

L30 Line Current Differential System



Instruction Manual

Product version: 7.6x

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L30 Line Current Differential System Instruction Manual for version 7.6x.

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Part number: 1601-9050-AF2 (October 2017)

L30 Line Current Differential System

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ABBREVIATIONS

INDEX

L30 Line Current Differential System

Chapter 1: Introduction

This chapter outlines safety and technical support information.

1.1 Safety symbols and definitions

Before attempting to install or use the device, review all safety indicators in this document to help prevent injury, equipment damage, or downtime.

The following safety and equipment symbols are used in this document.



Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.



Indicates practices not related to personal injury.

1.1.1 General cautions and warnings

The following general safety precautions and warnings apply.



Ensure that all connections to the product are correct so as to avoid accidental risk of shock and/or fire, for example such as can arise from high voltage connected to low voltage terminals.

Follow the requirements of this manual, including adequate wiring size and type, terminal torque settings, voltage, current magnitudes applied, and adequate isolation/clearance in external wiring from high to low voltage circuits.

Use the device only for its intended purpose and application.

Ensure that all ground paths are uncompromised for safety purposes during device operation and service.

Ensure that the control power applied to the device, the alternating current (AC), and voltage input match the ratings specified on the relay nameplate. Do not apply current or voltage in excess of the specified limits.

1

Only qualified personnel are to operate the device. Such personnel must be thoroughly familiar with all safety cautions and warnings in this manual and with applicable country, regional, utility, and plant safety regulations. Hazardous voltages can exist in the power supply and at the device connection to current transformers, voltage transformers, control, and test circuit terminals. Make sure all sources of such voltages are isolated prior to attempting work on the device.

Hazardous voltages can exist when opening the secondary circuits of live current transformers. Make sure that current transformer secondary circuits are shorted out before making or removing any connection to the current transformer (CT) input terminals of the device.

For tests with secondary test equipment, ensure that no other sources of voltages or currents are connected to such equipment and that trip and close commands to the circuit breakers or other switching apparatus are isolated, unless this is required by the test procedure and is specified by appropriate utility/plant procedure.

When the device is used to control primary equipment, such as circuit breakers, isolators, and other switching apparatus, all control circuits from the device to the primary equipment must be isolated while personnel are working on or around this primary equipment to prevent any inadvertent command from this device.

Use an external disconnect to isolate the mains voltage supply.

Personal safety can be affected if the product is physically modified by the end user. Modifications to the product outside of recommended wiring configuration, hardware, or programming boundaries is not recommended end-use practice. Product disassembly and repairs are not permitted. All service needs to be conducted by the factory.



LED transmitters are classified as IEC 60825-1 Accessible Emission Limit (AEL) Class 1M. Class 1M devices are considered safe to the unaided eye. Do not view directly with optical instruments.

NOTICE

This product is rated to Class A emissions levels and is to be used in Utility, Substation Industrial environments. Not to be used near electronic devices rated for Class B levels.

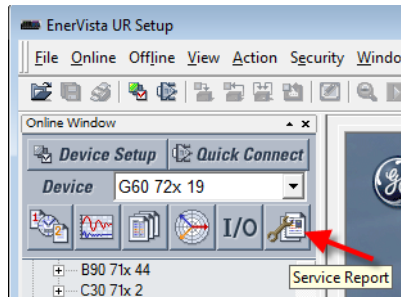
1.2 For further assistance

For product support, contact the information and call center as follows:

GE Grid Solutions
650 Markland Street
Markham, Ontario
Canada L6C 0M1
Worldwide telephone: +1 905 927 7070
Europe/Middle East/Africa telephone: +34 94 485 88 54
North America toll-free: 1 800 547 8629
Fax: +1 905 927 5098
Worldwide e-mail: multilin.tech@ge.com
Europe e-mail: multilin.tech.euro@ge.com
Website: <http://www.gegridsolutions.com/multilin>

When contacting GE by e-mail, optionally include a device information file, which is generated in the EnerVista software by clicking the **Service Report** button. The service report also can be generated in the field, for example with a USB cable connected between the graphical front panel and a computer, and the Device Setup configured for the USB connection.

Figure 1-1: Generate service report in EnerVista software





L30 Line Current Differential System

Chapter 2: Product description

This chapter outlines the product, order codes, and specifications.

2.1 Product description

The L30 Line Current Differential System is part of the Universal Relay (UR) series of products. It is a digital current differential relay system with an integral communications channel interface.

The L30 is intended to provide complete protection for transmission lines of any voltage level. Both three phase and single phase tripping schemes are available. Models of the L30 are available for application on both two and three terminal lines. The L30 uses per phase differential at 64 kbps transmitting two phaselets per cycle. The current differential scheme is based on innovative patented techniques developed by GE. The L30 algorithms are based on the Fourier transform–phaselet approach and an adaptive statistical restraint. The restraint is similar to a traditional percentage differential scheme, but is adaptive based on relay measurements. When used with a 64 kbps channel, the innovative phaselets approach yields an operating time of 1.0 to 1.5 cycles (typical). The adaptive statistical restraint approach provides both more sensitive and more accurate fault sensing. This allows the L30 to detect relatively higher impedance single line to ground faults that existing systems may not. The basic current differential element operates on current input only. Long lines with significant capacitance can benefit from charging current compensation if terminal voltage measurements are applied to the relay. The voltage input is also used for some protection and monitoring features, such as directional elements, fault locator, metering, and distance backup.

The L30 is designed to operate over different communications links with various degrees of noise encountered in power systems and communications environments. Since correct operation of the relay is completely dependent on data received from the remote end, special attention must be paid to information validation. The L30 incorporates a high degree of security by using a 32-bit CRC (cyclic redundancy code) inter-relay communications packet.

Several options are available for communication. An RS232 port (USB port with the graphical front panel) can be used to connect to a computer for the programming of settings and the monitoring of actual values. The rear RS485 port allows independent access by operating and engineering staff. It can be connected to system computers with baud rates up to 115.2 kbps. All serial ports use the Modbus RTU protocol. The IEC 60870-5-103 protocol is supported on the RS485 interface. IEC 60870-5-103, DNP, and Modbus cannot be enabled simultaneously on this interface. Also only one of the DNP, IEC 60870-5-103, and IEC 60870-5-104 protocols can be enabled at any time on the relay. When the IEC 60870-5-103 protocol is chosen, the RS485 port has a fixed even parity and the baud rate can be either 9.6 kbps or 19.2 kbps. The 100Base-FX or 100Base-T Ethernet interface provides fast, reliable communications in noisy environments. The Ethernet port supports IEC 61850, IEC 61850-90-5, Modbus/TCP, TFTP, and PTP (according to IEEE Std. 1588-2008 or IEC 61588), and it allows access to the relay via any standard web browser (L30 web pages). The IEC 60870-5-104 protocol is supported on the Ethernet port. The Ethernet port also supports the Parallel Redundancy Protocol (PRP) of IEC 62439-3 (clause 4, 2012) when purchased as an option.

Secure Routable GOOSE (R-GOOSE) is supported with software options.

In addition to current differential protection, the relay provides multiple backup protection for phase and ground faults. For overcurrent protection, the time overcurrent curves can be selected from a selection of standard curve shapes or a custom FlexCurve™ for optimum co-ordination.

The L30 incorporates charging current compensation for applications on very long transmission lines without loss of sensitivity. The line capacitive current is removed from the terminal phasors.

For breaker-and-a-half or ring applications, the L30 design provides secure operation during external faults with possible CT saturation.

Voltage, current, and power metering is built into the relay as a standard feature. Current parameters are available as total waveform RMS magnitude, or as fundamental frequency only RMS magnitude and angle (phasor).

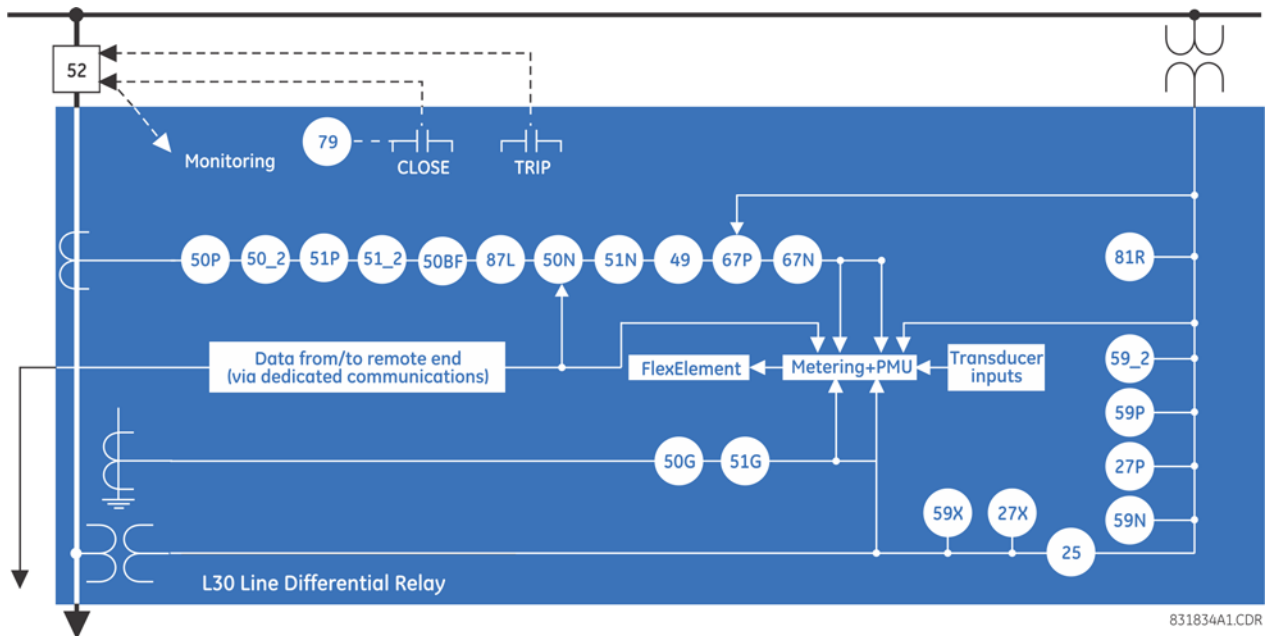
The L30 uses flash memory technology that allows field upgrading as new features are added. Firmware and software are upgradable.

The following single-line diagram illustrates the relay functionality using American National Standards Institute (ANSI) device numbers.

Table 2-1: ANSI device numbers and functions supported

Device number	Function	Device number	Function
25	Synchrocheck	51_2	Negative-sequence time overcurrent
27P	Phase undervoltage	52	AC circuit breaker
27X	Auxiliary undervoltage	59N	Neutral overvoltage
49	Thermal overload protection	59P	Phase overvoltage
50BF	Breaker failure	59_2	Negative-sequence overvoltage
50DD	Current disturbance detector	59X	Auxiliary overvoltage
50G	Ground instantaneous overcurrent	67N	Neutral directional overcurrent
50N	Neutral instantaneous overcurrent	67P	Phase directional overcurrent
50P	Phase instantaneous overcurrent	79	Automatic recloser
50_2	Negative-sequence instantaneous overcurrent	81R	Rate of change frequency
51G	Ground time overcurrent	81U	Underfrequency
51N	Neutral time overcurrent	87L	Segregated line current differential
51P	Phase time overcurrent	87LG	Line ground current differential

Figure 2-1: Single-line diagram



2

Table 2-2: Other device functions

Function	Function	Function
Breaker arcing current (I ² t)	Event recorder	Oscillography
Breaker control	Fault locator and fault reporting	Setting groups (6)
Channel tests	FlexElements™ (8)	Stub bus
Contact inputs (up to 120)	FlexLogic equations	Synchrophasor (PMU)
Contact outputs (up to 72)	IEC 60870-5-103 communications	Time synchronization over IRIG-B or IEEE 1588
Control pushbuttons	IEC 61850 communications	Time synchronization over SNTP
CT failure detector	IEC 62351-9 data and communications security	Transducer inputs and outputs
CyberSentry™ security	Incipient cable fault detection	User-definable displays
Data logger	Metering: Current, voltage, power, frequency, power factor, 87L current, local and remote phasors, harmonics, THD	User-programmable LEDs
Digital counters (8)	Modbus communications	User-programmable pushbuttons
Digital elements (48)	Modbus user map	User-programmable self-tests
Direct inputs (8 per pilot channel)	Non-volatile latches	Virtual inputs (64)
Disconnect switches	Non-volatile selector switch	Virtual outputs (96)
DNP 3.0 or IEC 60870-5-104 protocol	Open pole detector	VT fuse failure

2.1.1 Features

2.1.1.1 Line current differential

- Phase segregated, high-speed digital current differential system
- Overhead and underground AC transmission lines, series compensated lines
- Two-terminal and three-terminal line applications

- Zero-sequence removal for application on lines with tapped transformers connected in a grounded wye on the line side
- GE phaselets approach based on the Discrete Fourier Transform with 64 samples per cycle and transmitting two time-stamped phaselets per cycle
- Adaptive restraint approach improving sensitivity and accuracy of fault sensing
- Accommodates in-zone transformer with a magnitude and phase compensation and second harmonic inhibit during transformer magnetizing inrush
- Continuous clock synchronization via the distributed synchronization technique
- Increased transient stability through DC decaying offset removal
- Accommodates up to five times CT ratio differences
- Peer-to-peer (master-master) architecture changing to master-slave via DTT (if channel fails) at 64 kbps
- Charging current compensation
- Interfaces direct fiber, multiplexed RS422, IEEE C37.94, and G.703 connections with relay ID check
- Per-phase line differential protection direct transfer trip plus eight user-assigned pilot signals via the communications channel
- Secure 32-bit CRC protection against communications errors
- Channel asymmetry (up to 10 ms) compensation using GPS satellite-controlled clock

2.1.1.2 Backup protection

- DTT provision for pilot schemes
- Two-element time overcurrent and two-element instantaneous overcurrent directional phase overcurrent protection
- Two-element time overcurrent and two-element instantaneous overcurrent directional zero-sequence protection
- Two-element time overcurrent and two-element instantaneous overcurrent negative-sequence overcurrent protection
- Undervoltage and overvoltage protection

2.1.1.3 Additional protection

- Breaker failure protection
- Stub bus protection
- VT and CT supervision
- GE Multilin *sources* approach allowing grouping of different CTs and VTs from multiple input channels
- Open pole detection
- Breaker trip coil supervision and seal-in of trip command
- FlexLogic allowing creation of user-defined distributed protection and control logic

2.1.1.4 Control

- One and two breaker configuration for breaker-and-a-half and ring bus schemes, pushbutton control from the relay
- Auto-reclosing and synchrochecking
- Breaker arcing current

2.1.1.5 Monitoring

- Oscillography of current, voltage, FlexLogic operands, and digital signals (1 × 128 cycles to 31 × 8 cycles configurable)
- Events recorder: 1024 events
- Fault locator

2.1.1.6 Metering

- Actual 87L remote phasors, differential current, channel delay, and channel asymmetry at all line terminals of line current differential protection
- Line current, voltage, real power, reactive power, apparent power, power factor, and frequency

2.1.1.7 Communications

- Front panel RS232 port: 19.2 kbps
- Rear RS485 port: up to 115 kbps
- Rear 100Base-FX Ethernet port supporting the IEC 61850 protocol

2.2 Pilot channel relaying

2.2.1 Inter-relay communications

Dedicated inter-relay communications can operate over 64 kbps digital channels or dedicated fiber optic channels. Available interfaces include:

- RS422 at 64 kbps
- G.703 at 64 kbps
- Dedicated fiber optics at 64 kbps, including
 - 820 nm multimode fiber with an LED transmitter
 - 1300 nm multimode fiber with an LED transmitter
 - 1300 nm single-mode fiber with an ELED transmitter
 - 1300 nm single-mode fiber with a laser transmitter
 - 1550 nm single-mode fiber with a laser transmitter
 - IEEE C37.94 820 nm multimode fiber with an LED transmitter

All fiber optic options use an ST connector. L30 models are available for use on two or three terminal lines. A two terminal line application requires one bidirectional channel. However, in two terminal line applications, it is also possible to use an L30 relay with two bidirectional channels. The second bidirectional channel provides a redundant backup channel with automatic switchover if the first channel fails.

The L30 current differential relay is designed to function in a peer-to-peer or master-to-master architecture. In the peer-to-peer architecture, all relays in the system are identical and perform identical functions in the current differential scheme. In order for every relay on the line to be a peer, each relay must be able to communicate with all of the other relays. If there is a failure in communications among the relays, the relays revert to a master-to-peer architecture on a three-terminal system, with the master as the relay that has current phasors from all terminals. Using two different operational modes increases the dependability of the current differential scheme on a three-terminal system by reducing reliance on communications.

The main difference between a master and a slave L30 is that only a master relay performs the actual current differential calculation, and only a master relay communicates with the relays at all other terminals of the protected line.

At least one master L30 relay must have live communications to all other terminals in the current differential scheme; the other L30 relays on that line operate as slave relays. All master relays in the scheme are equal, and each performs all functions. Each L30 in the scheme determines if it is a master by comparing the number of terminals on the line to the number of active communication channels.

The slave terminals only communicate with the master; there is no slave-to-slave communications path. As a result, a slave L30 cannot calculate the differential current. When a master L30 relay issues a local trip signal, it also sends a direct transfer trip (DTT) signal to all of the other L30 relays on the protected line.

If a slave L30 issues a trip from one of its backup functions, it can send a transfer trip signal to its master and other slave relays if such option is designated. Because a slave cannot communicate with all the relays in the differential scheme, the master then “broadcasts” the direct transfer trip (DTT) signal to all other terminals.

The slave L30 performs the following functions:

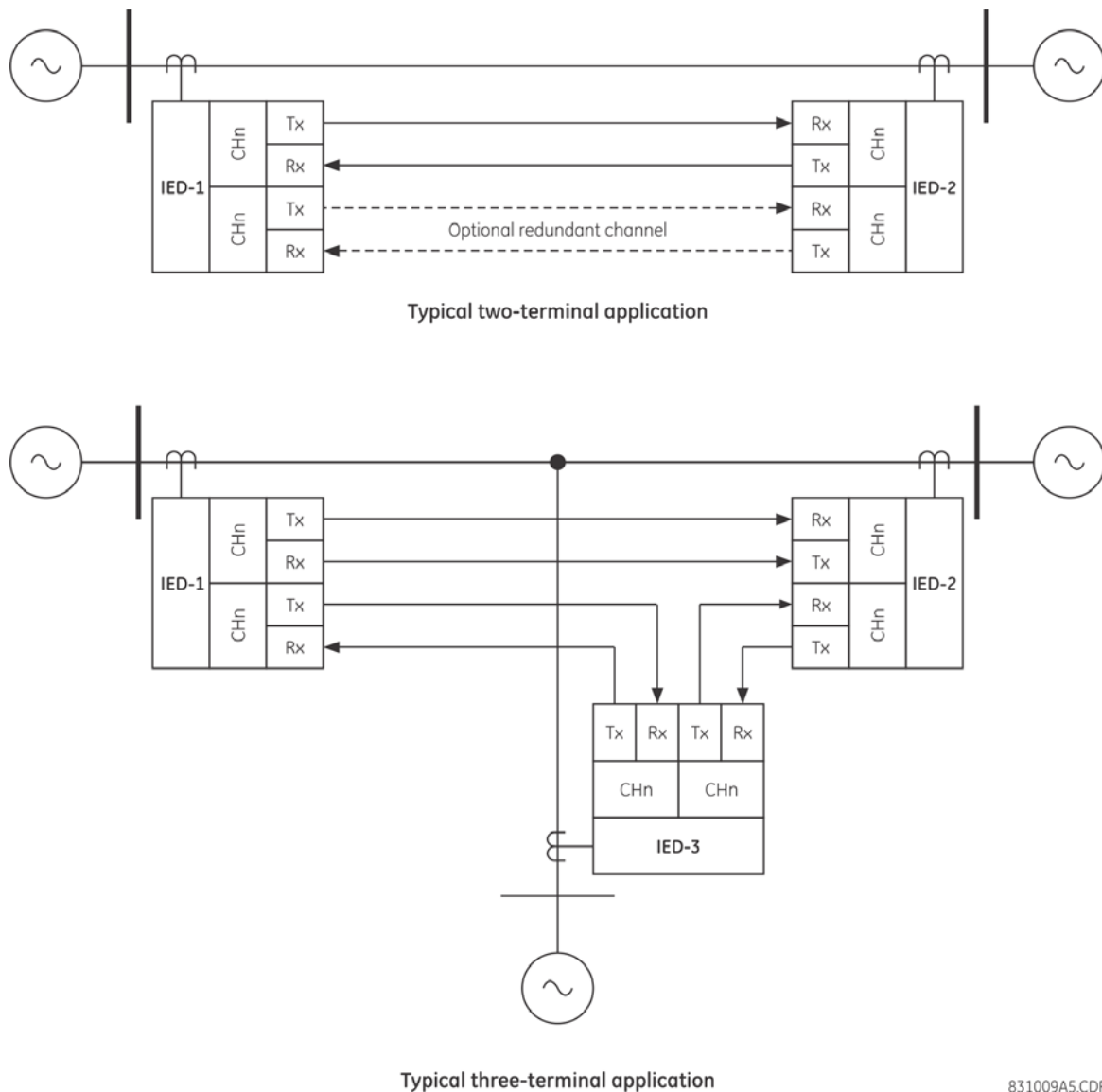
- Samples currents and voltages
- Removes DC offset from the current via the mimic algorithm
- Creates phaselets
- Calculates sum of squares data
- Transmits current data to all master L30 relays
- Performs all local relaying functions
- Receives current differential DTT and Direct Input signals from all other L30 relays
- Transmits direct output signals to all communicating relays
- Sends synchronization information of local clock to all other L30 clocks

The master L30 relay performs the following functions:

- Performs all functions of a slave L30
- Receives current phasor information from all relays
- Performs the current differential algorithm
- Sends a current differential DTT signal to all L30 relays on the protected line

In the peer-to-peer mode, all L30 relays act as masters.

Figure 2-2: Communication paths



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2.2.2 Channel monitor

The L30 has logic to detect that the communications channel is deteriorating or has failed completely. This can provide an alarm indication and disable the current differential protection. Note that a failure of the communications from the master to a slave does not prevent the master from performing the current differential algorithm; failure of the communications from a slave to the master prevents the master from performing the correct current differential logic. Channel propagation delay is being continuously measured and adjusted according to changes in the communications path. Every relay on the protection system can be assigned a unique ID to prevent inadvertent loopbacks at multiplexed channels.

2.2.3 Loopback test

This option allows the user to test the relay at one terminal of the line by looping the transmitter output to the receiver input. At the same time, the signal sent to the remote does not change. A local loopback feature is included in the relay to simplify single ended testing.

2.2.4 Direct transfer tripping

The L30 includes provision for sending and receiving a single-pole direct transfer trip (DTT) signal from current differential protection among the L30 relays at the line terminals using the pilot communications channel. The user can also initiate an additional eight pilot signals with an L30 communications channel to create trip, block, or signaling logic. A FlexLogic operand, an external contact closure, or a signal over the LAN communication channels can be assigned for that logic.

2

2.3 Security

The following security features are available:

- Password security — Basic security present by default
- EnerVista security — Role-based access to various EnerVista software screens and configuration elements. The feature is present by default in the EnerVista software.
- CyberSentry security — Advanced security available using a software option. When purchased, the option is automatically enabled, and the default Password security and EnerVista security are disabled.

2.3.0.1 EnerVista security

The EnerVista security management system is a role-based access control (RBAC) system that allows an administrator to manage the privileges of multiple users. This allows for access control of UR devices by multiple personnel within a substation and conforms to the principles of RBAC as defined in ANSI INCITS 359-2004. The EnerVista security management system is disabled by default to allow the administrator direct access to the EnerVista software after installation. It is recommended that security be enabled before placing the device in service.

Basic password or enhanced CyberSentry security applies, depending on purchase.

2.3.0.2 Password security

Password security is a basic security feature present by default.

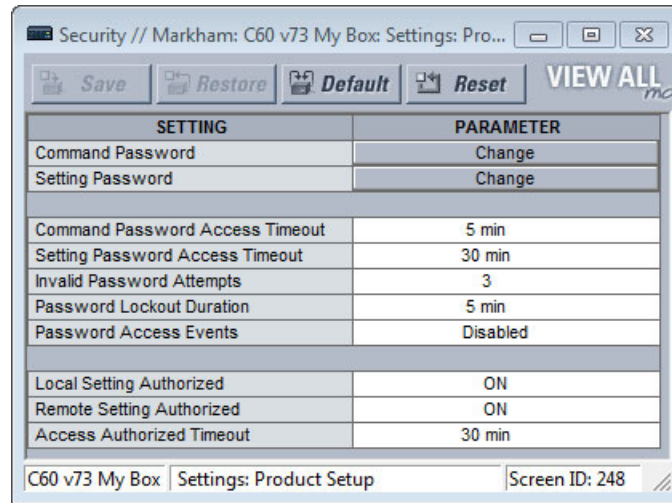
Two levels of password security are provided: command and setting. Use of a password for each level controls whether all users can enter commands and/or change settings.

Two types of connection security are provided: password entry from local or remote connection. Local access is defined as any access to settings or commands via the front panel interface. This includes both keypad entry and the through a front panel port. Remote access is defined as any access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. These two settings are on by default and apply to all users.

When entering a settings or command password via EnerVista or any serial interface, the user must enter the corresponding connection password. If the connection is to the back of the L30, the remote password is used. If the connection is to a front panel port, the local password applies. (These two local and remote password settings are not shown the figure.)

Password access events are logged in the Event Recorder.

Figure 2-3: Access control by passwords and connection type



2.3.0.3 CyberSentry security

CyberSentry security is available using software options that provide advanced security services. When an option is purchased, the basic password security is disabled automatically.

CyberSentry provides security through the following features:

- An Authentication, Authorization, Accounting (AAA) Remote Authentication Dial-In User Service (RADIUS) client that is centrally managed, enables user attribution, provides accounting of all user activities, and uses secure standards-based strong cryptography for authentication and credential protection
- A Role-Based Access Control (RBAC) system that provides a permission model that allows access to UR device operations and configurations based on specific roles and individual user accounts configured on the AAA server (that is, Administrator, Supervisor, Engineer, Operator, Observer roles)
- Security event reporting through the Syslog protocol for supporting Security Information Event Management (SIEM) systems for centralized cybersecurity monitoring
- Strong encryption of all access and configuration network messages between the EnerVista software and UR devices using the Secure Shell (SSH) protocol, the Advanced Encryption Standard (AES), and 128-bit keys in Galois Counter Mode (GCM) as specified in the U.S. National Security Agency Suite B extension for SSH and approved by the National Institute of Standards and Technology (NIST) FIPS-140-2 standards for cryptographic systems

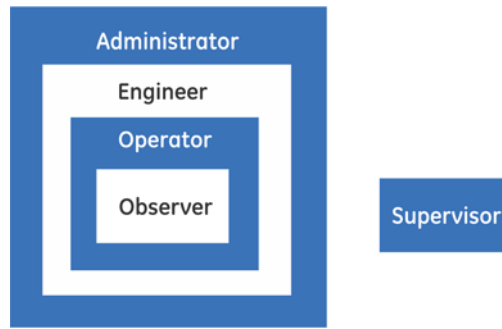
CyberSentry user roles

CyberSentry user roles (Administrator, Engineer, Operator, Supervisor, Observer) limit the levels of access to various UR functions. This means that the EnerVista software allows for access to functionality based on the user's logged in role.

Example: Administrative functions can be segmented from common operator functions, or engineering type access, all of which are defined by separate roles so that access of UR devices by multiple personnel within a substation is allowed.

One role of one type is allowed to be logged in at a time. For example, one Operator can be logged in but not a second Operator at the same time. This prevents subsets of settings from being changed at the same time.

Figure 2-4: CyberSentry user roles



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The table lists user roles and their corresponding capabilities.

Table 2-3: Permissions by user role for CyberSentry

	Administrator	Engineer	Operator	Supervisor	Observer
Summary	Complete access	Complete access except for CyberSentry Security	Command menu	Authorizes writing	Default role
Device Definition	R	R	R	R	R
Settings					
----- Product Setup					
----- Security (CyberSentry)	RW	R	R	R	R
----- Supervisory	See table notes	R	R	See table notes	R
----- Display Properties	RW	RW	R	R	R
----- Clear Relay Records (settings)	RW	RW	R	R	R
----- Communications	RW	RW	R	R	R
----- Modbus User Map	RW	RW	R	R	R
----- Real Time Clock	RW	RW	R	R	R
----- Oscillography	RW	RW	R	R	R
----- Data Logger	RW	RW	R	R	R
----- Demand	RW	RW	R	R	R
----- User-Programmable LEDs	RW	RW	R	R	R
----- User-Programmable Self Tests	RW	RW	R	R	R
----- Control Pushbuttons	RW	RW	R	R	R
----- User-Programmable Pushbuttons	RW	RW	R	R	R
----- Flex state Parameters	RW	RW	R	R	R
----- User-Definable Displays	RW	RW	R	R	R
----- Direct I/O	RW	RW	R	R	R
----- Teleprotection	RW	RW	R	R	R
----- Installation	RW	RW	R	R	R
----- System Setup	RW	RW	R	R	R

	Administrator	Engineer	Operator	Supervisor	Observer
----- FlexLogic	RW	RW	R	R	R
----- Grouped Elements	RW	RW	R	R	R
----- Control Elements	RW	RW	R	R	R
----- Inputs / Outputs	RW	RW	R	R	R
----- Contact Inputs	RW	RW	R	R	R
----- Contact Input threshold	RW	RW	R	R	R
----- Virtual Inputs	RW	RW	R	R	R
----- Contact Outputs	RW	RW	R	R	R
----- Virtual Outputs	RW	RW	R	R	R
----- Resetting	RW	RW	R	R	R
----- Direct Inputs	RW	RW	R	R	R
----- Direct Outputs	RW	RW	R	R	R
----- Teleprotection	RW	RW	R	R	R
----- Direct Analogs	RW	RW	R	R	R
----- Direct Integers	RW	RW	R	R	R
----- Transducer I/O	RW	RW	R	R	R
----- Testing	RW	RW	R	R	R
----- Front Panel Labels Designer	NA	NA	NA	NA	NA
----- Protection Summary	NA	NA	NA	NA	NA
Commands	RW	RW	RW	R	R
----- Virtual Inputs	RW	RW	RW	R	R
----- Clear Records	RW	RW	RW	R	R
----- Set Date and Time	RW	RW	RW	R	R
User Displays	R	R	R	R	R
Targets	R	R	R	R	R
Actual Values	R	R	R	R	R
----- Front panel labels designer	R	R	R	R	R
----- Status	R	R	R	R	R
----- Metering	R	R	R	R	R
----- Transducer I/O	R	R	R	R	R
----- Records	R	R	R	R	R
----- Product Info	R	R	R	R	R
Maintenance	RW	RW	R	R	R
----- Modbus Analyzer	NA	NA	NA	NA	NA
----- Change front panel	RW	RW	RW	R	R
----- Update firmware	Yes	No	No	No	No
----- Retrieve file	Yes	No	No	No	No

Table Notes:

RW = read and write access

R = read access

Supervisor = RW (default), Administrator = R (default), Administrator = RW (only if Supervisor role is disabled)

NA = the permission is not enforced by CyberSentry security

CyberSentry user authentication

The following types of authentication are supported by CyberSentry to access the UR device:

- Device Authentication (local UR device authenticates)
- Server Authentication (RADIUS server authenticates)

The EnerVista software allows access to functionality that is determined by the user role, which comes either from the local UR device or the RADIUS server.

The EnerVista software has a device authentication option on the login screen for accessing the UR device. When the "Device" button is selected, the UR uses its local authentication database and not the RADIUS server to authenticate the user. In this case, it uses its built-in roles (Administrator, Engineer, Supervisor, Observer, Operator, or Administrator and Supervisor when Device Authentication is disabled) as login names and the associated passwords are stored on the UR device. As such, when using the local accounts, access is not user-attributable.

In cases where user-attributable access is required especially to facilitate auditable processes for compliance reasons, use RADIUS authentication.

When the "Server" Authentication Type option is selected, the UR uses the RADIUS server and not its local authentication database to authenticate the user.

No password or security information is displayed in plain text by the EnerVista software or UR device, nor is such information ever transmitted without cryptographic protection.

CyberSentry server authentication

The UR has been designed to direct automatically the authentication requests based on user names. In this respect, local account names on the UR are considered as reserved and not used on a RADIUS server.

The UR detects automatically whether an authentication request is to be handled remotely or locally. As there are five local accounts possible on the UR, if the user ID credential does not match one of the five local accounts, the UR forwards automatically the request to a RADIUS server when one is provided.

If a RADIUS server is provided, but is unreachable over the network, server authentication requests are denied. In this situation, use local UR accounts to gain access to the UR system.

2.4 Order codes

The order code is on the product label and indicates the product options applicable.

The L30 is available as a 19-inch rack horizontal mount or reduced-size (¾) vertical unit. It consists of the following modules: power supply, CPU, CT/VT, contact input and output, transducer input and output, and inter-relay communications. Module options are specified at the time of ordering.

The order codes shown here are subject to change without notice. See the web page for the product for the latest options.

The order code depends on the mounting option (horizontal or vertical) and the type of CT/VT modules (enhanced diagnostic CT/VT modules or HardFiber™ process bus module). The process bus module provides an interface to HardFiber Bricks.



The R-GOOSE protocol described in IEC 61850-8-1 is available through the IEC 61850 software option. R-GOOSE security requires the CyberSentry software option.

For Japanese, the settings display in Japanese on the graphical front panel, while the keys printed on the panel are in English.

High density input/output modules 6W and 6X are not for use with the SL low voltage power supply.



