F36	26		*	*	*	*	*	*
GOOSE Out 27	ON/OFF	GOOSE Output 28	6	0F36	27		*	*	*	*	*	*
GOOSE Out 28	ON/OFF	GOOSE Output 29	6	0F36	28		*	*	*	*	*	*
GOOSE Out 29	ON/OFF	GOOSE Output 30	6	0F36	29		*	*	*	*	*	*

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	P541	P542	P543	P544	P545	P546
GOOSE Out 30	ON/OFF	GOOSE Output 31	6	0F36	30	*	*	*	*	*	*
GOOSE Out 31	ON/OFF	GOOSE Output 32	6	0F36	31	*	*	*	*	*	*
		General Events			Unsigned Integer (32 bits)						
Alarms Cleared		Relay Alarms Cleared	7	FFFF	0	*	*	*	*	*	*
Events Cleared		Relay Event Records Cleared	7	0B01	1	*	*	*	*	*	*
Faults Cleared		Relay Fault Records Cleared	7	0B02	2	*	*	*	*	*	*
Maint Cleared		Relay Maintenance Records Cleared	7	0B03	3	*	*	*	*	*	*
PW Unlocked UI		Password Unlocked via User Interface	7	0002	4	*	*	*	*	*	*
PW Invalid UI		Invalid Password entered on User Interface	7	0002	5	*	*	*	*	*	*
PW1 Modified UI		Password Level 1 Modified on User Interface	7	0002	6	*	*	*	*	*	*
PW2 Modified UI		Password Level 2 Modified on User Interface	7	0002	7	*	*	*	*	*	*
PW Expired UI		Password unlock expired User Interface	7	0002	8	*	*	*	*	*	*
PW Unlocked F		Password Unlocked via Front Port	7	0002	9	*	*	*	*	*	*
PW Invalid F		Invalid Password entered on Front Port	7	0002	10	*	*	*	*	*	*
PW1 Modified F		Password Level 1 Modified on Front Port	7	0002	11	*	*	*	*	*	*
PW2 Modified F		Password Level 2 Modified on Front Port	7	0002	12	*	*	*	*	*	*
PW Expired F		Password unlock expired Front Port	7	0002	13	*	*	*	*	*	*
PW Unlocked R		Password Unlocked via Rear Port	7	0002	14	*	*	*	*	*	*
PW Invalid R		Invalid Password entered on Rear Port	7	0002	15	*	*	*	*	*	*
PW1 Modified R		Password Level 1 Modified on Rear Port	7	0002	16	*	*	*	*	*	*
PW2 Modified R		Password Level 2 Modified on Rear Port	7	0002	17	*	*	*	*	*	*
PW Expired R		Password unlock expired Rear Port	7	0002	18	*	*	*	*	*	*
IRIG-B Active		IRIG-B Timesync Active (Valid Signal)	7	0805	19	*	*	*	*	*	*
IRIG-B Inactive		IRIG-B Timesync Inactive (No Signal)	7	0805	20	*	*	*	*	*	*
Time Synch		Relay Clock Adjusted	7	0801	21	*	*	*	*	*	*
C&S Changed		Disturbance Recorder Settings Changed	7	FFFF	22	*	*	*	*	*	*
Dist Changed		Control and Support Settings Changed	7	0904	23	*	*	*	*	*	*
Group 1 Changed		Change to Protection Setting Group 1	7	0904	24	*	*	*	*	*	*
Group 2 Changed		Change to Protection Setting Group 2	7	0904	25	*	*	*	*	*	*
Group 3 Changed		Change to Protection Setting Group 3	7	0904	26	*	*	*	*	*	*
Group 4 Changed		Change to Protection Setting Group 4	7	0904	27	*	*	*	*	*	*
Act Grp Changed		Active Group Selection Changed	7	0903	28	*	*	*	*	*	*
Indication Reset		Relay Indications Reset	7	01FF	29	*	*	*	*	*	*
Power On		Relay Powered Up	7	FFFF	30	*	*	*	*	*	*
Bad GOOSE Logic		Invalid GOOSE Scheme Logic	7	FFFF	31	*	*	*	*	*	*
Bad Masks		Invalid Ethernet Card Masks	7	FFFF	32	*	*	*	*	*	*

Event Text 16 Chars	Additional Text	Event Description	Modbus Event Type G13	Courier Cell Ref	Value	P541	P542	P543	P544	P545	P546
Bad Deadbands		Invalid Ethernet Card Deadbands	7	FFFF	33	*	*	*	*	*	*
Bad DI Object		Invalid Ethernet Card DI Object	7	FFFF	34	*	*	*	*	*	*
Rear Comm 2 Fail		Rear Port 2 Communications Failure	7	FFFF	35	*	*	*	*	*	*
PW Unlocked R2		Password Unlocked via Rear Port 2	7	0002	36	*	*	*	*	*	*
PW Invalid R2		Invalid Password entered on Rear Port 2	7	0002	37	*	*	*	*	*	*
PW1 Modified R2		Password Level 1 Modified on Rear Port 2	7	0002	38	*	*	*	*	*	*
PW2 Modified R2		Password Level 2 Modified on Rear Port 2	7	0002	39	*	*	*	*	*	*
PW Expired R2		Password unlock expired Rear Port 2	7	0002	40	*	*	*	*	*	*
No Fibre Card		CS103 Optic Fibre Port Not Fitted	7	FFFF	41	*	*	*	*	*	*
NIC Link Fail		Ethernet Card Link Failure	7	FFFF	42	*	*	*	*	*	*
Fault Recorded		Fault Records:	8	Cell Ref 0100	Value Extraction Column 0 B000	Record Number 16bit UINT					
Text		Self Monitoring:		Cell Ref	Value Extraction Column	Record Number					
Maint Recorded		Maintenance Records	9	FFFF	0 B100	16bit UINT					
Maintenance Record Text:		**Description**			Continuous						
Fast W'Dog Error		Fast Watchdog Error				*	*	*	*	*	*
Battery Failure		Battery Failure			*	*	*	*	*	*	*
BBRAM Failure		Battery Back RAM Failure			*	*	*	*	*	*	*
Field Volt Fail		Field Voltage Failure			*	*	*	*	*	*	*
Bus Reset Error		Bus Error				*	*	*	*	*	*
Slow W'Dog Error		Slow Watchdog Error				*	*	*	*	*	*
SRAM Failure Bus		SRAM Bus Failure			*	*	*	*	*	*	*
SRAM Failure Blk		SRAM Block Failure			*	*	*	*	*	*	*
FLASH Failure		Flash checksum Error			*	*	*	*	*	*	*
Code Verify Fail		Software Code Verification Failure			*	*	*	*	*	*	*
EEPROM Failure		EEPROM Failure			*	*	*	*	*	*	*
Software Failure		Software Error			*	*	*	*	*	*	*
Hard Verify Fail		Hardware Verification Error				*	*	*	*	*	*
Non Standard		General Error			*	*	*	*	*	*	*
Ana. Sample fail		Ana. Sample fail			*	*	*	*	*	*	*
Set Commit Error		Setting commit failure			*	*	*	*	*	*	*

Digital Data Bus

DDB No	Source	Description	English Text	1	2	3	4	5	6
0	Output Condition	Output Relay 1	Output Label 1(Setting)	*	*	*	*	*	*
1	Output Condition	Output Relay 2	Output Label 2(Setting)	*	*	*	*	*	*
2	Output Condition	Output Relay 3	Output Label 3(Setting)	*	*	*	*	*	*
3	Output Condition	Output Relay 4	Output Label 4(Setting)	*	*	*	*	*	*
4	Output Condition	Output Relay 5	Output Label 5(Setting)	*	*	*	*	*	*
5	Output Condition	Output Relay 6	Output Label 6(Setting)	*	*	*	*	*	*
6	Output Condition	Output Relay 7	Output Label 7(Setting)	*	*	*	*	*	*
7	Output Condition	Output Relay 8	Output Label 8(Setting)		*	*	*	*	*
8	Output Condition	Output Relay 9	Output Label 9(Setting)		*	*	*	*	*
9	Output Condition	Output Relay 10	Output Label 10(Setting)		*	*	*	*	*
10	Output Condition	Output Relay 11	Output Label 11(Setting)		*	*	*	*	*
11	Output Condition	Output Relay 12	Output Label 12(Setting)		*	*	*	*	*
12	Output Condition	Output Relay 13	Output Label 13(Setting)		*	*	*	*	*
13	Output Condition	Output Relay 14	Output Label 14(Setting)		*	*	*	*	*
14	Output Condition	Output Relay 15	Output Label 15(Setting)					*	*
15	Output Condition	Output Relay 16	Output Label 16(Setting)					*	*
16	Output Condition	Output Relay 17	Output Label 17(Setting)					*	*
17	Output Condition	Output Relay 18	Output Label 18(Setting)					*	*
18	Output Condition	Output Relay 19	Output Label 19(Setting)					*	*
19	Output Condition	Output Relay 20	Output Label 20(Setting)					*	*
20	Output Condition	Output Relay 21	Output Label 21(Setting)					*	*
21	Output Condition	Output Relay 22	Output Label 22(Setting)					*	*
22	Output Condition	Output Relay 23	Output Label 23(Setting)					*	*
23	Output Condition	Output Relay 24	Output Label 24(Setting)					*	*
24	Output Condition	Output Relay 25	Output Label 25(Setting)					*	*
25	Output Condition	Output Relay 26	Output Label 26(Setting)					*	*
26	Output Condition	Output Relay 27	Output Label 27(Setting)					*	*
27	Output Condition	Output Relay 28	Output Label 28(Setting)					*	*
28	Output Condition	Output Relay 29	Output Label 29(Setting)					*	*
29	Output Condition	Output Relay 30	Output Label 30(Setting)					*	*
30	Output Condition	Output Relay 31	Output Label 31(Setting)					*	*
31	Output Condition	Output Relay 32	Output Label 32(Setting)					*	*
32	Opto	Opto Input 1	Opto Label 1(Setting)	*	*	*	*	*	*
33	Opto	Opto Input 2	Opto Label 2(Setting)	*	*	*	*	*	*
34	Opto	Opto Input 3	Opto Label 3(Setting)	*	*	*	*	*	*
35	Opto	Opto Input 4	Opto Label 4(Setting)	*	*	*	*	*	*
36	Opto	Opto Input 5	Opto Label 5(Setting)	*	*	*	*	*	*
37	Opto	Opto Input 6	Opto Label 6(Setting)	*	*	*	*	*	*
38	Opto	Opto Input 7	Opto Label 7(Setting)	*	*	*	*	*	*
39	Opto	Opto Input 8	Opto Label 8(Setting)	*	*	*	*	*	*
40	Opto	Opto Input 9	Opto Label 9(Setting)		*	*	*	*	*
41	Opto	Opto Input 10	Opto Label 10(Setting)		*	*	*	*	*
42	Opto	Opto Input 11	Opto Label 11(Setting)		*	*	*	*	*
43	Opto	Opto Input 12	Opto Label 12(Setting)		*	*	*	*	*
44	Opto	Opto Input 13	Opto Label 13(Setting)		*	*	*	*	*
45	Opto	Opto Input 14	Opto Label 14(Setting)		*	*	*	*	*
46	Opto	Opto Input 15	Opto Label 15(Setting)		*	*	*	*	*
47	Opto	Opto Input 16	Opto Label 16(Setting)		*	*	*	*	*
48	Opto	Opto Input 17	Opto Label 17(Setting)					*	*
49	Opto	Opto Input 18	Opto Label 18(Setting)					*	*
50	Opto	Opto Input 19	Opto Label 19(Setting)					*	*
51	Opto	Opto Input 20	Opto Label 20(Setting)					*	*
52	Opto	Opto Input 21	Opto Label 21(Setting)					*	*
53	Opto	Opto Input 22	Opto Label 22(Setting)					*	*
54	Opto	Opto Input 23	Opto Label 23(Setting)					*	*
55	Opto	Opto Input 24	Opto Label 24(Setting)					*	*
56		Unused							
57		Unused							
58		Unused							
59		Unused							
60		Unused							
61		Unused							
62		Unused							
63		Unused							
64	Output Condition	Programmable LED 1	LED 1	*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
65	Output Condition	Programmable LED 2	LED 2	*	*	*	*	*	*
66	Output Condition	Programmable LED 3	LED 3	*	*	*	*	*	*
67	Output Condition	Programmable LED 4	LED 4	*	*	*	*	*	*
68	Output Condition	Programmable LED 5	LED 5	*	*	*	*	*	*
69	Output Condition	Programmable LED 6	LED 6	*	*	*	*	*	*
70	Output Condition	Programmable LED 7	LED 7	*	*	*	*	*	*
71	Output Condition	Programmable LED 8	LED 8	*	*	*	*	*	*
72	PSL	Input to Relay Output Condition	Relay Cond 1	*	*	*	*	*	*
73	PSL	Input to Relay Output Condition	Relay Cond 2	*	*	*	*	*	*
74	PSL	Input to Relay Output Condition	Relay Cond 3	*	*	*	*	*	*
75	PSL	Input to Relay Output Condition	Relay Cond 4	*	*	*	*	*	*
76	PSL	Input to Relay Output Condition	Relay Cond 5	*	*	*	*	*	*
77	PSL	Input to Relay Output Condition	Relay Cond 6	*	*	*	*	*	*
78	PSL	Input to Relay Output Condition	Relay Cond 7	*	*	*	*	*	*
79	PSL	Input to Relay Output Condition	Relay Cond 8		*	*	*	*	*
80	PSL	Input to Relay Output Condition	Relay Cond 9		*	*	*	*	*
81	PSL	Input to Relay Output Condition	Relay Cond 10		*	*	*	*	*
82	PSL	Input to Relay Output Condition	Relay Cond 11		*	*	*	*	*
83	PSL	Input to Relay Output Condition	Relay Cond 12		*	*	*	*	*
84	PSL	Input to Relay Output Condition	Relay Cond 13		*	*	*	*	*
85	PSL	Input to Relay Output Condition	Relay Cond 14		*	*	*	*	*
86	PSL	Input to Relay Output Condition	Relay Cond 15					*	*
87	PSL	Input to Relay Output Condition	Relay Cond 16					*	*
88	PSL	Input to Relay Output Condition	Relay Cond 17					*	*
89	PSL	Input to Relay Output Condition	Relay Cond 18					*	*
90	PSL	Input to Relay Output Condition	Relay Cond 19					*	*
91	PSL	Input to Relay Output Condition	Relay Cond 20					*	*
92	PSL	Input to Relay Output Condition	Relay Cond 21					*	*
93	PSL	Input to Relay Output Condition	Relay Cond 22					*	*
94	PSL	Input to Relay Output Condition	Relay Cond 23					*	*
95	PSL	Input to Relay Output Condition	Relay Cond 24					*	*
96	PSL	Input to Relay Output Condition	Relay Cond 25					*	*
97	PSL	Input to Relay Output Condition	Relay Cond 26					*	*
98	PSL	Input to Relay Output Condition	Relay Cond 27					*	*
99	PSL	Input to Relay Output Condition	Relay Cond 28					*	*
100	PSL	Input to Relay Output Condition	Relay Cond 29					*	*
101	PSL	Input to Relay Output Condition	Relay Cond 30					*	*
102	PSL	Input to Relay Output Condition	Relay Cond 31					*	*
103	PSL	Input to Relay Output Condition	Relay Cond 32					*	*
104	PSL	Input to LED Output Condition	LED Cond IN 1	*	*	*	*	*	*
105	PSL	Input to LED Output Condition	LED Cond IN 2	*	*	*	*	*	*
106	PSL	Input to LED Output Condition	LED Cond IN 3	*	*	*	*	*	*
107	PSL	Input to LED Output Condition	LED Cond IN 4	*	*	*	*	*	*
108	PSL	Input to LED Output Condition	LED Cond IN 5	*	*	*	*	*	*
109	PSL	Input to LED Output Condition	LED Cond IN 6	*	*	*	*	*	*
110	PSL	Input to LED Output Condition	LED Cond IN 7	*	*	*	*	*	*
111	PSL	Input to LED Output Condition	LED Cond IN 8	*	*	*	*	*	*
112	PSL	Input to Auxiliary Timer 1	Timer in 1	*	*	*	*	*	*
113	PSL	Input to Auxiliary Timer 2	Timer in 2	*	*	*	*	*	*
114	PSL	Input to Auxiliary Timer 3	Timer in 3	*	*	*	*	*	*
115	PSL	Input to Auxiliary Timer 4	Timer in 4	*	*	*	*	*	*
116	PSL	Input to Auxiliary Timer 5	Timer in 5	*	*	*	*	*	*
117	PSL	Input to Auxiliary Timer 6	Timer in 6	*	*	*	*	*	*
118	PSL	Input to Auxiliary Timer 7	Timer in 7	*	*	*	*	*	*
119	PSL	Input to Auxiliary Timer 8	Timer in 8	*	*	*	*	*	*
120	PSL	Input to Auxiliary Timer 9	Timer in 9	*	*	*	*	*	*
121	PSL	Input to Auxiliary Timer 10	Timer in 10	*	*	*	*	*	*
122	PSL	Input to Auxiliary Timer 11	Timer in 11	*	*	*	*	*	*
123	PSL	Input to Auxiliary Timer 12	Timer in 12	*	*	*	*	*	*
124	PSL	Input to Auxiliary Timer 13	Timer in 13	*	*	*	*	*	*
125	PSL	Input to Auxiliary Timer 14	Timer in 14	*	*	*	*	*	*
126	PSL	Input to Auxiliary Timer 15	Timer in 15	*	*	*	*	*	*
127	PSL	Input to Auxiliary Timer 16	Timer in 16	*	*	*	*	*	*
128	Auxiliary Timer	Output from Auxiliary Timer 1	Timer out 1	*	*	*	*	*	*
129	Auxiliary Timer	Output from Auxiliary Timer 2	Timer out 2	*	*	*	*	*	*
130	Auxiliary Timer	Output from Auxiliary Timer 3	Timer out 3	*	*	*	*	*	*
131	Auxiliary Timer	Output from Auxiliary Timer 4	Timer out 4	*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
132	Auxiliary Timer	Output from Auxiliary Timer 5	Timer out 5	*	*	*	*	*	*
133	Auxiliary Timer	Output from Auxiliary Timer 6	Timer out 6	*	*	*	*	*	*
134	Auxiliary Timer	Output from Auxiliary Timer 7	Timer out 7	*	*	*	*	*	*
135	Auxiliary Timer	Output from Auxiliary Timer 8	Timer out 8	*	*	*	*	*	*
136	Auxiliary Timer	Output from Auxiliary Timer 9	Timer out 9	*	*	*	*	*	*
137	Auxiliary Timer	Output from Auxiliary Timer 10	Timer out 10	*	*	*	*	*	*
138	Auxiliary Timer	Output from Auxiliary Timer 11	Timer out 11	*	*	*	*	*	*
139	Auxiliary Timer	Output from Auxiliary Timer 12	Timer out 12	*	*	*	*	*	*
140	Auxiliary Timer	Output from Auxiliary Timer 13	Timer out 13	*	*	*	*	*	*
141	Auxiliary Timer	Output from Auxiliary Timer 14	Timer out 14	*	*	*	*	*	*
142	Auxiliary Timer	Output from Auxiliary Timer 15	Timer out 15	*	*	*	*	*	*
143	Auxiliary Timer	Output from Auxiliary Timer 16	Timer out 16	*	*	*	*	*	*
144	PSL	Trigger for Fault Recorder	Fault REC TRIG	*	*	*	*	*	*
145	Group Selection	Setting Group via opto invalid	SG-opto Invalid	*	*	*	*	*	*
146	Commission Test	Test Mode Enabled	Prot'n Disabled	*	*	*	*	*	*
147	VT Supervision	VTS Indication	VT Fail Alarm			*	*	*	*
148	Distance	Power Swing	Power Swing			*	*	*	*
149	Breaker Fail	BF Block AR	CB Fail Alarm	*	*	*	*	*	*
150	CB Monitoring	Broken Current Alarm	I^ Maint Alarm	*	*	*		*	
151	CB Monitoring	Broken Current lookout	I^ Lockout Alarm	*	*	*		*	
152	CB Monitoring	Maintenance Alarm	CB OPs Maint	*	*	*		*	
153	CB Monitoring	Maintenance Lockout	CB OPs Lock	*	*	*		*	
154	CB Monitoring	Excessive Op Time Alarm	CB Time Maint	*	*	*		*	
155	CB Monitoring	Excessive Op Time Lookout	CB Time Lockout	*	*	*		*	
156	CB Monitoring	EFF Lockout	Fault Freq Lock	*	*	*		*	
157	CB Status	CB Status Alarm	CB Status Alarm	*	*	*	*	*	*
158	Current Differential	GPS Alarm	GPS Alarm					*	*
159	CB Control	CB Failed to Trip	CB Trip Fail	*	*	*	*	*	*
160	CB Control	CB Failed to Close	CB Close Fail	*	*	*	*	*	*
161	CB Control	Control CB Unhealthy	Man CB Unhealthy	*	*	*	*	*	*
162	CB Control	Control No Checksync	No C/S Man Close			*		*	
163	Autoreclose	Autoclose Lockout/RLY BAR	A/R Lockout		*	*		*	
163	Breaker Fail	Autoclose Lockout/RLY BAR	CB2 Fail Alarm				*		*
164	Autoreclose	No Healthy (AR)	A/R CB Unhealthy		*	*		*	
165	Autoreclose	No Check Sync / AR Fail	A/R No Checksync			*		*	
166	Current Differential	Incompatible relays	Incompatible Rly	*	*	*	*	*	*
167	Commission Test	Loop Back Test Enabled	Test Loopback	*	*	*	*	*	*
168	Current Differential	Signaling failure alarm	Signalling Fail	*	*	*	*	*	*
169	Current Differential	Signaling Propagation Delay Alarm	Comm Delay Alarm	*	*	*	*	*	*
170	Current Differential	Differential protection failure alarm	C Diff Failure	*	*	*	*	*	*
171	Current Differential	Diff Protection inhibited	C Diff Inhibited	*	*	*	*	*	*
172	Current Differential	Configuration Error	Config Error	*	*	*	*	*	*
173	Current Differential	Re-Configuration Error	Re-Config Error	*	*	*	*	*	*
174	Frequency Tracking	Frequency out of range	F out of range	*	*	*	*	*	*
175		Unused	Alarm 36	*	*	*	*	*	*
176		Unused	Alarm 37	*	*	*	*	*	*
177		Unused	Alarm 38	*	*	*	*	*	*
178		Unused	Alarm 39	*	*	*	*	*	*
179		Unused	Alarm 40	*	*	*	*	*	*
180		Unused	Alarm 41	*	*	*	*	*	*
181		Unused	Alarm 42	*	*	*	*	*	*
182		Unused	Alarm 43	*	*	*	*	*	*
183		Unused	Alarm 44	*	*	*	*	*	*
184		C Diff Protection Comms Mode	Alarm 45	*	*	*	*	*	*
185		IEEE C37.94 Communications Alarms	Alarm 46	*	*	*	*	*	*
186		System Split alarm	Alarm 47	*	*	*	*	*	*
187	PSL	SR User Alarm 1	Alarm 48	*	*	*	*	*	*
188	PSL	SR User Alarm 2	Alarm 49	*	*	*	*	*	*
189	PSL	SR User Alarm 3	Alarm 50	*	*	*	*	*	*
190	PSL	SR User Alarm 4	Alarm 51	*	*	*	*	*	*
191	PSL	SR User Alarm 5	Alarm 52	*	*	*	*	*	*
192	PSL	SR User Alarm 6	Alarm 53	*	*	*	*	*	*
193	PSL	SR User Alarm 7	Alarm 54	*	*	*	*	*	*
194	PSL	SR User Alarm 8	Alarm 55	*	*	*	*	*	*
195	PSL	MR User Alarm 9	Alarm 56	*	*	*	*	*	*
196	PSL	MR User Alarm 10	Alarm 57	*	*	*	*	*	*
197	PSL	MR User Alarm 11	Alarm 58	*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
198	PSL	MR User Alarm 12	Alarm 59	*	*	*	*	*	*
199	PSL	MR User Alarm 13	Alarm 60	*	*	*	*	*	*
200	PSL	MR User Alarm 14	Alarm 61	*	*	*	*	*	*
201	PSL	MR User Alarm 15	Alarm 62	*	*	*	*	*	*
202	PSL	MR User Alarm 16	Alarm 63	*	*	*	*	*	*
203		Reserved							
204		Reserved							
205		Reserved							
206		Reserved							
207		Unused							
208		Unused							
209		Unused							
210		Unused							
211		Unused							
212		Unused							
213		Unused							
214		Unused							
215		Unused							
216		Unused							
217		Unused							
218		Unused							
219		Unused							
220		Unused							
221		Unused							
222		Unused							
223		Unused							
224	Menu		Control Input 1	*	*	*	*	*	*
225	Menu		Control Input 2	*	*	*	*	*	*
226	Menu		Control Input 3	*	*	*	*	*	*
227	Menu		Control Input 4	*	*	*	*	*	*
228	Menu		Control Input 5	*	*	*	*	*	*
229	Menu		Control Input 6	*	*	*	*	*	*
230	Menu		Control Input 7	*	*	*	*	*	*
231	Menu		Control Input 8	*	*	*	*	*	*
232	Menu		Control Input 9	*	*	*	*	*	*
233	Menu		Control Input 10	*	*	*	*	*	*
234	Menu		Control Input 11	*	*	*	*	*	*
235	Menu		Control Input 12	*	*	*	*	*	*
236	Menu		Control Input 13	*	*	*	*	*	*
237	Menu		Control Input 14	*	*	*	*	*	*
238	Menu		Control Input 15	*	*	*	*	*	*
239	Menu		Control Input 16	*	*	*	*	*	*
240	Menu		Control Input 17	*	*	*	*	*	*
241	Menu		Control Input 18	*	*	*	*	*	*
242	Menu		Control Input 19	*	*	*	*	*	*
243	Menu		Control Input 20	*	*	*	*	*	*
244	Menu		Control Input 21	*	*	*	*	*	*
245	Menu		Control Input 22	*	*	*	*	*	*
246	Menu		Control Input 23	*	*	*	*	*	*
247	Menu		Control Input 24	*	*	*	*	*	*
248	Menu		Control Input 25	*	*	*	*	*	*
249	Menu		Control Input 26	*	*	*	*	*	*
250	Menu		Control Input 27	*	*	*	*	*	*
251	Menu		Control Input 28	*	*	*	*	*	*
252	Menu		Control Input 29	*	*	*	*	*	*
253	Menu		Control Input 30	*	*	*	*	*	*
254	Menu		Control Input 31	*	*	*	*	*	*
255	Menu		Control Input 32	*	*	*	*	*	*
256	PSL	Permissive Intertrip	Perm Intertrip	*	*	*	*	*	*
257	PSL	Stub Bus Enabled	Stub Bus Enabled				*		*
258	PSL	Inhibit Current Differential	Inhibit C Diff	*	*	*	*	*	*
259	PSL	Reconfiguration Interlock	Recon Interlock	*	*	*	*	*	*
260	PSL	Block Phase Overcurrent Stage 1 time delay	I>1 Timer Block	*	*	*	*	*	*
261	PSL	Block Phase Overcurrent Stage 2 time delay	I>2 Timer Block	*	*	*	*	*	*
262	PSL	Block Phase Overcurrent Stage 3 time delay	I>3 Timer Block	*	*	*	*	*	*
263	PSL	Block Phase Overcurrent Stage 4 time delay	I>4 Timer Block	*	*	*	*	*	*
264	PSL	Block Standby Earth Fault Stage 1 time delay	IN>1 Timer Block	*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
265	PSL	Block Standby Earth Fault Stage 2 time delay	IN>2 Timer Block	*	*	*	*	*	*
266	PSL	Block Standby Earth Fault Stage 3 time delay	IN>3 Timer Block	*	*	*	*	*	*
267	PSL	Block Standby Earth Fault Stage 4 time delay	IN>4 Timer Block	*	*	*	*	*	*
268	PSL	Block SEF Stage 1 time delay	ISEF>1 Timer Blk			*	*	*	*
269	PSL	Block SEF Stage 2 time delay	ISEF>2 Timer Blk			*	*	*	*
270	PSL	Block SEF Stage 3 time delay	ISEF>3 Timer Blk			*	*	*	*
271	PSL	Block SEF Stage 4 time delay	ISEF>4 Timer Blk			*	*	*	*
272	PSL	External Trip 3ph	External Trip3ph	*	*	*	*	*	*
273	PSL	External Trip A	External Trip A			*	*	*	*
274	PSL	External Trip B	External Trip B			*	*	*	*
275	PSL	External Trip C	External Trip C			*	*	*	*
276	PSL	CB2 External Trip 3Ph	CB2 Ext Trip3ph				*		*
277	PSL	CB2 External Trip Aph	CB2 Ext Trip A				*		*
278	PSL	CB2 External Trip Bph	CB2 Ext Trip B				*		*
279	PSL	CB2 External Trip Cph	CB2 Ext Trip C				*		*
280	PSL	52-A CB Contact Input	CB Aux 3ph(52-A)	*	*	*	*	*	*
281	PSL	52-A CB Contact Input A Phase	CB Aux A(52-A)			*	*	*	*
282	PSL	52-A CB Contact Input B Phase	CB Aux B(52-A)			*	*	*	*
283	PSL	52-A CB Contact Input C Phase	CB Aux C(52-A)			*	*	*	*
284	PSL	52-B CB Contact Input	CB Aux 3ph(52-B)	*	*	*	*	*	*
285	PSL	52-B CB Contact Input A Phase	CB Aux A(52-B)			*	*	*	*
286	PSL	52-B CB Contact Input B Phase	CB Aux B(52-B)			*	*	*	*
287	PSL	52-B CB Contact Input C Phase	CB Aux C(52-B)			*	*	*	*
288	PSL	52-A CB 2 Contact Input	CB2Aux 3ph(52-A)				*		*
289	PSL	52-A CB Contact Input A Phase	CB2Aux A(52-A)				*		*
290	PSL	52-A CB Contact Input B Phase	CB2Aux B(52-A)				*		*
291	PSL	52-A CB Contact Input C Phase	CB2Aux C(52-A)				*		*
292	PSL	52-B CB Contact Input	CB2Aux 3ph(52-B)				*		*
293	PSL	52-B CB Contact Input A Phase	CB2Aux A(52-B)				*		*
294	PSL	52-B CB Contact Input B Phase	CB2Aux B(52-B)				*		*
295	PSL	52-B CB Contact Input C Phase	CB2Aux C(52-B)				*		*
296	PSL	CB Healthy	CB Healthy	*	*	*	*	*	*
297	PSL	CB Healthy 2	CB2 Healthy				*		*
298	PSL	MCB/VTS opto	MCB/VTS			*	*	*	*
299	PSL	Logic Input Trip	Trip CB	*	*	*	*	*	*
300	PSL	Logic Input Close	Close CB	*	*	*	*	*	*
301	PSL	Logic Input Trip 2	Trip CB2				*		*
302	PSL	Logic Input Close 2	Close CB2				*		*
303	PSL	Reset Manual CB Close Timer Delay	Reset Close Dly	*	*	*	*	*	*
304	PSL	Reset Latched Relays & LED's	Reset Relays/LED	*	*	*	*	*	*
305	PSL	Reset Thermal State	Reset Thermal	*	*	*	*	*	*
306	PSL	Reset Lockout Opto Input	Reset Lockout		*	*		*	
307	PSL	Reset CB Maintance values	Reset CB Data	*	*	*		*	
308	PSL	Block Autoreclose / BAR	BAR		*	*		*	
309	PSL	Enable 1 pole reclose	En 1pole reclose			*		*	
310	PSL	Enable 3 pole reclose	En 3pole reclose			*		*	
311	PSL	Pole Discrepancy	Pole Discrepancy			*		*	
312		Unused							
313	PSL	Inhibit Power Swing Blocking	Inhibit PSB			*	*	*	*
314	PSL	Trip 3 Phase - Input to Trip Latching Logic	Any 3 Pole Trip			*	*	*	*
315	PSL	A Phase Trip- Input to Trip Latching Logic	Any Trip A			*	*	*	*
316	PSL	B Phase Trip- Input to Trip Latching Logic	Any Trip B			*	*	*	*
317	PSL	C Phase Trip- Input to Trip Latching Logic	Any Trip C			*	*	*	*
318	PSL	Commissioning Tests	Test Mode	*	*	*	*	*	*
319	PSL	Propagagtion Delay Equal	Prop Delay Equal	*	*	*	*	*	*
320	PSL	User Defined Intertrip	Ch 1 Intertrip 1	*	*	*	*	*	*
321	PSL	User Defined Intertrip	Ch 1 Intertrip 2	*	*	*	*	*	*
322	PSL	User Defined Intertrip	Ch 1 Intertrip 3	*	*	*	*	*	*
323	PSL	User Defined Intertrip	Ch 1 Intertrip 4	*	*	*	*	*	*
324	PSL	User Defined Intertrip	Ch 1 Intertrip 5	*	*	*	*	*	*
325	PSL	User Defined Intertrip	Ch 1 Intertrip 6	*	*	*	*	*	*
326	PSL	User Defined Intertrip	Ch 1 Intertrip 7	*	*	*	*	*	*
327	PSL	User Defined Intertrip	Ch 1 Intertrip 8	*	*	*	*	*	*
328	PSL	User Defined Intertrip	Ch 2 Intertrip 1	*	*	*	*	*	*
329	PSL	User Defined Intertrip	Ch 2 Intertrip 2	*	*	*	*	*	*
330	PSL	User Defined Intertrip	Ch 2 Intertrip 3	*	*	*	*	*	*
331	PSL	User Defined Intertrip	Ch 2 Intertrip 4	*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
332	PSL	User Defined Intertrip	Ch 2 Intertrip 5	*	*	*	*	*	*
333	PSL	User Defined Intertrip	Ch 2 Intertrip 6	*	*	*	*	*	*
334	PSL	User Defined Intertrip	Ch 2 Intertrip 7	*	*	*	*	*	*
335	PSL	User Defined Intertrip	Ch 2 Intertrip 8	*	*	*	*	*	*
336	PSL	Loopback	Loopback Mode	*	*	*	*	*	*
337	PSL	Block Distance Zone 1	Z1 Block			*	*	*	*
338	PSL	Block Distance Zone 2	Z2 Block			*	*	*	*
339	PSL	Block Distance Zone 3	Z3 Block			*	*	*	*
340	PSL	Command Blocking	Command Blocking	*	*	*	*	*	*
341	PSL	Monitor Blocking	Monitor Blocking	*	*	*	*	*	*
342	PSL	PSB Unblock	PSB Unblock			*	*	*	*
343	PSL	CS1 Enabled	CS1 Enabled			*		*	
344	PSL	CS2 Enabled	CS2 Enabled			*		*	
345	PSL	SysSplit Enabled	SysSplit Enabled			*		*	
346	PSL		AR Check Sync OK			*		*	
347	PSL	Time Synch	Time Synch	*	*	*	*	*	*
348		Unused							
349		Unused							
350	All Protection	Any Trip	Any Trip	*	*	*	*	*	*
351	Current Differential	Differential Trip	Diff Trip	*	*	*	*	*	*
352	Current Differential	Differential Trip A	Diff Trip A	*	*	*	*	*	*
353	Current Differential	Differential Trip B	Diff Trip B	*	*	*	*	*	*
354	Current Differential	Differential Trip C	Diff Trip C	*	*	*	*	*	*
355	Current Differential	Differential Intertrip	Diff Intertrip	*	*	*	*	*	*
356	Current Differential	Differential Intertrip A	Diff Intertrip A	*	*	*	*	*	*
357	Current Differential	Differential Intertrip B	Diff Intertrip B	*	*	*	*	*	*
358	Current Differential	Differential Intertrip C	Diff Intertrip C	*	*	*	*	*	*
359	Current Differential	Direct Intertrip	Direct Intertrip						
360	Current Differential	Permissive Intertrip	Perm Intertrip	*	*	*	*	*	*
361	Distance	Any Zone 1 Trip	Zone 1 Trip			*	*	*	*
362	Distance	Zone 1 A Phase Trip	Zone 1 A Trip			*	*	*	*
363	Distance	Zone 1 B Phase Trip	Zone 1 B Trip			*	*	*	*
364	Distance	Zone 1 C Phase Trip	Zone 1 C Trip			*	*	*	*
365	Distance	Zone 1 N Trip	Zone 1 N Trip			*	*	*	*
366	Distance	Any Zone 2 Trip	Zone 2 Trip			*	*	*	*
367	Distance	Zone 2 A Phase Trip	Zone 2 A Trip			*	*	*	*
368	Distance	Zone 2 B Phase Trip	Zone 2 B Trip			*	*	*	*
369	Distance	Zone 2 C Phase Trip	Zone 2 C Trip			*	*	*	*
370	Distance	Zone 2 N Trip	Zone 2 N Trip			*	*	*	*
371	Distance	Any Zone 3 Trip	Zone 3 Trip			*	*	*	*
372	Distance	Zone 3 A Phase Trip	Zone 3 A Trip			*	*	*	*
373	Distance	Zone 3 B Phase Trip	Zone 3 B Trip			*	*	*	*
374	Distance	Zone 3 C Phase Trip	Zone 3 C Trip			*	*	*	*
375	Distance	Zone 3 N Trip	Zone 3 N Trip			*	*	*	*
376	Autoreclose	Pole Discrepancy	Pole Discrepancy			*		*	
377	Current Differential	BU Intertrip	BU Intertrip	*	*	*	*	*	*
378	Current Differential	BU Intertrip A	BU Intertrip A	*	*	*	*	*	*
379	Current Differential	BU Intertrip B	BU Intertrip B	*	*	*	*	*	*
380	Current Differential	BU Intertrip C	BU Intertrip C	*	*	*	*	*	*
381	Current Differential	Force 3 pole backup Intertrip	Force 3pole BU			*	*	*	*
382	Phase Overcurrent	1st Stage O/C Trip 3ph	I>1 Trip	*	*	*	*	*	*
383	Phase Overcurrent	1st Stage O/C Trip A	I>1 Trip A	*	*	*	*	*	*
384	Phase Overcurrent	1st Stage O/C Trip B	I>1 Trip B	*	*	*	*	*	*
385	Phase Overcurrent	1st Stage O/C Trip C	I>1 Trip C	*	*	*	*	*	*
386	Phase Overcurrent	2nd Stage O/C Trip 3ph	I>2 Trip	*	*	*	*	*	*
387	Phase Overcurrent	2nd Stage O/C Trip A	I>2 Trip A	*	*	*	*	*	*
388	Phase Overcurrent	2nd Stage O/C Trip B	I>2 Trip B	*	*	*	*	*	*
389	Phase Overcurrent	2nd Stage O/C Trip C	I>2 Trip C	*	*	*	*	*	*
390	Phase Overcurrent	3rd Stage O/C Trip 3ph	I>3 Trip	*	*	*	*	*	*
391	Phase Overcurrent	3rd Stage O/C Trip A	I>3 Trip A	*	*	*	*	*	*
392	Phase Overcurrent	3rd Stage O/C Trip B	I>3 Trip B	*	*	*	*	*	*
393	Phase Overcurrent	3rd Stage O/C Trip C	I>3 Trip C	*	*	*	*	*	*
394	Phase Overcurrent	4th Stage O/C Trip 3ph	I>4 Trip	*	*	*	*	*	*
395	Phase Overcurrent	4th Stage O/C Trip A	I>4 Trip A	*	*	*	*	*	*
396	Phase Overcurrent	4th Stage O/C Trip B	I>4 Trip B	*	*	*	*	*	*
397	Phase Overcurrent	4th Stage O/C Trip C	I>4 Trip C	*	*	*	*	*	*
398	Earth Fault	1st Stage SBEF Trip	IN>1 Trip	*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
399	Earth Fault	2nd Stage SBEF Trip	IN>2 Trip	*	*	*	*	*	*
400	Earth Fault	3rd Stage SBEF Trip	IN>3 Trip	*	*	*	*	*	*
401	Earth Fault	4th Stage SBEF Trip	IN>4 Trip	*	*	*	*	*	*
402	Sensitive Earth Fault	1st Stage SEF Trip	ISEF>1 Trip			*	*	*	*
403	Sensitive Earth Fault	2nd Stage SEF Trip	ISEF>2 Trip			*	*	*	*
404	Sensitive Earth Fault	3rd Stage SEF Trip	ISEF>3 Trip			*	*	*	*
405	Sensitive Earth Fault	4th Stage SEF Trip	ISEF>4 Trip			*	*	*	*
406	Broken Conductor	Broken Conductor Trip	Broken Wire Trip	*	*	*	*	*	*
407	Thermal Overload	Thermal Overload Trip	Thermal Trip	*	*	*	*	*	*
408	Current Differential	Stub Bus Trip	Stub Bus Trip				*		*
409	Autoreclose	Autoreclose trip test	Trip 3 Pole		*	*		*	
410	Autoreclose	Autoreclose trip test A phase	Trip Pole A			*		*	
411	Autoreclose	Autoreclose trip test B phase	Trip Pole B			*		*	
412	Autoreclose	Autoreclose trip test C Phase	Trip Pole C			*		*	
413		Unused							
414		Unused							
415		Unused							
416		Unused							
417		Unused							
418		Unused							
419		Unused							
420		Unused							
421		Unused							
422		Unused							
423		Unused							
424		Unused							
425		Unused							
426		Unused							
427		Unused							
428		Unused							
429		Unused							
430		Zone 1 Start	Zone 1 Start			*	*	*	*
431		Zone 2 Start	Zone 2 Start			*	*	*	*
432		Zone 3 Start	Zone 3 Start			*	*	*	*
433		Differential Start	Diff Start	*	*	*	*	*	*
434	All Protection	Any Start	Any Start	*	*	*	*	*	*
435	Current Differential	Differential Start A	Diff Start A	*	*	*	*	*	*
436	Current Differential	Differential Start B	Diff Start B	*	*	*	*	*	*
437	Current Differential	Differential Start C	Diff Start C	*	*	*	*	*	*
438	Distance	Zone 1 A Phase Start	Zone 1 A Start			*	*	*	*
439	Distance	Zone 1 B Phase Start	Zone 1 B Start			*	*	*	*
440	Distance	Zone 1 C Phase Start	Zone 1 C Start			*	*	*	*
441	Distance	Zone 1 N Start	Zone 1 N Start			*	*	*	*
442	Distance	Zone 2 A Phase Start	Zone 2 A Start			*	*	*	*
443	Distance	Zone 2 B Phase Start	Zone 2 B Start			*	*	*	*
444	Distance	Zone 2 C Phase Start	Zone 2 C Start			*	*	*	*
445	Distance	Zone 2 N Start	Zone 2 N Start			*	*	*	*
446	Distance	Zone 3 A Phase Start	Zone 3 A Start			*	*	*	*
447	Distance	Zone 3 B Phase Start	Zone 3 B Start			*	*	*	*
448	Distance	Zone 3 C Phase Start	Zone 3 C Start			*	*	*	*
449	Distance	Zone 3 N Start	Zone 3 N Start			*	*	*	*
450	Distance	Zone 6 Start (PSB Start)	Zone 6 Start			*	*	*	*
451	Overcurrent	1st Stage O/C Start 3ph	I>1 Start	*	*	*	*	*	*
452	Overcurrent	1st Stage O/C Start A	I>1 Start A	*	*	*	*	*	*
453	Overcurrent	1st Stage O/C Start B	I>1 Start B	*	*	*	*	*	*
454	Overcurrent	1st Stage O/C Start C	I>1 Start C	*	*	*	*	*	*
455	Overcurrent	2nd Stage O/C Start 3ph	I>2 Start	*	*	*	*	*	*
456	Overcurrent	2nd Stage O/C Start A	I>2 Start A	*	*	*	*	*	*
457	Overcurrent	2nd Stage O/C Start B	I>2 Start B	*	*	*	*	*	*
458	Overcurrent	2nd Stage O/C Start C	I>2 Start C	*	*	*	*	*	*
459	Overcurrent	3rd Stage O/C Start 3ph	I>3 Start	*	*	*	*	*	*
460	Overcurrent	3rd Stage O/C Start A	I>3 Start A	*	*	*	*	*	*
461	Overcurrent	3rd Stage O/C Start B	I>3 Start B	*	*	*	*	*	*
462	Overcurrent	3rd Stage O/C Start C	I>3 Start C	*	*	*	*	*	*
463	Overcurrent	4th Stage O/C Start 3ph	I>4 Start	*	*	*	*	*	*
464	Overcurrent	4th Stage O/C Start A	I>4 Start A	*	*	*	*	*	*
465	Overcurrent	4th Stage O/C Start B	I>4 Start B	*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
466	Overcurrent	4th Stage O/C Start C	I>4 Start C	*	*	*	*	*	*
467	Earth Fault	1st Stage SBEF Start	IN>1 Start	*	*	*	*	*	*
468	Earth Fault	2nd Stage SBEF Start	IN>2 Start	*	*	*	*	*	*
469	Earth Fault	3rd Stage SBEF Start	IN>3 Start	*	*	*	*	*	*
470	Earth Fault	4th Stage SBEF Start	IN>4 Start	*	*	*	*	*	*
471	Sensitive Earth Fault	1st Stage SEF Start	ISEF>1 Start			*	*	*	*
472	Sensitive Earth Fault	2nd Stage SEF Start	ISEF>2 Start			*	*	*	*
473	Sensitive Earth Fault	3rd Stage SEF Start	ISEF>3 Start			*	*	*	*
474	Sensitive Earth Fault	4th Stage SEF Start	ISEF>4 Start			*	*	*	*
475	Thermal Overload	Thermal Overload Alarm	Thermal Alarm	*	*	*	*	*	*
476	Overcurrent	I> Blocked O/C Start	I> BlockStart	*	*	*	*	*	*
477	Overcurrent	IN/ISEF> Blocked O/C Start	IN/SEF>Blk Start	*	*	*	*	*	*
478		Unused							
479		Unused							
480		Unused							
481		Unused							
482		Unused							
483		Unused							
484		Unused							
485		Unused							
486		Unused							
487	Battery Fail Monitor	Platform Alarm 0	Battery Fail	*	*	*	*	*	*
488		Platform Alarm 2		*	*	*	*	*	*
489	Ehernet Card	Platform Alarm 3	GOOSE IED Absent	*	*	*	*	*	*
490	Ehernet Card	Platform Alarm 4	NIC Not Fitted	*	*	*	*	*	*
491	Ehernet Card	Platform Alarm 5	NIC No Response	*	*	*	*	*	*
492	Ehernet Card	Platform Alarm 6	NIC Fatal Error	*	*	*	*	*	*
493	Ehernet Card	Platform Alarm 7	NIC Soft. Reload	*	*	*	*	*	*
494	Ehernet Card	Platform Alarm 8	Bad TCP/IP Cfg.	*	*	*	*	*	*
495	Ehernet Card	Platform Alarm 9	Bad OSI Config.	*	*	*	*	*	*
496	Ehernet Card	Platform Alarm 10	NIC Link Fail	*	*	*	*	*	*
497	Ehernet Card	Platform Alarm 11	NIC SW Mis-Match	*	*	*	*	*	*
498	Ehernet Card	Platform Alarm 12	IP Addr Conflict	*	*	*	*	*	*
499		Platform Alarm 13		*	*	*	*	*	*
500		Platform Alarm 14		*	*	*	*	*	*
501		Platform Alarm 15		*	*	*	*	*	*
502		Platform Alarm 16		*	*	*	*	*	*
503		Platform Alarm 17	Backup Setting	*	*	*	*	*	*
504		Platform Alarm 18		*	*	*	*	*	*
505		Platform Alarm 19		*	*	*	*	*	*
506		Platform Alarm 20		*	*	*	*	*	*
507		Platform Alarm 21		*	*	*	*	*	*
508		Platform Alarm 22		*	*	*	*	*	*
509		Platform Alarm 23		*	*	*	*	*	*
510		Platform Alarm 24		*	*	*	*	*	*
511		Platform Alarm 25		*	*	*	*	*	*
512		Platform Alarm 26		*	*	*	*	*	*
513		Platform Alarm 27		*	*	*	*	*	*
514		Platform Alarm 28		*	*	*	*	*	*
515		Platform Alarm 29		*	*	*	*	*	*
516		Platform Alarm 30		*	*	*	*	*	*
517		Platform Alarm 31		*	*	*	*	*	*
518	VT Supervision	VTS Fast Block	VTS Fast Block			*	*	*	*
519	VT Supervision	VTS Slow Block	VTS Slow Block			*	*	*	*
520	Breaker Fail	tBF1 Trip 3Ph	Bfail1 Trip 3ph	*	*	*	*	*	*
521	Breaker Fail	tBF2 Trip 3Ph	Bfail2 Trip 3ph	*	*	*	*	*	*
522	Breaker Fail	Autoreclose Block Main Protection	CB2 Fail1 Trip				*		*
523	Breaker Fail	Autoreclose Block SEF Protection	CB2 Fail2 Trip				*		*
524	CB Control	Control Trip	Control Trip	*	*	*	*	*	*
525	CB Control	Control Close	Control Close	*	*	*	*	*	*
526	CB Control	Control Trip 2	Control Trip 2				*		*
527	CB Control	Control Close 2	Control Close 2				*		*
528	CB Control	Control Close in Progress	Close in Prog	*	*	*	*	*	*
529	Autoreclose	AR Block Main Protection	Block Main Prot		*				
530	Autoreclose	AR Block SEF Protection	Block SEF Prot		*				
531	Autoreclose	Auto Reclose/(AR 3 pole) in Progress	AR 3pole in prog		*	*		*	
532	Autoreclose	AR 1pole in progress	AR 1pole in prog			*		*	

DDB No	Source	Description	English Text	1	2	3	4	5	6
533	Autoreclose	Seq Counter = 0	Seq Counter = 0		*	*		*	
534	Autoreclose	Seq Counter = 1	Seq Counter = 1		*	*		*	
535	Autoreclose	Seq Counter = 2	Seq Counter = 2		*	*		*	
536	Autoreclose	Seq Counter = 3	Seq Counter = 3		*	*		*	
537	Autoreclose	Seq Counter = 4	Seq Counter = 4		*	*		*	
538	Autoreclose	Seq Counter = 5	Seq Counter = 5			*		*	
539	Autoreclose	Successful Reclosure	Successful Close		*	*		*	
540	Autoreclose	Dead Time in Progress	Dead T in Prog		*				
541	Autoreclose	Auto Close/ AR Close	Auto Close		*	*		*	
542	Autoreclose	Autoreclose In/Out of service	A/R Status		*				
543	Autoreclose	Autoreclose In/Out of service	A/R Status 3P			*		*	
544	Autoreclose	Autoreclose In/Out of service	AR Status 1P			*		*	
545	Autoreclose	AR Force 3 pole trips	Force 3 pole			*		*	
546	CB Control	Composite Lockout Alarm	Lockout Alarm	*	*	*		*	
547	Field Voltage Monitor	Field Voltage Failure	Field Volts Fail	*	*	*	*	*	*
548	Undercurrent	IA< operate	IA< Start	*	*	*	*	*	*
549	Undercurrent	IB< operate	IB< Start	*	*	*	*	*	*
550	Undercurrent	IC< operate	IC< Start	*	*	*	*	*	*
551	Undercurrent	ISEF< operate	ISEF< Start	*	*	*	*	*	*
552	Undercurrent	PSL Internal Node 5	CB1 IA< Start				*		*
553	PSL	PSL Internal Node 6	CB1 IB< Start				*		*
554	Undercurrent	PSL Internal Node 7	CB1 IC< Start				*		*
555	Undercurrent	PSL Internal Node 8	CB1 ISEF< Start				*		*
556	Undercurrent	PSL Internal Node 9	CB2 IA< Start				*		*
557	Undercurrent	PSL Internal Node 10	CB2 IB< Start				*		*
558	Undercurrent	PSL Internal Node 11	CB2 IC< Start				*		*
559	Undercurrent	PSL Internal Node 12	CB2 ISEF< Start				*		*
560	Poledead	All Poles Dead	All Poles Dead	*	*	*	*	*	*
561	Poledead	Any Pole Dead	Any Pole Dead	*	*	*	*	*	*
562	Poledead	Phase A Pole Dead	Pole Dead A			*	*	*	*
563	Poledead	Phase B Pole Dead	Pole Dead B			*	*	*	*
564	Poledead	Phase C Pole Dead	Pole Dead C			*	*	*	*
565	All Protection	Accelerate Ind	VTS Acc Ind			*	*	*	*
566	All Protection	Any Voltage Dependent	VTS Volt Dep			*	*	*	*
567	VT Supervision	Ia over threshold	VTS Ia>			*	*	*	*
568	VT Supervision	Ib over threshold	VTS Ib>			*	*	*	*
569	VT Supervision	Ic over threshold	VTS Ic>			*	*	*	*
570	VT Supervision	Va over threshold	VTS Va>			*	*	*	*
571	VT Supervision	Vb over threshold	VTS Vb>			*	*	*	*
572	VT Supervision	Vc over threshold	VTS Vc>			*	*	*	*
573	VT Supervision	I2 over threshold	VTS I2>			*	*	*	*
574	VT Supervision	V2 over threshold	VTS V2>			*	*	*	*
575	VT Supervision	Superimposed Ia over threshold	VTS Ia delta>			*	*	*	*
576	VT Supervision	Superimposed Ib over threshold	VTS Ib delta>			*	*	*	*
577	VT Supervision	Superimposed Ic over threshold	VTS Ic delta >			*	*	*	*
578	All SEF Stages	Current Prot SEF Trip	B Fail SEF Trip			*	*	*	*
579	Autoreclose	Control System Check OK	Ctl Check Synch			*		*	
580	Autoreclose	AR System Check OK/SYNC	AR Sys Check OK			*		*	
581	Autoreclose	Pre-Lockout	Pre-Lockout		*				
582	CB Status Monitor	3 ph CB Open	CB Open 3 ph	*	*	*	*	*	*
583	CB Status Monitor	Ph A CB Open	CB Open A ph			*	*	*	*
584	CB Status Monitor	Ph B CB Open	CB Open B ph			*	*	*	*
585	CB Status Monitor	Ph C CB Open	CB Open C ph			*	*	*	*
586	CB Status Monitor	3 ph CB Closed	CB Closed 3 ph	*	*	*	*	*	*
587	CB Status Monitor	Ph A CB Closed	CB Closed A ph			*	*	*	*
588	CB Status Monitor	Ph B CB Closed	CB Closed B ph			*	*	*	*
589	CB Status Monitor	Ph C CB Closed	CB Closed C ph			*	*	*	*
590	CB Status Monitor	3 ph CB2 Open	CB2 Open 3 ph				*		*
591	CB Status Monitor	Ph A CB2 Open	CB2 Open A ph				*		*
592	CB Status Monitor	Ph B CB2 Open	CB2 Open B ph				*		*
593	CB Status Monitor	Ph C CB2 Open	CB2 Open C ph				*		*
594	CB Status Monitor	3 ph CB2 Closed	CB2 Closed 3 ph				*		*
595	CB Status Monitor	Ph A CB2 Closed	CB2 Closed A ph				*		*
596	CB Status Monitor	Ph B CB2 Closed	CB2 Closed B ph				*		*
597	CB Status Monitor	Ph C CB2 Closed	CB2 Closed C ph				*		*
598	Frequency Tracking	Freq High	Freq High	*	*	*	*	*	*
599	Frequency Tracking	Freq Low	Freq Low	*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
600	Frequency Tracking	Freq Not found	Freq Not found	*	*	*	*	*	*
601	Frequency Tracking	Stop Freq Track	Stop Freq Track	*	*	*	*	*	*
602	Current Differential	Protection Signaling Failure Alarm - Ch1 Rx	SignalFail Ch1Rx	*	*	*	*	*	*
603	Current Differential	Protection Signaling Failure Alarm - Ch1 Tx	SignalFail Ch1Tx	*	*	*	*	*	*
604	Current Differential	Protection Signaling Failure Alarm - Ch2 Rx	SignalFail Ch2Rx	*	*	*	*	*	*
605	Current Differential	Protection Signaling Failure Alarm - Ch2 Tx	SignalFail Ch2Tx	*	*	*	*	*	*
606	PSL	Remote 1 GPS Fail	Ch 1 GPS Fail					*	*
607	PSL	Remote 2 GPS Fail	Ch 2 GPS Fail					*	*
608	Current Differential	relay is already configured	Config Same	*	*	*	*	*	*
609	Current Differential	reconfigure was successful	Reconfig Pass	*	*	*	*	*	*
610	Current Differential	reconfigure was unsuccessful	Reconfig Fail	*	*	*	*	*	*
611	Current Differential	restore was successful	Restore Pass	*	*	*	*	*	*
612	Current Differential	restore was unsuccessful	Restore Fail	*	*	*	*	*	*
613	Current Differential	Inhibit Current Differential	Inhibit C Diff	*	*	*	*	*	*
614	Overcurrent	Overcurrent Intertrip Enabled	I>3 Intertrip	*	*	*	*	*	*
615	Distance	Zone 1 Intertrip Enabled	Z1 Intertrip			*	*	*	*
616	Distance	Zone 2 Intertrip Enabled	Z2 Intertrip			*	*	*	*
617	Distance	Zone 3 Intertrip Enabled	Z3 Intertrip			*	*	*	*
618	Menu	Single Pole Trip Enable	1 Pole Trip En			*	*	*	*
619	CB Status	CB Status Alarm	CB Status Alarm	*	*	*	*	*	*
620	CB Status	CB Status Alarm 2	CB2 Status Alarm				*		*
621	PSL	User Defined Intertrip	Ch 1 Intertrip 1	*	*	*	*	*	*
622	PSL	User Defined Intertrip	Ch 1 Intertrip 2	*	*	*	*	*	*
623	PSL	User Defined Intertrip	Ch 1 Intertrip 3	*	*	*	*	*	*
624	PSL	User Defined Intertrip	Ch 1 Intertrip 4	*	*	*	*	*	*
625	PSL	User Defined Intertrip	Ch 1 Intertrip 5	*	*	*	*	*	*
626	PSL	User Defined Intertrip	Ch 1 Intertrip 6	*	*	*	*	*	*
627	PSL	User Defined Intertrip	Ch 1 Intertrip 7	*	*	*	*	*	*
628	PSL	User Defined Intertrip	Ch 1 Intertrip 8	*	*	*	*	*	*
629	PSL	User Defined Intertrip	Ch 2 Intertrip 1	*	*	*	*	*	*
630	PSL	User Defined Intertrip	Ch 2 Intertrip 2	*	*	*	*	*	*
631	PSL	User Defined Intertrip	Ch 2 Intertrip 3	*	*	*	*	*	*
632	PSL	User Defined Intertrip	Ch 2 Intertrip 4	*	*	*	*	*	*
633	PSL	User Defined Intertrip	Ch 2 Intertrip 5	*	*	*	*	*	*
634	PSL	User Defined Intertrip	Ch 2 Intertrip 6	*	*	*	*	*	*
635	PSL	User Defined Intertrip	Ch 2 Intertrip 7	*	*	*	*	*	*
636	PSL	User Defined Intertrip	Ch 2 Intertrip 8	*	*	*	*	*	*
637	PFSO	I2> detector	I2>			*	*	*	*
638	UI	HMI Access Lvl 1	HMI Access Lvl 1	*	*	*	*	*	*
639	UI	HMI Access Lvl 2	HMI Access Lvl 2	*	*	*	*	*	*
640	UI	FPort AccessLvl1	FPort AccessLvl1	*	*	*	*	*	*
641	UI	FPort AccessLvl2	FPort AccessLvl2	*	*	*	*	*	*
642	UI	RPrt1 AccessLvl1	RPrt1 AccessLvl1	*	*	*	*	*	*
643	UI	RPrt1 AccessLvl2	RPrt1 AccessLvl2	*	*	*	*	*	*
644	UI	RPrt2 AccessLvl1	RPrt2 AccessLvl1	*	*	*	*	*	*
645	UI	RPrt2 AccessLvl2	RPrt2 AccessLvl2	*	*	*	*	*	*
646	AR	Unused							
647		Live Line	Live Line			*		*	
648		Dead Line	Dead Line			*		*	
649		Live Bus	Live Bus			*		*	
650		Dead Bus	Dead Bus			*		*	
651		Check Sync 1 OK	Check Sync 1 OK			*		*	
652		Check Sync 2 OK	Check Sync 2 OK			*		*	
653		SysChks Inactive	SysChks Inactive			*		*	
654		Unused							
655		Unused							
656		Unused							
657		Ch1 Loss Of Signal	Ch1 Signal Lost	*	*	*	*	*	*
658		Ch1 Path "Yellow"	Ch1 Path Yellow	*	*	*	*	*	*
659		Ch1 Mismatch Received N	Ch1 Mismatch RxN	*	*	*	*	*	*
660		Ch2 Loss Of Signal	Ch2 Signal Lost	*	*	*	*	*	*
661		Ch2 Path "Yellow"	Ch2 Path Yellow	*	*	*	*	*	*
662		Ch2 Mismatch Received N	Ch2 Mismatch RxN	*	*	*	*	*	*
663		Unused							
664		Unused							
665		Unused							
666		Unused							

DDB No	Source	Description	English Text	1	2	3	4	5	6
667		Unused							
668		Unused							
669		Unused							
670		Unused							
671		Unused							
672		GOOSE VIP 1	Virtual Input 1	*	*	*	*	*	*
673		GOOSE VIP 2	Virtual Input 2	*	*	*	*	*	*
674		GOOSE VIP 3	Virtual Input 3	*	*	*	*	*	*
675		GOOSE VIP 4	Virtual Input 4	*	*	*	*	*	*
676		GOOSE VIP 5	Virtual Input 5	*	*	*	*	*	*
677		GOOSE VIP 6	Virtual Input 6	*	*	*	*	*	*
678		GOOSE VIP 7	Virtual Input 7	*	*	*	*	*	*
679		GOOSE VIP 8	Virtual Input 8	*	*	*	*	*	*
680		GOOSE VIP 9	Virtual Input 9	*	*	*	*	*	*
681		GOOSE VIP 10	Virtual Input 10	*	*	*	*	*	*
682		GOOSE VIP 11	Virtual Input 11	*	*	*	*	*	*
683		GOOSE VIP 12	Virtual Input 12	*	*	*	*	*	*
684		GOOSE VIP 13	Virtual Input 13	*	*	*	*	*	*
685		GOOSE VIP 14	Virtual Input 14	*	*	*	*	*	*
686		GOOSE VIP 15	Virtual Input 15	*	*	*	*	*	*
687		GOOSE VIP 16	Virtual Input 16	*	*	*	*	*	*
688		GOOSE VIP 17	Virtual Input 17	*	*	*	*	*	*
689		GOOSE VIP 18	Virtual Input 18	*	*	*	*	*	*
690		GOOSE VIP 19	Virtual Input 19	*	*	*	*	*	*
691		GOOSE VIP 20	Virtual Input 20	*	*	*	*	*	*
692		GOOSE VIP 21	Virtual Input 21	*	*	*	*	*	*
693		GOOSE VIP 22	Virtual Input 22	*	*	*	*	*	*
694		GOOSE VIP 23	Virtual Input 23	*	*	*	*	*	*
695		GOOSE VIP 24	Virtual Input 24	*	*	*	*	*	*
696		GOOSE VIP 25	Virtual Input 25	*	*	*	*	*	*
697		GOOSE VIP 26	Virtual Input 26	*	*	*	*	*	*
698		GOOSE VIP 27	Virtual Input 27	*	*	*	*	*	*
699		GOOSE VIP 28	Virtual Input 28	*	*	*	*	*	*
700		GOOSE VIP 29	Virtual Input 29	*	*	*	*	*	*
701		GOOSE VIP 30	Virtual Input 30	*	*	*	*	*	*
702		GOOSE VIP 31	Virtual Input 31	*	*	*	*	*	*
703		GOOSE VIP 32	Virtual Input 32	*	*	*	*	*	*
704		GOOSE Out 1	Virtual Output 1	*	*	*	*	*	*
705		GOOSE Out 2	Virtual Output 2	*	*	*	*	*	*
706		GOOSE Out 3	Virtual Output 3	*	*	*	*	*	*
707		GOOSE Out 4	Virtual Output 4	*	*	*	*	*	*
708		GOOSE Out 5	Virtual Output 5	*	*	*	*	*	*
709		GOOSE Out 6	Virtual Output 6	*	*	*	*	*	*
710		GOOSE Out 7	Virtual Output 7	*	*	*	*	*	*
711		GOOSE Out 8	Virtual Output 8	*	*	*	*	*	*
712		GOOSE Out 9	Virtual Output 9	*	*	*	*	*	*
713		GOOSE Out 10	Virtual Output10	*	*	*	*	*	*
714		GOOSE Out 11	Virtual Output11	*	*	*	*	*	*
715		GOOSE Out 12	Virtual Output12	*	*	*	*	*	*
716		GOOSE Out 13	Virtual Output13	*	*	*	*	*	*
717		GOOSE Out 14	Virtual Output14	*	*	*	*	*	*
718		GOOSE Out 15	Virtual Output15	*	*	*	*	*	*
719		GOOSE Out 16	Virtual Output16	*	*	*	*	*	*
720		GOOSE Out 17	Virtual Output17	*	*	*	*	*	*
721		GOOSE Out 18	Virtual Output18	*	*	*	*	*	*
722		GOOSE Out 19	Virtual Output19	*	*	*	*	*	*
723		GOOSE Out 20	Virtual Output20	*	*	*	*	*	*
724		GOOSE Out 21	Virtual Output21	*	*	*	*	*	*
725		GOOSE Out 22	Virtual Output22	*	*	*	*	*	*
726		GOOSE Out 23	Virtual Output23	*	*	*	*	*	*
727		GOOSE Out 24	Virtual Output24	*	*	*	*	*	*
728		GOOSE Out 25	Virtual Output25	*	*	*	*	*	*
729		GOOSE Out 26	Virtual Output26	*	*	*	*	*	*
730		GOOSE Out 27	Virtual Output27	*	*	*	*	*	*
731		GOOSE Out 28	Virtual Output28	*	*	*	*	*	*
732		GOOSE Out 29	Virtual Output29	*	*	*	*	*	*
733		GOOSE Out 30	Virtual Output30	*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
734		GOOSE Out 31	Virtual Output31	*	*	*	*	*	*
735		GOOSE Out 32	Virtual Output32	*	*	*	*	*	*
736		Unused							
737		Unused							
738		Unused							
739		Unused							
740		Unused							
741		Unused							
742		Unused							
743		Unused							
744		Unused							
745		Unused							
746		Unused							
747		Unused							
748		Unused							
749		Unused							
750	FL	Fixed Logic Internal Node				*	*	*	*
751	FL	Fixed Logic Internal Node				*	*	*	*
752	FL	Fixed Logic Internal Node				*	*	*	*
753	FL	Fixed Logic Internal Node				*	*	*	*
754	FL	Fixed Logic Internal Node				*	*	*	*
755	FL	Fixed Logic Internal Node				*	*	*	*
756	FL	Fixed Logic Internal Node				*	*	*	*
757	FL	Fixed Logic Internal Node				*	*	*	*
758	FL	Fixed Logic Internal Node				*	*	*	*
759	FL	Fixed Logic Internal Node				*	*	*	*
760	FL	Fixed Logic Internal Node				*	*	*	*
761	FL	Fixed Logic Internal Node				*	*	*	*
762	FL	Fixed Logic Internal Node				*	*	*	*
763	FL	Fixed Logic Internal Node	BU Trip Send A	*	*	*	*	*	*
764	FL	Fixed Logic Internal Node	BU Trip Send B	*	*	*	*	*	*
765	FL	Fixed Logic Internal Node	BU Trip Send C	*	*	*	*	*	*
766	FL	Fixed Logic Internal Node	Backup Enabled	*	*	*	*	*	*
767		Unused							
768		Unused							
769		Unused							
770		Unused							
771		Unused							
772		Unused							
773		Unused							
774		Unused							
775		Unused							
776		Unused							
777		Unused							
778		Unused							
779		Unused							
780		Unused							
781		Unused							
782		Unused							
783		Unused							
784		Unused							
785		Unused							
786		Unused							
787		Unused							
788		Unused							
789		Unused							
790		Unused							
791		Unused							
792		Unused							
793		Unused							
794		Unused							
795		Unused							
796		Unused							
797		Unused							
798		Unused							
799		Unused							
800		Unused							