BASE UNIT	L30	- *	**	- *	* *	- P **	- H **	- L **	- N **	- S **	- U **	- W/X **	Full Size Horizontal Mount
	L30												Base Unit
													IEEE 1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection, + IEC 61850
													IEEE 1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection + PMU
													IEEE 1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850 + PMU
													IEC 60870-5-103
													IEC 60870-5-103 + IEC 61850
													IEC 60870-5-103 + PMU
													IEC 60870-5-103 + IEC 61850 + PMU
													IEC 60870-5-103 + three-pole autoreclose + synchrocheck
													IEC 60870-5-103 + three-pole autoreclose + PMU + synchrocheck + IEC 61850
													IEC 60870-5-103 + in-zone transformer protection
													IEC 60870-5-103 + in-zone transformer protection + IEC 61850
													IEC 60870-5-103 + in-zone transformer protection + PMU
													IEC 60870-5-103 + in-zone transformer protection + IEC 61850 + PMU
													IEEE1588 + PRP + IEC 60870-5-103
													IEEE1588 + PRP + IEC 60870-5-103 + IEC 61850
													IEEE1588 + PRP + IEC 60870-5-103 + PMU
													IEEE1588 + PRP + IEC 60870-5-103 + IEC 61850 + PMU
													IEEE1588 + PRP + IEC 60870-5-103 + three-pole autoreclose + synchrocheck + IEC 61850
													IEEE1588 + PRP + IEC 60870-5-103 + three-pole autoreclose + PMU + synchrocheck + IEC 61850
													IEEE1588 + PRP + IEC 60870-5-103 + in-zone transformer protection
													IEEE1588 + PRP + IEC 60870-5-103 + in-zone transformer protection + IEC 61850
													IEEE1588 + PRP + IEC 60870-5-103 + in-zone transformer protection + IEC 61850 + PMU
													IEEE1588 + PRP + IEC 60870-5-103 + in-zone transformer protection + PMU
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry Lvl 1
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry Lvl 1 + IEC 61850
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry Lvl 1 + PMU
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry Lvl 1 + IEC 61850 + PMU
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry Lvl 1 + three-pole autoreclose + synchrocheck + IEC 61850
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry Lvl 1 + three-pole autoreclose + PMU + synchrocheck + IEC 61850
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection + PMU
													IEC 61850 + PMU + 61850-90-5
													In-zone TX protection + IEC 61850 + PMU + 61850-90-5
													CyberSentry UR Lvl 1 + IEC 61850 + PMU + 61850-90-5
													CyberSentry UR Lvl 1 + In-zone TX protection + IEC 61850 + PMU + 61850-90-5
													IEEE 1588 + IEC 61850 + PMU + 61850-90-5
													IEEE 1588 + In-zone TX protection + IEC 61850 + PMU + 61850-90-5
													PRP + IEC 61850 + PMU + 61850-90-5
													PRP + In-zone TX protection + IEC 61850 + PMU + 61850-90-5
													IEEE 1588 + CyberSentry UR Lvl 1 + IEC 61850 + PMU + 61850-90-5
													IEEE 1588 + CyberSentry UR Lvl 1 + In-zone TX protection + IEC 61850 + PMU + 61850-90-5
													IEEE 1588 + PRP + IEC 61850 + PMU + 61850-90-5
													IEEE 1588 + PRP + In-zone TX protection + IEC 61850 + PMU + 61850-90-5
													PRP + CyberSentry UR Lvl 1 + IEC 61850 + PMU + 61850-90-5
													PRP + CyberSentry UR Lvl 1 + In-zone TX protection + IEC 61850 + PMU + 61850-90-5
													IEEE 1588 + PRP + CyberSentry UR Lvl 1 + IEC 61850 + PMU + 61850-90-5
													IEEE 1588 + PRP + CyberSentry UR Lvl 1 + In-zone TX protection + IEC 61850 + PMU + 61850-90-5
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry UR Lvl 1 + IEC 61850 + PMU + 61850-90-5
													IEC 60870-5-103 + IEE1588 + PRP + CyberSentry UR Lvl 1 + In-zone TX protection + IEC 61850 + PMU + 61850-90-5
MOUNT/COATING													Horizontal (19" rack)
													Horizontal (19" rack) with harsh environmental coating
FRONT PANEL + INTERFACE													English display
													French display
													Russian display
													Chinese display
													English display with 4 small and 12 large programmable pushbuttons
													French display with 4 small and 12 large programmable pushbuttons
													Russian display with 4 small and 12 large programmable pushbuttons
													Chinese display with 4 small and 12 large programmable pushbuttons
													Enhanced front panel with English display
													Enhanced front panel with French display
													Enhanced front panel with Russian display
													Enhanced front panel with Chinese display
													Enhanced front panel with English display and user-programmable pushbuttons
													Enhanced front panel with French display and user-programmable pushbuttons
													Enhanced front panel with Russian display and user-programmable pushbuttons
													Enhanced front panel with Chinese display and user-programmable pushbuttons
													Enhanced front panel with Turkish display

Table 2-5: L30 order codes for reduced-size vertical units

BASE UNIT	L30	*	**	*	*	*	F **	- H **	- L **	- N **	- R **	Reduced Size Vertical Mount
CPU	L30	U										Base Unit RS485 and three multi-mode fiber 100Base-FX Ethernet (SFP with LC) RS485 and two multi-mode fiber 100Base-FX Ethernet (SFP with LC), one 10/100Base-TX Ethernet (SFP with RJ45)
SOFTWARE OPTIONS		V										RS485 and three 10/100Base-TX Ethernet (SFP with RJ45) RS485 with two 100Base-FX Ethernet, multimode ST + 10/100Base-TX Ethernet, RJ-45
		W										No software options IEC 61850 Phasor measurement unit (PMU) IEC 61850 + PMU Synchrocheck + three-pole autoreclose + IEC 61850 Synchrocheck + three-pole autoreclose + PMU In-zone transformer protection In-zone transformer protection + IEC 61850 In-zone transformer protection + PMU In-zone transformer protection + IEC 61850 + PMU CyberSentry Lvl 1 CyberSentry Lvl 1 + IEC 61850 CyberSentry Lvl 1 + PMU CyberSentry Lvl 1 + IEC 61850 + PMU CyberSentry Lvl 1 + three-pole autoreclose + synchrocheck + IEC 61850 CyberSentry Lvl 1 + three-pole autoreclose + synchrocheck + PMU + IEC 61850 CyberSentry Lvl 1 + in-zone transformer protection CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850 CyberSentry Lvl 1 + in-zone transformer protection + PMU CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850 + PMU IEEE 1588 IEEE 1588 + IEC 61850 IEEE 1588 + PMU IEEE 1588 + IEC 61850 + PMU IEEE 1588 + three-pole autoreclose + synchrocheck + IEC 61850 IEEE 1588 + three-pole autoreclose + synchrocheck + PMU + IEC 61850 IEEE 1588 + in-zone transformer protection IEEE 1588 + in-zone transformer protection + IEC 61850 IEEE 1588 + in-zone transformer protection + PMU IEEE 1588 + in-zone transformer protection + IEC 61850 + PMU Parallel Redundancy Protocol (PRP) PRP + IEC 61850 PRP + PMU PRP + IEC 61850 + PMU PRP + three-pole autoreclose + synchrocheck + IEC 61850 PRP + three-pole autoreclose + PMU + synchrocheck + IEC 61850 PRP + in-zone transformer protection PRP + in-zone transformer protection + IEC 61850 PRP + in-zone transformer protection + PMU PRP + in-zone transformer protection + IEC 61850 + PMU IEEE 1588 + CyberSentry Lvl 1 IEEE 1588 + CyberSentry Lvl 1 + IEC 61850 IEEE 1588 + CyberSentry Lvl 1 + PMU IEEE 1588 + CyberSentry Lvl 1 + IEC 61850 + PMU IEEE 1588 + CyberSentry Lvl 1 + three-pole autoreclose + synchrocheck + IEC 61850 IEEE 1588 + CyberSentry Lvl 1 + three-pole autoreclose + synchrocheck + PMU + IEC 61850 IEEE 1588 + CyberSentry Lvl 1 + in-zone transformer protection IEEE 1588 + CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850 IEEE 1588 + CyberSentry Lvl 1 + in-zone transformer protection + PMU IEEE 1588 + CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850 + PMU IEEE 1588 and PRP IEEE 1588 + PRP + IEC 61850 IEEE 1588 + PRP + PMU IEEE 1588 + PRP + IEC 61850 + PMU IEEE 1588 + PRP + three-pole autoreclose + synchrocheck + IEC 61850 IEEE 1588 + PRP + three-pole autoreclose + PMU + synchrocheck + IEC 61850 IEEE 1588 + PRP + in-zone transformer protection IEEE 1588 + PRP + in-zone transformer protection + IEC 61850 IEEE 1588 + PRP + in-zone transformer protection + PMU IEEE 1588 + PRP + in-zone transformer protection + IEC 61850 + PMU PRP + CyberSentry Lvl 1 PRP + CyberSentry Lvl 1 + IEC 61850 PRP + CyberSentry Lvl 1 + PMU PRP + CyberSentry Lvl 1 + IEC 61850 + PMU PRP + CyberSentry Lvl 1 + three-pole autoreclose + synchrocheck + IEC 61850 PRP + CyberSentry Lvl 1 + three-pole autoreclose + PMU + synchrocheck + IEC 61850 PRP + CyberSentry Lvl 1 + in-zone transformer protection PRP + CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850 PRP + CyberSentry Lvl 1 + in-zone transformer protection + PMU PRP + CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850 + PMU IEEE 1588 + PRP + CyberSentry Lvl 1 IEEE 1588 + PRP + CyberSentry Lvl 1 + IEC 61850 IEEE 1588 + PRP + CyberSentry Lvl 1 + PMU IEEE 1588 + PRP + CyberSentry Lvl 1 + IEC 61850 + PMU IEEE 1588 + PRP + CyberSentry Lvl 1 + three-pole autoreclose + synchrocheck + IEC 61850 IEEE 1588 + PRP + CyberSentry Lvl 1 + three-pole autoreclose + PMU + synchrocheck + IEC 61850 IEEE 1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection IEEE 1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850 IEEE 1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection + PMU IEEE 1588 + PRP + CyberSentry Lvl 1 + in-zone transformer protection + IEC 61850 + PMU IEC 60870-5-103 IEC 60870-5-103 + IEC 61850 IEC 60870-5-103 + PMU IEC 60870-5-103 + IEC 61850 + PMU IEC 60870-5-103 + three-pole autoreclose + synchrocheck + IEC 61850 IEC 60870-5-103 + three-pole autoreclose + PMU + synchrocheck + IEC 61850 IEC 60870-5-103 + in-zone transformer protection IEC 60870-5-103 + in-zone transformer protection + IEC 61850 IEC 60870-5-103 + in-zone transformer protection + PMU IEC 60870-5-103 + in-zone transformer protection + IEC 61850 + PMU IEEE1588 + PRP + IEC 60870-5-103 IEEE1588 + PRP + IEC 60870-5-103 + IEC 61850 IEEE1588 + PRP + IEC 60870-5-103 + PMU IEEE1588 + PRP + IEC 60870-5-103 + IEC 61850 + PMU IEEE1588 + PRP + IEC 60870-5-103 + three-pole autoreclose + synchrocheck + IEC 61850



BASE UNIT	L30	- *	**	- *	* *	- F **	- H **	- L **	- N **	- S **	- W/X **	
	L30											Full Size Horizontal Mount Base Unit English display with 4 small and 12 large programmable pushbuttons French display with 4 small and 12 large programmable pushbuttons Russian display with 4 small and 12 large programmable pushbuttons Chinese display with 4 small and 12 large programmable pushbuttons Enhanced front panel with English display Enhanced front panel with French display Enhanced front panel with Russian display Enhanced front panel with Chinese display Enhanced front panel with English display and user-programmable pushbuttons Enhanced front panel with French display and user-programmable pushbuttons Enhanced front panel with Russian display and user-programmable pushbuttons Enhanced front panel with Chinese display and user-programmable pushbuttons Enhanced front panel with Turkish display Enhanced front panel with Turkish display and user-programmable pushbuttons Enhanced front panel with German display Enhanced front panel with German display and user-programmable pushbuttons Enhanced front panel with Polish display Enhanced front panel with Polish display and user-programmable pushbuttons 7" Graphical front panel display in multiple languages with USB front port and programmable pushbuttons (English, French, Chinese, Russian, Turkish, German, Polish, Japanese)
POWER SUPPLY (redundant supply must be same type as main supply)												H H L L SH SL
PROCESS BUS MODULE						81						XX
CONTACT INPUTS/OUTPUTS								XX	XX	XX	XX	XX
												4A 4A 4B 4B 4C 4C 4D 4D 4L 4L 67 67 6A 6A 6B 6B 6C 6C 6D 6D 6E 6E 6F 6F 6G 6G 6H 6H 6K 6K 6L 6L 6M 6M 6N 6N 6P 6P 6R 6R 6S 6S 6T 6T 6U 6U 6V 6V 6W 6W 6X 6X
INTER-RELAY COMMUNICATIONS (select a maximum of 1 per unit)												2A 2B 2E 2F 2G 2H 2I 2J 72 73 74 75 76 77 7A 7B 7C 7D 7E 7F 7G 7H 7I 7J 7K 7L 7M 7N 7P 7Q 7R 7S 7T 7V 7W

Table 2-7: L30 order codes for reduced-size vertical units with process bus

BASE UNIT	L30	- *	**	- *	* *	- F **	- H **	- L **	- N **	- R **	
CPU	L30										Reduced Size Vertical Mount Base Unit RS485 and three multi-mode fiber 100Base-FX Ethernet (SFP with LC) RS485 and two multi-mode fiber 100Base-FX Ethernet (SFP with LC), one 10/100Base-TX Ethernet (SFP with RJ45) RS485 and three 10/100Base-TX Ethernet (SFP with RJ45) RS485 with two 100Base-FX Ethernet, multimode ST + 10/100Base-TX Ethernet, RJ-45
		T									
		U									
		V									
		W									

L30	- *	**	- *	* *	- F **	- H **	- L **	- N **	- R **	
										Reduced Size Vertical Mount
										7G Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
										7H 820 nm, multimode, LED, 2 Channels
										7I 1300 nm, multimode, LED, 2 Channels
										7J 1300 nm, single-mode, ELED, 2 Channels
										7K 1300 nm, single-mode, Laser, 2 Channels
										7L Channel 1 - RS422; Channel 2 - 820 nm, multimode, LED
										7M Channel 1 - RS422; Channel 2 - 1300 nm, multimode, LED
										7N Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, ELED
										7P Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, Laser
										7Q Channel 1 - G.703; Channel 2 - 1300 nm, single-mode Laser
										7R G.703, 1 Channel
										7S G.703, 2 Channels
										7T RS422, 1 Channel
										7V RS422, 2 Channels, 2 Clock Inputs
										7W RS422, 2 Channels

2.4.3 Replacement modules

Replacement modules can be ordered separately. When ordering a replacement CPU module or front panel, provide the serial number of your existing unit.

Not all replacement modules apply to the L30 relay. The modules specified in the order codes for the L30 are available as replacement modules for the L30.

The order codes shown here are subject to change without notice. See the web page for the product for the latest options.

Table 2-8: UR order codes for replacement modules, horizontal units

	UR	- *	**	- *	
POWER SUPPLY redundant supply only available in horizontal units and must be same type as main supply CPU	SH	A			125 / 300 V AC/DC
	SL	H			24 to 48 V (DC only)
FRONT PANEL + INTERFACE	T				RS485 with 3 100Base-FX Ethernet, multimode, SFP with LC
	U				RS485 with 1 100Base-TX Ethernet, SFP RJ-45 + 2 100Base-FX Ethernet, multimode, SFP with LC
	V				RS485 with 3 100Base-TX Ethernet, SFP with RJ-45
	W				RS485 with 2 100Base-FX Ethernet, multimode ST + 10/100Base-TX Ethernet, RJ-45
	3C				Horizontal front panel with keypad and English display
	3D				Horizontal front panel with keypad and French display
	3R				Horizontal front panel with keypad and Russian display
	3A				Horizontal front panel with keypad and Chinese display
	3P				Horizontal front panel with keypad, user-programmable pushbuttons, and English display
	3G				Horizontal front panel with keypad, user-programmable pushbuttons, and French display
	3S				Horizontal front panel with keypad, user-programmable pushbuttons, and Russian display
	3B				Horizontal front panel with keypad, user-programmable pushbuttons, and Chinese display
	3K				Enhanced front panel with English display
	3M				Enhanced front panel with French display
	CONTACT INPUTS AND OUTPUTS	3O			
3U					Enhanced front panel with Chinese display
3L					Enhanced front panel with English display and user-programmable pushbuttons
3N					Enhanced front panel with French display and user-programmable pushbuttons
3T					Enhanced front panel with Russian display and user-programmable pushbuttons
3V					Enhanced front panel with Chinese display and user-programmable pushbuttons
3I					Enhanced front panel with German display
3J					Enhanced front panel with German display and user-programmable pushbuttons
3H					Enhanced front panel with Polish display
3O					Enhanced front panel with Polish display and user-programmable pushbuttons
3Z					Enhanced front panel with Japanese display
3X					Enhanced front panel with Japanese display and user-programmable pushbuttons
3E				7" Graphical front panel display in multiple languages with USB front port and user-programmable pushbuttons	
4A				4 Solid-State (no monitoring) MOSFET outputs	
4B				4 Solid-State (voltage with optional current) MOSFET outputs	
4C				4 Solid-State (current with optional voltage) MOSFET outputs	
4D				16 Contact inputs with Auto-Burnishing	
4L				14 Form-A (no monitoring) Latching outputs	
67				8 Form-A (no monitoring) outputs	
6A				2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 contact inputs	
6B				2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 contact inputs	
6C				8 Form-C outputs	
6D				16 Contact inputs	
6E				4 Form-C outputs, 8 contact inputs	
6F				8 Fast Form-C outputs	
6G				4 Form-A (voltage with optional current) outputs, 8 contact inputs	
6H				6 Form-A (voltage with optional current) outputs, 4 contact inputs	
6K				4 Form-C and 4 Fast Form-C outputs	
6L				2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 contact inputs	
6M				2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 contact inputs	
6N				4 Form-A (current with optional voltage) outputs, 8 contact inputs	
6P				6 Form-A (current with optional voltage) outputs, 4 contact inputs	
6R				2 Form-A (no monitoring) and 2 Form-C outputs, 8 contact inputs	
6S				2 Form-A (no monitoring) and 4 Form-C outputs, 4 contact inputs	
6T				4 Form-A (no monitoring) outputs, 8 contact inputs	
6U				6 Form-A (no monitoring) outputs, 4 contact inputs	
6V				2 Form-A outputs, 1 Form-C output, 2 Form-A (no monitoring) latching outputs, 8 contact inputs	
6W				30 Contact inputs - pin terminals (max 4 modules)	
6X				18 Form-A (no monitoring) outputs - pin terminals (max 4 modules)	
CT/VT MODULES (not available for the C30)	8L				Standard 4CT/4VT with enhanced diagnostics
	8N				Standard 8CT with enhanced diagnostics
	8M				Sensitive Ground 4CT/4VT with enhanced diagnostics
	8R				Sensitive Ground 8CT with enhanced diagnostics
INTER-RELAY COMMUNICATIONS	2A				C37.94SM, 1300 nm single-mode, ELED, 1 channel single-mode
	2B				C37.94SM, 1300 nm single-mode, ELED, 2 channel single-mode
	2E				Bi-phase, single channel
	2F				Bi-phase, dual channel
	2G				IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 1 Channel
	2H				IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 2 Channels
	2I				Channel 1 - IEEE C37.94, multimode, 64/128 kbps; Channel 2 - 1300 nm, single-mode, Laser

UR	-	**	-	*	
2J					Channel 1 - IEEE C37.94, multimode, 64/128 kbps; Channel 2 - 1550 nm, single-mode, Laser
72					1550 nm, single-mode, Laser, 1 Channel
73					1550 nm, single-mode, Laser, 2 Channel
74					Channel 1 - RS422; Channel 2 - 1550 nm, single-mode, Laser
75					Channel 1 - G.703; Channel 2 - 1550 nm, single-mode Laser
76					IEEE C37.94, 820 nm, multimode, LED, 1 Channel
77					IEEE C37.94, 820 nm, multimode, LED, 2 Channels
7A					820 nm, multimode, LED, 1 Channel
7B					1300 nm, multimode, LED, 1 Channel
7C					1300 nm, single-mode, ELED, 1 Channel
7D					1300 nm, single-mode, Laser, 1 Channel
7E					Channel 1 - G.703; Channel 2 - 820 nm, multimode
7F					Channel 1 - G.703; Channel 2 - 1300 nm, multimode
7G					Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
7H					820 nm, multimode, LED, 2 Channels
7I					1300 nm, multimode, LED, 2 Channels
7J					1300 nm, single-mode, ELED, 2 Channels
7K					1300 nm, single-mode, Laser, 2 Channels
7L					Channel 1 - RS422; Channel 2 - 820 nm, multimode, LED
7M					Channel 1 - RS422; Channel 2 - 1300 nm, multimode, LED
7N					Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, ELED
7P					Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, Laser
7Q					Channel 1 - G.703; Channel 2 - 1300 nm, single-mode Laser
7R					G.703, 1 Channel
7S					G.703, 2 Channels
7T					RS422, 1 Channel
7W					RS422, 2 Channels

Table 2-9: UR order codes for replacement modules, vertical units

	UR	-	**	-	*	
POWER SUPPLY	SH	B				125 / 300 V AC/DC
	SL	V				24 to 48 V (DC only)
CPU	T					RS485 with 3 100Base-FX Ethernet, multimode, SFP with LC
	U					RS485 with 1 100Base-TX Ethernet, SFP RJ-45 + 2 100Base-FX Ethernet, multimode, SFP with LC
	V					RS485 with 3 100Base-TX Ethernet, SFP with RJ-45
	W					RS485 with 2 100Base-FX Ethernet, multimode ST + 10/100Base-TX Ethernet, RJ-45
FRONT PANEL + INTERFACE	3F					Vertical front panel with keypad and English display
	3D					Vertical front panel with keypad and French display
	3R					Vertical front panel with keypad and Russian display
	3A					Vertical front panel with keypad and Chinese display
	3K					Enhanced front panel with English display
	3M					Enhanced front panel with French display
	3Q					Enhanced front panel with Russian display
	3U					Enhanced front panel with Chinese display
	3L					Enhanced front panel with English display and user-programmable pushbuttons
	3N					Enhanced front panel with French display and user-programmable pushbuttons
	3T					Enhanced front panel with Russian display and user-programmable pushbuttons
	3V					Enhanced front panel with Chinese display and user-programmable pushbuttons
	3I					Enhanced front panel with German display
CONTACT INPUTS/OUTPUTS	3J					Enhanced front panel with German display and user-programmable pushbuttons
	4A					4 Solid-State (no monitoring) MOSFET outputs
	4B					4 Solid-State (voltage with optional current) MOSFET outputs
	4C					4 Solid-State (current with optional voltage) MOSFET outputs
	4D					16 Contact inputs with Auto-Burnishing
	4L					14 Form-A (no monitoring) Latching outputs
	67					8 Form-A (no monitoring) outputs
	6A					2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 contact inputs
	6B					2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 contact inputs
	6C					8 Form-C outputs
	6D					16 Contact inputs
	6E					4 Form-C outputs, 8 contact inputs
	6F					8 Fast Form-C outputs
	6G					4 Form-A (voltage with optional current) outputs, 8 contact inputs
	6H					6 Form-A (voltage with optional current) outputs, 4 contact inputs
	6K					4 Form-C and 4 Fast Form-C outputs
	6L					2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 contact inputs
	6M					2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 contact inputs
	6N					4 Form-A (current with optional voltage) outputs, 8 contact inputs
	6P					6 Form-A (current with optional voltage) outputs, 4 contact inputs
6R					2 Form-A (no monitoring) and 2 Form-C outputs, 8 contact inputs	
6S					2 Form-A (no monitoring) and 4 Form-C outputs, 4 contact inputs	
6T					4 Form-A (no monitoring) outputs, 8 contact inputs	
6U					6 Form-A (no monitoring) outputs, 4 contact inputs	
6V					2 Form-A outputs, 1 Form-C output, 2 Form-A (no monitoring) latching outputs, 8 contact inputs	
6W					30 Contact inputs - pin terminals (max 4 modules)	
CT/VT MODULES (not available for the C30)	6X					18 Form-A (no monitoring) outputs - pin terminals (max 4 modules)
	8L					Standard 4CT/4VT with enhanced diagnostics
	8N					Standard 8CT with enhanced diagnostics
INTER-RELAY COMMUNICATIONS	8M					Sensitive Ground 4CT/4VT with enhanced diagnostics
	8R					Sensitive Ground 8CT with enhanced diagnostics
	2A					C37.94SM, 1300 nm single-mode, ELED, 1 channel single-mode
	2B					C37.94SM, 1300 nm single-mode, ELED, 2 channel single-mode
	2E					Bi-phase, single channel
	2F					Bi-phase, dual channel
	2G					IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 1 Channel
	2H					IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 2 Channels
	2I					Channel 1 - IEEE C37.94, multimode, 64/128 kbps; Channel 2 - 1300 nm, single-mode, Laser
	2J					Channel 1 - IEEE C37.94, multimode, 64/128 kbps; Channel 2 - 1550 nm, single-mode, Laser
	72					1550 nm, single-mode, Laser, 1 Channel
	73					1550 nm, single-mode, Laser, 2 Channel
	74					Channel 1 - RS422; Channel 2 - 1550 nm, single-mode, Laser
75					Channel 1 - G.703; Channel 2 - 1550 nm, single-mode Laser	
76					IEEE C37.94, 820 nm, 64 kbps, multimode, LED, 1 Channel	
77					IEEE C37.94, 820 nm, 64 kbps, multimode, LED, 2 Channels	
7A					820 nm, multimode, LED, 1 Channel	
7B					1300 nm, multimode, LED, 1 Channel	
7C					1300 nm, single-mode, ELED, 1 Channel	
7D					1300 nm, single-mode, Laser, 1 Channel	
7E					Channel 1 - G.703; Channel 2 - 820 nm, multimode	

UR	Channel 1	Channel 2
7F	G.703	1300 nm, multimode
7G	G.703	1300 nm, single-mode ELED
7H	820 nm, multimode, LED	2 Channels
7I	1300 nm, multimode, LED	2 Channels
7J	1300 nm, single-mode, ELED	2 Channels
7K	1300 nm, single-mode, Laser	2 Channels
7L	RS422	820 nm, multimode, LED
7M	RS422	1300 nm, multimode, LED
7N	RS422	1300 nm, single-mode, ELED
7P	RS422	1300 nm, single-mode, Laser
7Q	G.703	1300 nm, single-mode Laser
7R	G.703	1 Channel
7S	G.703	2 Channels
7T	RS422	1 Channel
7W	RS422	2 Channels

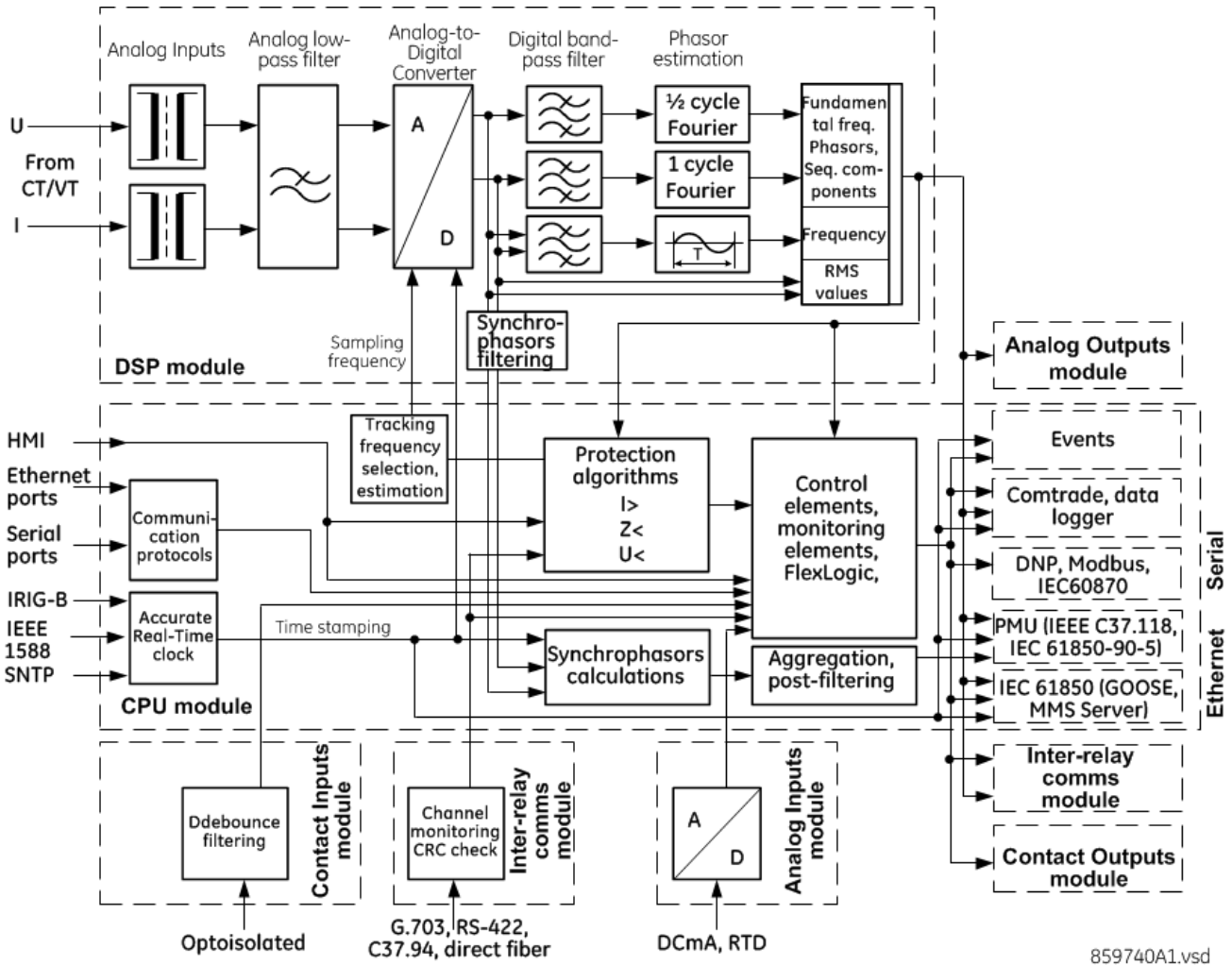
2.5 Signal processing

2.5.1 UR signal processing

The UR series relays are microprocessor-based protective relays that are designed to measure power system conditions directly via CT and VT inputs and via other sources of information, such as analog inputs, communications inputs, and contact inputs. The following figure shows the overall signal processing in URs.

An analog low pass anti-aliasing filter with a 3 dB corner frequency is set at 2.4 kHz and is used for current and voltage analog filtering as well as signal conditioning. The same filtering is applied for phase, ground currents, phase-to-phase (when applicable), and auxiliary voltages. The 2.4 kHz cut-off frequency applies to both 50 Hz and 60 Hz applications and fixed in the hardware, and thus is not dependent on the system nominal frequency setting.

Figure 2-5: UR signal processing



The UR samples its AC signals at 64 samples per cycle, that is, at 3840 Hz in 60 Hz systems, and 3200 Hz in 50 Hz systems. The sampling rate is dynamically adjusted to the actual system frequency by an accurate and fast frequency tracking system.

The analog/digital converter has the following ranges of AC signals:

Voltages:

$$\pm\sqrt{2} \cdot 260(V) \tag{Eq. 2-1}$$

Currents:

$$\pm\sqrt{2} \cdot 46rated(A) \tag{Eq. 2-2}$$

Current harmonics are estimated based on raw samples with the use of the full-cycle Fourier filter. Harmonics 2nd through 25th are estimated.

True RMS value for the current is calculated on a per-phase basis. The true RMS can be used for demand recording or as an input signal to Time Overcurrent function, if the latter is intended for thermal protection. The true RMS is calculated as per the widely accepted definition:

$$I_{RMS(t)} = \sqrt{\frac{1}{T} \int_{(t-T)}^t i^2(t) dt}$$

Eq. 2-3

RMS values include harmonics, inter-harmonics, DC components, and so on, along with fundamental frequency values. The true RMS value reflects thermal effects of the current and is used for the thermal related monitoring and protection functions.

Protection and control functions respond to phasors of the fundamental and/or harmonic frequency components (magnitudes and angles), with an exception for some functions that have an option for RMS or fundamental measurements, or some function responding to RMS only. This type of response is explained typically in each element's section in this instruction manual.

Currents are pre-filtered using a Finite Impulse Response (FIR) digital filter. The filter is designed to reject DC components and low-frequency distortions, without amplifying high-frequency noise. This filter is referred to as a modified MIMIC filter, which provides excellent filtering and overall balance between speed and accuracy of filtering. The filter is cascaded with the full-cycle Fourier filter for the current phasor estimation.

Voltages are pre-filtered using a patented Finite Impulse Response (FIR) digital filter. The filter has been optimized to reject voltage-transformer-specific distortions, such as Capacitive Voltage Transformer (CVT) noise and high-frequency oscillatory components. The filter is cascaded with the half-cycle Fourier filter for the voltage phasor estimation.

The URs measure power system frequency using the Clarke transformation by estimating the period of the waveform from two consecutive zero-crossings in the same direction (negative-to-positive). Voltage or current samples are pre-filtered using a Finite Impulse Response (FIR) digital filter to remove high frequency noise contained in the signal. The period is used after several security conditions are met, such as true RMS signal must be above 6% nominal for a certain time. If these security conditions are not met, the last valid measurement is used for a specific time after which the UR reverts to nominal system frequency.

Synchrophasors are calculated using a patented convolution integral algorithm. This algorithm allows use of the same time-stamped samples, which are used for protection and taken at the same sampling frequency. This allows URs to use one sampling clock for both protection algorithms and synchrophasors.

Synchrophasors on firmware versions 7.23 and up have been tested and certified to meet IEEE C37.118-2011 and C37.118.1a-2014 standards for both metering and protection classes with outputs available up to 60 synchrophasors per second for the metering class and 120 synchrophasors per second for the protection class. Synchrophasors measurement is also available via IEC 61850-90-5 protocol.

The contact inputs threshold is settable in the firmware with 17, 33, 84, 166 V DC settings available. Inputs are scanned every 0.5 ms and can be conditioned for the critical applications, using debounce time timer, settable from 0.0 to 16.0 ms. Contact inputs with auto-burnishing are available as well, when external contacts are exposed to the contamination in a harsh industrial environment.

All measured values are available in the UR metering section on the front panel and via communications protocols. Measured analog values and binary signals can be captured in COMTRADE format with sampling rates from 8 to 64 samples per power cycle. Analog values can be captured with the Data Logger, allowing much slower rates extended over a long period of time.

Other advanced UR order code options are available to support IEC 61850 Ed2.0 (including fast GOOSE, MMS server, 61850 services, ICD/CID/IID files, and so on), IEEE 1588 (IEEE C37.238 power profile) based time synchronization, CyberSentry (advanced cyber security), the Parallel Redundancy Protocol (PRP), IEC 60870-5-103, and so on.

2.6 Specifications

Specifications are subject to change without notice.

2.6.1 Protection elements

The operating times include the activation time of a trip rated form-A output contact unless otherwise indicated. FlexLogic operands of a given element are 4 ms faster. Take this into account when using FlexLogic to interconnect with other protection or control elements of the relay, building FlexLogic equations, or interfacing with other intelligent electronic devices (IEDs) or power system devices via communications or different output contacts. If not specified, the operate times given here are for a 60 Hz system at nominal system frequency. Operate times for a 50 Hz system are 1.2 times longer.

2

LINE CURRENT DIFFERENTIAL (87L)

Application:	2 or 3 terminal line, series compensated line, tapped line, with charging current compensation
Characteristic:	Dual slope percent differential
Pickup current level:	0.20 to 4.00 pu in steps of 0.01
CT Tap (CT mismatch factor):	0.20 to 5.00 in steps of 0.01
Slope # 1:	1 to 50%
Slope # 2:	1 to 70%
Level accuracy:	±3% of reading of the maximum circuit current
Breakpoint between slopes:	0.0 to 20.0 pu in steps of 0.1
DTT:	Direct Transfer Trip (1 and 3 pole) to remote L90
Operating Time:	1.0 to 1.5 power cycles duration
Asymmetrical channel delay compensation using GPS:	asymmetry up to 10 ms
In-zone transformer group compensation:	0 to 330° in steps of 30°
Inrush inhibit level:	1.0 to 40.0% f_0 in steps of 0.1
Inrush inhibit mode:	per-phase, 2-out-of-3, average
Zero-sequence current differential (87LG):	
87LG pickup level:	0.05 to 1.00 pu in steps of 0.01
87LG slope:	1 to 50%
87LG pickup delay:	0.00 to 5.00 s in steps of 0.01
87LG operate time:	1.5 to 2.5 cycles

PHASE/NEUTRAL/GROUND TOC

Current:	Phasor or RMS
Pickup level:	0.020 to 30.000 pu in steps of 0.001
Dropout level:	97% to 98% of pickup
Level accuracy:	
0.1 to 2.0 × CT:	±0.5% of reading or ±0.4% of rated (whichever is greater)
> 2.0 × CT:	±1.5% of reading > 2.0 × CT rating
Curve shapes:	IEEE Moderately/Very/Extremely Inverse; IEC (and BS) A/B/C and Short Inverse; GE IAC Inverse, Short/Very/Extremely Inverse; I ² t; FlexCurves™ (programmable); Definite Time (0.01 s base curve)
Curve multiplier:	Time Dial = 0.00 to 600.00 in steps of 0.01
Reset type:	Instantaneous/Timed (per IEEE)
Curve timing accuracy at 1.03 to 20 × pickup:	±3.5% of operate time or ±½ cycle (whichever is greater) from pickup to operate
Voltage restraint:	Modifies pickup current for voltage in the range of 0.1 < V < 0.9 VT Nominal in a fixed linear relationship

PHASE/NEUTRAL/GROUND IOC

Pickup level:	0.020 to 30.000 pu in steps of 0.001
Dropout level:	97 to 98% of pickup
Level accuracy:	
0.1 to 2.0 × CT rating:	±0.5% of reading or ±0.4% of rated (whichever is greater)
> 2.0 × CT rating:	±1.5% of reading
Overreach:	<2%
Pickup delay:	0.00 to 600.00 s in steps of 0.01

Reset delay:	0.00 to 600.00 s in steps of 0.01
Operate time:	<16 ms at 3 × pickup at 60 Hz (Phase/Ground IOC) <20 ms at 3 × pickup at 60 Hz (Neutral IOC)
Timer accuracy:	±3% of operate time or ±1/4 cycle (whichever is greater)

NEGATIVE SEQUENCE TOC

Current:	Phasor
Pickup level:	0.020 to 30.000 pu in steps of 0.001
Dropout level:	97% to 98% of pickup
Level accuracy:	±0.5% of reading or ±0.4% of rated (whichever is greater) from 0.1 to 2.0 × CT rating ±1.5% of reading > 2.0 × CT rating
Curve shapes:	IEEE Moderately/Very/Extremely Inverse; IEC (and BS) A/B/C and Short Inverse; GE IAC Inverse, Short/Very/Extremely Inverse; I ² t; FlexCurves™ (programmable); Definite Time (0.01 s base curve)
Curve multiplier (Time dial):	0.00 to 600.00 in steps of 0.01
Reset type:	Instantaneous/Timed (per IEEE) and Linear
Curve timing accuracy at 1.03 to 20 × pickup:	±3.5% of operate time or ±½ cycle (whichever is greater) from pickup to operate

NEGATIVE SEQUENCE IOC

Current:	Phasor
Pickup level:	0.020 to 30.000 pu in steps of 0.001
Dropout level:	97 to 98% of pickup
Level accuracy:	0.1 to 2.0 × CT rating: ±0.5% of reading or ±0.4% of rated (whichever is greater); >2.0 × CT rating: ±1.5% of reading
Overreach:	<2%
Pickup delay:	0.00 to 600.00 s in steps of 0.01
Reset delay:	0.00 to 600.00 s in steps of 0.01
Operate time:	<20 ms at 3 × pickup at 60 Hz
Timer accuracy:	±3% of operate time or ±1/4 cycle (whichever is greater)

PHASE DIRECTIONAL OVERCURRENT

Relay connection:	90° (quadrature)
Quadrature voltage:	ABC phase seq.: phase A (V _{BC}), phase B (V _{CA}), phase C (V _{AB}); ACB phase seq.: phase A (V _{CB}), phase B (V _{AC}), phase C (V _{BA})
Polarizing voltage threshold:	0.004 to 3.000 pu in steps of 0.001
Current sensitivity threshold:	0.05 pu
Characteristic angle:	0 to 359° in steps of 1
Angle accuracy:	±2°
Operation time (FlexLogic operands):	
Tripping (reverse load, forward fault):	<12 ms, typically
Blocking (forward load, reverse fault):	<8 ms, typically

NEUTRAL DIRECTIONAL OVERCURRENT

Directionality:	Co-existing forward and reverse
Polarizing:	Voltage, Current, Dual, Dual-V, Dual-I
Polarizing voltage:	V ₀ or VX
Polarizing current:	IG
Operating current:	I ₀
Level sensing:	3 × (I ₀ - K × I ₁), IG
Restraint, K:	0.000 to 0.500 in steps of 0.001
Characteristic angle:	-90 to 90° in steps of 1
Limit angle:	40 to 90° in steps of 1, independent for forward and reverse
Angle accuracy:	±2°
Offset impedance:	0.00 to 250.00 Ω in steps of 0.01
Pickup level:	0.002 to 30.000 pu in steps of 0.01
Dropout level:	97 to 98%

Operation time: <16 ms at 3 × pickup at 60 Hz

PHASE UNDERVOLTAGE

Voltage: Phasor only
 Pickup level: 0.004 to 3.000 pu in steps of 0.001
 Dropout level: 102 to 103% of pickup
 Level accuracy: ±0.5% of reading from 10 to 208 V
 Curve shapes: GE IAV Inverse;
 Definite Time (0.1 s base curve)
 Curve multiplier: Time dial = 0.00 to 600.00 in steps of 0.01
 Curve timing accuracy at <0.90 × pickup:
 ±3.5% of operate time or ±1/2 cycle (whichever is greater) from pickup to operate
 Operate time: <30 ms at 0.9 pickup at 60 Hz for Definite Time mode

AUXILIARY UNDERVOLTAGE

Pickup level: 0.004 to 3.000 pu in steps of 0.001
 Dropout level: 102 to 103% of pickup
 Level accuracy: ±0.5% of reading from 10 to 208 V
 Curve shapes: GE IAV Inverse, Definite Time
 Curve multiplier: Time Dial = 0 to 600.00 in steps of 0.01
 Curve timing accuracy at <0.90 × pickup:
 ±3.5% of operate time or ±1/2 cycle (whichever is greater) from pickup to operate
 Operate time: <30 ms at 0.9 pickup at 60 Hz for Definite Time mode

PHASE OVERVOLTAGE

Voltage: Phasor only
 Pickup level: 0.004 to 3.000 pu in steps of 0.001
 Dropout level: 97 to 98% of pickup
 Level accuracy: ±0.5% of reading from 10 to 208 V
 Pickup delay: 0.00 to 600.00 in steps of 0.01 s
 Operate time: <30 ms at 1.10 × pickup at 60 Hz
 Timer accuracy: ±3% of operate time or ±1/4 cycle (whichever is greater)

NEUTRAL OVERVOLTAGE

Pickup level: 0.004 to 3.000 pu in steps of 0.001
 Dropout level: 97 to 98% of pickup
 Level accuracy: ±0.5% of reading from 10 to 208 V
 Pickup delay: 0.00 to 600.00 s in steps of 0.01 (definite time) or user-defined curve
 Reset delay: 0.00 to 600.00 s in steps of 0.01
 Curve timing accuracy at >1.1 × pickup: ±3.5% of operate time or ±1 cycle (whichever is greater) from pickup to operate
 Operate time: <30 ms at 1.10 × pickup at 60 Hz

AUXILIARY OVERVOLTAGE

Pickup level: 0.004 to 3.000 pu in steps of 0.001
 Dropout level: 97 to 98% of pickup
 Level accuracy: ±0.5% of reading from 10 to 208 V
 Pickup delay: 0 to 600.00 s in steps of 0.01
 Reset delay: 0 to 600.00 s in steps of 0.01
 Timer accuracy: ±3% of operate time or ±1/4 cycle (whichever is greater)
 Operate time: <30 ms at 1.10 × pickup at 60 Hz

NEGATIVE SEQUENCE OVERVOLTAGE

Pickup level: 0.004 to 1.250 pu in steps of 0.001
 Dropout level: 97 to 98% of pickup
 Level accuracy: ±0.5% of reading from 10 to 208 V
 Pickup delay: 0 to 600.00 s in steps of 0.01
 Reset delay: 0 to 600.00 s in steps of 0.01

Timer accuracy: $\pm 3\%$ of operate time or ± 20 ms, whichever is greater
 Operate time: < 30 ms at $1.10 \times$ pickup at 60 Hz

UNDERFREQUENCY

Minimum signal: 0.10 to 1.25 pu in steps of 0.01
 Pickup level: 20.00 to 65.00 Hz in steps of 0.01
 Dropout level: pickup + 0.03 Hz
 Level accuracy: ± 0.001 Hz
 Time delay: 0 to 65.535 s in steps of 0.001
 Timer accuracy: $\pm 3\%$ of operate time or $\pm 1/4$ cycle (whichever is greater)
 Operate time: typically 4 cycles at 0.1 Hz/s change
 typically 3.5 cycles at 0.3 Hz/s change
 typically 3 cycles at 0.5 Hz/s change

Typical times are average operate times including variables, such as frequency change instance, and test method, and can vary by ± 0.5 cycles.

RATE OF CHANGE OF FREQUENCY

df/dt trend: increasing, decreasing, bi-directional
 df/dt pickup level: 0.10 to 15.00 Hz/s in steps of 0.01
 df/dt dropout level: 96% of pickup
 df/dt level accuracy: 80 mHz/s or 3.5%, whichever is greater
 Overvoltage supv.: 0.100 to 3.000 pu in steps of 0.001
 Overcurrent supv.: 0.020 to 30.000 pu in steps of 0.001
 Pickup delay: 0 to 65.535 s in steps of 0.001
 Reset delay: 0 to 65.535 s in steps of 0.001
 Timer accuracy: $\pm 3\%$ of operate time or $\pm 1/4$ cycle (whichever is greater)
 95% settling time for df/dt: < 24 cycles
 Operate time: typically 9.5 cycles at $2 \times$ pickup
 typically 8.5 cycles at $3 \times$ pickup
 typically 6.5 cycles at $5 \times$ pickup

Typical times are average operate times including variables such as frequency change instance, test method, and so on, and can vary by ± 0.5 cycles.

BREAKER FAILURE

Mode: 1-pole, 3-pole
 Current supervision: phase, neutral current
 Current supv. pickup: 0.020 to 30.000 pu in steps of 0.001
 Current supv. dropout: 97 to 98% of pickup
 Current supv. accuracy:
 0.1 to $2.0 \times$ CT rating: $\pm 0.75\%$ of reading or $\pm 2\%$ of rated (whichever is greater)
 above $2 \times$ CT rating: $\pm 2.5\%$ of reading

BREAKER ARCING CURRENT

Principle: accumulates breaker duty (I^2t) and measures fault duration
 Initiation: programmable per phase from any FlexLogic operand
 Compensation for auxiliary relays: 0 to 65.535 s in steps of 0.001
 Alarm threshold: 0 to 50000 kA^2 -cycle in steps of 1
 Fault duration accuracy: 0.25 of a power cycle
 Availability: 1 per CT bank with a minimum of 2

INCIPIENT CABLE FAULT DETECTION

Principle: detection of $1/2$ cycle or less overcurrent condition during normal load
 Availability: two per CT/VT module (not including 8Z modules)
 Pickup level: 0.1 to 10.00 pu in steps of 0.01
 Reset delay: 0.000 to 65.535 s in steps of 0.001
 Operating mode: number of counts, counts per time window

SYNCHROCHECK

Max voltage difference:	0 to 400000 V in steps of 1
Max angle difference:	0 to 100° in steps of 1
Max freq. difference:	0.00 to 2.00 Hz in steps of 0.01
Hysteresis for max. freq. diff.:	0.00 to 0.10 Hz in steps of 0.01
Dead source function:	None, LV1 & DV2, DV1 & LV2, DV1 or DV2, DV1 xor DV2, DV1 & DV2 (L = Live, D = Dead)
S-CLS MAX dF:	0.10 to 2.00 Hz in steps of 0.01
S-CLS MIN dF:	0.00 to 1.00 Hz in steps of 0.01
V2 MAG CORR FACTOR:	0.10 to 10.00 in steps of 0.01
V2 ANGLE SHIFT:	-180° to +180° in steps of 1°

AUTORECLOSURE

Single breaker applications, 3-pole tripping schemes
 Up to four reclose attempts before lockout
 Independent dead time setting before each shot
 Possibility of changing protection settings after each shot with FlexLogic

THERMAL OVERLOAD PROTECTION

Thermal overload curves:	IEC 255-8 curve
Base current:	0.20 to 3.00 pu in steps of 0.01
Overload (k) factor:	1.00 to 1.20 pu in steps of 0.05
Trip time constant:	0 to 1000 min. in steps of 1
Reset time constant:	0 to 1000 min. in steps of 1
Minimum reset time:	0 to 1000 min. in steps of 1
Timer accuracy (cold curve):	±100 ms or 2%, whichever is greater
Timer accuracy (hot curve):	±500 ms or 2%, whichever is greater for $I_p < 0.9 \times k \times I_b$ and $I / (k \times I_b) > 1.1$

TRIP BUS (TRIP WITHOUT FLEXLOGIC)

Number of elements:	6
Number of inputs:	16
Operate time:	<2 ms at 60 Hz
Timer accuracy:	±3% or 10 ms, whichever is greater

2.6.2 User-programmable elements**FLEXLOGIC**

Programming language:	Reverse Polish Notation with graphical visualization (keypad programmable)
Lines of code:	1024
Internal variables:	64
Supported operations:	NOT, XOR, OR (2 to 16 inputs), AND (2 to 16 inputs), NOR (2 to 16 inputs), NAND (2 to 16 inputs), latch (reset-dominant), edge detectors, timers
Inputs:	any logical variable, contact, or virtual input
Number of timers:	32
Pickup delay:	0 to 60000 (ms, sec., min.) in steps of 1
Dropout delay:	0 to 60000 (ms, sec., min.) in steps of 1

FLEXCURVES™

Number:	4 (A through D)
Reset points:	40 (0 through 1 of pickup)
Operate points:	80 (1 through 20 of pickup)
Time delay:	0 to 65535 ms in steps of 1

FLEX STATES

Number:	up to 256 logical variables grouped under 16 Modbus addresses
Programmability:	any logical variable, contact, or virtual input

FLEXELEMENTS™

Number of elements:	8
Operating signal:	any analog actual value, or two values in differential mode
Operating signal mode:	signed or absolute value
Operating mode:	level, delta
Comparator direction:	over, under
Pickup Level:	-90.000 to 90.000 pu in steps of 0.001
Hysteresis:	0.1 to 50.0% in steps of 0.1
Delta dt:	20 ms to 60 days
Pickup and dropout delay:	0.000 to 65.535 s in steps of 0.001

NON-VOLATILE LATCHES

Type:	set-dominant or reset-dominant
Number:	16 (individually programmed)
Output:	stored in non-volatile memory
Execution sequence:	as input prior to protection, control, and FlexLogic

USER-PROGRAMMABLE LEDs (Enhanced and standard front panels)

Number:	48 plus trip and alarm
Programmability:	from any logical variable, contact, or virtual input
Reset mode:	self-reset or latched

LED TEST

Initiation:	from any contact input or user-programmable condition
Number of tests:	3, interruptible at any time
Duration of full test:	approximately 3 minutes
Test sequence 1:	all LEDs on
Test sequence 2:	all LEDs off, one LED at a time on for 1 s
Test sequence 3:	all LEDs on, one LED at a time off for 1 s

USER-DEFINABLE DISPLAYS (Enhanced and standard front panels)

Number of displays:	16
Lines of display:	2 × 20 alphanumeric characters
Parameters:	up to 5, any Modbus register addresses
Invoking and scrolling:	keypad, or any user-programmable condition, including pushbuttons

CONTROL PUSHBUTTONS (Enhanced and standard front panels)

Number of pushbuttons:	7
Operation:	drive FlexLogic operands

USER-PROGRAMMABLE PUSHBUTTONS (Optional)

Number of pushbuttons:	12 on standard front panel 16 on enhanced horizontal front panel 6 on enhanced vertical front panel 16 on graphical front panel (8 physical pushbuttons, 8 graphical interface pushbuttons)
Mode:	self-reset, latched
Display message:	2 lines of 20 characters each
Drop-out timer:	0.00 to 60.00 s in steps of 0.05
Autoreset timer:	0.2 to 600.0 s in steps of 0.1
Hold timer:	0.0 to 10.0 s in steps of 0.1

SELECTOR SWITCH

Number of elements:	2
Upper position limit:	1 to 7 in steps of 1
Selecting mode:	time-out or acknowledge
Time-out timer:	3.0 to 60.0 s in steps of 0.1
Control inputs:	step-up and 3-bit
Power-up mode:	restore from non-volatile memory or synchronize to a 3-bit control input or synch/restore mode

DIGITAL ELEMENTS

Number of elements:	48
Operating signal:	any FlexLogic operand
Pickup delay:	0.000 to 999999.999 s in steps of 0.001
Dropout delay:	0.000 to 999999.999 s in steps of 0.001
Timing accuracy:	±3% or ±4 ms, whichever is greater

2.6.3 Monitoring

OSCILLOGRAPHY

Maximum records:	64
Sampling rate:	64 samples per power cycle
Triggers:	any element pickup, dropout, or operate; contact input change of state; contact output change of state; FlexLogic equation
Data:	AC input channels; element state; contact input state; contact output state
Data storage:	in non-volatile memory

EVENT RECORDER

Capacity:	1024 events
Time-tag:	to 1 microsecond
Triggers:	any element pickup, dropout, or operate; contact input change of state; contact output change of state; self-test events
Data storage:	in non-volatile memory

DATA LOGGER

Number of channels:	1 to 16
Parameters:	any available analog actual value
Sampling rate:	15 to 3600000 ms in steps of 1
Trigger:	any FlexLogic operand
Mode:	continuous or triggered
Storage capacity:	(NN is dependent on memory) 1-second rate: 01 channel for NN days 16 channels for NN days ↓ 60-minute rate: 01 channel for NN days 16 channels for NN days

FAULT LOCATOR

Number of independent fault locators:	1 per CT bankMethod:single-ended
Voltage source:	wye-connected VTs, delta-connected VTs and neutral voltage, delta-connected VTs and zero-sequence current (approximation)
Maximum accuracy if:	fault resistance is zero or fault currents from all line terminals are in phase
Relay accuracy:	±1.5% (V > 10 V, I > 0.1 pu)
Worst-case accuracy:	
VT _{%error} +	user data
CT _{%error} +	user data
Z _{Line} _{%error} +	user data
RELAY ACCURACY _{%error} +	1.5%

PHASOR MEASUREMENT UNIT

Output format:	per IEEE C37.118-2011, C37.118.1a-2014, or IEC 61850-90-5 standard
Number of channels:	14 synchrophasors, 8 analogs, 16 digitals
TVE (total vector error):	<1%
Triggering:	frequency, voltage, current, power, rate of change of frequency, user-defined

Reporting rate:	1, 2, 5, 10, 12, 15, 20, 25, 30, 50, or 60 times per second for P and M class, and 100 or 120 times per second for P class only
Number of clients:	one over TCP/IP port and one over UDP/IP per aggregator
AC ranges:	as indicated in appropriate specification sections
Network reporting format:	16-bit integer (for IEEE C37.118) or 32-bit IEEE floating point numbers
Network reporting style:	rectangular (real and imaginary for IEEE C37.188) or polar (magnitude and angle) coordinates
Post-filtering:	none, 3-point, 5-point, 7-point
Calibration:	$\pm 5^\circ$ (angle) and $\pm 5\%$ (magnitude)

2.6.4 Metering

RMS CURRENT: PHASE, NEUTRAL, AND GROUND

Accuracy at

0.1 to $2.0 \times$ CT rating:	$\pm 0.25\%$ of reading or $\pm 0.1\%$ of rated (whichever is greater)
$> 2.0 \times$ CT rating:	$\pm 1.0\%$ of reading

RMS VOLTAGE

Accuracy: $\pm 0.5\%$ of reading from 10 to 208 V

REAL POWER (WATTS)

Accuracy at 0.1 to $1.5 \times$ CT rating and 0.8 to $1.2 \times$ VT rating:

$\pm 1.0\%$ of reading at $-1.0 \leq \text{PF} < -0.8$ and $0.8 < \text{PF} \leq 1.0$

REACTIVE POWER (VARs)

Accuracy at 0.1 to $1.5 \times$ CT rating and 0.8 to $1.2 \times$ VT rating:

$\pm 1.0\%$ of reading at $-0.2 \leq \text{PF} \leq 0.2$

APPARENT POWER (VA)

Accuracy at 0.1 to $1.5 \times$ CT rating and 0.8 to $1.2 \times$ VT rating:

$\pm 1.0\%$ of reading

CURRENT HARMONICS

Harmonics: 2nd to 25th harmonic: per phase, displayed as a % of f_1 (fundamental frequency phasor)

THD: per phase, displayed as a % of f_1

Accuracy:

HARMONICS:	1. $f_1 > 0.4\text{pu}$: $(0.20\% + 0.035\% / \text{harmonic})$ of reading or 0.15% of 100%, whichever is greater
	2. $f_1 < 0.4\text{pu}$: as above plus %error of f_1
THD:	1. $f_1 > 0.4\text{pu}$: $(0.25\% + 0.035\% / \text{harmonic})$ of reading or 0.20% of 100%, whichever is greater
	2. $f_1 < 0.4\text{pu}$: as above plus %error of f_1

VOLTAGE HARMONICS

Harmonics: 2nd to 25th harmonic: per phase, displayed as a % of f_1 (fundamental frequency phasor)

THD: per phase, displayed as a % of f_1

Accuracy:

HARMONICS:	1. $f_1 > 0.4\text{pu}$: $(0.20\% + 0.035\% / \text{harmonic})$ of reading or 0.15% of 100%, whichever is greater
	2. $f_1 < 0.4\text{pu}$: as above plus %error of f_1
THD:	1. $f_1 > 0.4\text{pu}$: $(0.25\% + 0.035\% / \text{harmonic})$ of reading or 0.20% of 100%, whichever is greater
	2. $f_1 < 0.4\text{pu}$: as above plus %error of f_1

FREQUENCY

Accuracy at

$V = 0.8$ to 1.2 pu:	± 0.001 Hz (when voltage signal is used for frequency measurement)
$I = 0.1$ to 0.25 pu:	± 0.005 Hz
$I > 0.25$ pu:	± 0.02 Hz (when current signal is used for frequency measurement)

2.6.5 Inputs

AC CURRENT

CT rated primary:	1 to 50000 A
CT rated secondary:	1 or 5 A by connection
Relay burden:	< 0.2 VA at rated secondary
Conversion range:	
Standard CT:	0.02 to 46 × CT rating RMS symmetrical
Sensitive Ground CT module:	0.002 to 4.6 × CT rating RMS symmetrical
Current withstand:	20 ms at 250 times rated 1 sec at 100 times rated continuous 4×Inom
Short circuit rating:	150000 RMS symmetrical amperes, 250 V maximum (primary current to external CT)

AC VOLTAGE

VT rated secondary:	50.0 to 240.0 V
VT ratio:	1.00 to 24000.00
Relay burden:	< 0.25 VA at 120 V
Conversion range:	1 to 275 V
Voltage withstand:	continuous at 260 V to neutral 1 min/hr at 420 V to neutral

FREQUENCY

Nominal frequency setting:	25 to 60 Hz
Sampling frequency:	64 samples per power cycle
Tracking frequency range:	45 to 65 Hz

CONTACT INPUTS

Dry contacts:	1000 Ω maximum
Wet contacts:	300 V DC maximum
Selectable thresholds:	17 V, 33 V, 84 V, 166 V
Tolerance:	±10%
Contacts per common return:	4
Recognition time:	< 1 ms
Debounce time:	0.0 to 16.0 ms in steps of 0.5
Continuous current draw:	4 mA (when energized)

CONTACT INPUTS WITH AUTO-BURNISHING

Dry contacts:	1000 Ω maximum
Wet contacts:	300 V DC maximum
Selectable thresholds:	17 V, 33 V, 84 V, 166 V
Tolerance:	±10%
Contacts per common return:	2
Recognition time:	< 1 ms
Debounce time:	0.0 to 16.0 ms in steps of 0.5
Continuous current draw:	4 mA (when energized)
Auto-burnish impulse current:	50 to 70 mA
Duration of auto-burnish impulse:	25 to 50 ms

DCMA INPUTS

Current input (mA DC):	0 to -1, 0 to +1, -1 to +1, 0 to 5, 0 to 10, 0 to 20, 4 to 20 (programmable)
Input impedance:	379 Ω ±10%
Conversion range:	-1 to + 20 mA DC
Accuracy:	±0.2% of full scale
Type:	Passive

RTD INPUTS

Types (3-wire):	100 Ω Platinum, 100 and 120 Ω Nickel, 10 Ω Copper
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Sensing current:	5 mA
Range:	-50 to +250°C
Accuracy:	±2°C
Isolation:	36 V pk-pk

IRIG-B INPUT

IRIG formats accepted:	B000...B007, B120...B127
IRIG control bits:	IEEE Std C37.118.1-2011
Amplitude modulation:	1 to 10 V pk-pk
DC shift:	TTL-Compatible
Input impedance:	50 kΩ
Isolation:	2 kV

2.6.6 Power supply

LOW RANGE

Nominal DC voltage:	24 to 48 V
Minimum DC voltage:	20 V
Maximum DC voltage:	75 V for SL power supply module
Voltage loss hold-up:	200 ms duration at maximum load

NOTE: Low range is DC only.

HIGH RANGE

Nominal DC voltage:	125 to 250 V
Minimum DC voltage:	88 V
Maximum DC voltage:	300 V
Nominal AC voltage:	100 to 240 V at 50/60 Hz
Minimum AC voltage:	88 V at 25 to 100 Hz
Maximum AC voltage:	265 V at 25 to 100 Hz
Voltage loss hold-up:	200 ms duration at maximum load

ALL RANGES

Volt withstand:	2 × Highest Nominal Voltage for 10 ms
Power consumption:	typical = 15 to 20 W/VA maximum = 45 W/VA contact factory for exact order code consumption

INTERNAL FUSE

Ratings:	
Low range power supply:	8 A / 250 V
High range power supply:	4 A / 250 V
Interrupting capacity:	
AC:	100 000 A RMS symmetrical
DC:	10 000 A

2.6.7 Outputs

FORM-A RELAY

Make and carry for 0.2 s:	30 A as per ANSI C37.90
Carry continuous:	6 A

Break (DC inductive, L/R = 40 ms):

Voltage	Current
24 V	1 A
48 V	0.5 A
125 V	0.3 A
250 V	0.2 A

Operate time: < 4 ms
 Contact material: silver alloy

LATCHING RELAY

Make and carry for 0.2 s: 30 A as per ANSI C37.90
 Carry continuous: 6 A as per IEEE C37.90
 Break (DC resistive as per IEC61810-1):

Voltage	Current
24 V	6 A
48 V	1.6 A
125 V	0.4 A
250 V	0.2 A

Operate time: < 4 ms
 Contact material: silver alloy
 Control: separate operate and reset inputs
 Control mode: operate-dominant or reset-dominant

FORM-A VOLTAGE MONITOR

Applicable voltage: approx. 15 to 250 V DC
 Trickle current: approx. 1 to 2.5 mA

FORM-A CURRENT MONITOR

Threshold current: approx. 80 to 100 mA

FORM-C AND CRITICAL FAILURE RELAY

Make and carry for 0.2 s: 30 A as per ANSI C37.90
 Carry continuous: 8 A
 Break (DC inductive, L/R = 40 ms):

Voltage	Current
24 V	1 A
48 V	0.5 A
125 V	0.3 A
250 V	0.2 A

Operate time: < 8 ms
 Contact material: silver alloy

FAST FORM-C RELAY

Make and carry: 0.1 A max. (resistive load)

Minimum load impedance:

Input voltage	Impedance	
	2 W Resistor	1 W Resistor
250 V DC	20 k Ω	50 k Ω
120 V DC	5 k Ω	2 k Ω
48 V DC	2 k Ω	2 k Ω
24 V DC	2 k Ω	2 k Ω

Note: values for 24 V and 48 V are the same due to a required 95% voltage drop across the load impedance.

Operate time: < 0.6 ms
Internal Limiting Resistor: 100 Ω , 2 W

SOLID-STATE OUTPUT RELAY

Operate and release time: <100 μ s
Maximum voltage: 265 V DC
Maximum leakage current in off state
(excluding voltage monitor circuit current): 100 μ A
Maximum continuous current: 5 A at 45°C; 4 A at 65°C
Make and carry:
for 0.2 s: 30 A as per ANSI C37.90
for 0.03 s: 300 A
Breaking capacity:

Specification	UL 508	Utility application (autoreclose scheme)	Industrial application
Operations per interval	5000 operations, 1 second on, 9 seconds off	5 operations 0.2 seconds on 0.2 seconds off within 1 minute	10000 operations 0.2 seconds on 30 seconds off
	1000 operations 0.5 seconds on, 0.5 seconds off		
Break capability (0 to 250 V DC)	3.2 A at L/R = 10 ms	10 A at L/R = 40 ms	10 A at L/R = 40 ms
	1.6 A at L/R = 20 ms		
	0.8 A L/R = 40 ms		

CONTROL POWER EXTERNAL OUTPUT (For dry contact input)

Capacity: 100 mA DC at 48 V DC
Isolation: \pm 300 Vpk

DCMA OUTPUTS

Range: -1 to 1 mA, 0 to 1 mA, 4 to 20 mA
Max. load resistance: 12 k Ω for -1 to 1 mA range
12 k Ω for 0 to 1 mA range
600 Ω for 4 to 20 mA range
Accuracy: \pm 0.75% of full-scale for 0 to 1 mA range
 \pm 0.5% of full-scale for -1 to 1 mA range
 \pm 0.75% of full-scale for 0 to 20 mA range
99% Settling time to a step change: 100 ms
Isolation: 1.5 kV
Driving signal: any FlexAnalog quantity
Upper and lower limit for the driving signal: -90 to 90 μ i in steps of 0.001

2.6.8 Communication protocols

IEC 61850

IEC 61850: Supports IEC 61850 Edition 2.0. See the UR Family Communications Guide and its conformance statements.

RS232 (Enhanced and standard front panels)

Front port: 19.2 kbps, Modbus RTU

USB (Graphical front panel)

Front port: USB 2.0 type B

RS485

1 rear port: up to 115 kbps, Modbus RTU, DNP 3, IEC 60870-5-103

Typical distance: 1200 m

Isolation: 2 kV, isolated together at 36 Vpk

FIBER ETHERNET PORT

Parameter	Fiber type
	100 Mb multimode
Wavelength	1310 nm
Connector	LC
Transmit power	-20 dBm
Receiver sensitivity	-30 dBm
Power budget	10 dB
Maximum input power	-14 dBm
Typical distance	2 km
Full duplex	yes
Redundancy	yes

ETHERNET (10/100 MB TWISTED PAIR)

Modes: 10 Mb, 10/100 Mb (auto-detect)

Connector: RJ45

SIMPLE NETWORK TIME PROTOCOL (SNTP)

Clock synchronization error: <10 ms (typical)

PRECISION TIME PROTOCOL (PTP)

PTP IEEE Std 1588 2008 (version 2)

Power Profile (PP) per IEEE Standard PC37.238TM2011

Slave-only ordinary clock

Peer delay measurement mechanism

PARALLEL REDUNDANCY PROTOCOL (PRP) (IEC 62439-3 CLAUSE 4, 2012)

Ethernet ports used: 2 and 3

Networks supported: 10/100 Mb Ethernet

OTHER

TFTP, SFTP, HTTP, IEC 60870-5-104, Ethernet Global Data (EGD), IEEE C37.118

2.6.9 Inter-relay communications

SHIELDED TWISTED-PAIR INTERFACE OPTIONS

Interface type	Typical distance
RS422	1200 m
G.703	100 m



RS422 distance is based on transmitter power and does not take into consideration the clock source provided by the user.

NOTE

LINK POWER BUDGET AND MAXIMUM OPTICAL INPUT POWER

The following specifications apply to filter interface modules manufactured from January 2012.

Emitter, fiber type	Cable type	Transmit power	Received sensitivity	Power budget	Maximum optical input power
820 nm, Multimode	62.5/125 μm	-16 dBm	-32 dBm	16 dBm	-8 dBm
	50/125 μm	-20 dBm		12 dBm	
1300 nm, Multimode	62.5/125 μm	-16 dBm	-32 dBm	16 dBm	-8 dBm
	50/125 μm	-20 dBm		12 dBm	
1300 nm, Single mode	9/125 μm	-15 dBm	-32 dBm	17 dBm	-8 dBm
1300 nm Laser, Single mode	9/125 μm	0 dBm	-34 dBm	34 dBm	-8 dBm
1550 nm Laser, Single mode	9/125 μm	5 dBm	-34 dBm	39 dBm	-10 dBm

The following specifications apply to filter interface modules implemented before January 2012.

Emitter, fiber type	Transmit power	Received sensitivity	Power budget	Maximum optical input power
820 nm LED, Multimode	-20 dBm	-30 dBm	10 dB	-7.6 dBm
1300 nm LED, Multimode	-21 dBm	-30 dBm	9 dB	-11 dBm
1300 nm ELED, Single mode	-23 dBm	-32 dBm	9 dB	-14 dBm
1300 nm Laser, Single mode	-1 dBm	-30 dBm	29 dB	-14 dBm
1550 nm Laser, Single mode	+5 dBm	-30 dBm	35 dB	-14 dBm



The power budgets are calculated from the manufacturer's worst-case transmitter power and worst case receiver sensitivity.

NOTE

The power budgets for the 1300 nm ELED are calculated from the manufacturer's transmitter power and receiver sensitivity at ambient temperature. At extreme temperatures these values deviate based on component tolerance. On average, the output power decreases as the temperature is increased by a factor of 1 dB / 5 °C.

TYPICAL LINK DISTANCE

Emitter, fiber type	Cable type	Connector type	Typical distance	
			Before January 2012	From January 2012
820 nm LED, multimode	62.5/125 μm	ST	1.65 km	2 km
	50/125 μm	ST	1.65 km	2 km
1300 nm LED, multimode	62.5/125 μm	ST	4 km	5 km
	50/125 μm	ST	4 km	5 km
1300 nm ELED, single mode	9/125 μm	ST	11.4 km	20 km
1300 nm Laser, single mode	9/125 μm	ST	64 km	65 km
1550 nm Laser, single mode	9/125 μm	ST	105 km	125 km



Typical distances listed are based on the following assumptions for system loss. As actual losses vary from one installation to another, the distance covered by your system can vary.

CONNECTOR LOSSES (Total of both ends)

ST connector: 0.7 dB (each)

FIBER LOSSES

820 nm multimode: 3 dB/km
 1300 nm multimode: 1 dB/km
 1300 nm single mode: 0.35 dB/km
 1550 nm single mode: 0.25 dB/km
 Splice losses: one splice every 2 km at 0.05 dB loss per splice

SYSTEM MARGIN

3 dB additional loss added to calculations to compensate for all other losses.

Compensated difference in transmitting and receiving (channel asymmetry) channel delays using GPS satellite clock: 10 ms

2.6.10 CyberSentry security

OPTIONS

Software options: Level 1

2.6.11 Graphical front panel

DISPLAY

Type: color graphical back-lit LCD display
 Size: 7 inches (17.8 cm)
 Resolution: 800 by 480 pixels
 Pages: 5 single-line diagram pages with controls, status, and metering values
 up to 8 annunciator pages with total of 96 annunciator windows
 1 phasor metering page for each AC Source
 5 tabular metering pages with dynamic metering and status
 event records page with dynamic update
 product information page
 settings, actual values, error messages (targets)

LED INDICATORS

Functions:	5 device status indicators 9 event cause indicators 8 user-programmable pushbutton indicators
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PUSHBUTTONS

Type:	membrane
Functions:	5 bottom Tab pushbuttons and 1 Home pushbutton for page recall 4 directional, 1 ENTER, and 1 ESCAPE pushbutton element selection 10 side pushbuttons for power system element control RESET pushbutton 8 physical user-programmable pushbuttons, 8 graphical interface pushbuttons

INGRESS PROTECTION

IP code:	IP54 front, IP10 back (IP20 back with IP20 cover accessory)
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2.6.12 Environmental**AMBIENT TEMPERATURES**

Storage temperature:	-40 to 85°C
Operating temperature:	-40 to 60°C; the LCD contrast can be impaired at temperatures less than -20°C

HUMIDITY

Humidity:	operating up to 95% (non-condensing) at 55°C (as per IEC60068-2-30 variant 1, 6 days)
-----------	---

OTHER

Altitude:	2000 m (maximum)
Pollution degree:	II
Overvoltage category:	II
Ingress protection:	IP20 front, IP10 back (standard front panel and old enhanced front panel) IP40 front, IP10 back (new enhanced front panel) IP54 front with IP54 mounting collar accessory (new enhanced front panel)
Ingress protection with IP20 cover accessory:	IP20 back
Noise:	0 dB

2.6.13 Type tests

L30 TYPE TESTS

Test	Reference standard	Test level
Dielectric voltage withstand	EN 60255-5 ¹	2.2 kV
Impulse voltage withstand	EN 60255-5 ¹	5 kV
Damped oscillatory	IEC 61000-4-18 / IEC 60255-22-1	2.5 kV CM, 1 kV DM
Electrostatic discharge	EN 61000-4-2 / IEC 60255-22-2	Level 3
RF immunity	EN 61000-4-3 / IEC 60255-22-3	Level 3
Fast transient disturbance	EN 61000-4-4 / IEC 60255-22-4	Class A and B
Surge immunity	EN 61000-4-5 / IEC 60255-22-5	Level 3 and 4
Conducted RF immunity	EN 61000-4-6 / IEC 60255-22-6	Level 3
Power frequency immunity	EN 61000-4-7 ¹ / IEC 60255-22-7	Class A and B
Voltage interruption and ripple DC	IEC 60255-11	12% ripple, 200 ms interrupts
Radiated and conducted emissions	CISPR11 / CISPR22 / IEC 60255-25	Class A
Sinusoidal vibration	IEC 60255-21-1	Class 1
Shock and bump	IEC 60255-21-2	Class 1
Seismic	IEC 60255-21-3	Class 1
Power magnetic immunity	IEC 61000-4-8	Level 5
Pulse magnetic immunity	IEC 61000-4-9	Level 4
Damped magnetic immunity	IEC 61000-4-10	Level 4
Voltage dip and interruption	IEC 61000-4-11	0, 40, 70, 80% dips; 250 / 300 cycle interrupts
Damped oscillatory	IEC 61000-4-12 ¹	2.5 kV CM, 1 kV DM
Conducted RF immunity, 0 to 150 kHz	IEC 61000-4-16	Level 4
Voltage ripple	IEC 61000-4-17	15% ripple
Ingress protection	IEC 60529 ¹	IP20 front, IP10 back
Cold	IEC 60068-2-1	-40°C for 16 hours
Hot	IEC 60068-2-2	85°C for 16 hours
Humidity	IEC 60068-2-30	6 days, variant 1
Damped oscillatory	IEEE/ANSI C37.90.1	2.5 kV, 1 MHz
RF immunity	IEEE/ANSI C37.90.2	20 V/m, 80 MHz to 1 GHz
Safety	UL 508	e83849 NKCR
Safety	UL C22.2-14	e83849 NKCR7
Safety	UL 1053	e83849 NKCR
Safety	IEC 60255-27	Insulation: class 1, Pollution degree: 2, Over voltage cat II

¹ Not tested by third party.