DDB No	Source	Description	English Text	1	2	3	4	5	6
801		Unused							
802		Unused							
803		Unused							
804		Unused							
805		Unused							
806		Unused							
807		Unused							
808		Unused							
809		Unused							
810		Unused							
811		Unused							
812		Unused							
813		Unused							
814		Unused							
815		Unused							
816		Unused							
817		Unused							
818		Unused							
819		Unused							
820		Unused							
821		Unused							
822		Unused							
823		Unused							
824	PSL	PSL Internal Node		*	*	*	*	*	*
825	PSL	PSL Internal Node		*	*	*	*	*	*
826	PSL	PSL Internal Node		*	*	*	*	*	*
827	PSL	PSL Internal Node		*	*	*	*	*	*
828	PSL	PSL Internal Node		*	*	*	*	*	*
829	PSL	PSL Internal Node		*	*	*	*	*	*
830	PSL	PSL Internal Node		*	*	*	*	*	*
831	PSL	PSL Internal Node		*	*	*	*	*	*
832	PSL	PSL Internal Node		*	*	*	*	*	*
833	PSL	PSL Internal Node		*	*	*	*	*	*
834	PSL	PSL Internal Node		*	*	*	*	*	*
835	PSL	PSL Internal Node		*	*	*	*	*	*
836	PSL	PSL Internal Node		*	*	*	*	*	*
837	PSL	PSL Internal Node		*	*	*	*	*	*
838	PSL	PSL Internal Node		*	*	*	*	*	*
839	PSL	PSL Internal Node		*	*	*	*	*	*
840	PSL	PSL Internal Node		*	*	*	*	*	*
841	PSL	PSL Internal Node		*	*	*	*	*	*
842	PSL	PSL Internal Node		*	*	*	*	*	*
843	PSL	PSL Internal Node		*	*	*	*	*	*
844	PSL	PSL Internal Node		*	*	*	*	*	*
845	PSL	PSL Internal Node		*	*	*	*	*	*
846	PSL	PSL Internal Node		*	*	*	*	*	*
847	PSL	PSL Internal Node		*	*	*	*	*	*
848	PSL	PSL Internal Node		*	*	*	*	*	*
849	PSL	PSL Internal Node		*	*	*	*	*	*
850	PSL	PSL Internal Node		*	*	*	*	*	*
851	PSL	PSL Internal Node		*	*	*	*	*	*
852	PSL	PSL Internal Node		*	*	*	*	*	*
853	PSL	PSL Internal Node		*	*	*	*	*	*
854	PSL	PSL Internal Node		*	*	*	*	*	*
855	PSL	PSL Internal Node		*	*	*	*	*	*
856	PSL	PSL Internal Node		*	*	*	*	*	*
857	PSL	PSL Internal Node		*	*	*	*	*	*
858	PSL	PSL Internal Node		*	*	*	*	*	*
859	PSL	PSL Internal Node		*	*	*	*	*	*
860	PSL	PSL Internal Node		*	*	*	*	*	*
861	PSL	PSL Internal Node		*	*	*	*	*	*
862	PSL	PSL Internal Node		*	*	*	*	*	*
863	PSL	PSL Internal Node		*	*	*	*	*	*
864	PSL	PSL Internal Node		*	*	*	*	*	*
865	PSL	PSL Internal Node		*	*	*	*	*	*
866	PSL	PSL Internal Node		*	*	*	*	*	*
867	PSL	PSL Internal Node		*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
868	PSL	PSL Internal Node		*	*	*	*	*	*
869	PSL	PSL Internal Node		*	*	*	*	*	*
870	PSL	PSL Internal Node		*	*	*	*	*	*
871	PSL	PSL Internal Node		*	*	*	*	*	*
872	PSL	PSL Internal Node		*	*	*	*	*	*
873	PSL	PSL Internal Node		*	*	*	*	*	*
874	PSL	PSL Internal Node		*	*	*	*	*	*
875	PSL	PSL Internal Node		*	*	*	*	*	*
876	PSL	PSL Internal Node		*	*	*	*	*	*
877	PSL	PSL Internal Node		*	*	*	*	*	*
878	PSL	PSL Internal Node		*	*	*	*	*	*
879	PSL	PSL Internal Node		*	*	*	*	*	*
880	PSL	PSL Internal Node		*	*	*	*	*	*
881	PSL	PSL Internal Node		*	*	*	*	*	*
882	PSL	PSL Internal Node		*	*	*	*	*	*
883	PSL	PSL Internal Node		*	*	*	*	*	*
884	PSL	PSL Internal Node		*	*	*	*	*	*
885	PSL	PSL Internal Node		*	*	*	*	*	*
886	PSL	PSL Internal Node		*	*	*	*	*	*
887	PSL	PSL Internal Node		*	*	*	*	*	*
888	PSL	PSL Internal Node		*	*	*	*	*	*
889	PSL	PSL Internal Node		*	*	*	*	*	*
890	PSL	PSL Internal Node		*	*	*	*	*	*
891	PSL	PSL Internal Node		*	*	*	*	*	*
892	PSL	PSL Internal Node		*	*	*	*	*	*
893	PSL	PSL Internal Node		*	*	*	*	*	*
894	PSL	PSL Internal Node		*	*	*	*	*	*
895	PSL	PSL Internal Node		*	*	*	*	*	*
896	PSL	PSL Internal Node		*	*	*	*	*	*
897	PSL	PSL Internal Node		*	*	*	*	*	*
898	PSL	PSL Internal Node		*	*	*	*	*	*
899	PSL	PSL Internal Node		*	*	*	*	*	*
900	PSL	PSL Internal Node		*	*	*	*	*	*
901	PSL	PSL Internal Node		*	*	*	*	*	*
902	PSL	PSL Internal Node		*	*	*	*	*	*
903	PSL	PSL Internal Node		*	*	*	*	*	*
904	PSL	PSL Internal Node		*	*	*	*	*	*
905	PSL	PSL Internal Node		*	*	*	*	*	*
906	PSL	PSL Internal Node		*	*	*	*	*	*
907	PSL	PSL Internal Node		*	*	*	*	*	*
908	PSL	PSL Internal Node		*	*	*	*	*	*
909	PSL	PSL Internal Node		*	*	*	*	*	*
910	PSL	PSL Internal Node		*	*	*	*	*	*
911	PSL	PSL Internal Node		*	*	*	*	*	*
912	PSL	PSL Internal Node		*	*	*	*	*	*
913	PSL	PSL Internal Node		*	*	*	*	*	*
914	PSL	PSL Internal Node		*	*	*	*	*	*
915	PSL	PSL Internal Node		*	*	*	*	*	*
916	PSL	PSL Internal Node		*	*	*	*	*	*
917	PSL	PSL Internal Node		*	*	*	*	*	*
918	PSL	PSL Internal Node		*	*	*	*	*	*
919	PSL	PSL Internal Node		*	*	*	*	*	*
920	PSL	PSL Internal Node		*	*	*	*	*	*
921	PSL	PSL Internal Node		*	*	*	*	*	*
922	PSL	PSL Internal Node		*	*	*	*	*	*
923	PSL	PSL Internal Node		*	*	*	*	*	*
924	PSL	PSL Internal Node		*	*	*	*	*	*
925	PSL	PSL Internal Node		*	*	*	*	*	*
926	PSL	PSL Internal Node		*	*	*	*	*	*
927	PSL	PSL Internal Node		*	*	*	*	*	*
928	PSL	PSL Internal Node		*	*	*	*	*	*
929	PSL	PSL Internal Node		*	*	*	*	*	*
930	PSL	PSL Internal Node		*	*	*	*	*	*
931	PSL	PSL Internal Node		*	*	*	*	*	*
932	PSL	PSL Internal Node		*	*	*	*	*	*
933	PSL	PSL Internal Node		*	*	*	*	*	*
934	PSL	PSL Internal Node		*	*	*	*	*	*

DDB No	Source	Description	English Text	1	2	3	4	5	6
935	PSL	PSL Internal Node		*	*	*	*	*	*
936	PSL	PSL Internal Node		*	*	*	*	*	*
937	PSL	PSL Internal Node		*	*	*	*	*	*
938	PSL	PSL Internal Node		*	*	*	*	*	*
939	PSL	PSL Internal Node		*	*	*	*	*	*
940	PSL	PSL Internal Node		*	*	*	*	*	*
941	PSL	PSL Internal Node		*	*	*	*	*	*
942	PSL	PSL Internal Node		*	*	*	*	*	*
943	PSL	PSL Internal Node		*	*	*	*	*	*
944	PSL	PSL Internal Node		*	*	*	*	*	*
945	PSL	PSL Internal Node		*	*	*	*	*	*
946	PSL	PSL Internal Node		*	*	*	*	*	*
947	PSL	PSL Internal Node		*	*	*	*	*	*
948	PSL	PSL Internal Node		*	*	*	*	*	*
949	PSL	PSL Internal Node		*	*	*	*	*	*
950	PSL	PSL Internal Node		*	*	*	*	*	*
951	PSL	PSL Internal Node		*	*	*	*	*	*
952	PSL	PSL Internal Node		*	*	*	*	*	*
953	PSL	PSL Internal Node		*	*	*	*	*	*
954	PSL	PSL Internal Node		*	*	*	*	*	*
955	PSL	PSL Internal Node		*	*	*	*	*	*
956	PSL	PSL Internal Node		*	*	*	*	*	*
957	PSL	PSL Internal Node		*	*	*	*	*	*
958	PSL	PSL Internal Node		*	*	*	*	*	*
959	PSL	PSL Internal Node		*	*	*	*	*	*
960	PSL	PSL Internal Node		*	*	*	*	*	*
961	PSL	PSL Internal Node		*	*	*	*	*	*
962	PSL	PSL Internal Node		*	*	*	*	*	*
963	PSL	PSL Internal Node		*	*	*	*	*	*
964	PSL	PSL Internal Node		*	*	*	*	*	*
965	PSL	PSL Internal Node		*	*	*	*	*	*
966	PSL	PSL Internal Node		*	*	*	*	*	*
967	PSL	PSL Internal Node		*	*	*	*	*	*
968	PSL	PSL Internal Node		*	*	*	*	*	*
969	PSL	PSL Internal Node		*	*	*	*	*	*
970	PSL	PSL Internal Node		*	*	*	*	*	*
971	PSL	PSL Internal Node		*	*	*	*	*	*
972	PSL	PSL Internal Node		*	*	*	*	*	*
973	PSL	PSL Internal Node		*	*	*	*	*	*
974		Unused							
975		Unused							
976		Unused							
977		Unused							
978		Unused							
979		Unused							
980		Unused							
981		Unused							
982		Unused							
983		Unused							
984		Unused							
985		Unused							
986		Unused							
987		Unused							
988		Unused							
989		Unused							
990		Unused							
991		Unused							
992		Unused							
993		Unused							
994		Unused							
995		Unused							
996		Unused							
997		Unused							
998		Unused							
999		Unused							
1000		Unused							
1001		Unused							

DDB No	Source	Description	English Text	1	2	3	4	5	6
1002		Unused							
1003		Unused							
1004		Unused							
1005		Unused							
1006		Unused							
1007		Unused							
1008		Unused							
1009		Unused							
1010		Unused							
1011		Unused							
1012		Unused							
1013		Unused							
1014		Unused							
1015		Unused							
1016		Unused							
1017		Unused							
1018		Unused							
1019		Unused							
1020		Unused							
1021		Unused							
1022		Unused							
		Event FIFO Overflow	Event FIFO full	*	*	*	*	*	*
		Fault FIFO Overflow	Fault FIFO full	*	*	*	*	*	*
		Fault Rec Overflow	Fault Rec full	*	*	*	*	*	*

The following table defines the visibility & Validity of each cell in the fault record

Cell	Text	Comment
0100	VIEW RECORDS	
0101	Last Record -	
0102	Menu Cell Ref	
0103	Time & Date	
0104	Record Text	
0105	Record Value	
0106	Select Fault	
N/A	Started Phase A B C N	Visible if (DDB_ANY_START = 1) x if (DDB_DIFFERENTIAL_START_x | DDB_ZONE_1_START_x | DDB_ZONE_2_START_x | DDB_ZONE_3_START_x | DDB_POC_1_PH_x_START | DDB_POC_2_PH_x_START | DDB_POC_3_PH_x_START | DDB_POC_4_PH_x_START=1) where x = A, B or C N if (DDB_ZONE_1_START_N | DDB_ZONE_2_START_N | DDB_ZONE_3_START_N | DDB_EF1_1_START | DDB_EF1_2_START | DDB_EF1_3_START | DDB_EF1_4_START | DDB_SEF_1_START | DDB_SEF_2_START | DDB_SEF_3_START | DDB_SEF_4_START =1)
N/A	Tripped Phase A B C N	Visible if (DDB_DIFFERENTIAL_TRIP | DDB_DIFFERENTIAL_INTERTRIP | DDB_ZONE_x_TRIP | DDB_BACKUP_INTERTRIP | DDB_POC_x_3PH_START | | DDB_EF1_x_TRIP | DDB_SEF_x_TRIP) x if(DDB_DIFFERENTIAL_TRIP_x | DDB_DIFFERENTIAL_INTERTRIP_x | DDB_ZONE_1_TRIP_x | DDB_ZONE_2_TRIP_x | DDB_ZONE_3_TRIP_x | DDB_BACKUP_INTERTRIP_x | DDB_POC_1_PH_x_TRIP | DDB_POC_2_PH_x_TRIP | DDB_POC_3_PH_x_TRIP | DDB_POC_4_PH_x_TRIP | DDB_AR_TRIP_TEST_x | = 1) where x = A, B or C N if (DDB_ZONE_1_TRIP_N | DDB_ZONE_2_TRIP_N | DDB_ZONE_3_TRIP_N | DDB_EF1_1_TRIP | DDB_EF1_2_TRIP | DDB_EF1_3_TRIP | DDB_EF1_4_TRIP | DDB_SEF_1_TRIP | DDB_SEF_2_TRIP | DDB_SEF_3_TRIP | DDB_SEF_4_TRIP = 1)
N/A	Current Diff Start	Visible if (DDB_DIFFERENTIAL_START_A | DDB_DIFFERENTIAL_START_B | DDB_DIFFERENTIAL_START_C = 1) Start
N/A	Current Diff Trip InterTrip Stub Bus	Visible if (DDB_DIFFERENTIAL_TRIP | DDB_DIFFERENTIAL_INTERTRIP = 1) Trip if (DDB_DIFFERENTIAL_TRIP = 1) InterTrip if (DDB_DIFFERENTIAL_INTERTRIP =1) Stub Bus if (DDB_STUB_BUS_TRIP =1)
	PIT DIT Dist/I>3	PIT if (DDB_PERMISSIVE_INTERTRIP = 1) DIT if (DDB_DIRECT_INTERTRIP = 1) dIST/I>3 if (DDB_BACKUP_INTERTRIP = 1)
N/A	Distance Start Z1 Z2 Z3	Visible if (DDB_ZONE_1_START_A | DDB_ZONE_1_START_B | DDB_ZONE_1_START_C | DDB_ZONE_2_START_A | DDB_ZONE_2_START_B | DDB_ZONE_2_START_C | DDB_ZONE_3_START_A | DDB_ZONE_3_START_B | DDB_ZONE_3_START_C =1) Start Z1 if (DDB_ZONE_1_START_A | DDB_ZONE_1_START_B | DDB_ZONE_1_START_C = 1)
		Start Z2 if (DDB_ZONE_2_START_A | DDB_ZONE_2_START_B | DDB_ZONE_2_START_C = 1) Start Z3 if (DDB_ZONE_3_START_A | DDB_ZONE_3_START_B | DDB_ZONE_3_START_C = 1)
N/A	Distance Trip Z1 Z2 Z3	Visible if (DDB_ZONE_1_TRIP | DDB_ZONE_2_TRIP | DDB_ZONE_3_TRIP = 1) Trip Z1 if (DDB_ZONE_1_TRIP = 1) Trip Z2 if (DDB_ZONE_2_TRIP = 1) Trip Z3 if (DDB_ZONE_3_TRIP = 1)
N/A	Overcurrent Start I> 1234	Visible if (DDB_POC_1_3PH_START | DDB_POC_2_3PH_START | DDB_POC_3_3PH_START | DDB_POC_4_3PH_START = 1) Start I >1 if (DDB_POC_1_3PH_START = 1) Start I >2 if (DDB_POC_2_3PH_START = 1) Start I >3 if (DDB_POC_3_3PH_START = 1) Start I >4 if (DDB_POC_4_3PH_START = 1)

Note :
Differential InterTrip & Stub Bus are mutually exclusive

Cell	Text	Comment	
N/A	Overcurrent Trip I> 1234	Visible if (DDB_POC_1_3PH_TRIP | DDB_POC_2_3PH_TRIP | DDB_POC_3_3PH_TRIP | DDB_POC_4_3PH_TRIP = 1) Trip I>1 if (DDB_POC_1_3PH_TRIP = 1) Trip I>2 if (DDB_POC_2_3PH_TRIP = 1) Trip I>3 if (DDB_POC_3_3PH_TRIP = 1) Trip I>4 if (DDB_POC_4_3PH_TRIP = 1)	
N/A	Broken Conductor Trip	Visible if (DDB_BROKEN_CONDUCTOR_TRIP = 1) Trip	
N/A	Earth Fault Start IN> 1234	Visible if (DDB_EF1_1_START | DDB_EF1_2_START | DDB_EF1_3_START | DDB_EF1_4_START =1) Start IN>1 if (DDB_EF1_1_START =1) Start IN>2 if (DDB_EF1_2_START =1) Start IN>3 if (DDB_EF1_3_START =1) Start IN>4 if (DDB_EF1_4_START =1)	
N/A	Earth Fault Trip IN> 1234	Visible if (DDB_EF1_1_TRIP | DDB_EF1_2_TRIP | DDB_EF1_3_TRIP | DDB_EF1_4_TRIP =1) Trip IN>1 if (DDB_EF1_1_TRIP =1) Trip IN>2 if (DDB_EF1_2_TRIP =1) Trip IN>3 if (DDB_EF1_3_TRIP =1) Trip IN>4 if (DDB_EF1_4_TRIP =1)	
N/A	Sensitive E/F Start ISEF> 1234	Visible if (DDB_SEF_1_START | DDB_SEF_2_START | DDB_SEF_3_START | DDB_SEF_4_START =1) Start ISEF>1 if (DDB_SEF_1_START =1) Start ISEF>2 if (DDB_SEF_2_START =1) Start ISEF>3 if (DDB_SEF_3_START =1) Start ISEF>4 if (DDB_SEF_4_START =1)	
N/A	Sensitive E/F Trip ISEF> 1234	Visible if (DDB_SEF_1_TRIP | DDB_SEF_2_TRIP | DDB_SEF_3_TRIP | DDB_SEF_4_TRIP =1) Trip ISEF>1 if (DDB_SEF_1_TRIP =1) Trip ISEF>2 if (DDB_SEF_2_TRIP =1) Trip ISEF>3 if (DDB_SEF_3_TRIP =1) Trip ISEF>4 if (DDB_SEF_4_TRIP =1)	
N/A	Thermal Overload Alarm Trip	Visible if (DDB_THERMAL_ALARM | DDB_THERMAL_TRIP = 1) Alarm if (DDB_THERMAL_ALARM =1) Trip if (DDB_THERMAL_TRIP =1)	
N/A	Breaker Fail CB Fail 1 2	Visible if (DDB_BREAKER_FAIL_ALARM =1) 1 if (DDB_CBF1_TRIP_3PH = 1) 2 if (DDB_CBF2_TRIP_3PH = 1)	Model 1,2,3
N/A	Breaker Fail CB1 1 2 CB2 1 2	Visible if (DDB_BREAKER_FAIL_ALARM|DDB_BREAKER_FAIL_ALARM2 =1) 1 if (DDB_CBF1_TRIP_3PH = 1) 2 if (DDB_CBF2_TRIP_3PH = 1) 1 if (DDB_CB2F1_TRIP_3PH = 1) 2 if (DDB_CB2F2_TRIP_3PH = 1)	Model 4
N/A	Supervision VTS PSB	Visible if (DDB_VTS_INDICATION | DDB_PSB_ALARM = 1) VTS if (DDB_VTS_INDICATION = 1) PSB if (DDB_PSB_ALARM = 1)	
N/A	A/R State Shot 1 2 3 4 5	Visible if AR enabled	
0107	Faulted Phase	Bit 0,1,2 = (DDB_DIFFERENTIAL_START_x | DDB_ZONE_1_START_x | DDB_ZONE_2_START_x | DDB_ZONE_3_START_x | DDB_POC_1_PH_x_START | DDB_POC_2_PH_x_START | DDB_POC_3_PH_x_START | DDB_POC_4_PH_x_START) where x = A, B or C Bit 3 = (DDB_ZONE_1_START_N | DDB_ZONE_2_START_N | DDB_ZONE_3_START_N | DDB_EF1_1_START | DDB_EF1_2_START | DDB_EF1_3_START | DDB_EF1_4_START | DDB_SEF_1_START | DDB_SEF_2_START | DDB_SEF_3_START | DDB_SEF_4_START) Bit 4,5,6 = (DDB_DIFFERENTIAL_TRIP_x | DDB_DIFFERENTIAL_INTERTRIP_x | DDB_ZONE_1_TRIP_x | DDB_ZONE_2_TRIP_x | DDB_ZONE_3_TRIP_x | DDB_BACKUP_INTERTRIP_x | DDB_POC_1_PH_x_TRIP | DDB_POC_2_PH_x_TRIP | DDB_POC_3_PH_x_TRIP | DDB_POC_4_PH_x_TRIP | DDB_AR_TRIP_TEST_x) where x = A, B or C Bit 7 = (DDB_ZONE_1_TRIP_N | DDB_ZONE_2_TRIP_N | DDB_ZONE_3_TRIP_N | DDB_EF1_1_TRIP | DDB_EF1_2_TRIP | DDB_EF1_3_TRIP | DDB_EF1_4_TRIP | DDB_SEF_1_TRIP | DDB_SEF_2_TRIP | DDB_SEF_3_TRIP | DDB_SEF_4_TRIP)	

Cell	Text	Comment
0108	Start Elements	Bit 0 = DDB_ANY_START) Bit 1 = (DDB_DIFFERENTIAL_START_A | DDB_DIFFERENTIAL_START_B | DDB_DIFFERENTIAL_START_C) Bit 2 = (DDB_ZONE_1_START_A | DDB_ZONE_1_START_B | DDB_ZONE_1_START_C) Bit 3 = (DDB_ZONE_2_START_A | DDB_ZONE_2_START_B | DDB_ZONE_2_START_C) Bit 4 = (DDB_ZONE_3_START_A | DDB_ZONE_3_START_B | DDB_ZONE_3_START_C) Bit 5 = (DDB_POC_1_3PH_START) Bit 6 = (DDB_POC_2_3PH_START) Bit 7 = (DDB_POC_3_3PH_START) Bit 8 = (DDB_POC_4_3PH_START) Bit 9 = (DDB_EF1_1_START) Bit 10 = (DDB_EF1_2_START) Bit 11 = (DDB_EF1_3_START) Bit 12 = (DDB_EF1_4_START) Bit 13 = (DDB_SEF_1_START) Bit 14 = (DDB_SEF_2_START) Bit 15 = (DDB_SEF_3_START) Bit 16 = (DDB_SEF_4_START) Bit 17 = (DDB_THERMAL_ALARM)
010A	Trip Elements(1)	Bit 0 = (DDB_ANY_TRIP) Bit 1 = (DDB_DIFFERENTIAL_TRIP) Bit 2 = (DDB_DIFFERENTIAL_INTERTRIP) Bit 3 = (DDB_PERMISSIVE_INTERTRIP) Bit 4 = (DDB_DIRECT_INTERTRIP) Bit 5 = (DDB_ZONE_1_TRIP) Bit 6 = (DDB_ZONE_2_TRIP) Bit 7 = (DDB_ZONE_3_TRIP) Bit 8 = (DDB_BACKUP_INTERTRIP) Bit 9 = (DDB_POC_1_3PH_TRIP) Bit 10 = (DDB_POC_2_3PH_TRIP) Bit 11 = (DDB_POC_3_3PH_TRIP) Bit 12 = (DDB_POC_4_3PH_TRIP) Bit 13 = (DDB_BROKEN_CONDUCTOR_TRIP) Bit 14 = (DDB_EF1_1_TRIP) Bit 15 = (DDB_EF1_2_TRIP) Bit 16 = (DDB_EF1_3_TRIP) Bit 17 = (DDB_EF1_4_TRIP) Bit 18 = (DDB_SEF_1_TRIP) Bit 19 = (DDB_SEF_2_TRIP) Bit 20 = (DDB_SEF_3_TRIP) Bit 21 = (DDB_SEF_4_TRIP) Bit 22 = (DDB_THERMAL_TRIP) Bit 23 = (DDB_STUB_BUS_TRIP)
010C	Fault Alarms	Bit 0 = (DDB_CBF1_TRIP_3PH =1) Bit 1 = (DDB_CBF2_TRIP_3PH =1) Bit 2 = (DDB_SEQ_COUNT_1) Bit 3 = (DDB_SEQ_COUNT_2) Bit 4 = (DDB_SEQ_COUNT_3) Bit 5 = (DDB_SEQ_COUNT_4) Bit 6 = (DDB_SEQ_COUNT_5) Bit 7 = (DDB_VTS_INDICATION) Bit 8 = (DDB_PSB_ALARM) Bit 9 = (DDB_CB2F1_TRIP_3PH) Bit 10 = (DDB_CB2F2_TRIP_3PH)
010D	Fault Time	
010E	Active Group	
010F	System Frequency	Valid if ("Enabled flag" = 1)
0110	Fault Duration	Valid if “FaultDurTimeValid flag” = 1
0111	CB Operate Time	Valid if “CBOperateTimeValid flag” = 1
0112	Relay Trip Time	Valid if “ProtOperateTimeValid flag” = 1

Cell	Text	Comment
0113	Fault Location	Visible if (0D0A = 0 & 0D09 = 0 & “Fault Locator en flag” = 0) Valid if “FaultLocValid Flag” = 1
0114	Fault Location	Visible if (0D0A = 0 & 0D09 = 1 & “Fault Locator en flag” = 0) Valid if “FaultLocValid Flag” = 1
0115	Fault Location	Visible if (0D0A = 1 & “Fault Locator en flag” = 0) Valid if “FaultLocValid Flag” = 1
0116	Fault Location	Visible if (0D0A = 2 & “Fault Locator en flag” = 0) Valid if “FaultLocValid Flag” = 1
0117	IA	
0118	IB	
0119	IC	
011A	VAB	
011B	VBC	
011C	VCA	
011D	IA local	Valid if “Current Diff flag 1” = 1
011E	IB local	Valid if “Current Diff flag 1” = 1
011F	IC local	Valid if “Current Diff flag 1” = 1
0120	IA remote 1	Valid if “Current Diff flag 2” = 1
0121	IB remote 1	Valid if “Current Diff flag 2” = 1
0122	IC remote 1	Valid if “Current Diff flag 2” = 1
0123	IA remote 2	Visible if (1001 = 0) Valid if “Current Diff flag 3” = 1
0124	IB remote 2	Visible if (1001 = 0) Valid if “Current Diff flag 3” = 1
0125	IC remote 2	Visible if (1001 = 0) Valid if “Current Diff flag 3” = 1
0126	IA Diff	Valid if “Current Diff flag 4” = 1
0127	IB Diff	Valid if “Current Diff flag 4” = 1
0128	IC Diff	Valid if “Current Diff flag 4” = 1
012A	IA Bias	Valid if “Current Diff flag 4” = 1
012B	IB Bias	Valid if “Current Diff flag 4” = 1
012C	IC Bias	Valid if “Current Diff flag 4” = 1

1. INTRODUCTION

The purpose of this document is to describe the specific implementation of the Distributed Network Protocol (DNP) version 3.0 within P54x MiCOM relays.

The MiCOM P54x uses the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library version 2.31.

This document, in conjunction with the DNP 3.0 Basic 4 Document Set, and the DNP Subset Definitions Document, provides complete information on how to communicate with P54x relays with the DNP 3.0 protocol.

This implementation of DNP 3.0 is fully compliant with DNP 3.0 Subset Definition Level 2. It also contains many Subset Level 3 and above features.

2. DNP V3.0 DEVICE PROFILE

The following table provides a “Device Profile Document” in the standard format defined in the DNP 3.0 Subset Definitions Document. While it is referred to in the DNP 3.0 Subset Definitions as a “Document”, it is only a component of a total interoperability guide. This table, in combination with the following should provide a complete interoperability/configuration guide for the P54x range of MiCOM relays:

The Implementation Table provided in Section §3

The Point List Tables provided in Section §4

DNP 3.0

Device Profile Document

Vendor Name:	ALSTOM Grid
Device Name:	MiCOM P54x Current Differential
Models Covered:	P541, P542, P543, P544, P545, P546

Highest DNP Level Supported: For Requests: Level 2 For Responses: Level 2	Device Function: ☐ Master ☑ Slave

Notable objects, functions, and/or qualifiers supported in addition to the highest DNP levels supported (the complete list is described in the DNP 3.0 Implementation Table):

- For static (non-change-event) object requests, request qualifier codes 00 and 01 (start-stop), 07 and 08 (limited quantity), and 17 and 28 (index) are supported in addition to request qualifier code 06 (no range).
- Static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01.
- Static object requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28.
- For change-event object requests, qualifiers 17 or 28 are always responded.
- 16-bit and 32-bit Analog Change Events with Time may be requested.
- The read function code for Object 50 (Time and Date), variation 1, is supported.

Maximum Data Link Frame Size (octets): Transmitted: 292 Received: 292	Maximum Application Fragment Size (octets) Transmitted: 2048 Received: 249
Maximum Data Link Retries: ☐ None ☑ Fixed at 2 ☐ Configurable	Maximum Application Layer Retries: ☑ None ☐ Configurable
Requires Data Link Layer Confirmation: ☑ Never ☐ Always ☐ Sometimes ☐ Configurable	Requires Application Layer Confirmation: ☐ Never ☐ Always ☑ When reporting event data ☑ When sending multi-fragment responses ☐ Sometimes ☐ Configurable

Timeouts while waiting for:

Data Link Confirm:	☐ None	☑ Fixed at 100ms	☐ Variable	☐ Configurable
Complete Appl. Fragment:	☑ None	☐ Fixed at ___	☐ Variable	☐ Configurable
Application Confirm:	☐ None	☑ Fixed at 1s	☐ Variable	☐ Configurable
Complete Appl. Response:	☑ None	☐ Fixed at ___	☐ Variable	☐ Configurable

Others:				
Inter-character Delay:	4 character times at selected baud rate			
Select/Operate Arm Timeout:	Default 10s			
Need Time Interval:	Configurable, 0 or 30min			
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

Reports Binary Input Change Events when no specific variation requested: ☑ Never ☑ Only time-tagged variation 2 ☐ Only non-time-tagged ☐ Configurable	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
Sends Unsolicited Responses: ☑ Never ☐ Configurable ☐ Certain objects only ☐ Sometimes ☐ ENABLE/DISABLE UNSOLICITED function codes supported	Sends Static Data in Unsolicited Responses: ☑ Never ☐ When device restarts ☐ When status flags changes No other options are permitted.
Default Counter Object/Variation: ☐ No counters reported ☐ Configurable ☑ Default object: 20 ☑ Default variation: 5 ☑ Point-by-point list attached	Counters Roll Over at: ☐ No counters reported ☐ Configurable ☐ 16 bits ☑ 32 bits ☐ Other value: ______ ☑ Point-by-point list attached
Sends multi-fragment responses: ☑ Yes ☐ No	

3. IMPLEMENTATION TABLE

The following table identifies the variations, function codes, and qualifiers supported by the P54x in both request and response messages.

For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Static object requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event objects, qualifiers 17 or 28 are always responded.

Object			Request		Response	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
1	0	Binary Input (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)		
1	1 (default – see note 1)	Binary Input without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
1	2	Binary Input with Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
2	0	Binary Input Change (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
2	1	Binary Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
2	2 (default – see note 1)	Binary Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
10	0	Binary Output Status (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)		
10	2 (default – see note 1)	Binary Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
12	1	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, no ack)	00, 01 (start-stop) 06 (limited qty) 07, 08 (index) 17, 28	129 (response)	echo of request
20	0	Binary Counter (Variation 0 is used to request default variation)	1 (read) 7 (freeze) 8 (freeze no ack) 9 (freeze clear) 10 (frz. cl. no ack)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)		
20	1	32-Bit Binary Counter with Flag	1 (read) 7 (freeze) 8 (freeze no ack) 9 (freeze clear) 10 (frz. cl. no ack)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)

Object			Request		Response	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
20	2	16-Bit Binary Counter with Flag	1 (read) 7 (freeze) 8 (freeze no ack) 9 (freeze clear) 10 (frz. cl. no ack)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
20	5 (default – see note 1)	32-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze no ack) 9 (freeze clear) 10 (frz. cl. no ack)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
20	6	16-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze no ack) 9 (freeze clear) 10 (frz. cl. no ack)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
21	0	Frozen Counter (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)		
21	1	32-Bit Frozen Counter with Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
21	2	16-Bit Frozen Counter with Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
21	9 (default – see note 1)	32-Bit Frozen Counter without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
21	10	16-Bit Frozen Counter without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
30	0	Analog Input (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)		
30	1	32-Bit Analog Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
30	2 (default – see note 1)	16-Bit Analog Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
30	3	32-Bit Analog Input without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)

Object			Request		Response	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
30	4	16-Bit Analog Input without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
32	0	Analog Change Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
32	1	32-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
32	2 (default – see note 1)	16-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
32	3	32-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
32	4	16-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
50	0	Time and Date	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
50	1 (default – see note 1)	Time and Date	1 (read) 2 (write)	00, 01 (start-stop) 06 (no range, or all) 07 (limited qty = 1) 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
52	2	Time Delay Fine			129 (response)	07 (limited qty) (qty = 1)
60	0	Class 0, 1, 2, and 3 Data	1 (read)	06 (no range, or all)		
60	1	Class 0 Data	1 (read)	06 (no range, or all)	129 (response)	17, 28 (index)
60	2	Class 1 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
60	3	Class 2 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
60	4	Class 3 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
80	1	Internal Indications	1 (write)	00 (start–stop) (index must = 7)		
		No Object (function code only)	13 (cold restart)			
		No Object (function code only)	1 (warm restart)			
		No Object (function code only)	1 (delay meas.)			

Notes:

1. A Default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans.

2. For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. (For change-event objects, qualifiers 17 or 28 are always responded.)

4. POINT LIST

The tables in the following sections identify all the individual data points provided by this implementation of DNP 3.0.

4.1 Binary input points

The Binary Input objects (1 & 2) provide read-only access to a sub-set of the P54x's digital data bus (DDB).

By default, all the static object (object 1) points belong to the Class 0 data set. The default allocation of the points in the change-event object (object 2) to a change-event class (1, 2, 3) is indicated in the point-list table below. The MiCOM S1 setting support software may be used to alter both of these assignments. However, deselecting a point from class 0 also has the effect of removing the point from the point-list of objects 1 & 2 and renumbering the remaining points to ensure the point indices are contiguous.

The validity of each point is reported through the "online" bit in the "flag", which is supplied for each point with the "with flag" object variations. Points reported as being offline, will typically be points that are invalid for the relay's current configuration, which is a product of its model number and current settings.

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
						Output Relay Status			
0	0	0	0	0	0	Output Relay 1	0	2	FALSE
1	1	1	1	1	1	Output Relay 2	1	2	FALSE
2	2	2	2	2	2	Output Relay 3	2	2	FALSE
3	3	3	3	3	3	Output Relay 4	3	2	FALSE
4	4	4	4	4	4	Output Relay 5	4	2	FALSE
5	5	5	5	5	5	Output Relay 6	5	2	FALSE
6	6	6	6	6	6	Output Relay 7	6	2	FALSE
	7	7	7	7	7	Output Relay 8	7	2	FALSE
	8	8	8	8	8	Output Relay 9	8	2	FALSE
	9	9	9	9	9	Output Relay 10	9	2	FALSE
	10	10	10	10	10	Output Relay 11	10	2	FALSE
	11	11	11	11	11	Output Relay 12	11	2	FALSE
	12	12	12	12	12	Output Relay 13	12	2	FALSE
	13	13	13	13	13	Output Relay 14	13	2	FALSE
				14	14	Output Relay 15	14	2	FALSE
				15	15	Output Relay 16	15	2	FALSE
				16	16	Output Relay 17	16	2	FALSE
				17	17	Output Relay 18	17	2	FALSE
				18	18	Output Relay 19	18	2	FALSE
				19	19	Output Relay 20	19	2	FALSE
				20	20	Output Relay 21	20	2	FALSE
				21	21	Output Relay 22	21	2	FALSE
				22	22	Output Relay 23	22	2	FALSE
				23	23	Output Relay 24	23	2	FALSE
				24	24	Output Relay 25	24	2	FALSE
				25	25	Output Relay 26	25	2	FALSE
				26	26	Output Relay 27	26	2	FALSE
				27	27	Output Relay 28	27	2	FALSE
				28	28	Output Relay 29	28	2	FALSE
				29	29	Output Relay 30	29	2	FALSE
				30	30	Output Relay 31	30	2	FALSE
				31	31	Output Relay 32	31	2	FALSE
						Opto Isolator Status			
7	14	14	14	32	32	Opto Isolator Input 1	32	2	FALSE
8	15	15	15	33	33	Opto Isolator Input 2	33	2	FALSE
9	16	16	16	34	34	Opto Isolator Input 3	34	2	FALSE
10	17	17	17	35	35	Opto Isolator Input 4	35	2	FALSE
11	18	18	18	36	36	Opto Isolator Input 5	36	2	FALSE
12	19	19	19	37	37	Opto Isolator Input 6	37	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
13	20	20	20	38	38	Opto Isolator Input 7	38	2	FALSE
14	21	21	21	39	39	Opto Isolator Input 8	39	2	FALSE
	22	22	22	40	40	Opto Isolator Input 9	40	2	FALSE
	23	23	23	41	41	Opto Isolator Input 10	41	2	FALSE
	24	24	24	42	42	Opto Isolator Input 11	42	2	FALSE
	25	25	25	43	43	Opto Isolator Input 12	43	2	FALSE
	26	26	26	44	44	Opto Isolator Input 13	44	2	FALSE
	27	27	27	45	45	Opto Isolator Input 14	45	2	FALSE
	28	28	28	46	46	Opto Isolator Input 15	46	2	FALSE
	29	29	29	47	47	Opto Isolator Input 16	47	2	FALSE
				48	48	Opto Isolator Input 17	48	2	FALSE
				49	49	Opto Isolator Input 18	49	2	FALSE
				50	50	Opto Isolator Input 19	50	2	FALSE
				51	51	Opto Isolator Input 20	51	2	FALSE
				52	52	Opto Isolator Input 21	52	2	FALSE
				53	53	Opto Isolator Input 22	53	2	FALSE
				54	54	Opto Isolator Input 23	54	2	FALSE
				55	55	Opto Isolator Input 24	55	2	FALSE
						Alarm Indications			
15	30	30	30	56	56	Field Voltage Fail	547	2	FALSE
16	31	31	31	57	57	Setting Group Via Opto Invalid	145	2	FALSE
17	32	32	32	58	58	Test Mode Enabled	146	2	FALSE
		33	33	59	59	VTS Indication	147	2	FALSE
		34	34	60	60	Power Swing	148	2	FALSE
18	33	35	35	61	61	BF Block	149	2	FALSE
19	34	36		62		Broken Current Alarm	150	2	FALSE
20	35	37		63		Broken Current lookout	151	2	FALSE
21	36	38		64		Maintenance Alarm	152	2	FALSE
22	37	39		65		Maintenance Lockout	153	2	FALSE
23	38	40		66		Excessive Op Time Alarm	154	2	FALSE
24	39	41		67		Excessive Op Time Lockout	155	2	FALSE
25	40	42		68		EFF Lockout	156	2	FALSE
26	41	43	36	69	62	CB Alarm Status	619	2	FALSE
			37		63	CB Alarm Status 2	620	2	FALSE
27	42	44	38	70	64	CB Failed to Trip	159	2	FALSE
28	43	45	39	71	65	CB Failed to Close	160	2	FALSE
29	44	46	40	72	66	Control CB Unhealthy	161	2	FALSE
		47		73		Control No Checksync	162	2	FALSE
	45	48		74		Autoclose Locout/RLY BAR	163	2	FALSE
			41		67	CB2 Fail Alarm	163	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	**P542 Point Index**	**P543 Point Index**	**P544 Point Index**	**P545 Point Index**	**P546 Point Index**	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
	46	49		75		No Healthy (AR)	164	2	FALSE
		50		76		No Check Sync /AR Fail	165	2	FALSE
30	47	51	42	77	68	Incompatible relays	166	2	FALSE
31	48	52	43	78	69	Loop Back Test Enabled	167	2	FALSE
32	49	53	44	79	70	Signalling failure alarm	168	2	FALSE
33	50	54	45	80	71	Signalling Propagation Delay Alarm	169	2	FALSE
34	51	55	46	81	72	Differential protection failure alarm	170	2	FALSE
35	52	56	47	82	73	Diff Protection inhibited	171	2	FALSE
36	53	57	48	83	74	Configuration Error	172	2	FALSE
37	54	58	59	84	75	Re-Configuration Error	173	2	FALSE
38	55	59	60	85	76	Frequency our of range	174	2	FALSE
				86	77	GPS Alarm	158	2	FALSE
				87	78	Ch1 GPS Fail	606	2	FALSE
				88	79	Ch 2 GPS Fail	607	2	FALSE
						Miscellaneous Indications			
39	56	60	51	89	80	Battery Status	N/A	2	FALSE
40	57	61	52	90	81	IRIG-B Status	N/A	2	FALSE
						Protection Events (Digital Databus Signals)			
41	58	62	53	91	82	Any Trip	350	2	FALSE
42	59	63	54	92	83	Differential Trip	351	2	FALSE
43	60	64	55	93	84	Differential Trip A	352	2	FALSE
44	61	65	56	94	85	Differential Trip B	353	2	FALSE
45	62	66	57	95	86	Differential Trip C	354	2	FALSE
		67		96		Pole Discrepancy	376	2	FALSE
46	63	68	58	97	87	Differential Intertrip	355	2	FALSE
47	64	69	59	98	88	Differential Intertrip A	356	2	FALSE
48	65	70	60	99	89	Differential Intertrip B	357	2	FALSE
49	66	71	61	100	90	Differential Intertrip C	358	2	FALSE
50	67	72	62	101	91	Direct Intertrip	359	2	FALSE
51	68	73	63	102	92	Permissive Intertrip	360	2	FALSE
		74	64	103	93	Zone 1 Trip	361	2	FALSE
		75	65	104	94	Zone 1 A Trip	362	2	FALSE
		76	66	105	95	Zone 1 B Trip	363	2	FALSE
		77	67	106	96	Zone 1 C Trip	364	2	FALSE
		78	68	107	97	Zone 1 N Trip	365	2	FALSE
		79	69	108	98	Zone 2 Trip	366	2	FALSE
		80	70	109	99	Zone 2 A Trip	367	2	FALSE
		81	71	110	100	Zone 2 B Trip	368	2	FALSE
		82	72	111	101	Zone 2 C Trip	369	2	FALSE
		83	73	112	102	Zone 2 N Trip	370	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
		84	74	113	103	Zone 3 Trip	371	2	FALSE
		85	75	114	104	Zone 3 A Trip	372	2	FALSE
		86	76	115	105	Zone 3 B Trip	373	2	FALSE
		87	77	116	106	Zone 3 C Trip	374	2	FALSE
		88	78	117	107	Zone 3 N Trip	375	2	FALSE
52	69	89	79	118	108	BU Intertrip	377	2	FALSE
53	70	90	80	119	109	BU Intertrip A	378	2	FALSE
54	71	91	81	120	110	BU Intertrip B	379	2	FALSE
55	72	92	82	121	111	BU Intertrip C	380	2	FALSE
		93	83	122	112	Force 3pole BU	381	2	FALSE
56	73	94	84	123	113	1st Stage O/C Trip 3ph	382	2	FALSE
57	74	95	85	124	114	1st Stage O/C Trip A	383	2	FALSE
58	75	95	86	125	115	1st Stage O/C Trip B	384	2	FALSE
59	76	97	87	126	116	1st Stage O/C Trip C	385	2	FALSE
60	77	98	88	127	117	2nd Stage O/C Trip 3ph	386	2	FALSE
61	78	99	89	128	118	2nd Stage O/C Trip A	387	2	FALSE
62	79	100	90	129	119	2nd Stage O/C Trip B	388	2	FALSE
63	80	101	91	130	120	2nd Stage O/C Trip C	389	2	FALSE
64	81	102	92	131	121	3rd Stage O/C Trip 3ph	390	2	FALSE
65	82	103	93	132	122	3rd Stage O/C Trip A	391	2	FALSE
66	83	104	94	133	123	3rd Stage O/C Trip B	392	2	FALSE
67	84	105	95	134	124	3rd Stage O/C Trip C	393	2	FALSE
68	85	106	96	135	125	4th Stage O/C Trip 3ph	394	2	FALSE
69	86	107	97	136	126	4th Stage O/C Trip A	395	2	FALSE
70	87	108	98	137	127	4th Stage O/C Trip B	396	2	FALSE
71	88	109	99	138	128	4th Stage O/C Trip C	397	2	FALSE
72	89	110	100	139	129	1st Stage SBEF Trip	398	2	FALSE
73	90	111	101	140	130	2nd Stage SBEF Trip	399	2	FALSE
74	91	112	102	141	131	3rd Stage SBEF Trip	400	2	FALSE
75	92	113	103	142	132	4th Stage SBEF Trip	401	2	FALSE
		114	104	143	133	1st Stage SEF Trip	402	2	FALSE
		115	105	144	134	2nd Stage SEF Trip	403	2	FALSE
		116	106	145	135	3rd Stage SEF Trip	404	2	FALSE
		117	107	146	136	4th Stage SEF Trip	405	2	FALSE
76	93	118	108	147	137	Broken Conductor Trip	406	2	FALSE
77	94	119	109	148	138	Thermal Overload Trip	407	2	FALSE
			110		139	Stub Bus Trip	408	2	FALSE
78	95	120	111	149	140	Any Start	434	2	FALSE
79	96	121	112	150	141	Differential Start A	435	2	FALSE
80	97	122	113	151	142	Differential Start B	436	2	FALSE
81	98	123	114	152	143	Differential Start C	437	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
		124	115	153	144	Zone 1 A Start	438	2	FALSE
		125	116	154	145	Zone 1 B Start	439	2	FALSE
		126	117	155	146	Zone 1 C Start	440	2	FALSE
		127	118	156	147	Zone 1 N Start	441	2	FALSE
		128	119	157	148	Zone 2 A Start	442	2	FALSE
		129	120	158	149	Zone 2 B Start	443	2	FALSE
		130	121	159	150	Zone 2 C Start	444	2	FALSE
		131	122	160	151	Zone 2 N Start	445	2	FALSE
		132	123	161	152	Zone 3 A Start	446	2	FALSE
		133	124	162	153	Zone 3 B Start	447	2	FALSE
		134	125	163	154	Zone 3 C Start	448	2	FALSE
		135	126	164	155	Zone 3 N Start	449	2	FALSE
		136	127	165	156	Zone 6 Start	450	2	FALSE
82	99	137	128	166	157	1st Stage O/C Start 3ph	451	2	FALSE
83	100	138	129	167	158	1st Stage O/C Start A	452	2	FALSE
84	101	139	130	168	159	1st Stage O/C Start B	453	2	FALSE
85	102	140	131	169	160	1st Stage O/C Stage C	454	2	FALSE
86	103	141	132	170	161	2nd Stage O/C Start 3ph	455	2	FALSE
87	104	142	133	171	162	2nd Stage O/C Start A	456	2	FALSE
88	105	143	134	172	163	2nd Stage O/C Start B	457	2	FALSE
89	106	144	135	173	164	2nd Stage O/C Start C	458	2	FALSE
90	107	145	136	174	165	3rd Stage O/C Start 3ph	459	2	FALSE
91	108	146	137	175	166	3rd Stage O/C Start A	460	2	FALSE
92	109	147	138	176	167	3rd Stage O/C Start B	461	2	FALSE
93	110	148	139	177	168	3rd Stage O/C Start C	462	2	FALSE
94	111	149	140	178	169	4th Stage O/C Start 3ph	463	2	FALSE
95	112	150	141	179	170	4th Stage O/C Start A	464	2	FALSE
96	113	151	142	480	171	4th Stage O/C Start B	465	2	FALSE
97	114	152	143	181	172	4th Stage O/C Start C	466	2	FALSE
98	115	153	144	182	173	1st Stage SBEF Start	467	2	FALSE
99	116	154	145	183	174	2nd Stage SBEF Start	468	2	FALSE
100	117	155	146	184	175	3rd Stage SBEF Start	469	2	FALSE
101	118	156	147	185	176	4th Stage SBEF Start	470	2	FALSE
		157	148	186	177	1st Stage SEF Start	471	2	FALSE
		158	149	187	178	2nd Stage SEF Start	472	2	FALSE
		159	150	188	179	3rd Stage SEF Start	473	2	FALSE
		160	151	189	180	4th Stage SEF Start	474	2	FALSE
102	119	161	152	190	181	Thermal Overload Alarm	475	2	FALSE
103	120	162	153	191	182	tBF1 Trip 3ph	520	2	FALSE
104	121	163	154	192	183	tBF2 Trip 3ph	521	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
105	122	164	155	193	184	Control Trip	524	2	FALSE
106	123	165	156	194	185	Control Close	525	2	FALSE
			157		183	Control Trip 2	526	2	FALSE
			158		187	Control Close 2	527	2	FALSE
107	124	166	159	195	188	Control Close in Progress	528	2	FALSE
	125					AR Block Main Protection	529	2	FALSE
			160		189	CB2 Fail1 Trip	522	2	FALSE
	126					AR Block Main Protection	530	2	FALSE
			161		190	CB2 Fail2 Trip	523	2	FALSE
	127	167		196		Auto Reclose/(AR 3 pole) in Progress	531	2	FALSE
		168		197		AR 1pole in progress	532	2	FALSE
	128	169		198		Seq Counter = 1	534	2	FALSE
	129	170		199		Seq Counter = 2	535	2	FALSE
	130	171		200		Seq Counter = 3	536	2	FALSE
	131	172		201		Seq Counter = 4	537	2	FALSE
	132	173		202		Successful Reclosure	539	2	FALSE
	133					Dead Time in progress	540	2	FALSE
	134	174		203		Auto Close/AR Close	541	2	FALSE
	135	175		204		Autoreclose trip test	409	2	FALSE
		176		205		Autoreclose trip test A phase	410	2	FALSE
		177		206		Autoreclose trip test B phase	411	2	FALSE
		178		207		Autoreclose trip test C phase	412	2	FALSE
		179		208		Autoreclose In/Out of service	544	2	FALSE
108	136	180	163	209	191	Protection Signaling Failure Alarm – Ch1 Rx	602	2	FALSE
109	137	181	164	210	192	Protection Signaling Failure Alarm – Ch1 Tx	603	2	FALSE
110	138	182	165	211	193	Protection Signaling Failure Alarm – Ch2 Rx	604	2	FALSE
111	139	183	166	212	194	Protection Signaling Failure Alarm – Ch2 Tx	605	2	FALSE
112	140	184	166	213	195	Relay is already configured	608	2	FALSE
113	141	185	167	214	196	Reconfigure was successful	609	2	FALSE
114	142	186	168	215	197	Reconfigure was unsuccessful	610	2	FALSE
115	143	187	169	216	198	Restore was successful	611	2	FALSE
116	144	188	170	217	199	Restore was unsuccessful	612	2	FALSE
117	145	189	171	218	200	Inhibit C Diff	613	2	FALSE
118	146	190	172	219	201	Backup Enabled	766	2	FALSE
119	147	191	173	220	202	I>3 Intertrip	614	2	FALSE
		192	174	221	203	Z1 Intertrip	615	2	FALSE
		193	175	222	204	Z2 Intertrip	616	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
		194	176	223	205	Z3 Intertrip	617	2	FALSE
		195	177	224	206	1 Pole Trip En	618	2	FALSE
120	148	196		225		Composite Lockout Alarm	546	2	FALSE
	149					Autoreclose In/Out of service	542	2	FALSE
		197		226		Autoreclose In/Out of service	543	2	FALSE
		198		227		Seq Counter = 5	538	2	FALSE
			178		207	2B1 IA< Start	552	2	FALSE
			179		208	CB1 IB< Start	553	2	FALSE
			180		209	CB1 IC< Start	554	2	FALSE
			181		210	CB1 ISEF< Start	555	2	FALSE
			182		211	CB2 IA<Start	556	2	FALSE
			183		212	CB2 IB< Start	557	2	FALSE
			184		213	CB2 IC< Start	558	2	FALSE
			185		214	CB2 ISEF< Start	559	2	FALSE
						CB Status			
121	150	199	186	228	215	3 ph CB Open	582	2	FALSE
		200	187	229	216	Ph A CB Open	583	2	FALSE
		201	188	230	217	Ph B CB Open	584	2	FALSE
		202	189	231	218	Ph C CB Open	585	2	FALSE
122	151	203	190	232	219	3 ph CB Closed	586	2	FALSE
		204	191	233	220	Ph A CB Closed	587	2	FALSE
		205	192	234	221	Ph B CB Closed	588	2	FALSE
		206	193	235	222	Ph C CB Closed	589	2	FALSE
			194		223	3 ph CB 2 Open	590	2	FALSE
			195		224	Ph A CB2 Open	591	2	FALSE
			196		225	Ph B CB 2 Open	592	2	FALSE
			197		226	Ph C CB 2 Open	593	2	FALSE
			198		227	3 ph CB2 Closed	594	2	FALSE
			199		228	Ph A CB2 Closed	595	2	FALSE
			200		229	Ph B CB2 Closed	596	2	FALSE
			201		230	Ph C CB2 Closed	597	2	FALSE
123	152	207	202	236	231	IA< operate	548	2	FALSE
124	153	208	203	237	232	IB< operate	549	2	FALSE
125	154	209	204	238	233	IC< operate	550	2	FALSE
126	155	210	205	239	234	ISEF< operate	551	2	FALSE
127	156	211	206	240	235	All Poles Dead	560	2	FALSE
128	157	212	207	241	236	Any Pole Dead	561	2	FALSE
		213	208	242	237	Phase A Pole Dead	562	2	FALSE
		214	209	243	238	Phase B Pole Dead	563	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
		215	210	244	239	Phase C Pole Dead	564	2	FALSE
129	158	216	211	245	240	Unused	203	2	FALSE
130	159	217	212	246	241	Unused	204	2	FALSE
131	160	218	213	247	242	Unused	205	2	FALSE
132	161	219	214	248	243	Unused	206	2	FALSE
133	162	220	215	249	244	Not Used	175	2	FALSE
134	163	221	216	250	245	Not Used	176	2	FALSE
135	164	222	217	251	246	Not Used	177	2	FALSE
136	165	223	218	252	247	Not Used	178	2	FALSE
137	166	224	219	253	248	Not Used	179	2	FALSE
138	167	225	220	254	249	Not Used	180	2	FALSE
139	168	226	221	255	250	Not Used	181	2	FALSE
140	169	227	222	256	251	Not Used	182	2	FALSE
141	170	228	223	257	252	Not Used	183	2	FALSE
142	171	229	224	258	253	C Diff Protection Comms Mode	184	2	FALSE
143	172	230	225	259	254	IEEE 37.94 Communications Alarms	185	2	FALSE
144	173	231	226	260	255	System Split / Not Used	186	2	FALSE
145	174	232	227	261	256	SR User Alarm 1	187	2	FALSE
146	175	233	228	262	257	SR User Alarm 2	188	2	FALSE
147	176	234	229	263	258	SR User Alarm 3	189	2	FALSE
148	177	235	230	264	259	SR User Alarm 4	190	2	FALSE
149	178	236	231	265	260	SR User Alarm 5	191	2	FALSE
150	179	237	232	266	261	SR User Alarm 6	192	2	FALSE
151	180	238	233	267	262	SR User Alarm 7	193	2	FALSE
152	181	239	234	268	263	SR User Alarm 8	194	2	FALSE
153	182	240	235	269	264	MR User Alarm 9	195	2	FALSE
154	183	241	236	270	265	MR User Alarm 10	196	2	FALSE
155	184	242	237	271	266	MR User Alarm 11	197	2	FALSE
156	185	243	238	272	267	MR User Alarm 12	198	2	FALSE
157	186	244	239	273	268	MR User Alarm 13	199	2	FALSE
158	187	245	240	274	269	MR User Alarm 14	200	2	FALSE
159	188	246	241	275	270	MR User Alarm 15	201	2	FALSE
160	189	247	242	276	271	MR User Alarm 16	202	2	FALSE
		248	243	277	272	Zone 1 Start	430	2	FALSE
		249	244	278	273	Zone 2 Start	431	2	FALSE
		250	245	279	274	Zone 3 Start	432	2	FALSE
161	190	251	246	280	275	Differential Start	433	2	FALSE
162	191	252	247	281	276	Virtual Input 1	672	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
163	192	253	248	282	277	Virtual Input 2	673	2	FALSE
164	193	254	249	283	278	Virtual Input 3	674	2	FALSE
165	194	255	250	284	279	Virtual Input 4	675	2	FALSE
166	195	256	251	285	280	Virtual Input 5	676	2	FALSE
167	196	257	252	286	281	Virtual Input 6	677	2	FALSE
168	197	258	253	287	282	Virtual Input 7	678	2	FALSE
169	198	259	254	288	283	Virtual Input 8	679	2	FALSE
170	199	260	255	289	284	Virtual Input 9	680	2	FALSE
171	200	261	256	290	285	Virtual Input 10	681	2	FALSE
172	201	262	257	291	286	Virtual Input 11	682	2	FALSE
173	202	263	258	292	287	Virtual Input 12	683	2	FALSE
174	203	264	259	293	288	Virtual Input 13	684	2	FALSE
175	204	265	260	294	289	Virtual Input 14	685	2	FALSE
176	205	266	261	295	290	Virtual Input 15	686	2	FALSE
177	206	267	262	296	291	Virtual Input 16	687	2	FALSE
178	207	268	263	297	292	Virtual Input 17	688	2	FALSE
179	208	269	264	298	293	Virtual Input 18	689	2	FALSE
180	209	270	265	299	294	Virtual Input 19	690	2	FALSE
181	210	271	266	300	295	Virtual Input 20	691	2	FALSE
182	211	272	267	301	296	Virtual Input 21	692	2	FALSE
183	212	273	268	302	297	Virtual Input 22	693	2	FALSE
184	213	274	269	303	298	Virtual Input 23	694	2	FALSE
185	214	275	270	304	299	Virtual Input 24	695	2	FALSE
186	215	276	271	305	300	Virtual Input 25	696	2	FALSE
187	216	277	272	306	301	Virtual Input 26	697	2	FALSE
188	217	278	273	307	302	Virtual Input 27	698	2	FALSE
189	218	279	274	308	303	Virtual Input 28	699	2	FALSE
190	219	280	275	309	304	Virtual Input 29	700	2	FALSE
191	220	281	276	310	305	Virtual Input 30	701	2	FALSE
192	221	282	277	311	306	Virtual Input 31	702	2	FALSE
193	222	283	278	312	307	Virtual Input 32	703	2	FALSE
194	223	284	279	313	308	Virtual Output 1	704	2	FALSE
195	224	285	280	314	309	Virtual Output 2	705	2	FALSE
196	225	286	281	315	310	Virtual Output 3	706	2	FALSE
197	226	287	282	316	311	Virtual Output 4	707	2	FALSE
198	227	288	283	317	312	Virtual Output 5	708	2	FALSE
199	228	289	284	318	313	Virtual Output 6	709	2	FALSE
200	229	290	285	319	314	Virtual Output 7	710	2	FALSE
201	230	291	286	320	315	Virtual Output 8	711	2	FALSE
202	231	292	287	321	316	Virtual Output 9	712	2	FALSE
203	232	293	288	322	317	Virtual Output10	713	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
204	233	294	289	323	318	Virtual Output11	714	2	FALSE
205	234	295	290	324	319	Virtual Output12	715	2	FALSE
206	235	296	291	325	320	Virtual Output13	716	2	FALSE
207	236	297	292	326	321	Virtual Output14	717	2	FALSE
208	237	298	293	327	322	Virtual Output15	718	2	FALSE
209	238	299	294	328	323	Virtual Output16	719	2	FALSE
210	239	300	295	329	324	Virtual Output17	720	2	FALSE
211	240	301	296	330	325	Virtual Output18	721	2	FALSE
212	241	302	297	331	326	Virtual Output19	722	2	FALSE
213	242	303	298	332	327	Virtual Output20	723	2	FALSE
214	243	304	299	333	328	Virtual Output21	724	2	FALSE
215	244	305	300	334	329	Virtual Output22	725	2	FALSE
216	245	306	301	335	330	Virtual Output23	726	2	FALSE
217	246	307	302	336	331	Virtual Output24	727	2	FALSE
218	247	308	303	337	332	Virtual Output25	728	2	FALSE
219	248	309	304	338	333	Virtual Output26	729	2	FALSE
220	249	310	305	339	334	Virtual Output27	730	2	FALSE
221	250	311	306	340	335	Virtual Output28	731	2	FALSE
222	251	312	307	341	336	Virtual Output29	732	2	FALSE
223	252	313	308	342	337	Virtual Output30	733	2	FALSE
224	253	314	309	343	338	Virtual Output31	734	2	FALSE
225	254	315	310	344	339	Virtual Output32	735	2	FALSE
226	255	316	311	345	340	Battery Fail	487	2	FALSE
227	256	317	312	346	341	Not Used	488	2	FALSE
228	257	318	313	347	342	GOOSE IED Absent	489	2	FALSE
229	258	319	314	348	343	NIC Not Fitted	490	2	FALSE
230	259	320	315	349	344	NIC No Response	491	2	FALSE
231	260	321	316	350	345	NIC Fatal Error	492	2	FALSE
232	261	322	317	351	346	NIC Soft. Reload	493	2	FALSE
233	262	323	318	352	347	Bad TCP/IP Cfg.	494	2	FALSE
234	263	324	319	353	348	Bad OSI Config.	495	2	FALSE
235	264	325	320	354	349	NIC Link Fail	496	2	FALSE
236	265	326	321	355	350	NIC SW Mis-Match	497	2	FALSE
237	266	327	322	356	351	IP Addr Conflict	498	2	FALSE
238	267	328	323	357	352	Not Used	499	2	FALSE
239	268	329	324	358	353	Not Used	500	2	FALSE
240	269	330	325	359	354	Not Used	501	2	FALSE
241	270	331	326	360	355	Not Used	502	2	FALSE
242	271	332	327	361	356	Backup Setting	503	2	FALSE
243	272	333	328	362	357	Not Used	504	2	FALSE
244	273	334	329	363	358	Not Used	505	2	FALSE

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary Input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description		Change Event Assigned Class (1, 2, 3)	Initial Va,ue
245	274	335	330	364	359	Not Used	506	2	FALSE
246	275	336	331	365	360	Not Used	507	2	FALSE
247	276	337	332	366	361	Not Used	508	2	FALSE
248	277	338	333	367	362	Not Used	509	2	FALSE
249	278	339	334	368	363	Not Used	510	2	FALSE
250	279	340	335	369	364	Not Used	511	2	FALSE
251	280	341	336	370	365	Not Used	512	2	FALSE
252	281	342	337	371	366	Not Used	513	2	FALSE
253	282	343	338	372	367	Not Used	514	2	FALSE
254	283	344	339	373	368	Not Used	515	2	FALSE
255	284	345	340	374	369	Not Used	516	2	FALSE
256	285	346	341	375	370	Not Used	517	2	FALSE
257	286	347	342	376	371	Ch1 loss of Signal	654	2	FALSE
258	287	348	343	377	372	Ch1 Path “Yellow”	655	2	FALSE
259	288	349	344	378	373	Ch1 Mismatch Received N	656	2	FALSE
260	289	350	345	379	374	Ch2 Loss of Signal	657	2	FALSE
261	290	351	346	380	375	Ch2 Path “Yellow”	658	2	FALSE
262	291	352	347	381	376	Ch2 Mismatch Received N	659	2	FALSE

4.2 Binary output status points and control relay output block

The following table lists both the Binary Output Status Points (Object 10) and the Control Relay Output Block (Object 12).

Binary Output Status points are included in Class 0 data set. (Since there is not a change-event object for the binary outputs, the binary output points are not part of the class 1, 2, or 3 data sets). It is not possible to configure the class 0 membership of this object with MiCOM S1.

The validity of each point is reported through the “online” bit in the “flag”, which is supplied for each point with the “with flag” object variations. Points reported as being offline, will typically be points that are invalid for the relay’s current configuration, which is a product of its model number and current settings.

The Control Relay Output Block (CROB) implementation is compliant with the DNP technical bulletin TB2000-006, which rescinds CROB behaviours specified in the original four document set and addendum sub-set documents.

The following text is a brief summary of DNP technical bulletin TB2000-006:

Each control point in the CROB may be either a "complimentary control function" or a "single function".

Examples of complimentary control functions are:

- Trip and close
- On and Off

Examples of single-function controls are:

- Trip
- Activate

A point index cannot support both complimentary and single-function methods of operation.