2.6.14 Production tests

THERMAL

Products go through an environmental test based upon an Accepted Quality Level (AQL) sampling process.

2.6.15 Approvals

APPROVALS

Compliance	Applicable council directive	According to
CE	Low voltage directive	EN 60255-5
	EMC directive	EN 60255-26 / EN 50263
		EN 61000-6-5
C-UL-US	---	UL 508
		UL 1053
		C22.2 No. 14

2.6.16 Maintenance

MOUNTING

Attach mounting brackets using 20 inch-pounds (± 2 inch-pounds) of torque.

CLEANING

Normally, cleaning is not required. When dust has accumulated on the front panel display, wipe with a dry cloth.

NOTICE To avoid deterioration of electrolytic capacitors, power up units that are stored in a de-energized state once per year, for one hour continuously.

2

L30 Line Current Differential System

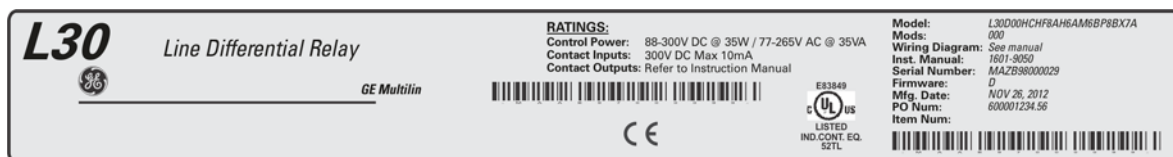
Chapter 3: Installation

This chapter outlines installation of hardware and software. You unpack, check, mount, wire the unit, turn on power, then install the software and configure settings.

3.1 Unpack and inspect

Use this procedure to unpack and inspect the unit.

1. Open the relay package and check that the following items have been delivered:
 - L30
 - Mounting screws
 - GE EnerVista™ DVD (software and documentation)
 - L30 Instruction Manual (soft copy on DVD; printed copy if ordered)
 - UR Family Communications Guide (soft copy on DVD; printed copy if Instruction Manual ordered)
 - Certificate of Calibration
 - Test Report
 - EC Declaration of Conformity
 - Front panel label package
2. Inspect the unit for physical damage.
3. View the rear nameplate and verify that the correct model has been delivered. The model number is at the top right.



4. Any protective plastic film on the front panel is normally peeled off, but also can be left on.
5. For any issues, contact GE as outlined in the For Further Assistance section in chapter 1.
6. Check that you have the latest copy of the L30 Instruction Manual and the UR Family Communications Guide, for the applicable firmware version, at <http://www.gegridsolutions.com/multilin/manuals/index.htm>

The Instruction Manual outlines how to install, configure, and use the unit. The Communications Guide is for advanced use with communication protocols. The warranty is included at the end of this instruction manual and on the GE Grid Solutions website.

3.2 Panel cutouts

This section does not apply to the HardFiber Brick; see its instruction manual.

Install the relay in an indoor environment within the environmental specifications. The relay complies with Pollution Category II, which means installation in an office, laboratory, or testing environment.

3.2.1 Horizontal units

The L30 is available as a 19-inch rack horizontal mount unit with a removable front panel. The front panel is specified as enhanced, standard, or graphical at the time of ordering. The enhanced and graphical front panels contain additional user-programmable pushbuttons and LED indicators.

The modular design allows the relay to be upgraded and repaired by qualified service personnel. The front panel is hinged to allow access to the modules. The front panel is itself removable to allow mounting on doors with limited rear depth and for upgrading.

In November 2017, GE began transitioning to a new enhanced horizontal front panel. This panel can be identified by the use of a screw instead of a knob to close the panel. It can conform to an IP54 rating with the IP54 mounting collar purchased separately. The IP54 mounting collar can be used in panel-mount installations, not 19-inch rack-mount installations. The IP54 mounting collar cannot be used with old enhanced front panels.

The case dimensions are shown in the following figures, along with panel cutout details for panel mounting. When planning the location of your panel cutout, ensure that provision is made for the front panel to swing open without interference to or from adjacent equipment.

The relay must be mounted such that the front panel sits semi-flush with the panel or switchgear door, allowing the operator access to the keypad and the front communications port.

Figure 3-1: Horizontal dimensions (old enhanced front panel)

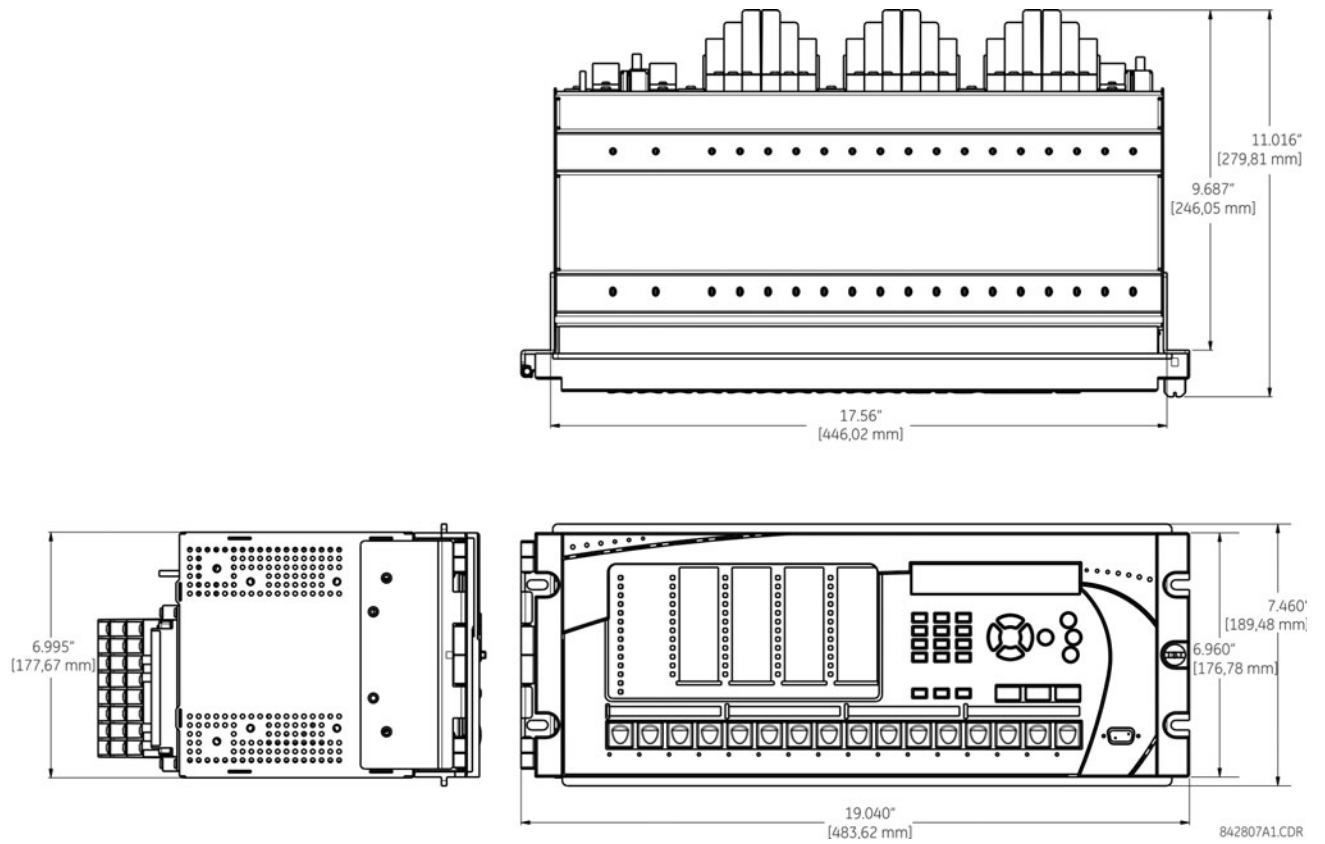


Figure 3-2: Horizontal dimensions (enhanced front panel)

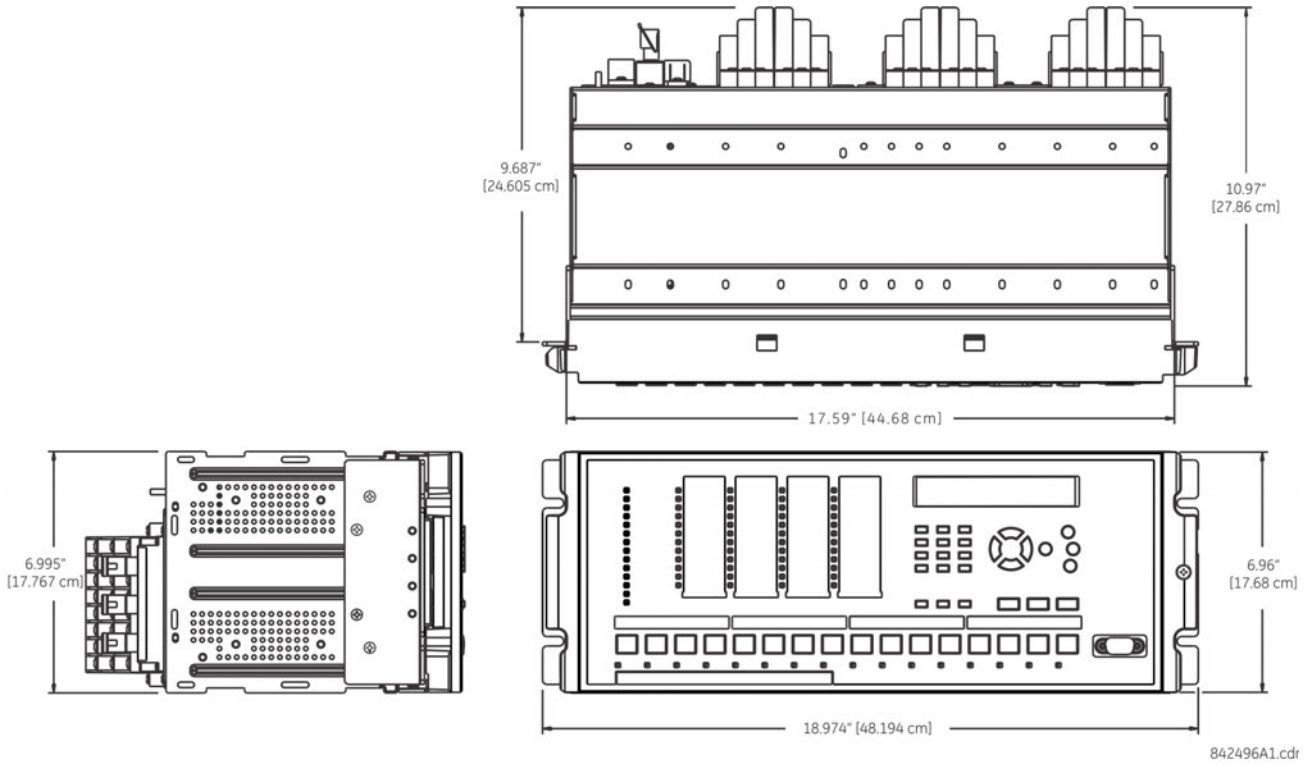


Figure 3-3: Horizontal mounting (enhanced and graphical front panels)

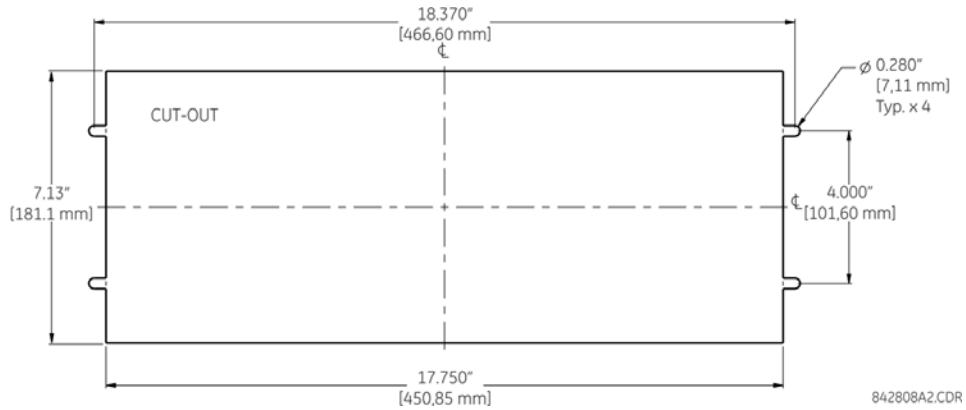


Figure 3-4: Horizontal dimensions and mounting (standard front panel)

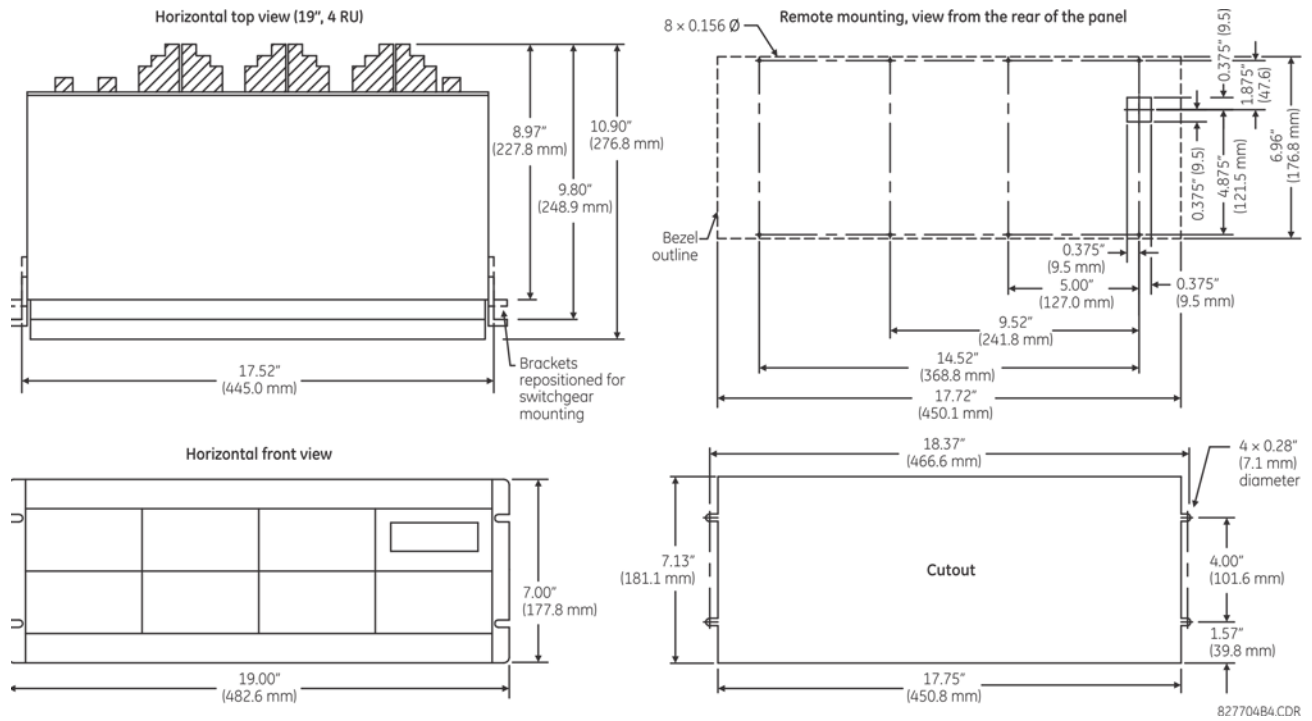


Figure 3-5: Horizontal dimensions (graphical front panel)

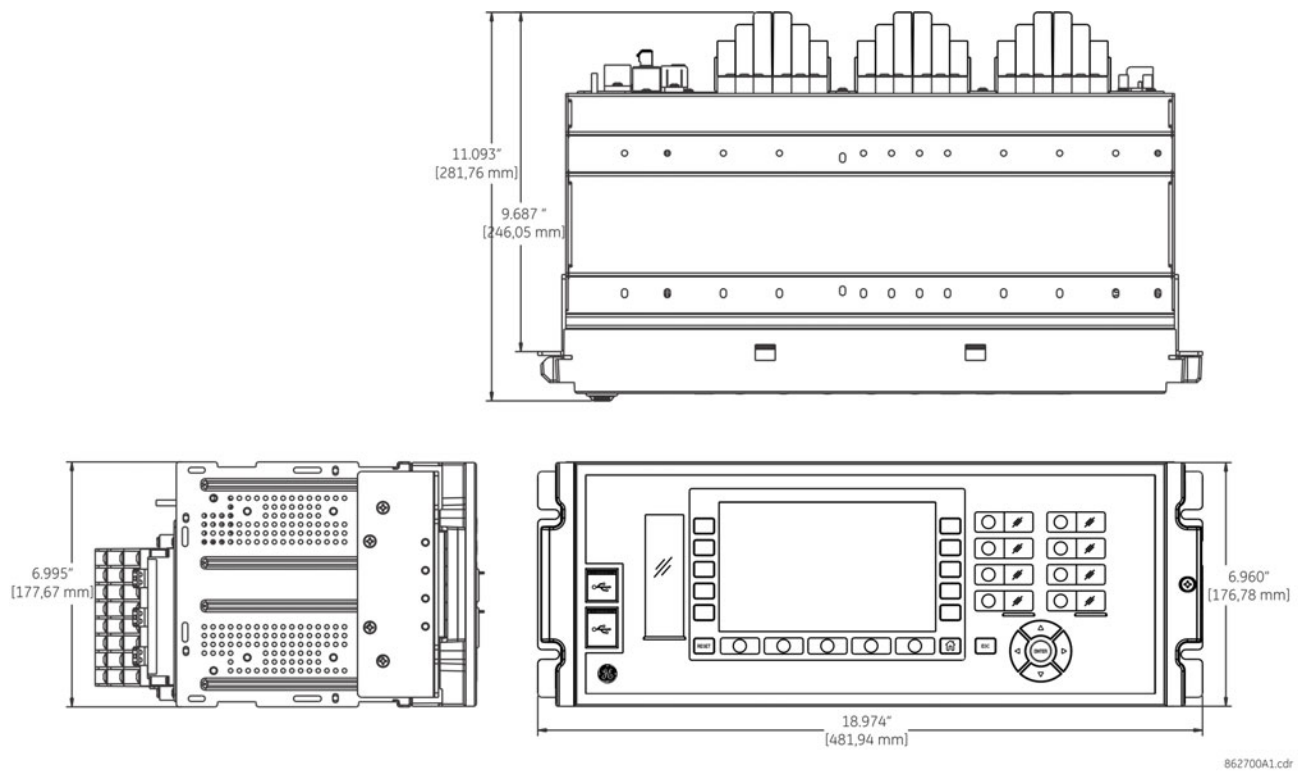
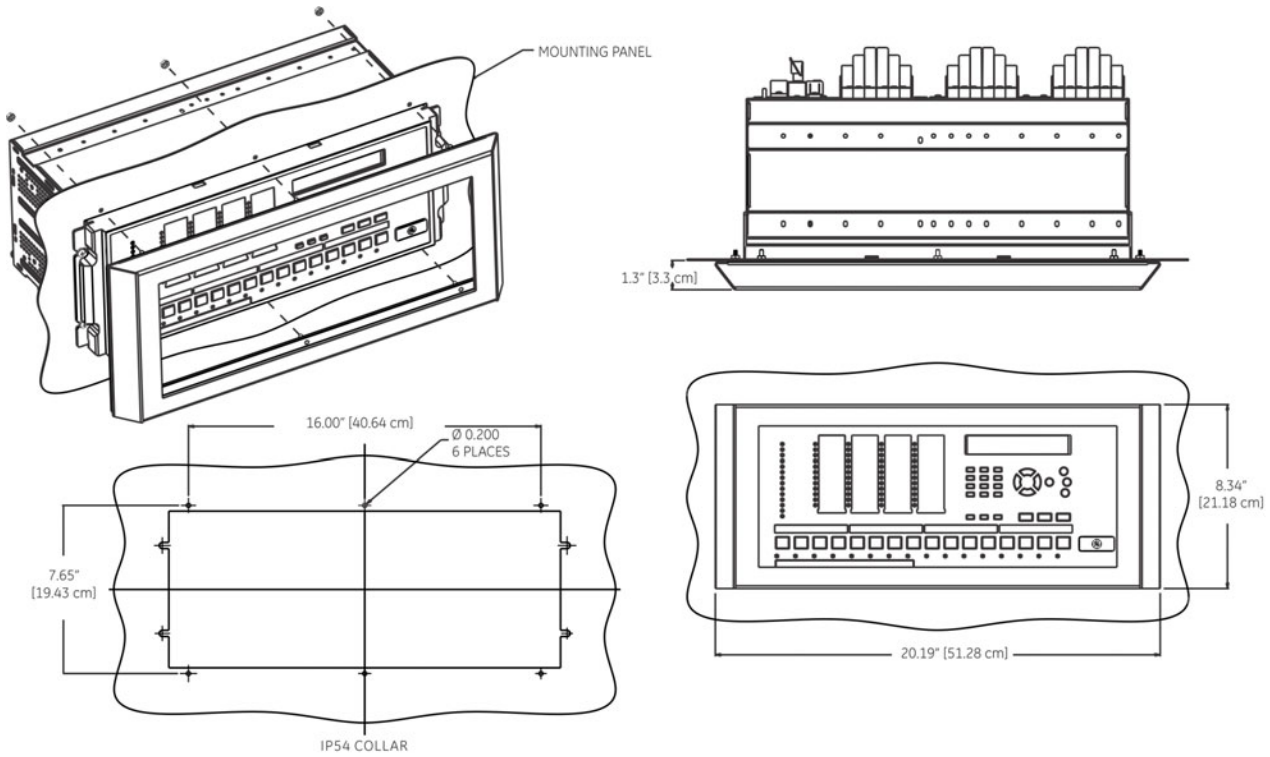


Figure 3-6: Horizontal dimensions (IP54 mounting collar)



- NOTES
1. INSPECT THE COLLAR BEFORE INSTALLATION, VERIFY GASKET IS ADHERED TO THE METAL ON ALL SIDES
 2. MAKE SURE THE RELAY IS POSITIONED CENTER TO THE CUT OUT
 3. INSTALL IP-54 COLLAR, CONFIRM THE GASKET PROPERLY MATES WITH THE PANEL ON ALL SIDES SECURE USING #8-32 HEX NUT AT 6 PLACES.

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3.2.2 Vertical units

The L30 is available as a reduced size (¾) vertical mount unit, with a removable front panel. The front panel is specified as enhanced or standard at the time of ordering. The enhanced front panel contains additional user-programmable pushbuttons and LED indicators.

The modular design allows the relay to be upgraded and repaired by qualified service personnel. The front panel is hinged to allow easy access to the modules. The front panel is itself removable to allow mounting on doors with limited rear depth and for upgrading.

The case dimensions are shown in the following figures, along with panel cutout details for panel mounting. When planning the location of your panel cutout, ensure that provision is made for the front panel to swing open without interference to or from adjacent equipment.

The relay must be mounted such that the front panel sits semi-flush with the panel or switchgear door, allowing the operator access to the keypad and the RS232 communications port.

Figure 3-7: Vertical dimensions and mounting (enhanced front panel)

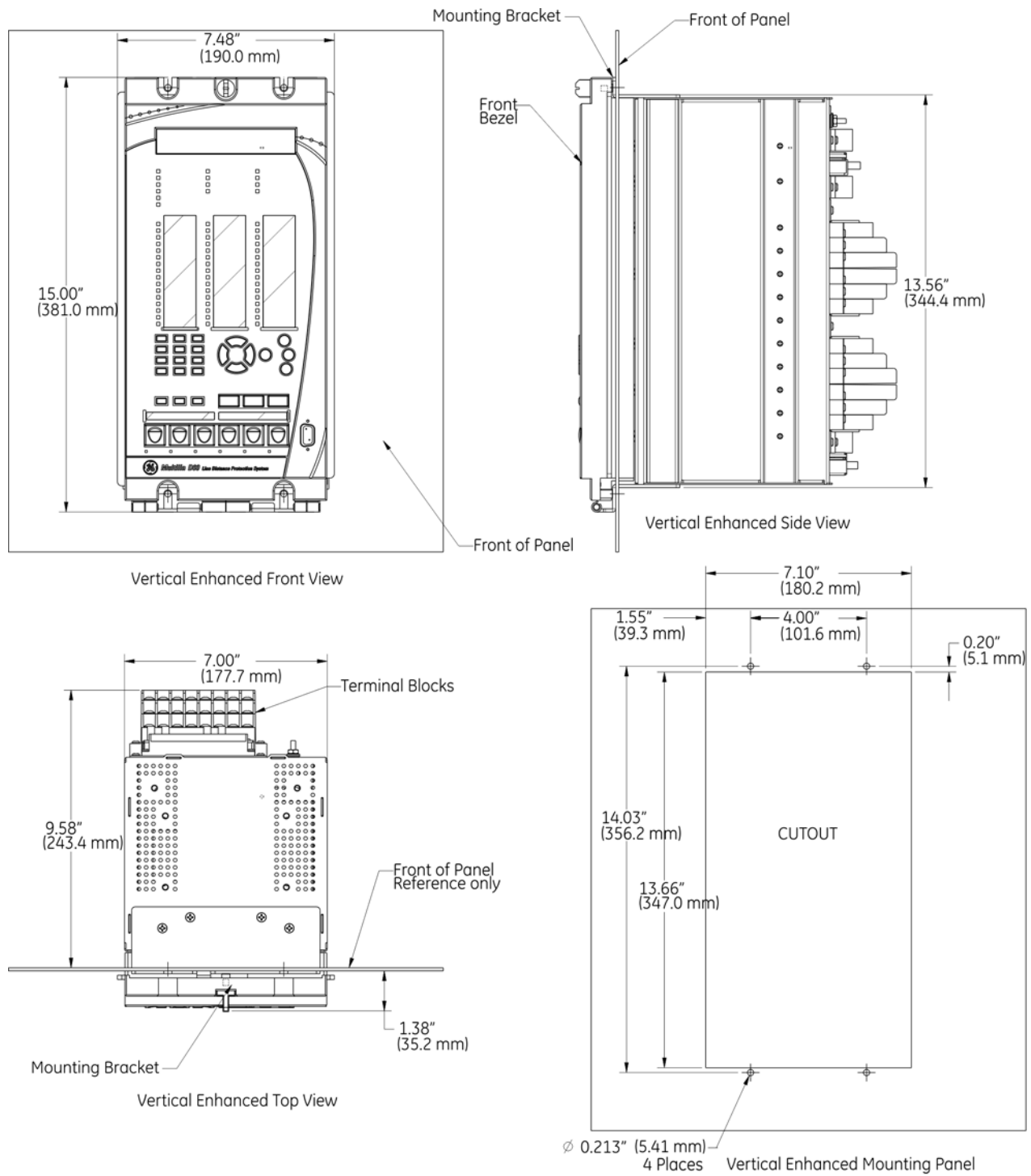
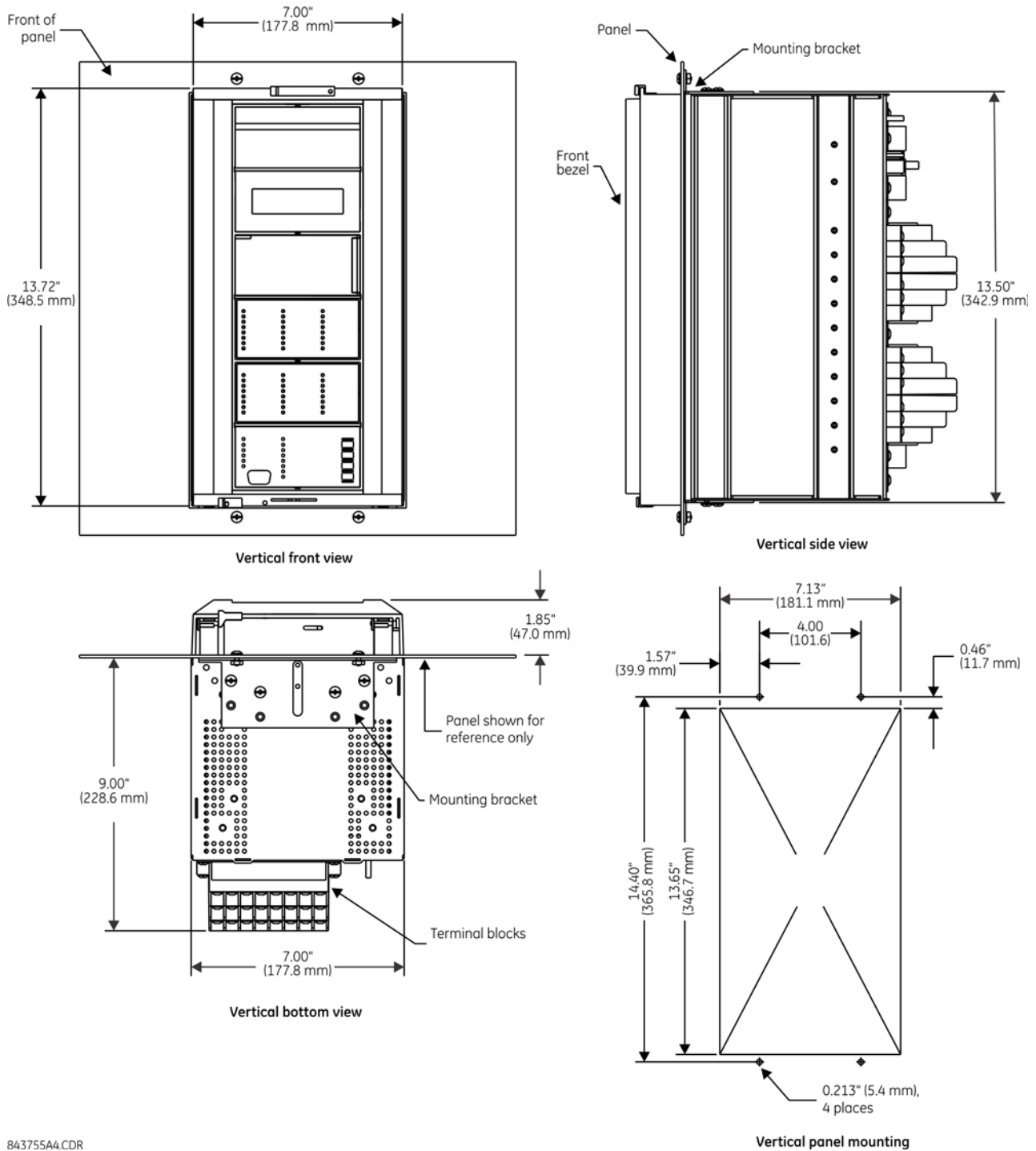


Figure 3-8: Vertical dimensions and mounting (standard front panel)



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For side-mounting L30 devices with the enhanced front panel, see the following documents available on the UR DVD and the GE Grid Solutions website:

- [GEK-113180](#) — UR-Series UR-V Side-Mounting Front Panel Assembly Instructions
- [GEK-113181](#) — Connecting a Remote UR-V Enhanced Front Panel to a Vertical UR Device Instruction Sheet
- [GEK-113182](#) — Connecting a Remote UR-V Enhanced Front Panel to a Vertically-Mounted Horizontal UR Device Instruction Sheet

For side-mounting L30 devices with the standard front panel, use the following figures.

Figure 3-9: Vertical side-mounting installation (standard front panel)

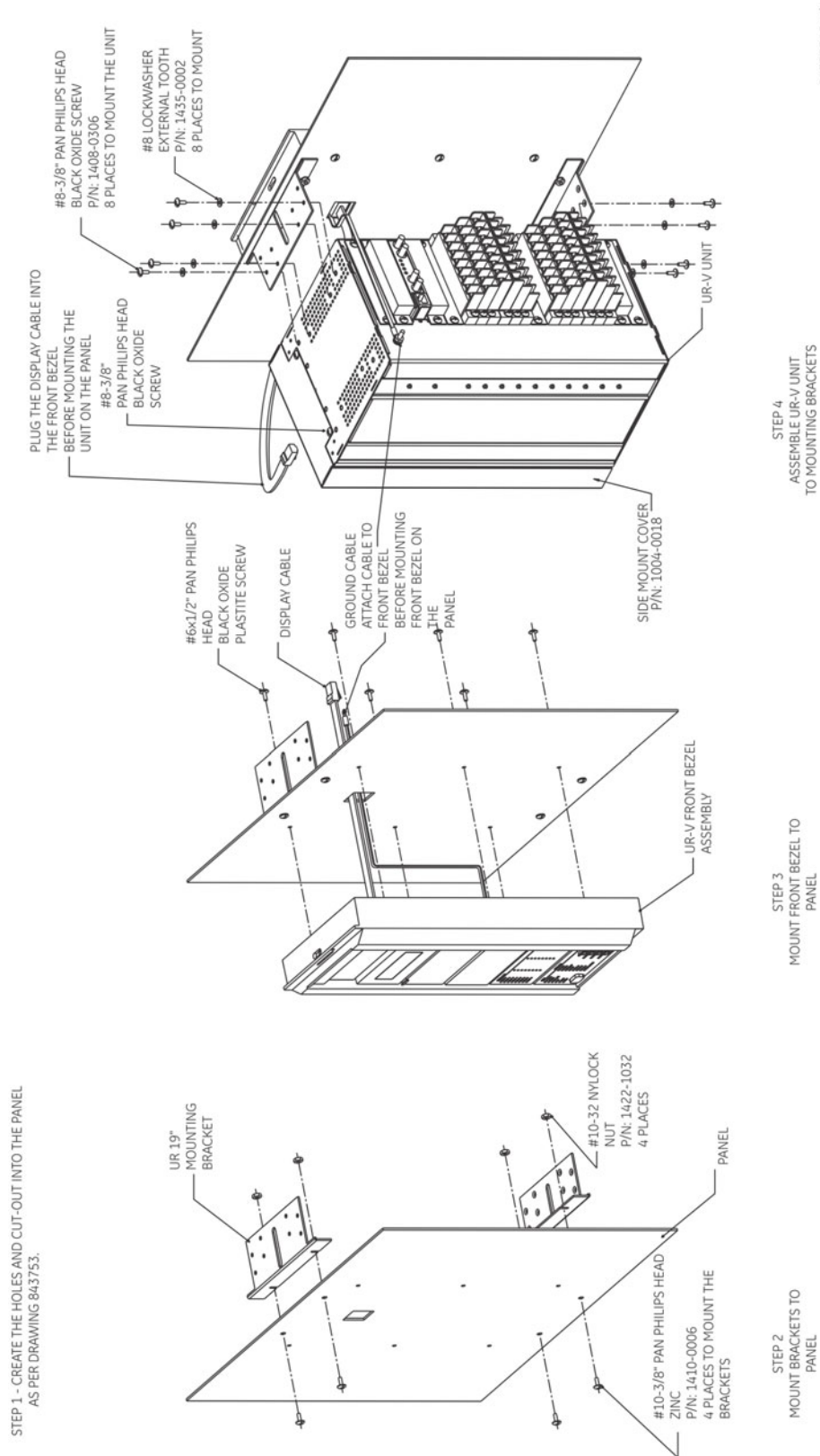
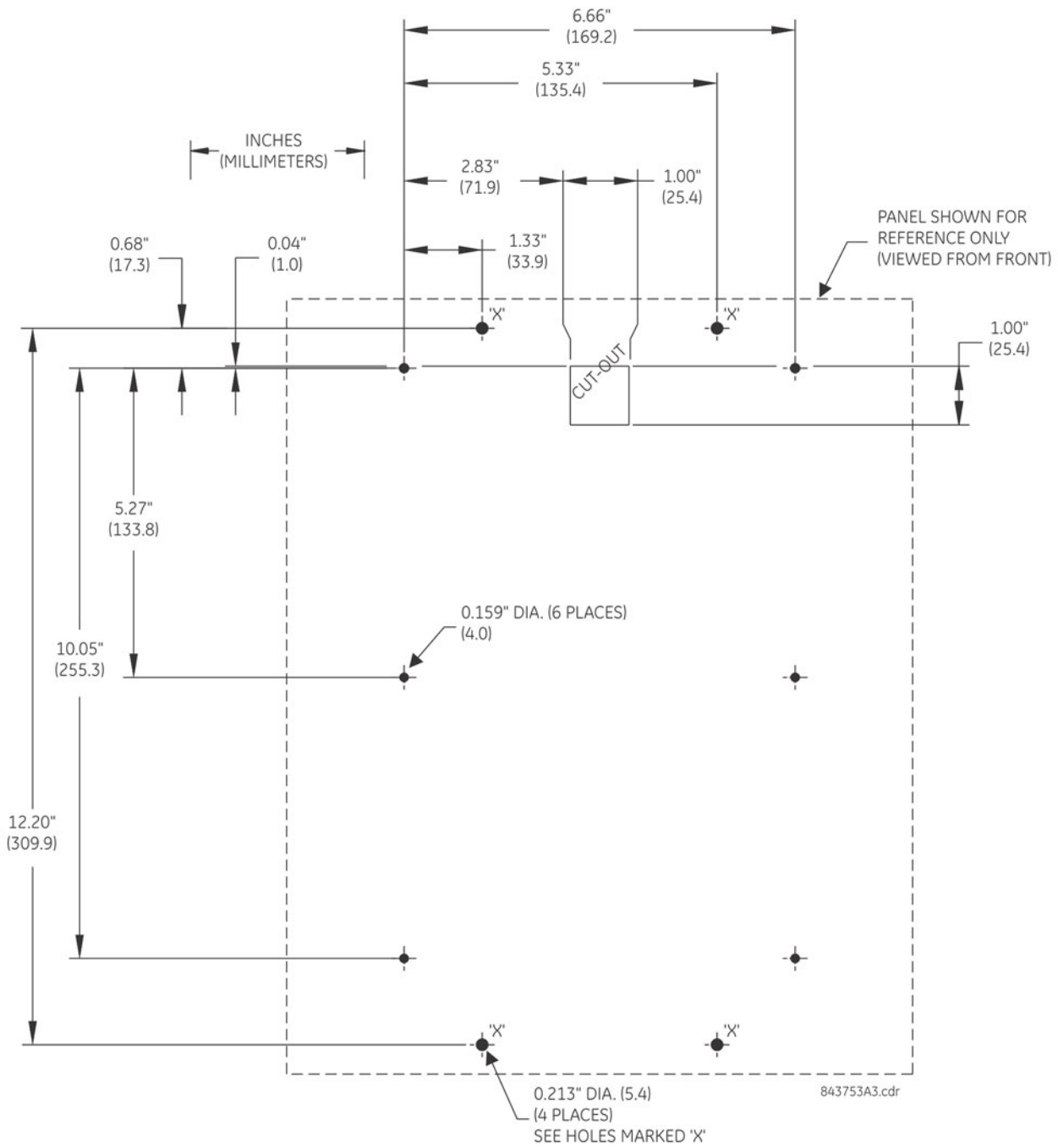
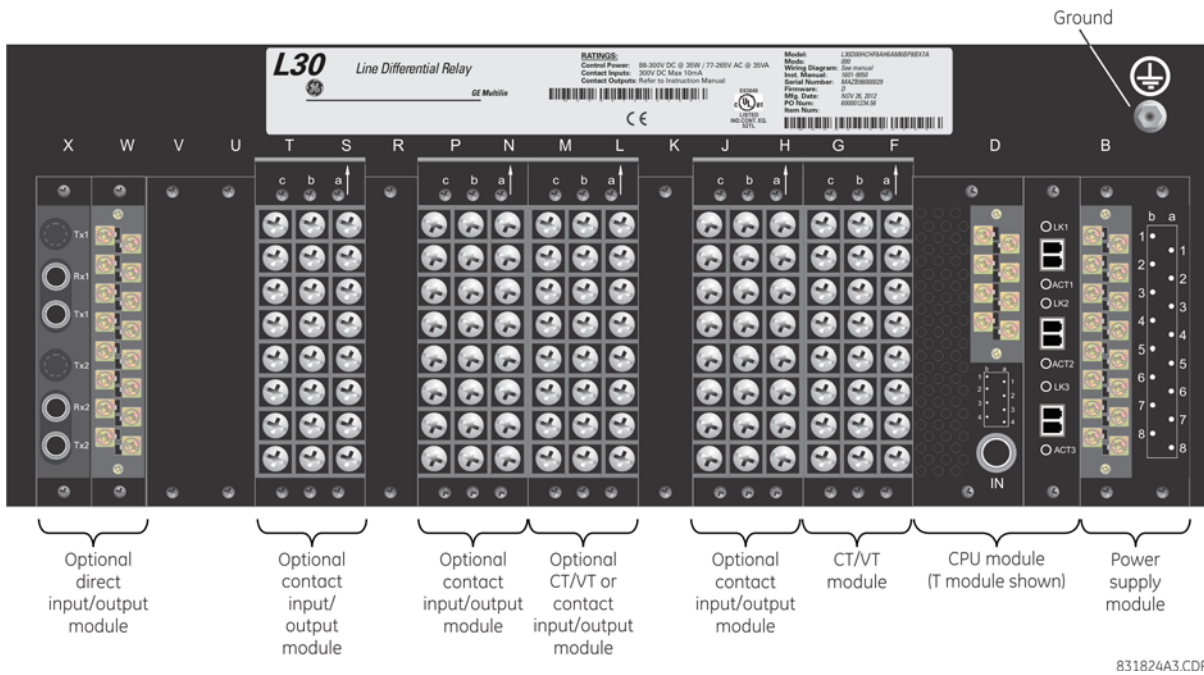


Figure 3-10: Vertical side-mounting rear dimensions (standard front panel)



3.2.3 Rear terminal layout



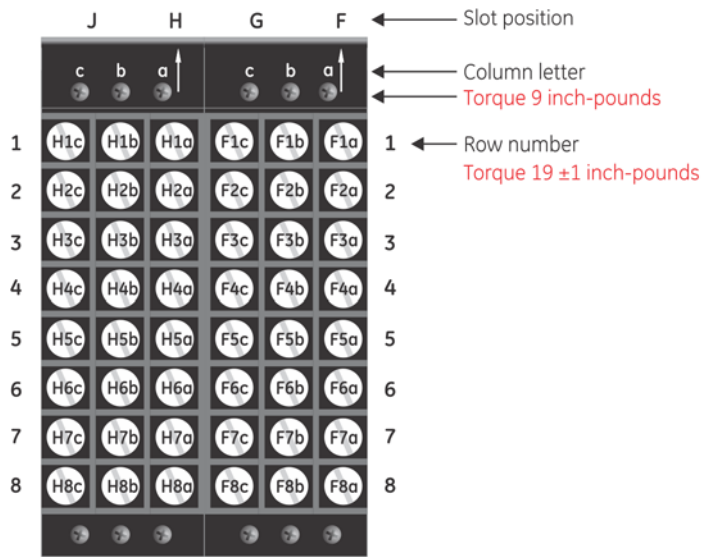
WARNING Do not touch any rear terminals while the relay is energized, else death or serious injury can result from electrical shock.



NOTICE Small form-factor pluggable ports (SFPs) are pluggable transceivers. They transmit, receive, and convert electrical signals to optical signals and vice-versa. They are inserted into the Ethernet ports on the CPU module. A photo in the Maintenance chapter shows this plug-in device. Do not use non-validated transceivers or install validated transceivers in the wrong Ethernet slot, else damage can occur.

The relay follows a convention for terminal number assignments, which are three characters long and assigned by module slot position, row number, and column letter. Two-slot wide modules take their slot designation from the first slot position (nearest to CPU module), indicated by an arrow on the terminal block. The figure shows an example of rear terminal assignments.

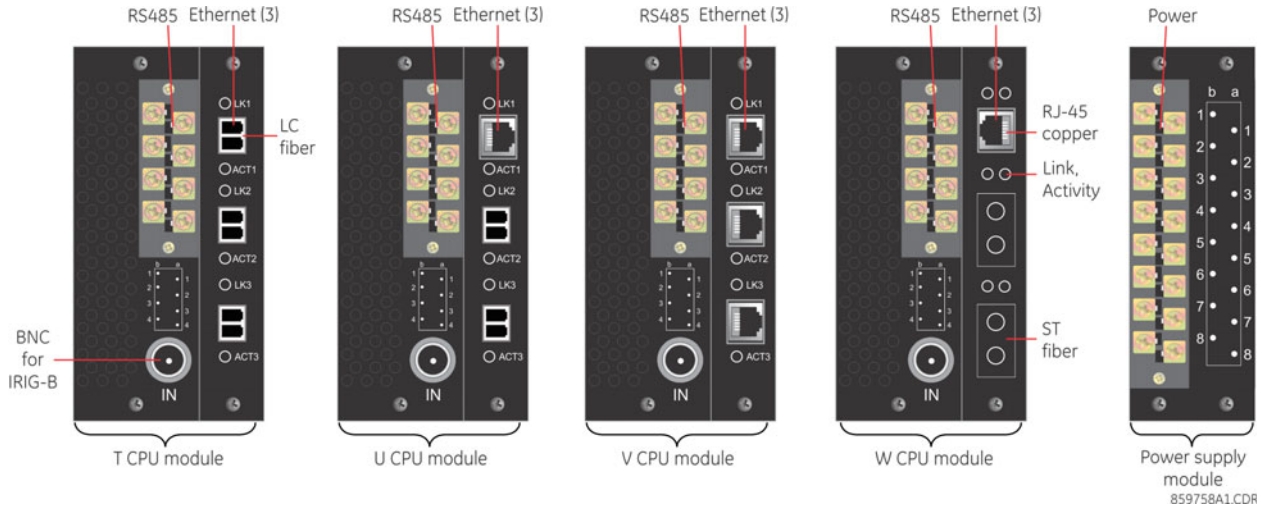
Figure 3-11: Example of modules in F and H slots



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The torque used to connect the screws that connect the terminal blocks (top screws a, b, c) and the metal plates over empty slots to the chassis is 9 inch-pounds. For the screws used to wire the terminal blocks (rows 1 to 8), use 19±1 inch-pounds. During manufacturing, the power supply and CPU modules are installed in slots B and D of the chassis with 13 inch-pounds of torque on the screws at the top and bottom of the modules. Wire connections to these two modules at 13 inch-pounds.

Figure 3-12: CPU modules and power supply



The following figure shows the optical connectors for CPU modules.

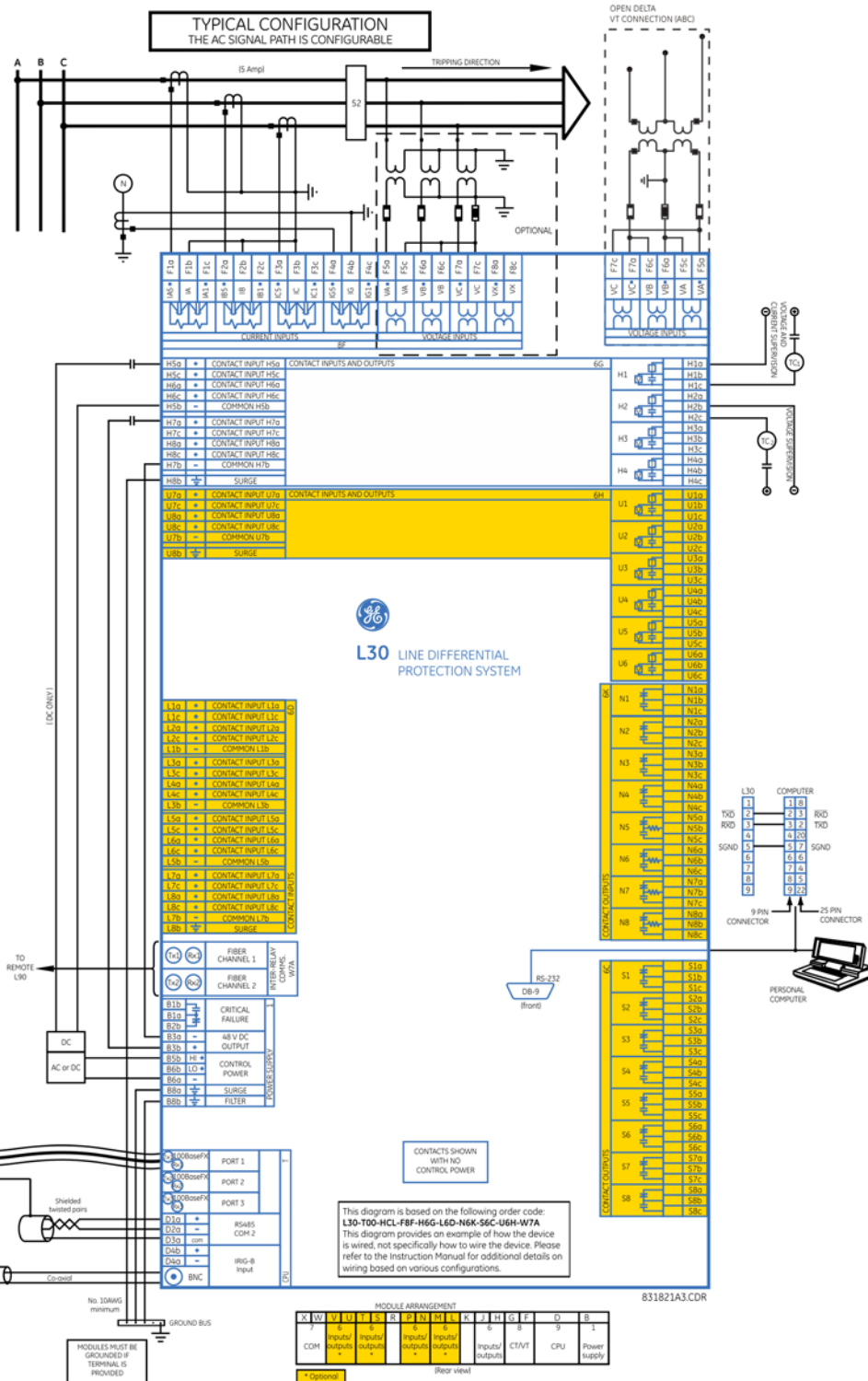
Figure 3-13: LC fiber connector (left) and ST fiber connector (right)



3.3 Wiring

3.3.1 Typical wiring

Figure 3-14: Typical wiring diagram (T module shown for CPU)



3

3.3.2 Dielectric strength

Dielectric strength is the maximum electric strength that can be sustained without breakdown. It is measured in volts. The table shows the dielectric strength of the UR-series module hardware.

Table 3-1: Dielectric strength of UR series modules

Module type	Module function	Terminals		Dielectric strength
		From	To	
1	Power supply	High (+); Low (+); (-)	Chassis	2000 V AC for 1 minute
1	Power supply	48 V DC (+) and (-)	Chassis	2000 V AC for 1 minute
1	Power supply	Relay terminals	Chassis	2000 V AC for 1 minute
2	Reserved	N/A	N/A	N/A
3	Reserved	N/A	N/A	N/A
4	Digital contact inputs/ outputs	All	Chassis	2000 V AC for 1 minute
5	Analog inputs/outputs	All except 8b	Chassis	< 50 V DC
6	Digital contact inputs/ outputs	All	Chassis	2000 V AC for 1 minute
7	G.703	All except 2b, 3a, 7b, 8a	Chassis	2000 V AC for 1 minute
	RS422	All except 6a, 7b, 8a	Chassis	< 50 V DC
8	CT/VT	All	Chassis	2000 V AC for 1 minute
9	CPU	All	Chassis	2000 V AC for 1 minute

NOTICE

Filter networks and transient protection clamps are used in the hardware to prevent damage caused by high peak voltage transients, radio frequency interference (RFI), and electromagnetic interference (EMI). These protective components can be damaged by application of the ANSI/IEEE C37.90 specified test voltage for longer than the specified minute.

3.3.3 Control power

NOTICE

Power supplied to the relay must be connected to the matching power supply range of the relay. If incorrect voltage is applied or voltage is applied to the wrong terminals, damage can occur.

The L30, like almost all electronic relays, contains electrolytic capacitors. These capacitors are well-known to deteriorate over time if voltage is not applied periodically. Deterioration can be avoided by powering up the relay at least once a year.

The power supply module can be ordered for two possible voltage ranges, and the L30 can be ordered with or without a redundant power supply module option. Each range has a dedicated input connection for proper operation. The ranges are as follows (see the Specifications section of chapter 2 for details):

- Low (LO) range — 24 to 48 V (DC only) nominal
- High (HI) range — 125 to 250 V nominal

The power supply module provides power to the relay and supplies power for dry contact input connections.

The power supply module provides 48 V DC power for dry contact input connections and a critical failure relay (see the Typical Wiring Diagram earlier). The critical failure relay is a form-C device that is energized once control power is applied and the relay has successfully booted up with no critical self-test failures. If ongoing self-test diagnostic checks detect a critical failure (see the Self-Test Errors section in chapter 7) or control power is lost, the relay de-energizes.

To connect power to the relay, 14 gauge stranded wire with disconnect devices is recommended. Connect all wires to the relay before turning on power.

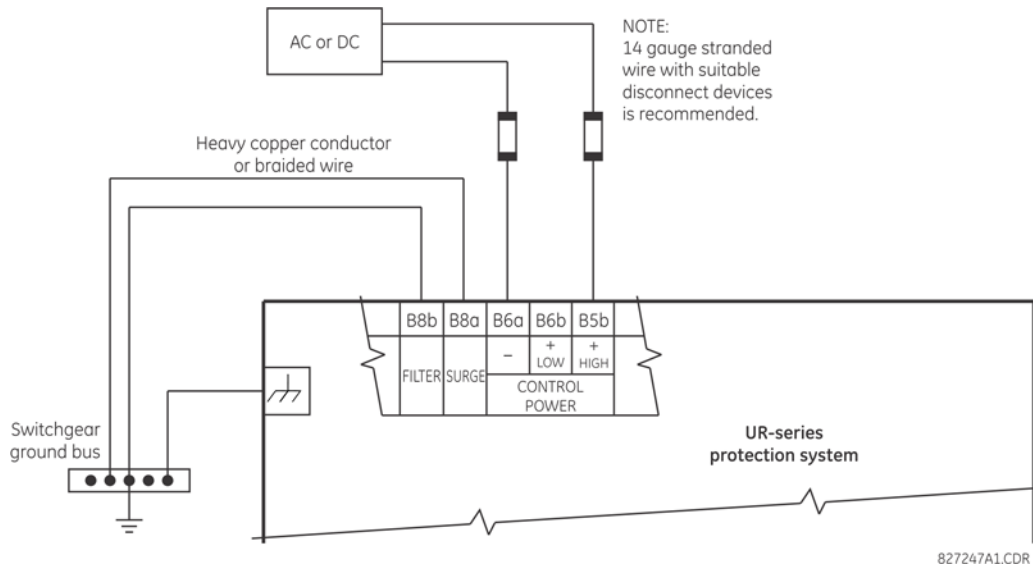
For high-reliability systems, the L30 has a redundant option in which two L30 power supplies are placed in parallel on the bus. If one of the power supplies becomes faulted, the second power supply assumes the full load of the relay without any interruptions. Each power supply has a green LED on the front of the module to indicate that it is functional. The critical fail relay of the module also indicates a faulted power supply.

An LED on the front of the control power module shows the status of the power supply, as outlined in the table.

Table 3-2: Power supply LED on module

LED indication	Power supply
Continuous on	OK
On/off cycling	Failure
Off	Failure or no power

Figure 3-15: Control power connection



NOTE When using a L30 with a HardFiber system, before powering off the L30, save data in the compact flash memory using **Commands > Relay Maintenance > Save Non-Volatile Data**. When not saved or the relay loses power, up to the last two minutes of data is not saved to the compact flash memory.

When using an SH power supply module, after disconnecting power and powering up again, some measured values displayed can change from that last displayed. This is because there is not enough time for the compact flash to store data. Upon power up the last stored value displays.

3.3.4 CT/VT modules

The CT and VT inputs are analog current transformer and voltage transformer signals used to monitor AC power lines. The UR-series relays support 1 A and 5 A CTs.

A CT/VT module can have current or voltage inputs on channels 1 through 4 inclusive, or channels 5 through 8 inclusive. Channels 1 and 5 are intended for connection to phase A, and are labelled as such in the relay. Likewise, channels 2 and 6 are intended for connection to phase B, and channels 3 and 7 are intended for connection to phase C.

Channels 4 and 8 are intended for connection to a single-phase source. For voltage inputs, these channels are labelled as auxiliary voltage (VX). For current inputs, these channels are intended for connection to a CT between system neutral and ground, and are labelled as ground current (IG).

NOTICE

Verify that the connection made to the relay terminals for nominal current of 1 A or 5 A matches the secondary rating of the connected CTs. Unmatched CTs can result in equipment damage or inadequate protection.

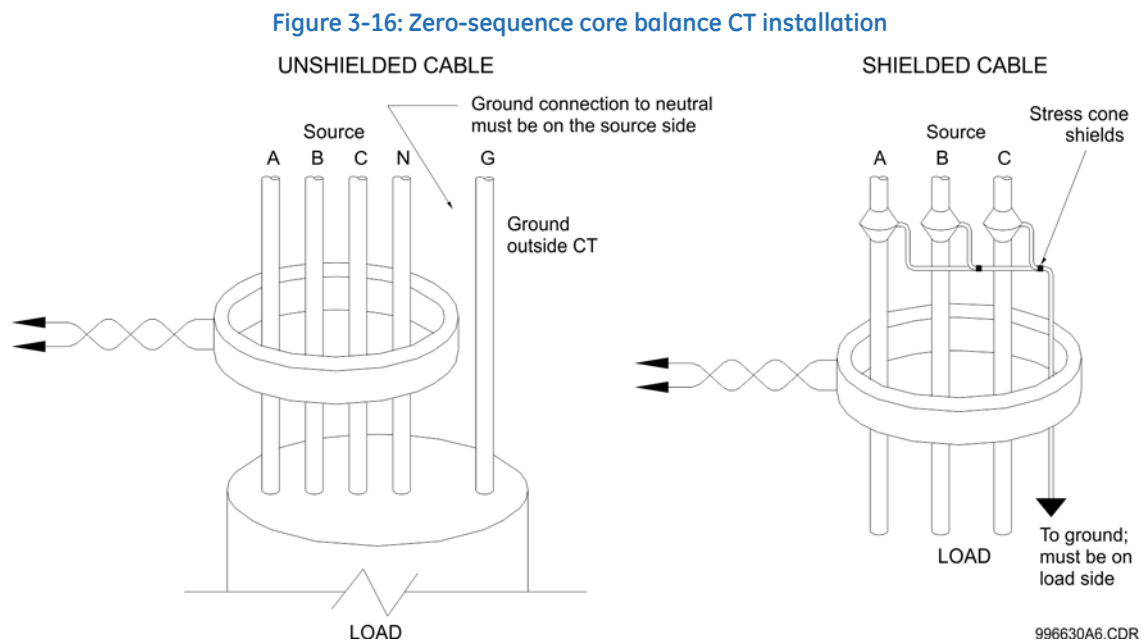
To connect to the module, size 12 American Wire Gauge (AWG) is used commonly; the maximum size is 10 AWG.

CT/VT modules can be ordered with a standard ground current input that is the same as the phase current input. Each AC current input has an isolating transformer and an automatic shorting mechanism that shorts the input when the module is withdrawn from the chassis. There are no internal ground connections on the current inputs. Current transformers with 1 to 50000 A primaries and 1 A or 5 A secondaries can be used.

These modules have enhanced diagnostics that can automatically detect CT/VT hardware failure and take the relay out of service.

CT connections for both ABC and ACB phase rotations are identical, as shown in the Typical Wiring Diagram.

The exact placement of a zero-sequence core balance CT to detect ground fault current is shown as follows. Twisted-pair cabling on the zero-sequence CT is recommended.

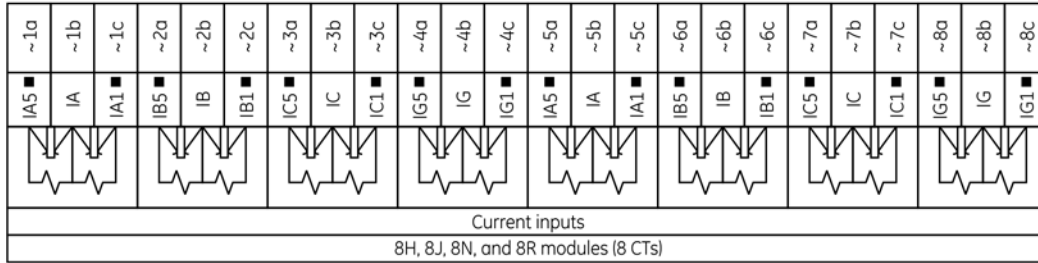
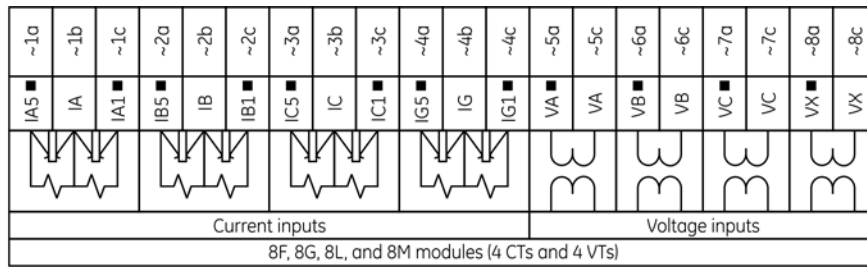


The phase voltage channels are used for most metering and protection purposes. The auxiliary voltage channel is used as input for the synchrocheck and volts-per-hertz features, which are optional features for some UR models.



Substitute the tilde "~" symbol with the slot position of the module in the following figure.

Figure 3-17: CT/VT module wiring



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3.3.5 Process bus modules

The L30 can be ordered with a process bus interface module. The module interfaces with the HardFiber Process Bus System, or HardFiber Brick, allowing bidirectional IEC 61850 fiber-optic communications with up to eight HardFiber Bricks. The HardFiber system integrates seamlessly with the existing UR-series applications, including protection functions, FlexLogic, metering, and communications.

This process bus system offers the following benefits:

- Reduces labor associated with design, installation, and testing of protection and control applications using the UR by reducing the number of individual copper terminations
- Integrates seamlessly with existing UR applications, since the IEC 61850 process bus interface module replaces the traditional CT/VT modules
- Communicates using open standard IEC 61850 messaging

For details on the HardFiber system, see its Instruction Manual.

3.3.6 Contact inputs and outputs

Nearly all contact input/output modules have 24 terminal connections. The connections are arranged typically as three terminals per row, with eight rows in total. A given row of three terminals can be used for the outputs of one relay. For example, for form-C relay outputs, the terminals connect to the normally open (NO), normally closed (NC), and common contacts of the relay. For a form-A output, there are options of using current or voltage detection for feature supervision, depending on the module ordered. The terminal configuration for contact inputs is different for the two applications.

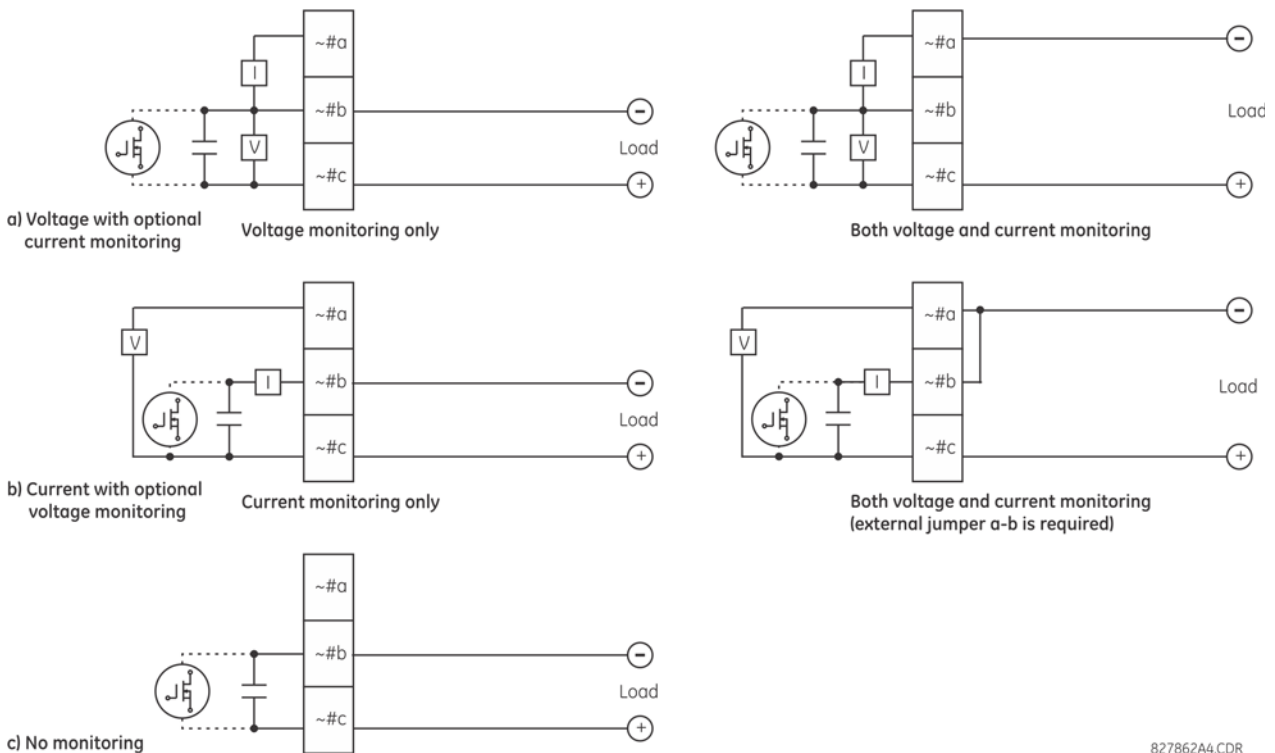
The contact inputs are grouped with a common return. The input/output modules have three versions of grouping: four inputs per common return, five inputs per common return on a high-density module, and two inputs per common return. When a contact input/output module is ordered, four inputs per common is used. If the inputs must be isolated per row, then two inputs per common return are selected (4D module). If the space limitation in the relay requires use of a high-density input module (6W), five inputs share one common return and the module has six banks of inputs.

The tables and diagrams that follow illustrate the module types (6A and so on) and contact arrangements that can be ordered for the relay. Since an entire row is used for a single contact output, the name is assigned using the module slot position and row number. However, since there are two contact inputs per row, these names are assigned by module slot position, row number, and column position.

Some form-A / solid-state relay outputs include circuits to monitor the DC voltage across the output contact when it is open, and the DC current through the output contact when it is closed. Each of the monitors contains a level detector whose output is set to logic “On = 1” when the current in the circuit is above the threshold setting. The voltage monitor is set to “On = 1” when there is a voltage across open contact (the detector allows a current of about 1 to 2.5 mA), and the current monitor is set to “On = 1” when the current flowing through the closed contact exceeds about 80 to 100 mA. The voltage monitor is intended to check the health of the overall trip circuit, and the current monitor can be used to seal-in the output contact until an external contact has interrupted current flow. If enabled, the current monitoring can be used as a seal-in signal to ensure that the form-A contact does not attempt to break the energized inductive coil circuit and weld the output contacts.

Block diagrams are shown as follows for form-A and solid-state relay outputs with optional voltage monitor, optional current monitor, and with no monitoring. The actual values shown for contact output 1 are the same for all contact outputs. Form-A contact output with or without a current or voltage monitoring option is not polarity sensitive. The polarity shown in the figure is required for solid-state contact output connection.

Figure 3-18: Form-A and solid-state contact outputs with voltage and current monitoring



The operation of voltage and current monitors is reflected with the corresponding FlexLogic operands (`CONT OP # VON`, `CONT OP # VOFF`, and `CONT OP # ION`) that can be used in protection, control, and alarm logic. The typical application of the voltage monitor is breaker trip circuit integrity monitoring; a typical application of the current monitor is seal-in of the control command.

See the Digital Elements section of chapter 5 for an example of how form-A and solid-state relay contacts can be applied for breaker trip circuit integrity monitoring.



Consider relay contacts unsafe to touch when the unit is energized. Death or serious injury can result from touching live relay contacts.



USE OF FORM-A AND SOLID-STATE RELAY OUTPUTS IN HIGH-IMPEDANCE CIRCUITS

For form-A and solid-state relay output contacts internally equipped with a voltage measuring circuit across the contact, the circuit has an impedance that can cause a problem when used in conjunction with external high-input impedance monitoring equipment, such as modern relay test set trigger circuits. These monitoring circuits can continue to read the form-A contact as being closed after it has closed and subsequently opened, when measured as an impedance.

The solution is to use the voltage measuring trigger input of the relay test set, and connect the form-A contact through a voltage-dropping resistor to a DC voltage source. If the 48 V DC output of the power supply is used as a source, a 500 Ω, 10 W resistor is appropriate. In this configuration, the voltage across either the form-A contact or the resistor can be used to monitor the state of the output.



Where a tilde “~” symbol appears, substitute the slot position of the module. Where a number sign “#” appears, substitute the contact number.

NOTICE

When current monitoring is used to seal-in the form-A and solid-state relay contact outputs, give the FlexLogic operand driving the contact output a reset delay of 10 ms to prevent damage of the output contact (in situations when the element initiating the contact output is bouncing, at values in the region of the pickup value).