Complimentary control function points require the use of a complementary control-code pair. The CROB provides two sets of control pairs:

- Code 03_{16} "Latch On" and code 04_{16} "Latch Off"
- Code 41_{16} "Pulse On/Close" and code 81_{16} "Pulse On/Trip"

In DNP there is no significance to these codes; they do the same thing. A complimentary-control point may "permit" either or both of these pairs. If a point permits both pairs of codes then:

- Latch On and Pulse Close must perform the same function
- Latch Off and Pulse Trip must perform the same function

Single-function control points may permit one or more of the following control codes:

- Code 01_{16} "Pulse On"
- Code 03_{16} "Latch On"
- Code 04_{16} "Latch Off"
- Code 41_{16} "Pulse On/Close
- Code 81_{16} "Pulse On/Trip"

There is no significance to these codes; they do the same thing. Each of the permitted single-function codes must perform the same function on a given single-function point index.

The original DNP 3.0 specification for the CROB "exposes the details of the device hardware to the protocol stack. This is unnecessary and creates interoperability issues". Moreover, "some IED vendors have implemented points that do different things based on the control code that is sent. " E.g. a point latches for the latch codes and pulses for the pulse codes. "This perverts the original intent of the CROB and makes it impossible for masters that statically configure control codes to be interoperable with such [IEDs]. This type of implementation is also not transportable across legacy protocol boundaries."

In the following table, point indices that are marked as “unpaired” will accept the correspondingly marked control codes and treat them identically as a “trigger” for the command action associated with the point. Unpaired points do not have a state value that can be read and a read request, whilst completing successfully, will always return a value of zero.

Points that are marked as “paired” behave as complimentary-controls and have a state value that can be read. The Latch On and Pulse On/Close control-codes set the specified output status point whilst the Latch Off and Pulse On/Trip codes reset it.

The Count field is not supported and must be either zero or one. The On-time, and Off-time fields are ignored. The Queue and Clear bits in the Control-Code field are not supported and must be zero. The “Pulse Off” control-code code is not supported.

Binary Output Status Points
Object Number: 10
Request Function Code supported: 1 (read)
Default Variation reported when variation 0 requested: 2 (Binary Output Status)
Control Relay Output Blocks (CROB)
Object Number: 12

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description	Supported Control Relay Output Block Fields
						Activate Setting Groups	
0	0	0	0	0	0	Activate Setting Group 1	Note 1
1	1	1	1	1	1	Activate Setting Group 2	Note 1
2	2	2	2	2	2	Activate Setting Group 3	Note 1
3	3	3	3	3	3	Activate Setting Group 4	Note 1
						Controls	
4	4	4	4	4	4	CB Trip	Note 1
5	5	5	5	5	5	CB Close	Note 1
6	6	6	6	6	6	Reset Indication	Note 1
7	7	7	7	7	7	Reset Demand	Note 1
8	8	8	8	8	8	Reset Thermal	Note 1
9	9	9	9	9	9	Clear Events	Note 1
10	10	10	10	10	10	Clear Faults	Note 1
11	11	11	11	11	11	Clear Maint	Note 1
12	12	12	12	12	12	Test LEDs	Note 1
	13	13		13		Test Autoreclose – 3 phase	Note 1
		14		14		Test Autoreclose – Phase A	Note 1
		15		15		Test Autoreclose – Phase B	Note 1
		16		16		Test Autoreclose – Phase C	Note 1
	14	17		17		LockoutReset	Note 1
	15	18		18		Reset Total A/R	Note 1
13	16	19		19		Reset CB Data	Note 1
	17					AR Telecontrol Auto	Note 1
	18					AR Telecontrol Non-Auto	Note 1
14	19	20	13	20	13	Clear Statistics	Note 1
			14		14	CB Trip 2	Note 1
			15		15	CB Close 2	Note 1
15	20	21	16	21	16	Control Input 1	Note 2
16	21	22	17	22	17	Control Input 2	Note 2
17	22	23	18	23	18	Control Input 3	Note 2
18	23	24	19	24	19	Control Input 4	Note 2
19	24	25	20	25	20	Control Input 5	Note 2
20	25	26	21	26	21	Control Input 6	Note 2
21	26	27	22	27	22	Control Input 7	Note 2
22	27	28	23	28	23	Control Input 8	Note 2
23	28	29	24	29	24	Control Input 9	Note 2
24	29	30	25	30	25	Control Input 10	Note 2
25	30	31	26	31	26	Control Input 11	Note 2
26	31	32	27	32	27	Control Input 12	Note 2

Binary Output Status Points
Object Number: 10
Request Function Code supported: 1 (read)
Default Variation reported when variation 0 requested: 2 (Binary Output Status)
Control Relay Output Blocks (CROB)
Object Number: 12

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description	Supported Control Relay Output Block Fields
27	32	33	28	33	28	Control Input 13	Note 2
28	33	33	29	34	29	Control Input 14	Note 2
29	34	34	30	35	30	Control Input 15	Note 2
30	35	35	31	36	31	Control Input 16	Note 2
31	36	36	32	37	32	Control Input 17	Note 2
32	37	37	33	38	33	Control Input 18	Note 2
33	38	38	34	39	34	Control Input 19	Note 2
34	39	39	35	40	35	Control Input 20	Note 2
35	40	40	36	41	36	Control Input 21	Note 2
36	41	41	37	42	37	Control Input 22	Note 2
37	42	42	38	43	38	Control Input 23	Note 2
38	43	43	39	44	39	Control Input 24	Note 2
39	44	44	40	45	40	Control Input 25	Note 2
40	45	45	41	46	41	Control Input 26	Note 2
41	46	46	42	47	42	Control Input 27	Note 2
42	47	47	43	48	43	Control Input 28	Note 2
43	48	48	44	49	44	Control Input 29	Note 2
44	49	49	45	50	45	Control Input 30	Note 2
45	50	50	46	51	46	Control Input 31	Note 2
46	51	52	47	52	47	Control Input 32	Note 2
47	52	53	48	53	48	Clear Disturbance Records	Note 1

Note 1: LATCH_ON and PULSE_ON operations are supported, although both have the same effect for these data points; the operation is carried out once.

Note 2: LATCH_ON and LATCH_OFF operations are supported. PULSE_ON is not supported. The queue, clear trip/close, on time and off time fields are ignored. A read of these points through object 10 will always return zero.

4.3 Counters

The following table lists both Binary Counters (Object 20) and Frozen Counters (Object 21). When a freeze function is performed on a Binary Counter point, the frozen value is available in the corresponding Frozen Counter point.

By default the Binary Counters (object 20) and Frozen Counters (object 21) are included in class 0 polls. The MiCOM S1 setting support software may be used to alter both of these assignments. (Since there is not a change-event object for the Binary Counters or Frozen Counters, the counter points are not part of the class 1, 2, or 3 data sets). However, deselecting a point from class 0 also has the effect of removing the point from the point-list of the associated object (20 or 21) and renumbering the remaining points to ensure the point indices are contiguous. Moreover, if a point is deselected from the running counter object (20) then it is also deselected from the frozen counter object (21).

The validity of each point is reported through the “online” bit in the “flag”, which is supplied for each point with the “with flag” object variations. Points reported as being offline, will typically be points that are invalid for the relay’s current configuration, which is a product of its model number and current settings.

Binary Counter Points
Static (Steady-State) Object Number: 20
Request Function Code supported: 1 (read), 7 (freeze), 8 (freeze no ack), **9 (freeze no ack), 10 (freeze and clear, no ack)**
Static Variation reported when variation 0 requested: 5 (32-Bit Binary Counter without Flag)
Change Event Variation reported when variation 0 requested: none - not supported
Frozen Counter Points
Static (Steady State) Object Number: 21
Request Function Code supported: 1 (read)

P541 Point Index	**P542 Point Index**	**P543 Point Index**	**P544 Point Index**	**P545 Point Index**	**P546 Point Index**	Name/Description	Data Type
						Activate Setting Groups	
		0	0	0	0	3Ph Whours Fwd	D10
		1	1	1	1	3Ph Whours Rev	D10
		2	2	2	2	3Ph VarHours Fwd	D10
		3	3	3	3	3Ph VarHours Rev	D10
0	0					CB Operations	
		4		4		CB A Operations	
		5		5		CB B Operations	
		6		6		CB C Operations	
	1	7		7		Total Reclosures	
1	2	8	4	8	4	Elapsed Time	
2	3	9	5	9	5	Ch1 No.Vald Mess	
3	4	10	6	10	6	Ch1 No.Err Mess	
4	5	11	7	11	7	Ch1 No.Errored s	
5	6	12	8	12	8	Ch1 No.Sev Err s	
6	7	13	9	13	9	Ch1 No.Dgraded m	
7	8	14	10	14	10	Ch2 No.Vald Mess	
8	9	15	11	15	11	Ch2 No.Err Mess	
9	10	16	12	16	12	Ch2 No.Errored s	
10	11	17	13	17	13	Ch2 No.Sev Err s	
11	12	18	14	18	14	Ch2 No Dgraded m	

4.4 Analog inputs

The following table lists the Analog Inputs (Object 30).

For each point, the “Data Type” code refers to the points scaling information in section §4.5; analog values are provided in a fixed-point integer format derived from the relay’s internal per-unit quantities. The scaling information associated with each data-type code, in section §4.5, will result in an equivalent secondary (i.e. relay input) value. Additional scaling will be required to produce the primary (i.e. power system) values.

By default, all the static object (object 30) points belong to the Class 0 data set. The “Default Deadband”, and the “Default Change Event Assigned Class” columns are used to represent the absolute amount by which the point must change before an analog change event will be generated. The default allocation of the points in the change-event object (object 32) to a change-event class (1, 2, 3) is also indicated. The class 0, deadband, and event class values may be changed with the MiCOM S1 setting support software. However, deselecting a point from class 0 also has the effect of removing the point from the point-list of objects 30 & 32 and renumbering the remaining points to ensure the point indices are contiguous.

The validity of each point is reported through the “online” bit in the “flag”, which is supplied for each point with the “with flag” object variations. Points reported as being offline, will typically be points that are invalid for the relay’s current configuration, which is a product of its model number and current settings.

Analog Inputs

Static (Steady State) Object Number:	**30**
Change Event Object Number:	**32**
Request Function Codes supported:	**1 (read)**
Static Variation reported when variation 0 requested:	**2 (16-Bit Analog Input)**
Change Event Variation reported when variation 0 requested:	**2 (16-Bit Analog Change Event without Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description	Data Type	Valid Range	Default Deadband	Default Change Event Class (1, 2, 3, or none)
						Active Group				
0	0	0	0	0	0	Active Group	D9	1 … 4	1	3
						Measurements 1				
1	1	1	1	1	1	IA Magnitude	D1	0.000…65.534	0.1	3
2	2	2	2	2	2	IA Phase Angle	D4	-180.00…+180.00	1	3
3	3	3	3	3	3	IB Magnitude	D1	0.000…65.534	0.1	3
4	4	4	4	4	4	IB Phase Angle	D4	-180.00…+180.00	1	3
5	5	5	5	5	5	IC Magnitude	D1	0.000…65.534	0.1	3
6	6	6	6	6	6	IC Phase Angle	D4	-180.00…+180.00	1	3
7	7	7	7	7	7	IN Measured Magnitude	D2	0.0000…2.0000	0.01	3
8	8	8	8	8	8	IN Measured Angle	D4	-180.00…+180.00	1	3
9	9	9	9	9	9	IN Derived Magnitude	D1	0.000…65.534	0.1	3
10	10	10	10	10	10	IN Derived Angle	D4	-180.00…+180.00	1	3
11	11	11	11	11	11	I1 Magnitude	D1	0.000…65.534	0.1	3
12	12	12	12	12	12	I2 Magnitude	D1	0.000…65.534	0.1	3
13	13	13	13	13	13	I0 Magnitude	D1	0.000…65.534	0.1	3
14	14	14	14	14	14	IA RMS	D1	0.000…65.534	0.1	3
15	15	15	15	15	15	IB RMS	D1	0.000…65.534	0.1	3
16	16	16	16	16	16	IC RMS	D1	0.000…65.534	0.1	3
		17	17	17	17	VAB Magnitude	D3	0.00…220.00	5	3
		18	18	18	18	VAB Phase Angle	D4	-180.00..+180.00	1	3

Analog Inputs	
Static (Steady State) Object Number:	**30**
Change Event Object Number:	**32**
Request Function Codes supported:	**1 (read)**
Static Variation reported when variation 0 requested:	**2 (16-Bit Analog Input)**
Change Event Variation reported when variation 0 requested:	**2 (16-Bit Analog Change Event without Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description	Data Type	Valid Range	Default Deadband	Default Change Event Class (1, 2, 3, or none)
		19	19	19	19	VBC Magnitude	D3	0.00…220.00	5	3
		20	20	20	20	VBC Phase Angle	D4	-180.00…+180.00	1	3
		21	21	21	21	VCA Magnitude	D3	0.00…220.00	5	3
		22	22	22	22	VBA Phase Angle	D4	-180.00…+180.00	1	3
		23	23	23	23	VAN Magnitude	D3	0.00…220.00	5	3
		24	24	24	24	VAN Phase Angle	D4	-180.00…+180.00	1	3
		25	25	25	25	VBN Magnitude	D3	0.00…220.00	5	3
		26	26	26	26	VBN Phase Angle	D4	-180.00…+180.00	1	3
		27	27	27	27	VCN Magnitude	D3	0.00…220.00	5	3
		28	28	28	28	VCN Phase Angle	D4	-180.00…+180.00	1	3
		29	29	29	29	V1 Magnitude	D3	0.00…220.00	5	3
		30	30	30	30	V2 Magnitude	D3	0.00…220.00	5	3
		31	31	31	31	V0 Magnitude	D3	0.00…220.00	5	3
		32	32	32	32	VAN RMS	D3	0.00…220.00	5	3
		33	33	33	33	VBN RMS	D3	0.00…220.00	5	3
		34	34	34	34	VCN RMS	D3	0.00…220.00	5	3
17	17	35	35	35	35	Frequency	D5	5.00…70.00	5	3
		36		36		C/S Voltage Mag	D3	0.00…220.00	5	3
		37		37		C/S Voltage Ang	D4	-180.00…+180.00	1	3
		38		38		C/S Bus-Line Ang	D3	-180.00…+180.00	1	3
		39		39		Sin Frequency	D5	5.00…70.00	0.5	3
		40	36	40	36	IM Magnitude	D1	0.000…65.534	0.1	3
		41	37	41	37	IM Phase Angle	D4	-180.00…+180.00	1	3
						Measurements 2				
		42	38	42	38	A Phase Watts	D6	-3150.0…+3150.0	1	3
		43	39	43	39	B Phase Watts	D6	-3150.0…+3150.0	1	3
		44	40	44	40	C Phase Watts	D6	-3150.0…+3150.0	1	3
		45	41	45	41	A Phase VArs	D6	-3150.0…+3150.0	1	3
		46	42	46	42	B Phase VArs	D6	-3150.0…+3150.0	1	3
		47	43	47	43	C Phase VArs	D6	-3150.0…+3150.0	1	3
		48	44	48	43	A Phase VA	D6	-3150.0…+3150.0	1	3
		49	45	49	45	B Phase VA	D6	-3150.0…+3150.0	1	3
		50	46	50	46	C Phase VA	D6	-3150.0…+3150.0	1	3
		51	47	51	47	3 Phase Watts	D6	-31,500…+31,500	1	3
		52	48	52	48	3 Phase VArs	D6	-31,500…+31,500	1	3
		53	49	53	49	3 Phase VA	D6	-31,500…+31,500	1	3
		54	50	54	50	3Ph Power Factor	D8	0.000…1.000	0.1	3
		55	51	55	51	APh Power Factor	D8	0.000…1.000	0.1	3
		56	52	56	52	BPh Power Factor	D8	0.000…1.000	0.1	3
		57	53	57	53	CPh Power Factor	D8	0.000…1.000	0.1	3

Analog Inputs
Static (Steady State) Object Number: **30**
Change Event Object Number: **32**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **2 (16-Bit Analog Input)**
Change Event Variation reported when variation 0 requested: **2 (16-Bit Analog Change Event without Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description	Data Type	Valid Range	Default Deadband	Default Change Event Class (1, 2, 3, or none)
		58	54	58	54	3Ph W Fix Demand	D6	-31,500…+31,500	1	3
		59	55	59	55	3Ph VArs Fix Demand	D6	-31,500…+31,500	1	3
18	18	60	56	60	56	IA Fixed Demand	D1	0.000…65.534	0.1	3
19	19	61	57	61	57	IB Fixed Demand	D1	0.000…65.534	0.1	3
20	20	62	58	62	58	IC Fixed Demand	D1	0.000…65.534	0.1	3
		63	59	63	59	3 Ph W Roll Demand	D6	-31,500…+31,500	1	3
		64	60	64	60	3 Ph VArs Roll Demand	D6	-31,500…+31,500	1	3
21	21	65	61	65	61	IA Roll Demand	D1	0.000…65.534	1	3
22	22	66	62	66	62	IB Roll Demand	D1	0.000…65.534	1	3
23	23	67	63	67	63	IC Roll Demand	D1	0.000…65.534	1	3
		68	64	68	64	3Ph W Peak Demand	D6	-31,500…+31,500	1	3
		69	65	69	65	3Ph VAr Peak Demand	D6	-31,500…+31,500	1	3
24	24	70	66	70	66	IA Peak Demand	D1	0.000…65.534	0.1	3
25	25	71	67	71	67	IB Peak Demand	D1	0.000…65.534	0.1	3
26	26	72	68	72	68	IC Peak Demand	D1	0.000…65.534	0.1	3
						Measurements 3				
27	27	73	69	73	69	IA Local	D1	0.000…65.534	0.1	3
28	28	74	70	74	70	IA Angle Local	D4	-180.00…+180.00	1	3
29	29	75	71	75	71	IB Local	D1	0.000…65.534	0.1	3
30	30	76	72	76	72	IB Angle Local	D4	-180.00…+180.00	1	3
31	31	77	73	77	73	IC Local	D1	0.000…65.534	0.1	3
32	32	78	74	78	74	IC Angle Local	D4	-180.00…+180.00	1	3
33	33	79	75	79	75	IA remote 1	D1	0.000…65.534	0.1	3
34	34	80	76	80	76	IA Ang remote 1	D4	-180.00…+180.00	1	3
35	35	81	77	81	77	IB remote 1	D1	0.000…65.534	0.1	3
36	36	82	78	82	78	IB Ang remote 1	D4	-180.00…+180.00	1	3
37	37	83	79	83	79	IC remote 1	D1	0.000…65.534	0.1	3
38	38	84	80	84	80	IC Ang remote 1	D4	-180.00…+180.00	1	3
39	39	85	81	85	81	IA remote 2	D1	0.000…65.534	0.1	3
40	40	86	82	86	82	IA Ang remote 2	D4	-180.00…+180.00	1	3
41	41	87	83	87	83	IB remote 2	D1	0.000…65.534	0.1	3
42	42	88	84	88	84	IB ANG remote 2	D4	-180.00…+180.00	1	3
43	43	89	85	89	85	IC remote 2	D1	0.000…65.534	0.1	3
44	44	90	86	90	86	IC Ang remote 2	D4	-180.00…+180.00	1	3
45	45	91	87	91	87	IA Differential	D1	0.000…65.534	0.1	3
46	46	92	88	92	88	IB Differential	D1	0.000…65.534	0.1	3
47	47	93	89	93	89	IC Differential	D1	0.000…65.534	0.1	3
48	48	94	90	94	90	IA Bias	D1	0.000…65.534	0.1	3

Analog Inputs
Static (Steady State) Object Number: **30**
Change Event Object Number: **32**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **2 (16-Bit Analog Input)**
Change Event Variation reported when variation 0 requested: **2 (16-Bit Analog Change Event without Time)**

P541 Point Index	P542 Point Index	P543 Point Index	P544 Point Index	P545 Point Index	P546 Point Index	Name/Description	Data Type	Valid Range	Default Deadband	Default Change Event Class (1, 2, 3, or none)
49	49	95	91	95	91	IB Bias	D1	0.000…65.534	0.1	3
50	50	96	92	96	92	IC Bias	D1	0.000…65.534	0.1	3
51	51	97	93	97	93	Thermal State	D7	0.00…327.67	10	3
						Measurements 4				
52	52	98	94	98	94	Ch 1 Prop Delay	D15	0.00000…0.32767	0.001	3
53	53	99	95	99	95	Ch 2 Prop Delay	D15	0.00000…0.32767	0.001	3
				100	96	Ch1 Rx Prop data	D15	0.00000…0.32767	0.001	3
				101	97	Ch1 Tx Prop data	D15	0.00000…0.32767	0.001	3
				102	98	Ch 2 Rx Prop data	D15	0.00000…0.32767	0.001	3
				103	99	Ch 2 Tx Prop data	D15	0.00000…0.32767	0.001	3

4.5 Data type codes

Data Type	Name/Description	Scaling	Default Change Event Deadband	Change Event Deadband MIN	Change Event Deadband MAX	Change Event Deadband STEP	Standard Numeric Range
D1	Standard Phase, RMS, & sequence current	x In / 500	0.1	0.05 In	64 In	0.01 In	0.000…65.534
D2	Sensitive currents	x In / 10,000	0.01	0.01 In	2 In	0.001 In	0.0000…2.0000
D3	Voltage	x Vn /(110 x 100)	5	0.1 Vn / 110	220 Vn / 110	0.1 Vn / 110	0.00…220.00
D4	Angle	x 0.01	1	0.1	180	0.1	-180.00…+180.00
D5	Frequency	x 0.01	0.5	0.1	70	0.1	5.00…70.00
D6	Power	x 0.1In .Vn / 110	1	0.1In .Vn / 110	3200 In .Vn / 110	0.1In .Vn / 110	-3150.0…+3150.0
D7	Percentage	x 0.01	10	0.1	320	0.1	0.00…327.67
D8	Power Factor	X 0.001	0.1	0.01	1	0.01	0.000…1.000
D9	Setting Group	x 1	1	1	4	1	1…4
D10	Energy	x In .Vn / 110		In .Vn / 110	32000 In .Vn / 110	In .Vn / 110	0…(2^31)-1
D11	Admittance (Standard current)	x (In / 1000).(110 / Vn)	0.1	(0.01 In).(110 / Vn)	32 In .(110 / Vn)	(0.01 In).(110 / Vn)	-7.040...+7.040
D12	Admittance (Sensitive current)	x (In / 10000).(110 / Vn)	0.01	(0.001 In).(110 / Vn)	2 In .(110 / Vn)	(0.001 In).(110 / Vn)	-0.0220…+0.0220
D13	Time (minutes)	x 0.01	5	1	30	0.5	0.00…327.67
D14	Temperature	x 0.1	1	0.1	300	0.1	-40.0…300.0
D15	Time (seconds)	x 0.00001	0.001	0.0001	0.03	0	0.0000…0.32767
D16	CLIO Input value	x 0.1	10	0.1	9999	0.1	-9999.9…+9999.9

Notes:

1. Type D6 can represent Watts, VArs or VA; the exact unit applied depends on the description of the item.
2. The default change event deadband is used unless specified otherwise in the point list.
3. The scaling value represents the multiplier required at the master station.
4. In and Vn represent the rated current and rated voltage respectively.

UCA 2.0

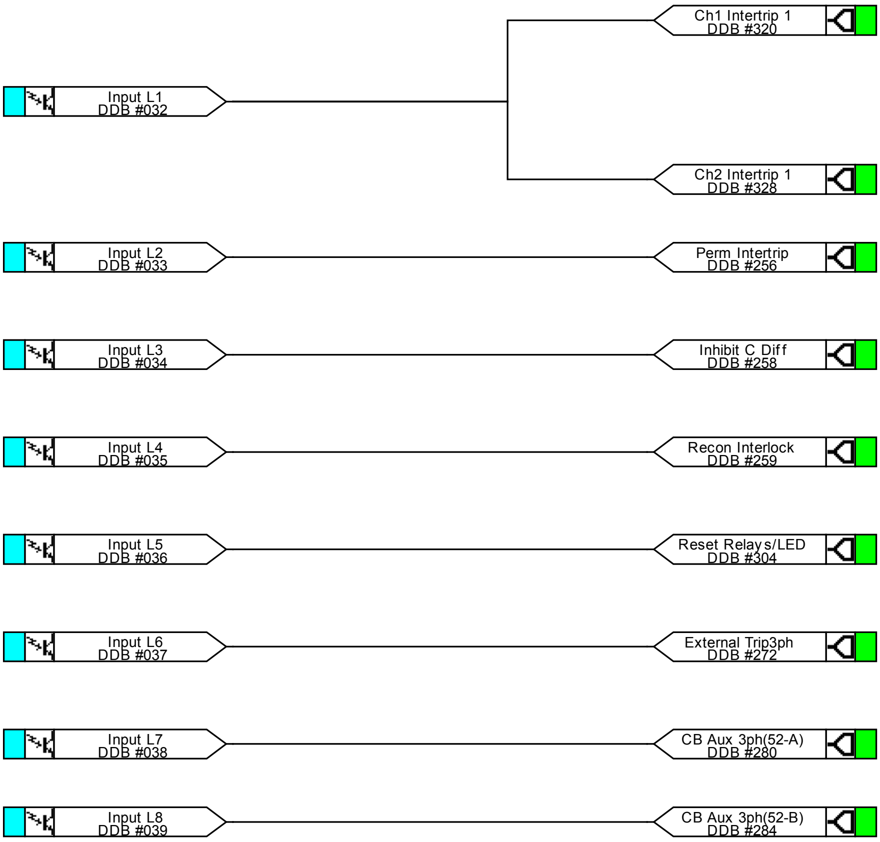
PROTOCOL IMPLEMENTATION & CONFORMANCE STATEMENT (PICS)

Vendor Name: **ALSTOM Grid**
Device Name: **P540 DIFFERENTIAL PROTECTION Relay**, Model numbers: **P541, P542, P543, P544, P545 & P546**

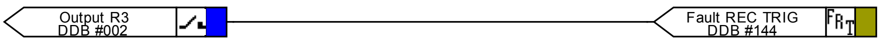
Ethernet Medium Supported: Copper: **S10baseT S100baseTx** ≤1000baseT Fibre: **S10baseFL S100baseFX** ≤1000baseSX	Device Function: ≤ Client **Σ Server**
TCP/IP Support: IP Address ≤ Fixed **Σ Configurable, IP1.IP2.IP3.IP4** IP NetMask ≤ Fixed **Σ Configurable, IP1.IP2.IP3.IP4** IP Gateways ≤ Fixed **Σ Configurable, up to 4** **- Target Network IP** **- Gateway IP**	OSI Support: Address PSEL **Σ Fixed** **00 00 00 00** ≤ Configurable SSEL S Fixed 00 00 ≤ Configurable TSEL **Σ Fixed** **00 00** ≤ Configurable NSAP ≤ Fixed **Σ Configurable, via IP Address** **05 49 IP1 IP2 IP3 IP4**
Connection Management Services: **Σ Initiate** **Σ Conclude** **Σ Abort** **Σ Reject** ≤ Cancel Maximum Simultaneous Connections: **4**	GOOSE: Supported: ≤ Yes **Σ No** IED Name: **Σ Not Applicable** **≤ Fixed** ≤ Configurable, using GOOSE Editor Timeout Logic: **Σ Not Applicable** ≤ Supported ≤ Not Supported
VMD Support Services: **Σ Status** ≤ Extended Status **Σ Identify** **Σ GetNameList** ≤ GetCapability	Variable Access Services: **Σ Read** **Σ Write** **Σ Information Report** **Σ GetVariableAccessAttributes** **Σ GetVariableListAttributes**
Reporting Services: ≤ Create Report Control Block ≤ Delete Report Control Block **Σ Get Report Control Block** **Σ Get Report Control Block names** **Σ Set Report Control Block**	Domain Management Services: **Σ Get Domain attributes** ≤ InitiateDownloadSequenceRequest ≤ DeleteDomainRequest
Maximum MMS Pdu Size (bytes): Transmitted: **8000** Received: **8000**	Minimum MMS Pdu Size (bytes): Transmitted: **64** Received: **64**
Sends Unsolicited Responses: ≤ Never **Σ Configurable**	Multi-Fragment Responses: Supported: **Σ Yes** ≤ No
Σ Only certain Objects ≤ Sometimes	Time Syncronisation: Supported: **Σ Yes** ≤ No

MiCOM P541 PROGRAMMABLE LOGIC

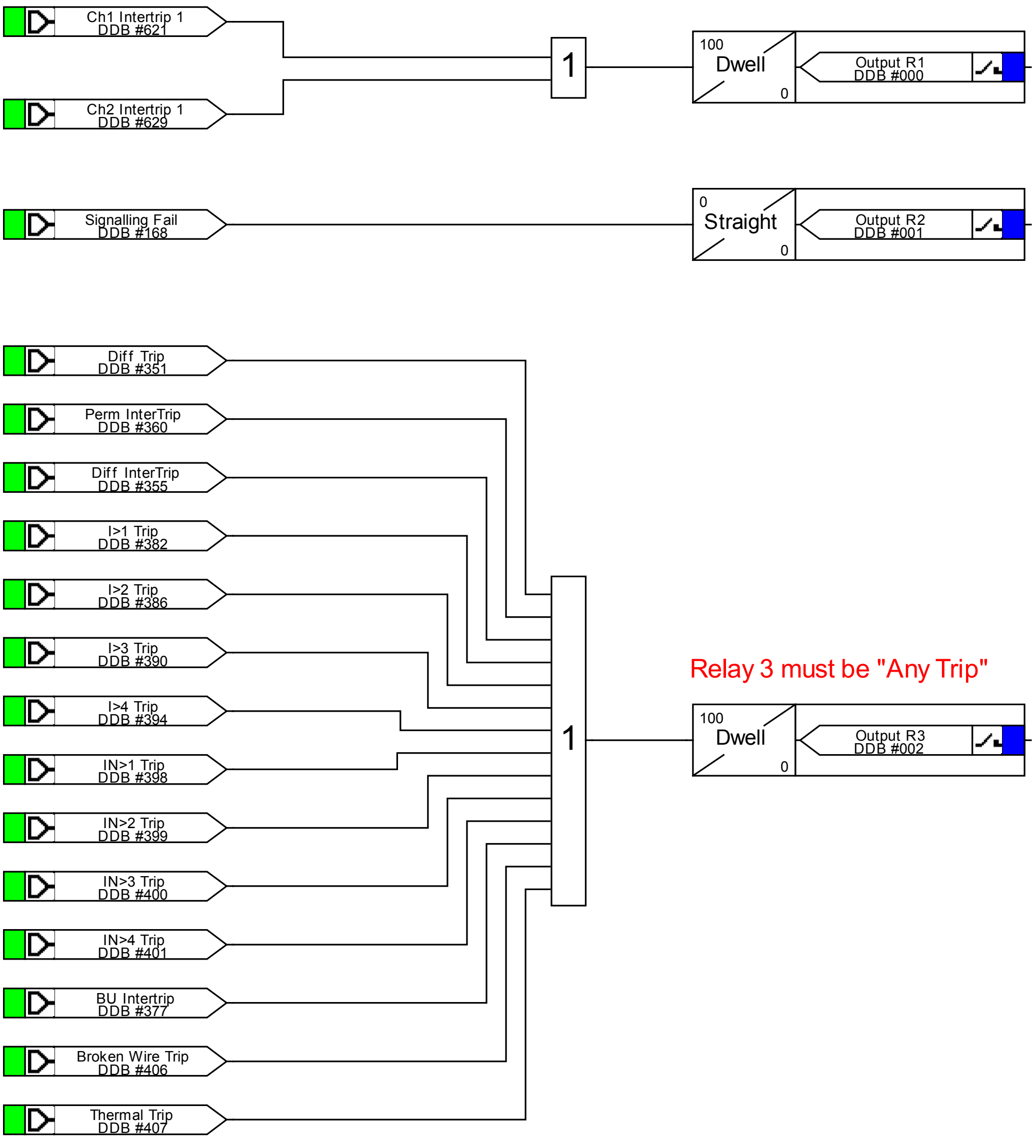
Opto Input Mappings



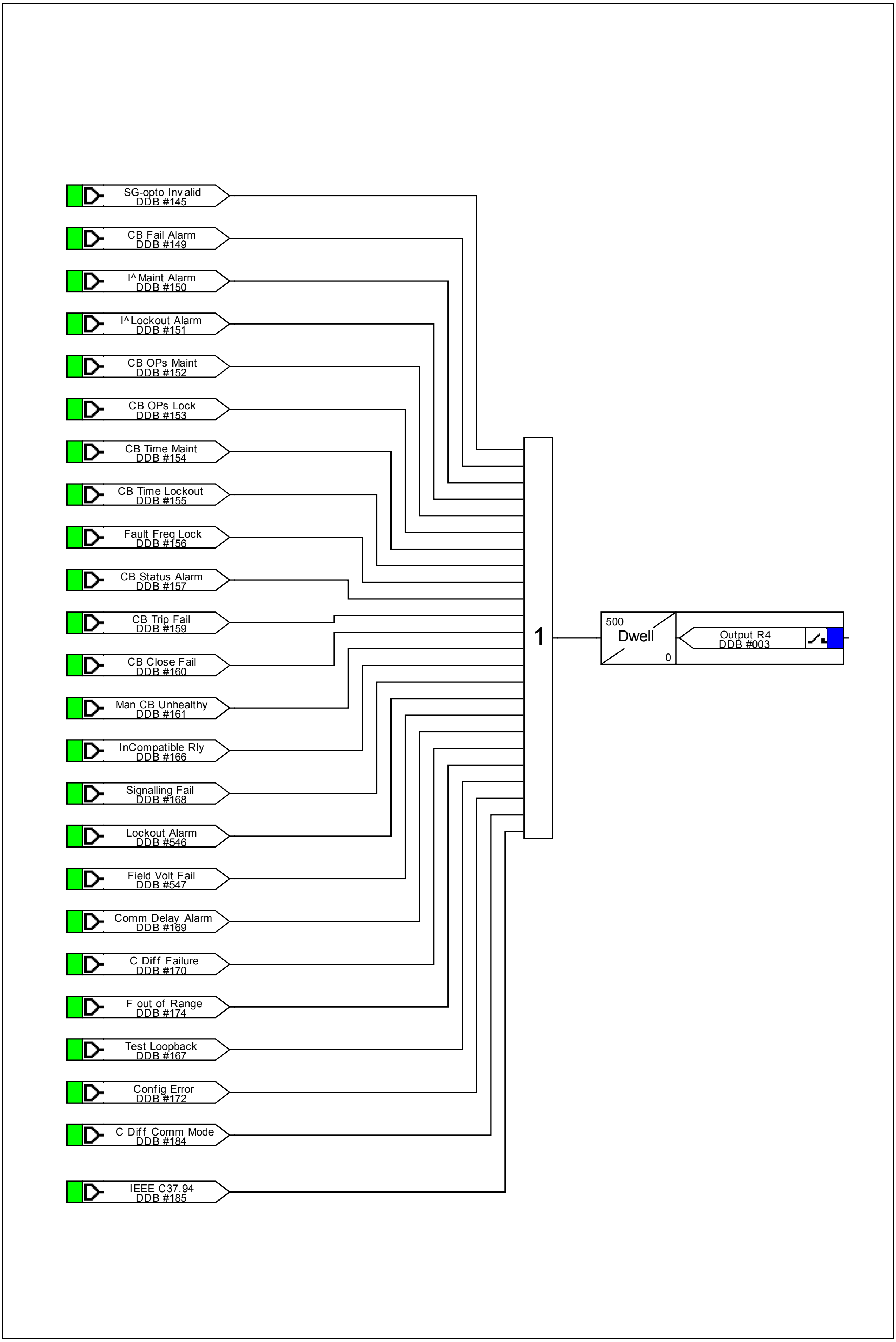
Fault Record Trigger Mapping



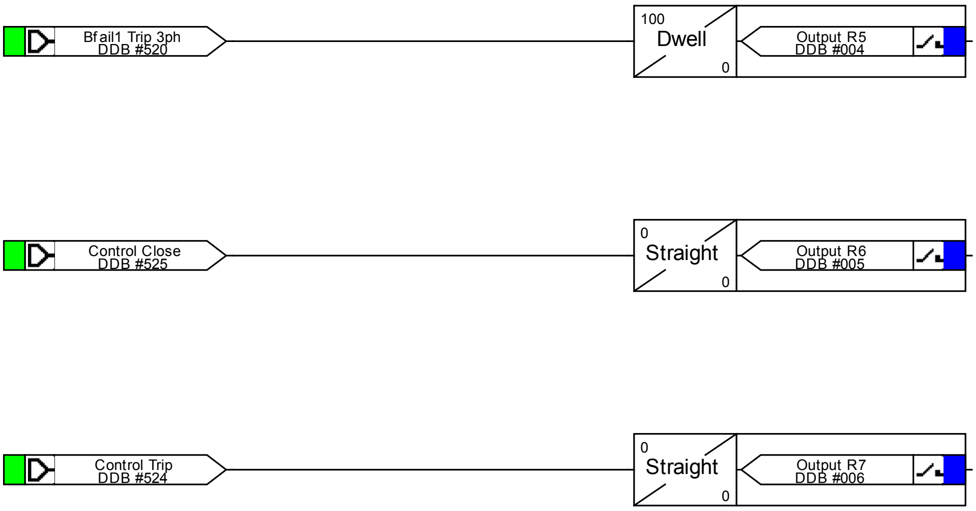
Output Relay Mapping



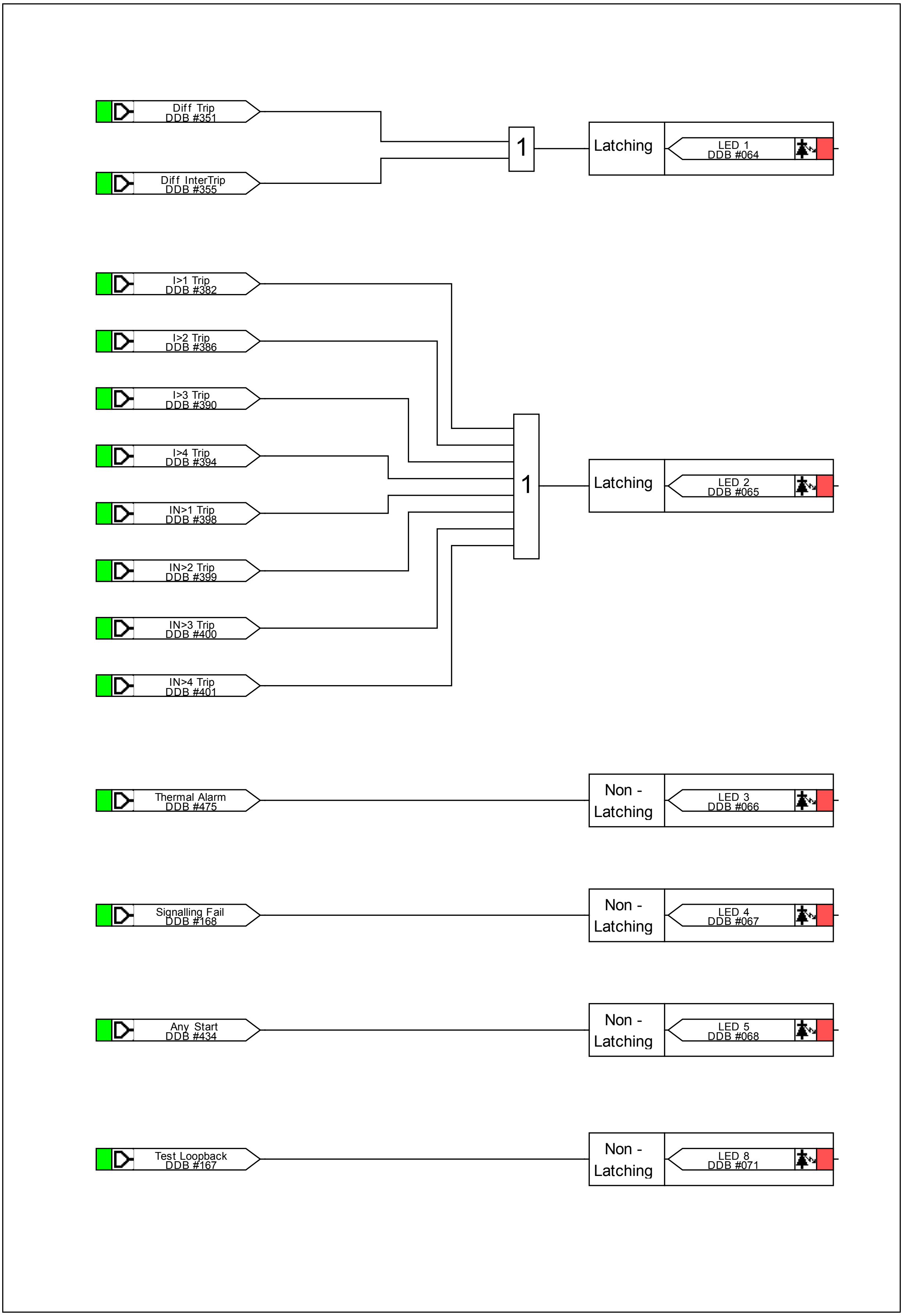
Output Relay Mapping



Output Relay Mapping



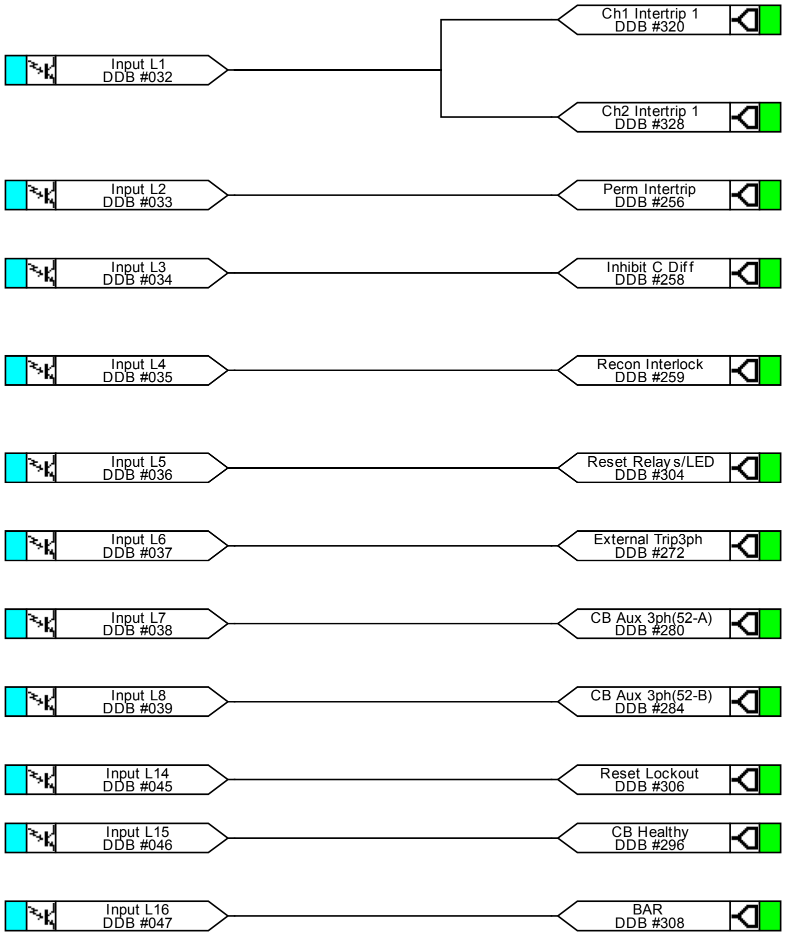
LED Mapping



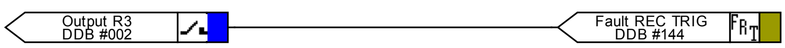
Diff Trip
DDB #351
Diff InterTrip
DDB #355
1
Latching
LED 1
DDB #064
I>1 Trip
DDB #382
I>2 Trip
DDB #386
I>3 Trip
DDB #390
I>4 Trip
DDB #394
IN>1 Trip
DDB #398
IN>2 Trip
DDB #399
IN>3 Trip
DDB #400
IN>4 Trip
DDB #401
1
Latching
LED 2
DDB #065
Thermal Alarm
DDB #475
Non - Latching
LED 3
DDB #066
Signalling Fail
DDB #168
Non - Latching
LED 4
DDB #067
Any Start
DDB #434
Non - Latching
LED 5
DDB #068
Test Loopback
DDB #167
Non - Latching
LED 8
DDB #071

MiCOM P542 PROGRAMMABLE LOGIC

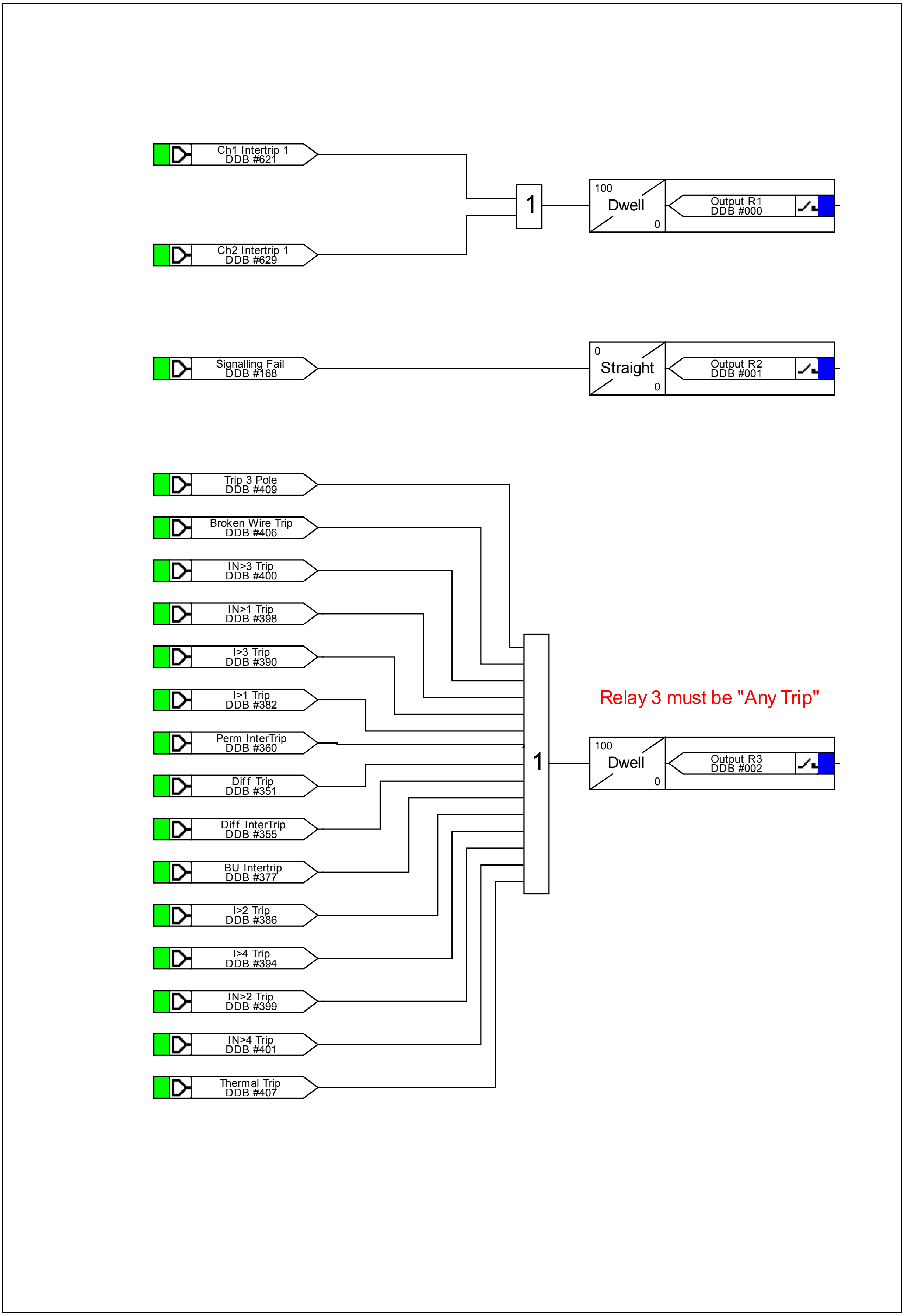
Opto Input Mappings



Fault Record Trigger Mapping

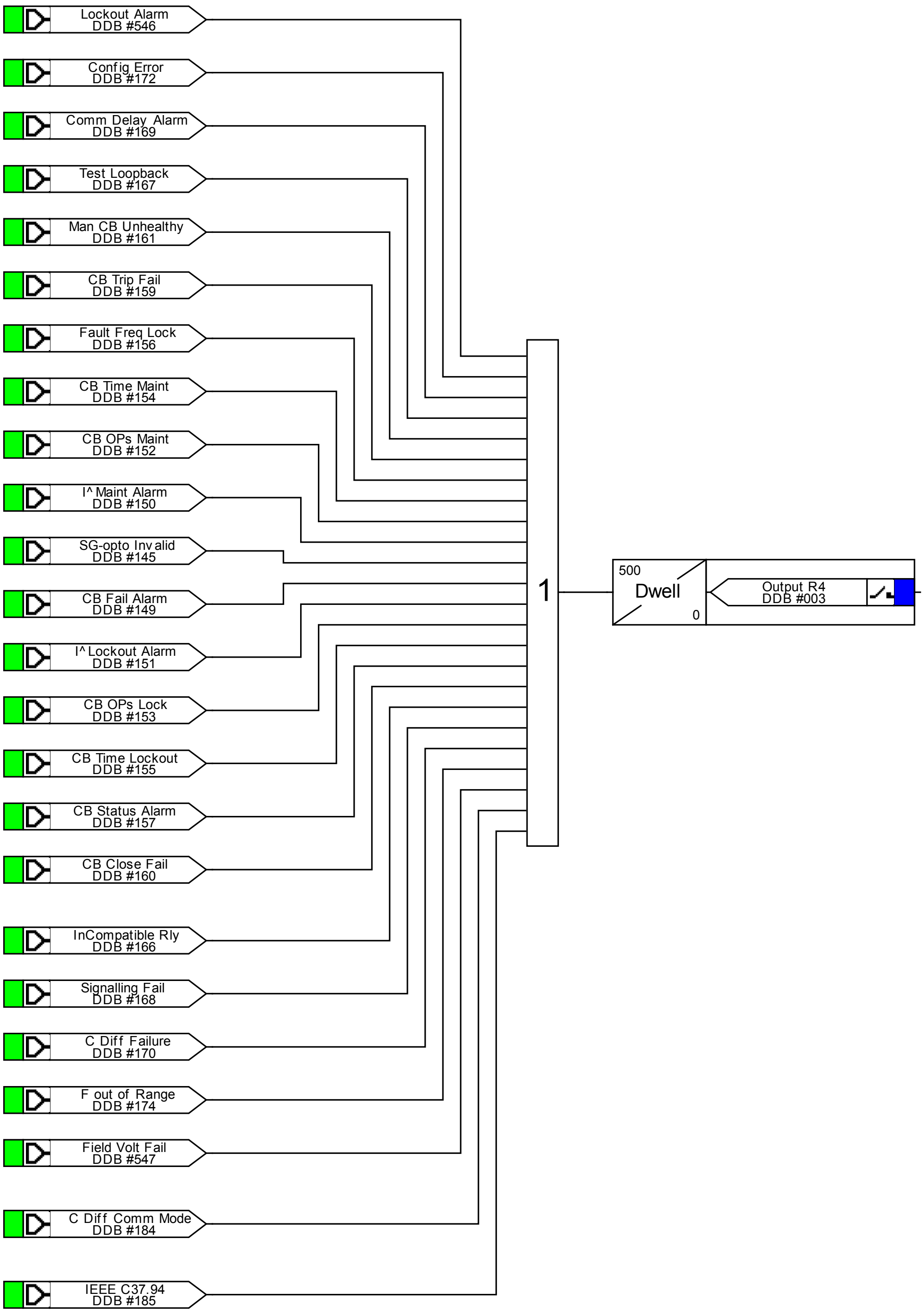


Output Relay Mapping



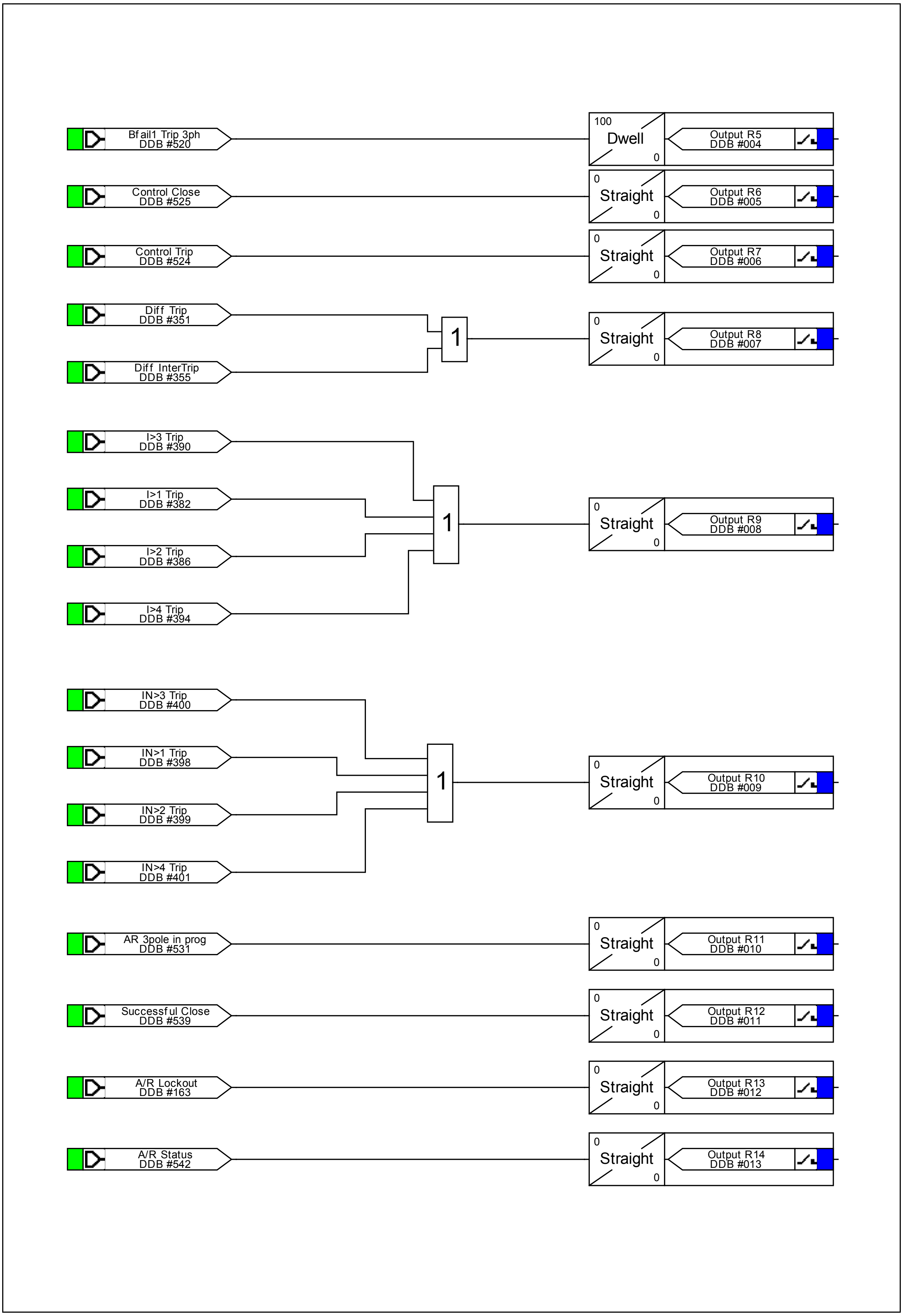
MiCOM P542, Page 2

Output Relay Mapping



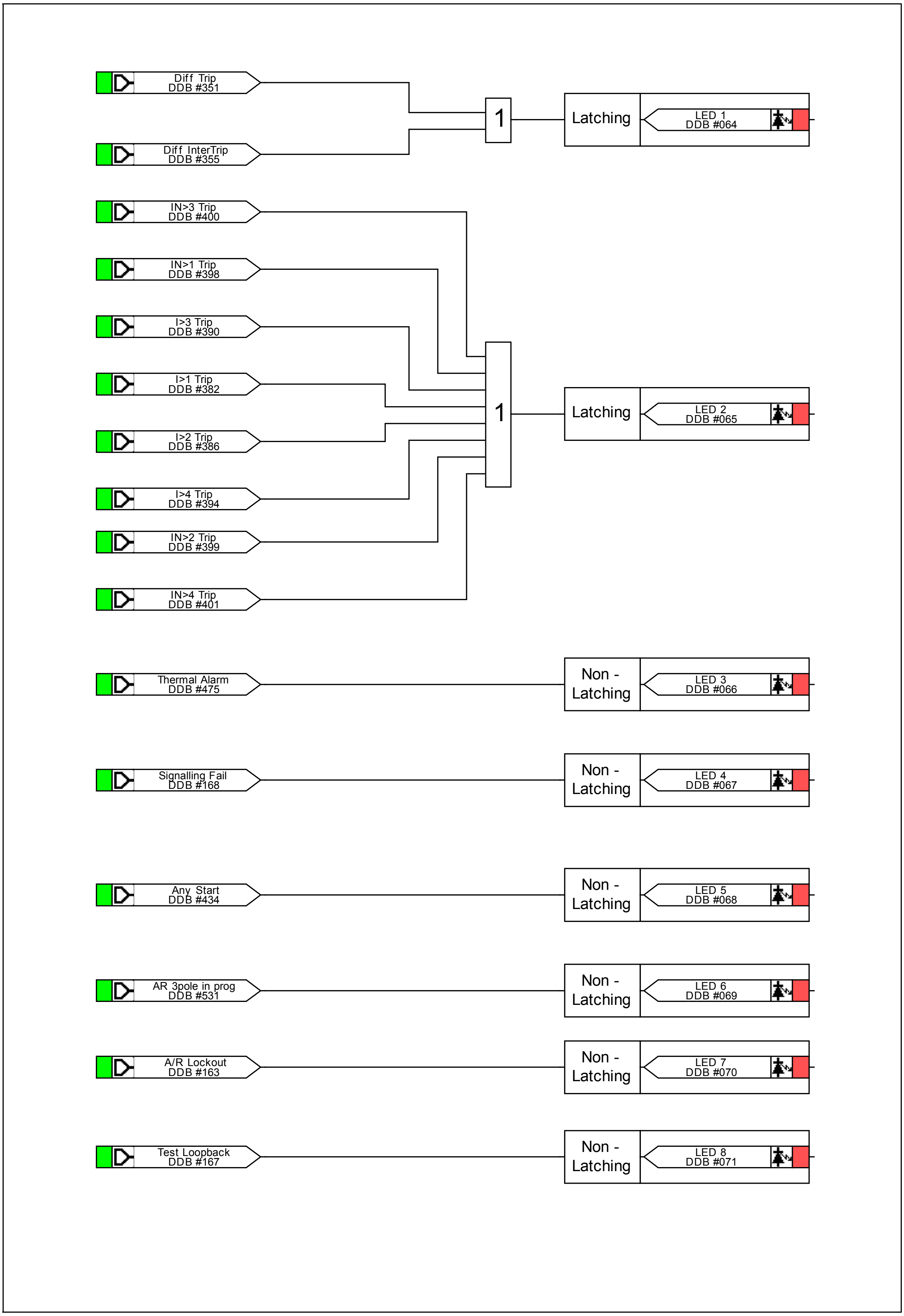
MiCOM P542, Page 3

Output Relay Mapping



MiCOM P542, Page 4

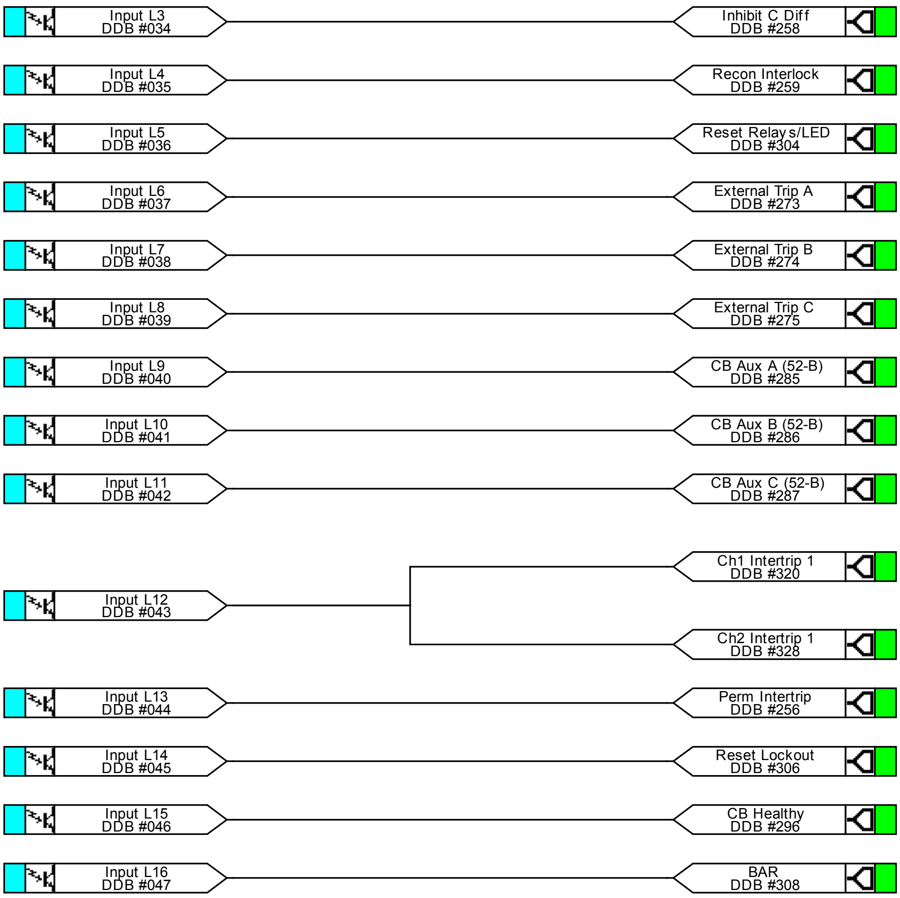
LED Mapping



MiCOM P542, Page 5

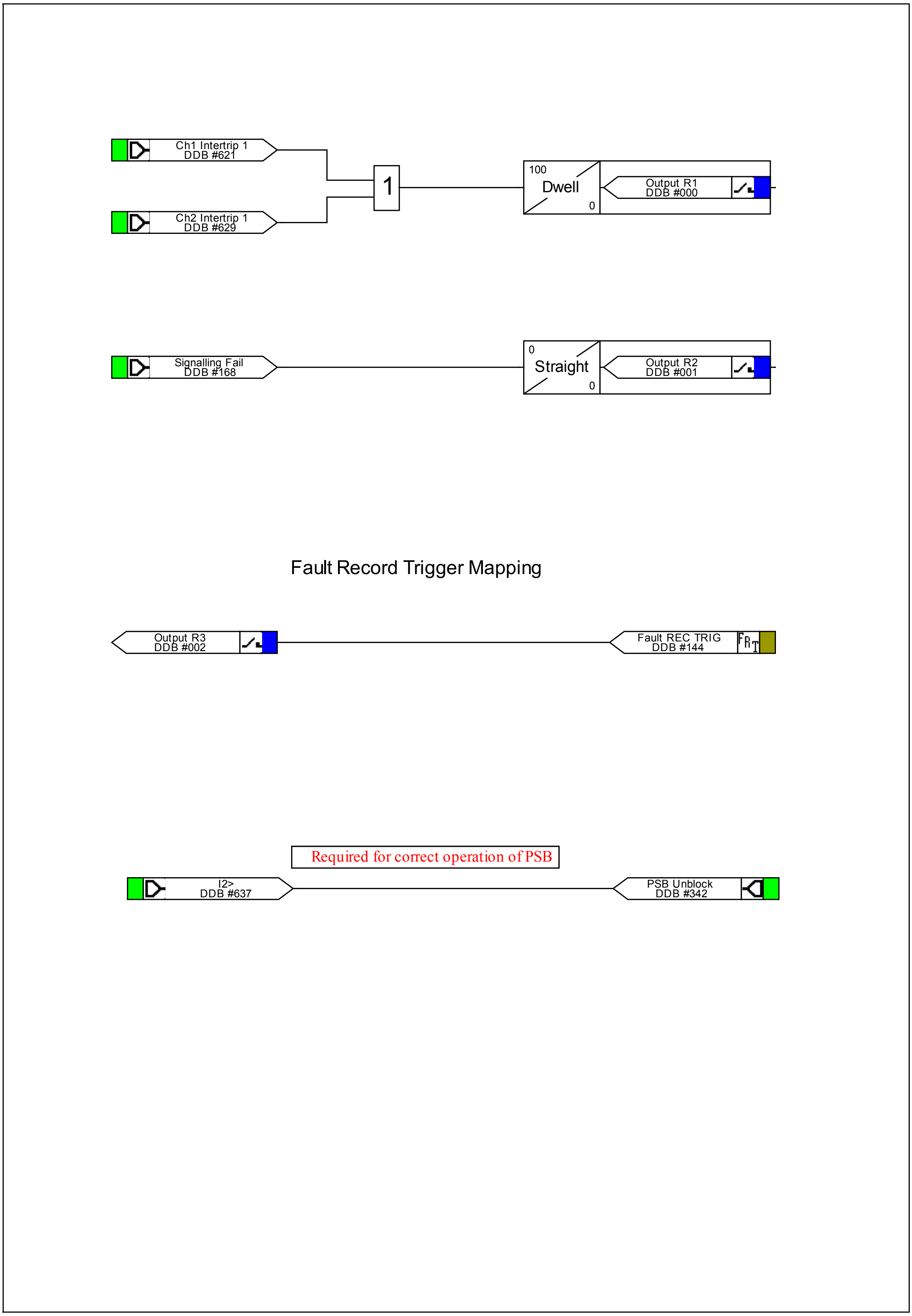
MICOM P543 PROGRAMMABLE LOGIC

Opto Input Mappings



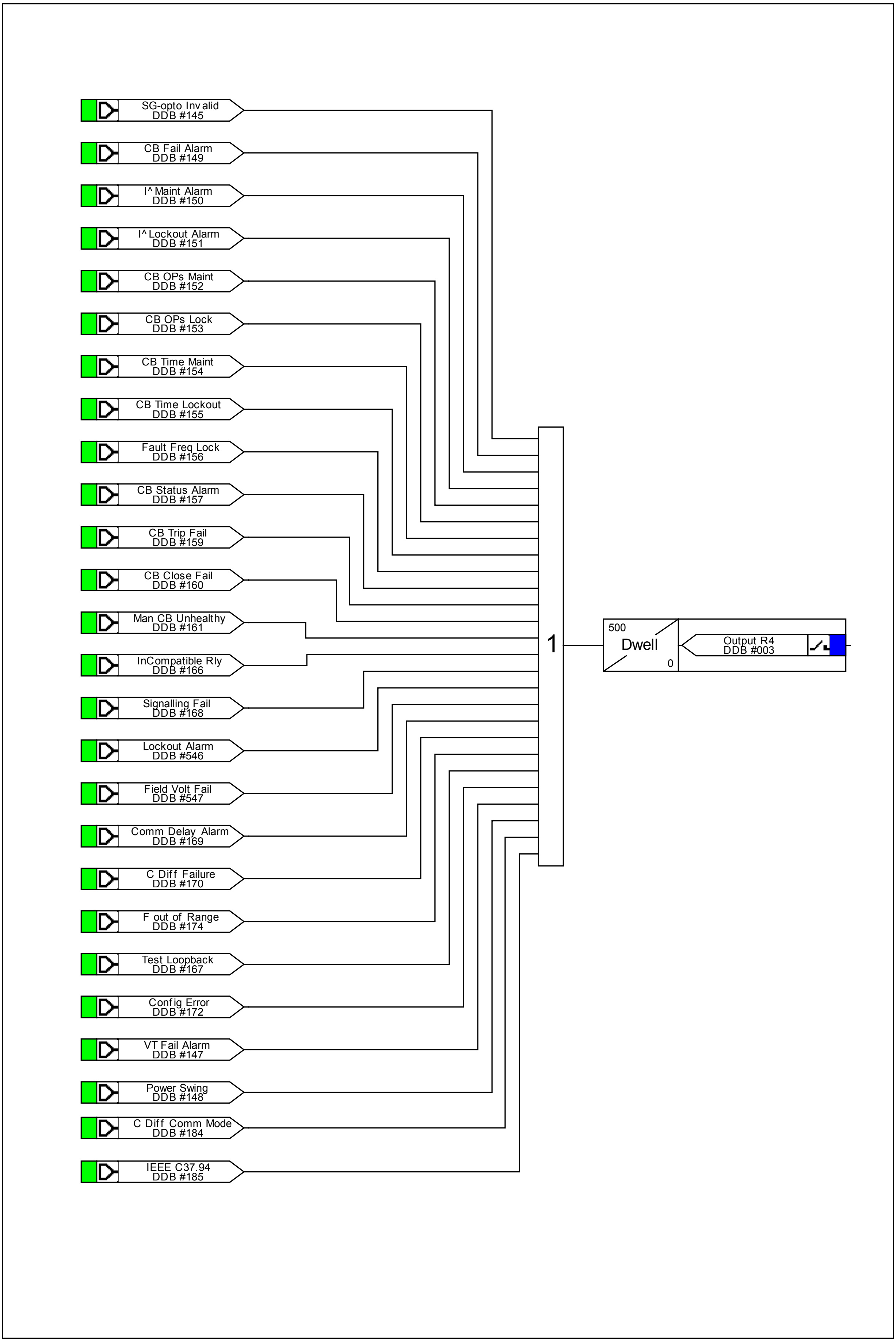
MiCOM P543, Page 1

Output Relay Mapping

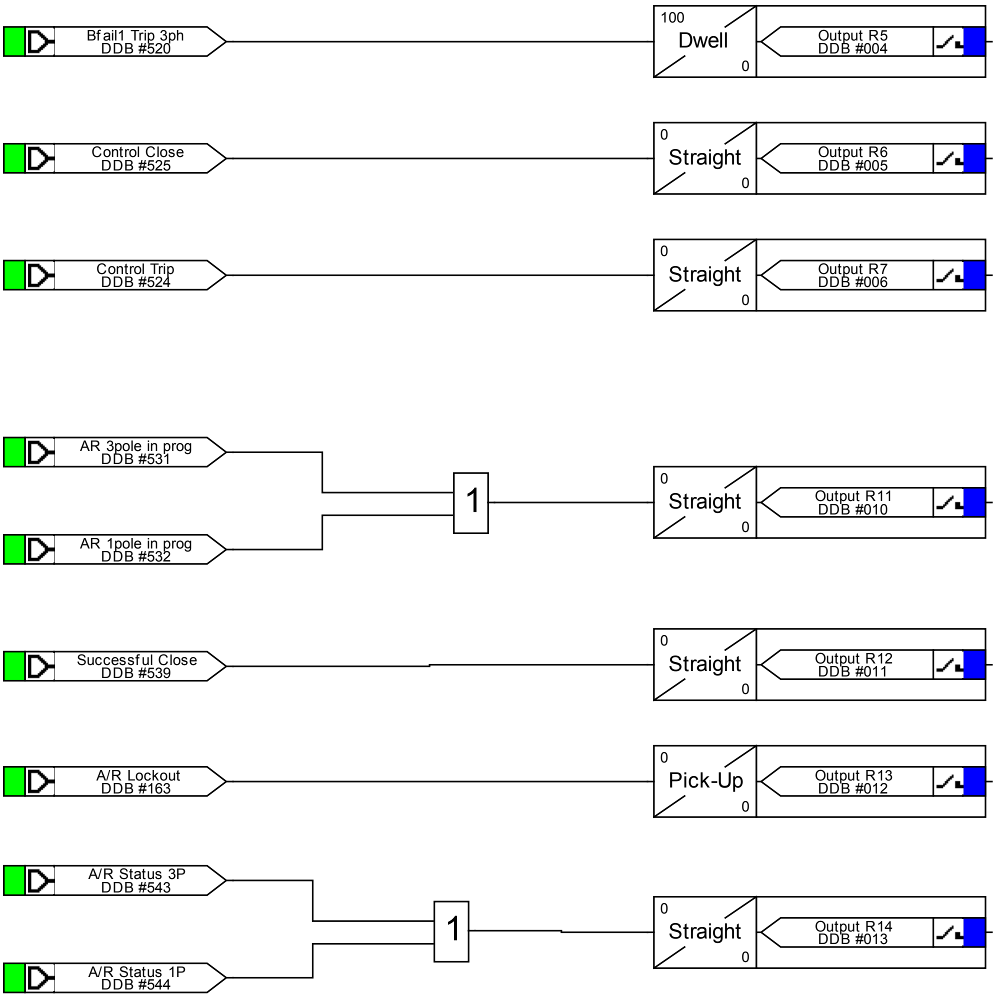


MiCOM P543, Page 2

Output Relay Mapping

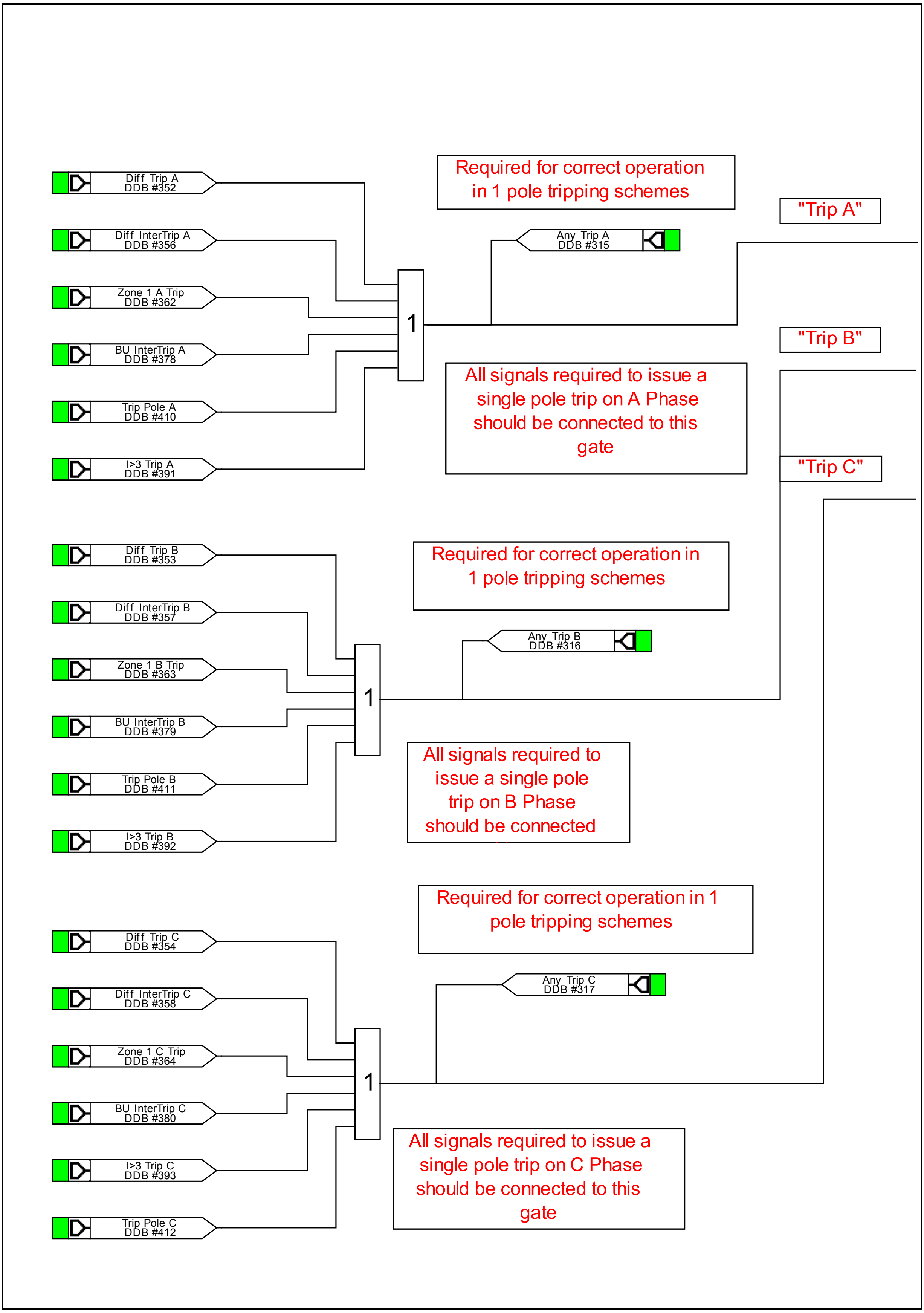


Output Relay Mapping



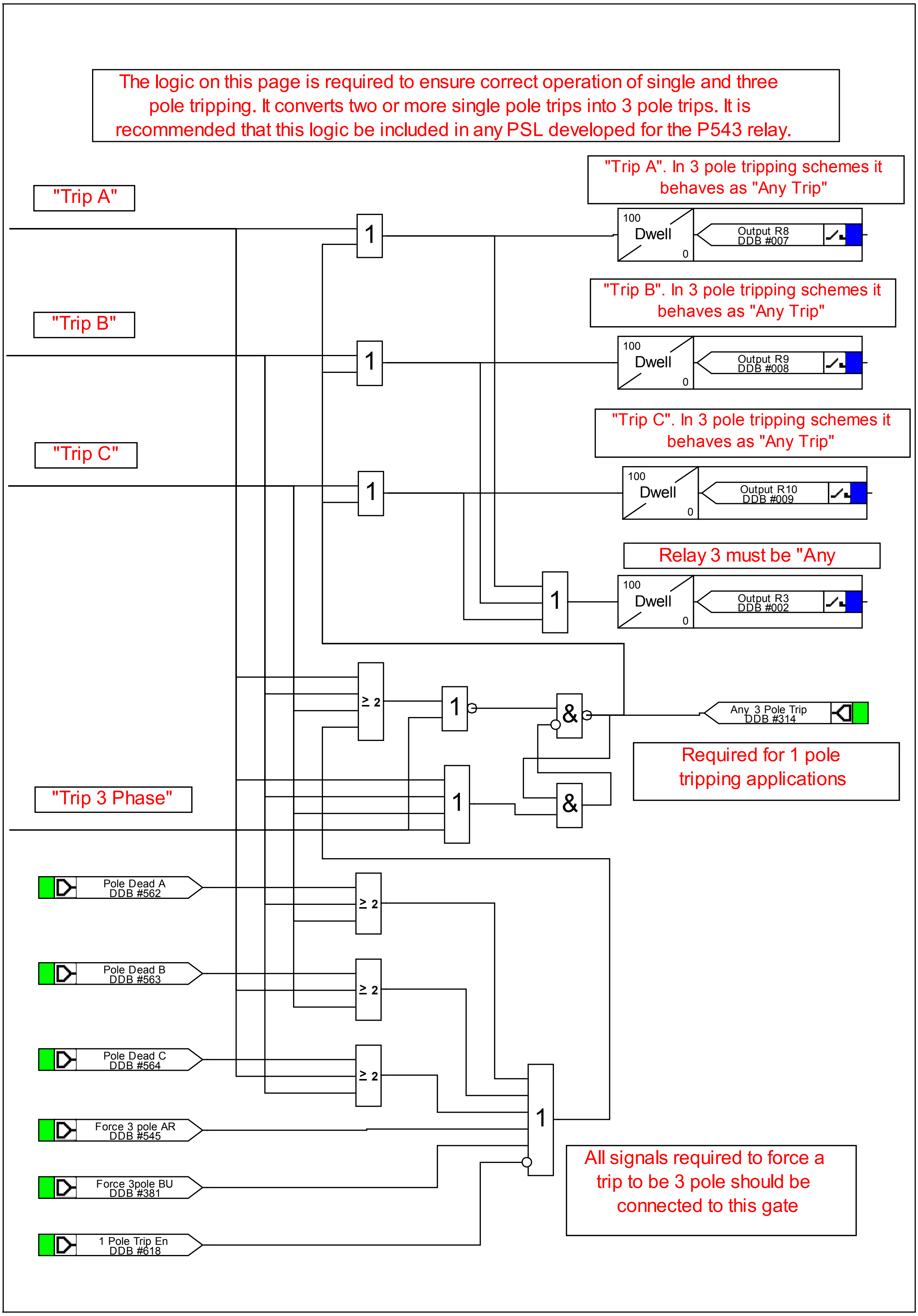
MiCOM P543, Page 4

Trip Logic Mapping

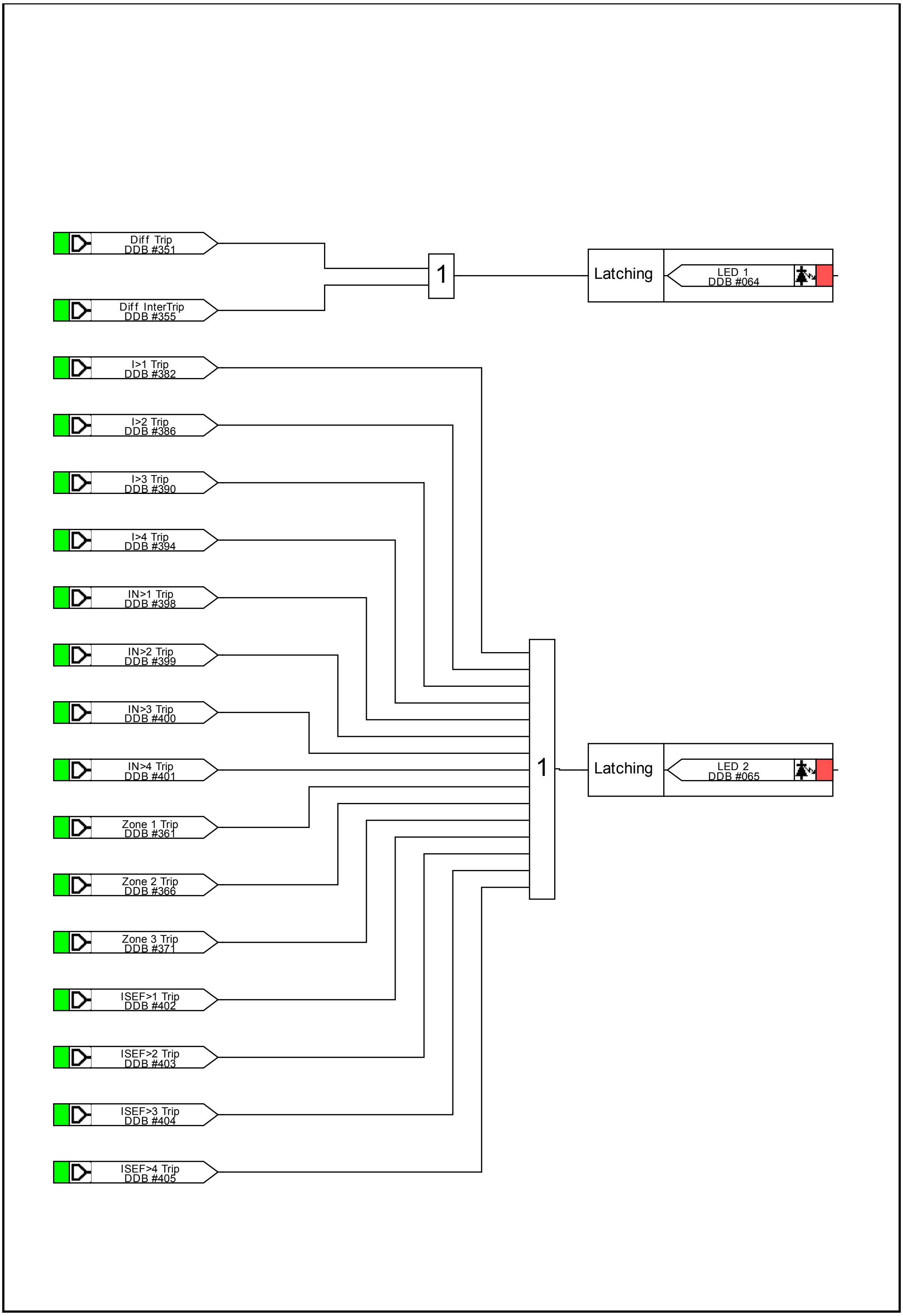


MiCOM P543, Page 5

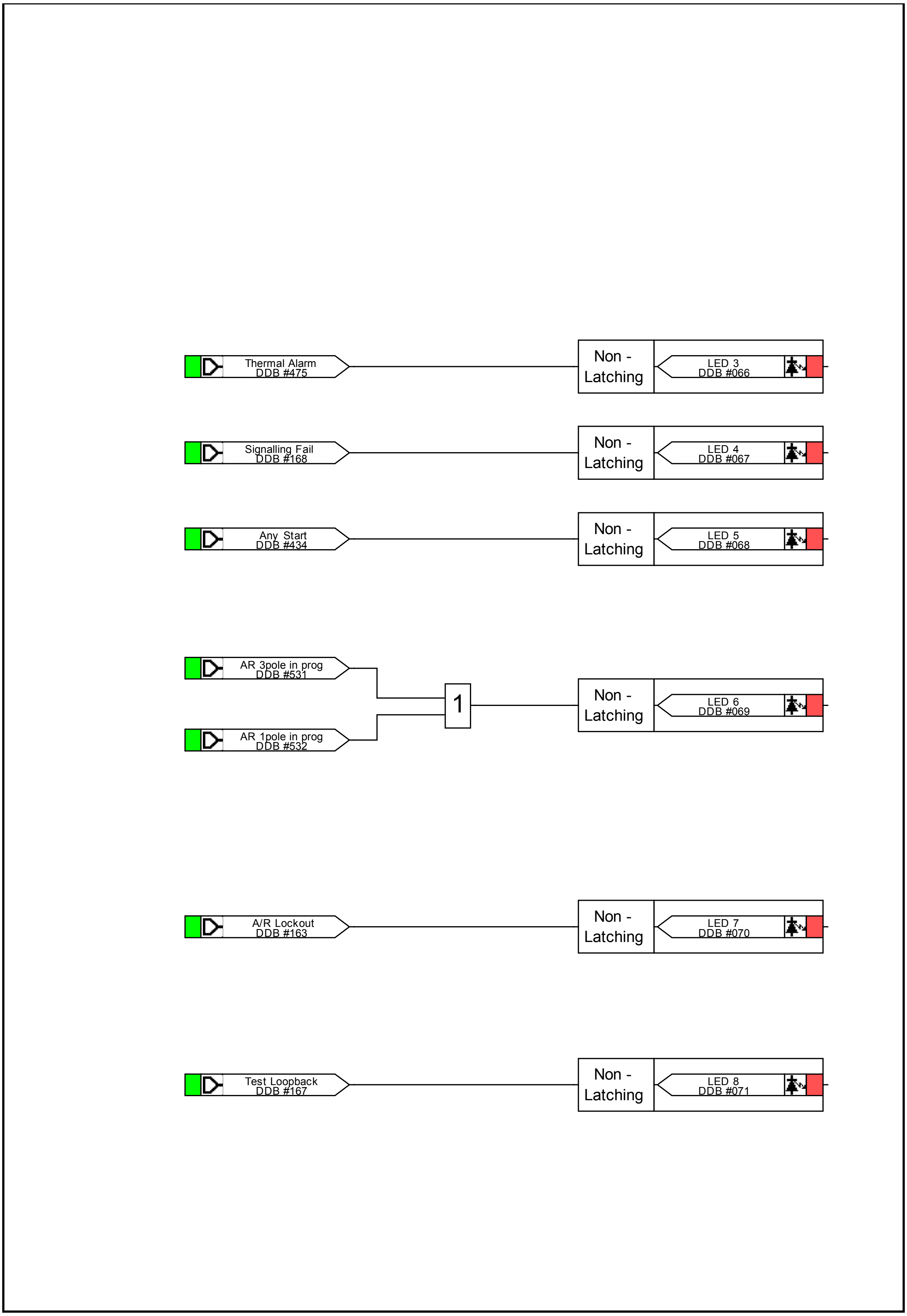
Trip Conversion Logic and Mapping



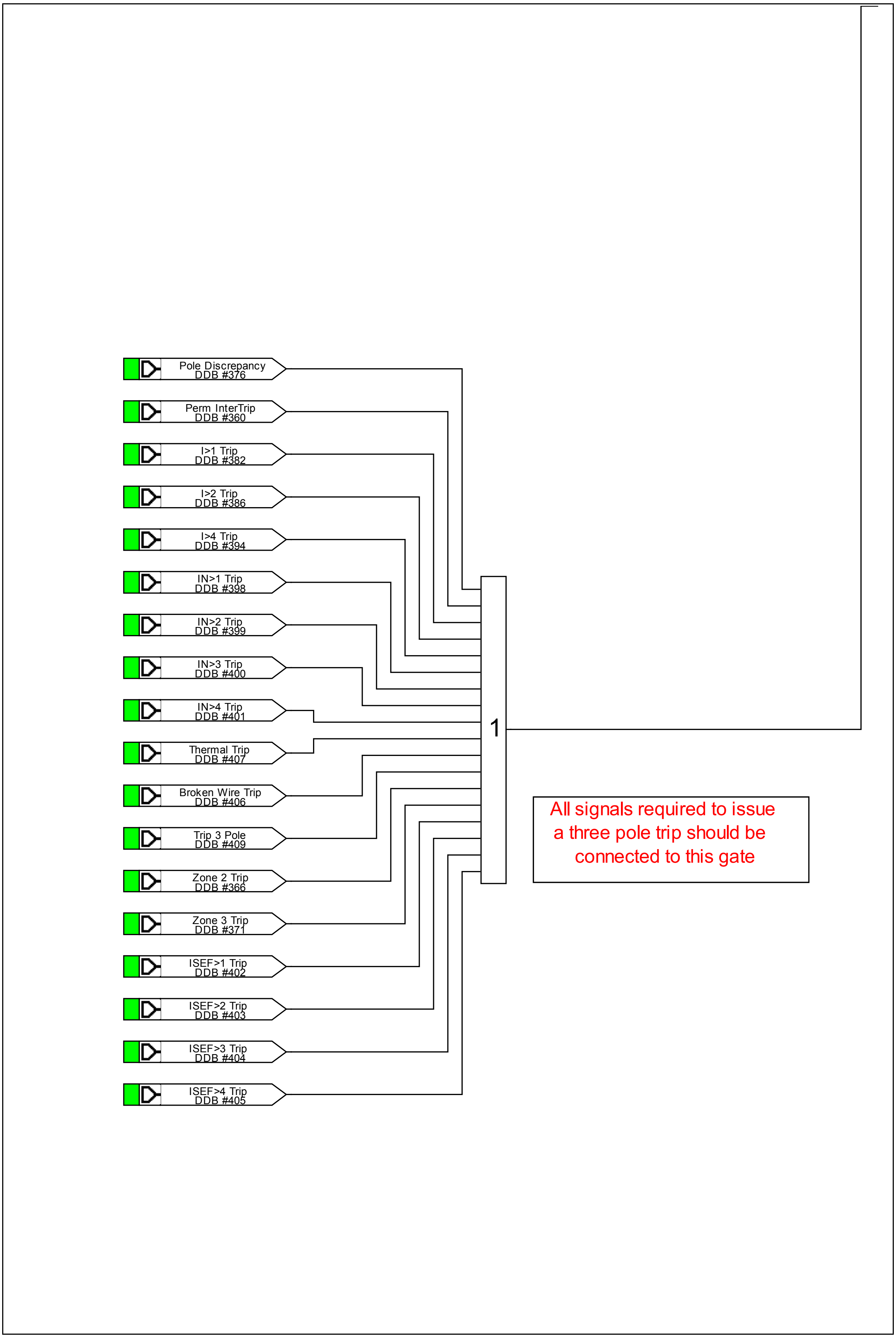
LED Mapping


Diff Trip
DDB #351
Diff InterTrip
DDB #355
1
Latching
LED 1
DDB #064
I>1 Trip
DDB #382
I>2 Trip
DDB #386
I>3 Trip
DDB #390
I>4 Trip
DDB #394
IN>1 Trip
DDB #398
IN>2 Trip
DDB #399
IN>3 Trip
DDB #400
IN>4 Trip
DDB #401
Zone 1 Trip
DDB #361
Zone 2 Trip
DDB #366
Zone 3 Trip
DDB #371
ISEF>1 Trip
DDB #402
ISEF>2 Trip
DDB #403
ISEF>3 Trip
DDB #404
ISEF>4 Trip
DDB #405
1
Latching
LED 2
DDB #065

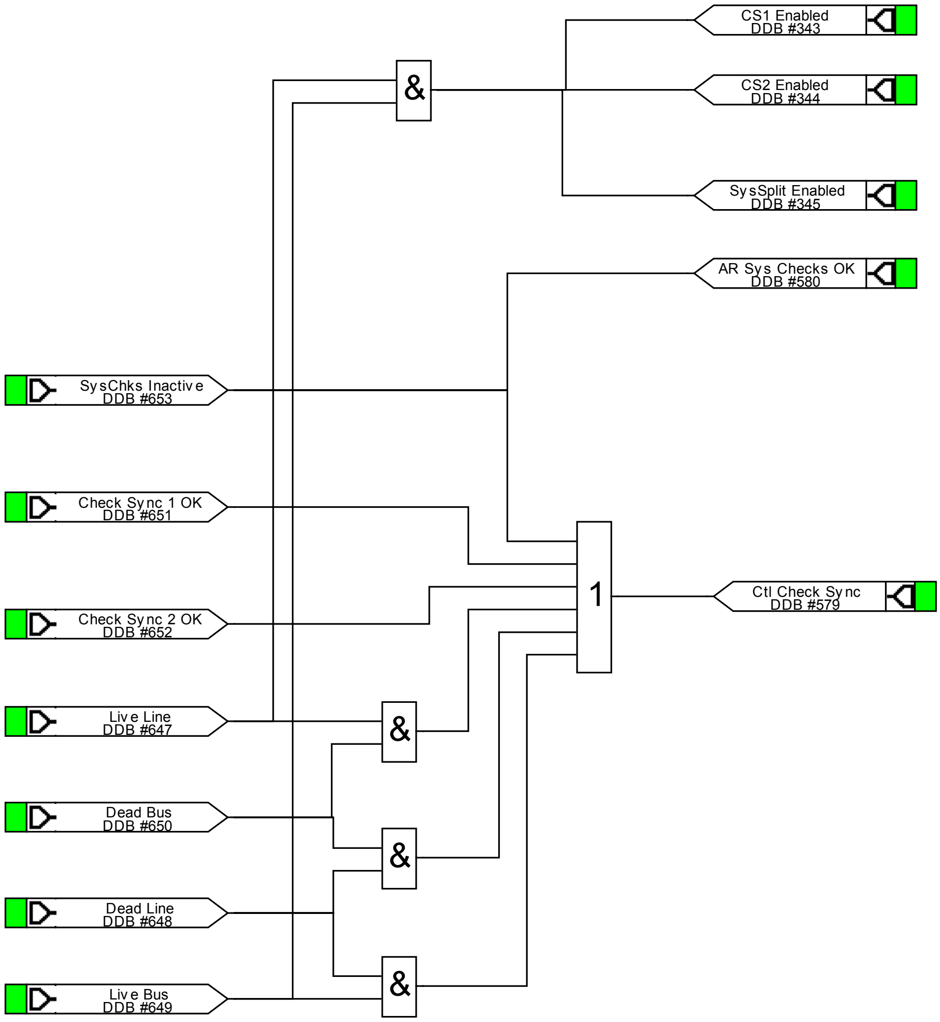
LED Mapping


Thermal Alarm
DDB #475
Non - Latching
LED 3
DDB #066
Signalling Fail
DDB #168
Non - Latching
LED 4
DDB #067
Any Start
DDB #434
Non - Latching
LED 5
DDB #068
AR 3pole in prog
DDB #531
AR 1pole in prog
DDB #532
1
Non - Latching
LED 6
DDB #069
A/R Lockout
DDB #163
Non - Latching
LED 7
DDB #070
Test Loopback
DDB #167
Non - Latching
LED 8
DDB #071

Trip Logic Mapping

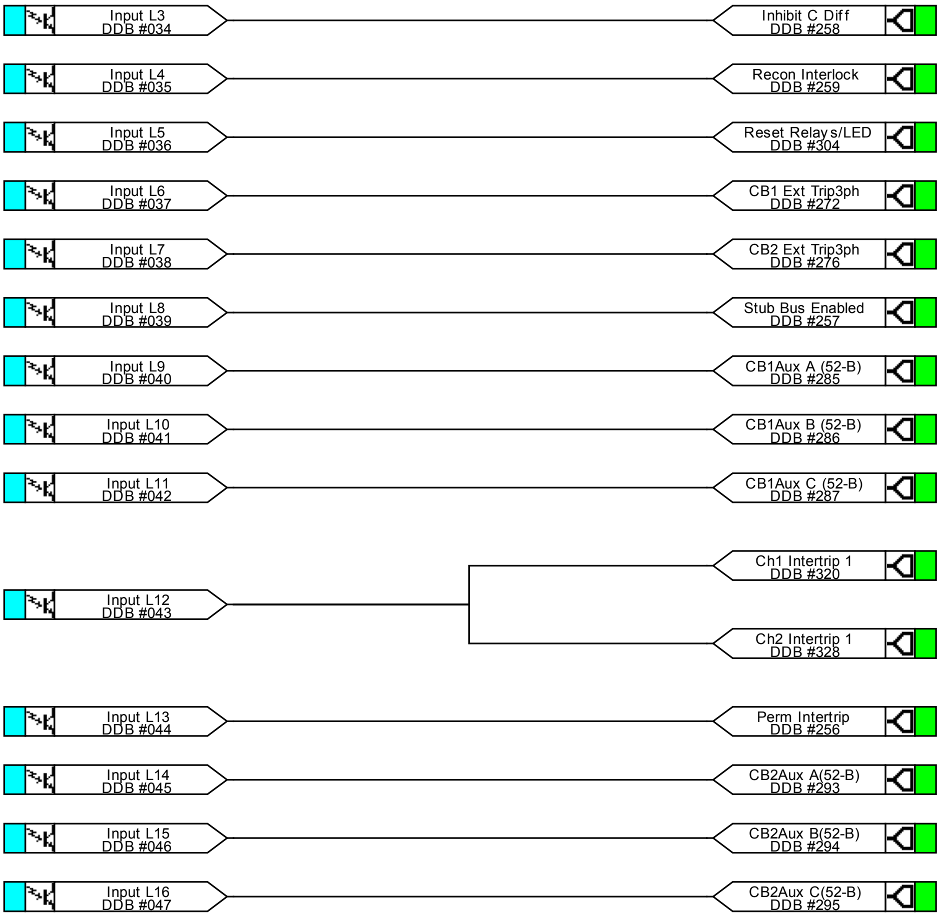


Check Synch. and Voltage Monitor Mapping

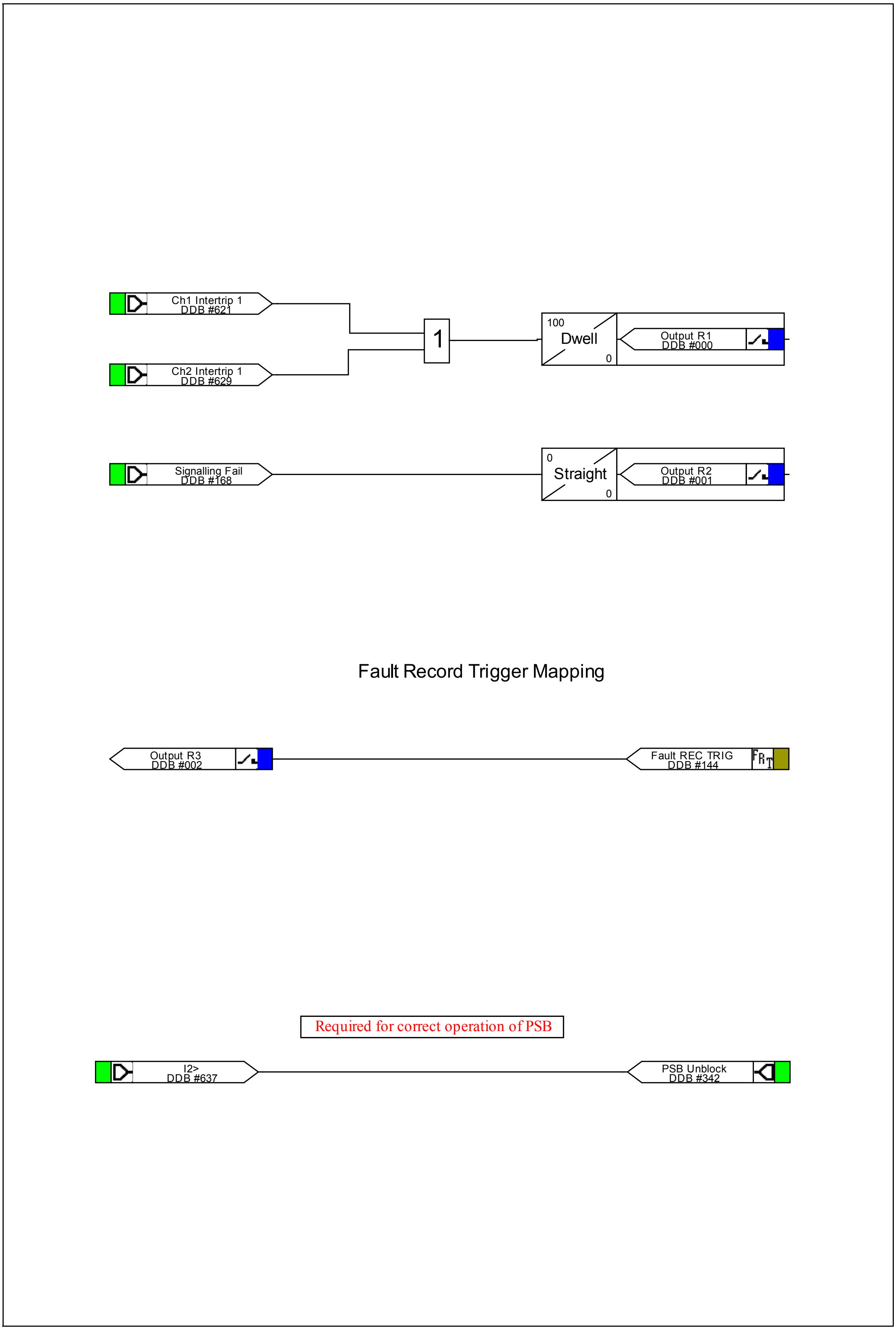


MiCOM P544 PROGRAMMABLE LOGIC

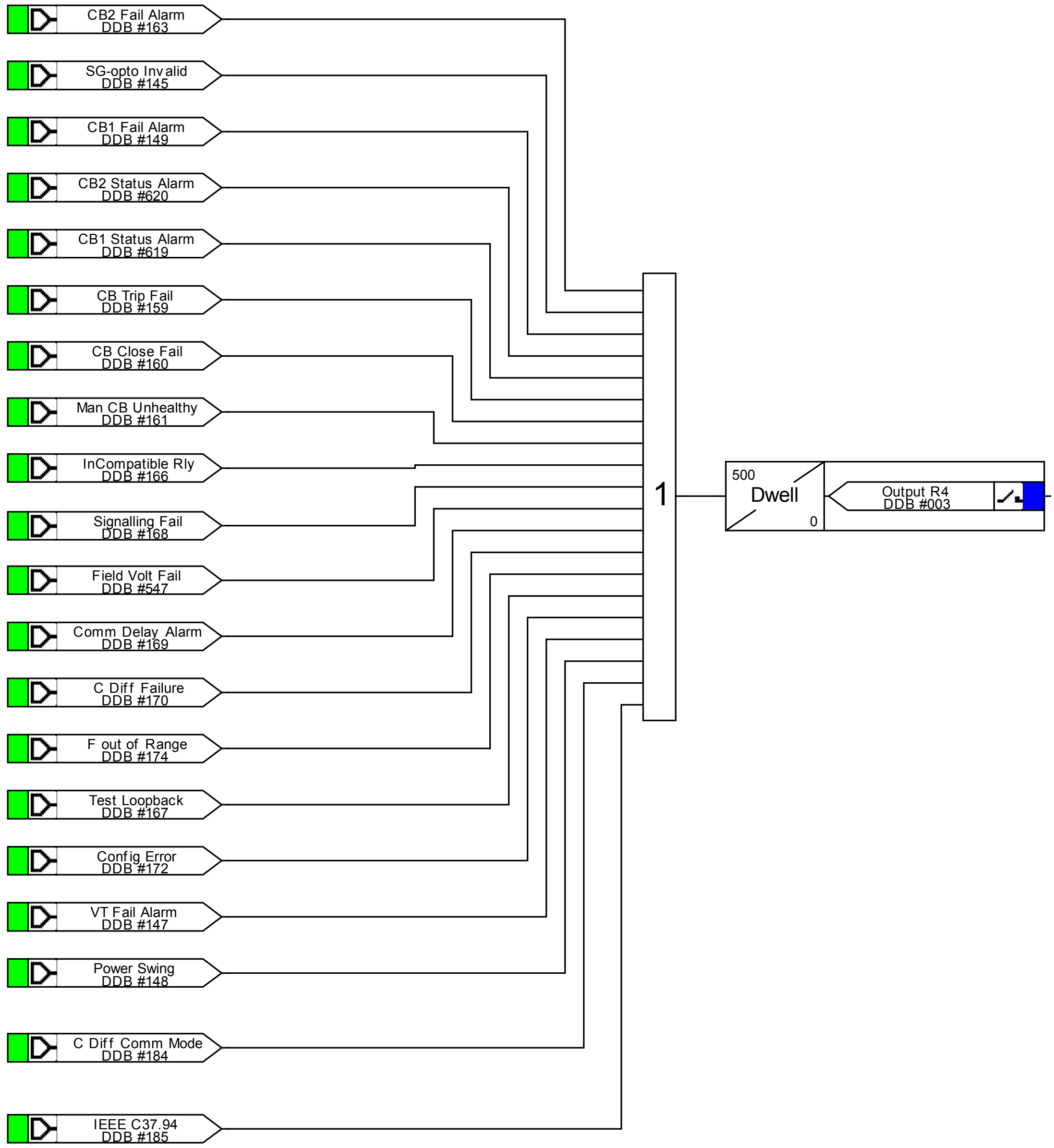
Opto Input Mappings



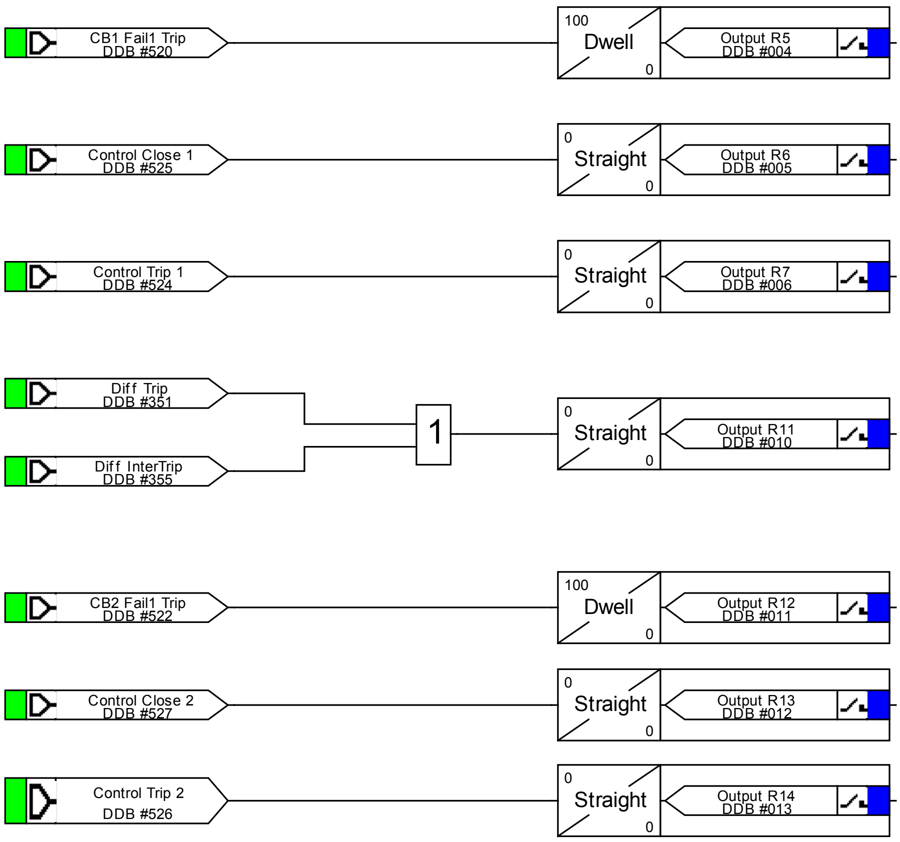
Output Relay Mapping



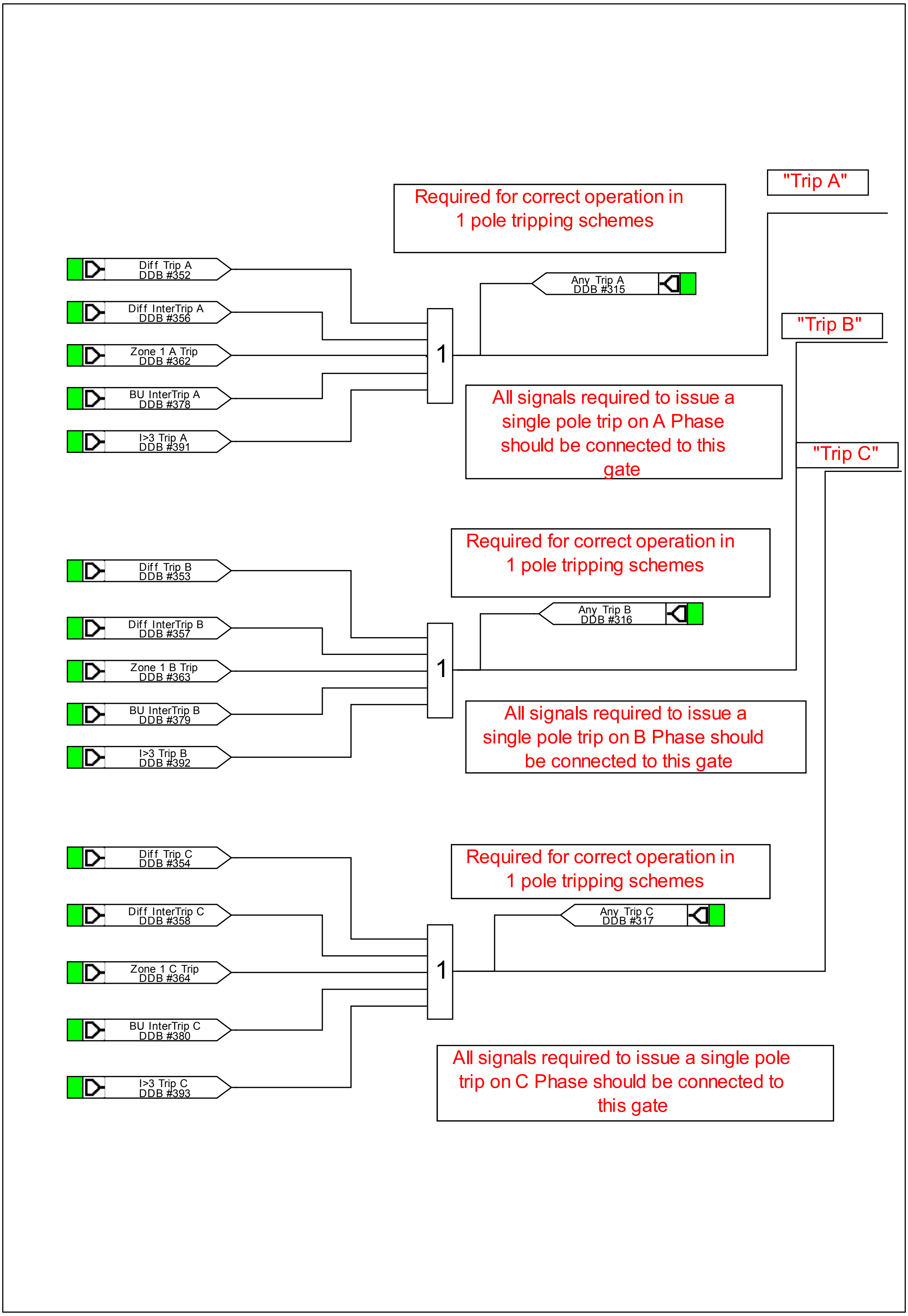
Output Relay Mapping



Output Relay Mapping

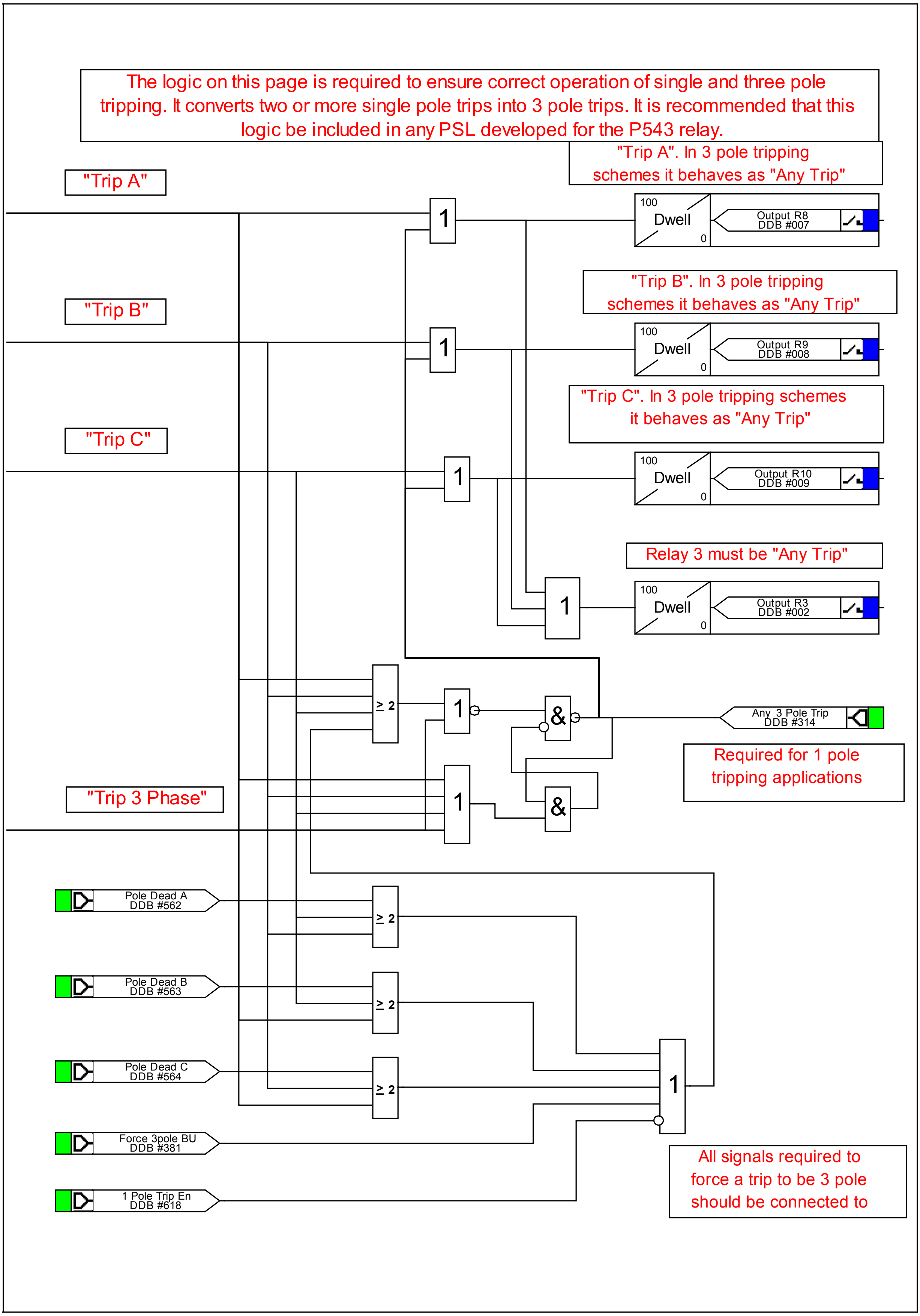


Trip Logic Mapping



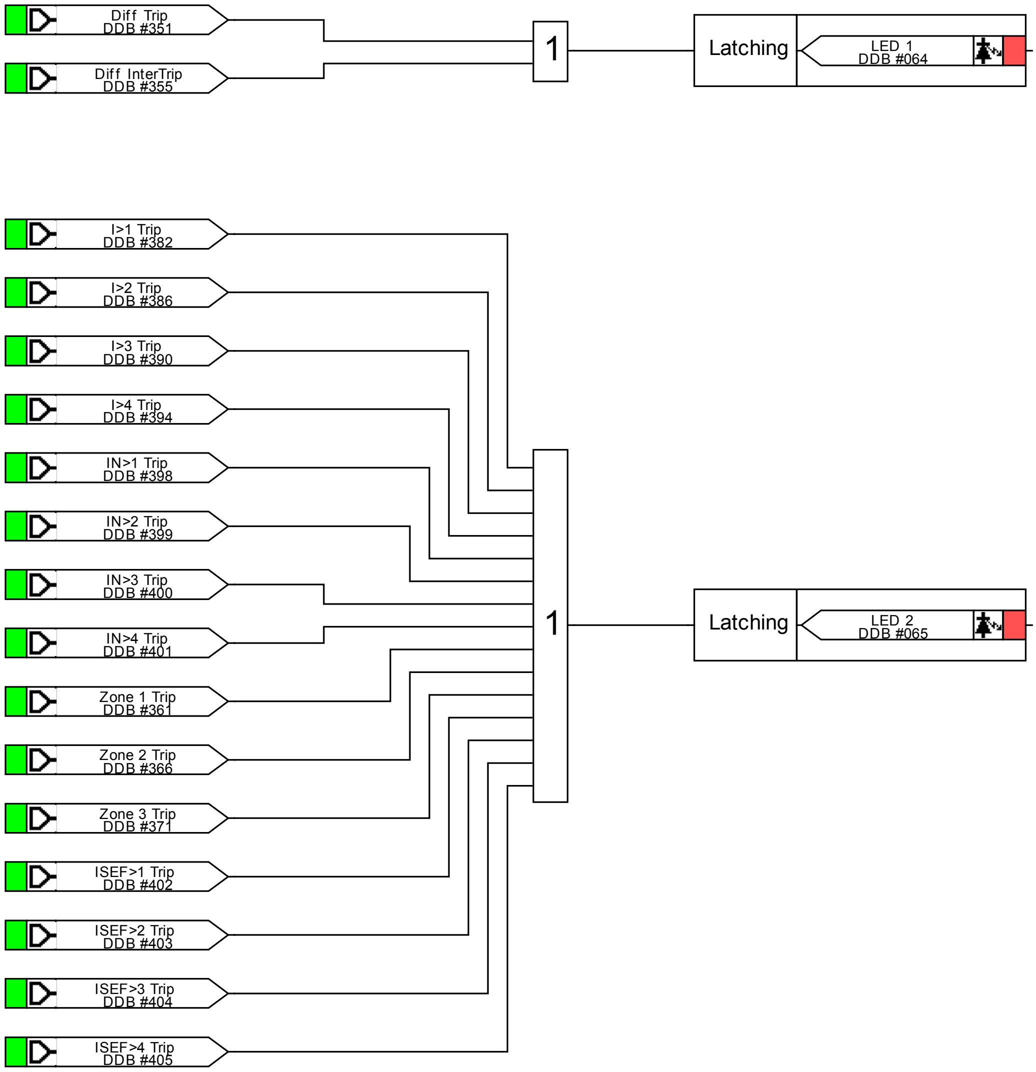
MiCOM P544, Page 5

Trip Conversion Logic and Mapping

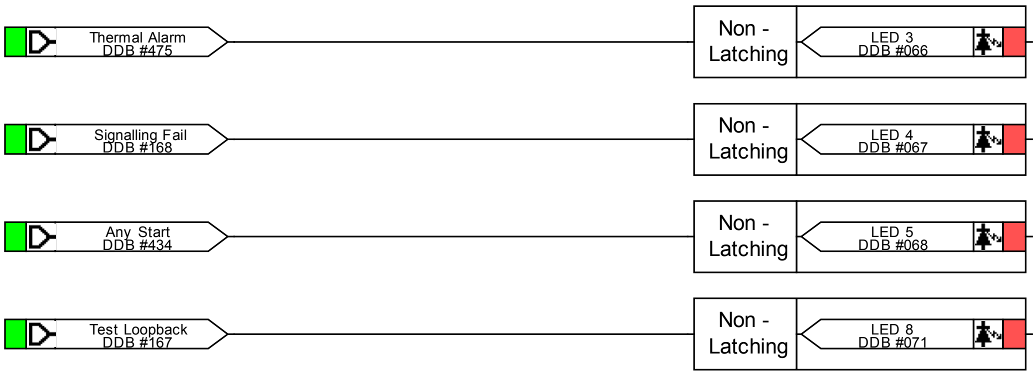


MiCOM P544, Page 6

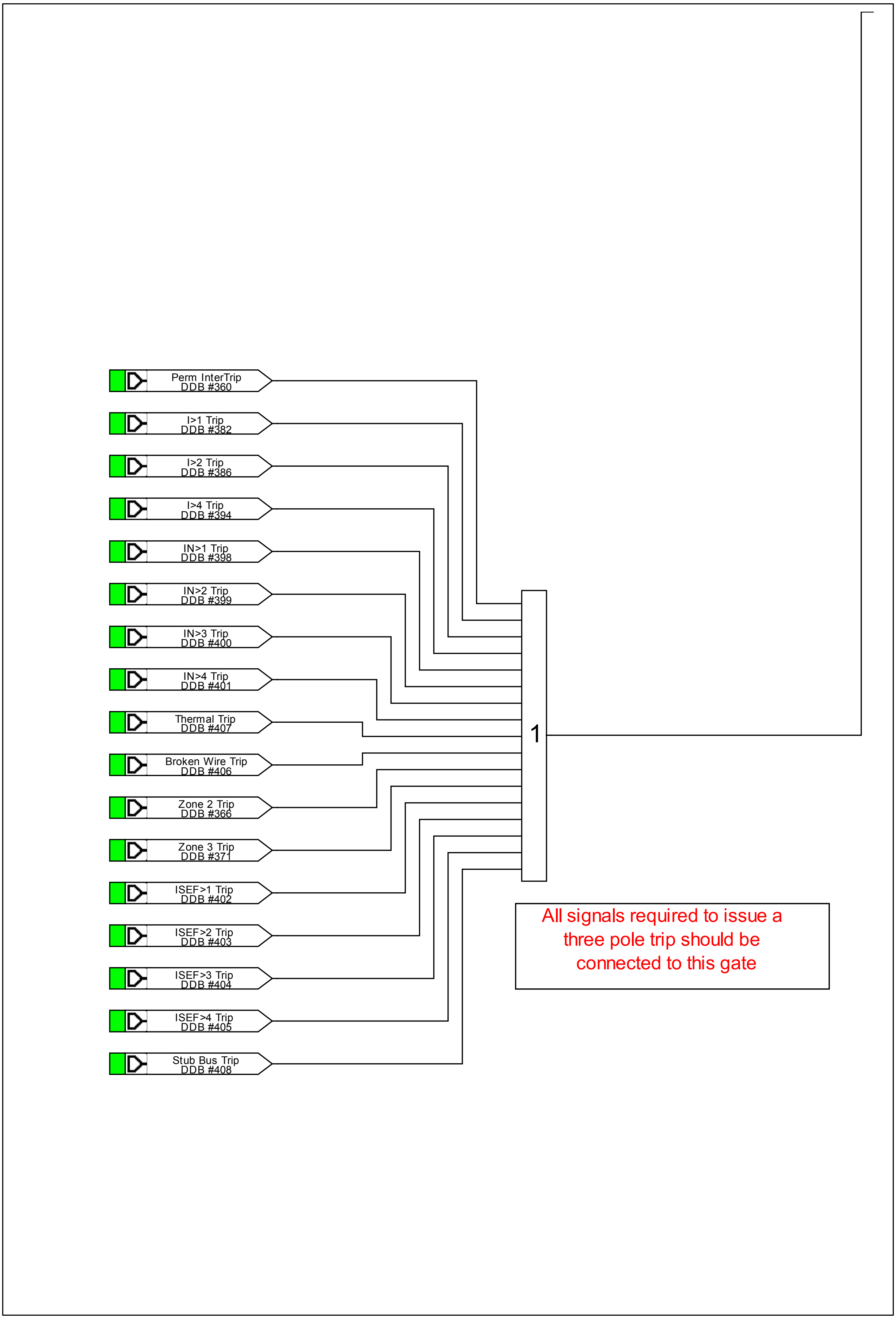
LED Mapping


Diff Trip
DDB #351
Diff InterTrip
DDB #355
1
Latching
LED 1
DDB #064
I>1 Trip
DDB #382
I>2 Trip
DDB #386
I>3 Trip
DDB #390
I>4 Trip
DDB #394
IN>1 Trip
DDB #398
IN>2 Trip
DDB #399
IN>3 Trip
DDB #400
IN>4 Trip
DDB #401
Zone 1 Trip
DDB #361
Zone 2 Trip
DDB #366
Zone 3 Trip
DDB #371
ISEF>1 Trip
DDB #402
ISEF>2 Trip
DDB #403
ISEF>3 Trip
DDB #404
ISEF>4 Trip
DDB #405
1
Latching
LED 2
DDB #065

LED Mapping

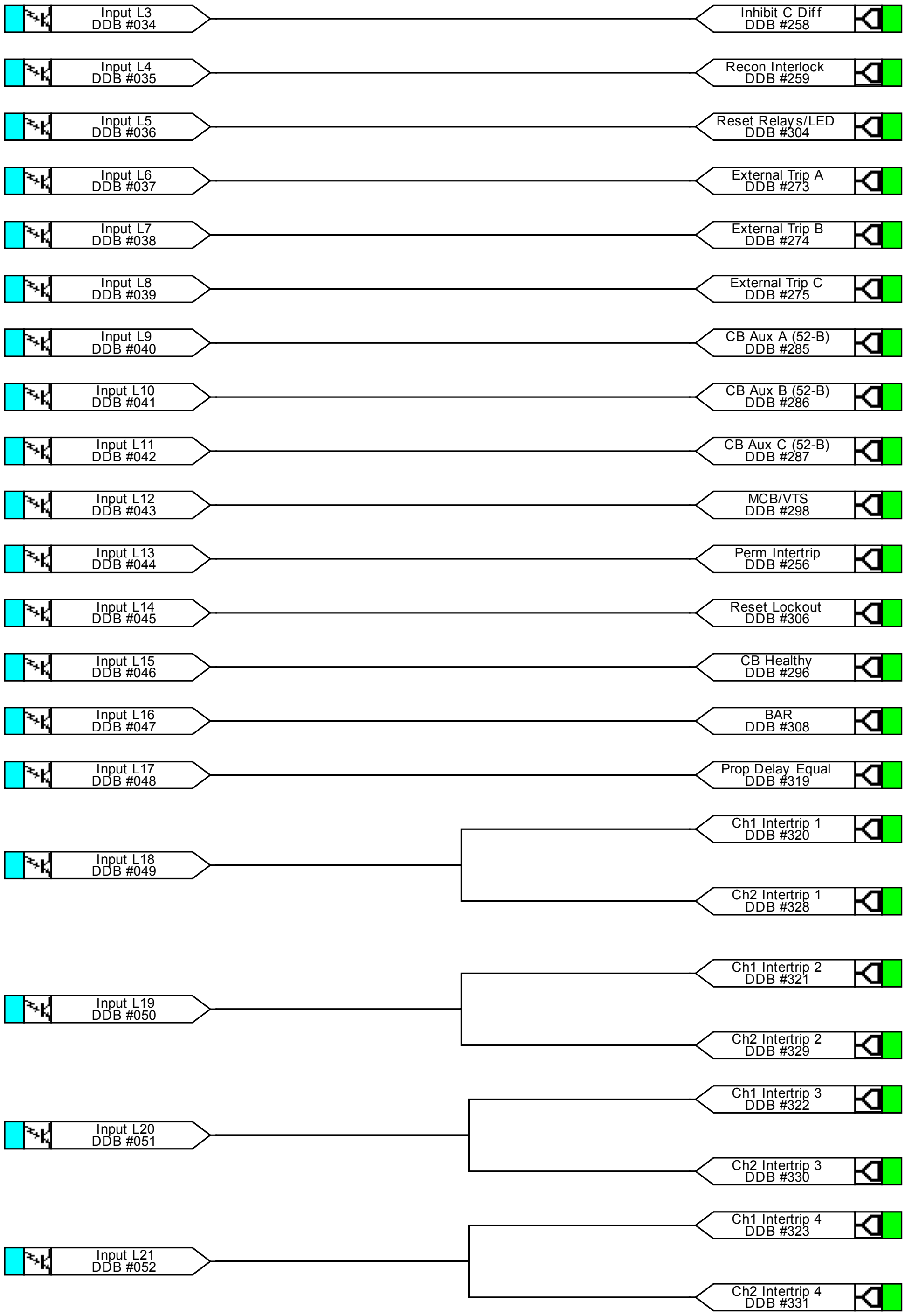

Thermal Alarm
DDB #475
Signalling Fail
DDB #168
Any Start
DDB #434
Test Loopback
DDB #167
Non - Latching
LED 3
DDB #066
Non - Latching
LED 4
DDB #067
Non - Latching
LED 5
DDB #068
Non - Latching
LED 8
DDB #071