For high-density input/output modules 6W and 6X, use the following guidelines to connect:

- 12 to 24 AWG (3.3 mm² to 0.2 mm²), single wire termination
- 16 to 24 AWG (1.31 mm² to 0.2 mm²), multiple wire termination with matching wire sizes and stranding. Two wires maximum per circuit.
- Suggested wiring screw tightening torque is a minimum 4.43 in-lb (0.5 Nm) and maximum 5.31 in-lb (0.6 Nm)
- Minimum suggested temperature rating for the conductors is 75°C
- Wire type: copper
- Do not use with SL power supply module

Table 3-3: Contact input and output module assignments

~6A module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6B module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5	Form-C
~6	Form-C
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6C module	
Terminal assignment	Output
~1	Form-C
~2	Form-C
~3	Form-C
~4	Form-C
~5	Form-C
~6	Form-C
~7	Form-C
~8	Form-C

~6D module	
Terminal assignment	Output
~1a, ~1c	2 Inputs
~2a, ~2c	2 Inputs
~3a, ~3c	2 Inputs
~4a, ~4c	2 Inputs
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6E module	
Terminal assignment	Output or input
~1	Form-C
~2	Form-C
~3	Form-C
~4	Form-C

~6F module	
Terminal assignment	Output
~1	Fast Form-C
~2	Fast Form-C
~3	Fast Form-C
~4	Fast Form-C

~6G module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A

~6H module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A

~6E module	
Terminal assignment	Output or input
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6F module	
Terminal assignment	Output
~5	Fast Form-C
~6	Fast Form-C
~7	Fast Form-C
~8	Fast Form-C

~6G module	
Terminal assignment	Output or input
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6H module	
Terminal assignment	Output or input
~5	Form-A
~6	Form-A
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6K module	
Terminal assignment	Output
~1	Form-C
~2	Form-C
~3	Form-C
~4	Form-C
~5	Fast Form-C
~6	Fast Form-C
~7	Fast Form-C
~8	Fast Form-C

~6L module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6M module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5	Form-C
~6	Form-C
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6N module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6P module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5	Form-A
~6	Form-A
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6R module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6S module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5	Form-C
~6	Form-C
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6T module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6U module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5	Form-A
~6	Form-A
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs
---	---
---	---
---	---

~6V module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	2 Outputs
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs
---	---
---	---
---	---

~6W module	
Terminal assignment	Output or input
~1a - ~2a	Output
~3a - ~4a	Output
~5a - ~6a	Output
~7a - ~8a	Output
~9a - ~10a	Output
~11a - ~12a	Output
~13a - ~14a	Output
~15a - ~16a	Output
~17a - ~18a	Output
~1b - ~2b	Output
~3b - ~4b	Output

6X module	
Terminal assignment	Output or input
~1a, ~1b	2 Inputs
~2a, ~2b	2 Inputs
~3a, ~3b	2 Inputs
~4a, ~4b	2 Inputs
~5a, ~5b	2 Inputs
~7a, ~7b	2 Inputs
~8a, ~8b	2 Inputs
~9a, ~9b	2 Inputs
~10a, ~10b	2 Inputs
~11a, ~11b	2 Inputs
~13a, ~13b	2 Inputs

~6U module	
Terminal assignment	Output or input
---	---
---	---
---	---
---	---
---	---
---	---
---	---

~6V module	
Terminal assignment	Output or input
---	---
---	---
---	---
---	---
---	---
---	---
---	---

~6W module	
Terminal assignment	Output or input
~5b - ~6b	Output
~7b - ~8b	Output
~9b - ~10b	Output
~11b - ~12b	Output
~13b - ~14b	Output
~15b - ~16b	Output
~17b - ~18b	Output

6X module	
Terminal assignment	Output or input
~14a, ~14b	2 Inputs
~15a, ~15b	2 Inputs
~16a, ~16b	2 Inputs
~17a, ~17b	2 Inputs
---	---
---	---
---	---

3

~67 module	
Terminal assignment	Output
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5	Form-A
~6	Form-A
~7	Form-A
~8	Form-A

~4A module	
Terminal assignment	Output
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State
~7	Not Used
~8	Solid-State

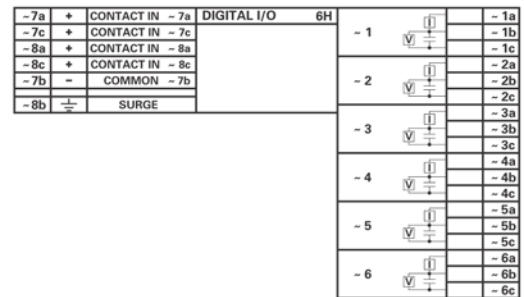
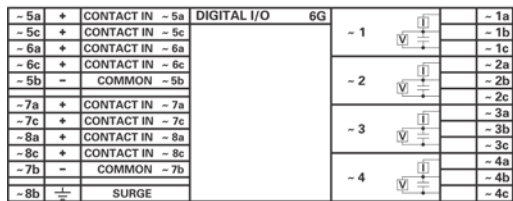
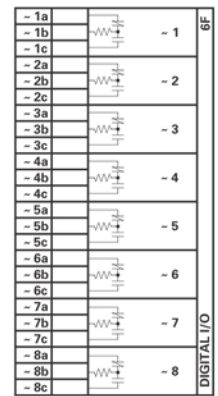
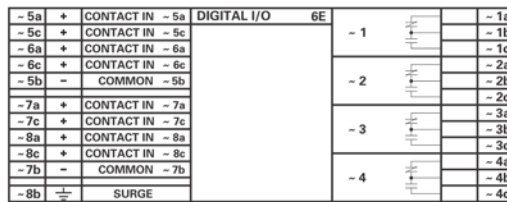
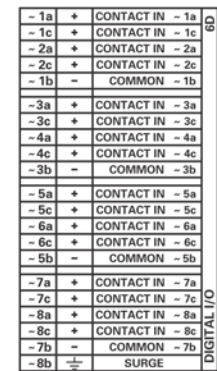
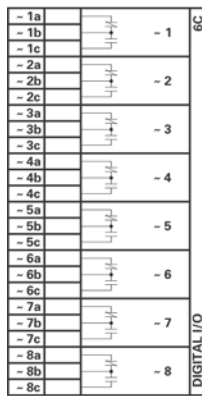
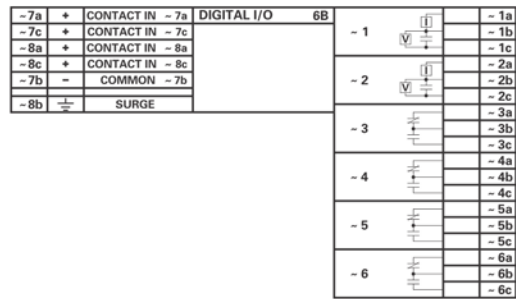
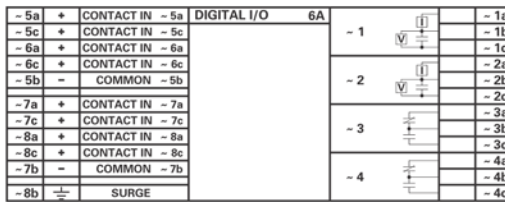
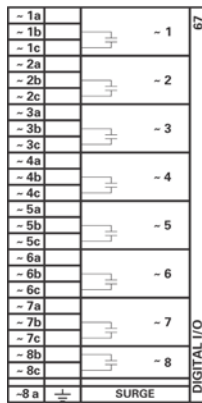
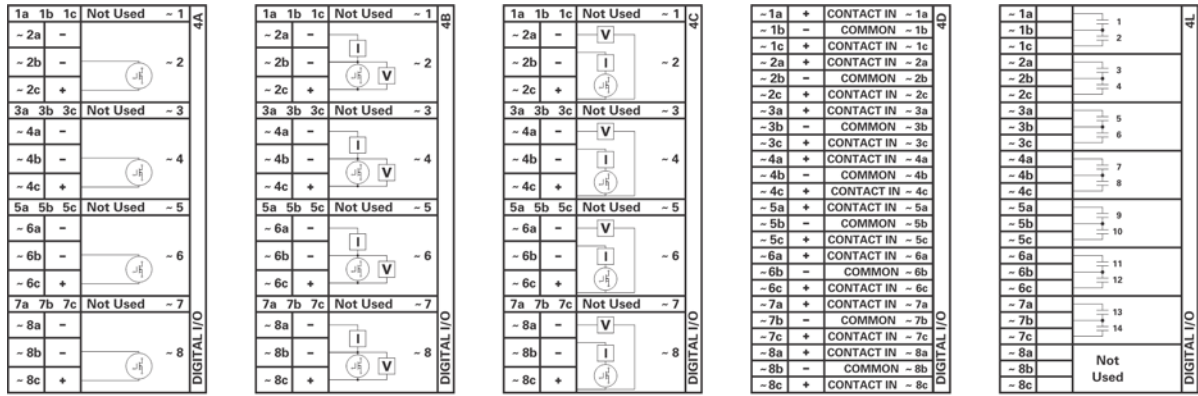
~4B module	
Terminal assignment	Output
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State
~7	Not Used
~8	Solid-State

~4C module	
Terminal assignment	Output
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State
~7	Not Used
~8	Solid-State

~4D module	
Terminal assignment	Output
~1a, ~1c	2 Inputs
~2a, ~2c	2 Inputs
~3a, ~3c	2 Inputs
~4a, ~4c	2 Inputs
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

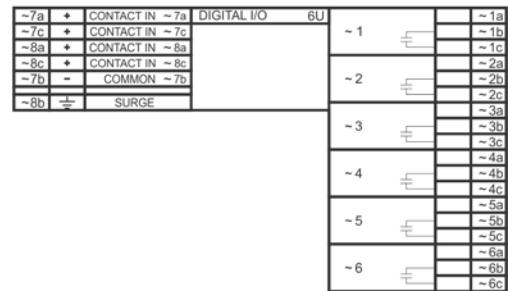
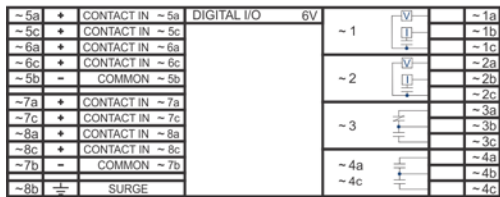
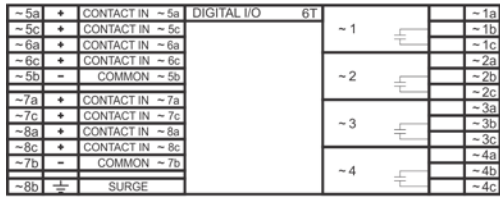
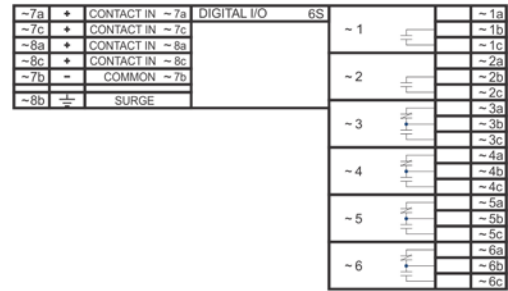
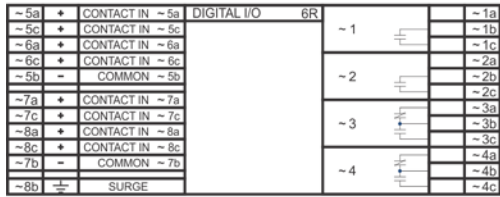
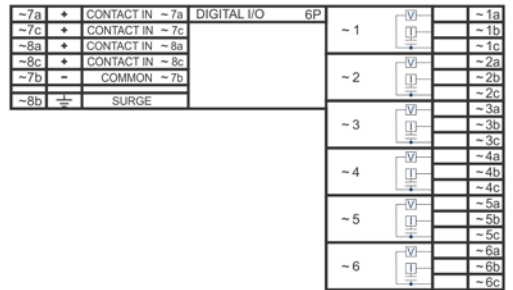
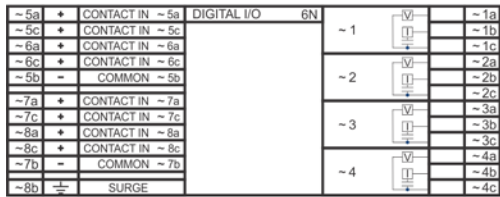
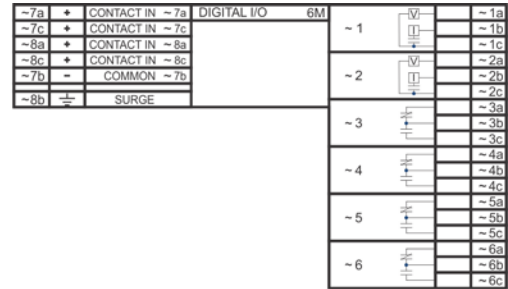
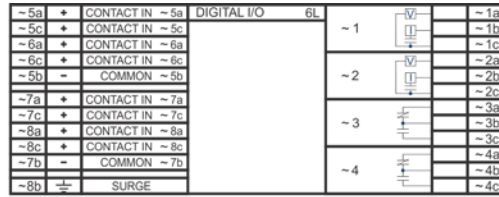
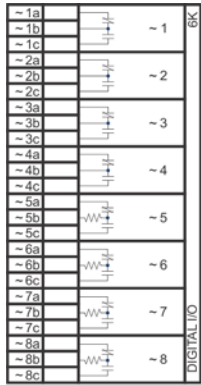
~4L module	
Terminal assignment	Output
~1	2 Outputs
~2	2 Outputs
~3	2 Outputs
~4	2 Outputs
~5	2 Outputs
~6	2 Outputs
~7	2 Outputs
~8	Not Used

Figure 3-19: Contact input and output module wiring (Sheet 1 of 3)



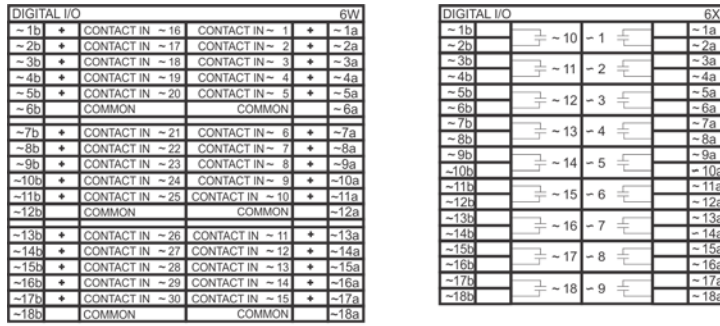
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Figure 3-20: Contact input and output module wiring (Sheet 2 of 3)



842763A2.CDR

Figure 3-21: Contact input and output module wiring (Sheet 3 of 3)



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NOTICE

For proper functionality, observe the polarity shown in the figures for all contact input and output connections.

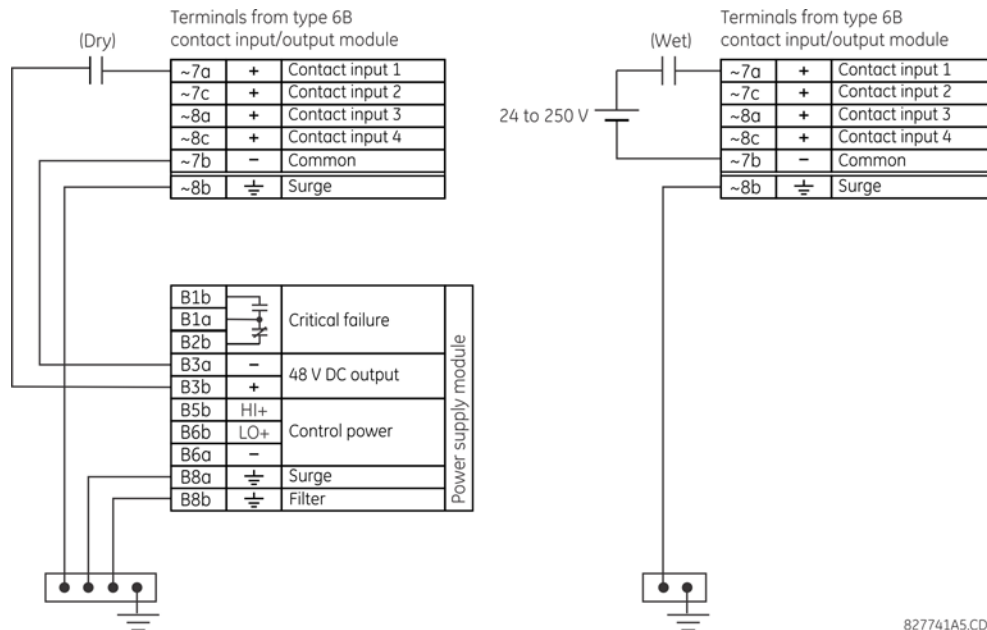
3.3.6.1 Contact inputs

A dry contact has one side connected to terminal B3b. This is the positive 48 V DC voltage rail supplied by the power supply module. The other side of the dry contact is connected to the required contact input terminal. Each contact input group has its own common (negative) terminal that must be connected to the DC negative terminal (B3a) of the power supply module. When a dry contact closes, a current of 1 to 3 mA flows through the associated circuit.

A wet contact has one side connected to the positive terminal of an external DC power supply. The other side of this contact is connected to the required contact input terminal. If a wet contact is used, then the negative side of the external source must be connected to the relay common (negative) terminal of each contact group. The maximum external source voltage for this arrangement is 300 V DC.

The voltage threshold at which each group of four contact inputs detects a closed contact input is programmable as 17 V DC for 24 V sources, 33 V DC for 48 V sources, 84 V DC for 110 to 125 V sources, and 166 V DC for 250 V sources.

Figure 3-22: Dry and wet contact input connections



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Where a tilde “~” symbol appears, substitute the slot position of the module.

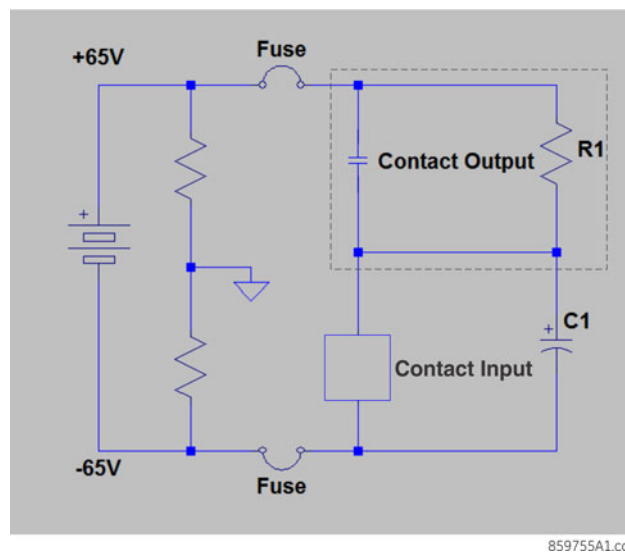
There is no provision in the relay to detect a DC ground fault on 48 V DC control power external output. We recommend using an external DC supply.

3.3.6.2 General application considerations

Contacts outputs of protective relays, auxiliary contacts from breakers, disconnectors and other devices are connected generally to contacts inputs of protective relays. In some situations, the contact outputs of some protective relays can have high impedance connected across it. When such a contact output is connected across a L30 contact input, it can spuriously operate the L30 input even when the output is open, if there is a substantial distributed capacitance (represented by C1) present in the wiring between the output and the L30 input, and the debounce time setting in the L30 relay is low enough. This false assertion of the contact input, when there is inadvertent ground present at the DC positive terminal, can be prevented by inserting a resistor across the L30 input.

The following figure shows a typical DC circuit, with battery ground detection, of contact input. The contact output has parallel impedance across it (represented by R1).

Figure 3-23: Typical contact input DC circuit

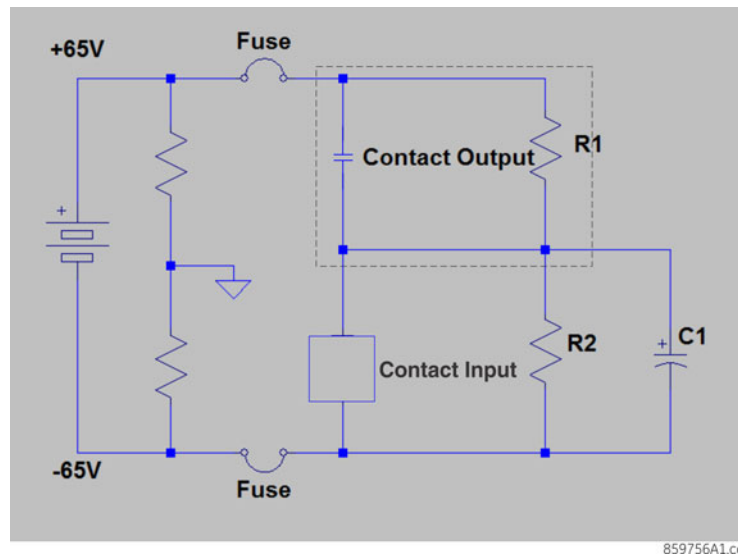


The presence of the impedance path (R1) across the contact output allows the stray (distributed) capacitance C1 to charge as shown, thus developing a voltage across the contact input enough to momentarily operate the input while the capacitance discharges in the presence of DC ground on the positive terminal of the battery.

The duration of the discharge depends on the value of the distributed capacitance, the initial voltage of the distributed capacitance, and the input impedance of the contact input. If the duration is greater than the debounce time setting, then the contact input operates.

The application example that follows describes how to mitigate this issue by connecting a resistor across the contact input, as shown in the next figure, or by adjusting the debounce time setting to a value greater than the discharge time to prevent spurious operation of the contact input only if the voltage (with output open) across the contact input due to trickle current is less than the threshold voltage. This operation of contact inputs also can be prevented by using the Auto-Burnish contact inputs or contact inputs with active impedance.

Figure 3-24: Contact input connected to a contact output with resistor (R2) across the input



Application example

This example is for illustrative purposes only and the calculations present the worst-case scenario. In practice, the value of debounce time can be lower.

Contact input ON state impedance used in the calculation of the discharge period is based on the following table.

Table 3-4: Discharge period

Battery voltage (V)	Input impedance (kΩ)
130	50
250	97

Debounce time setting = 2 ms

Assume a stray capacitance of 0.1 μF.

Assume an initial voltage across the stray capacitance "Vinitial" = 19 V (Vthreshold - 65 V), where Vthreshold = 84 V. The initial voltage Vinitial depends on values of impedance of R1 and contact inputs when the contact input is OFF (non-activated state).

Therefore, discharge time constant (τ) = 50 kΩ * 0.1 μF = 5 ms.

Discharge period t is calculated from the following equation:

$$V_{\text{threshold}} = (V_{\text{batt}} - V_{\text{initial}}) * e^{(-t/\tau)}$$

$$84 = -149 * e^{(t/0.005)}$$

$$T = -0.005 * \ln (84/149) = 0.0029 \text{ s}$$

Eq. 3-1

Therefore, in this example the contact inputs operate.

To prevent this operation, the debounce time must be increased to 4 ms (set debounce time as per the following table) or insert a resistor less than or equal to "R" as calculated later.

Table 3-5: Typical debounce time setting

Stray capacitance (μF)	Battery voltage (V)	Debounce time (ms)
0.05	130	2
0.1	130	4
0.2	130	6
0.05	250	3

Stray capacitance (µF)	Battery voltage (V)	Debounce time (ms)
0.1	250	6 *
0.2	250	11

* Default debounce time on contact inputs is 6 ms.

The value of this resistor "R" is calculated as follows:

1. Determine the minimum voltage (V threshold) required to turn on the input. This is determined by direct measurement or referenced in the input specifications.
2. Calculate the resistance necessary to limit the voltage to 1/3 V threshold (when the contact is OFF, the non-activated state) as follows:

$$R = (V_{\text{threshold}} / 3) / (2 \text{ mA}) \tag{Eq. 3-2}$$

The 2 mA current is used in case the contact input is connected across the GE Form A contact output with voltage monitoring. Otherwise use the amperage of the active circuit connected to the contact input when its contact output is open and the voltage across the contact input is third trigger threshold to calculate the resistor value.

3. When the contact is ON (operate state), the battery voltage appears across the resistor. The wattage rating of the resistor is then:

$$PR = 1.3 * (V_{\text{batt}})^2 / R \text{ Watts} \tag{Eq. 3-3}$$

4. Applying the following equation to our example:

$$R = 84 \text{ V} / 3 * (1 / 2 \text{ mA}) = 14 \text{ k}\Omega$$

$$PR = 1.57 \text{ Watts} \tag{Eq. 3-4}$$

5. Calculating the voltage across the contact input with the Burden Resistor, Voltage across the contact Input:

$$V_{\text{resistor}} = 2 \text{ mA} * 14 \text{ Kohm} = 28 \text{ V}$$

$$V_{\text{resistor}} < \text{contact input threshold (84 V)} \tag{Eq. 3-5}$$

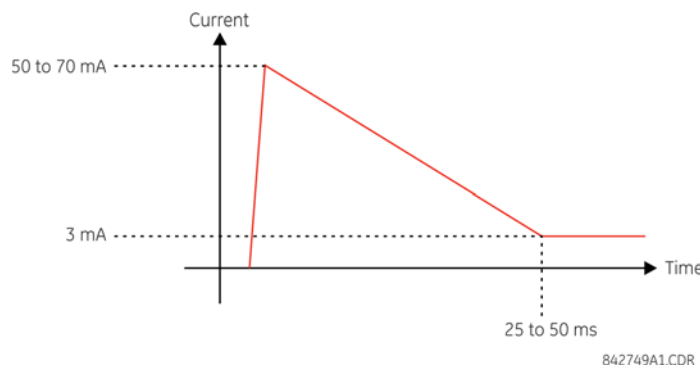
In conclusion, in this example, the contact input does NOT operate falsely with the Burden Resistor across its input AND when a battery ground is present.

3.3.6.3 Use of contact inputs with auto-burnishing

The contact inputs sense a change of state of the external device contact based on the measured current. When external devices are located in a harsh industrial environment (either outdoor or indoor), their contacts can be exposed to various types of contamination. Normally, there is a thin film of insulating sulfidation, oxidation, or contaminates on the surface of the contacts, sometimes making it difficult or impossible to detect a change of state. This film must be removed to establish circuit continuity — an impulse of higher than normal current can accomplish this.

The contact inputs with auto-burnish create a high current impulse when the threshold is reached to burn off this oxidation layer as a maintenance to the contacts. Afterwards the contact input current is reduced to a steady-state current. The impulse has a five-second delay after a contact input changes state.

Figure 3-25: Current through contact inputs with auto-burnishing

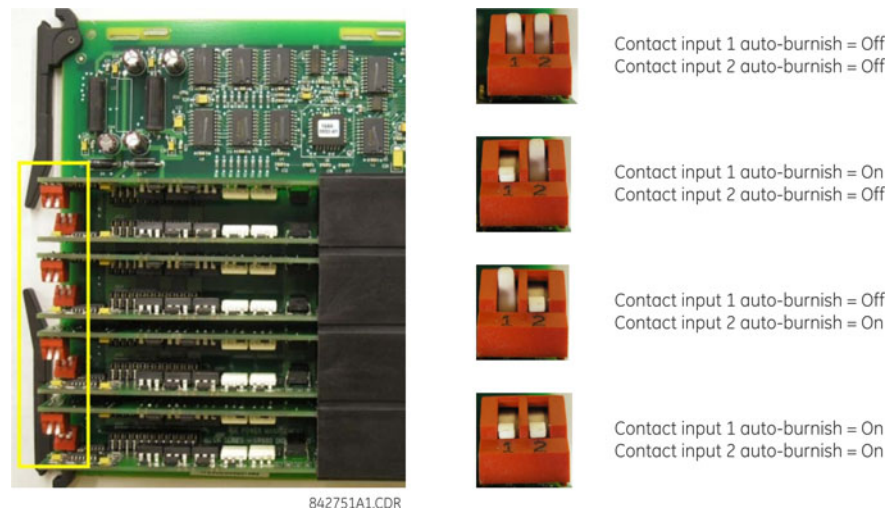


Regular contact inputs limit current to less than 3 mA to reduce station battery burden. In contrast, contact inputs with auto-burnishing allow currents up to 50 to 70 mA at the first instance when the change of state is sensed. Then, within 25 to 50 ms, this current is slowly reduced to 3 mA as indicated. The 50 to 70 mA peak current burns any film on the contacts, allowing for proper sensing of state changes. If the external device contact is bouncing, the auto-burnishing starts when external device contact bouncing is over.

Another important difference between the auto-burnishing input module and the regular input modules is that only two contact inputs have common ground, as opposed to four contact inputs sharing one common ground (see the Contact Input and Output Module Wiring diagrams). This is beneficial when connecting contact inputs to separate voltage sources. Consequently, the threshold voltage setting is also defined per group of two contact inputs.

The auto-burnish feature can be disabled or enabled using the DIP switches found on each daughter card. There is a DIP switch for each contact, for a total of 16 inputs.

Figure 3-26: Auto-burnish DIP switches



The auto-burnish circuitry has an internal fuse for safety purposes. During regular maintenance, check the auto-burnish functionality using an oscilloscope.

3.3.6.4 Use of contact inputs with active impedance

Contact inputs can be susceptible to parasitic capacitance, caused by long cable runs affected by switching surges from external circuits. This can result in inadvertent activation of contact inputs with the external contact open. In this case, GE recommends using the contact I/O module with active impedance circuit.

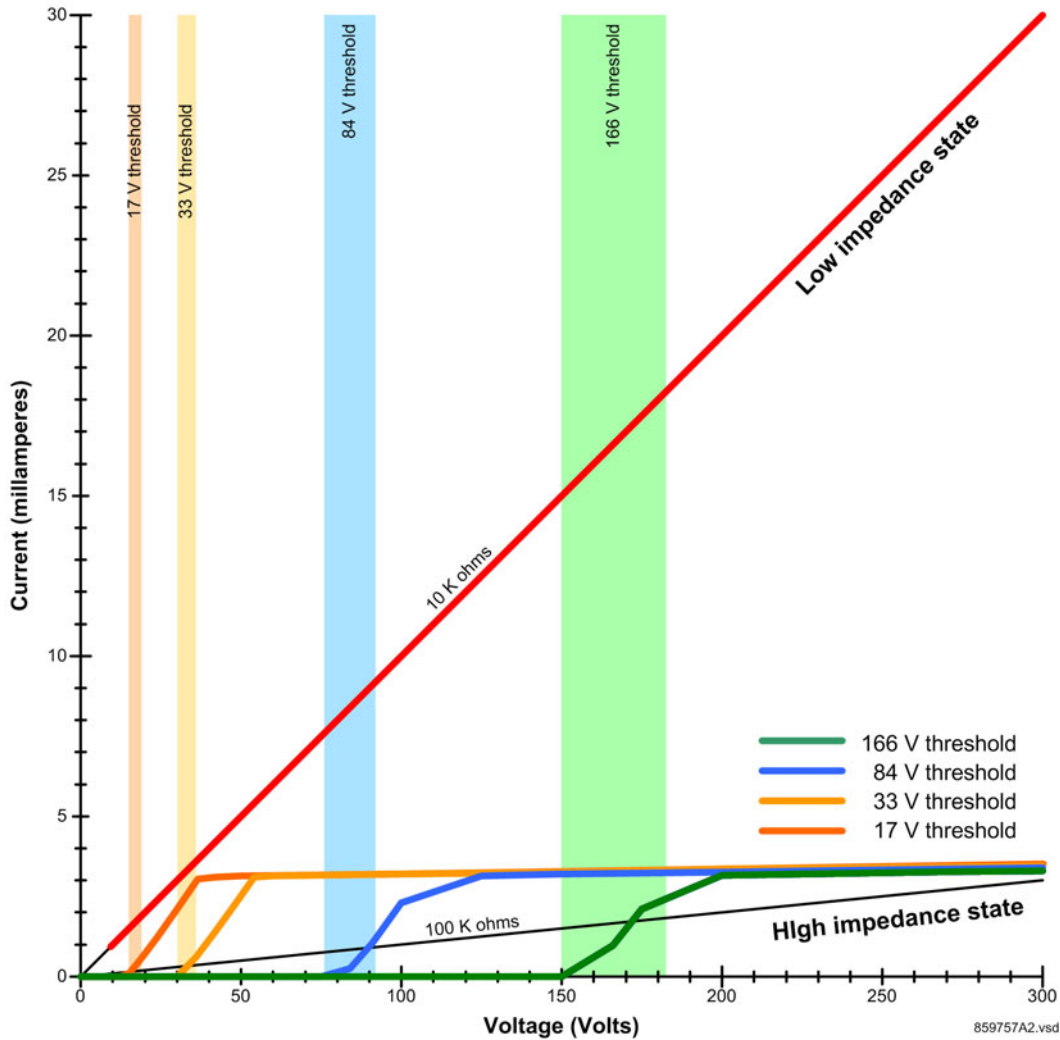
Active impedance contact input can tolerate external cable capacitance of up to 0.2 μF , without entering the ON state for more than 2 ms. The contact input debounce time can still be set above 2 ms for added security to prevent contact input activations caused by external transient ON states.

An active impedance contact input is normally in Low impedance mode during OFF contact state (non-activated condition). During Low impedance state, contact input impedance is maintained at 10 K Ohms impedance to allow fast discharge of the stray capacitance of the long cables.

When the contact input voltage exceeds the set threshold, active impedance maintains 10 K Ohms impedance. If voltage starts rapidly decreasing, this indicates that stray capacitance is being discharged through the contact input. If, however, voltage stabilizes above the set threshold, the input impedance is switched to High impedance mode of 100 K Ohms. This value reduces the input current to <3 mA, and contact input switches to the ON state (operated state).

The figure shows the active impedance contact input V-I characteristic. Different thresholds with their corresponding characteristics are shown by color. The contact input is in the ON (operated) state if the input voltage is to the right of the colored threshold band (+/- 10% tolerance), and the contact input is in the OFF (non-activated) state when input voltage is to the left of the band. A contact input is in LOW state during non-operated system condition, and actively switches to HIGH state upon detection of input voltage above the settable threshold.

Figure 3-27: Active impedance contact input V-I characteristic



3.3.7 Transducer inputs and outputs

Transducer input modules receive input signals from external DCmA output transducers (DCmA In) or resistance temperature detectors (RTDs). Hardware and software are provided to receive signals from these external transducers and convert these signals into a digital format for use as required.

Transducer output modules provide DC current outputs in several standard DCmA ranges. Software is provided to configure virtually any analog quantity used in the relay to drive the analog outputs.

Each transducer input/output module has 24 terminal connections. These connections are arranged as three terminals per row over eight rows. A given row can be used for either inputs or outputs, with terminals in column "a" having positive polarity and terminals in column "c" having negative polarity. Since an entire row is used for a single input/output channel, the name of the channel is assigned using the module slot position and row number.

Each module also requires that a connection from an external ground bus be made to terminal 8b. The current outputs require a twisted-pair shielded cable, where the shield is grounded at one end only. The following figure illustrates the transducer module types (5A, 5C, 5D, 5E, and 5F) and channel arrangements that can be ordered for the relay.



Where a tilde “~” symbol appears, substitute the slot position of the module.

Figure 3-28: Transducer input/output module wiring

~1a	+		
~1c	-	dcmA In	~1
~2a	+		
~2c	-	dcmA In	~2
~3a	+		
~3c	-	dcmA In	~3
~4a	+		
~4c	-	dcmA In	~4
~5a	+		
~5c	-	dcmA Out	~5
~6a	+		
~6c	-	dcmA Out	~6
~7a	+		
~7c	-	dcmA Out	~7
~8a	+		
~8c	-	dcmA Out	~8
~8b	SURGE		

~1a	Hot	RTD	~1
~1c	Comp		
~1b	Return for RTD ~1& ~2		
~2a	Hot	RTD	~2
~2c	Comp		
~3a	Hot	RTD	~3
~3c	Comp		
~3b	Return for RTD ~3& ~4		
~4a	Hot	RTD	~4
~4c	Comp		
~5a	Hot	RTD	~5
~5c	Comp		
~5b	Return for RTD ~5& ~6		
~6a	Hot	RTD	~6
~6c	Comp		
~7a	Hot	RTD	~7
~7c	Comp		
~7b	Return for RTD ~7& ~8		
~8a	Hot	RTD	~8
~8c	Comp		
~8b	SURGE		

~1a	Hot	RTD	~1
~1c	Comp		
~1b	Return for RTD ~1& ~2		
~2a	Hot	RTD	~2
~2c	Comp		
~3a	Hot	RTD	~3
~3c	Comp		
~3b	Return for RTD ~3& ~4		
~4a	Hot	RTD	~4
~4c	Comp		
~5a	+	dcmA Out	~5
~5c	-		
~6a	+	dcmA Out	~6
~6c	-		
~7a	+	dcmA Out	~7
~7c	-		
~8a	+	dcmA Out	~8
~8c	-		
~8b	SURGE		

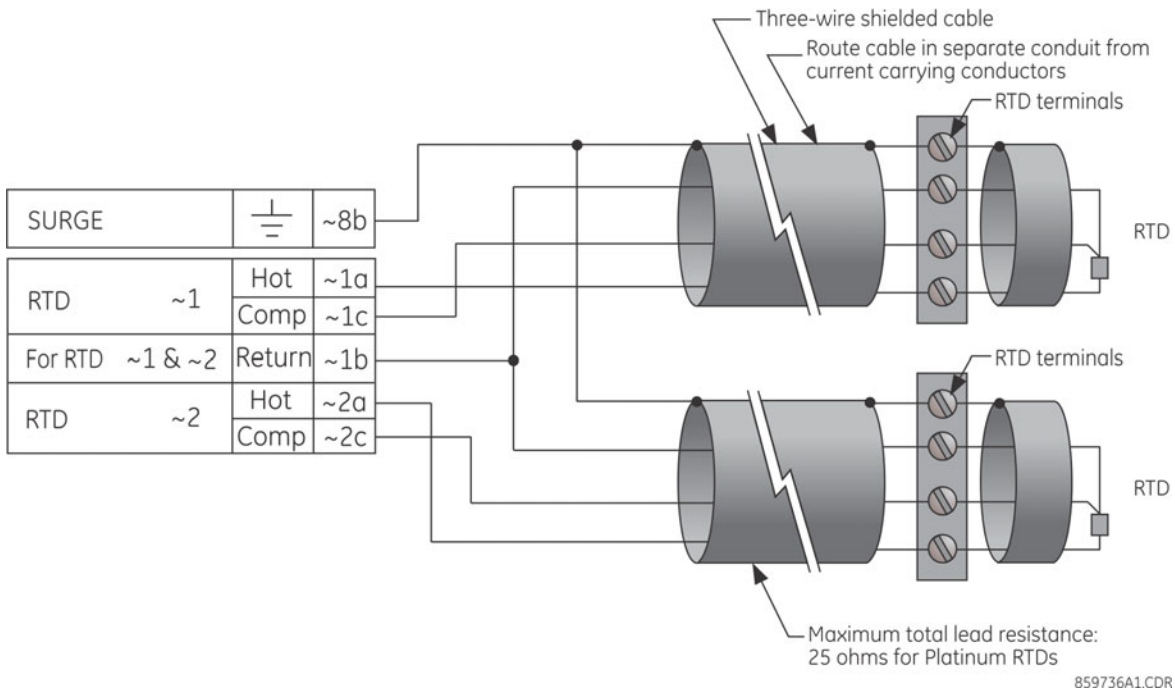
~1a	+		
~1c	-	dcmA In	~1
~2a	+		
~2c	-	dcmA In	~2
~3a	+		
~3c	-	dcmA In	~3
~4a	+		
~4c	-	dcmA In	~4
~5a	Hot	RTD	~5
~5c	Comp		
~5b	Return for RTD ~5& ~6		
~6a	Hot	RTD	~6
~6c	Comp		
~7a	Hot	RTD	~7
~7c	Comp		
~7b	Return for RTD ~7& ~8		
~8a	Hot	RTD	~8
~8c	Comp		
~8b	SURGE		

~1a	+		
~1c	-	dcmA In	~1
~2a	+		
~2c	-	dcmA In	~2
~3a	+		
~3c	-	dcmA In	~3
~4a	+		
~4c	-	dcmA In	~4
~5a	+		
~5c	-	dcmA In	~5
~6a	+		
~6c	-	dcmA In	~6
~7a	+		
~7c	-	dcmA In	~7
~8a	+		
~8c	-	dcmA In	~8
~8b	SURGE		

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The following figure show how to connect RTDs.