Trip Logic Mapping



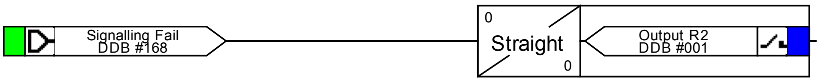
MiCOM P545 PROGRAMMABLE LOGIC

Opto Input Mappings

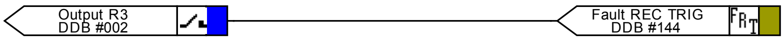


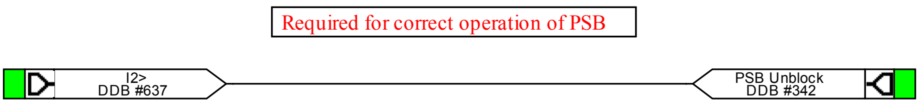
MiCOM P545, Page 1

Output Relay Mapping

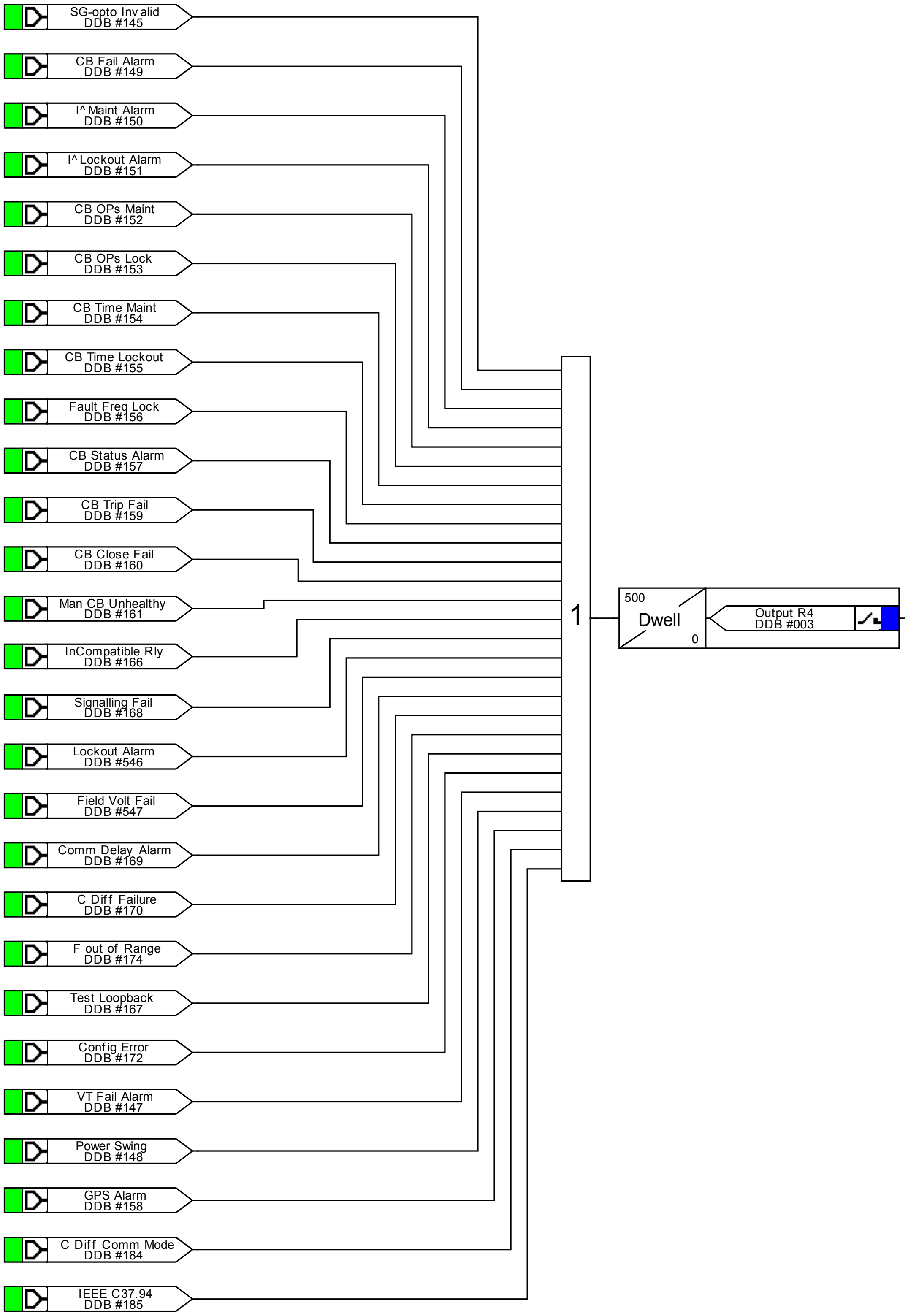


Fault Record Trigger Mapping

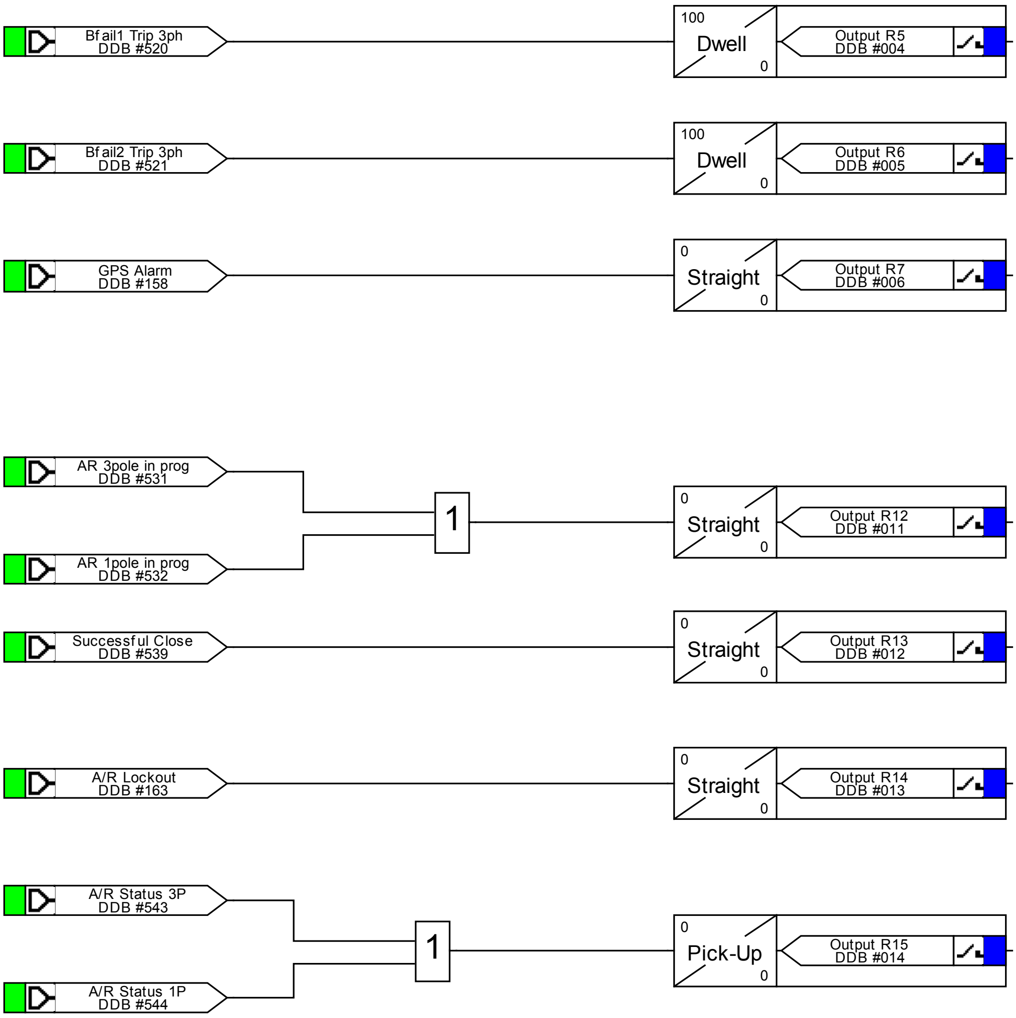




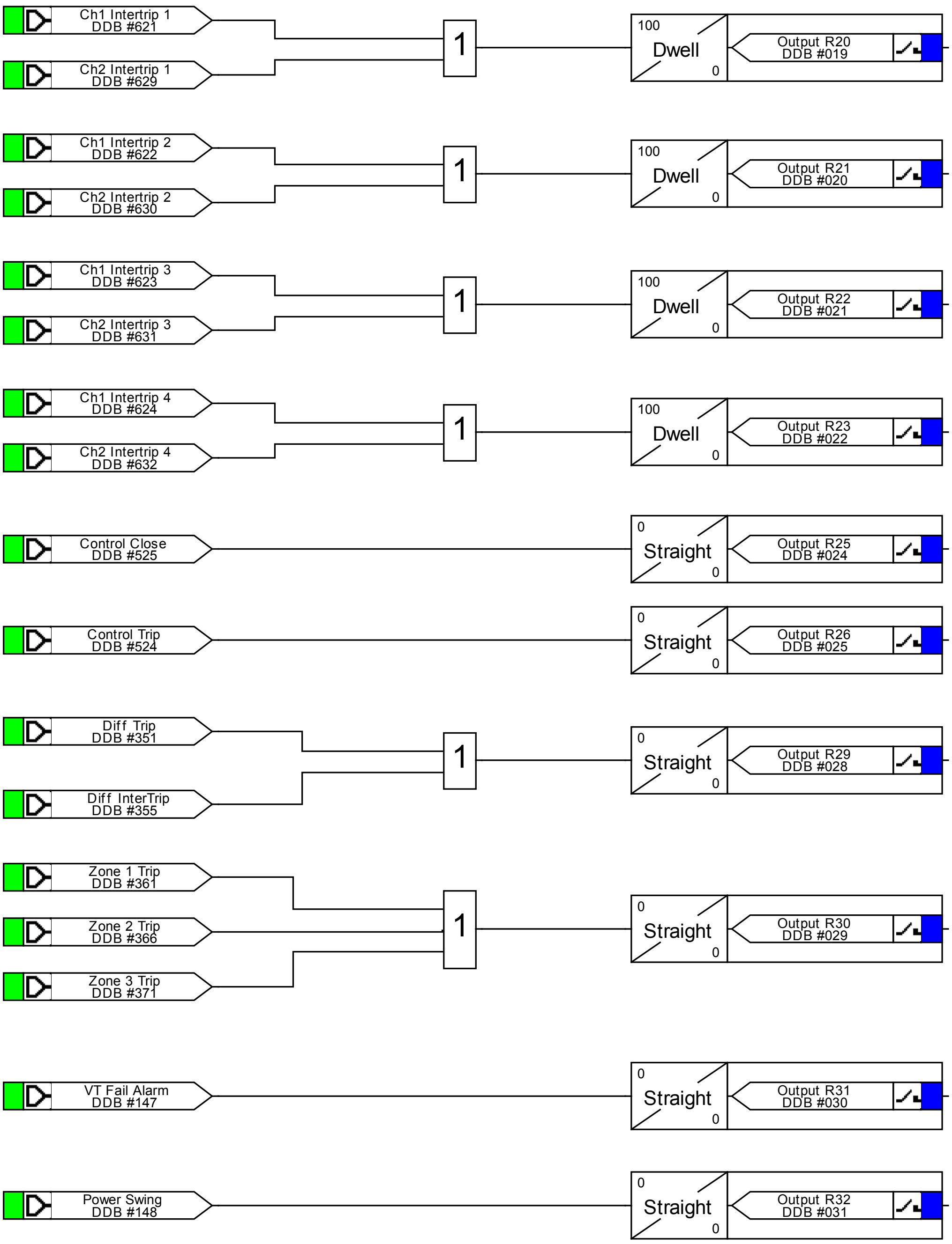
Output Relay Mapping



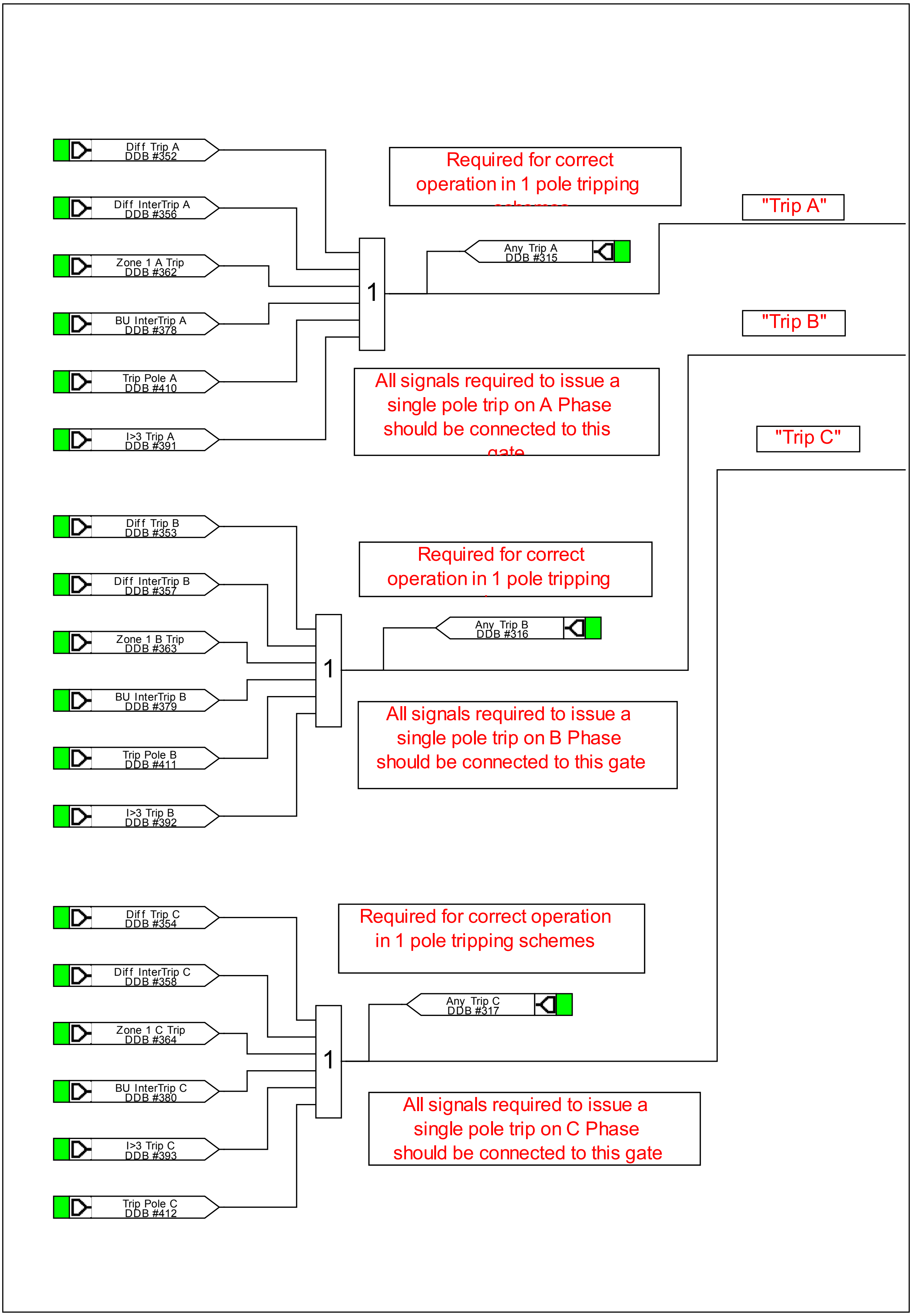
Output Relay Mapping



Output Relay Mapping

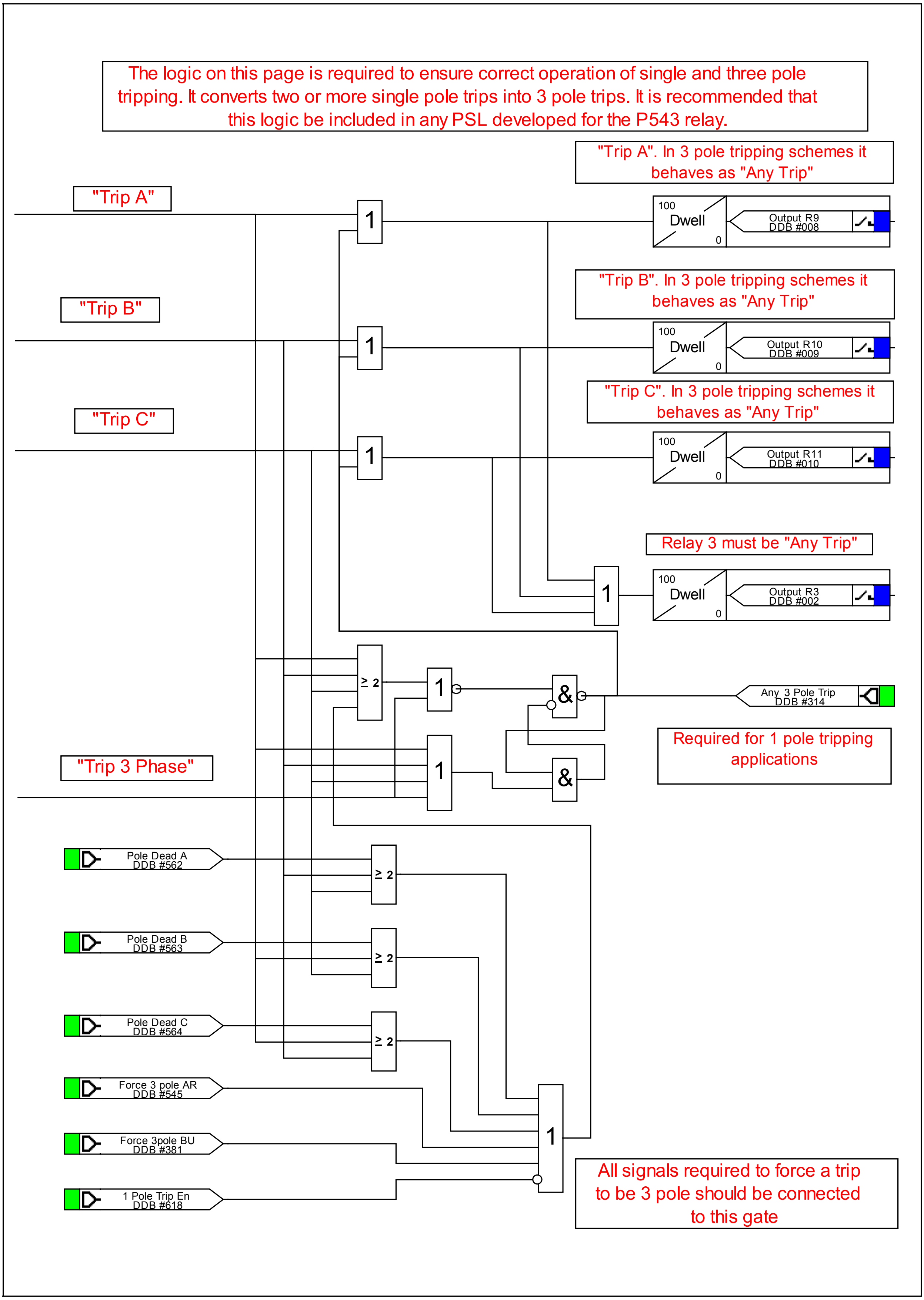


Trip Logic Mapping

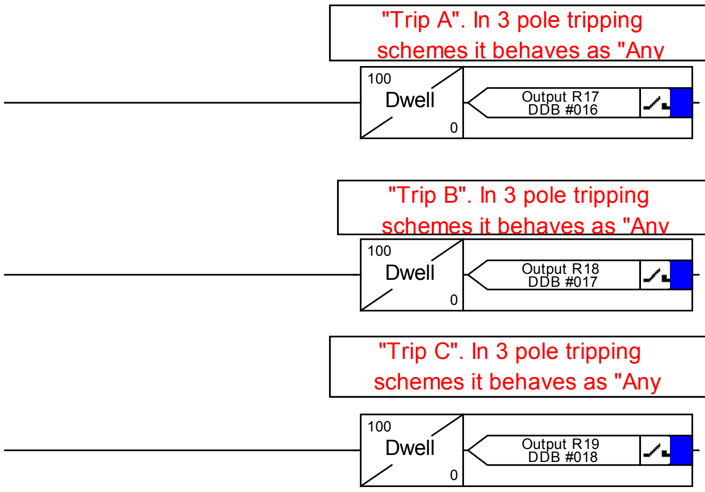


MiCOM P545, Page 6

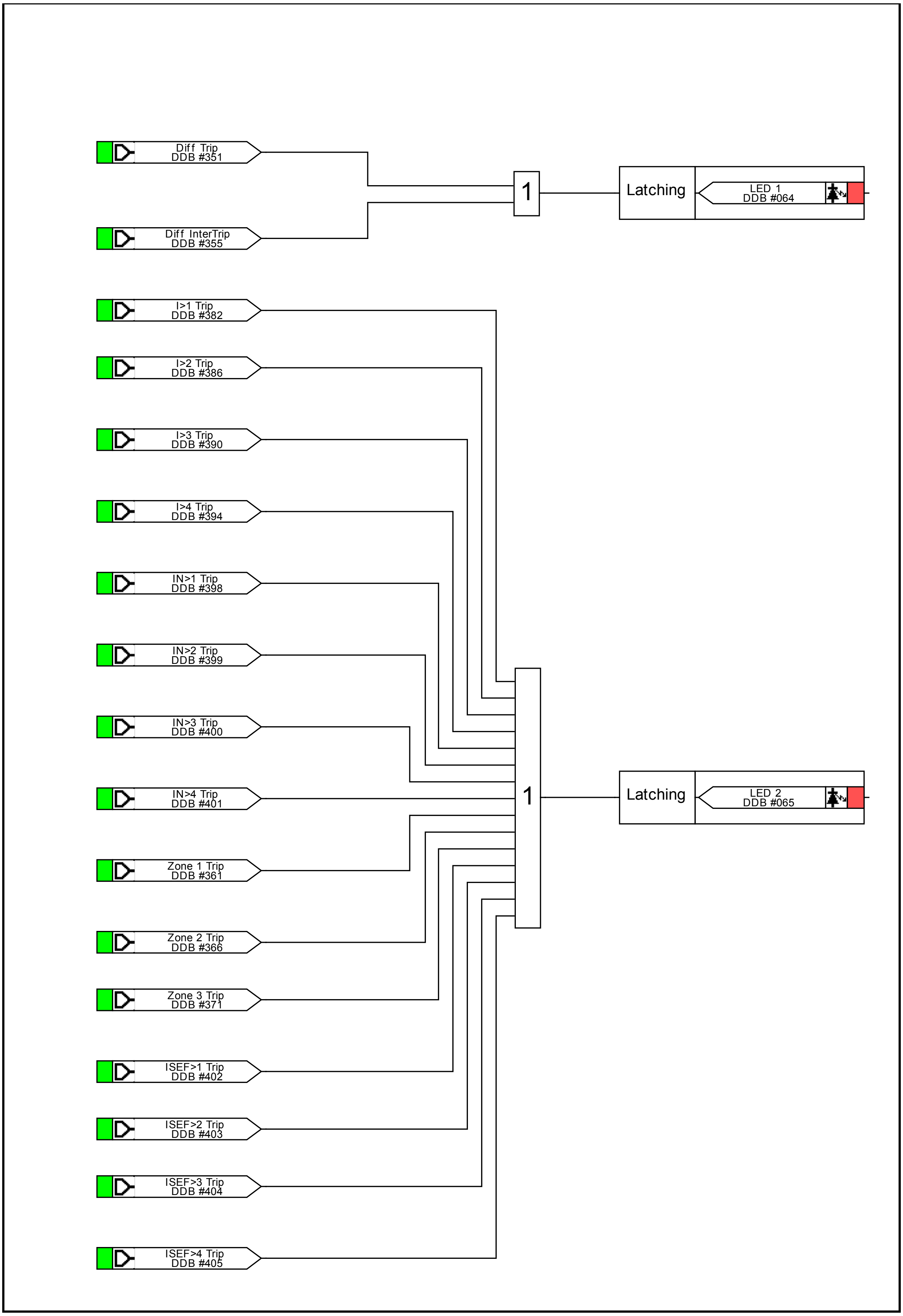
Trip Conversion and Logic Mapping



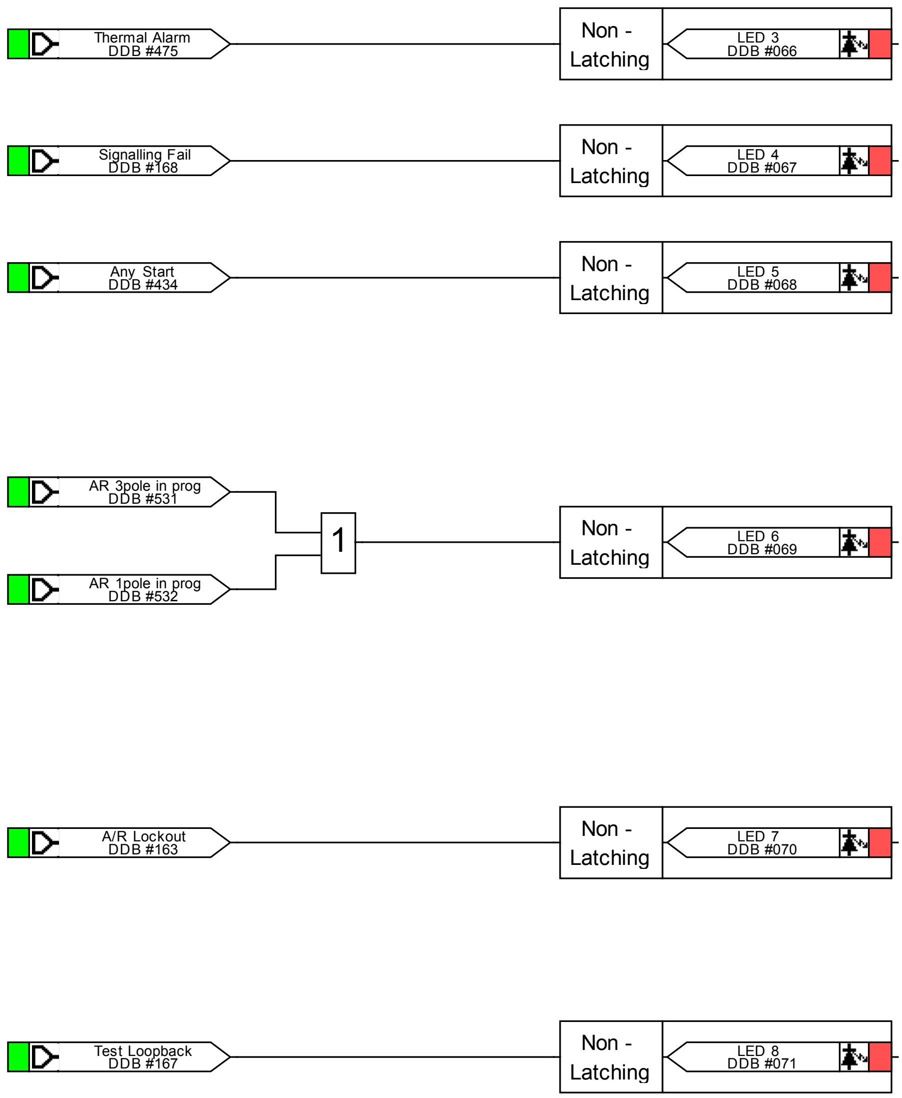
Output Relay Mapping



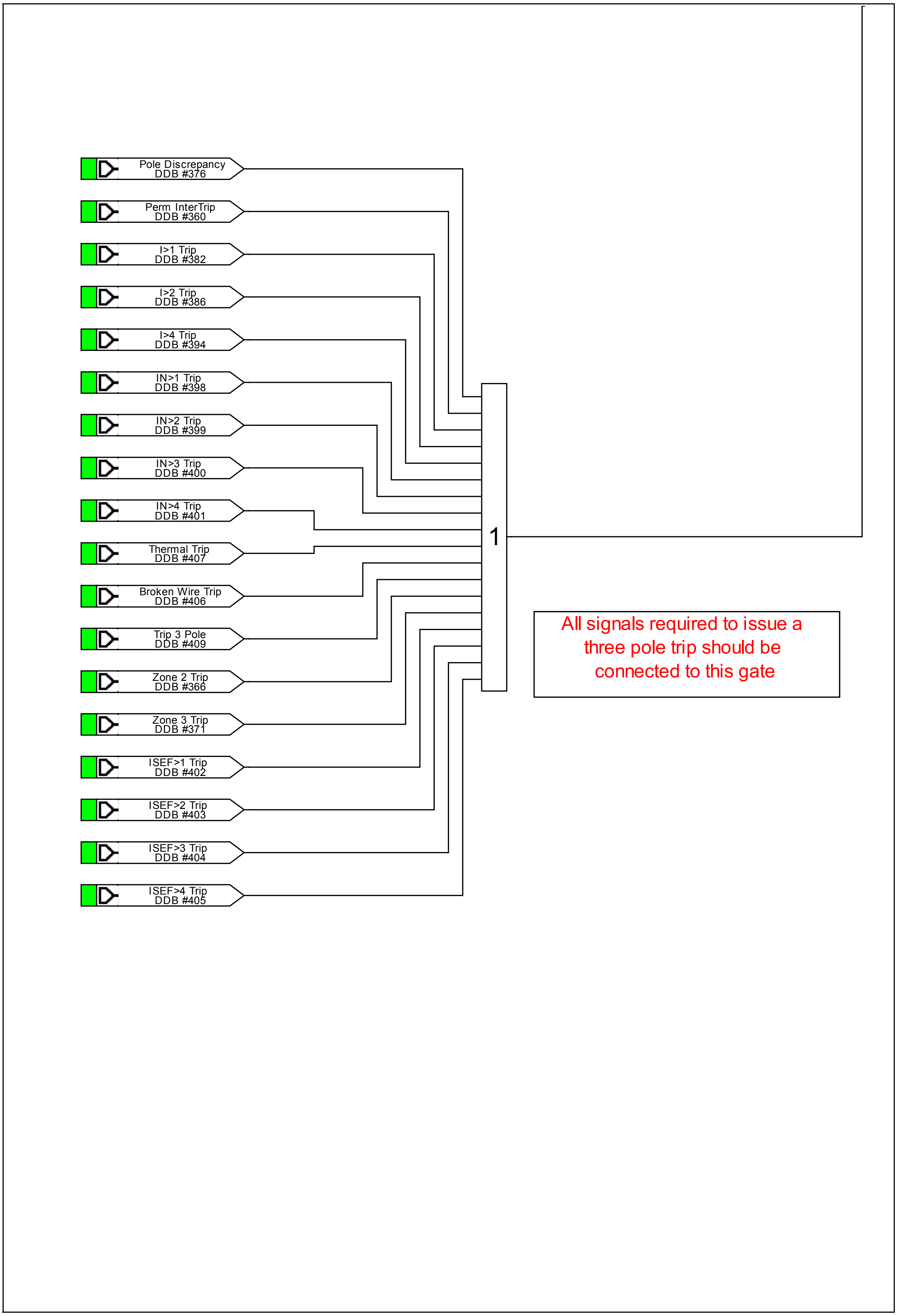
LED Mapping


Diff Trip
DDB #351
Diff InterTrip
DDB #355
1
Latching
LED 1
DDB #064
I>1 Trip
DDB #382
I>2 Trip
DDB #386
I>3 Trip
DDB #390
I>4 Trip
DDB #394
IN>1 Trip
DDB #398
IN>2 Trip
DDB #399
IN>3 Trip
DDB #400
IN>4 Trip
DDB #401
1
Latching
LED 2
DDB #065
Zone 1 Trip
DDB #361
Zone 2 Trip
DDB #366
Zone 3 Trip
DDB #371
ISEF>1 Trip
DDB #402
ISEF>2 Trip
DDB #403
ISEF>3 Trip
DDB #404
ISEF>4 Trip
DDB #405

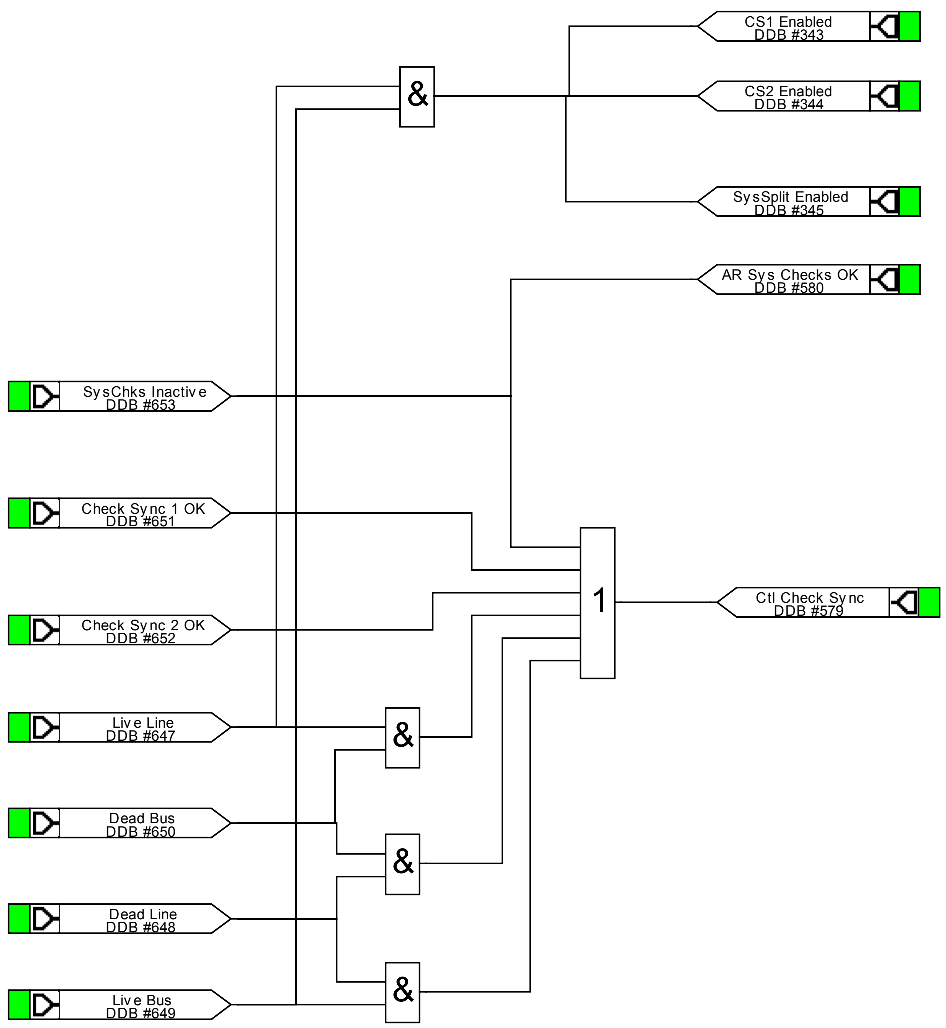
LED Mapping


Thermal Alarm
DDB #475
Non - Latching
LED 3
DDB #066
Signalling Fail
DDB #168
Non - Latching
LED 4
DDB #067
Any Start
DDB #434
Non - Latching
LED 5
DDB #068
AR 3pole in prog
DDB #531
AR 1pole in prog
DDB #532
1
Non - Latching
LED 6
DDB #069
A/R Lockout
DDB #163
Non - Latching
LED 7
DDB #070
Test Loopback
DDB #167
Non - Latching
LED 8
DDB #071

Trip Logic Mapping

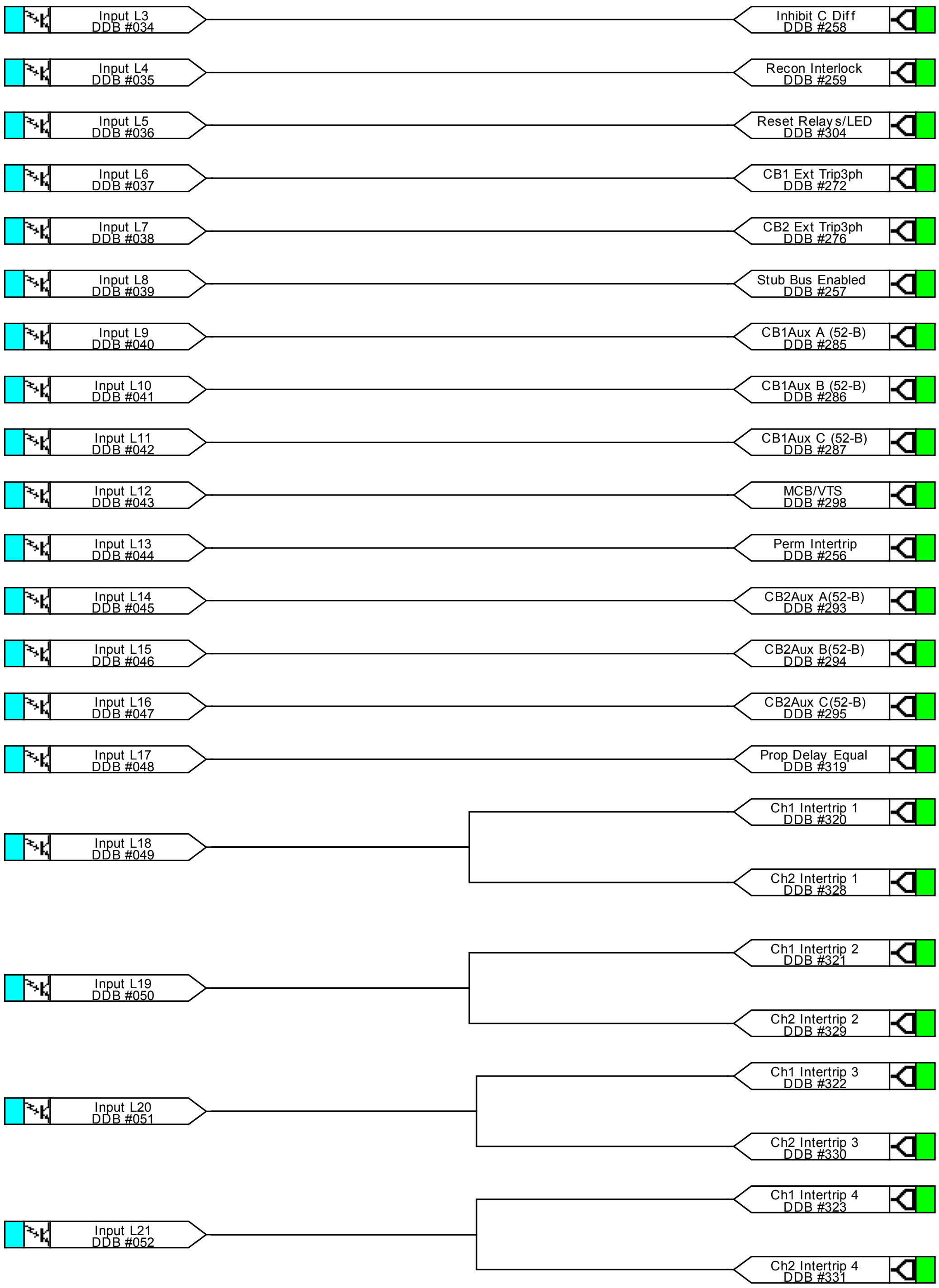


Check Synch. and Voltage Monitor Mapping



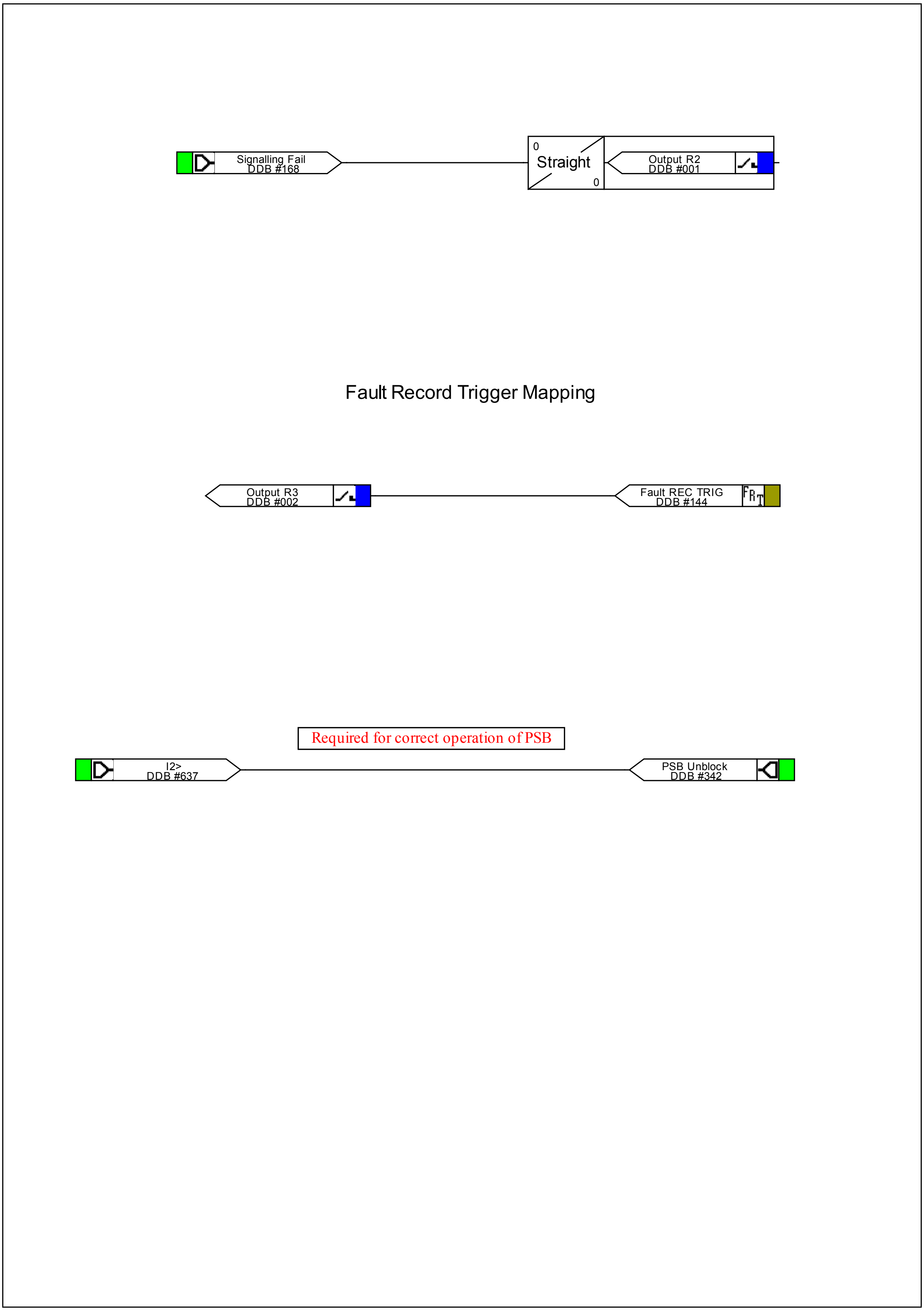
MiCOM P546 PROGRAMMABLE LOGIC

Opto Input Mappings



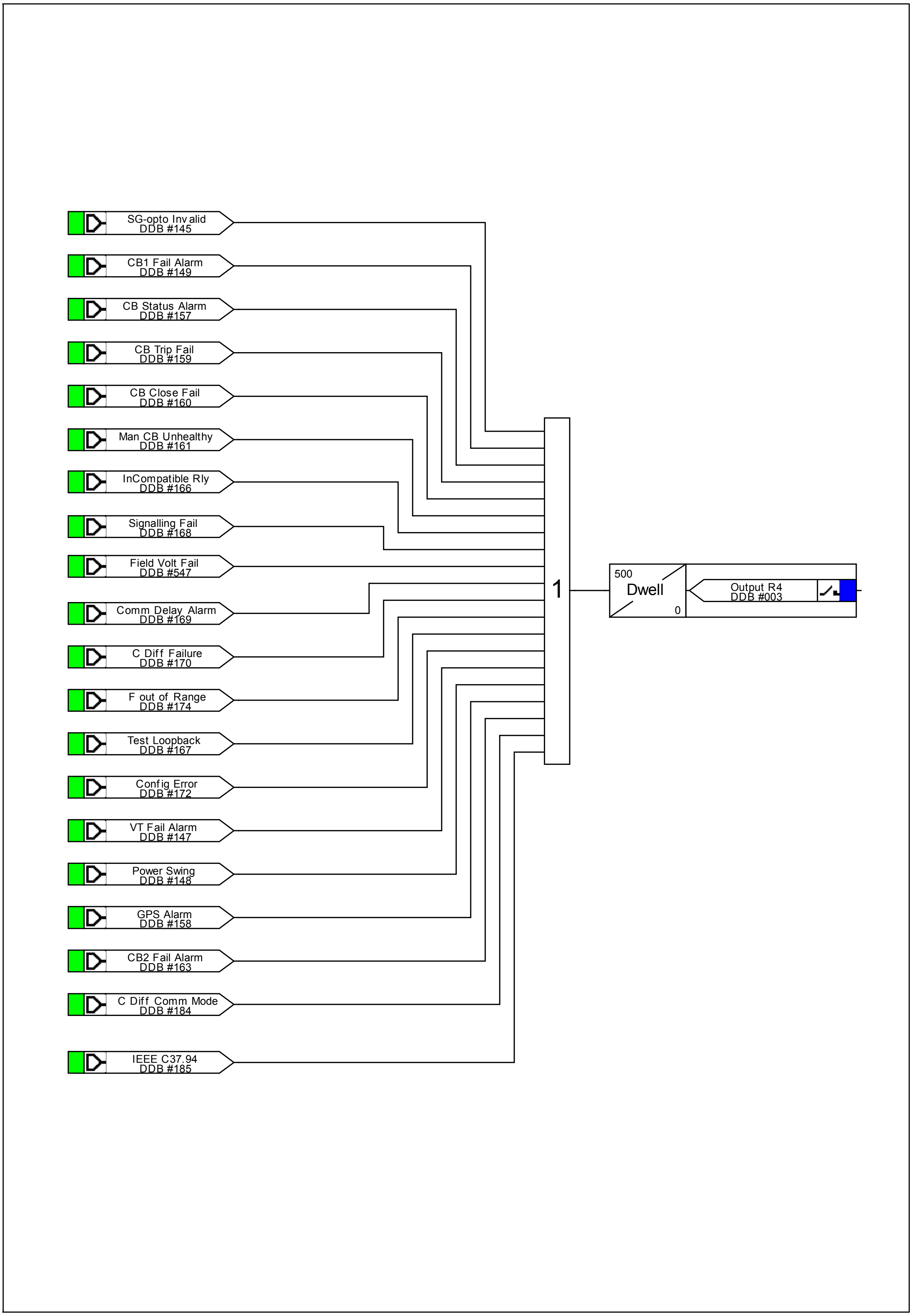
MiCOM P546, Page 1

Output Relay Mapping

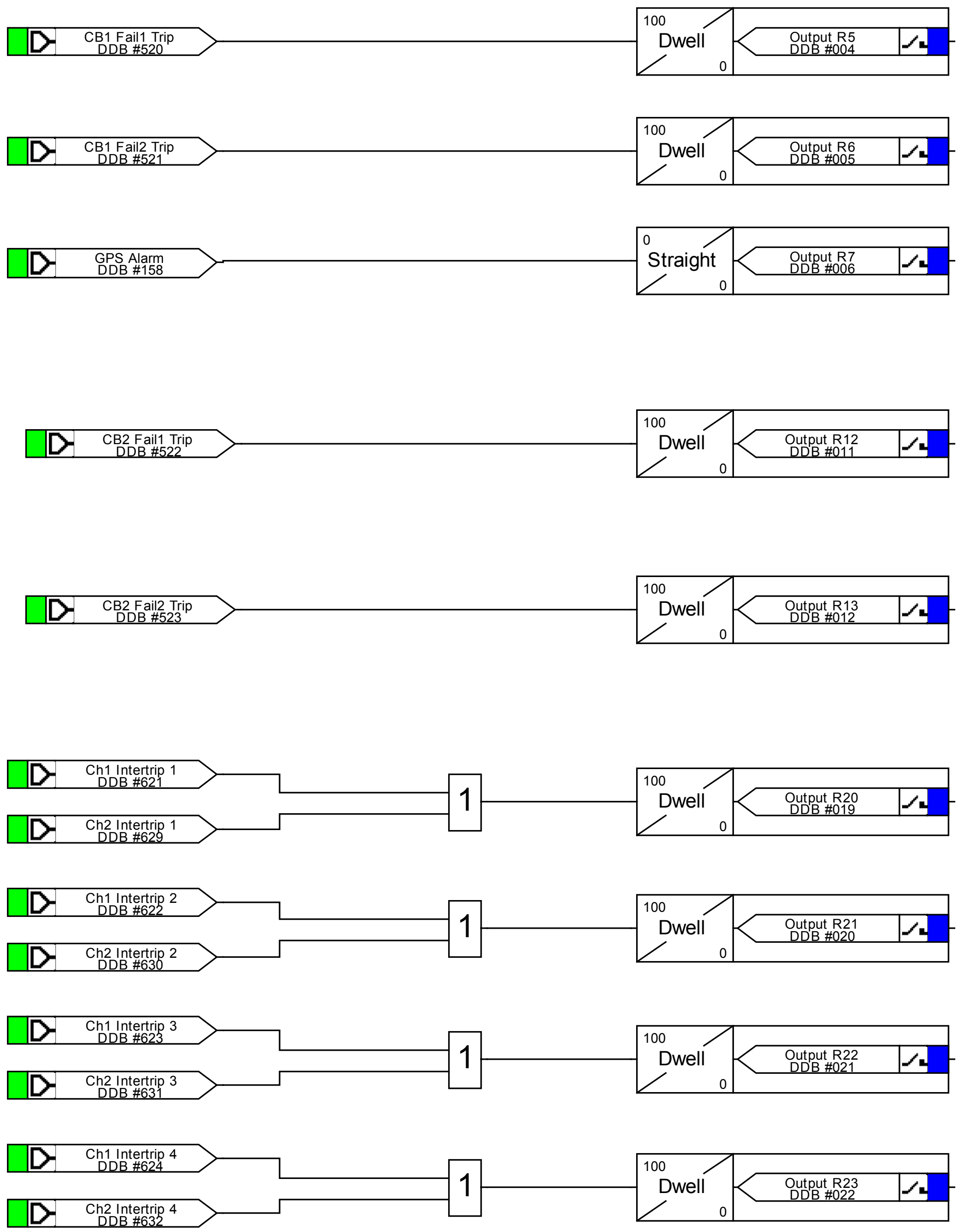


MiCOM P546, Page 2

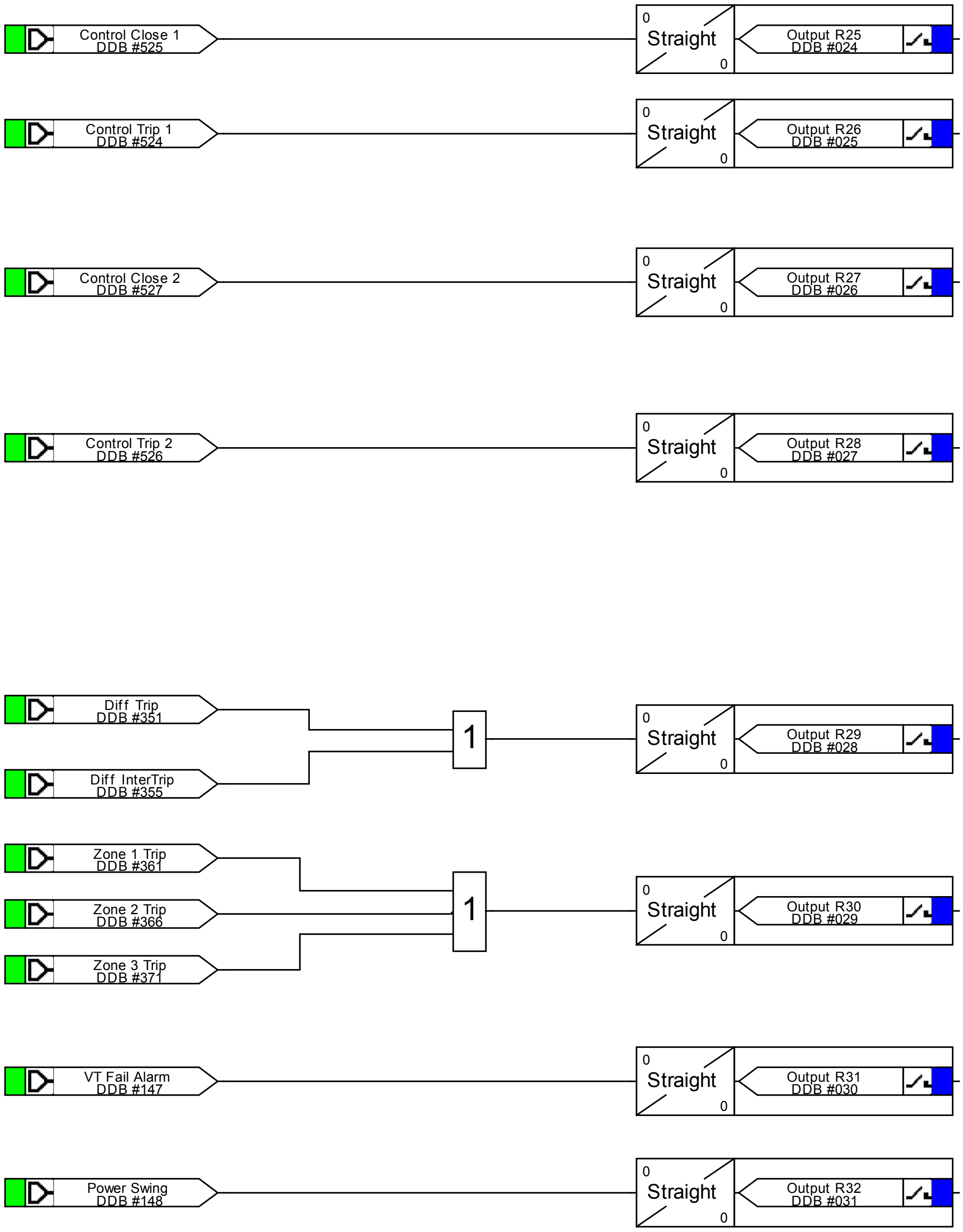
Output Relay Mapping



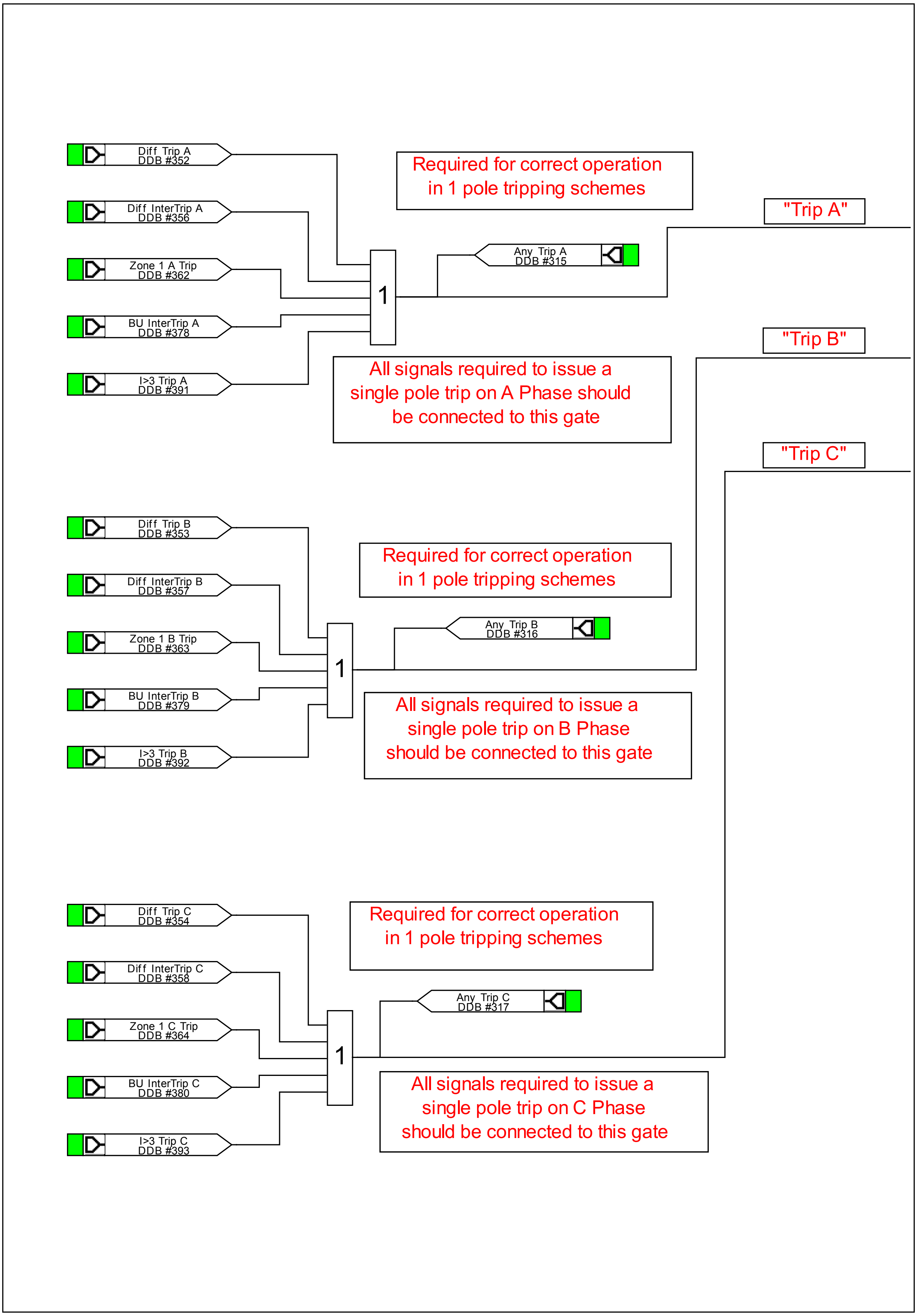
Output Relay Mapping



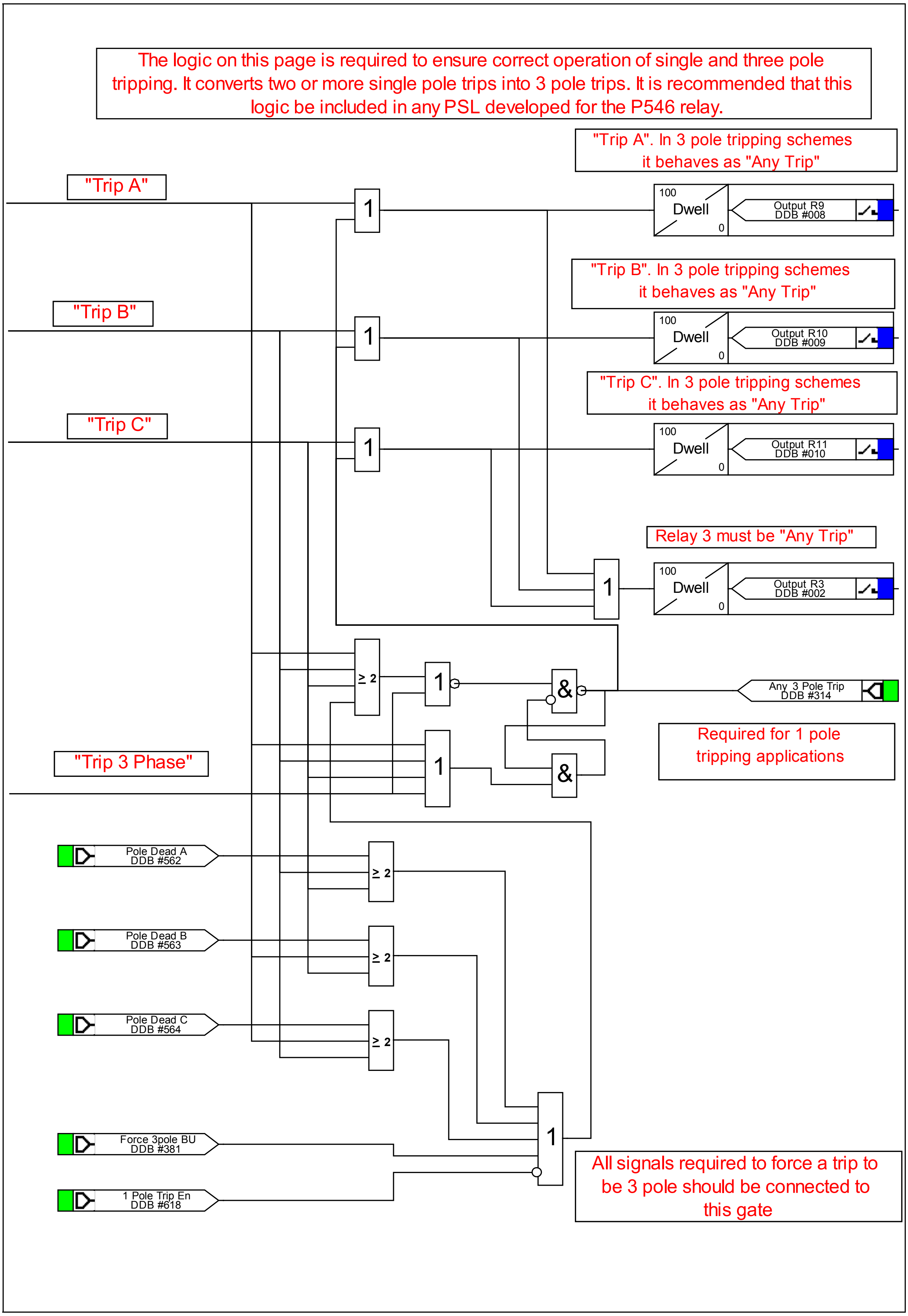
Output Relay Mapping



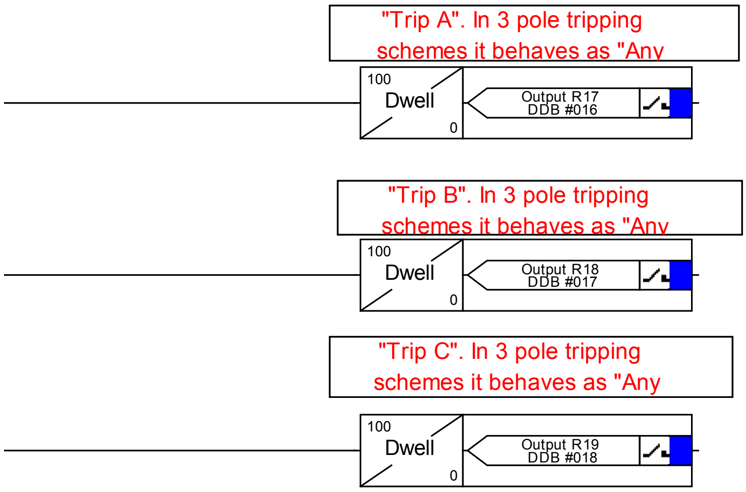
Trip Logic Mapping



Trip Conversion and Logic Mapping

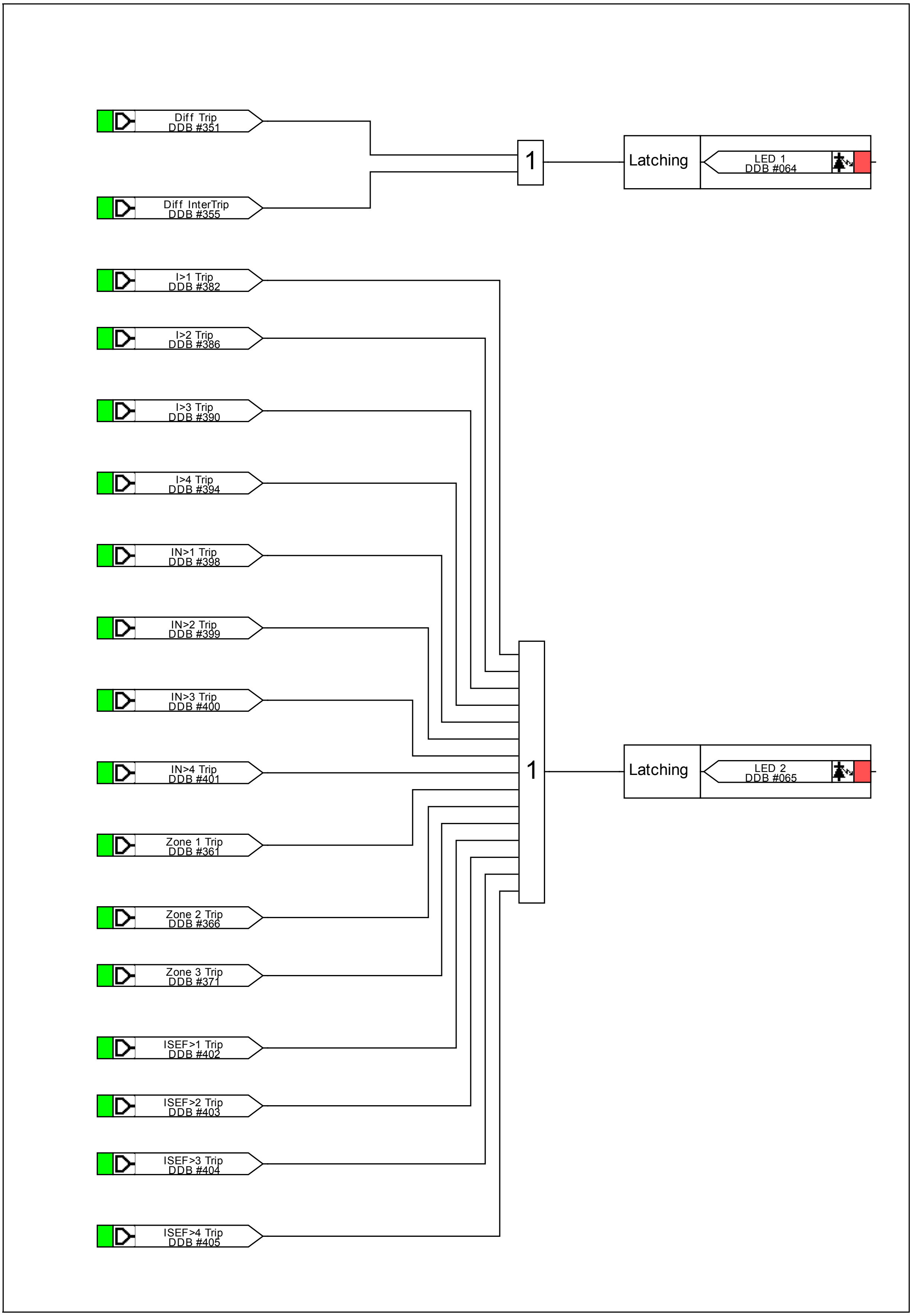


Output Relay Mapping

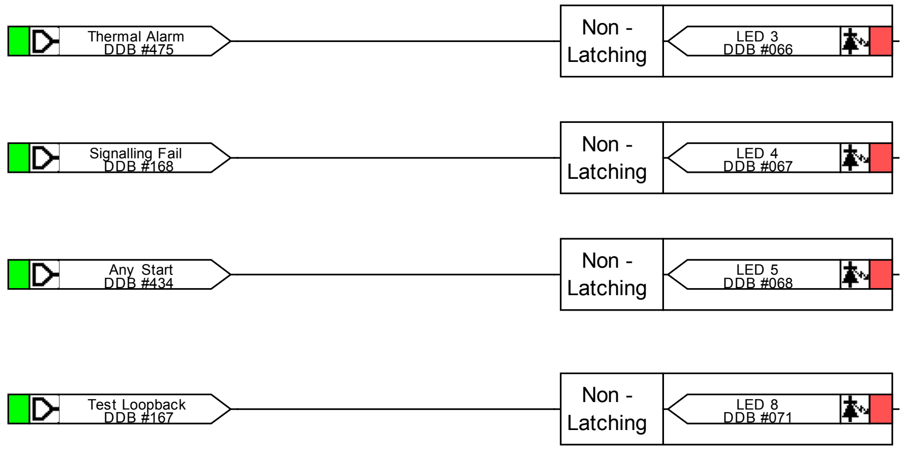


MiCOM P546, Page 8

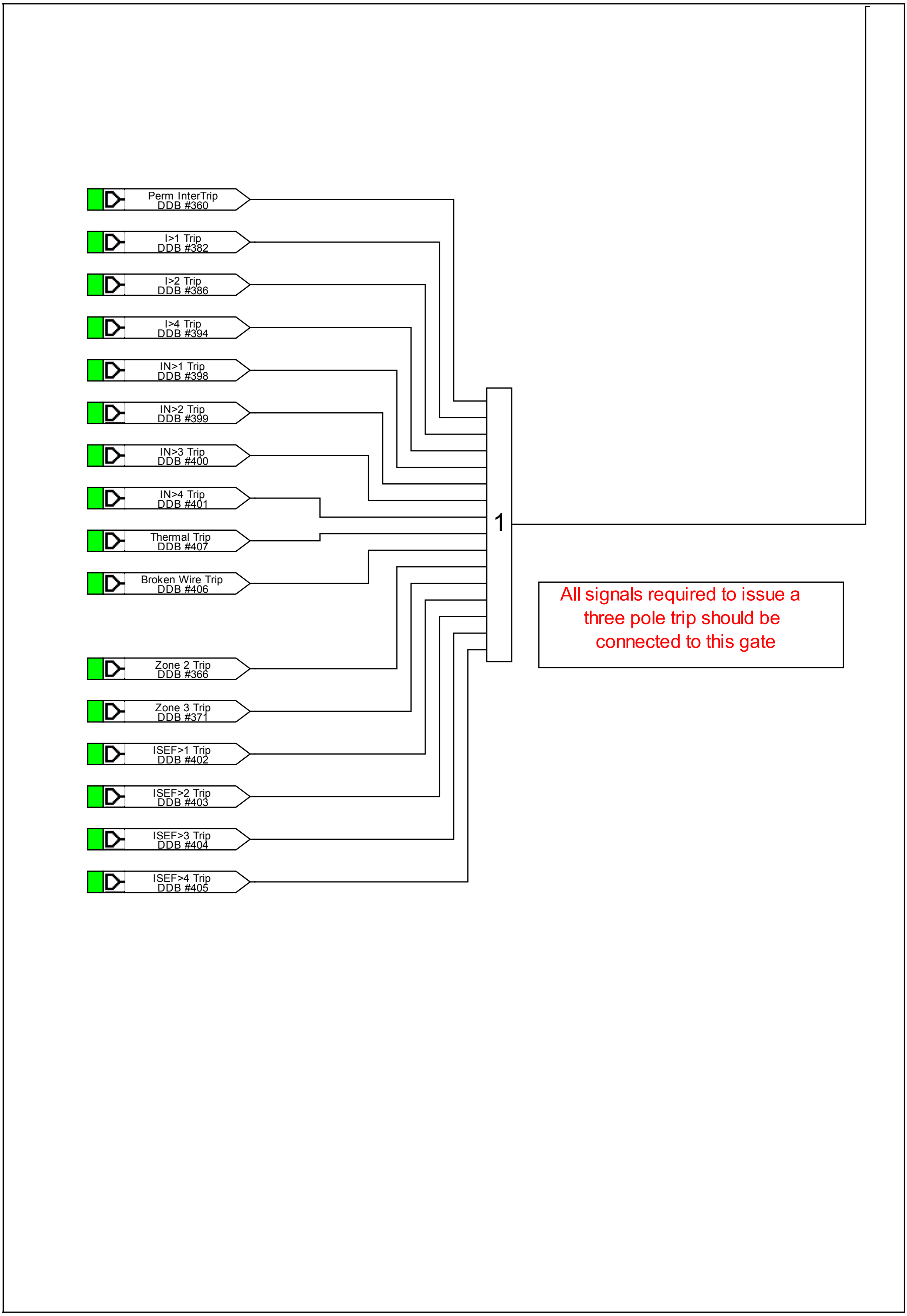
Trip Logic Mapping



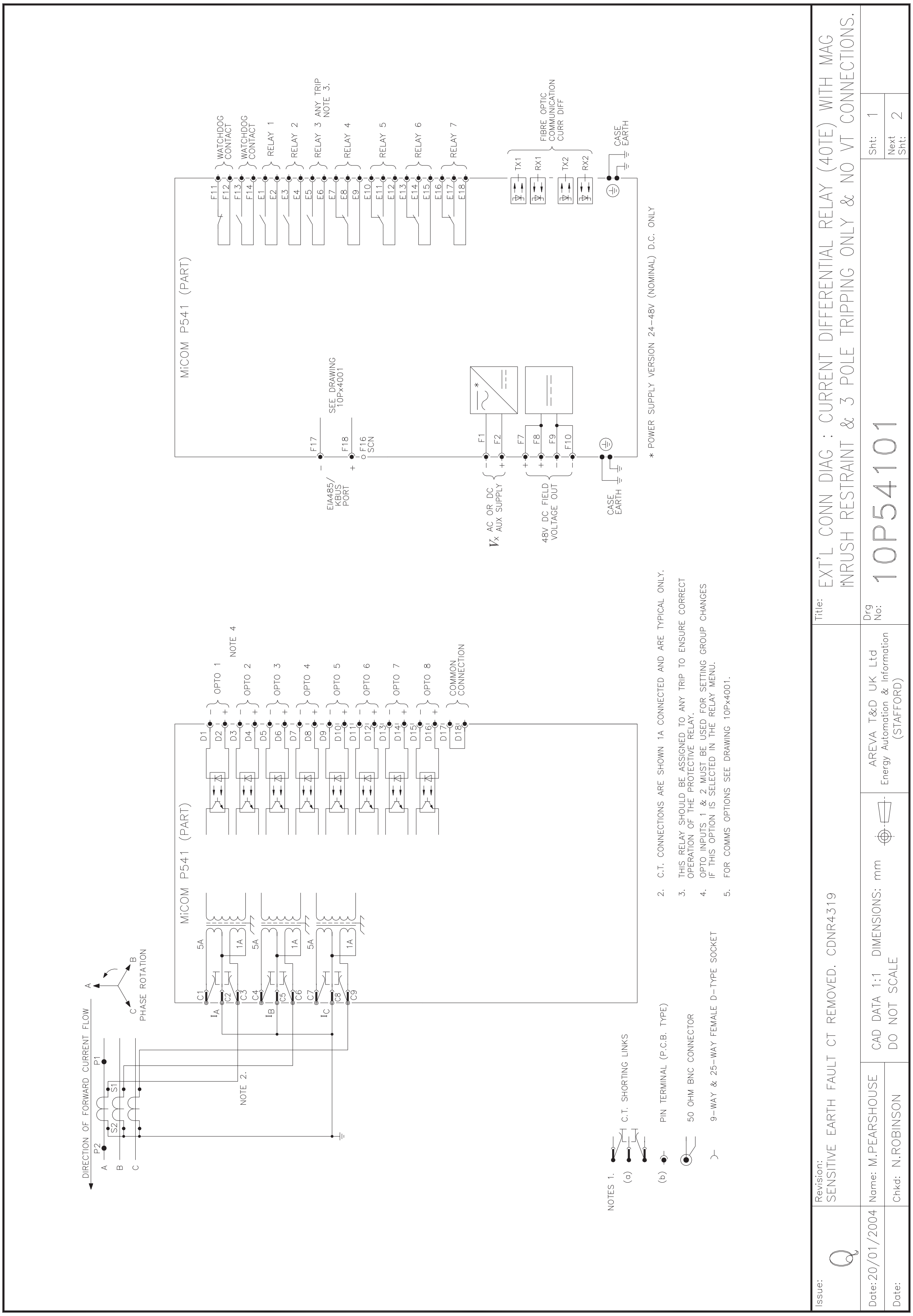
LED Mapping

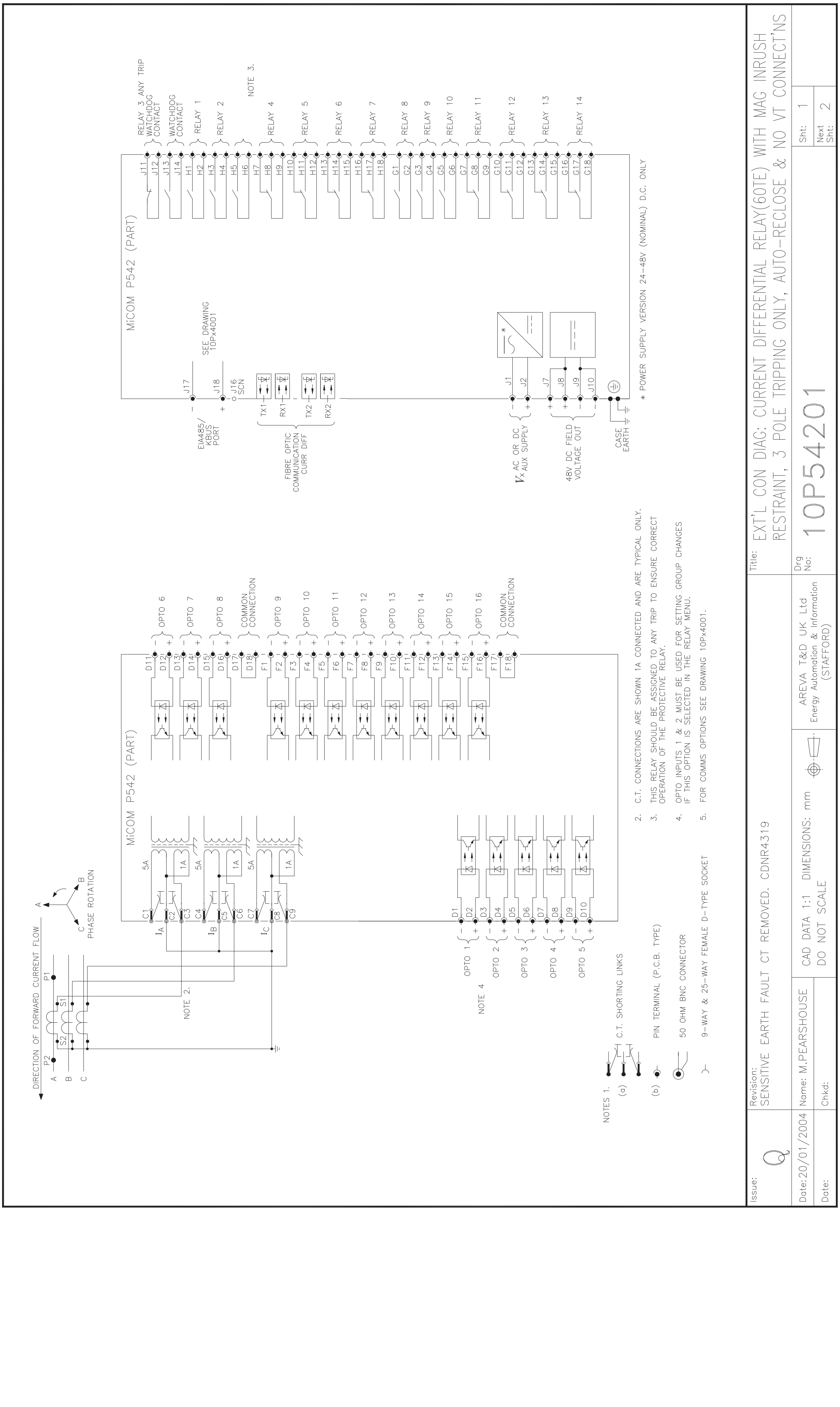

Thermal Alarm
DDB #475
Non - Latching
LED 3
DDB #066
Signalling Fail
DDB #168
Non - Latching
LED 4
DDB #067
Any Start
DDB #434
Non - Latching
LED 5
DDB #068
Test Loopback
DDB #167
Non - Latching
LED 8
DDB #071

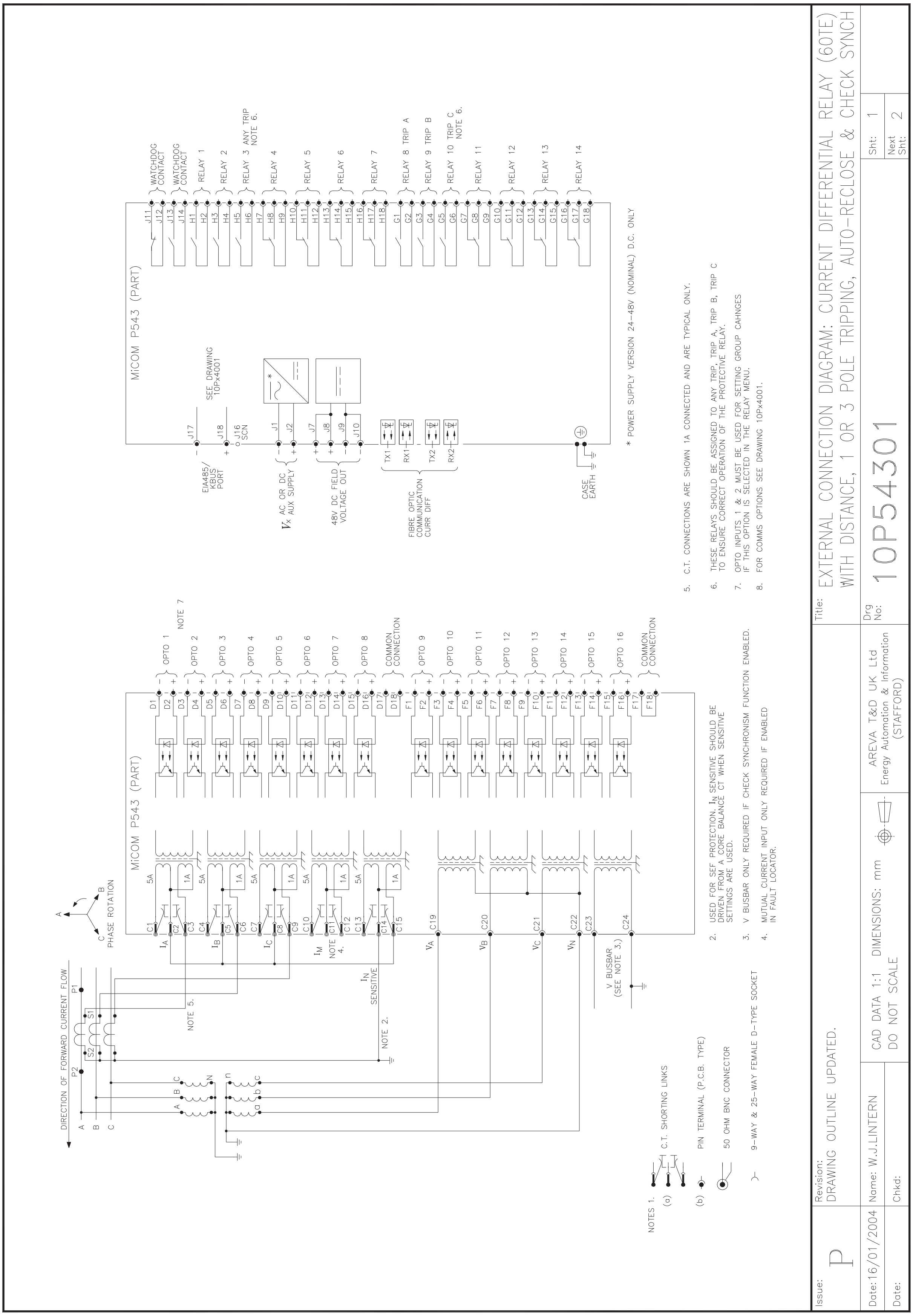
Trip Logic Mapping

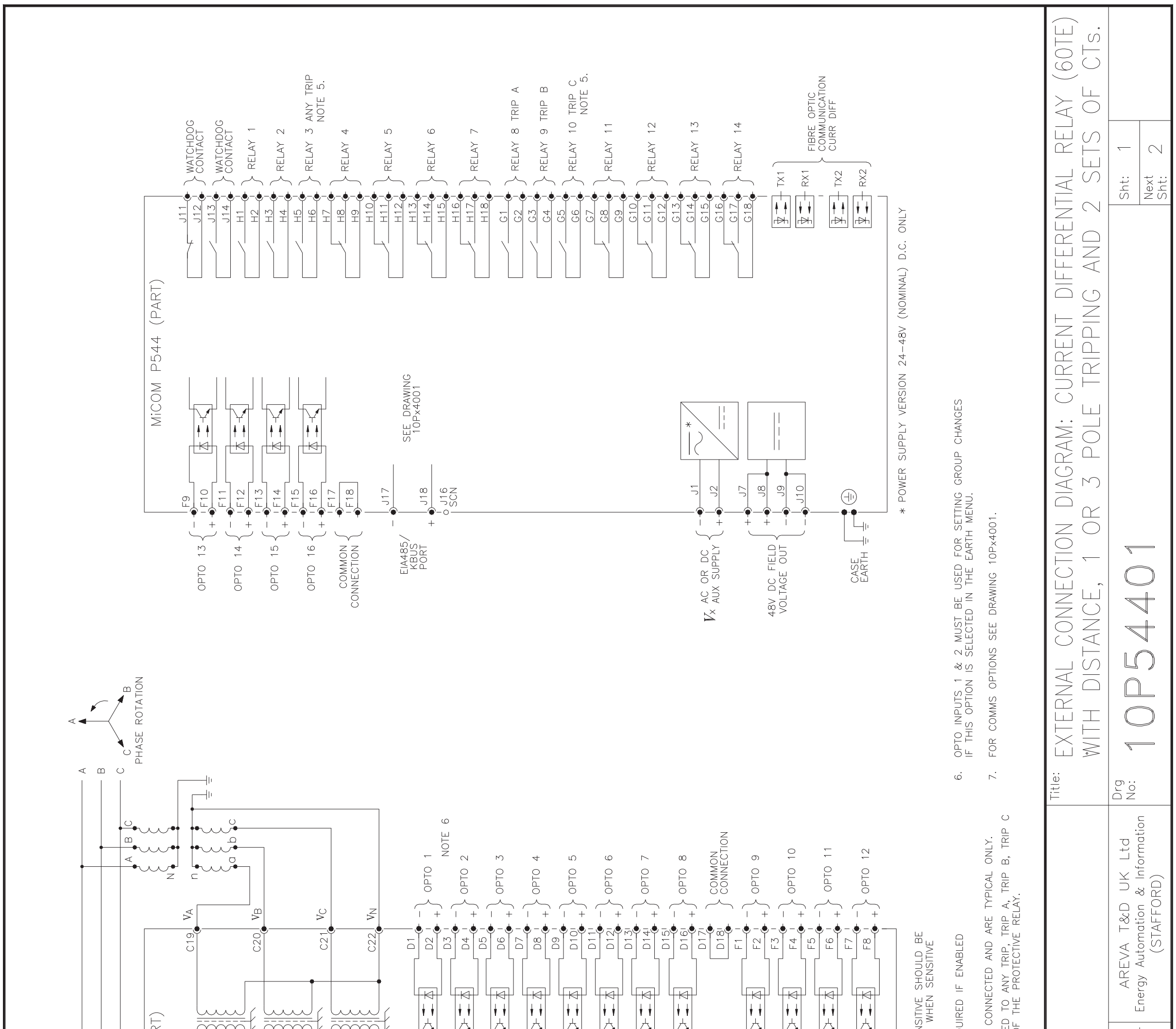


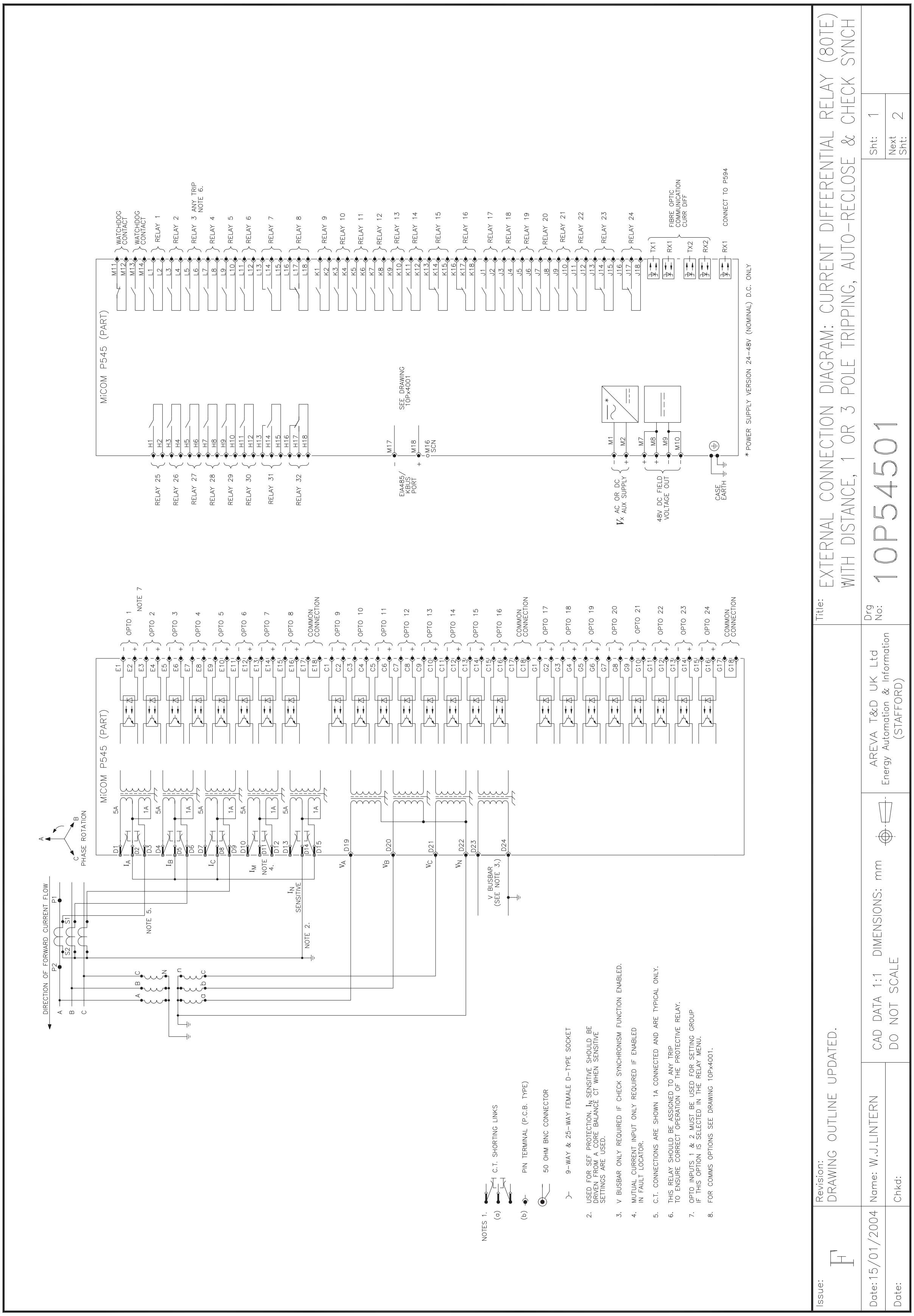
EXTERNAL CONNECTION DIAGRAMS

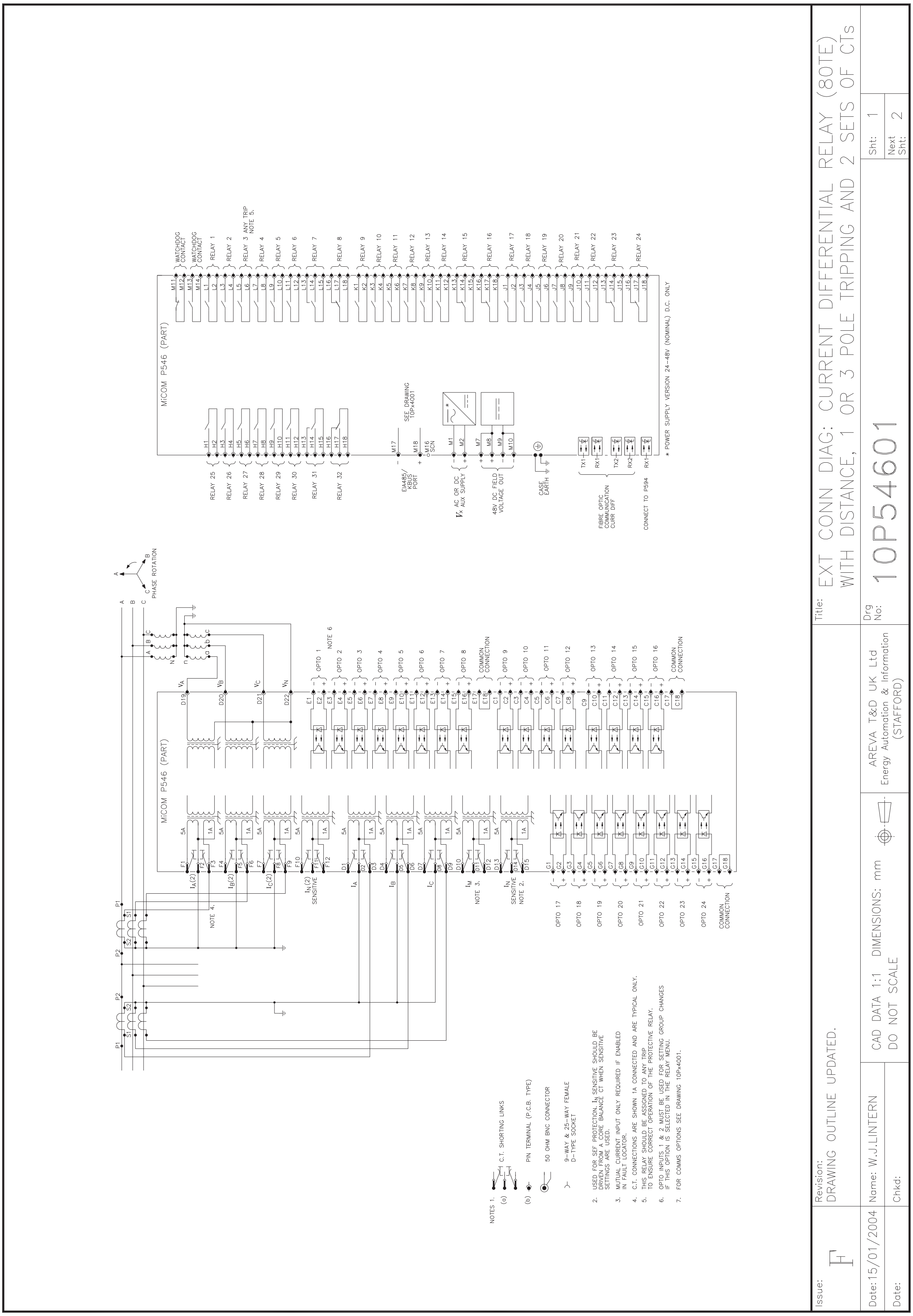

MiCOM P541 (PART)
WATCHDOG CONTACT
RELAY 1
RELAY 2
RELAY 3 ANY TRIP NOTE 3.
RELAY 4
RELAY 5
RELAY 6
RELAY 7
FIBRE OPTIC COMMUNICATION CURR DIFF
CASE EARTH
SEE DRAWING 10Px4001
EIA485/ KBUS PORT
AC OR DC AUX SUPPLY
48V DC FIELD VOLTAGE OUT
* POWER SUPPLY VERSION 24-48V (NOMINAL) D.C. ONLY
OPTO 1
OPTO 2
OPTO 3
OPTO 4
OPTO 5
OPTO 6
OPTO 7
OPTO 8
NOTE 4
COMMON CONNECTION
PHASE ROTATION
DIRECTION OF FORWARD CURRENT FLOW
NOTE 2.
NOTES 1.
(a) C.T. SHORTING LINKS
(b) PIN TERMINAL (P.C.B. TYPE)
50 OHM BNC CONNECTOR
9-WAY & 25-WAY FEMALE D-TYPE SOCKET
2. C.T. CONNECTIONS ARE SHOWN 1A CONNECTED AND ARE TYPICAL ONLY.
3. THIS RELAY SHOULD BE ASSIGNED TO ANY TRIP TO ENSURE CORRECT OPERATION OF THE PROTECTIVE RELAY.
4. OPTO INPUTS 1 & 2 MUST BE USED FOR SETTING GROUP CHANGES IF THIS OPTION IS SELECTED IN THE RELAY MENU.
5. FOR COMMS OPTIONS SEE DRAWING 10Px4001.
Title: EXT'L CONN DIAG : CURRENT DIFFERENTIAL RELAY (40TE) WITH MAG INRUSH RESTRAINT & 3 POLE TRIPPING ONLY & NO VT CONNECTIONS.
Drg No: 10P54101
Sht: 1
Next Sht: 2
AREVA T&D UK Ltd
Energy Automation & Information (STAFFORD)
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
Revision: SENSITIVE EARTH FAULT CT REMOVED. CDNR4319
Issue: Q
Date: 20/01/2004
Name: M.PEARSHOUSE
Chkd: N.ROBINSON
Date:

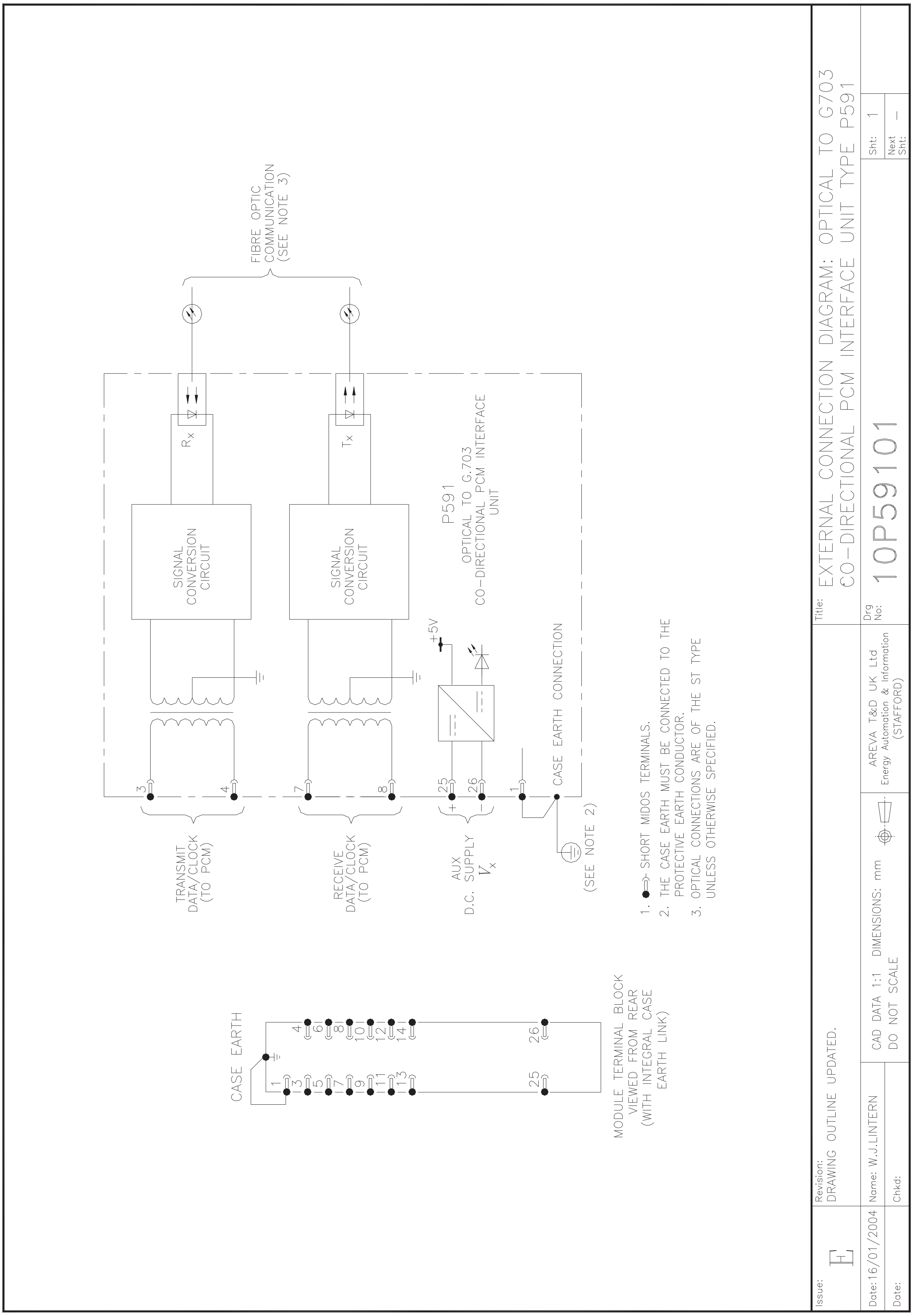

MiCOM P542 (PART)
DIRECTION OF FORWARD CURRENT FLOW
PHASE ROTATION
NOTE 2.
NOTE 4
NOTE 3.
SEE DRAWING 10Px4001
EIA485/ KBUS PORT
FIBRE OPTIC COMMUNICATION CURR DIFF
Vx AC OR DC AUX SUPPLY
48V DC FIELD VOLTAGE OUT
CASE EARTH
* POWER SUPPLY VERSION 24-48V (NOMINAL) D.C. ONLY
RELAY 3 ANY TRIP
WATCHDOG CONTACT
WATCHDOG CONTACT
RELAY 1
RELAY 2
RELAY 4
RELAY 5
RELAY 6
RELAY 7
RELAY 8
RELAY 9
RELAY 10
RELAY 11
RELAY 12
RELAY 13
RELAY 14
OPTO 1
OPTO 2
OPTO 3
OPTO 4
OPTO 5
OPTO 6
OPTO 7
OPTO 8
COMMON CONNECTION
OPTO 9
OPTO 10
OPTO 11
OPTO 12
OPTO 13
OPTO 14
OPTO 15
OPTO 16
COMMON CONNECTION
NOTES 1.
(a) C.T. SHORTING LINKS
(b) PIN TERMINAL (P.C.B. TYPE)
50 OHM BNC CONNECTOR
9-WAY & 25-WAY FEMALE D-TYPE SOCKET
2. C.T. CONNECTIONS ARE SHOWN 1A CONNECTED AND ARE TYPICAL ONLY.
3. THIS RELAY SHOULD BE ASSIGNED TO ANY TRIP TO ENSURE CORRECT OPERATION OF THE PROTECTIVE RELAY.
4. OPTO INPUTS 1 & 2 MUST BE USED FOR SETTING GROUP CHANGES IF THIS OPTION IS SELECTED IN THE RELAY MENU.
5. FOR COMMS OPTIONS SEE DRAWING 10Px4001.
Issue: Q
Revision: SENSITIVE EARTH FAULT CT REMOVED. CDNR4319
Title: EXT'L CON DIAG: CURRENT DIFFERENTIAL RELAY(60TE) WITH MAG INRUSH RESTRAINT, 3 POLE TRIPPING ONLY, AUTO-RECLOSE & NO VT CONNECT'NS
Date: 20/01/2004
Name: M.PEARSHOUSE
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
AREVA T&D UK Ltd
Energy Automation & Information (STAFFORD)
Drg No: 10P54201
Sht: 1
Next Sht: 2
Chkd:
Date:

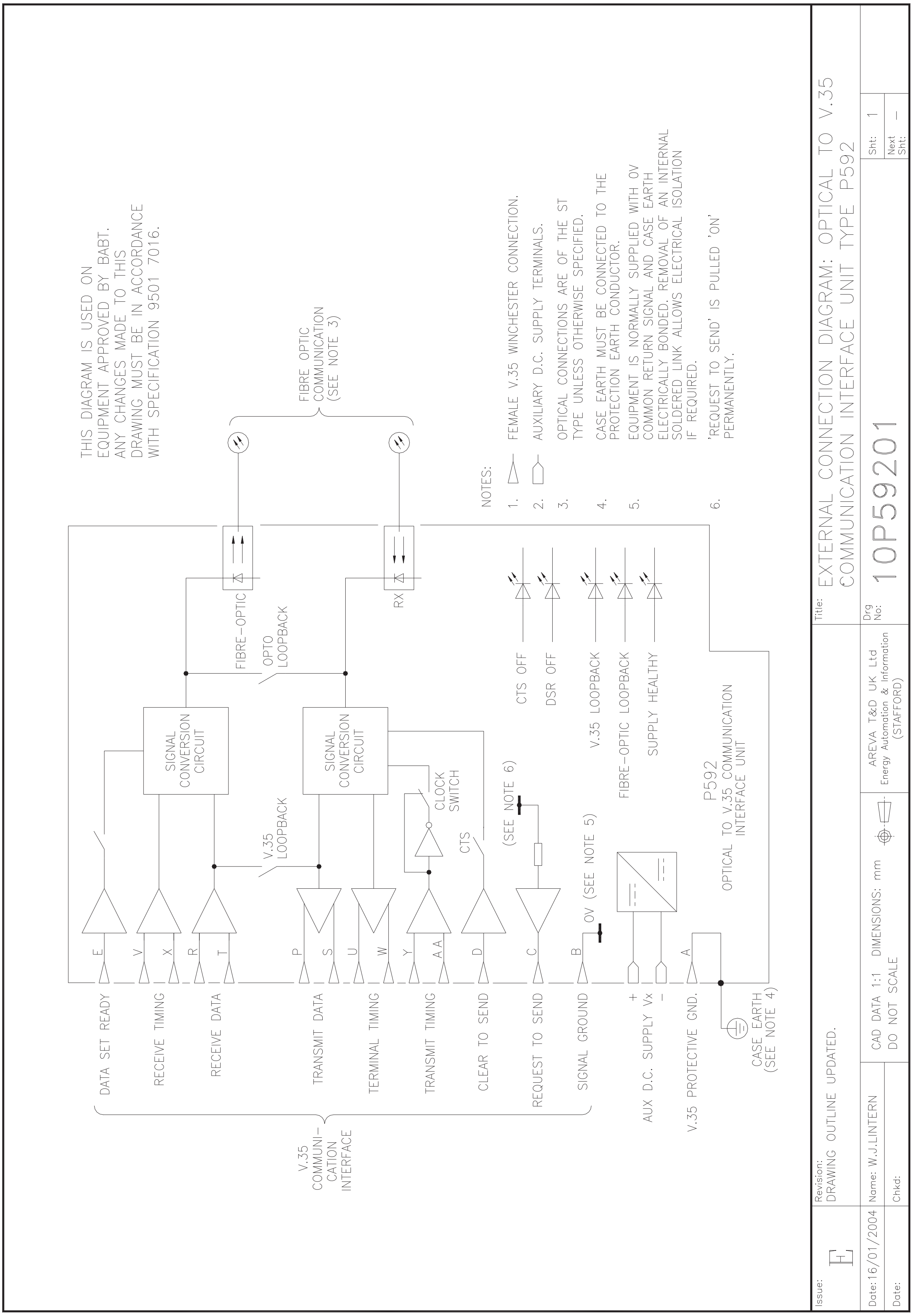

MiCOM P543 (PART)
DIRECTION OF FORWARD CURRENT FLOW
PHASE ROTATION
V BUSBAR (SEE NOTE 3.)
IN SENSITIVE
EIA485/ KBUS PORT
SEE DRAWING 10Px4001
AC OR DC AUX SUPPLY
48V DC FIELD VOLTAGE OUT
FIBRE OPTIC COMMUNICATION CURR DIFF
CASE EARTH
WATCHDOG CONTACT
COMMON CONNECTION
NOTES 1. (a) C.T. SHORTING LINKS
(b) PIN TERMINAL (P.C.B. TYPE)
50 OHM BNC CONNECTOR
9-WAY & 25-WAY FEMALE D-TYPE SOCKET
2. USED FOR SEF PROTECTION. IN SENSITIVE SHOULD BE DRIVEN FROM A CORE BALANCE CT WHEN SENSITIVE SETTINGS ARE USED.
3. V BUSBAR ONLY REQUIRED IF CHECK SYNCHRONISM FUNCTION ENABLED.
4. MUTUAL CURRENT INPUT ONLY REQUIRED IF ENABLED IN FAULT LOCATOR.
5. C.T. CONNECTIONS ARE SHOWN 1A CONNECTED AND ARE TYPICAL ONLY.
6. THESE RELAYS SHOULD BE ASSIGNED TO ANY TRIP, TRIP A, TRIP B, TRIP C TO ENSURE CORRECT OPERATION OF THE PROTECTIVE RELAY.
7. OPTO INPUTS 1 & 2 MUST BE USED FOR SETTING GROUP CAHNGES IF THIS OPTION IS SELECTED IN THE RELAY MENU.
8. FOR COMMS OPTIONS SEE DRAWING 10Px4001.
* POWER SUPPLY VERSION 24-48V (NOMINAL) D.C. ONLY
Title: EXTERNAL CONNECTION DIAGRAM: CURRENT DIFFERENTIAL RELAY (60TE) WITH DISTANCE, 1 OR 3 POLE TRIPPING, AUTO-RECLOSE & CHECK SYNCH
Drg No: 10P54301
Sht: 1
Next Sht: 2
AREVA T&D UK Ltd Energy Automation & Information (STAFFORD)
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
Revision: DRAWING OUTLINE UPDATED.
Issue: P
Date: 16/01/2004 Name: W.J.LINTERN
Date: Chkd:

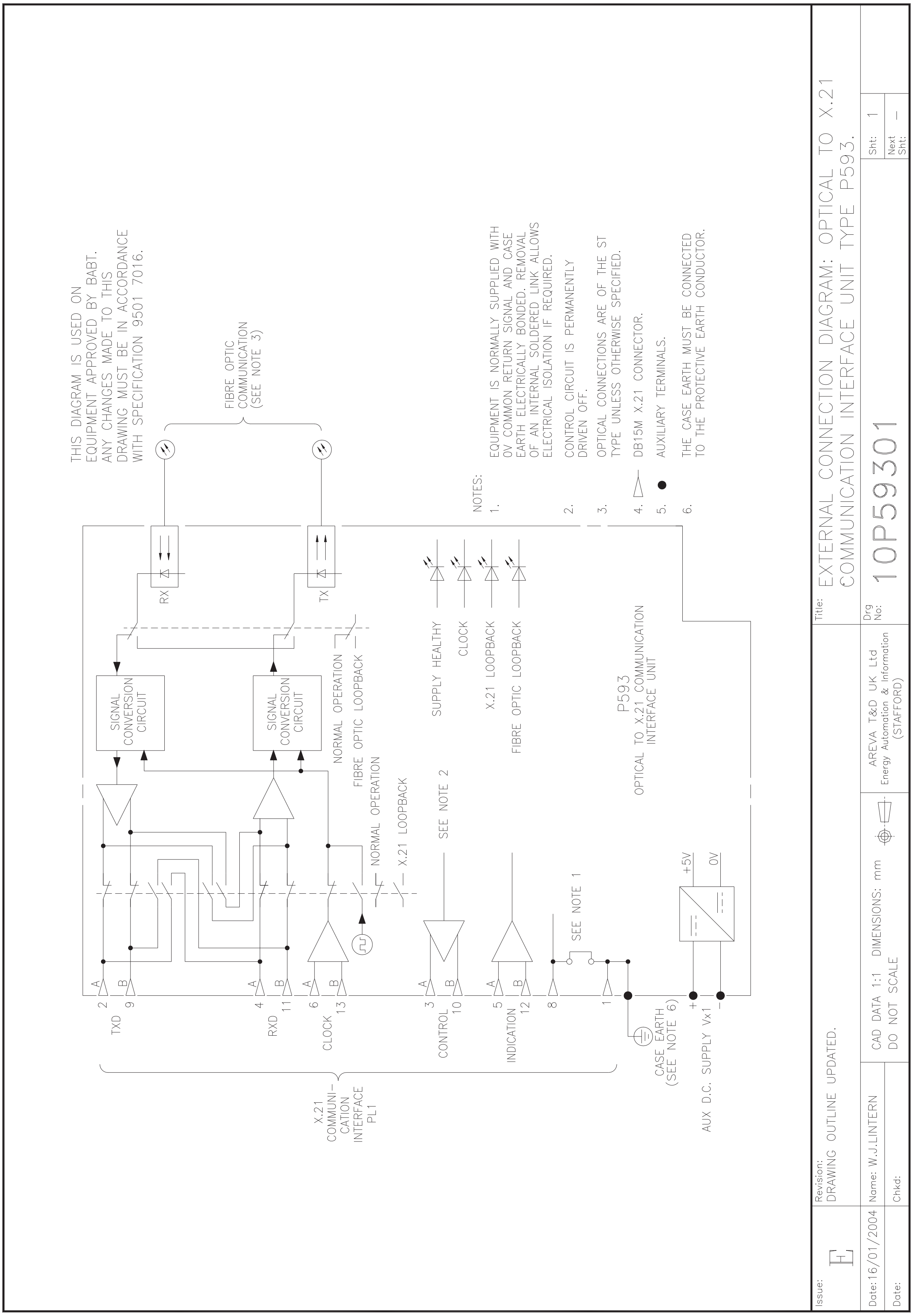

MiCOM P544 (PART)
PHASE ROTATION
NOTES 1. (a) C.T. SHORTING LINKS
(b) PIN TERMINAL (P.C.B. TYPE)
50 OHM BNC CONNECTOR
9-WAY & 25-WAY FEMALE D-TYPE SOCKET
2. USED FOR SEF PROTECTION. IN SENSITIVE SHOULD BE DRIVEN FROM A CORE BALANCE CT WHEN SENSITIVE SETTINGS ARE USED.
3. MUTUAL CURRENT INPUT ONLY REQUIRED IF ENABLED IN FAULT LOCATOR.
4. C.T. CONNECTIONS ARE SHOWN 1A CONNECTED AND ARE TYPICAL ONLY.
5. THESE RELAYS SHOULD BE ASSIGNED TO ANY TRIP, TRIP A, TRIP B, TRIP C TO ENSURE CORRECT OPERATION OF THE PROTECTIVE RELAY.
6. OPTO INPUTS 1 & 2 MUST BE USED FOR SETTING GROUP CHANGES IF THIS OPTION IS SELECTED IN THE EARTH MENU.
7. FOR COMMS OPTIONS SEE DRAWING 10Px4001.
* POWER SUPPLY VERSION 24-48V (NOMINAL) D.C. ONLY
Issue: P
Date: 16/01/2004
Revision: DRAWING OUTLINE UPDATED.
Name: W.J.LINTERN
Chkd:
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
AREVA T&D UK Ltd
Energy Automation & Information
(STAFFORD)
Title: EXTERNAL CONNECTION DIAGRAM: CURRENT DIFFERENTIAL RELAY (60TE) WITH DISTANCE, 1 OR 3 POLE TRIPPING AND 2 SETS OF CTs.
Drg No: 10P54401
Sht: 1
Next Sht: 2

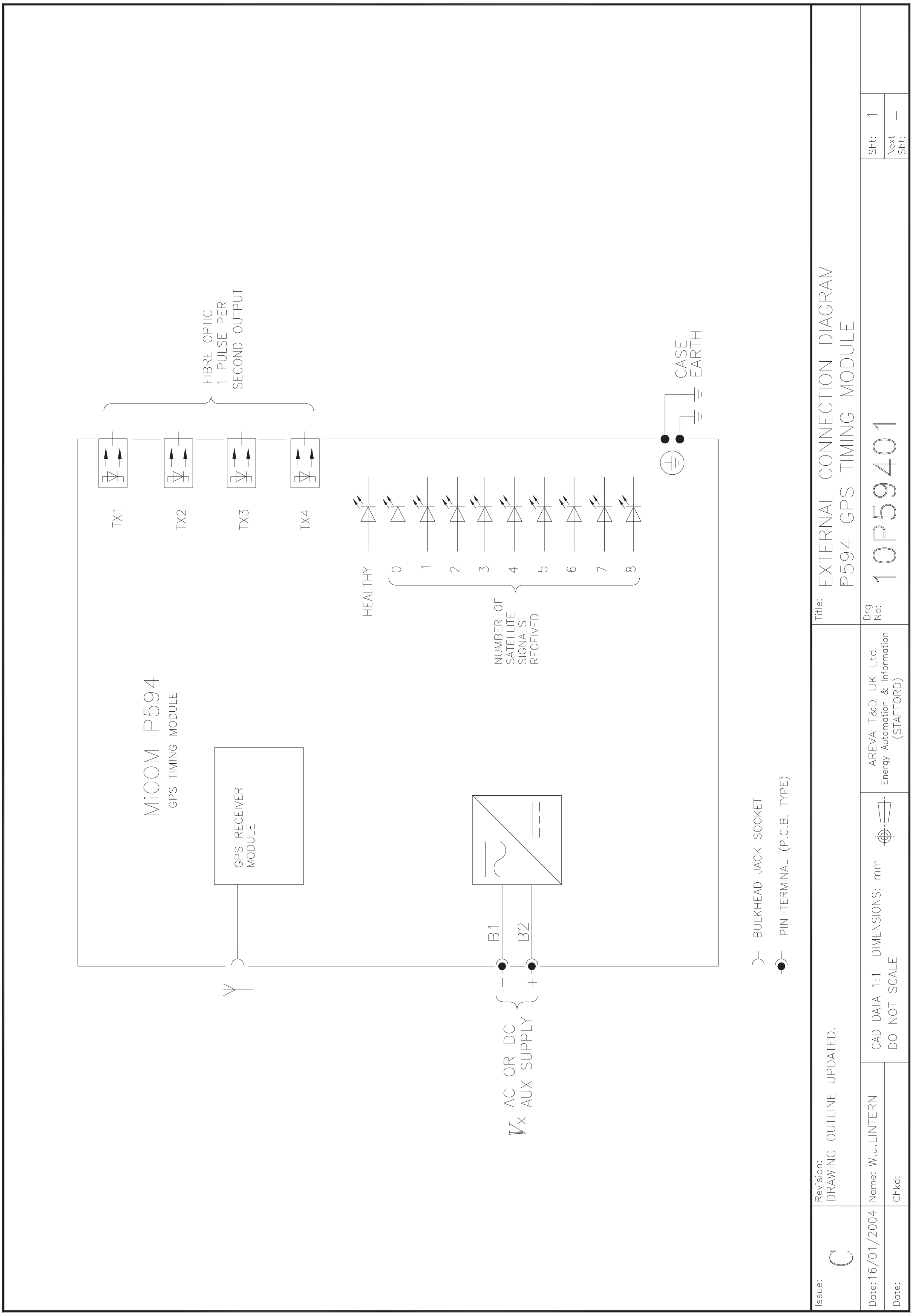

EXTERNAL CONNECTION DIAGRAM: CURRENT DIFFERENTIAL RELAY (80TE)
WITH DISTANCE, 1 OR 3 POLE TRIPPING, AUTO-RECLOSE & CHECK SYNCH
Sht: 1
Next Sht: 2
Drg No: 10P54501
AREVA T&D UK Ltd
Energy Automation & Information
(STAFFORD)
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
Revision:
DRAWING OUTLINE UPDATED.
Name: W.J.LINTERN
Chkd:
Issue: F
Date:15/01/2004
Date:
MiCOM P545 (PART)
NOTES 1. (a) C.T. SHORTING LINKS
(b) PIN TERMINAL (P.C.B. TYPE)
50 OHM BNC CONNECTOR
9-WAY & 25-WAY FEMALE D-TYPE SOCKET
2. USED FOR SEF PROTECTION. IN SENSITIVE SHOULD BE DRIVEN FROM A CORE BALANCE CT WHEN SENSITIVE SETTINGS ARE USED.
3. V BUSBAR ONLY REQUIRED IF CHECK SYNCHRONISM FUNCTION ENABLED.
4. MUTUAL CURRENT INPUT ONLY REQUIRED IF ENABLED IN FAULT LOCATOR.
5. C.T. CONNECTIONS ARE SHOWN 1A CONNECTED AND ARE TYPICAL ONLY.
6. THIS RELAY SHOULD BE ASSIGNED TO ANY TRIP TO ENSURE CORRECT OPERATION OF THE PROTECTIVE RELAY.
7. OPTO INPUTS 1 & 2 MUST BE USED FOR SETTING GROUP IF THIS OPTION IS SELECTED IN THE RELAY MENU.
8. FOR COMMS OPTIONS SEE DRAWING 10Px4001.
* POWER SUPPLY VERSION 24-48V (NOMINAL) D.C. ONLY


MiCOM P546 (PART)
Title: EXT CONN DIAG: CURRENT DIFFERENTIAL RELAY (80TE)
WITH DISTANCE, 1 OR 3 POLE TRIPPING AND 2 SETS OF CTs
Sht: 1
Next Sht: 2
Drg No: 10P54601
AREVA T&D UK Ltd
Energy Automation & Information
(STAFFORD)
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
Revision:
DRAWING OUTLINE UPDATED.
Name: W.J.LINTERN
Cnkd:
Issue: F
Date: 15/01/2004
Date:


EXTERNAL CONNECTION DIAGRAM: OPTICAL TO G703
CO-DIRECTIONAL PCM INTERFACE UNIT TYPE P591
10P59101
Sht: 1
Next Sht: -
AREVA T&D UK Ltd
Energy Automation & Information
(STAFFORD)
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
Issue: E
Revision: DRAWING OUTLINE UPDATED.
Date: 16/01/2004 Name: W.J.LINTERN
Chkd:
FIBRE OPTIC
COMMUNICATION
(SEE NOTE 3)
Rx
Tx
SIGNAL
CONVERSION
CIRCUIT
P591
OPTICAL TO G.703
CO-DIRECTIONAL PCM INTERFACE
UNIT
+5V
CASE EARTH CONNECTION
TRANSMIT
DATA/CLOCK
(TO PCM)
RECEIVE
DATA/CLOCK
(TO PCM)
AUX
D.C. SUPPLY
V_x
(SEE NOTE 2)
CASE EARTH
MODULE TERMINAL BLOCK
VIEWED FROM REAR
(WITH INTEGRAL CASE
EARTH LINK)
1. SHORT MIDOS TERMINALS.
2. THE CASE EARTH MUST BE CONNECTED TO THE
PROTECTIVE EARTH CONDUCTOR.
3. OPTICAL CONNECTIONS ARE OF THE ST TYPE
UNLESS OTHERWISE SPECIFIED.


THIS DIAGRAM IS USED ON EQUIPMENT APPROVED BY BABT. ANY CHANGES MADE TO THIS DRAWING MUST BE IN ACCORDANCE WITH SPECIFICATION 9501 7016.
FIBRE OPTIC COMMUNICATION (SEE NOTE 3)
NOTES:
1. FEMALE V.35 WINCHESTER CONNECTION.
2. AUXILIARY D.C. SUPPLY TERMINALS.
3. OPTICAL CONNECTIONS ARE OF THE ST TYPE UNLESS OTHERWISE SPECIFIED.
4. CASE EARTH MUST BE CONNECTED TO THE PROTECTION EARTH CONDUCTOR.
5. EQUIPMENT IS NORMALLY SUPPLIED WITH 0V COMMON RETURN SIGNAL AND CASE EARTH ELECTRICALLY BONDED. REMOVAL OF AN INTERNAL SOLDERED LINK ALLOWS ELECTRICAL ISOLATION IF REQUIRED.
6. 'REQUEST TO SEND' IS PULLED 'ON' PERMANENTLY.
FIBRE-OPTIC
RX
OPTO LOOPBACK
SIGNAL CONVERSION CIRCUIT
SIGNAL CONVERSION CIRCUIT
CTS OFF
DSR OFF
V.35 LOOPBACK
FIBRE-OPTIC LOOPBACK
SUPPLY HEALTHY
V.35 LOOPBACK
CLOCK SWITCH
CTS
(SEE NOTE 6)
0V (SEE NOTE 5)
P592
OPTICAL TO V.35 COMMUNICATION INTERFACE UNIT
E
V
X
R
T
P
S
U
W
Y
AA
D
C
B
A
DATA SET READY
RECEIVE TIMING
RECEIVE DATA
TRANSMIT DATA
TERMINAL TIMING
TRANSMIT TIMING
CLEAR TO SEND
REQUEST TO SEND
SIGNAL GROUND
+
AUX D.C. SUPPLY Vx
−
V.35 PROTECTIVE GND.
CASE EARTH (SEE NOTE 4)
V.35 COMMUNI-CATION INTERFACE
Title: EXTERNAL CONNECTION DIAGRAM: OPTICAL TO V.35 COMMUNICATION INTERFACE UNIT TYPE P592
Sht: 1
Next Sht: -
Drg No: 10P59201
AREVA T&D UK Ltd Energy Automation & Information (STAFFORD)
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
Revision: DRAWING OUTLINE UPDATED.
Name: W.J.LINTERN
Chkd:
Issue: E
Date: 16/01/2004
Date:


THIS DIAGRAM IS USED ON EQUIPMENT APPROVED BY BABT. ANY CHANGES MADE TO THIS DRAWING MUST BE IN ACCORDANCE WITH SPECIFICATION 9501 7016.
FIBRE OPTIC COMMUNICATION (SEE NOTE 3)
RX
TX
SIGNAL CONVERSION CIRCUIT
SIGNAL CONVERSION CIRCUIT
NORMAL OPERATION
FIBRE OPTIC LOOPBACK
NORMAL OPERATION
X.21 LOOPBACK
SEE NOTE 2
SUPPLY HEALTHY
CLOCK
X.21 LOOPBACK
FIBRE OPTIC LOOPBACK
P593
OPTICAL TO X.21 COMMUNICATION INTERFACE UNIT
SEE NOTE 1
+5V
0V
TXD
RXD
CLOCK
CONTROL
INDICATION
X.21 COMMUNI- CATION INTERFACE PL1
CASE EARTH (SEE NOTE 6)
AUX D.C. SUPPLY Vx1
NOTES:
1. EQUIPMENT IS NORMALLY SUPPLIED WITH 0V COMMON RETURN SIGNAL AND CASE EARTH ELECTRICALLY BONDED. REMOVAL OF AN INTERNAL SOLDERED LINK ALLOWS ELECTRICAL ISOLATION IF REQUIRED.
2. CONTROL CIRCUIT IS PERMANENTLY DRIVEN OFF.
3. OPTICAL CONNECTIONS ARE OF THE ST TYPE UNLESS OTHERWISE SPECIFIED.
4. DB15M X.21 CONNECTOR.
5. AUXILIARY TERMINALS.
6. THE CASE EARTH MUST BE CONNECTED TO THE PROTECTIVE EARTH CONDUCTOR.
Title: EXTERNAL CONNECTION DIAGRAM: OPTICAL TO X.21 COMMUNICATION INTERFACE UNIT TYPE P593.
Sht: 1
Next Sht: -
Drg No: 10P59301
AREVA T&D UK Ltd Energy Automation & Information (STAFFORD)
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
Issue: E
Revision: DRAWING OUTLINE UPDATED.
Date: 16/01/2004 Name: W.J.LINTERN
Date:
Chkd:


FIBRE OPTIC
1 PULSE PER
SECOND OUTPUT
TX1
TX2
TX3
TX4
CASE
EARTH
HEALTHY
0
1
2
3
4
5
6
7
8
NUMBER OF
SATELLITE
SIGNALS
RECEIVED
MiCOM P594
GPS TIMING MODULE
GPS RECEIVER
MODULE
B1
B2
-
+
Vx AC OR DC
AUX SUPPLY
BULKHEAD JACK SOCKET
PIN TERMINAL (P.C.B. TYPE)
Title: EXTERNAL CONNECTION DIAGRAM
P594 GPS TIMING MODULE
Drg No: 10P59401
Sht: 1
Next Sht: -
AREVA T&D UK Ltd
Energy Automation & Information
(STAFFORD)
CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE
Issue: C
Revision: DRAWING OUTLINE UPDATED.
Date:16/01/2004 Name: W.J.LINTERN
Date: Chkd:

HARDWARE / SOFTWARE VERSION HISTORY AND COMPATIBILITY

(Note: Includes versions released and supplied to customers only)

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
01	A	A	Feb 2000	First release to production.	V1.07 or later	TG8613A
02	A	A	Mar 2000	✓ PSB. Three settings added to set Zone 6 to increase flexibility ✓ Protection Address. Universal Address added ✓ SEF & EF. Polarising voltage setting range increased ✓ Thermal. Setting range increased ✓ Trip Conversion Logic. 3 DDB signals added to simplify logic for users ✓ Distance. Min polarising voltage increased to prevent tripping for close up three phase faults ✓ Check Sync. Angle measurement improved ✓ PSB. Text for Power Swing indication improved ✓ Include pole discrepancy logic to P543 ✓ Remove DDB elements for Neutral Diff. ✓ Modify IEC870 Test Mode operation ✓ Susceptance setting corrected	V1.08 or later	TG8613B
03	A	A	May 2000	✓ German text changed ✓ Spanish text changed ✓ Changes to DDB names & properties ✓ Improvements in autoreclose and reset from lockout code ✓ Changes to pole dead & Trip Conversion Logic ✓ Changes to P544 circuit breaker fail logic ✓ Added DDB for CS103 Test Mode × Recommend upgrading to 03B software or later	V1.09 or later	TG8613B

Relay type: P54x …						
Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
03	B	A	Feb 2002	All builds released for maintenance upgrades. ✓ Resolved possible reboot caused by Disturbance Recorder ✓ Resolved possible reboot caused by invalid modbus requests ✓ Resolved a loss of measurements (column 3 & 4) problem that can occur in 3 terminal applications ✓ Problem whereby MiCOM S1 could only set group 1 line length corrected ✓ Fixed capactive charging current compensation in P544 ✓ Corrected P544 display of Phase C current phase angle ✓ IDMT curve improvements ✓ Removed rounding error in tp calculation ✓ Menu dependence using ripple bit corrected ✓ Directional / non direction Earth Fault changes ✓ Battery Fail Alarm improvement ✓ Power measurements read over modbus corrected ✓ Improving read key functionality in the presence of alarms ✓ Prevented software errors from clearing event log	V1.09 or later	TG8613B
04	A	A	Aug 2000	✓ Trip conversion logic moved from internal fixed logic to PSL	V1.10 or later	TG8613B
04	B	A	Mar 2001	Only P543 CS103 builds released. ✓ Improvements to the CS103 time synchronisation	V1.10 or later	TG8613B
04	C	A	Jun 2001	Only P543 CS103 builds released. Based on 04B. ✓ Resolved a loss of measurements (columns 3 & 4) problem that can occur in 3 terminal applications	V1.10 or later	TG8613B
04	D	A	Jun 2001	Only P543 CS103 build released. Based on 04C. ✓ Prevents a reboot on power-up when battery is removed	V1.10 or later	TG8613B

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
05	B	A	Oct 2000	✓ Includes DNP3.0 ✓ Courier Bay Module compatibility modification ✓ Modbus Bay Module compatibility modification ✓ Distance – Z3 selectable forward / reverse ✓ Spanish text corrected ✓ Menu dependencies improved ✓ Modbus reading of fault location corrected ✓ RDF file modified ✓ Directional / non direction Earth Fault directionality improvements ✓ Some modbus address changed ✓ Requirement to use relays 8, 9 & 10 for Trip A, B & C removed ✓ Modbus communication when used with140 harmonised ✓ Battery Fail Alarm improvement ✓ Blocking negative sign for fault location for close-up faults ✓ Power measurements read over modbus corrected ✓ Modbus status register reports disturbance records incorrectly following power up cycle ✓ Recommend upgrading to 05G software or later, or 05H+ for modbus	V2.0 or later	TG8613B
05	E	A	Jun 2001	✓ Improvements to measurements 3 and 4 columns for three terminal applications ✗ Recommend upgrading to 05G software or later, or 05K or later	V2.0 or later	TG8613B

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
05	F	A	Sep 2001	All builds released to production. Based on 05E software. ✓ Problem whereby MiCOM S1 could only set group 1 line length correct ✓ Fixed capacitive charging current compensation in P544 ✓ Corrected P544 display of Phase C current phase angle ✓ IDMT curve improvements ✓ Removed rounding error in tp calculation ✓ Fixed problems caused by changes to DNP3 address ✓ Recommend upgrading to 05K or later	V2.0 or later	TG8613B
05	G	A	Jan 2002	✓ Resolved possible reboot caused by Disturbance Recorder × Problem in modbus build which could cause a reboot. Recommend upgrading to 05K or later	V2.0 or later	TG8613B
05	H	A	Jan 2002	✓ Resolved possible reboot caused by invalid modbus requests × Recommend upgrading to 05K or later	V2.0 or later	TG8613B
05	I	A	Oct 2002	✓ Correct the format used to display frequency over the modbus interface × Recommended upgrading to 05K or later	V2.0 or later	TG8613B
05	J	A	Nov 2002	✓ Resolved incorrect operation of C Diff Failure Alarm in 3 terminal schemes ✓ Correct operation of Capacitive Charging Current Compensation in 3 terminal schemes ✓ Resolved problem with resample timer on microprocessor × Recommended upgrading to 05K or later	V2.0 or later	TG8613B
05	K	A	Feb 2003	✓ Resolved problem with IEC60870-5-103 time synchronisation	V2.0 or later	TG8613B

Relay type: P54x …

Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
05	L	A	Jan 2004	Maintenance Release based on 05K (not formally released) ✓ Prevents compressed disturbance recorder stalling. ✓ Prevent a maintenance record when reading from an inaccessible modbus register	V2.0 or Later	TG8613B
05	M	A	Jun 2004	Maintenance Release based on 05L ✓ Improved Self-checking of Analogue data acquisition ✓ Improved self checking of SRAM ✓ Reception of modbus frame improved ✓ Rejection of spurious messages injected onto RS485 network improved ✓ Permissive Intertrip in dual redundant schemes corrected	V2.0 or Later	TG8613B
11	A	B	Sep 2001	✓ GPS synchronisation for P545 & P546 ✓ Flexible intertripping ✓ Event Optimisation & Filtering ✓ Watt Hour Measurement Change ✓ Addition of digital opto filtering control ✓ Increase in protection signalling address to 20 ✓ DDB increased in size to 1022 ✓ Support for universal optos (Model number suffix B) ✓ Internal loopback added ✓ Restore defaults now restores DNP3 cells correctly ✓ Prevent non DNP3 builds generating fatal error when S1 request DNP3 upload ✓ Modbus enabling/disabling of IRIG-B improved	V2.03 or later	P54x/EN x/D11

Relay type: P54x …

Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
11 Cont	A	B	Sep 2001	✓ Courier/modbus event bit functionality corrected ✓ Rear port address setting improvement ✓ Improving read key functionality in the presence of alarm ✓ Prevented software errors from clearing event log ✓ Unextracted Disturbance records now set the courier status flag on power up ✓ Added support for modbus function code 7 ✓ Corrected the modbus status bit 0 ✓ Changes to OTEV bit in the Status of Fault in IEC60870-5-103 ✓ PSL version history reference identifier added ✓ Reset LEDs DDB name change ✓ Change to line length of fault locator ✓ Control inputs added ✓ Changes to capacitive charging current compensation in P544 & P546 ✓ Minor changes to IDMT characteristics ✓ Added a 1s drop off timer to C Diff inhibit ✓ Changed max value of Char mod timer to 2s ✓ Increased number of PSL timers to 16 (all models) ✓ Added a setting to P543/5 AR to select which edge of trip initiates AR ✓ Added 3 DDB signals to block distance ✓ Removed force 3 pole trip DDB ✓ DNP & modbus address are compatible but there are several new ones	V2.03 or later	P54x/EN x/D11

Relay type: P54x …

Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
11 Cont	A	B	Sep 2001	✓ Software is not compatible with previous software (signalling message) ✓ Distance. Directional line now inclined at –30 degrees and +150 degrees on polar plot (previously perpendicular to line impedance angle) ✓ Power swing blocking. Unblocking for faults during power swing now selectable in PSL (default uses I2 unblocking to match phase 1) ✓ Power swing blocking logic improved ✓ Enhancements to IEC60870-5-103 builds to add disturbance recorder, private codes and monitor blocking × Recommend upgrading to software 11G or later	V2.03 or later	P54x/EN x/D11
11	B	B	Oct 2001	✓ Modified the co-processor start-up routine to work with alternative types of SRAM ✓ Improved response to a CS103 poll class 1 when monitor blocked was active ✓ Resolved a time alignment problem which resulted in C Diff failure Alarms being raised ✓ Corrected some modbus address for P545 & P546 ✓ Fixed a problem with the relays response to modbus commands read coils and read inputs ✓ Fixed an incorrect response to a DNP3.0 command × Recommended upgrading to 11G or later	V2.03 or Later	P54x/EN x/D11
11	C	B	Dec 2001	✓ Voltage and power measurements in CS103 build now marked as invalid ✓ Fixed a problem in P544 & P546 where the SEF current measurement was incorrect when set to 1A & 60Hz	V2.03 or later	P54x/EN x/D11

Relay type: P54x …						
Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
11 **Cont**	C	B	Dec 2001	× Recommend upgrading to software 11G or later	V2.03 or later	P54x/EN x/D11
11	D	B	Jan 2002	✓ Resolved possible reboot caused by Disturbance Recorder ✓ Resolved possible reboot caused by invalid modbus requests ✓ Resolved problem when internal loopback was selected with external clocks ✓ Resolved a problem which caused the loss of IEC60870-5-103 class 1 messages × Recommend upgrading to 11G or later	V2.03 or later	P54x/EN X/D11
11	E	B	Oct 2002	✓ Resolved incorrect operation of C Diff Failure Alarm in 3 terminal schemes ✓ Correct operation of Capacitive Charging Current Compensation on 3 terminal schemes ✓ Resolved problem which caused short duration GPS Failure Alarms ✓ Recommended upgrading to 11G or later	V2.03 or later	P54x/En x/D11
11	F	B	Feb 2003	✓ Resolved several problems related to the IEC 60870-5-103 protocol ✓ Resolved problem with resample timer on microprocessor ✓ Corrected the format used to display frequency over the modbus interface × Recommend upgrading to 11G or later.	V2.03 or later	P54x/EN x/D11
11	G	B	May 2003	✓ Changes to clock recovery circuits to improve operation with mutliplexers ✓ PSL logic for user defined intertrips corrected P545 & P546 ✓ Permissive intertrip in dual redundant schemes corrected	V2.03 or later	P54x/EN x/D11