Figure 3-29: RTD connections

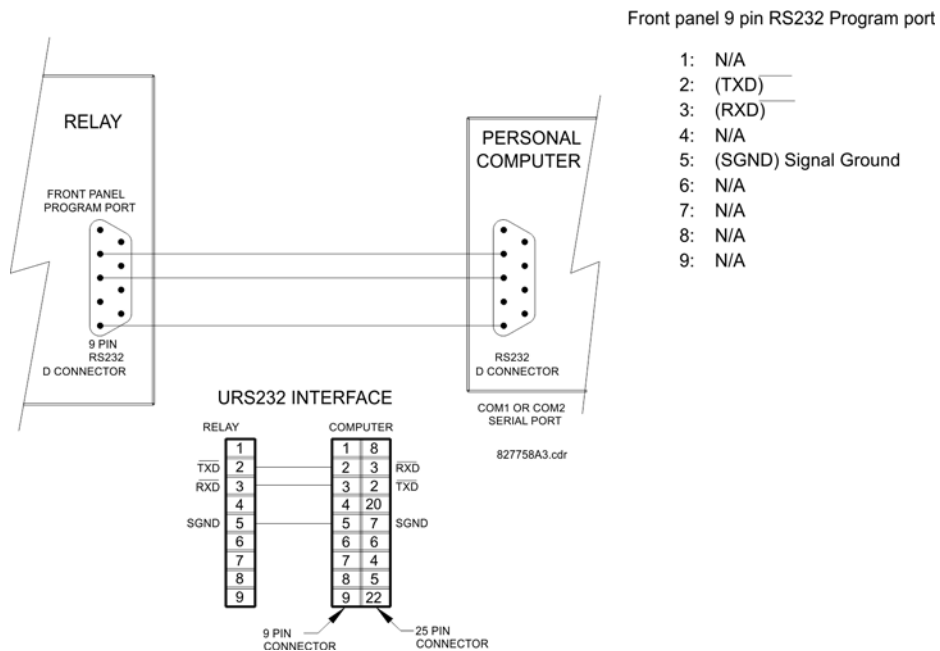


3.3.8 RS232 port

On the enhanced and standard front panels is a nine-pin RS232C serial port for programming with a computer. All that is required to use this interface is a computer running the EnerVista UR Setup software provided with the relay. Cabling for the RS232 port is shown in the following figure for the nine-pin connector on the UR and nine or 25-pin connector on a computer.

The baud rate for this port can be set, with a default of 115200 bps.

Figure 3-30: RS232 front panel port connection

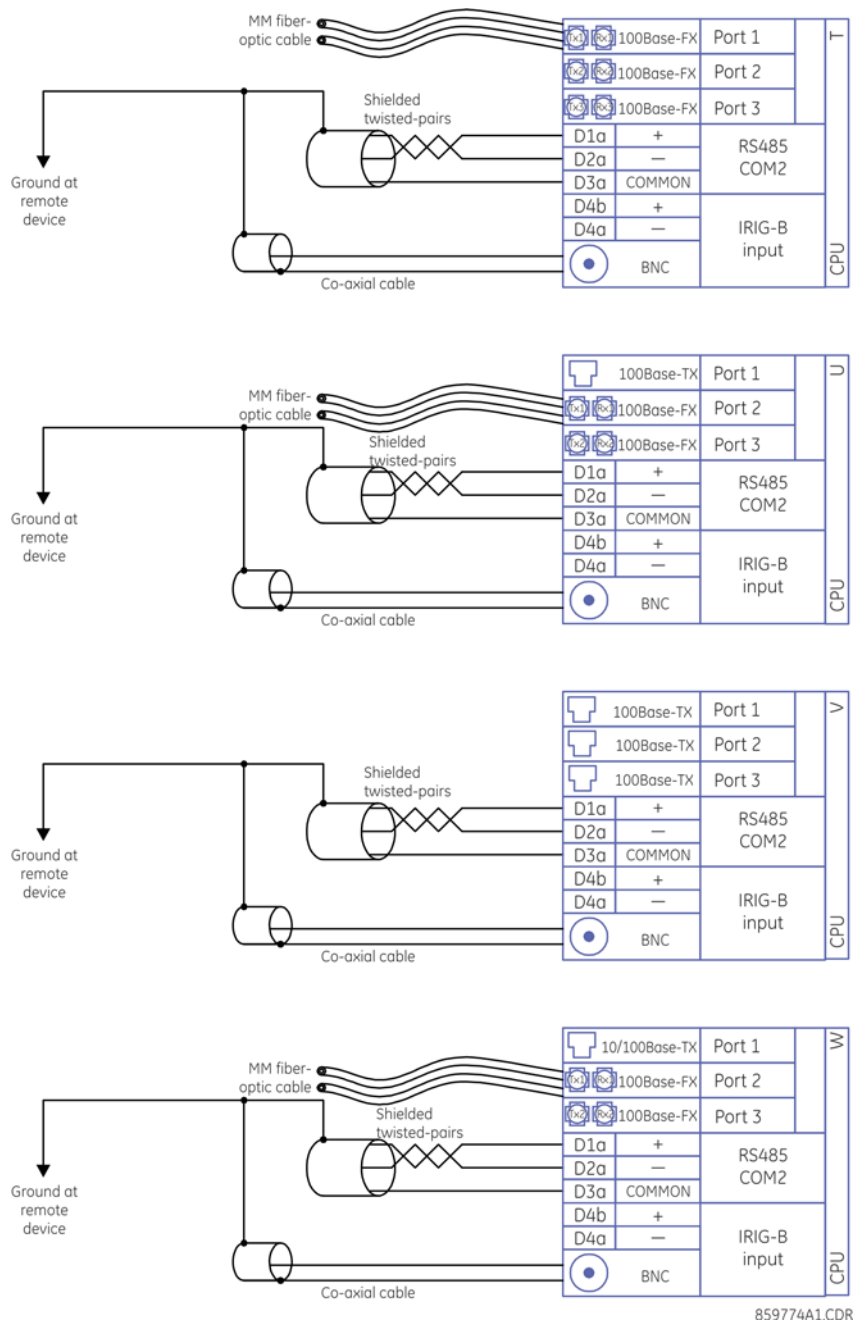


3.3.9 CPU communication ports

3.3.9.1 Overview

There is a rear RS485 communication port on the CPU module. The CPU module does not require a surge ground connection.

Figure 3-31: CPU module communications wiring



3.3.9.2 RS485 port

RS485 data transmission and reception are accomplished over a single twisted-pair wire with transmit and receive data alternating over the same two wires. Through the use of the port, continuous monitoring and control from a remote computer, SCADA system, or Power Line Carrier (PLC) is possible.

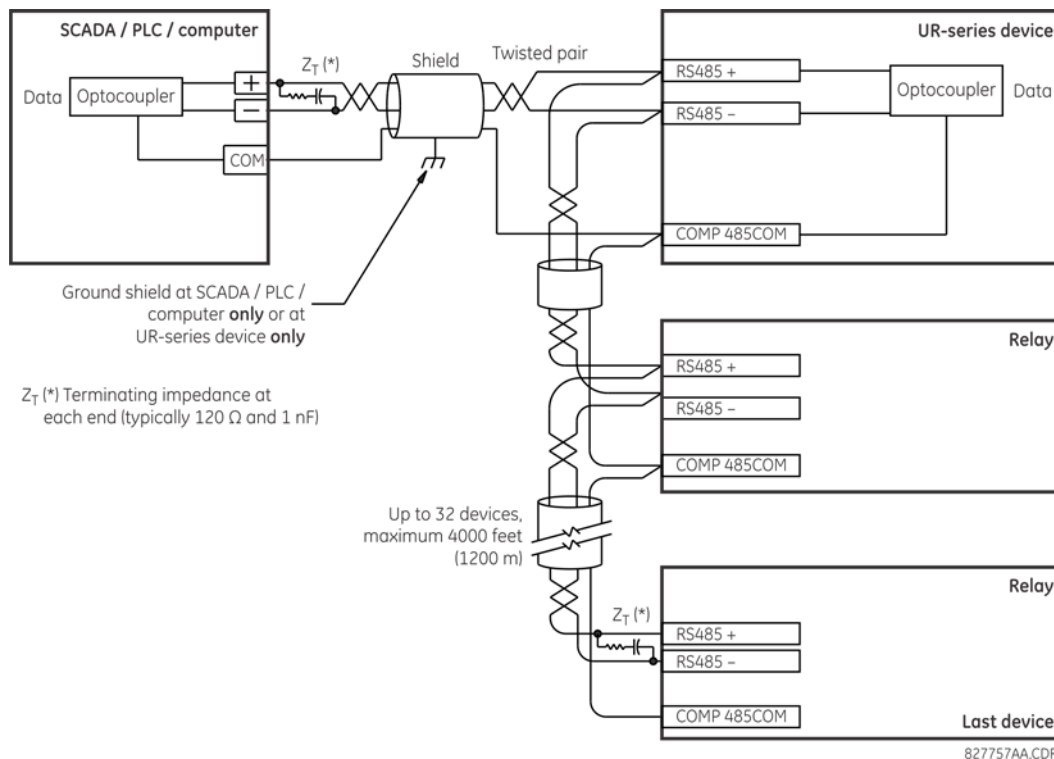
To minimize errors from noise, the use of shielded twisted-pair wire is recommended. Correct polarity must be observed. For instance, the relays must be connected with all RS485 “+” terminals connected together, and all RS485 “-” terminals connected together. Though data is transmitted over a two-wire twisted pair, all RS485 devices require a shared reference, or common voltage. This common voltage is implied to be a power supply common. Some systems allow the shield (drain wire) to be used as common wire and to connect directly to the L30 COM terminal (#3); others function correctly only if the common wire is connected to the L30 COM terminal, but insulated from the shield.

To avoid loop currents, ground the shield at only one point. If other system considerations require the shield to be grounded at more than one point, install resistors (typically 100 ohms) between the shield and ground at each grounding point. Each relay needs to be daisy-chained to the next one in the link. A maximum of 32 relays can be connected in this manner without exceeding driver capability. For larger systems, additional serial channels must be added. It is also possible to use commercially available repeaters to have more than 32 relays on a single channel. Avoid star or stub connections entirely.

Lightning strikes and ground surge currents can cause large momentary voltage differences between remote ends of the communication link. For this reason, surge protection devices are provided internally at both communication ports. An isolated power supply with an optocoupled data interface also acts to reduce noise coupling. To ensure maximum reliability, ensure that all equipment has similar transient protection devices installed.

Terminate both ends of the RS485 circuit with an impedance as shown in the figure.

Figure 3-32: RS485 serial connection



3.3.9.3 100Base-FX fiber optic ports

The fiber-optic communication ports allow for fast and efficient communications between relays at 100 Mbps. Optical fiber can be connected to the relay supporting a wavelength of 1310 nm in multimode.

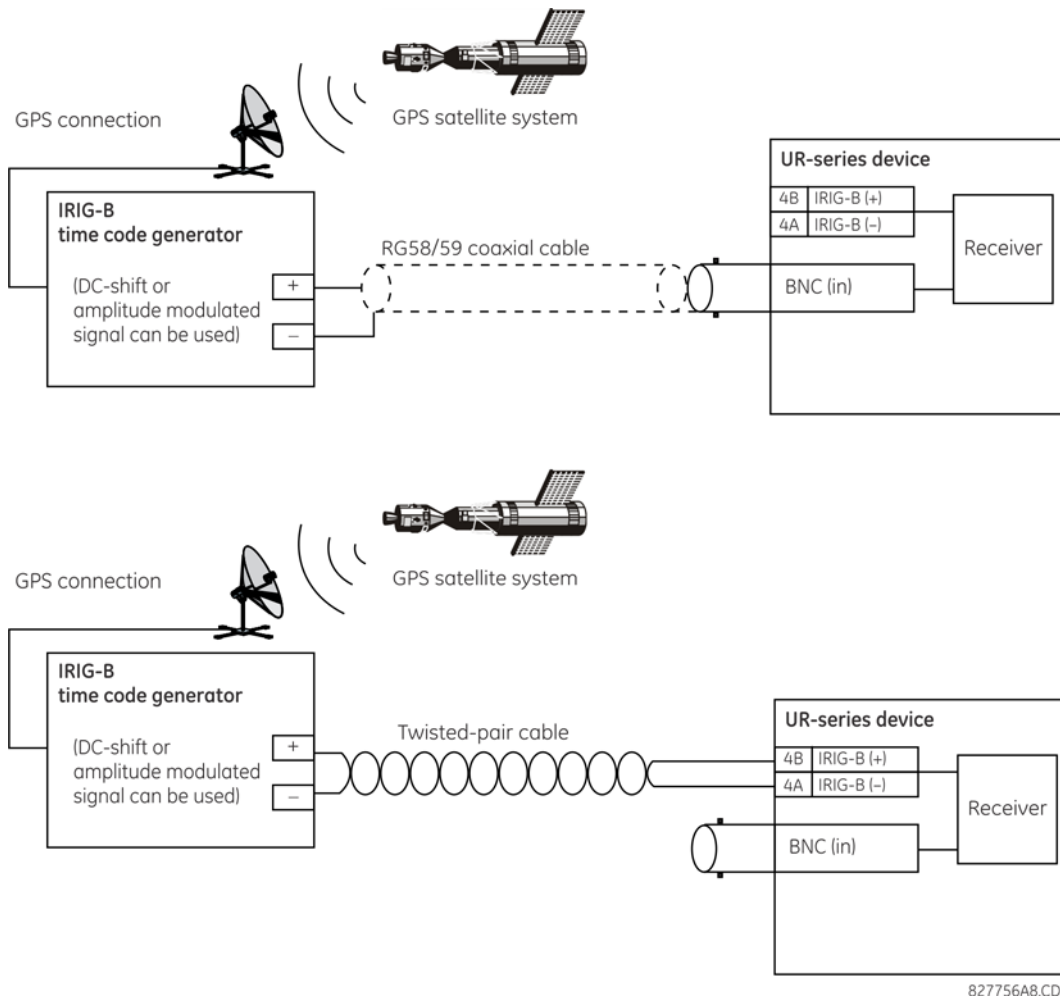
Ensure that the dust covers are installed when the fiber is not in use. Dirty or scratched connectors can lead to high losses on a fiber link.

3.3.10 IRIG-B

There is a round IRIG-B connector at the back of the CPU module, marked "IN". Use is optional.

IRIG-B is a standard time code format that allows stamping of events to be synchronized among connected devices. The IRIG-B code allows time accuracies of up to 100 ns. The GE MultiSync 100 1588 GPS Clock as well as third-party equipment are available for generating the IRIG-B signal. This equipment can use a global positioning system (GPS) satellite system to obtain the time reference so that devices at different geographic locations can be synchronized. The IRIG time code formats are serial, pulse width-modulated codes that can be either DC level shifted or amplitude modulated (AM). Using IRIG-B input, the L30 operates an internal oscillator with 1 μ s resolution and accuracy.

Figure 3-33: Options for IRIG-B connection



Using an amplitude-modulated receiver causes errors up to 1 ms in event time stamping.



When IRIG-B is used as the time synchronization source for synchrophasors, the DC level shifted option must be used in order to achieve the 1% Total Vector Error specified by the standard. If amplitude modulated IRIG-B is used, it results in a 20 to 25 degree error in the synchrophasor angle measurement. The IEEE 1588 Precision Time Protocol can also be used to achieve accurate time synchronization for synchrophasor calculation.

3.4 Pilot channel communications

A special inter-relay communications module is available for the L30. This module is plugged into slot “W” in horizontally mounted units and slot “R” in vertically mounted units. Inter-relay channel communications is not the same as 10/100Base-F interface communications (available as an option with the CPU module). Channel communication is used for sharing data among relays.

The inter-relay communications modules are available with several interfaces and some are outlined here in more detail. Those that apply depend on options purchased. The options are outlined in the Inter-Relay Communications section of the Order Code tables in Chapter 2.

All of the fiber modules use ST type connectors. For two-terminal applications, each L30 relay requires at least one communications channel.



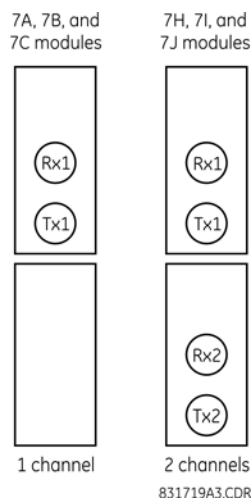
The current differential function must be “Enabled” for the communications module to properly operate. See the **SETTINGS ⇒ GROUPED ELEMENTS ⇒ LINE DIFFERENTIAL ⇒ CURRENT DIFFERENTIAL** menu.

The fiber optic modules (7A to 7W) are designed for back-to-back connections of UR-series relays only. For connections to higher-order systems, use the 72 to 77 modules or the 2A and 2B modules.

3.4.1 Fiber: LED and ELED transmitters

The following figure shows the configuration for the 7A, 7B, 7C, 7H, 7I, and 7J fiber-only modules.

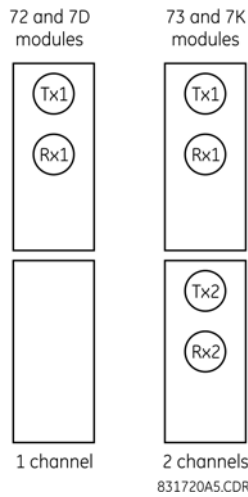
Figure 3-34: LED and ELED fiber modules



3.4.2 Fiber laser transmitters

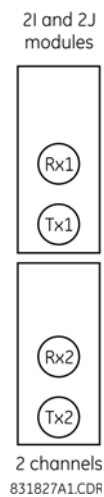
The following figure shows the configuration for the 72, 73, 7D, and 7K fiber-laser modules.

Figure 3-35: 7x Laser fiber modules



The following figure shows configuration for the 2I and 2J fiber-laser modules.

Figure 3-36: 2I and 2J laser fiber modules



Observing any fiber transmitter output can injure the eye.



When using a laser Interface, attenuators can be necessary to ensure that you do not exceed the maximum optical input power to the receiver.

3.4.3 G.703 interface

3.4.3.1 Description

G.703 is an International Telecommunications Union (ITU) standard for the transmission of data and voice signals. Modules 7R (one channel) and 7S (two channels) apply.

The following figure shows the 64K ITU G.703 co-directional interface configuration. This is module 7S.

The G.703 module is fixed at 64 kbps. The **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **DIRECT I/O** ⇒ **DIRECT I/O DATA RATE** setting is not applicable to this module.

AWG 24 twisted shielded pair wiring is recommended for external connections, with the shield grounded only at one end. Connecting the shield to pin X1a or X6a grounds the shield since these pins are connected internally to ground. Thus, if pin X1a or X6a is used to ground the shield at one end, do not ground the shield at the other end. This interface module is protected by surge suppression devices.

Figure 3-37: G.703 interface configuration

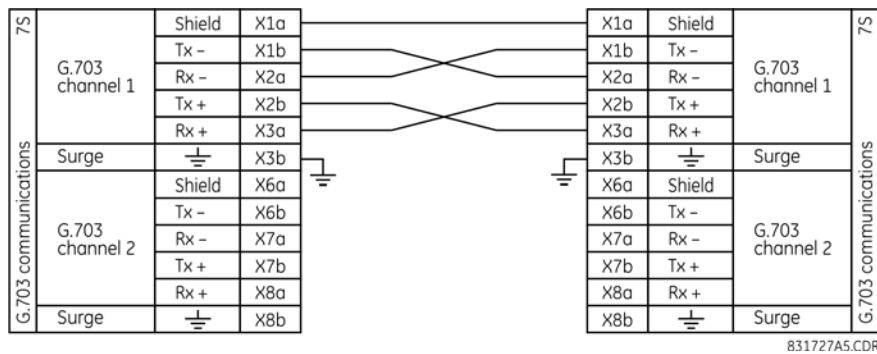
7S	G.703 channel 1	Shield	~1a
		Tx -	~1b
		Rx -	~2a
		Tx +	~2b
		Rx +	~3a
	Surge	⏏	~3b
	G.703 channel 2	Shield	~6a
		Tx -	~6b
		Rx -	~7a
		Tx +	~7b
Rx +		~8a	
Surge	⏏	~8b	

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The following figure shows the typical pin interconnection between two G.703 interfaces. For the actual physical arrangement of these pins, see the Rear Terminal Layout section earlier in this chapter. All pin interconnections are to be maintained for a connection to a multiplexer.

Figure 3-38: Typical pin interconnection between two G.703 interfaces

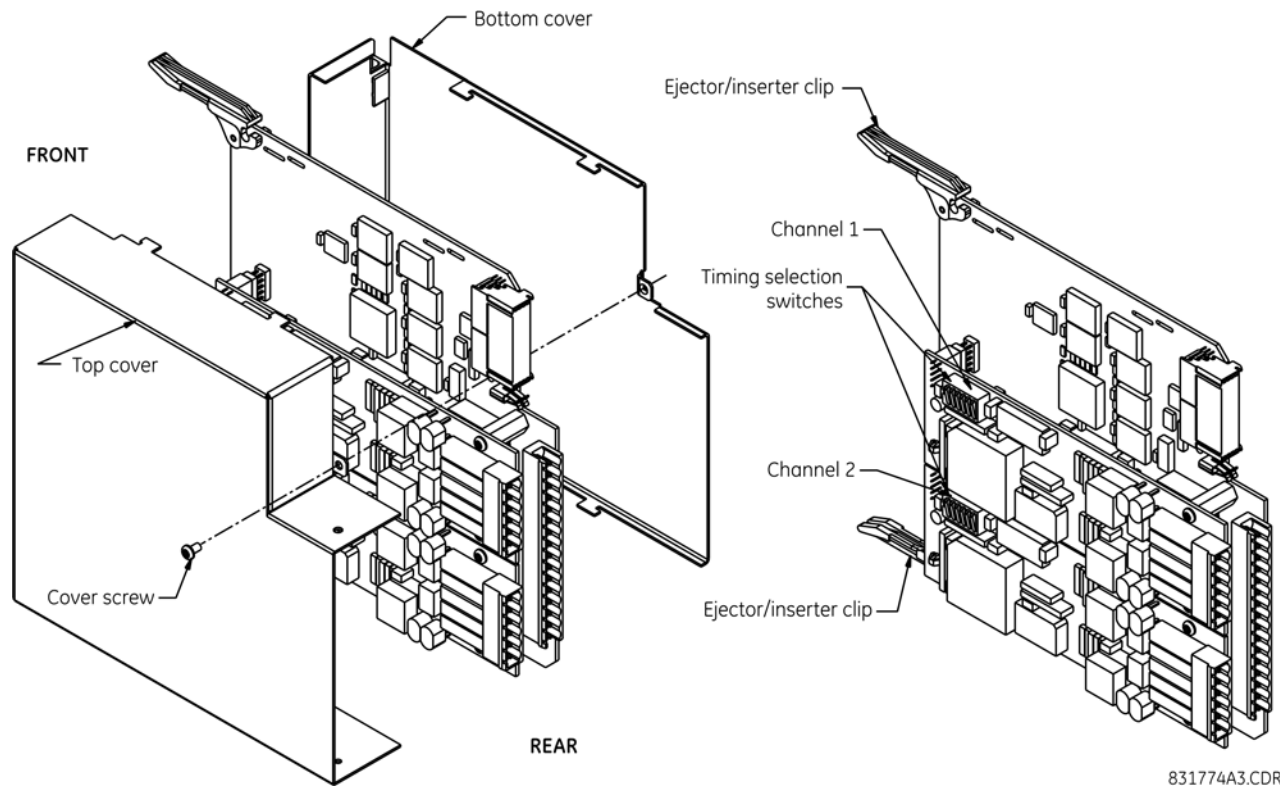


Pin nomenclature differs from one manufacturer to another. It is not uncommon to see pinouts numbered TxA, TxB, RxA, and RxB. In such cases, assume that "A" is equivalent to "+" and "B" is equivalent to "-."

3.4.3.2 G.703 selection switch procedures

1. With the power to the relay off, remove the G.703 module (7R or 7S) as follows. Record the original location of the module to help ensure that the same or replacement module is inserted into the correct slot.
2. Simultaneously pull the ejector/inserters clips located at the top and at the bottom of each module in order to release the module for removal. (For more information on accessing modules, see the Maintenance chapter.)
3. Remove the module cover screw.
4. Remove the top cover by sliding it towards the rear and then lift it upwards.
5. Set the timing selection switches (channels 1 and 2) to the required timing modes.
6. Replace the top cover and the cover screw.
7. Re-insert the G.703 module. Take care to ensure that the correct module type is inserted into the correct slot position. The ejector/inserters clips located at the top and bottom of each module must be in the disengaged position as the module is inserted smoothly into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module is inserted fully.

Figure 3-39: G.703 timing selection switch setting



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Table 3-6: G.703 timing selections

Switches	Function
S1	OFF → octet timing disabled ON → octet timing 8 kHz
S5 and S6	S5 = OFF and S6 = OFF → loop timing mode S5 = ON and S6 = OFF → internal timing mode S5 = OFF and S6 = ON → minimum remote loopback mode S5 = ON and S6 = ON → dual loopback mode

3.4.3.3 G.703 octet timing

If octet timing is enabled (ON), this 8 kHz signal is asserted during the violation of bit 8 (LSB) necessary for connecting to higher order systems. When L30s are connected back-to-back, octet timing is disabled (OFF).

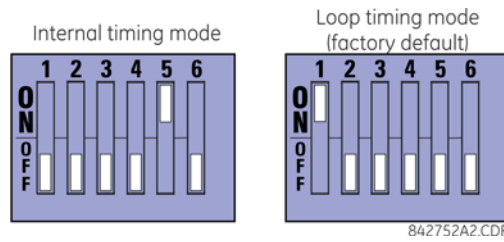
3.4.3.4 G.703 timing modes

There are two timing modes for the G.703 module: internal timing mode and loop timing mode (default).

- **Internal Timing Mode** — The system clock is generated internally. Therefore, set the G.703 timing selection to internal timing mode for back-to-back (UR-to-UR) connections. For back-to-back connections, set octet timing (S1 = OFF) and timing mode to internal timing (S5 = ON and S6 = OFF).
- **Loop Timing Mode** — The system clock is derived from the received line signal. Therefore, set the G.703 timing selection to loop timing mode for connections to higher order systems. For connection to a higher order system (UR-to-multiplexer, factory defaults), set to octet timing (S1 = ON) and set timing mode to loop timing (S5 = OFF and S6 = OFF).

The switch settings for the internal and loop timing modes are shown.

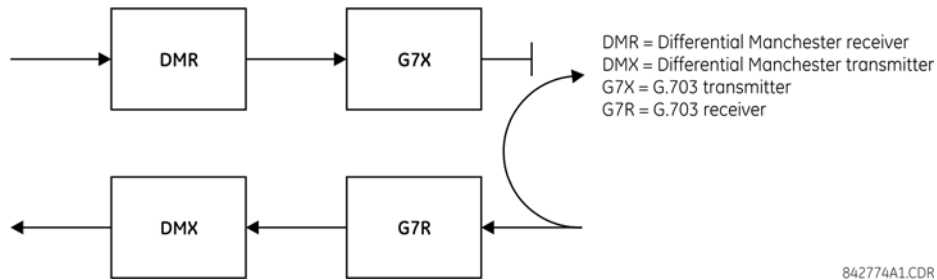
Figure 3-40: Switches



3.4.3.5 G.703 test modes

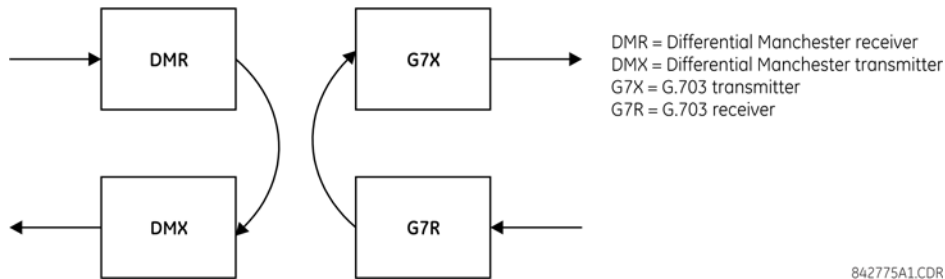
In *minimum remote loopback mode*, the multiplexer is enabled to return the data from the external interface without any processing to assist in diagnosing G.703 line-side problems irrespective of clock rate. Data enters from the G.703 inputs, passes through the data stabilization latch that also restores the proper signal polarity, passes through the multiplexer, and then returns to the transmitter. The differential received data is processed and passed to the G.703 transmitter module after which point the data is discarded. The G.703 receiver module is fully functional and continues to process data and passes it to the differential Manchester transmitter module. Since timing is returned as it is received, the timing source is expected to be from the G.703 line side of the interface.

Figure 3-41: G.703 minimum remote loopback mode



In *dual loopback mode*, the multiplexers are active and the functions of the circuit are divided into two with each receiver/transmitter pair linked together to deconstruct and then reconstruct their respective signals. Differential Manchester data enters the Differential Manchester receiver module and then is returned to the differential Manchester transmitter module. Likewise, G.703 data enters the G.703 receiver module and is passed through to the G.703 transmitter module to be returned as G.703 data. Because of the complete split in the communications path and because, in each case, the clocks are extracted and reconstructed with the outgoing data, in this mode there must be two independent sources of timing. One source lies on the G.703 line side of the interface while the other lies on the differential Manchester side of the interface.

Figure 3-42: G.703 dual loopback mode



3.4.4 RS422 interface

3.4.4.1 Description

There are three RS422 inter-relay communications modules available: single-channel (module 7T), dual-channel (module 7W), and dual-channel dual-clock RS422 (module 7V). The modules can be configured to run at 64 or 128 kbps. AWG 24 twisted shielded pair cable is recommended for external connections. These modules are protected by optically-isolated surge suppression devices.



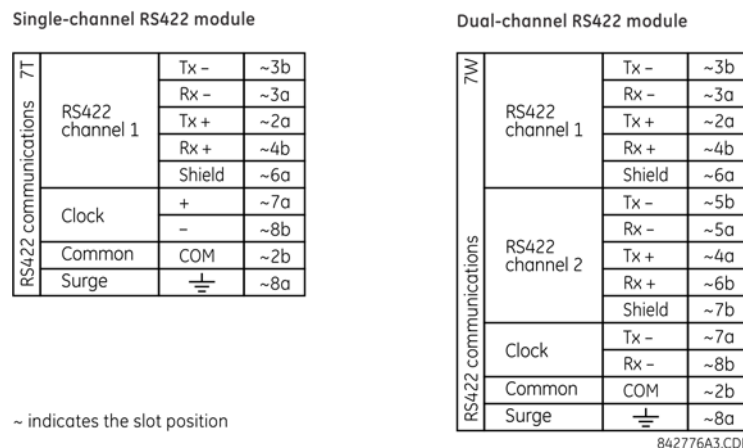
The two-channel two-clock RS422 interface (module 7V) is intended for use with two independent channel banks with two independent clocks. It is intended for situations where a single clock for both channels is not acceptable.

The shield pins (6a and 7b) are connected internally to the ground pin (8a). Proper shield termination is as follows:

- Site 1 — Terminate shield to pins 6a or 7b or both
- Site 2 — Terminate shield to COM pin 2b

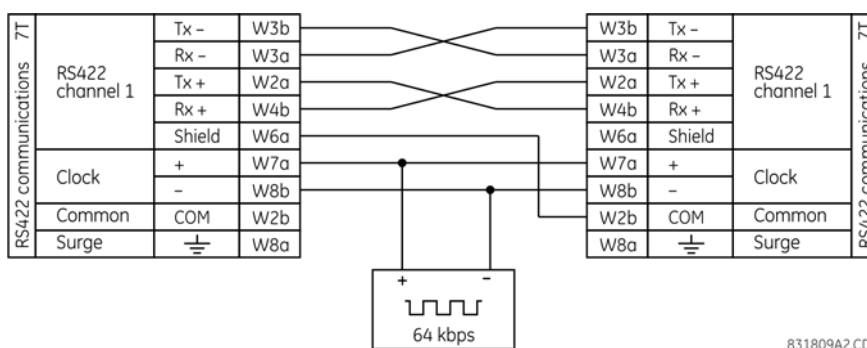
Match the clock terminating impedance with the impedance of the line.

Figure 3-43: RS422 interface connections



The following figure shows the typical pin interconnection between two single-channel RS422 interfaces installed in slot W. All pin interconnections are to be maintained for a connection to a multiplexer.

Figure 3-44: Typical pin interconnection between two RS422 interfaces

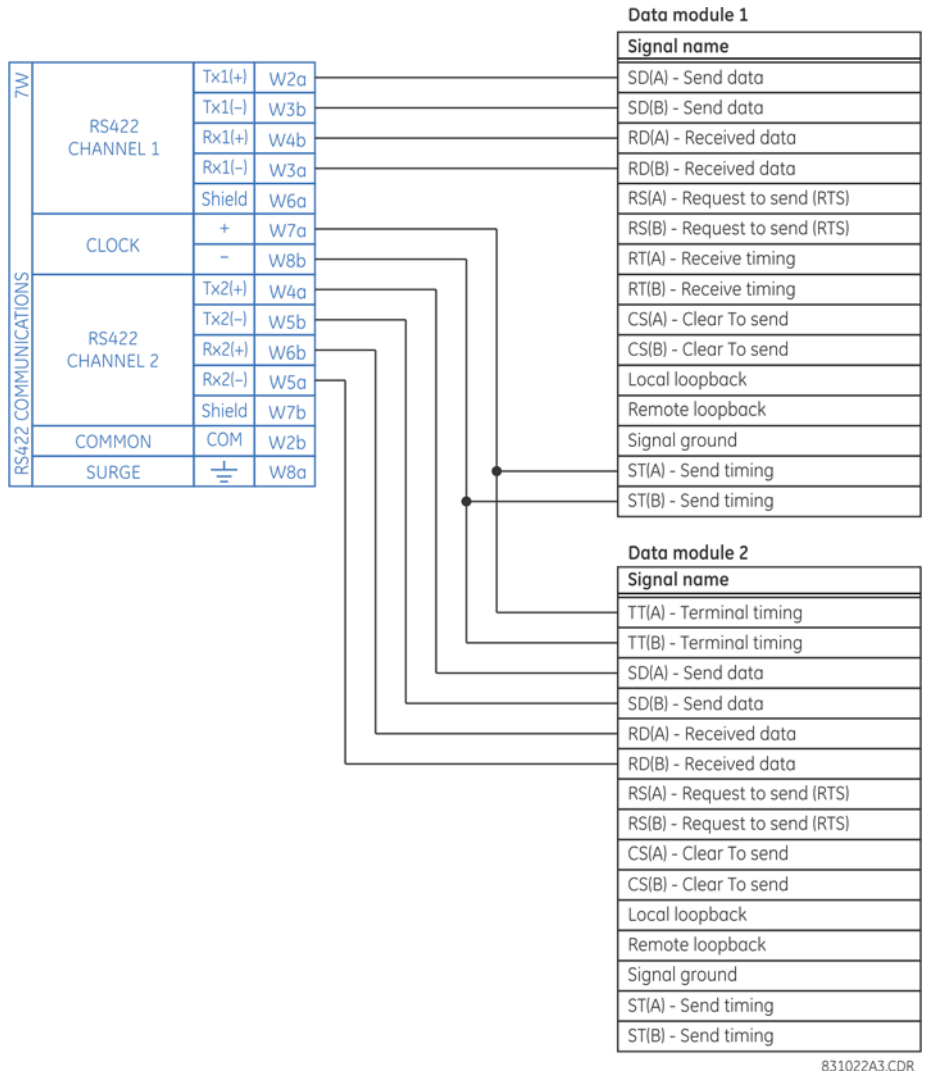


3.4.4.2 Two-channel application via multiplexers

The RS422 interface can be used for single-channel or two-channel applications over SONET/SDH or multiplexed systems. When used in single-channel applications, the RS422 interface links to higher-order systems in a typical way, observing transmit (Tx), receive (Rx), and send timing (ST) connections. However, when used in two-channel applications, certain

criteria must be followed since there is one clock input for the two RS422 channels. The system functions correctly when the following connections are observed and your data module has a terminal timing feature. Terminal timing is a common feature in most synchronous data units that allows the module to accept timing from an external source. Using the terminal timing feature, two-channel applications can be achieved if these connections are followed: the send timing outputs from the multiplexer (data module 1) connects to the clock inputs of the UR RS422 interface in the usual way. In addition, the send timing outputs of data module 1 are also paralleled to the terminal timing inputs of data module 2. By using this configuration, the timing for both data modules and both UR RS422 channels is derived from a single clock source. As a result, data sampling for both of the UR RS422 channels is synchronized via the send timing leads on data module 1, shown as follows. If the terminal timing feature is not available or this type of connection is not wanted, the G.703 interface is a viable option that does not impose timing restrictions.