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
11 Cont	G	B	May 2003	✓ Prevented unwanted Comms Delay Alarms	V2.03 or later	P54x/EN x/D11
11	H	B	Sept 2003	✓ Prevents compressed disturbance recorder stalling. ✓ Prevents CS103 reporting more non-compressed disturbance records than actually present.	V2.03 or later	P54x/EN x/D11
11	I	B	Oct 2004	All builds released to production. Based on 11G software. ✓ Improved Self-checking of Analogue data acquisition ✓ Differential Intertrip in IEC60870-5-103 reported with correct FAN ✓ SRAM self checking added to co-processor board ✓ Reception of modbus frame improved ✓ Rejection of spurious messages injected onto RS485 network improved ✓ Improved self checking of SRAM ✓ Fixed an incorrect response of the summertime time bit in IEC60870-5-103 protocol ✓ Prevented incorrect behaviour of P545/P546 when one relay is energised when there is noise on the signalling channel ✓ Status of local GPS reported incorrectly in dual redundant schemes ✓ Setting “Char Mod Time” was missing on P541- P544 ✓ Prevent a maintenance record when reading from an inaccessible modbus register ✓ Prevents relay crashing when phase 2 software used with phase 1 optos ✓ Cell 0709 now replies OK Change	V2.03 or Later	P54x/EN x/D11

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
12	B	B	Mar 2002	✓ 2nd Rear Communications supported ✓ Alarms increased to 64 with user programmable alarms ✓ Enhancements and corrections to CS103 ✓ Suppression of certain events in power up ✓ French language text improvements ✓ Prevent a maintenance record when reading from an inaccessible modbus register ✓ Setting “Char Mod Time” was missing on P541-P544 ✓ Cell 0709 corrected × Maximum pre-trigger time for Disturbance recorder in IEC870-103-5 builds reduced, to allow extraction via rear port ✓ Resolved incorrect operation of C Diff Failure Alarm in 3 terminal schemes ✓ Correct operation of Capactive Charging Current Compensation in 3 terminal schemes Resolved problem which caused short duration GPS Failure Alarms ✓ Resolved problem selecting setting via optos ✓ Resolved a Circuit Breaker Lockout problem ✓ Corrected the thermal measurement displayed when thermal protection is disabled ✓ Failure Alarms ✓ Resolved problem selecting setting via optos ✓ Resolved a Circuit Breaker Lockout problem ✓ Corrected the thermal measurement displayed when thermal protection is disabled ✓ Spanish text for user defined alarms contained an extra letter	V2.05 or later	P54x/EN x/E21

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
12 Cont	B	B	Mar 2002	✓ Blocked overcurrent elements now generate events ✓ Correct DNP3 operation of object 10 ✓ Resolved problem with P541 & P542 IEC60870-5-103 builds not running ✓ Resolved a problem with IEC60870-5-103 class 1 polling ✓ Resolved a problem with IEC60870-5-103 ASDU2 events which occurred prior to a start event ✓ Correct the format used to display frequency over the modbus interface ✓ Resolved problem related to incorrect CB trip/close commands via Modbus being accepted when not selected ✓ Resolved a problem which prevented protection setting being saved after control and support setting had been saved ✓ Corrected the saving of Fault Locator settings in groups 2, 3, 7, 4 when made via user interface ✓ Added object 10 to DNP3 class 0 poll ✓ Corrected the way DNP3 handled the season bit in the time & date × Recommended upgrading to 12D or later	V2.05 or later	P54x/EN x/E21
12	C	B	Mar 2003	✓ Resolved several problems related to the IEC 60870-5-103 protocol ✓ Resolved problem with resample timer on microprocessor ✓ Improved self diagnostics relating to input module clock ✓ Modified courier block transfer mechanism so it can handle more than 255 blocks ✓ Intermittent loss of data from 2nd rear comms port corrected	V2.05 or later	P54x/EN x/E21

Relay type: P54x …

Software Version Major	Software Version Minor	Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
12 Cont	C	B	Mar 2003	✓ PSL logic for user defined intertrips corrected P545 & P546 ✓ Permissive Intertrip in dual redundant schemes corrected ✗ Recommended upgrading to 12D or later	V2.05 or later	P54x/EN x/E21
12	D	B	Jun 2003	✓ Changes to clock recovery circuits to improve operation with multiplexers ✓ Prevented unwanted Comms Delay Alarms	V2.05 or later	P54x/EN x/E21
12	E	B	Sept 2003	✓ Prevents compressed disturbance recorder stalling. ✓ Correction to operation of Reset Relays / LEDs opto. ✓ Prevents CS103 reporting more non-compressed disturbance records than actually present.	V2.05 or later	P54x/EN x/E21
12	F	B	Jun 2004	Not released to production. Supplied to one customer. Based on 12E software. ✓ Improved Self-checking of Analogue data acquisition ✓ Differential Intertrip in IEC60870-5-103 reported with correct FAN	V2.05 or Later	P54x/EN x/E21
12	G	B	Oct 2004	All builds released to production. Based on 12E software. ✓ Improved Self-checking of Analogue data acquisition ✓ Differential Intertrip in IEC60870-5-103 reported with correct FAN ✓ SRAM self checking added to co-processor board ✓ Reception of modbus frame improved ✓ Rejection of spurious messages injected onto RS485 network improved ✓ Improved self checking of SRAM ✓ Fixed an incorrect response of the summertime time bit in IEC60870-5-103 protocol	V2.05 or Later	P54x/EN x/E21

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
12 Cont	G	B	Oct 2004	✓ Prevented incorrect behaviour of P545/P546 when one relay is energised when there is noise on the signalling channel ✓ Status of local GPS reported incorrectly in dual redundant schemes	V2.05 or Later	P54x/EN x/E21
13	A	B	April 2004	All builds released to production. Based on 12E software. ✓ Control inputs enhancements including non-volatile, latched, pulsed and support for DNP3 pulsed. ✓ Enhanced DNP3 ✓ Distance Residual compensation angle range extended ✓ Display of number of good messages via modbus is corrected ✓ Prevented DNP3 time sync causes relay to reboot when IRIG-B is active ✓ Improved self-checking of analogue data acquisition ✓ Improved self-checking of SRAM ✓ Added TRIP & ALARM to modbus status word ✓ Addition of MODBUS only setting to allow transmission of IEC time format in reverse IEC byte order ✓ Reception of modbus frame improved ✓ Rejection of spurious messages injected onto RS485 network improved ✓ Handling of FAN in IEC60870-5-103 improved ✓ Differential Intertrip in IEC60870-5-103 reported with correct FAN	V2.10 or later	P54x/EN x/E21

Relay type: P54x …

Software Version Major	Software Version Minor	Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
13	B	B	Aug 2004	All builds released to production. Based on 13A software. ✓ SRAM self checking added to co-processor board ✓ Fault location & cumulative broken current measurements reported over dnp3 ✓ Accuracy of modbus time sync improved ✓ Invalid modbus register 4x00966 removed ✓ Reception of modbus frame improved	V2.10 or Later DNP3 files different to 13A	P54x/EN x/E21
13	C	B	Oct 2004	All builds released to production. Based on 13B software. ✓ Resolved a problem relating to co-processor SRAM checking ✓ Fixed an incorrect response of the summertime time bit in IEC60870-5-103 protocol ✓ Prevented incorrect behaviour of P545/P546 when one relay is energised when there is noise on the signalling channel ✓ Status of local GPS reported incorrectly in dual redundant schemes	V2.10 or Later DNP3 files different to 13A	P54x/EN x/E21
20	E	G	Oct 2002	All builds released to production – runs on phase 2 processor board. Based on 12B. ✓ UCA2 option added ✓ Added Fault Location ✓ Added TRIP and ALARM to modbus status word ✓ Distance direction setting added ✓ Distance residual compensation angle range extended ✓ Password status indicated on DDBs ✓ Improvements to Autoreclose ✓ Alarms increased to 96 ✓ Russian text added	V2.09 or later	P54x/EN x/F32

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
20 Cont	E	G	Oct 2002	✓ Disturbance recorder sampling rate increased to 24 samples per cycle and changed to non compressed design ✓ IDMT IEEE curves corrected ✓ Corrected the response to courier SEND EVENT ✓ Improved self diagnostics relating to input module clock ✓ Removed the setting for IEC60870-5-103 over fibre when hardware not present ✓ Resolved problem related to CB trip/close commands via Modbus being accepted when not selected ✓ Corrected the saving of Fault locator settings in groups 2, 3, 7, 4 when made via user interface ✓ Added object 10 to DNP3 class 0 poll ✓ Corrected the way DNP3 handled the season bit in the time & date ✓ Enhanced Check Synchronisation feature ✓ Control inputs enhancements including non-volatile, latched, pulsed and support for DNP3 pulsed ✓ Resolved several problems related to the IEC60870-5-103 protocol ✓ Resolved problem with resample timer on microprocessor ✓ Improved self diagnostics relating to input module clock ✓ PSL logic for user defined intertrips corrected P545 & P546 ✓ Operation of manual reset alarms corrected ✓ CB Control via hot keys ✓ Changes to clock recovery circuits to improve operation with multiplexers ✓ Prevented unwanted Comms Delay Alarms ✓ Alarms handled better in CS103 GI	V2.09 or later	P54x/EN x/F32

Relay type: P54x …

Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
20 Cont	E	G	Oct 2002	✓ Time synchronisation via opto added ✓ Platform Alarms copied to DDB ✓ Correction to operation of Reset Relays / LEDs opto ✓ Backup protection run if co-processor fails to start up on power on ✓ Correction to cell OB25	V2.09 or later	P54x/EN x/F32
20	F	G	Feb 2004	Release to production ✓ UCA2: Increase Max. pending requests & Max. Connected clients ✓ Enhanced DNP3 ✓ Prevented DNP3 time sync causes relay to reboot when IRIG-B is active ✓ Corrected cause of transmission which may be returned for “fault location” ✓ Prevents relay rebooting during EMC ANSI Fast transient and IEC high frequency ✓ A number of bug fixes relating to CPU2	V2.09 or later	P54x/EN x/F32
20	G	G	Jun 2004	Release to production ✓ Prevented repeated downloads of GSL files without Ethernet card restart rebooting Ethernet card ✓ Correction to uploading of Disturbance Records over UCA2. ✓ Corrected operation of ethernet card link LED for 10 Base-FL ✓ Closed UCA2 association after ‘dirty’ client disconnection ✓ Made UAC2 Disturbance Record directory service compatible with PACiS ✓ Improved Self-checking of Analogue data acquisition ✓ Handling of FAN in IEC60870-5-103 improved ✓ Differential intertrip in IEC60870-5-103 reported with correct FAN	V2.09 or later	P54x/EN x/G42

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
20 Cont	G	G	Jun 2004	✓ Prevented C Diff Fail alarm occurs before Signaling Fail alarm for loss of communications ✓ Improved self checking of SRAM	V2.09 or later	P54x/EN x/G42
20	H	G	Oct 2005	Release to Production. Based on 20G software. ✓ SRAM self checking added to co-processor board ✓ Fixed an incorrect response of the summertime time bit in IEC60870-5-103 protocol ✓ Prevented incorrect behaviour of P545/P546 when one relay is energised when there is noise on the signalling channel ✓ Status of local GPS reported incorrectly in dual redundant schemes ✓ Accuracy of modbus time sync improved ✓ Fixed an incorrect response of the summertime time bit in IEC60870-5-103 protocol ✓ Prevented Ethernet card restarting after approximately 20 hours when no connection made ✓ Improvements to time sync for Courier, CS103 and DNP3 ✓ Invalid modbus register 4x00966 removed	V2.09 or later	P54x/EN x/G42
20	I	G	Nov 2004	Release to Production. Based on 20G software. ✓ Display of No. Valid messages on LCD corrected ✓ Operation of CB Maintenance alarm corrected ✓ Corrections to allow Extended Courier characters to be used in string setting cells for Courier and Modbus ✓ Corrected default display of neutral current for 5A CTs ✓ Prevented a reboot for modbus versions during event extraction when messages where close together ✓ Correction to prevent the 2nd rear comms locking up	V2.09 or later	P54x/EN x/G42

Relay type: P54x …

Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
30	C	J	Nov 2004	Released to production, Based on 20G ✓ Interface to Optical Multiplexer (IEEE standard C37.94) ✓ SRAM checking in Co-processor ✓ Dual range optos ✓ AREVA Livery & software changes ✓ Extended Residual angle in fault locator to match Distance ✓ Rename GOOSE signals in line with P443 ✓ Add virtual signals, control inputs & user alarms to DR in line with P443 ✓ Relay settings shall be stored in FLASH EEPROM instead of EEPROM memory. ✓ Extend Range of Time Dial to line up with P140 ✓ Accuracy of modbus time sync improved ✓ Invalid modbus register 4x00966 removed ✓ Improvements to time sync for Courier, CS103 and DNP3 ✓ Addition of MODBUS only time and Date format setting to common Courier settings for access from the other interfaces. ✓ Vector group compensations for YY2 and YY10 corrected ✓ Prevented Ethernet card restarting after approximately 20 hours when no connection made ✓ Prevented incorrect behaviour of P545/P546 when one relay is energised when there is noise on the signalling channel ✓ Courier, Modbus & DNP3 communications over Fibre added ✓ Display of No. Valid messages on LCD corrected ✓ Operation of CB Maintenance alarm corrected ✓ Some text in autoreclose column made consistent with that in overcurrent column ✓ Improvements to VTS and Autoreclose in single pole tripping	V2.11 or Later	P54x/EN x/H53

Relay type: P54x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
30 Cont	C	J	Nov 2004	applications ✓ Corrections to allow Extended Courier characters to be used in string setting cells for Courier and Modbus ✓ Fixed an incorrect response of the summertime time bit in IEC60870-5-103 protocol ✓ Corrected reporting of local GPS fail in dual redundant schemes ✓ Corrected default display of neutral current for 5A CTs ✓ Prevented a reboot for dnp3 versions when control & support settings are changed rapidly. ✓ Prevented a reboot for modbus versions during event extraction when messages where close together ✓ Correction to prevent the 2nd rear comms locking up ✓ Changes to co-processor start-up to eliminate a timing problem	V2.11 or Later	P54x/EN x/H53
30	D	J	Dec 2004 Mar 2011	Released to Production, Based on 30C ✓ Improvements to operation when subjected to multiple communication switches when operating in non-GPS mode. Rebranded from AREVA to ALSTOM	V2.11 or Later	P54x/EN x/H53 P54x/EN T/I53

Setting File Compatibility

Setting File Software Version	Relay Software Version: 01	02	03	04	05	07	11	12	13	14	15	20	30
01	✓	×	×	×	×	×	×	×	×	×	×	×	×
02	×	✓	×	×	×	×	×	×	×	×	×	×	×
03	×	×	✓	1	×	×	×	×	×	×	×	×	×
04	×	×	×	✓	2	2	×	×	×	×	×	×	×
05	×	×	×	×	✓	✓	×	×	×	×	×	×	×
07	×	×	×	×	✓	✓	×	×	×	×	×	2	×
11	×	×	×	×	×	×	✓	✓	2	2	×	2	×
12	×	×	×	×	×	×	✓	✓	2	2	×	2	×
13	×	×	×	×	×	×	✓	✓	✓	2	×	2	×
14	×	×	×	×	×	×	×	×	×	✓	×	×	×
15	×	×	×	×	×	×	×	×	×	×	✓	×	×
20	×	×	×	×	×	×	×	×	×	×	×	✓	3
30	×	×	×	×	×	×	×	×	×	×	×	×	✓

1 Compatible except for Disturbance recorder digital channel selection.
2 Additional functionality added such that's setting files from earlier software versions will need additional settings to be made.
3 Compatible except for Disturbance recorder digital channel selection & settings for additional functionality will be missing.

PSL File Compatibility

PSL File Software Version \ Relay Software Version	01	02	03	04	05	07	11	12	13	14	15	20	30
01	✓	×	×	×	×	×	×	×	×	×	×	×	×
02	×	✓	×	×	×	×	×	×	×	×	×	×	×
03	×	×	✓	×	×	×	×	×	×	×	×	×	×
04	×	×	×	✓	×	×	×	×	×	×	×	×	×
05	×	×	×	×	✓	1	×	×	×	×	×	×	×
07	×	×	×	×	×	✓	×	×	×	×	×	×	×
11	×	×	×	×	×	×	✓	✓	✓	×	×	1	1
12	×	×	×	×	×	×	×	✓	✓	×	×	1	1
13	×	×	×	×	×	×	×	×	✓	×	×	1	1
14	×	×	×	×	×	×	×	×	×	✓	×	×	×
15	×	×	×	×	×	×	×	×	×	×	✓	×	×
20	×	×	×	×	×	×	×	×	×	×	×	✓	1
30	×	×	×	×	×	×	×	×	×	×	×	×	✓

1 Additional DDBs were added such that PSL files from earlier software versions will not be able to access them.

Menu Text File Compatibility

Menu Text File Software Version \ Relay Software Version	01	02	03	04	05	07	11	12	13	14	15	20	30
01	✓	×	×	×	×	×	×	×	×	×	×	×	×
02	×	✓	×	×	×	×	×	×	×	×	×	×	×
03	×	×	✓	×	×	×	×	×	×	×	×	×	×
04	×	×	×	✓	×	×	×	×	×	×	×	×	×
05	×	×	×	×	✓	✓	×	×	×	×	×	×	×
07	×	×	×	×	✓	✓	×	×	×	×	×	×	×
11	×	×	×	×	×	×	✓	×	×	×	×	×	×
12	×	×	×	×	×	×	×	✓	×	×	×	×	×
13	×	×	×	×	×	×	×	×	✓	×	×	×	×
14	×	×	×	×	×	×	×	×	×	✓	×	×	×
15	×	×	×	×	×	×	×	×	×	×	✓	×	×
20	×	×	×	×	×	×	×	×	×	×	×	✓	×
30	×	×	×	×	×	×	×	×	×	×	×	×	✓

Menu text remains compatible within each software version but is NOT compatible across different versions.

MiCOM CURRENT DIFFERENTIAL NOMENCLATURE Design Suffix A

Software Number	P	5	4	*	_	_	_	_	*	_	0	0	5	0	_	H

Character Type (A=Alpha, N=Numeric, X = Alpha-numeric)	A	N	N	N	A	X	X	X	A	X	X	N	N	X	A
Character Numbering (Maximum = 15)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Model Number/Cortec Number	P	5	4	*	*	1	*	*	*	A	0	0	5	0	A

Current Differential - standard version	1
Current Differential - with 3 pole autoreclose	2
C Diff with Distance, 1/3 pole autoreclose	3
C Diff with Distance,for 2 breaker configuration:	4

Vx Aux Rating	
24/48 Vdc	1
48/125 Vdc	2
110/250 Vdc	3

Hardware options	
Nothing	1
IRIG-B only	2
Fibre Optic Converter only	3
IRIG-B & Fibre Optic Converter	4

Product Specific	
850nm dual channel	A
1300nm SM single channel	B
1300nm SM dual channel	C
1300nm MM single channel	D
1300nm MM dual channel	E
1550nm SM single channel	F
1550nm SM dual channel	G
RWE Special (one version of P543 only)	Y

Protocol Options	
K-Bus	1
Modbus	2
IEC870	3
DNP3.0	4

Software Number	05

Setting Files	
Default	0
Customer	1

Hardware Design Suffix	
Original	A

Software Letter of Issue	H

MiCOM CURRENT DIFFERENTIAL NOMENCLATURE Design Suffix B

Software Number	P	5	4	*	_	_	_	_	*	_	0	1	3	0	_	C
Character Type (A=Alpha, N=Numeric, X = Alpha-numeric)	A	N	N	N	A	X	X	X	A	X	X	N	N	X	A
Character Numbering (Maximum = 15)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Model Number/Cortec Number	P	5	4	*	*	1	*	*	*	A	0	1	3	0	B

Current Differential - standard version	1
Current Differential - with 3 pole autoreclose	2
C Diff with Distance, 1/3 pole autoreclose	3
C Diff with Distance,for 2 breaker configuration	4
P543 with extra I/O plus GPS	5
P544 with extra I/O plus GPS	6

Vx Aux Rating	
24/48 Vdc	1
48/125 Vdc	2
110/250 Vdc	3

Hardware options	
Nothing	1
IRIG-B only	2
Fibre Optic Converter only	3
IRIG-B & Fibre Optic Converter	4
Rear Comms Board	7
IRIG-B plus Rear Comms Board	8

Product Specific	
850nm dual channel	A
1300nm SM single channel	B
1300nm SM dual channel	C
1300nm MM single channel	D
1300nm MM dual channel	E
1550nm SM single channel	F
1550nm SM dual channel	G

Protocol Options	
K-Bus	1
Modbus	2
IEC870	3
DNP3.0	4

Software Number	13

Setting Files	
Default	0
Customer	1

Hardware Design Suffix	
Phase 2 post April 2001	B

Software Letter of Issue	C

Note Design Suffix
A = Original
B = Universal Optos, New Relays, New Co-Processor Board, New PSU

MiCOM CURRENT DIFFERENTIAL NOMENCLATURE Design Suffix G

Software Number	P	5	4	*	_	_	_	_	*	_	_	2	0	0	_	I

Character Type (A=Alpha, N=Numeric, X = Alpha-numeric)	A	N	N	N	A	X	X	X	A	X	X	N	N	X	A
Character Numbering (Maximum = 15)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Model Number/Cortec Number	P	5	4	*	*	1	*	*	*	*	*	2	0	0	G

Current Differential - standard version	1
Current Differential - with 3 pole autoreclose	2
C Diff with Distance, 1/3 pole autoreclose	3
C Diff with Distance,for 2 breaker configurations	4
P543 with extra I/O plus GPS	5
P544 with extra I/O plus GPS	6

Vx Aux Rating	
24/48 Vdc	1
48/125 Vdc	2
110/250 Vdc	3

Hardware options	
Nothing	1
IRIG-B only	2
Fibre Optic Converter only	3
IRIG-B & Fibre Optic Converter	4
Ethernet (10MHz)	5
Ethernet (100MHz)	6
Rear Comms Board	7
IRIG-B plus Rear Comms Board	8

Product Specific *	
850nm dual channel	A
1300nm SM single channel	B
1300nm SM dual channel	C
1300nm MM single channel	D
1300nm MM dual channel	E
1550nm SM single channel	F
1550nm SM dual channel	G
850nm MM + 1300mn SM	H
850nm MM + 1300mn MM	J
850nm MM + 1550mn SM	K
1300mn SM + 850nm MM	L
1300mn MM + 850nm MM	M
1550mn SM + 850nm MM	R
Reserved for future single channel	N
Reserved for future single channel	P
Reserved - was used for RWE special	Y

Protocol Options	
K-Bus	1
Modbus	2
IEC870	3
DNP3.0	4
UCA2	5

Mounting	
Flush Panel	A
Rack (P545 P546 only)	B

Language Options	
English, French, German, Spanish	0
English, French, German, Spanish	0
English, French, German, Spanish	0
English, French, German, Spanish	0
English, French, German, Russian	5

Software Number	20

Setting Files	
Default	0
Customer	1

Hardware Design Suffix	G

Software Letter of Issue	I

Note Design Suffix
A = Original
B = Universal Optos, New Relays, New Co-Processor Board, New PSU
G = CPU2

Note on Hardware Options
Any other letter = two channel

MiCOM CURRENT DIFFERENTIAL NOMENCLATURE Design Suffix J

Software Number

P	5	4	*	_	_	_	_	*	_	_	3	0	0	_	D

Character Type (A=Alpha, N=Numeric, X = Alpha-numeric)
Character Numbering (Maximum = 15)
Model Number/Cortec Number

A	N	N	N	A	X	X	X	A	X	X	N	N	X	A
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
P	5	4	*	*	1	*	*	*	*	*	3	0	0	J

Current Differential - standard version	1
Current Differential - with 3 pole autoreclose	2
C Diff with Distance, 1/3 pole autoreclose	3
C Diff with Distance,for 2 breaker configurations	4
P543 with extra I/O plus GPS	5
P544 with extra I/O plus GPS	6

Vx Aux Rating	
24/48 Vdc	1
48/125 Vdc	2
110/250 Vdc	3

Hardware options	
Nothing	1
IRIG-B only	2
Fibre Optic Converter only	3
IRIG-B & Fibre Optic Converter	4
Ethernet (10MHz)	5
Ethernet (100MHz)	6
Rear Comms Board	7
IRIG-B plus Rear Comms Board	8

Product Specific *	
850nm dual channel	A
1300nm SM single channel	B
1300nm SM dual channel	C
1300nm MM single channel	D
1300nm MM dual channel	E
1550nm SM single channel	F
1550nm SM dual channel	G
850nm MM + 1300mn SM	H
850nm MM + 1300mn MM	J
850nm MM + 1550mn SM	K
1300mn SM + 850nm MM	L
1300mn MM + 850nm MM	M
1550mn SM + 850nm MM	R
Reserved for future single channel	N
Reserved for future single channel	P
Reserved - was used for RWE special	Y

Protocol Options	
K-Bus	1
Modbus	2
IEC870	3
DNP3.0	4
UCA2	5

Mounting	
Flush Panel	M
Rack (P545 P546 only)	N

Language Options	
English, French, German, Spanish	0
English, French, German, Spanish	0
English, French, German, Spanish	0
English, French, German, Spanish	0
English, French, German, Russian	5

Software Number	30

Setting Files	
Default	0
Customer	1

Hardware Design Suffix	
	J

Software Letter of Issue	D

Note Design Suffix
A = Original
B = Universal Optos, New Relays, New Co-Processor Board, New PSU
G = CPU2
J = Dual rated optos

Note on Hardware Options
Any other letter = two channel

P594
HARDWARE / SOFTWARE VERSION HISTORY AND COMPATIBILITY

Interface type: P594 ...

Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
N/A	N/A	A	July 2001	First release to production.	N/A	P54x/EN x/E21
N/A	N/A	B	April 2003	Resolved problems after startup and GPS module problems with on board SRAM causing module to fail to start up.	N/A	P54x/EN x/E21
N/A	N/A	C	May 2004	Hardware and software design enhancements to improve performance. New antenna and cable employed New GPS receiver	N/A	P54x/EN x/G42

P594 LINE DIFFERENTIAL PROTECTION : GPS TIMING MODULE KIT Design Suffix C

Software Number

P	5	9	4	_	0	_	_	_	_	C

Character Type (A=Alpha, N=Numeric, X = Alpha-numeric)	A	N	N	N	A	A	A	A	A	A	X
Character Numbering (Maximum = 15)	1	2	3	4	5	6	7	8	9	10	11
Model Number/Cortec Number	P	5	9	4	*	0	*	*	*	*	C

P594 - GPS Timing Module Kit

Vx Aux Rating	
Select one of:	
48 - 250 Vdc / 96 - 240 Vac	8
24 - 125 Vdc	7

Timing module casing

Hardware options	
Select one of:	
Timing module ONLY	000
Kit 1 : Timing module + kit + 25 metres (overall length) antenna cables	025
Kit 2 : Timing module + kit + 50 metres (overall length) antenna cables + amplifier	050

Language Options	
Select one of:	
English	1
French	2
German	3
Spanish	4

Design Suffix (Factory determined)	C

SCHEME LOGIC DIAGRAMS

Current Differential Relays

Scheme Logic Diagrams

Note 1: The diagrams in this chapter are fixed, and are an accurate indication of the relay's performance.

Note 2: The diagrams in this chapter correspond to the latest version of the relay at time of manual issue.

KEY:

SET	Setting
DDB	Digital Data Bus
INTSIG	Internal Signal
LD	Level Detector
CTRL SET	Control Setting (from front panel display or remote communications)
COMMAND	Command (from front panel display or communications)
RD	Reset Dominant
SD	Set Dominant
	Raising Edge / Falling Edge

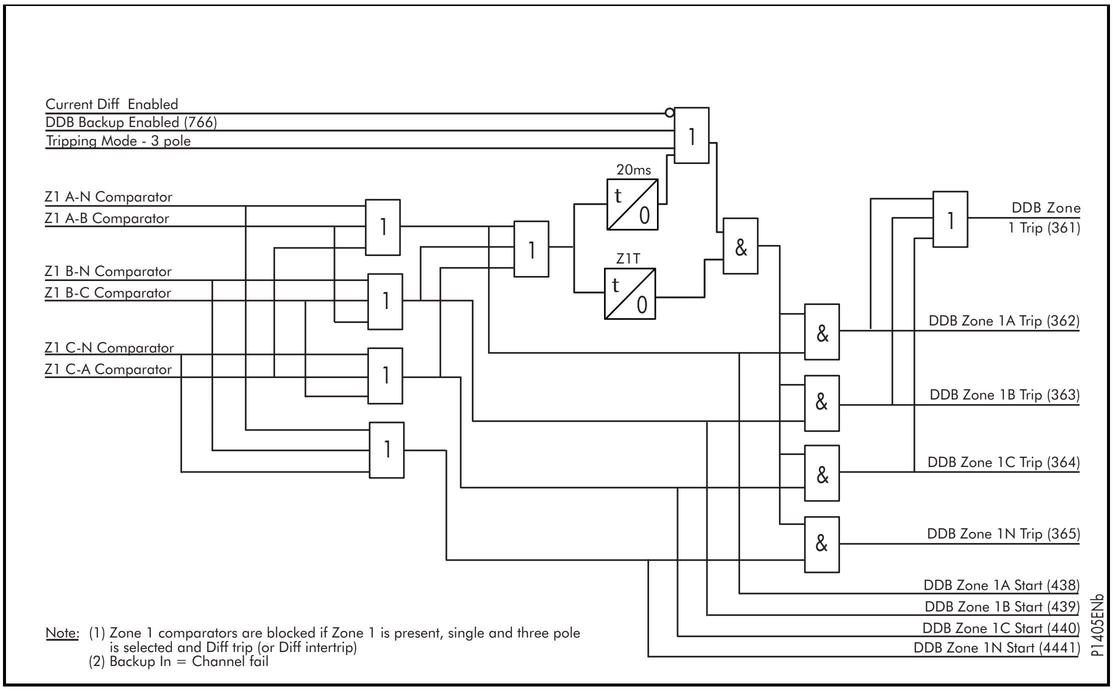


Figure 1: Distance P543/P544/P545/P546 Zone 1 Tripping Logic

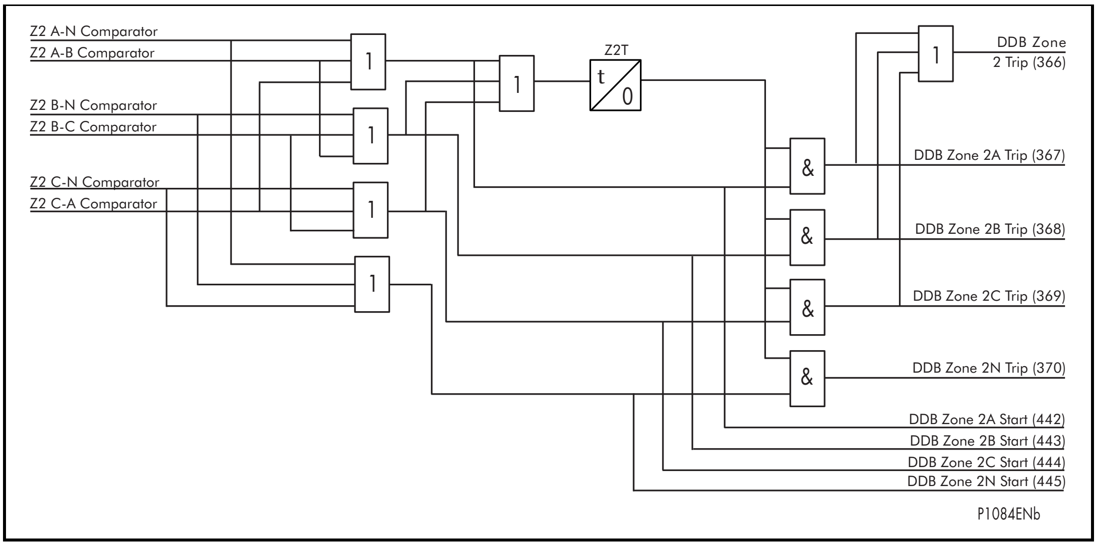


Figure 2: Distance P543/P544/P545/P546 Zone 2 Tripping Logic

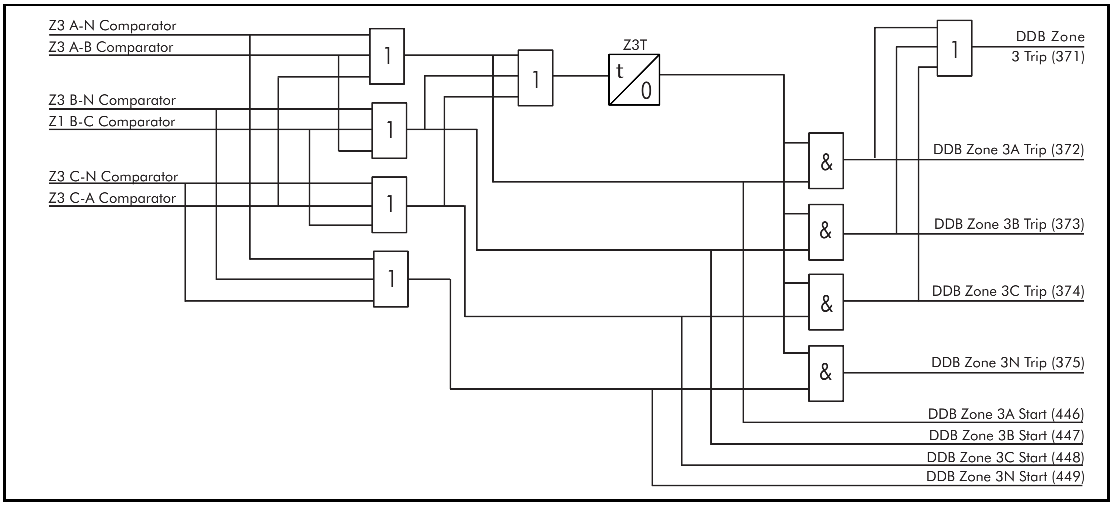


Figure 3: Distance P543/P544/P545/P546 Zone 3 Tripping Logic

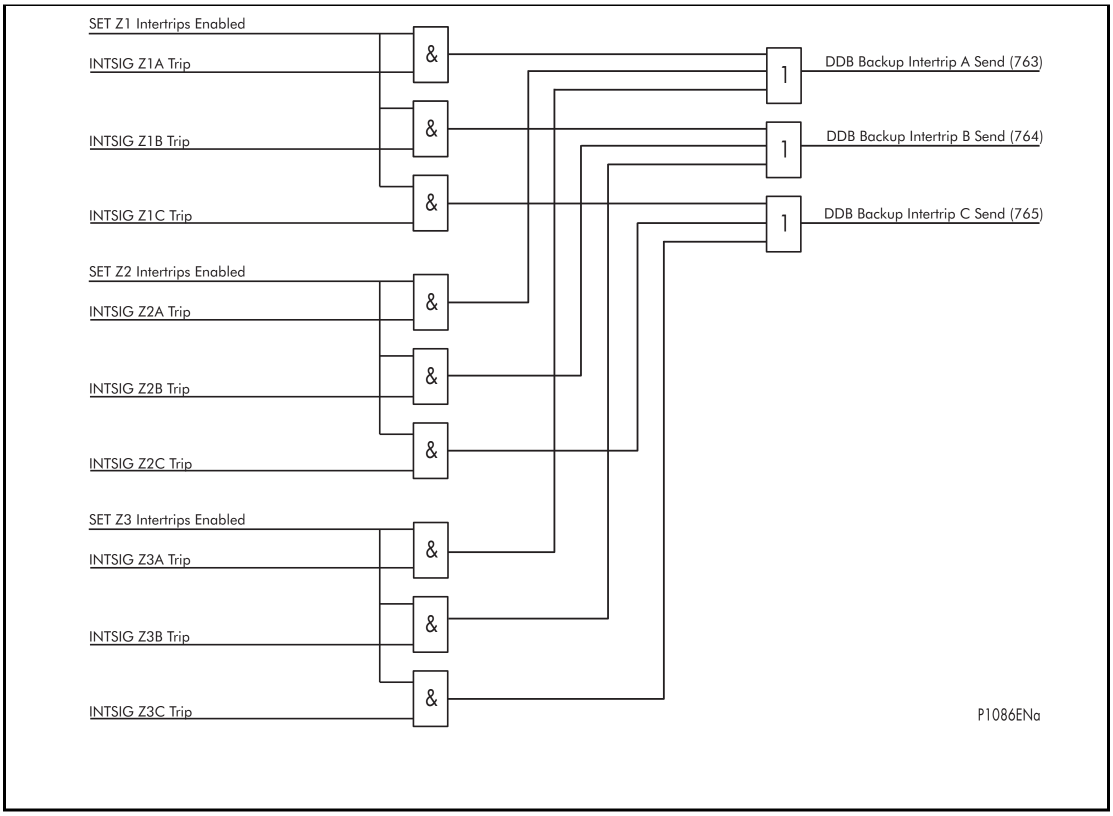


Figure 4: Distance P543/P544/P545/P546 Intertrip Logic

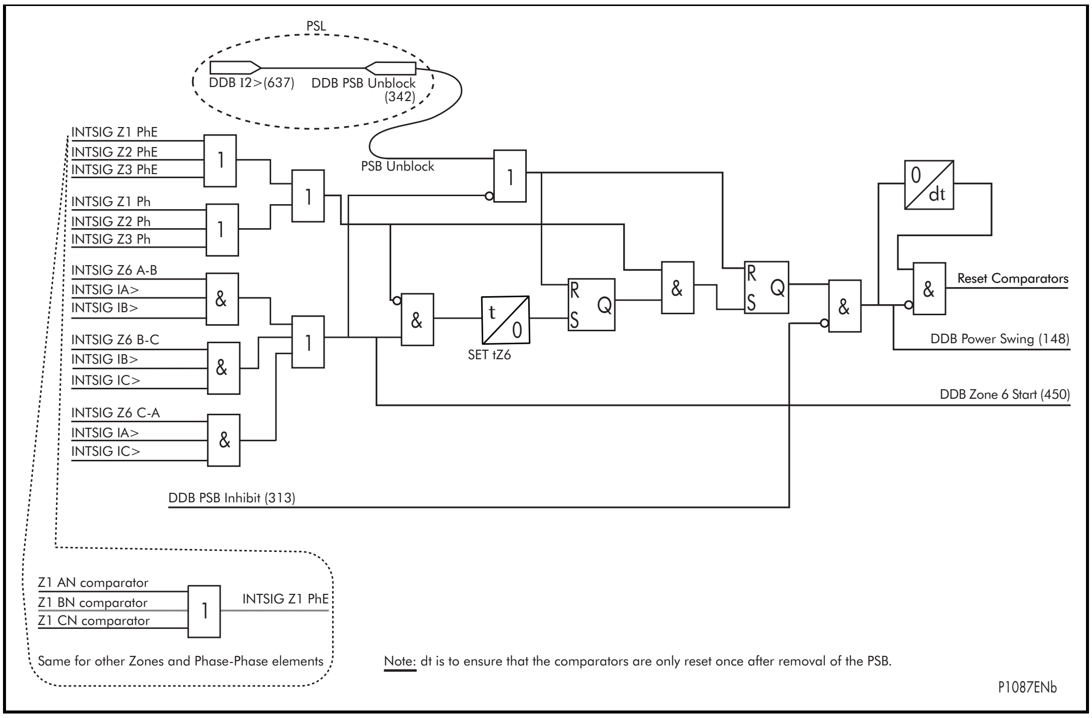


Figure 5: Distance P543/P544/P545/P546 Power Swing Logic (Phase 2)

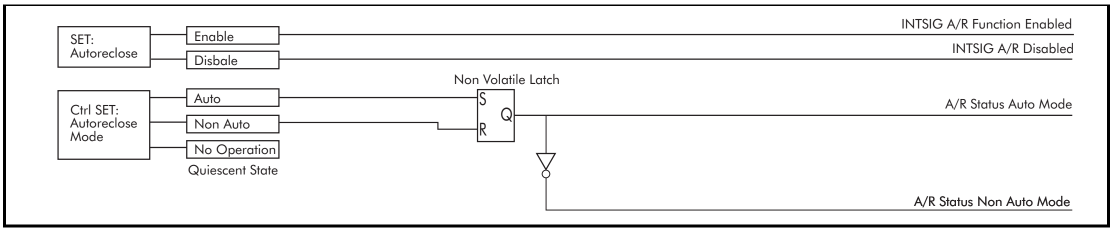


Figure 6: Autoreclose P542 In/Out of Service Selection

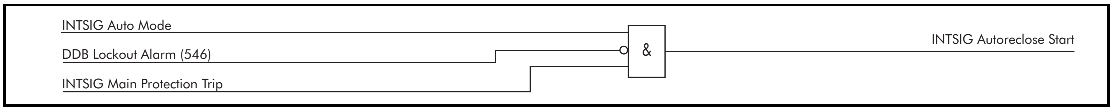


Figure 7: Autoreclose P542 Protection Monitor

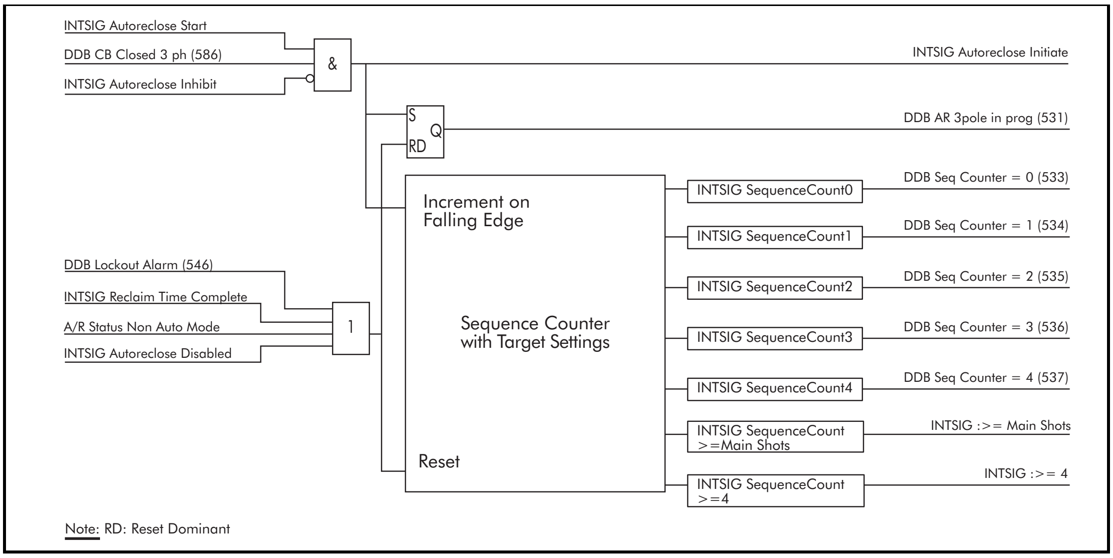


Figure 8: Autoreclose P542 Initiate Sequence

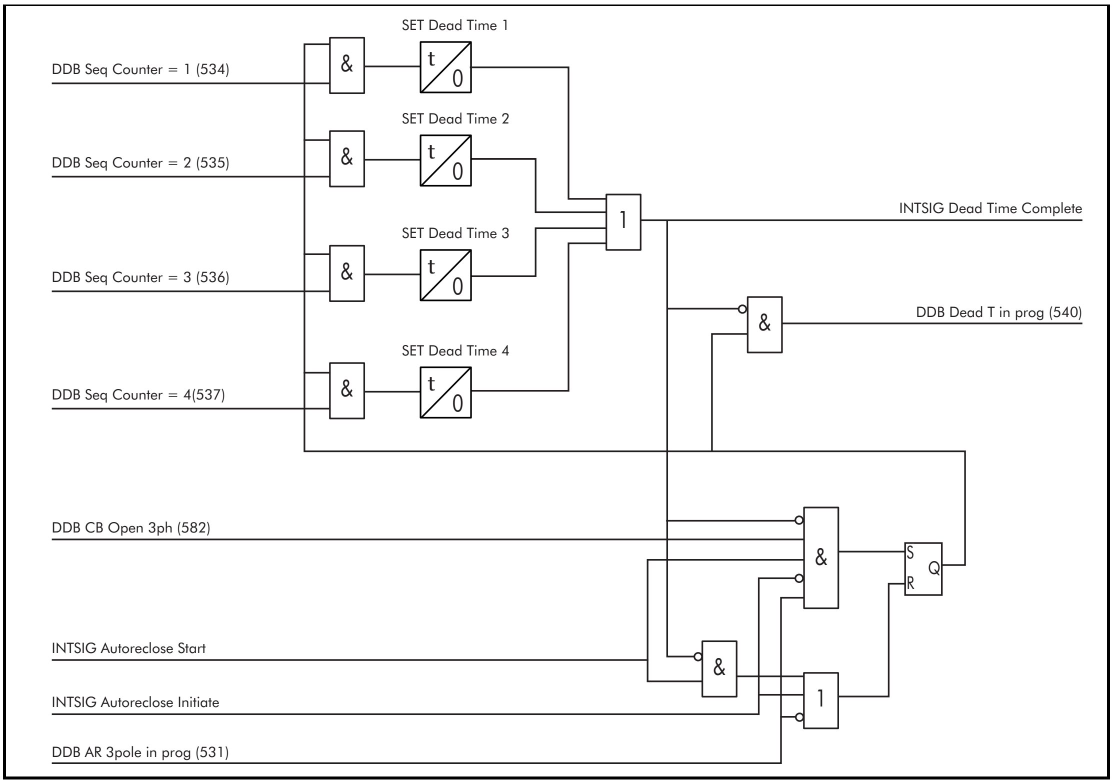


Figure 9: Autoreclose P542 Dead Times

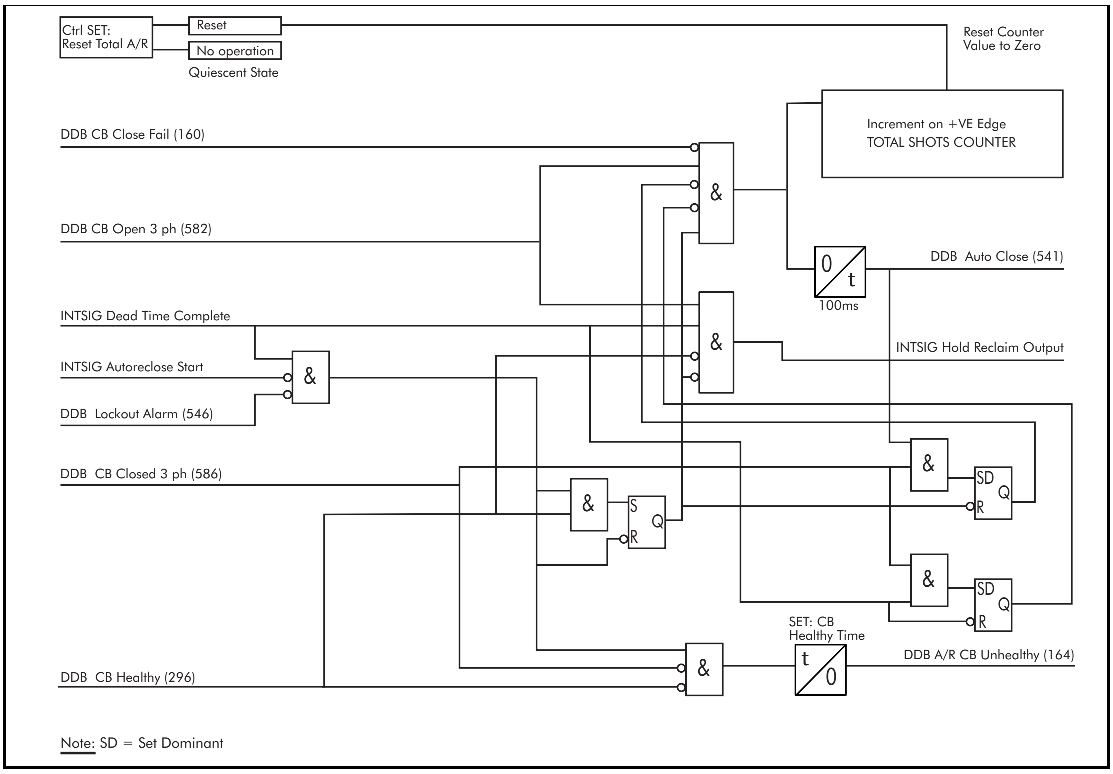


Figure 10: Autoreclose P542 Close Circuit Breaker

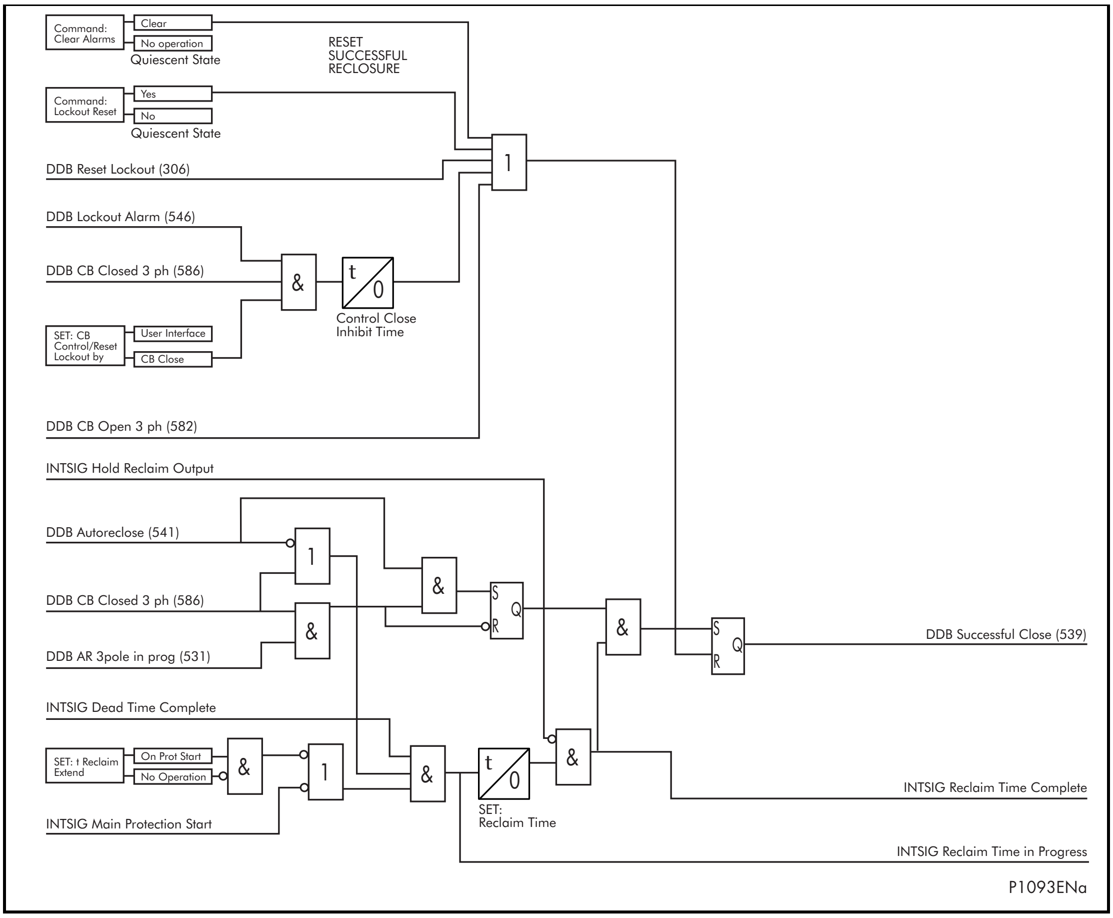


Figure 11: Autoreclose P542 Reclaim Time

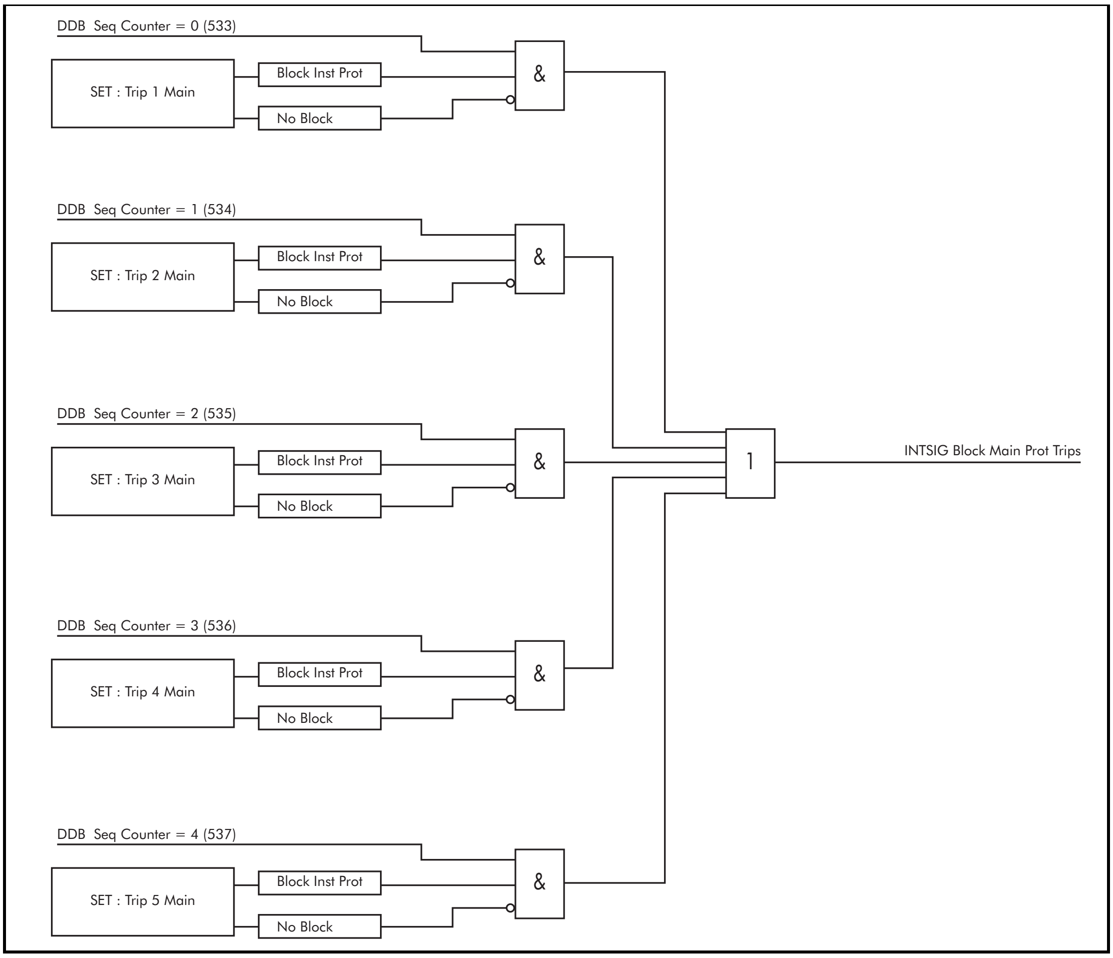


Figure 12: Autoreclose P542: Block Protection (1)

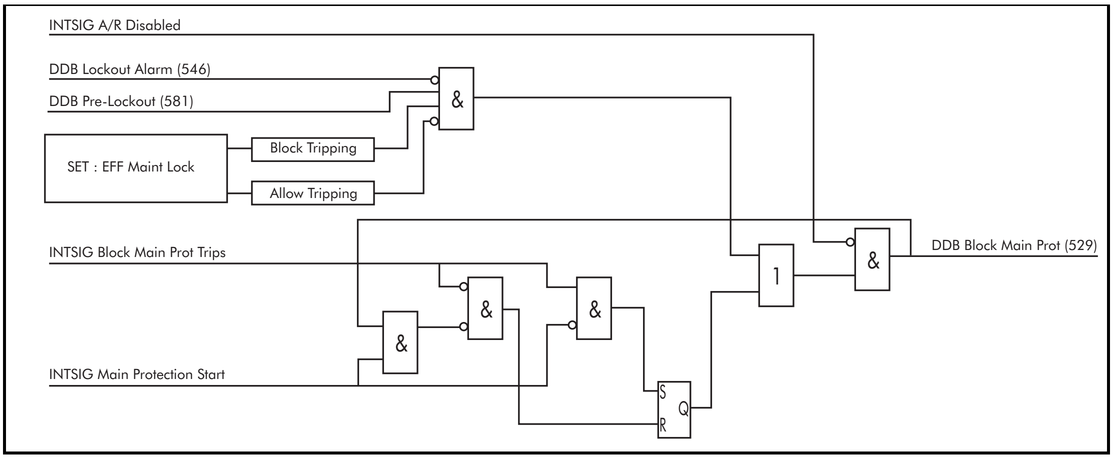


Figure 13: Autoreclose P542 Block Protection (2)

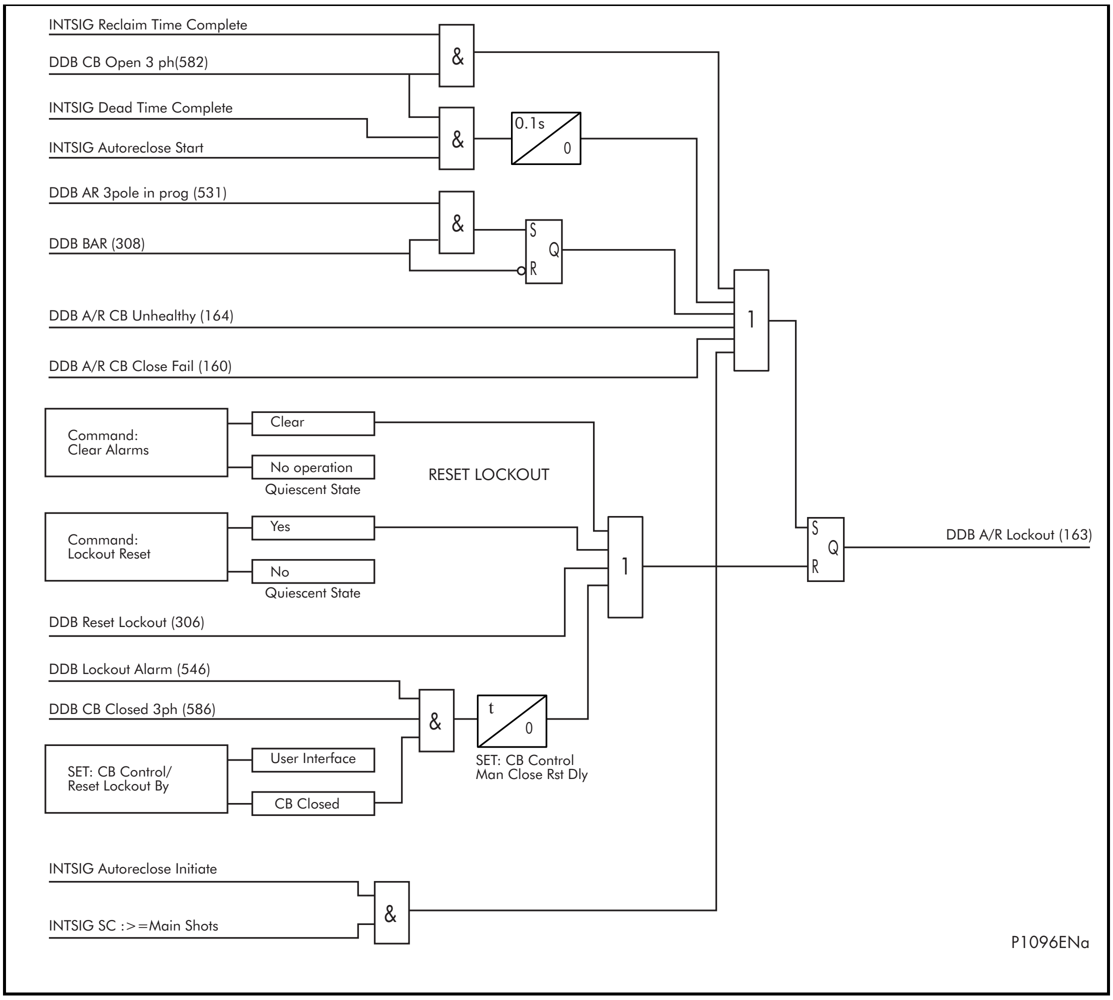


Figure 14: Autoreclose P542 Lockout

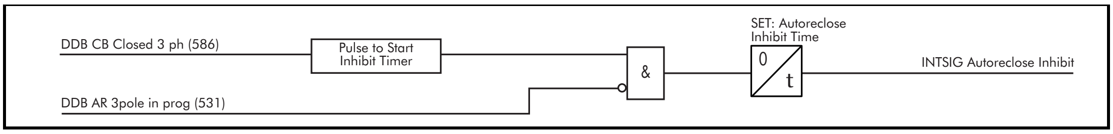


Figure 15: Autoreclose P542 Inhibit

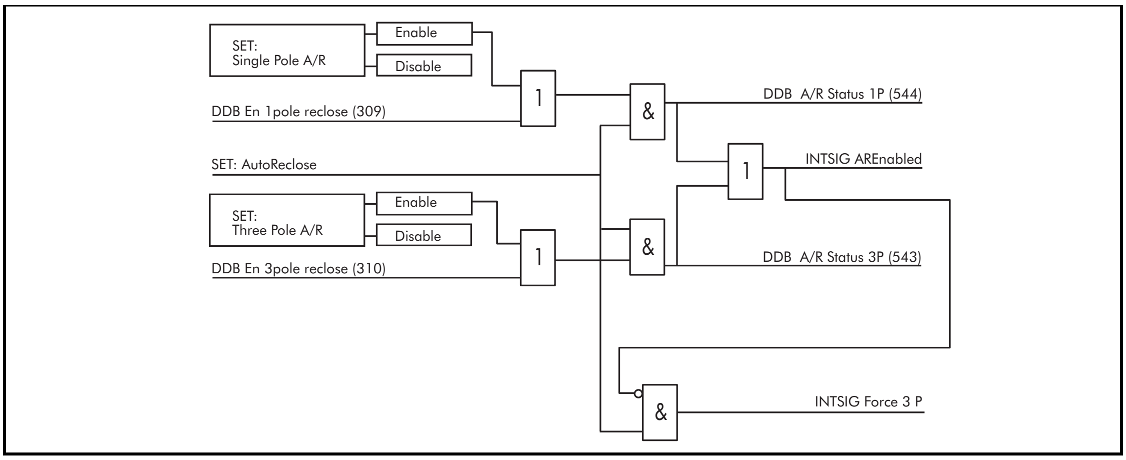


Figure 16: Autoreclose P543/P545 Enable Logic

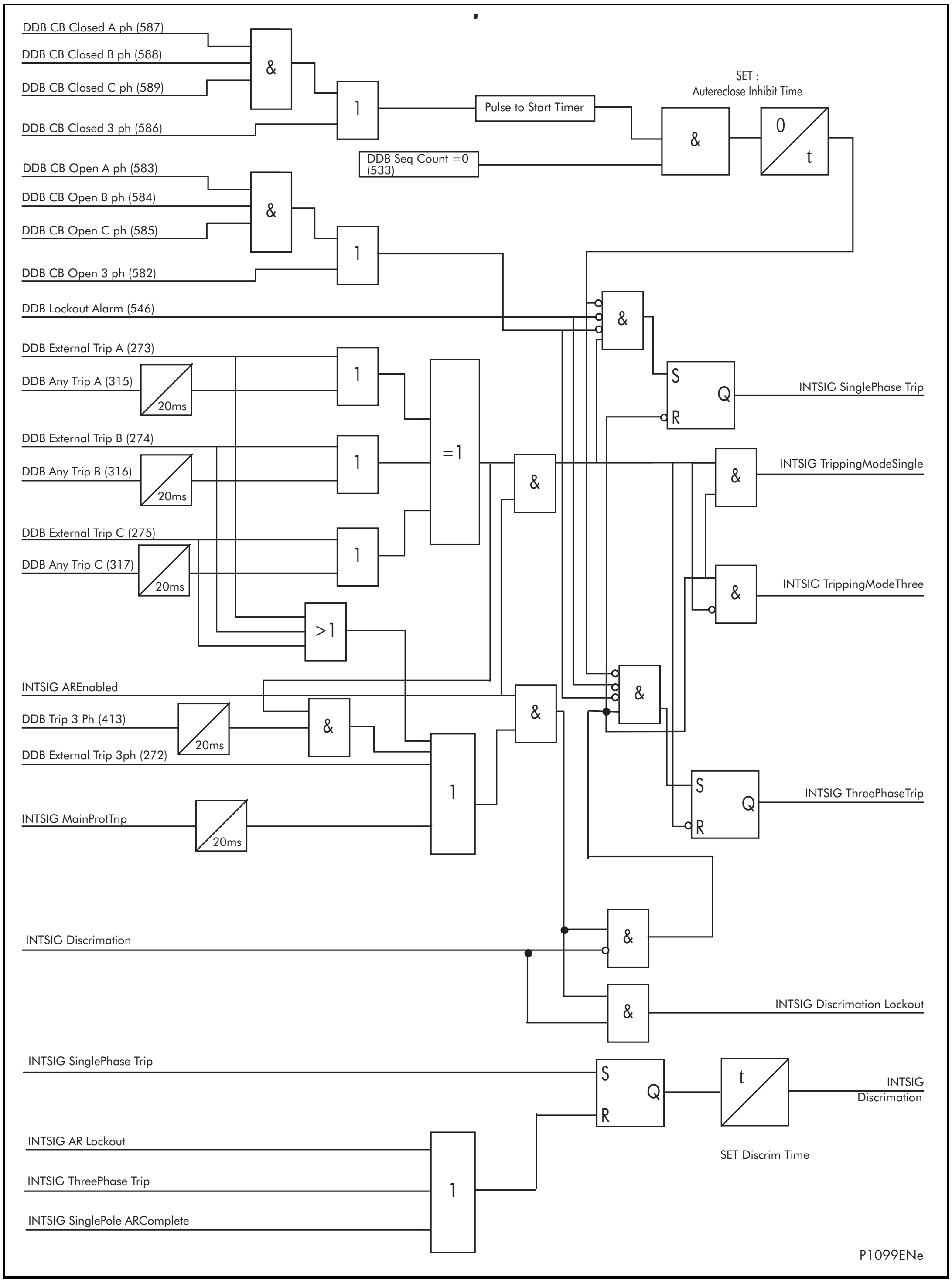


Figure 17: Autoreclose P543/P545 Single/Three Pole Tripping

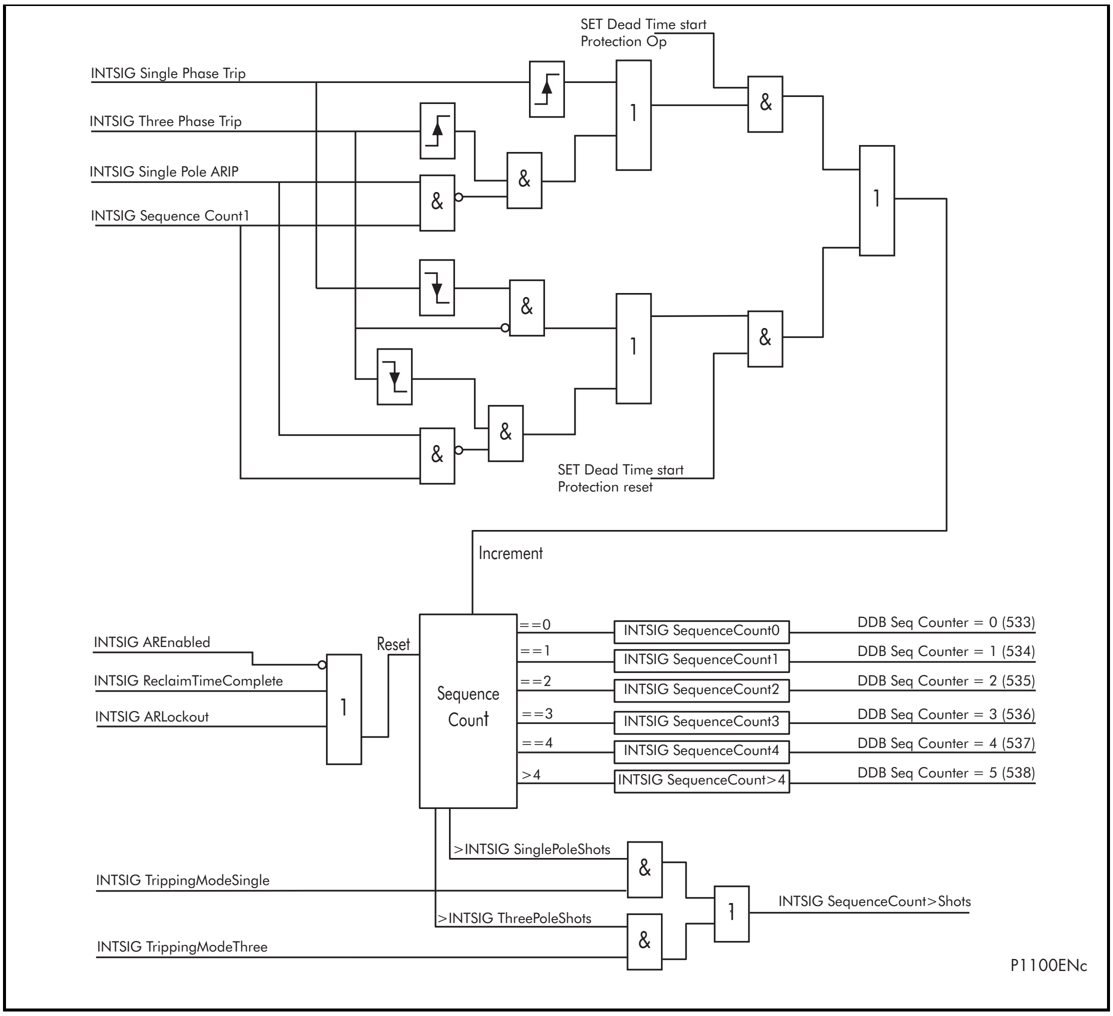


Figure 18: Autoreclose P543/P545 Inhibit Sequence Count

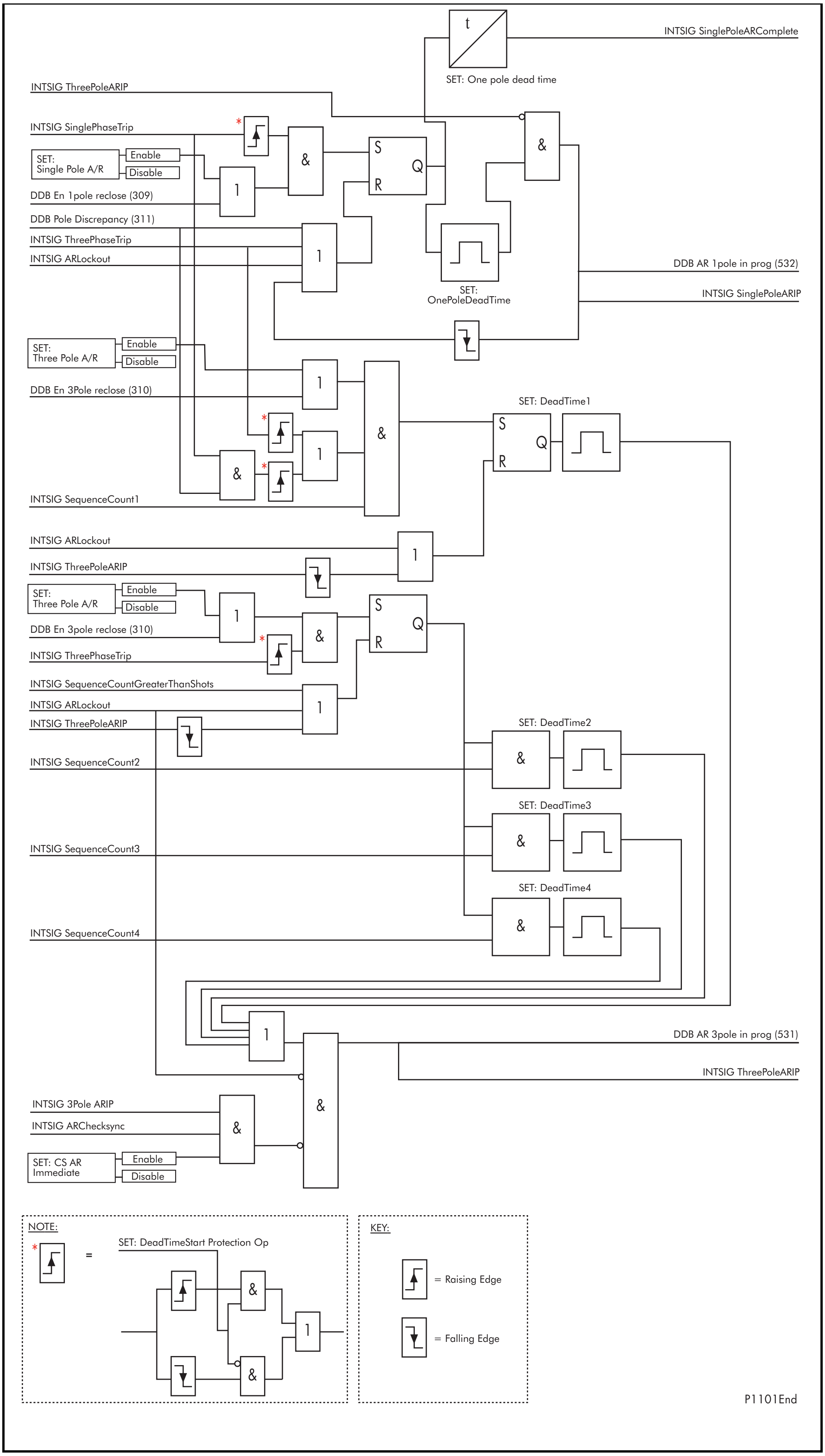


Figure 19: Autoreclose P543/P545 Cycles

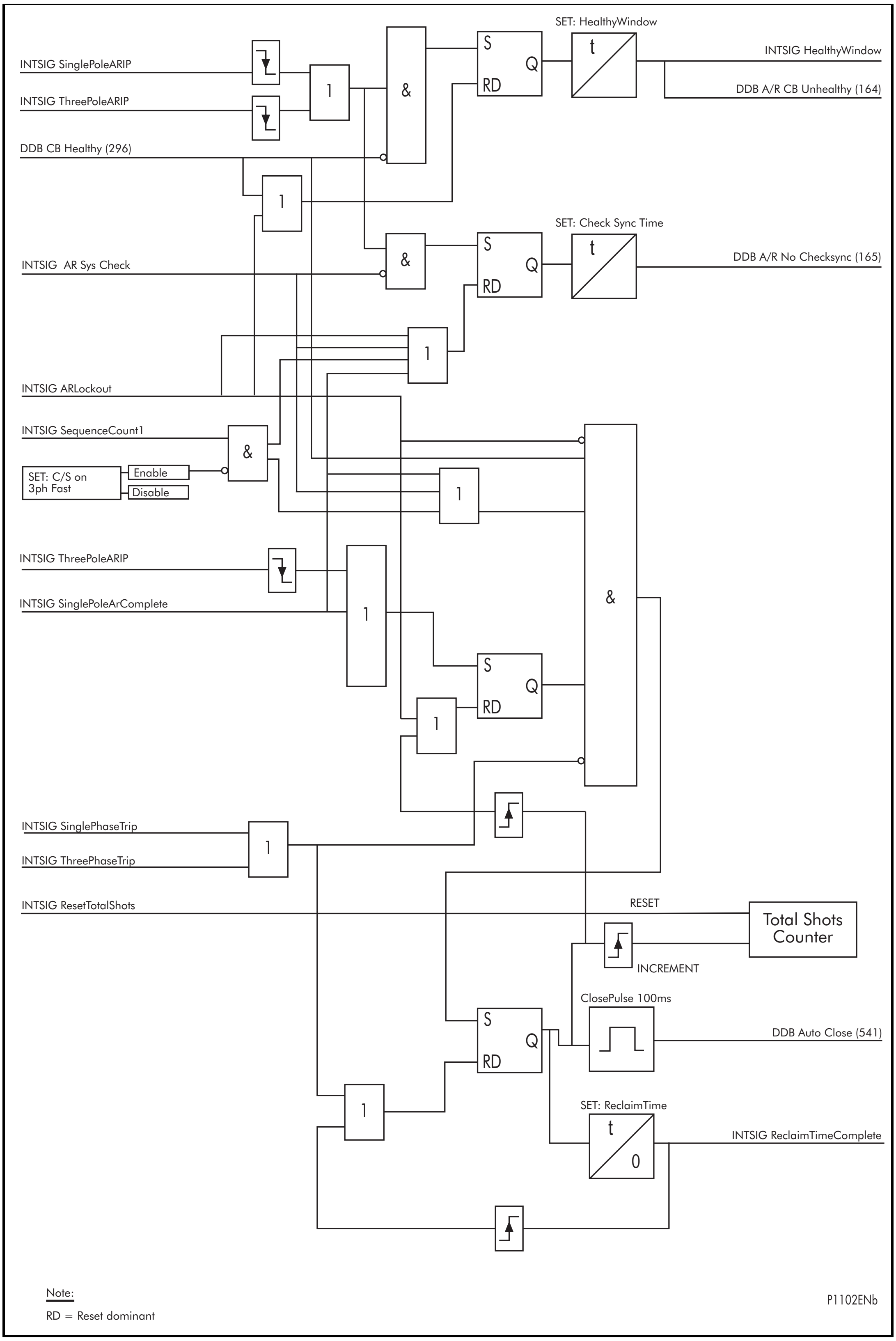


Figure 20: Autoreclose P543/P545 Close

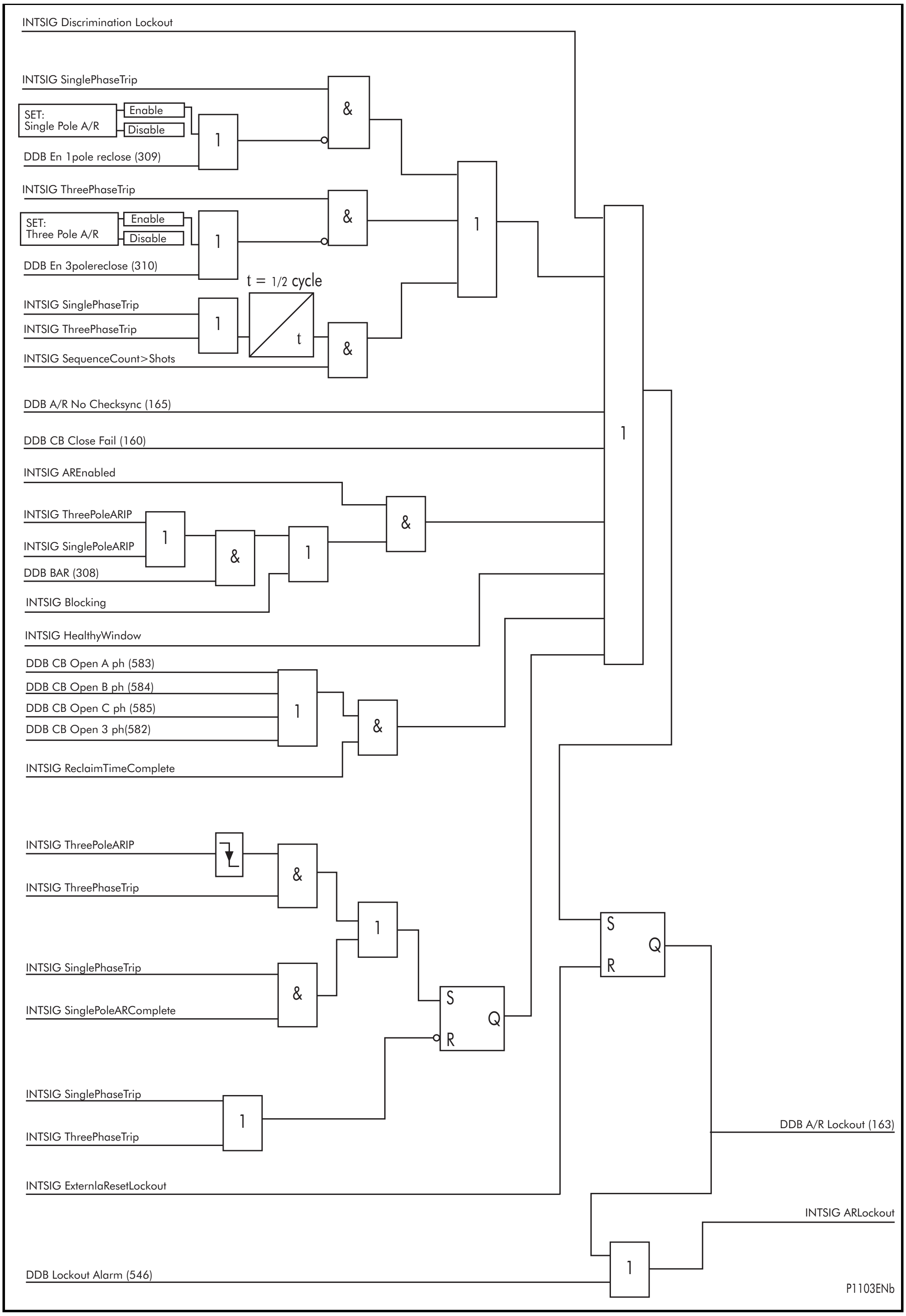


Figure 21: Autoreclose P543/P545 Lockout Logic

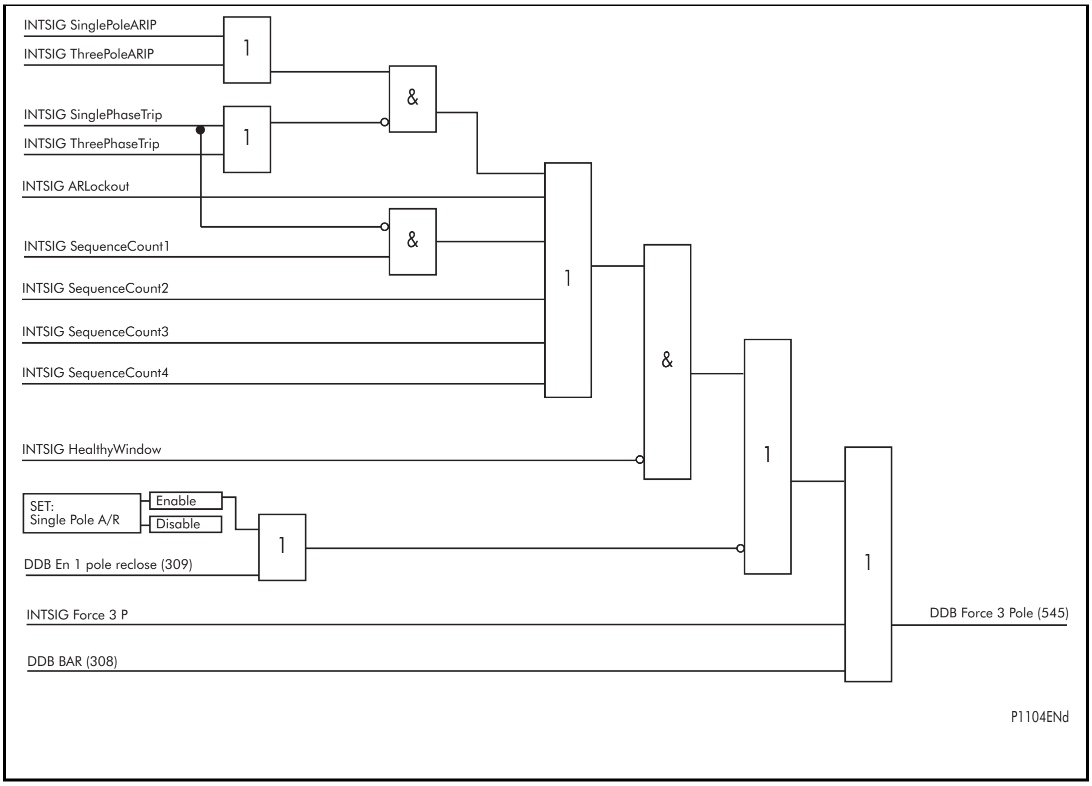


Figure 22: Autoreclose P543/P545 Force 3 Pole Trip

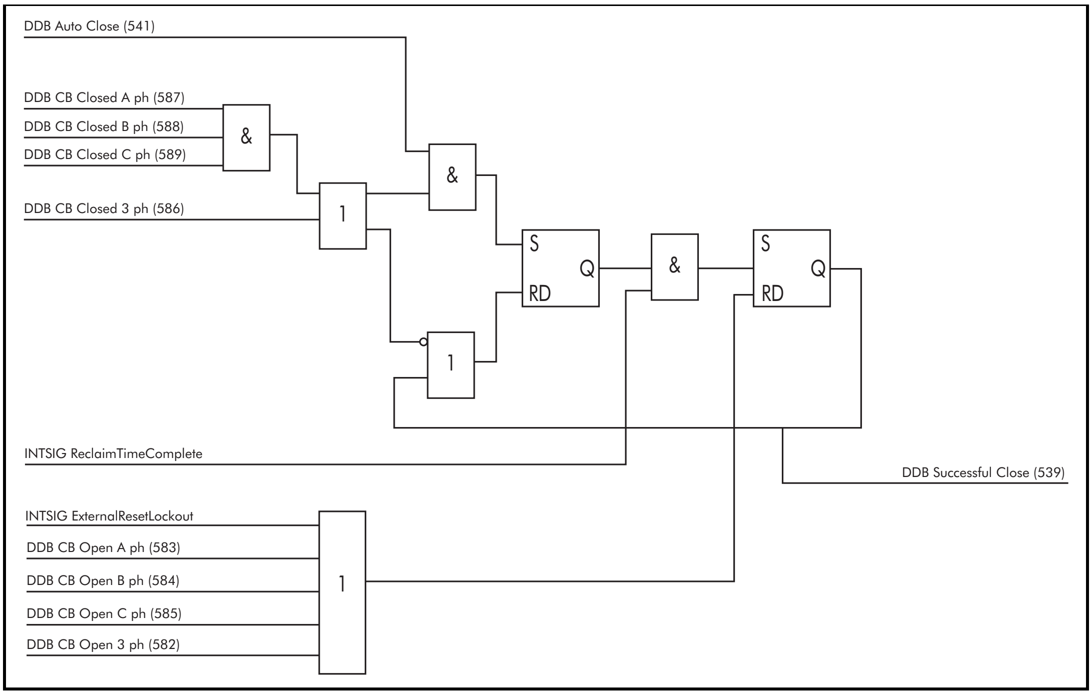


Figure 23: Autoreclose P543/P545 Close Notify

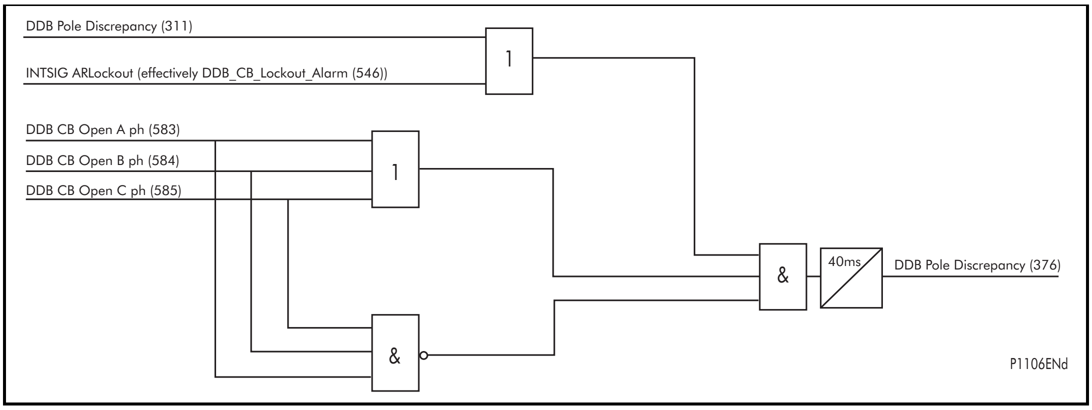


Figure 24: P543/P545 DDB Pole Discrepancy Trip

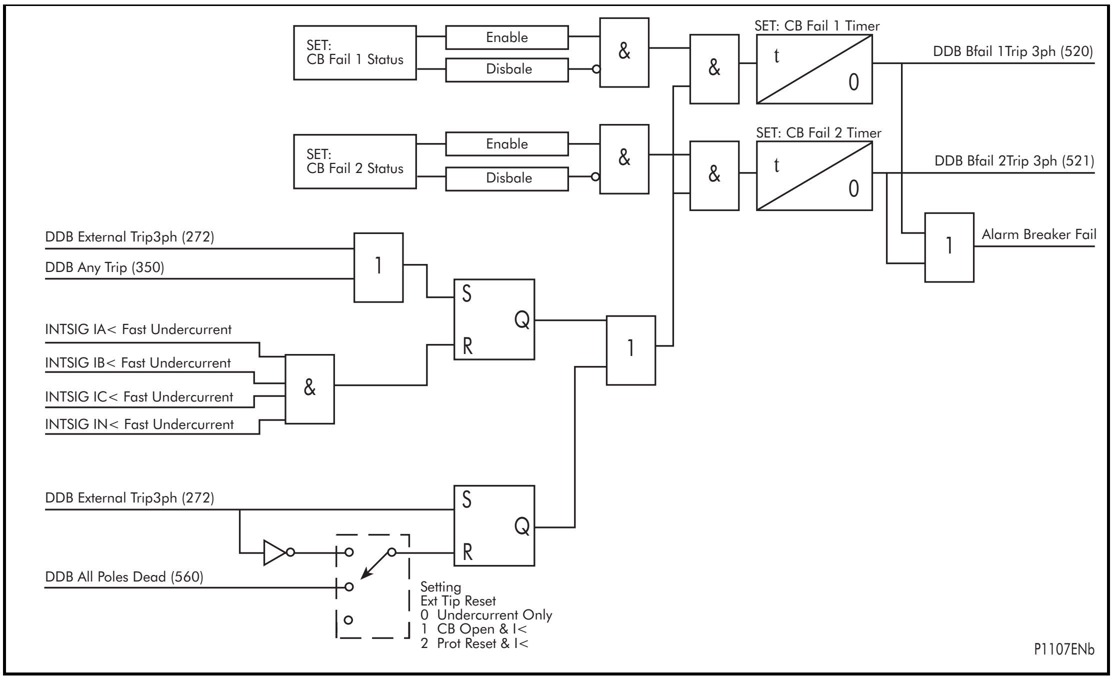


Figure 25: CB failure for P541/P542 with Three Pole Tripping

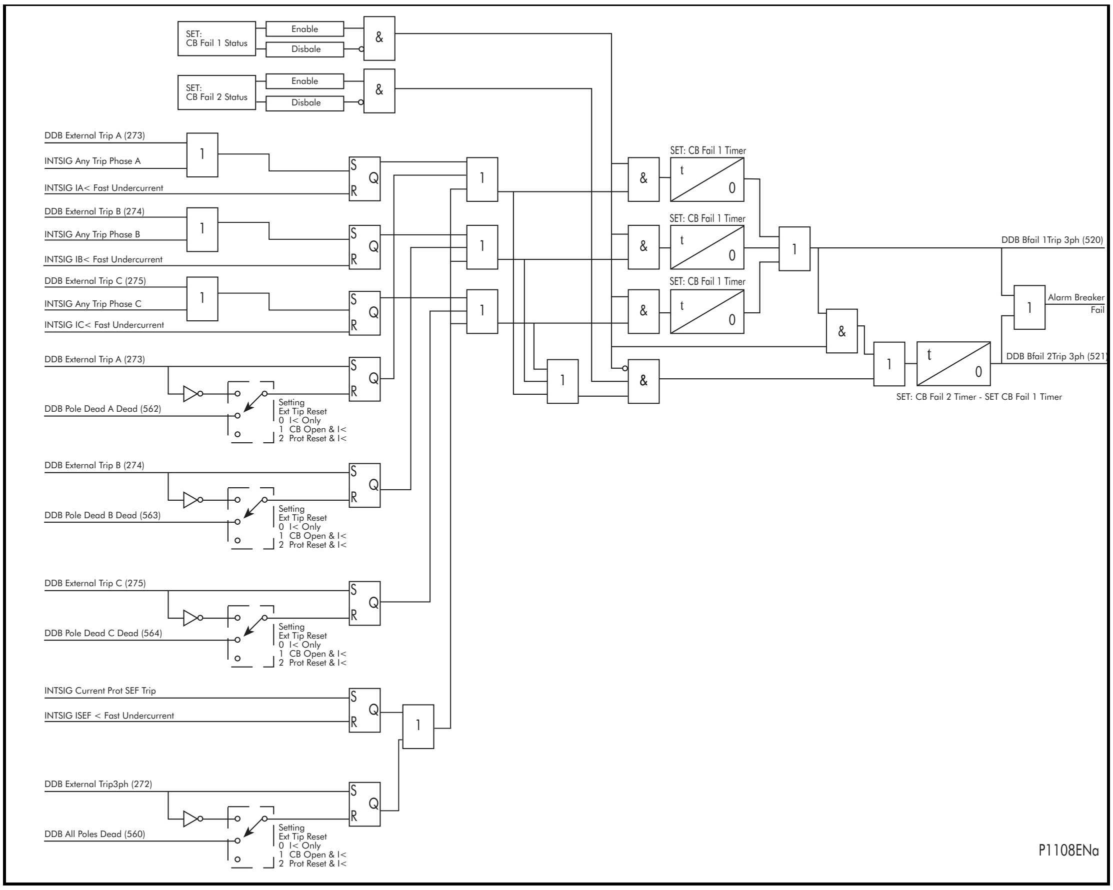


Figure 26: CB Failure for P543/P545 with Single/Three Pole Tripping

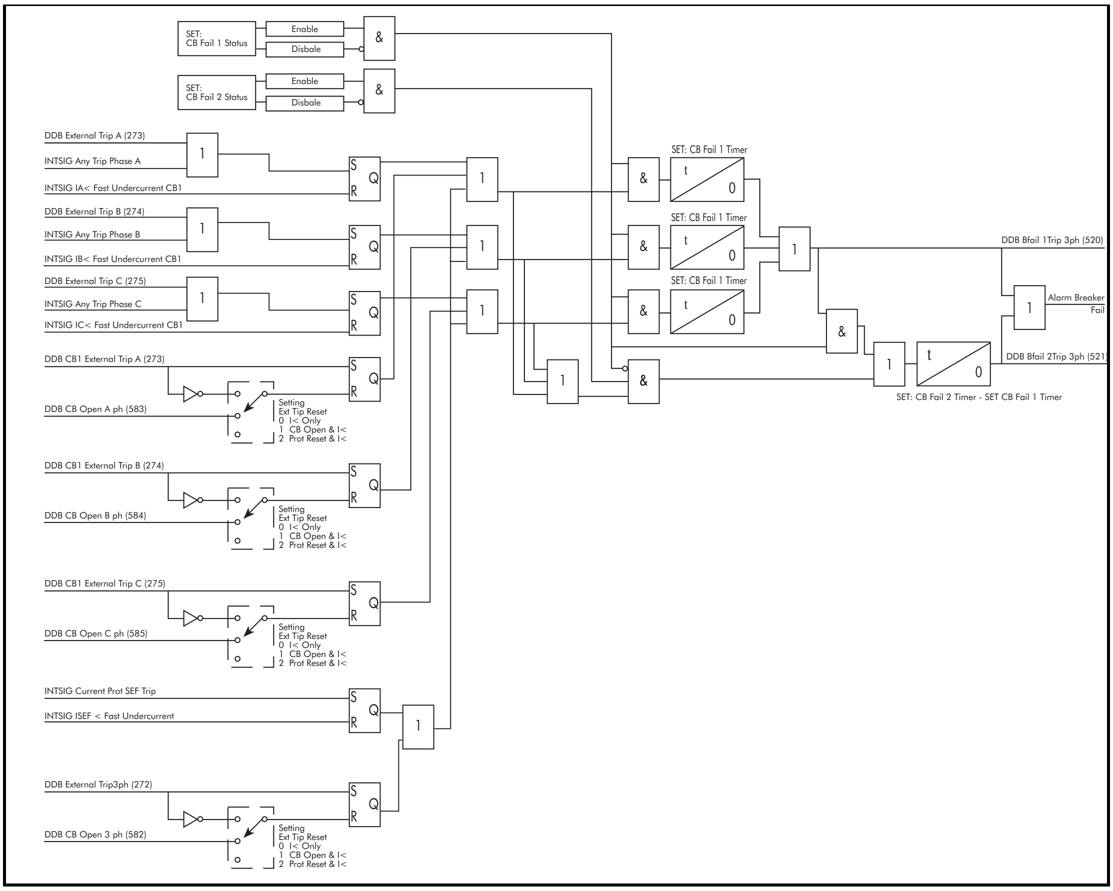


Figure 27: CB failure for P544/P546 (repeated for each CB)

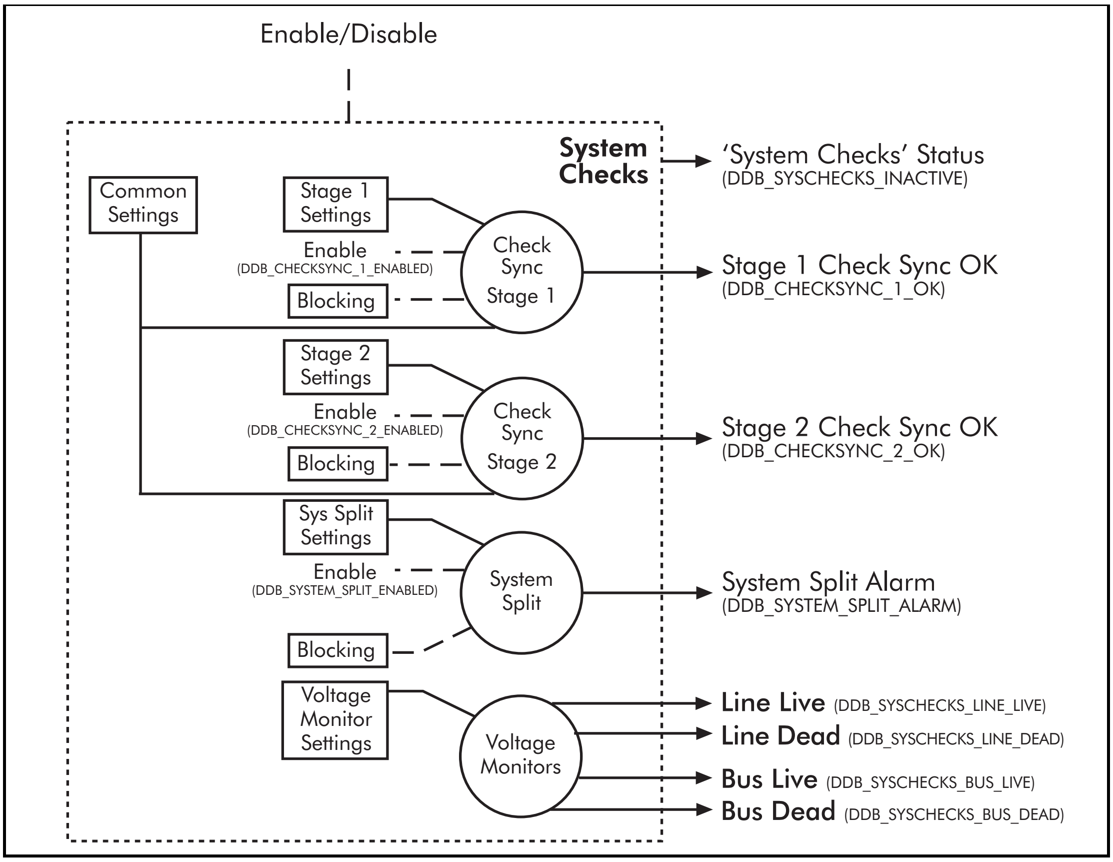


Figure 28: Check Synch

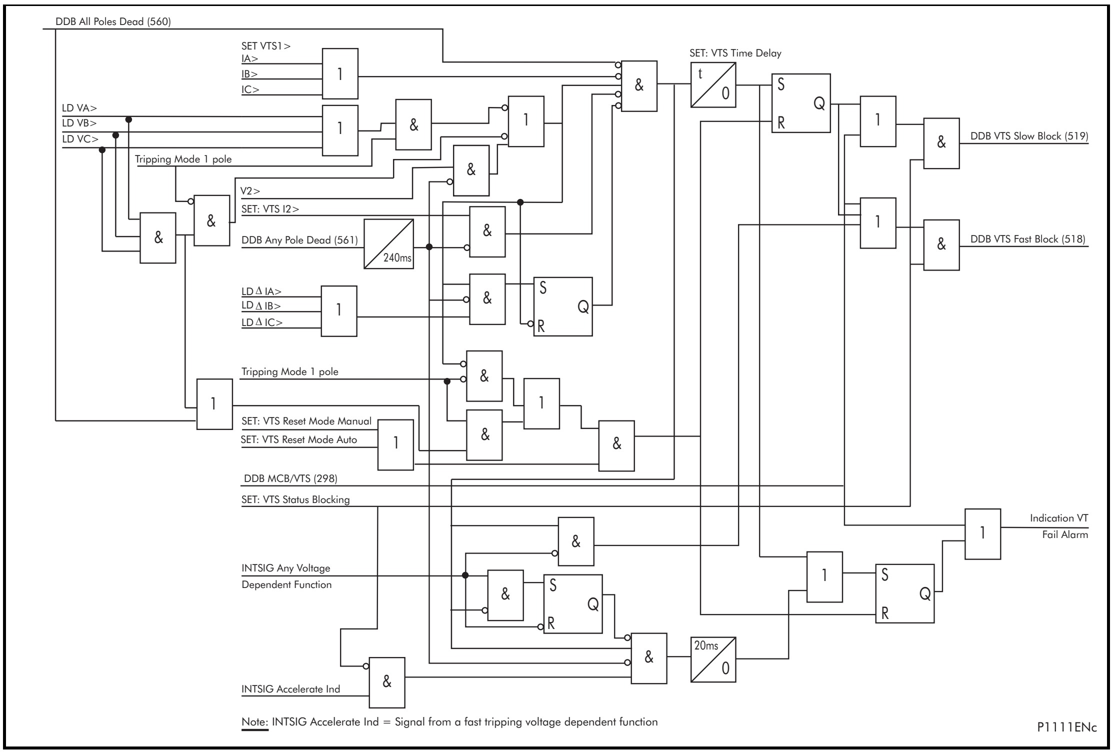


Figure 29: VTS Logic

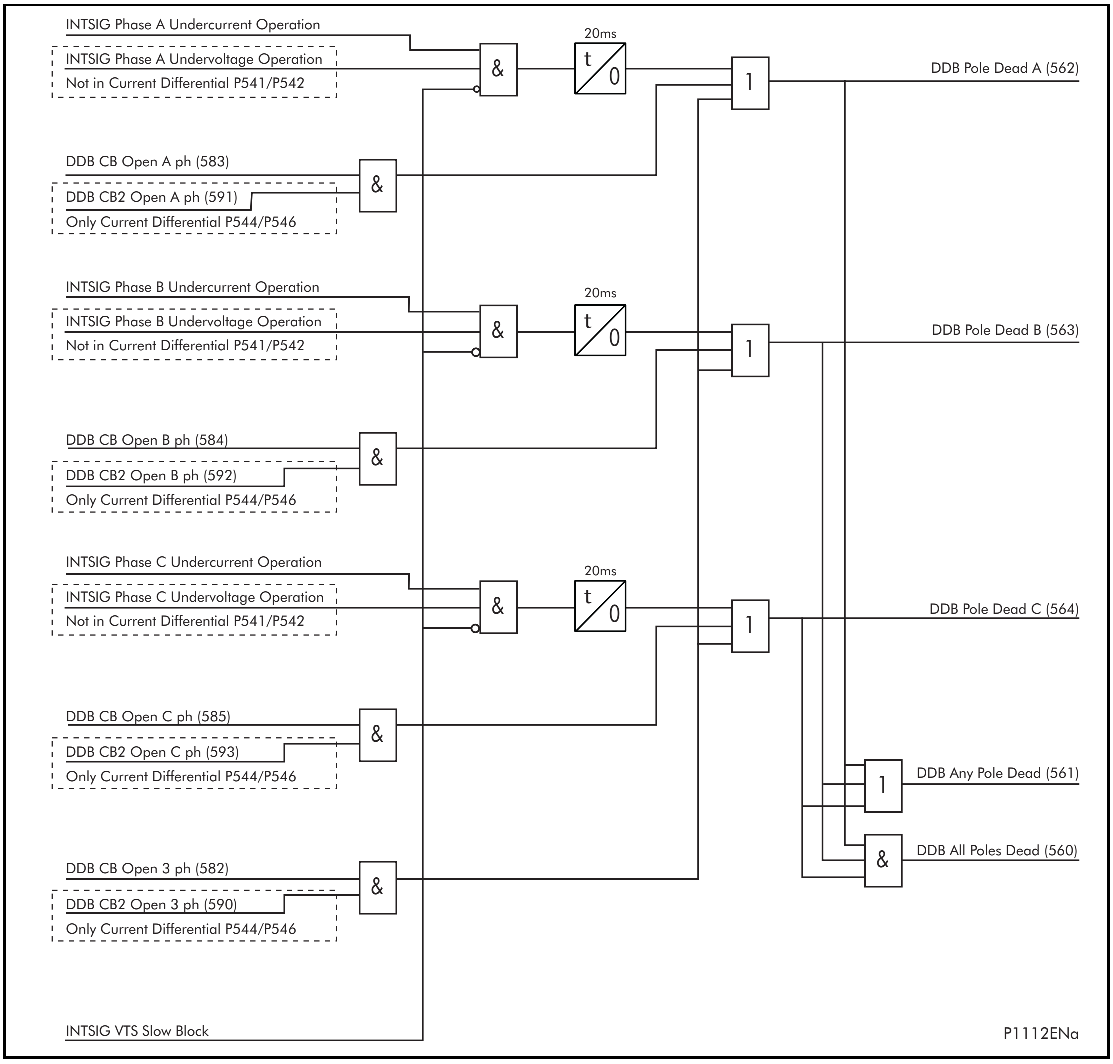


Figure 30: Pole Dead Logic

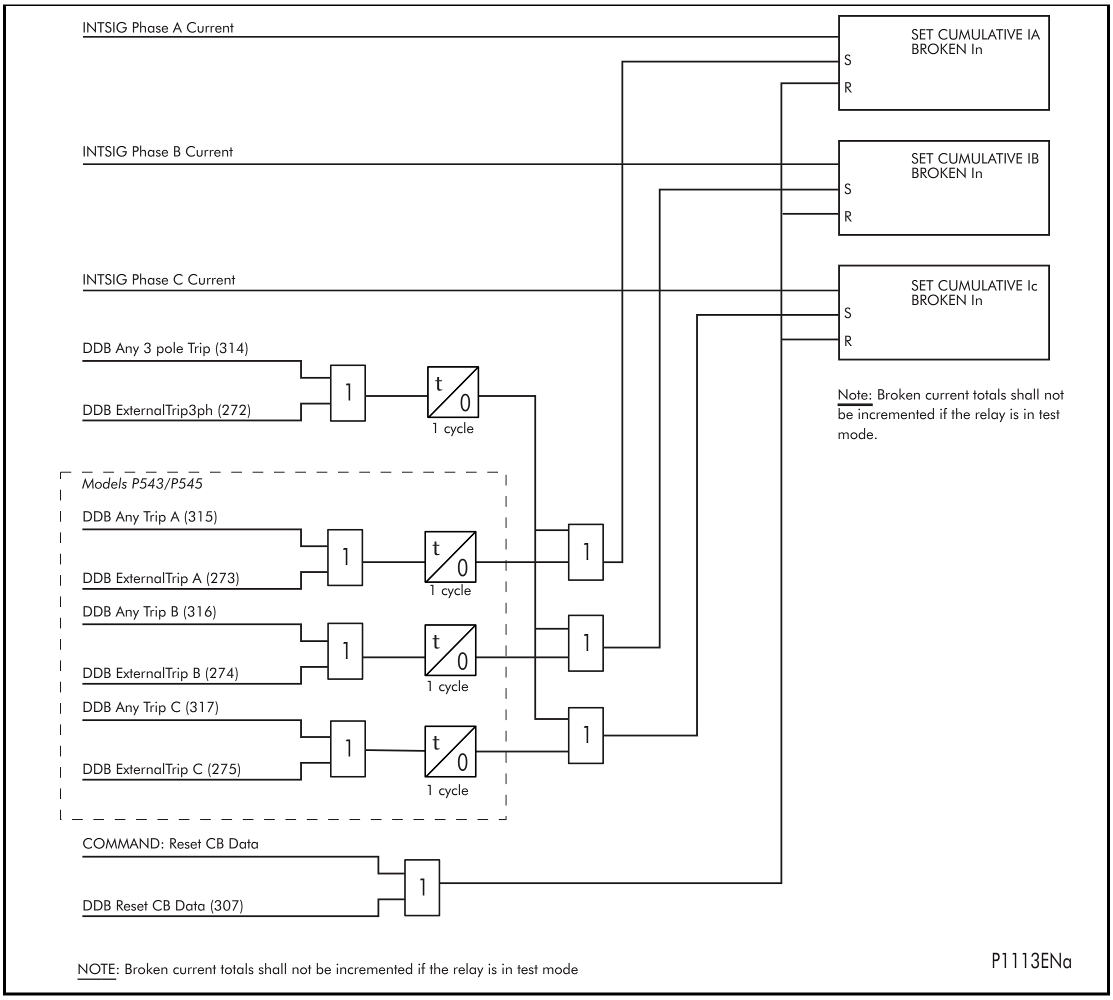


Figure 31: Circuit Breaker Condition Monitoring Broken Current P541/P542/P543

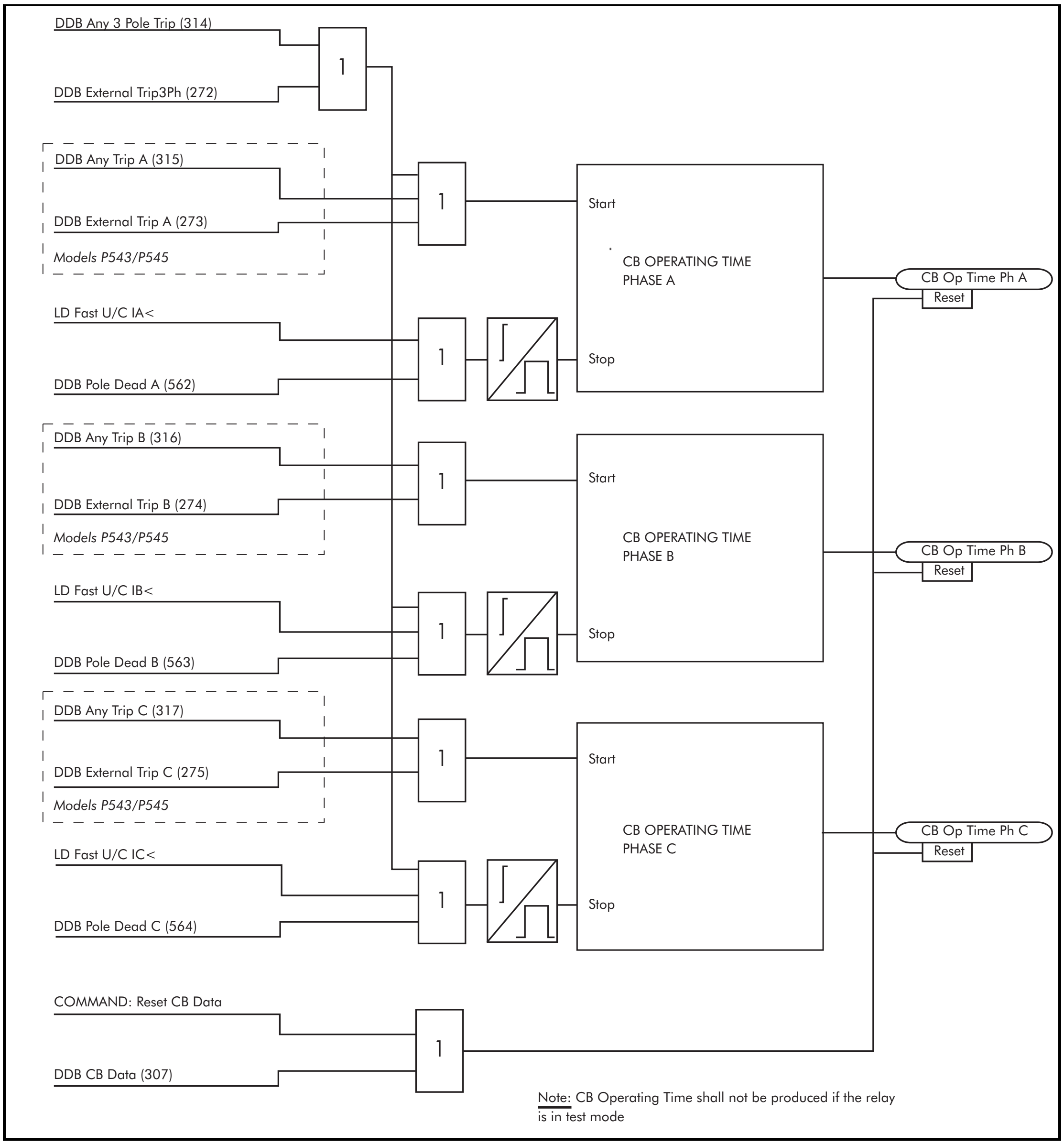


Figure 32: Circuit Breaker Condition Monitoring – Operation Time P541/P542/P543/P545

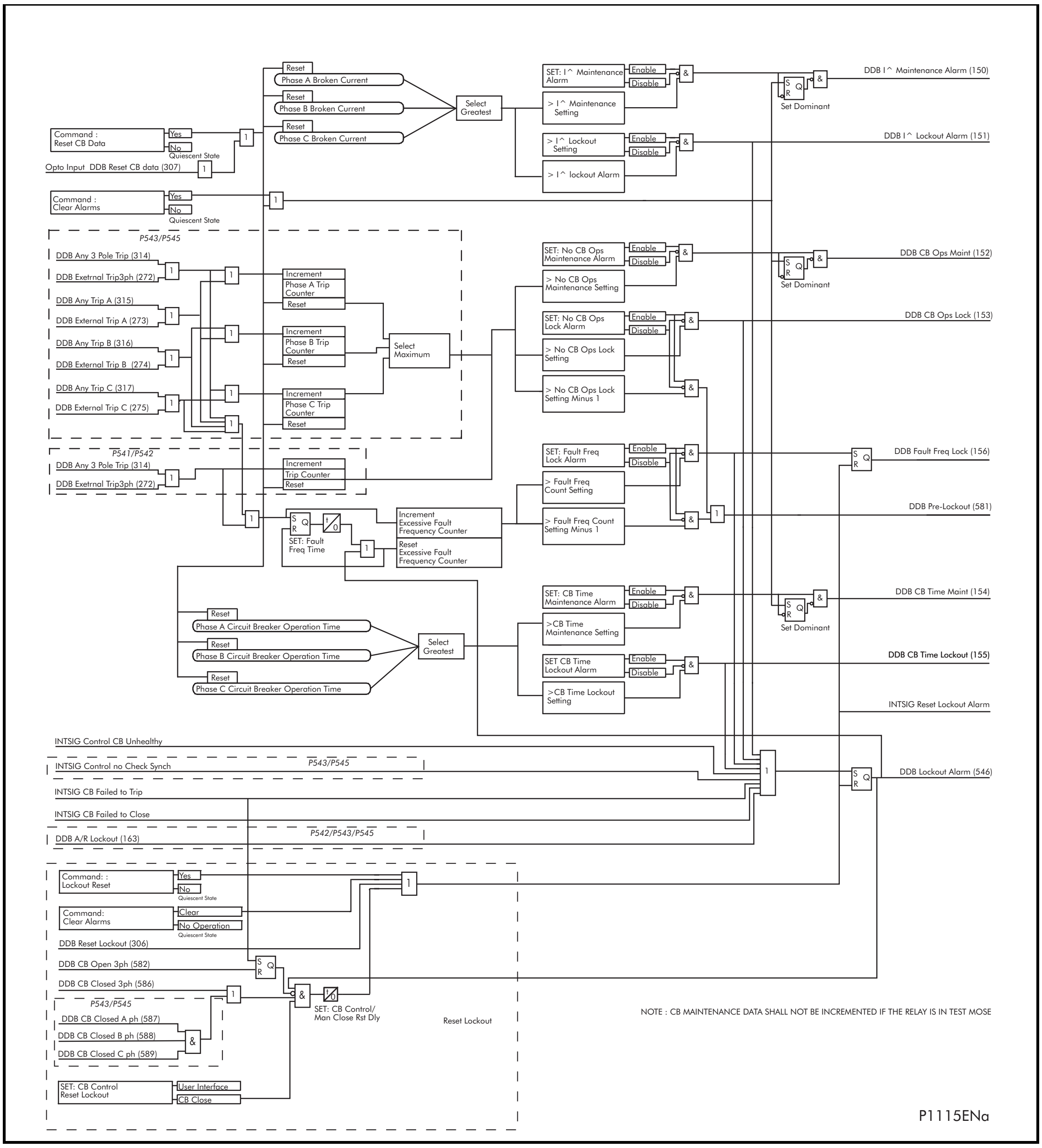


Figure 33: CB Monitoring P541/P542/P543/P545

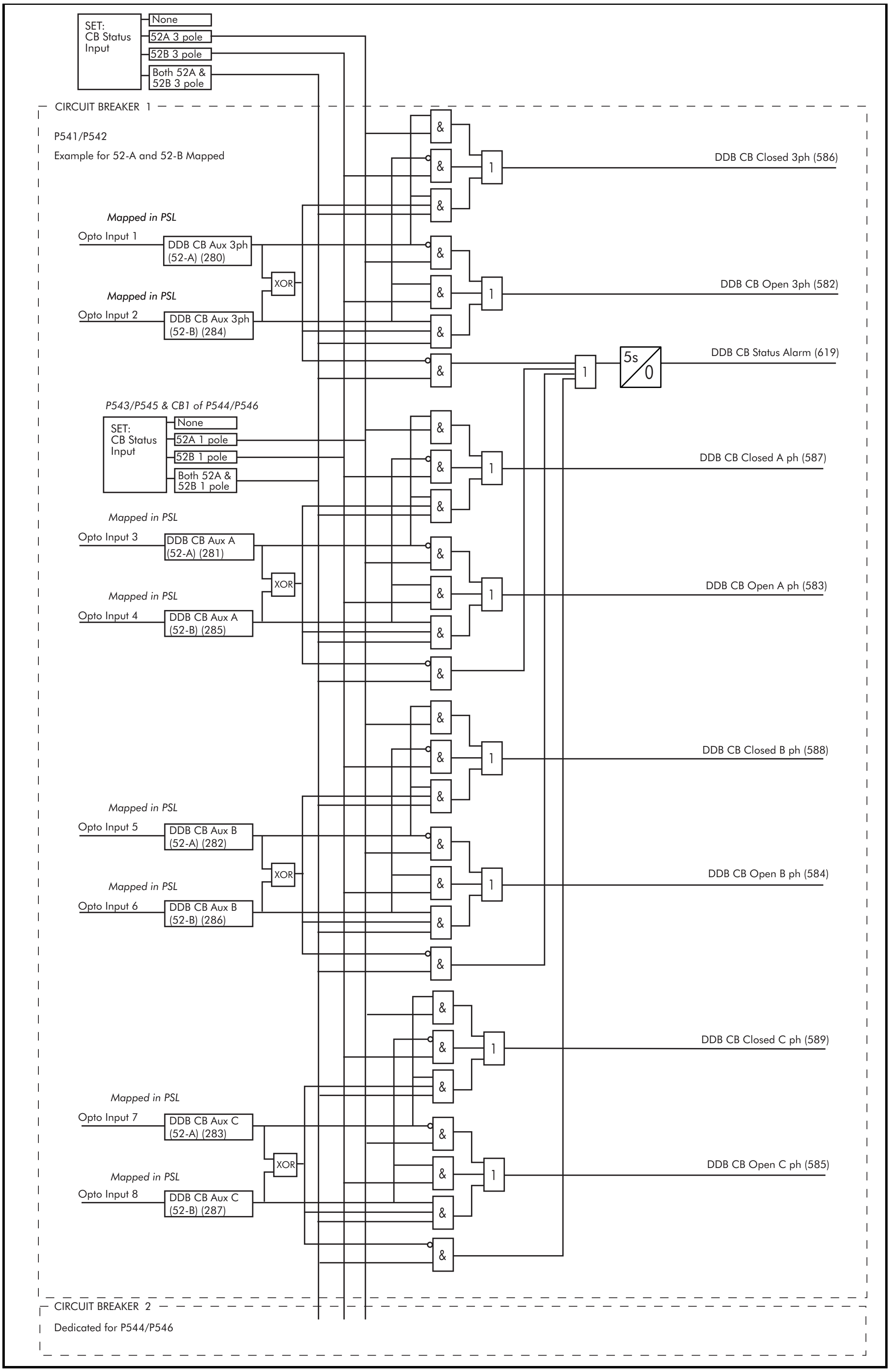


Figure 34: Circuit Breaker State Monitor P541/P542/P543/P544/P545/P546

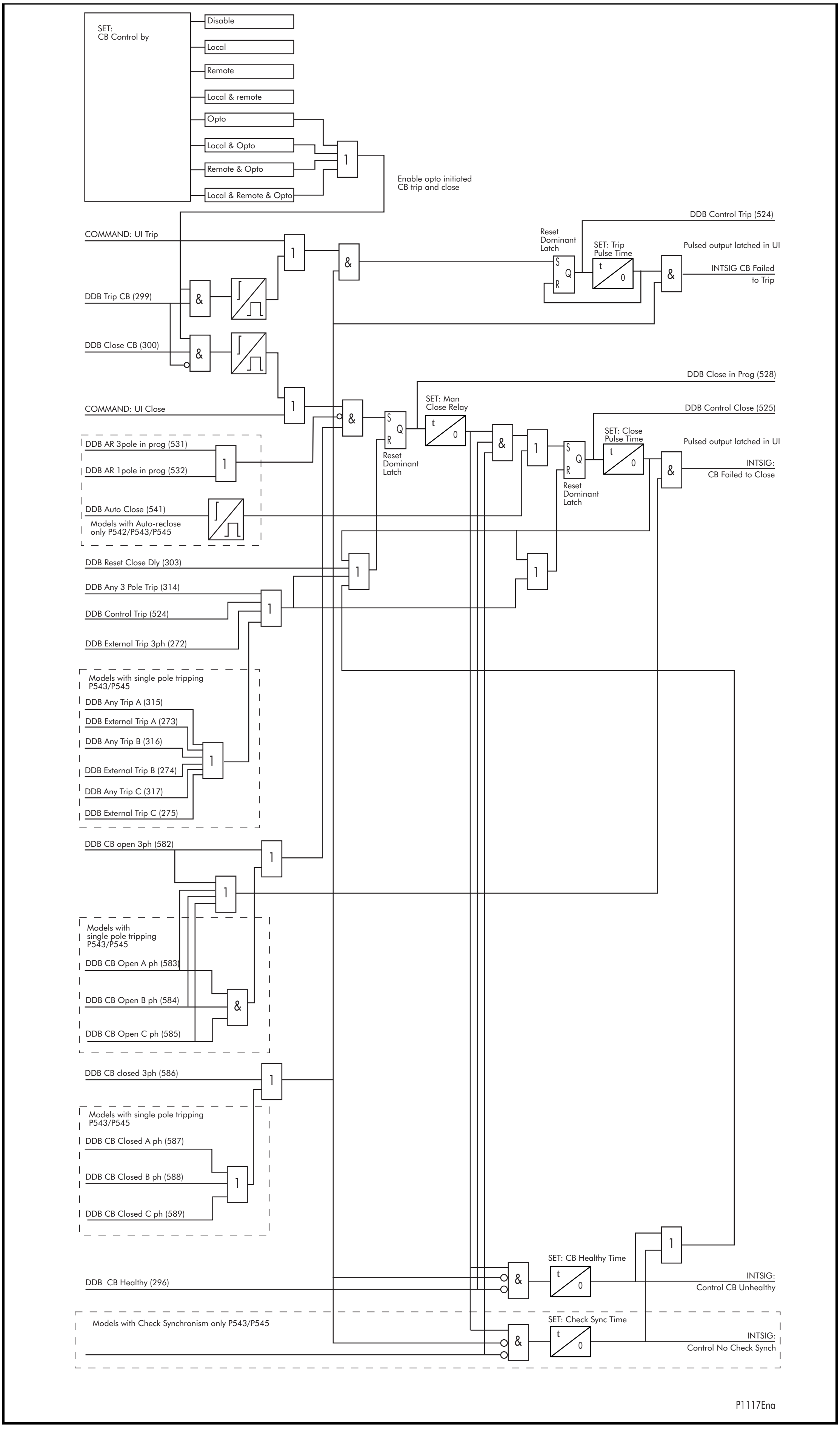


Figure 35: Circuit Breaker Control for P541/P542/P543/P545

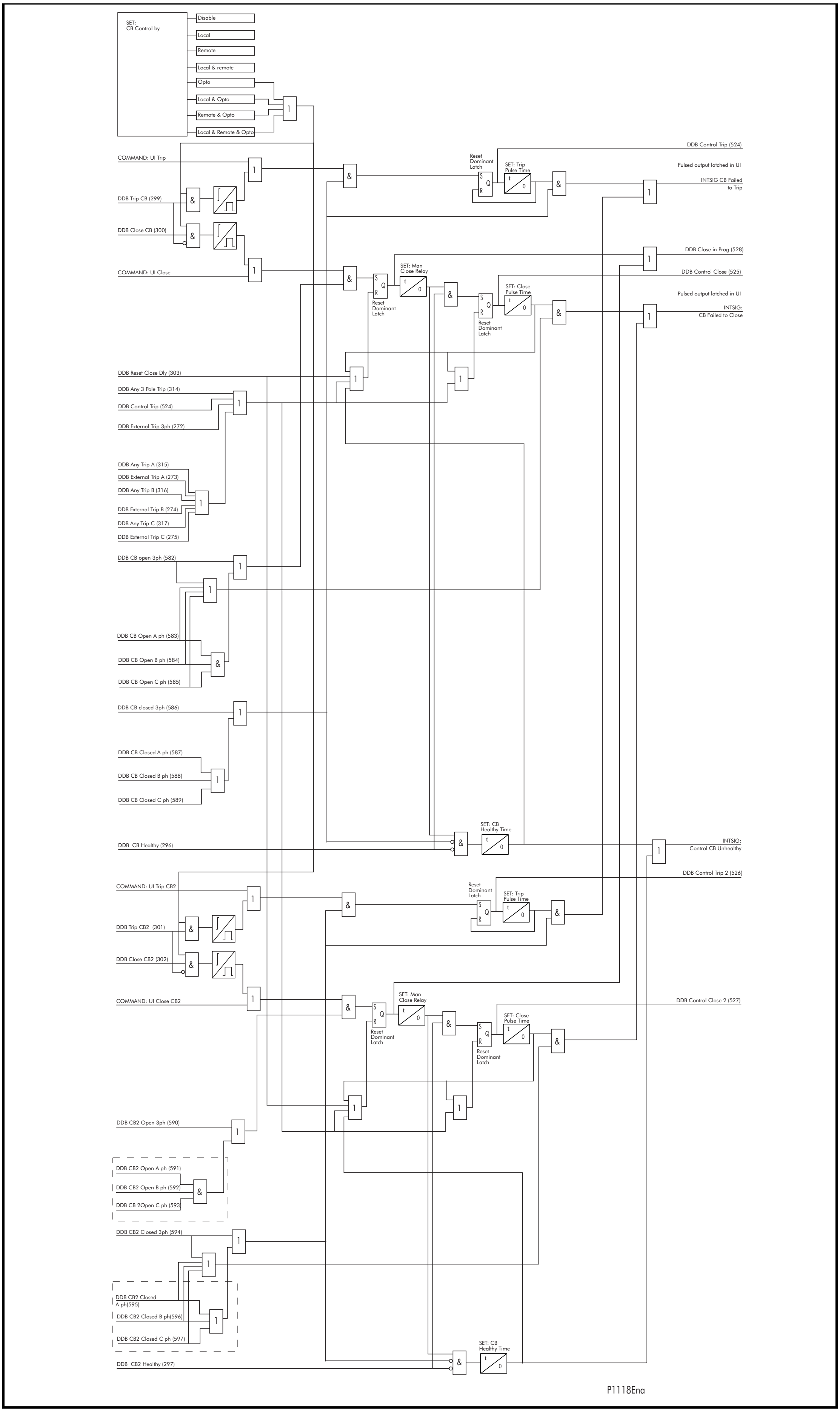


Figure 36: Circuit Breaker Control P544/P546

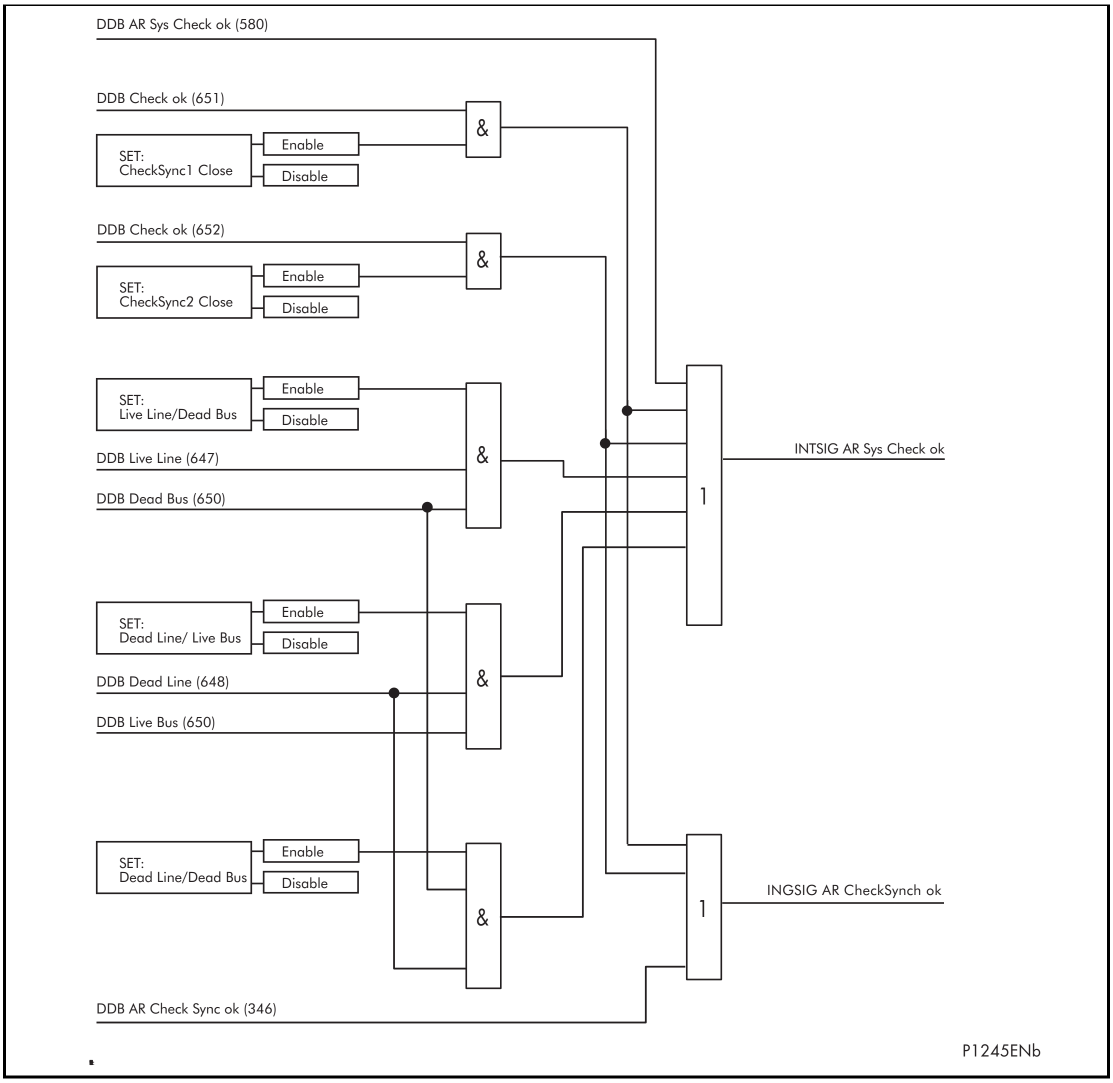


Figure 37: Autoreclose P543/P545 Repeat Closer

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