Figure 3-45: Timing configuration for RS422 two-channel, three-terminal application

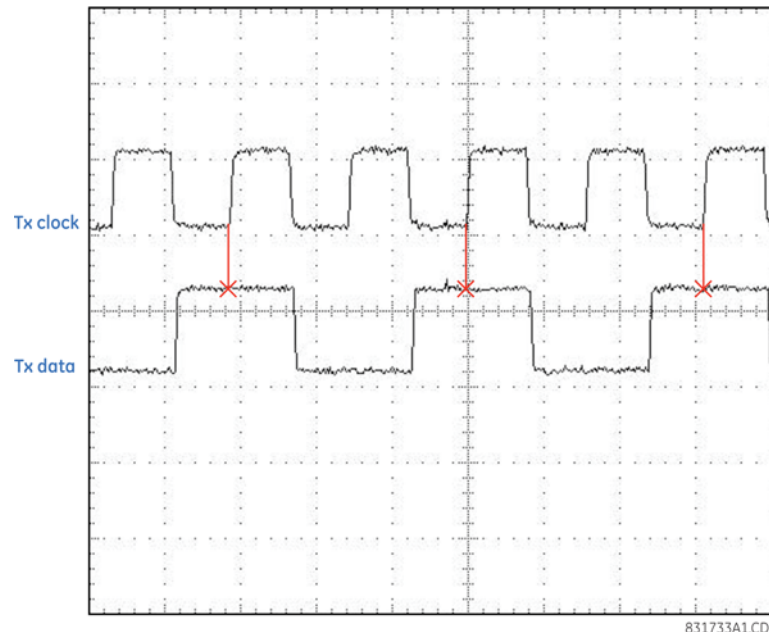


Data module 1 provides timing to the L30 RS422 interface via the ST(A) and ST(B) outputs. Data module 1 also provides timing to data module 2 TT(A) and TT(B) inputs via the ST(A) and AT(B) outputs. The data module pin numbers have been omitted in the figure because they vary by manufacturer.

3.4.4.3 Transmit timing

The RS422 interface accepts one clock input for transmit timing. It is important that the rising edge of the 64 kHz transmit timing clock of the multiplexer interface is sampling the data in the center of the transmit data window. Therefore, it is important to confirm clock and data transitions to ensure proper system operation. For example, the following figure shows the positive edge of the Tx clock in the center of the Tx data bit.

Figure 3-46: Clock and data transitions



3.4.4.4 Receive timing

The RS422 interface utilizes NRZI-MARK modulation code and therefore does not rely on an Rx clock to recapture data. NRZI-MARK is an edge-type, invertible, self-clocking code.

To recover the Rx clock from the data-stream, an integrated digital phase lock loop (DPLL) circuit is utilized. The DPLL is driven by an internal clock, which is 16-times over-sampled, and uses this clock along with the data-stream to generate a data clock that can be used as the serial communication controller (SCC) receive clock.

3.4.5 Two-channel two-clock RS422 interface

The two-channel two-clock RS422 interface (module 7V) is for use with the synchrophasor feature. The figure shows the module connections.

Figure 3-47: Two-channel two-clock RS422 interface connections

RS422 communications	RS422 channel 1	Tx -	~3b
		Rx -	~3a
		Tx +	~2a
		Rx +	~4b
		Shield	~6a
	RS422 channel 2	Tx -	~5b
		Rx -	~5a
		Tx +	~4a
		Rx +	~6b
	Channel 1 clock	Tx -	~7a
		Rx -	~8b
	Channel 2 clock	Tx -	~1b
		Rx -	~1a
	Common	COM	~2b
Surge		~8a	

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3.4.6 RS422 and fiber interface

The following figure shows the combined RS422 plus fiberoptic interface configuration at 64 K baud. The 7L, 7M, 7N, 7P, and 74 modules are used in two-terminal with a redundant channel or three-terminal configurations where channel 1 is employed via the RS422 interface (possibly with a multiplexer) and channel 2 via direct fiber.

AWG 20 to 24 twisted shielded pair wiring is recommended for external RS422 connections. Ground the shield only at one end. For the direct fiber channel, address power budget issues properly.

NOTICE When using a laser interface, attenuators can be necessary to ensure that you do not exceed maximum optical input power to the receiver.

Figure 3-48: RS422 and fiber interface connection

RS422 communications	Clock channel 1	+	~1a
		-	~1b
	Common	COM	~2b
	RS422 channel 1	Tx -	~3b
		Rx -	~3a
		Tx +	~2a
		Rx +	~4b
		Shield	~6a
	Fiber channel 2		
Surge		~8a	

842777A3.CDR

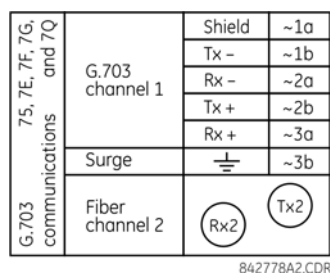
The connections shown in the figure are for multiplexers configured as data communications equipment (DCE) units.

3.4.7 G.703 and fiber interface

The following figure shows the combined G.703 plus fiber-optic interface configuration at 64 kbps. The 7E, 7F, 7G, 7Q, and 75 modules are used in configurations where channel 1 is employed via the G.703 interface (possibly with a multiplexer) and channel 2 via direct fiber. AWG 24 twisted shielded pair wiring is recommended for external G.703 connections connecting the shield to pin 1a at one end only. For the direct fiber channel, address power budget issues properly. See previous sections for details on the G.703 and fiber interfaces.

NOTICE When using a laser interface, attenuators can be necessary to ensure that you do not exceed the maximum optical input power to the receiver.

Figure 3-49: G.703 and fiber interface connection



3.4.8 IEEE C37.94 interface

IEEE C37.94 is a standard interface between teleprotection equipment and digital multiplexers.

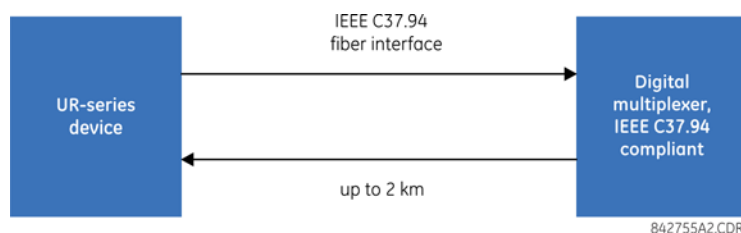
The UR-series IEEE C37.94 modules (module types 2I, 2J, 76, and 77) are designed to interface with IEEE C37.94 compliant digital multiplexers or an IEEE C37.94 compliant interface converter for use with direct input and output applications. The IEEE C37.94 standard defines a point-to-point optical link for synchronous data between a multiplexer and a teleprotection device. Data speed is typically 64 kbps, but the standard provides for speeds up to $64n$ kbps, where $n = 1, 2, \dots, 12$. The UR-series C37.94 communication modules are either 64 kbps (with n fixed at 1) or 128 kbps (with n fixed at 2). The frame is a valid International Telecommunications Union (ITU-T) recommended G.704 pattern from the standpoint of framing and data rate. The frame is 256 bits and is repeated at a frame rate of 8000 Hz, with a resultant bit rate of 2048 kbps.

The specifications for the module are as follows:

- IEEE standard — C37.94 for 2×64 kbps optical fiber interface (for 76 and 77 modules)
- Fiber-optic cable type — 50 nm or 62.5 μm core diameter optical fiber
- Fiber-optic mode — multimode
- Fiber-optic cable length — up to 2 km
- Fiber-optic connector — type ST
- Wavelength — 820 ± 40 nm
- Connection — as per all fiber-optic connections, a Tx-to-Rx connection is required

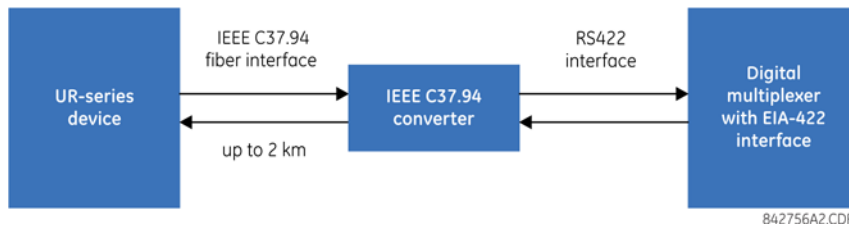
The UR-series C37.94 module can be connected directly to any compliant digital multiplexer that supports the IEEE C37.94 standard. The figure shows the concept.

Figure 3-50: IEEE C37.94 connection to compliant digital multiplexer



The UR-series C37.94 communication module can be connected to the electrical interface (G.703, RS422, or X.21) of a non-compliant digital multiplexer via an optical-to-electrical interface converter that supports the IEEE C37.94 standard. The following figure shows the concept.

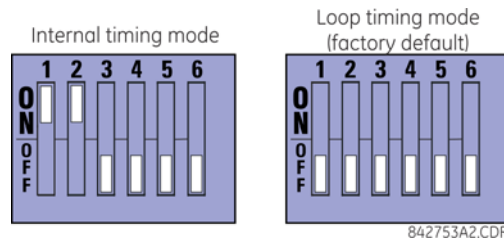
Figure 3-51: IEEE C37.94 connection to non-compliant digital multiplexer



In 2008, GE Grid Solutions released revised modules 76 and 77 for C37.94 communication to enable multi-ended fault location functionality with firmware 5.60 release and higher. All modules 76 and 77 shipped since the change support this feature and are fully backward compatible with firmware releases below 5.60. For customers using firmware release 5.60 and higher, the module can be identified with "Rev D" printed on it and is to be used on all ends of L30 communication for two and three terminal applications. Failure to use it at all ends results in intermittent communication alarms. For customers using firmware revisions below 5.60, it is not required to match the revision of the modules installed.

The UR-series C37.94 communication module has six switches to set the clock configuration. The following figure shows the functions of these control switches.

Figure 3-52: Switches



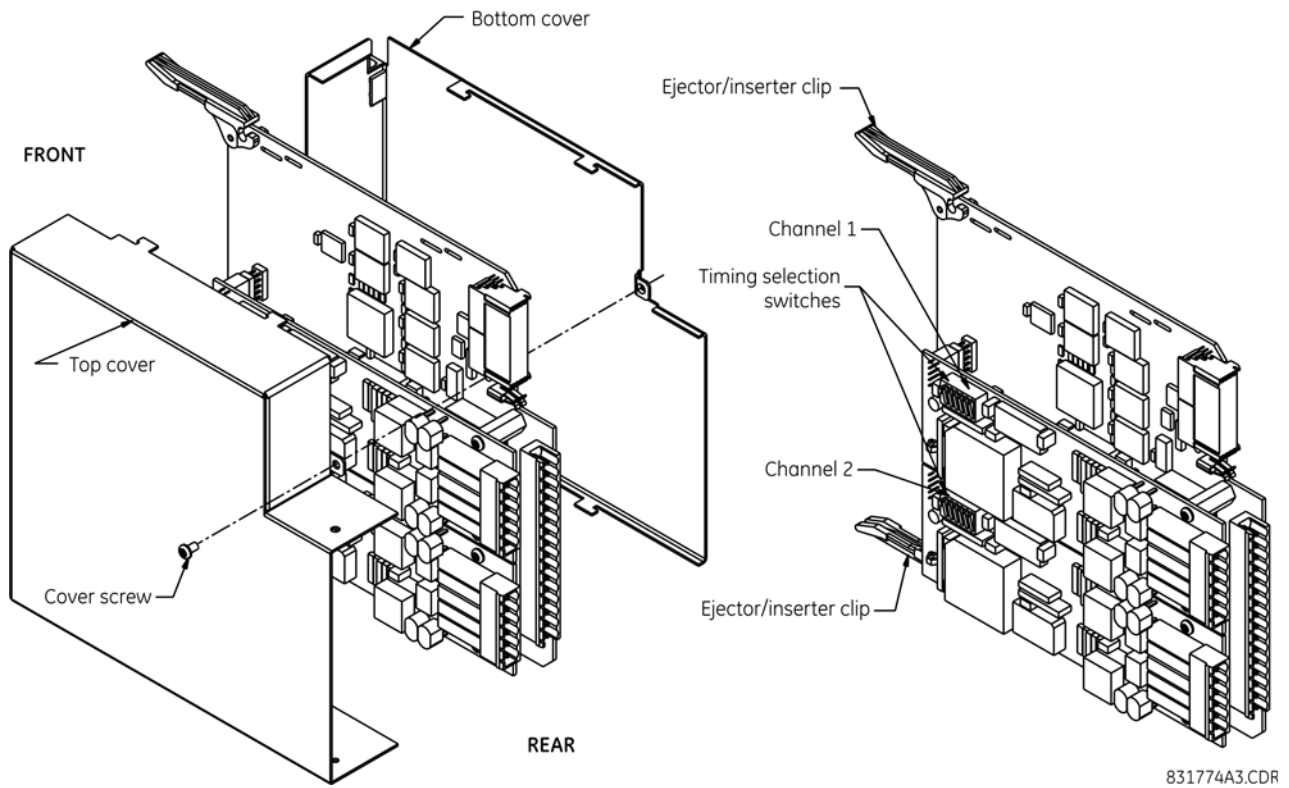
For the internal timing mode, the system clock is generated internally. Therefore, set the timing switch selection to internal timing for relay 1 and loop timed for relay 2. There must be only one timing source configured.

For the looped timing mode, the system clock is derived from the received line signal. Therefore, set the timing selection to loop timing mode for connections to higher order systems.

The IEEE C37.94 communications module cover removal procedure is as follows:

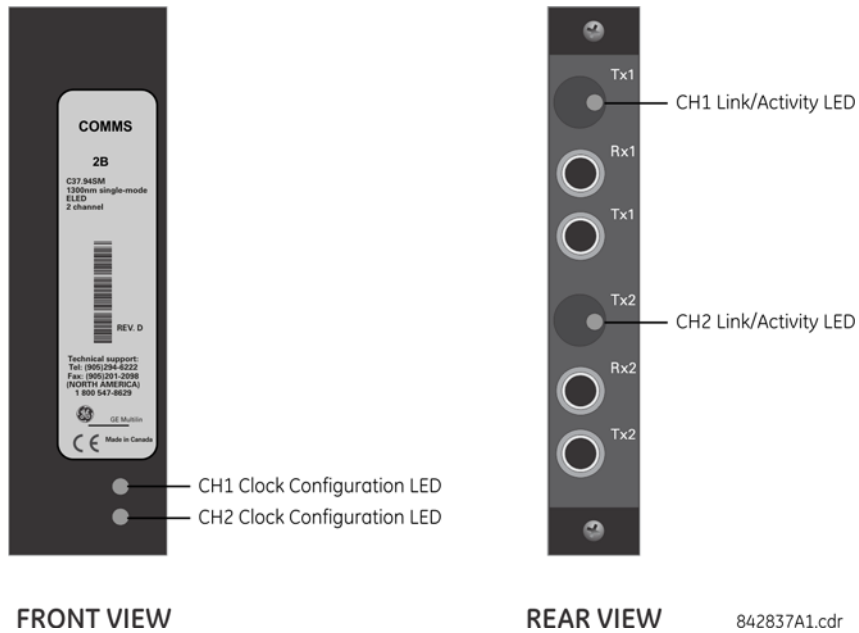
1. With power to the relay off, remove the IEEE C37.94 module (type 2I, 2J, 76, or 77 module) as follows. Record the original location of the module to help ensure that the same or replacement module is inserted into the correct slot.
2. Simultaneously pull the ejector/insertion clips located at the top and bottom of each module in order to release the module for removal.
3. Remove the module cover screw.
4. Remove the top cover by sliding it towards the rear and then lift it upwards.
5. Set the timing selection switches (channels 1 and 2) to the required timing modes (see description earlier).
6. Replace the top cover and the cover screw.
7. Re-insert the IEEE C37.94 module. Take care to ensure that the correct module type is inserted into the correct slot position. The ejector/insertion clips located at the top and at the bottom of each module must be in the disengaged position as the module is inserted smoothly into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module is inserted fully.

Figure 3-53: IEEE C37.94 timing selection switch setting



Modules shipped since January 2012 have status LEDs that indicate the status of the DIP switches, as shown in the following figure.

Figure 3-54: Status LEDs



The clock configuration LED status is as follows:

- Flashing green — loop timing mode while receiving a valid data packet

- Flashing yellow — internal mode while receiving a valid data packet
- Solid red — (switch to) internal timing mode while not receiving a valid data packet

The link/activity LED status is as follows:

- Flashing green — FPGA is receiving a valid data packet
- Solid yellow — FPGA is receiving a "yellow bit" and remains yellow for each "yellow bit"
- Solid red — FPGA is not receiving a valid packet or the packet received is invalid

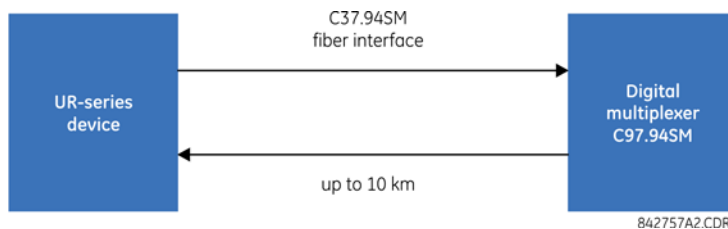
3.4.9 C37.94SM interface

The UR-series C37.94SM communication modules (2A and 2B) are designed to interface with modified IEEE C37.94 compliant digital multiplexers or IEEE C37.94 compliant interface converters that have been converted from 820 nm multi-mode fiber optics to 1300 nm ELED single-mode fiber optics. The IEEE C37.94 standard defines a point-to-point optical link for synchronous data between a multiplexer and a teleprotection device. This data is typically 64 kbps, but the standard provides for speeds up to $64n$ kbps, where $n = 1, 2, \dots, 12$. The UR-series C37.94SM communication module is 64 kbps only with n fixed at 1. The frame is a valid ITU-recommended G.704 pattern from the standpoint of framing and data rate. The frame is 256 bits and is repeated at a frame rate of 8000 Hz, with a resultant bit rate of 2048 kbps.

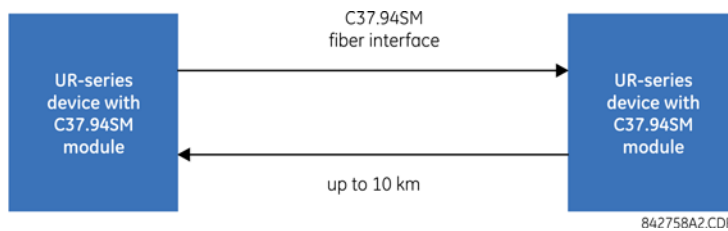
The specifications for the module are as follows:

- Emulated IEEE standard — Emulates C37.94 for 1×64 kbps optical fiber interface (modules set to $n = 1$ or 64 kbps)
- Fiber-optic cable type — 9/125 μ m core diameter optical fiber
- Fiber-optic mode — Single-mode, ELED compatible with HP HFBR-1315T transmitter and HP HFBR-2316T receiver
- Fiber-optic cable length — Up to 11.4 km
- Fiber-optic connector — Type ST
- Wavelength — 1300 \pm 40 nm
- Connection — As per all fiber-optic connections, a Tx-to-Rx connection is required

The UR-series C37.94SM communication module can be connected directly to any compliant digital multiplexer that supports C37.94SM, as shown.



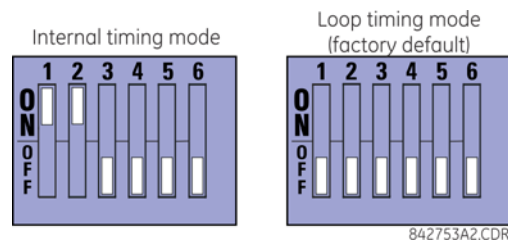
It also can be connected directly to any other UR-series relay with a C37.94SM module, as shown.



In 2008, GE Grid Solutions released revised modules 2A and 2B for C37.94SM communication to enable multi-ended fault location functionality with firmware 5.60 release and higher. All modules 2A and 2B shipped since the change support this feature and are fully backward compatible with firmware releases below 5.60. For customers using firmware release 5.60 and higher, the module can be identified with "Rev D" printed on it and is to be used on all ends of L30 communication for two and three terminal applications. Failure to use it at all ends results in intermittent communication alarms. For customers using firmware revisions below 5.60, it is not required to match the revision of the modules installed.

The UR-series C37.94SM module has six switches that are used to set the clock configuration. The following figure shows the functions of these control switches.

Figure 3-55: Switches



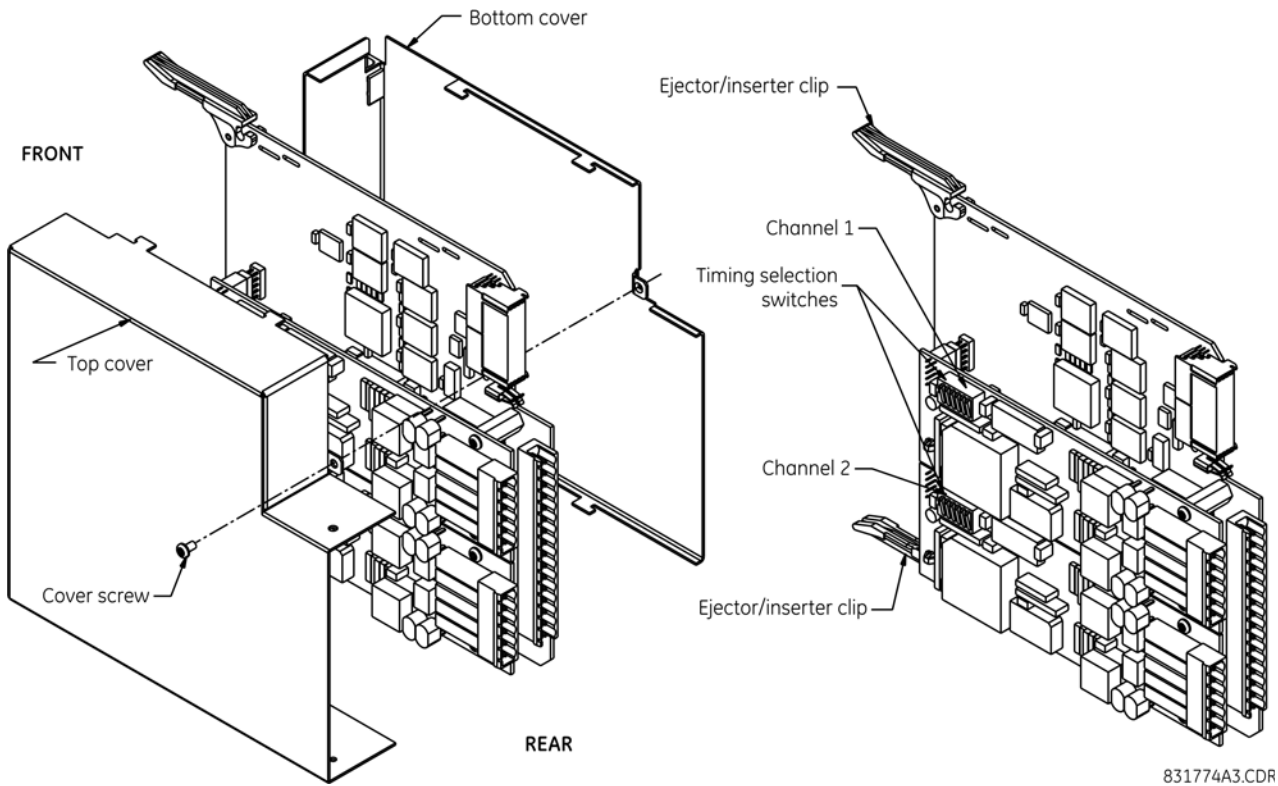
For the internal timing mode, the system clock is generated internally. Therefore, set the timing switch selection to internal timing for relay 1 and loop timed for relay 2. There must be only one timing source configured.

For the looped timing mode, the system clock is derived from the received line signal. Therefore, set the timing selection to loop timing mode for connections to higher-order systems.

The C37.94SM communications module cover removal procedure is as follows:

1. With power to the relay off, remove the C37.94SM module (module 2A or 2B) as follows. Record the original location of the module to help ensure that the same or replacement module is inserted into the correct slot.
2. Simultaneously pull the ejector/insert clips located at the top and at the bottom of each module in order to release the module for removal.
3. Remove the module cover screw.
4. Remove the top cover by sliding it towards the rear and then lift it upwards.
5. Set the timing selection switches (channels 1 and 2) to the required timing modes (see description earlier).
6. Replace the top cover and the cover screw.
7. Re-insert the C37.94SM module. Take care to ensure that the correct module type is inserted into the correct slot position. The ejector/insert clips located at the top and at the bottom of each module must be in the disengaged position as the module is inserted smoothly into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module is inserted fully.

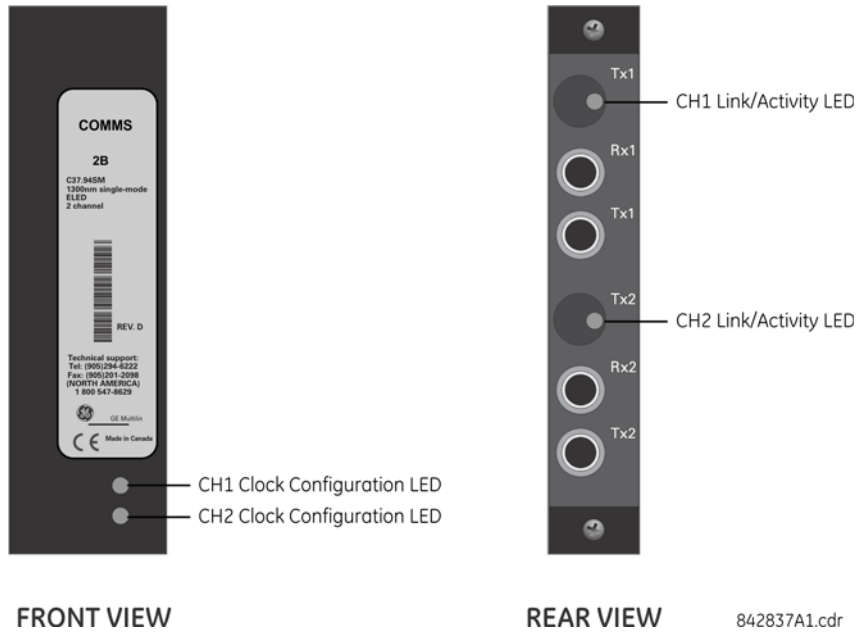
Figure 3-56: C37.94SM timing selection switch setting



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Modules shipped since January 2012 have status LEDs that indicate the status of the DIP switches, as shown in the following figure.

Figure 3-57: Status LEDs



842837A1.cdr

The clock configuration LED status is as follows:

- Flashing green — loop timing mode while receiving a valid data packet

- Flashing yellow — internal mode while receiving a valid data packet
- Solid red — (switch to) internal timing mode while not receiving a valid data packet

The link/activity LED status is as follows:

- Flashing green — FPGA is receiving a valid data packet
- Solid yellow — FPGA is receiving a "yellow bit" and remains yellow for each "yellow bit"
- Solid red — FPGA is not receiving a valid packet or the packet received is invalid

3.5 Activate relay

The relay is in the default "Not Programmed" state when it leaves the factory. When powered up successfully, looking at the front panel, the "Trouble" LED is on and the "In Service" LED is off. The relay in the "Not Programmed" state blocks signaling of any output relay. These conditions remain until the relay is explicitly put into "Programmed" state.

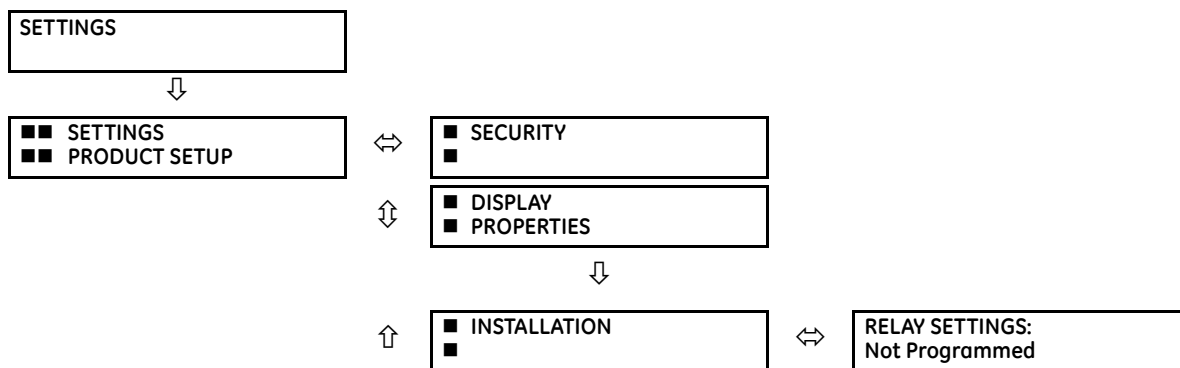
RELAY SETTINGS: Not Programmed

When the relay is powered up, the "Trouble LED" is on, the "In Service" LED is off, and this message displays, indicating that the relay is in the "Not Programmed" state and is safeguarding (output relays blocked) against the installation of a relay whose settings have not been entered. This message remains until the relay is explicitly put into "Programmed" state.

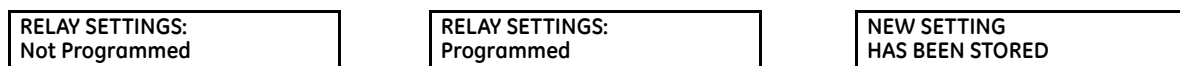
The relay can be activated on the front panel or in the EnerVista software.

To activate the relay using the front panel:

1. Press the **MENU** key until the **SETTINGS** header flashes momentarily and the **PRODUCT SETUP** message displays.
2. Press the **MESSAGE** right arrow until the **SECURITY** message displays.
3. Press the **MESSAGE** down arrow until the **INSTALLATION** message displays.
4. Press the **MESSAGE** right arrow until the **RELAY SETTINGS: Not Programmed** message displays.



5. After the **RELAY SETTINGS: Not Programmed** message displays, press a **VALUE** key to change the selection to "Programmed."
6. Press the **ENTER** key to save the change.



7. When the "NEW SETTING HAS BEEN STORED" message appears, the relay is in "Programmed" state and the "In Service" LED turns on.

To activate the relay using EnerVista software:

1. Navigate to **Settings > Product Setup > Installation** and change the **Relay Settings** field to "Programmed."
2. Save the change.

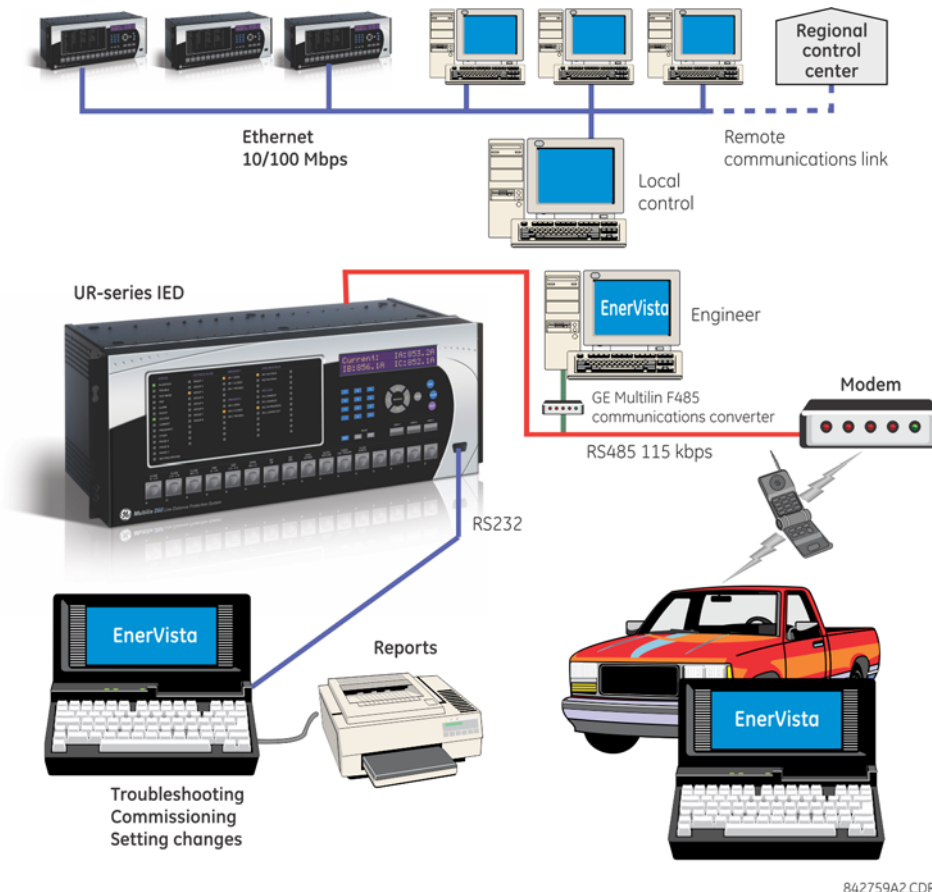
3.6 Install software

3.6.1 EnerVista communication overview

The EnerVista UR Setup software communicates to the relay via the front panel RS232 or USB port or the rear RS485 / Ethernet ports.

To communicate via the RS232 port, use a standard straight-through serial cable. Connect the DB-9 male end to the relay and the DB-9 or DB-25 female end to the computer COM2 port as described in the CPU Communication Ports section earlier in this chapter.

Figure 3-58: Relay communication options



To communicate through the L30 rear RS485 port from a computer RS232 port, the GE Grid Solutions RS232/RS485 converter box is required. This device (catalog number F485) connects to the computer using a straight-through serial cable. A shielded twisted-pair wire (20, 22, or 24 AWG) connects the F485 converter to the L30 rear communications port. The converter terminals (+, -, GND) are connected to the L30 communication module (+, -, COM) terminals. See the CPU Communication Ports section in chapter 3 for details. The line is terminated with an R-C network (that is, 120 Ω, 1 nF) as described in this chapter.

3.6.2 System requirements

The relay front panel or the EnerVista UR Setup software can be used to communicate with the relay. The software interface is the preferred method to edit settings and view actual values because the computer monitor can display more information.

The minimum system requirements for the EnerVista software are as follows:

- Intel Pentium processor (dual core)
- Microsoft Windows 7 with Service Pack 1 (32-bit or 64-bit) or Windows Server 2008 Release 2 with Service Pack 1 (64-bit), in the required EnerVista language, such as French or Japanese
- 1 GB free hard drive space
- 2 GB RAM
- 1280 x 800 display screen

3.6.3 Install software

After ensuring that the requirements for using EnerVista UR Setup software are met, there are three ways to install the software:

- From the DVD
- Download EnerVista Launchpad software from <http://www.gegridsolutions.com/multilin> and install it
- Download the EnerVista UR Setup software from <http://www.gegridsolutions.com/multilin> and install it

Install on a computer that has an operating system in the required language, for example a German operating system for use with EnerVista software in German.



The front panel can be switched in the EnerVista software between enhanced and standard panels under **Maintenance > Change Front Panel**.

To install the software from the DVD and using EnerVista Launchpad:

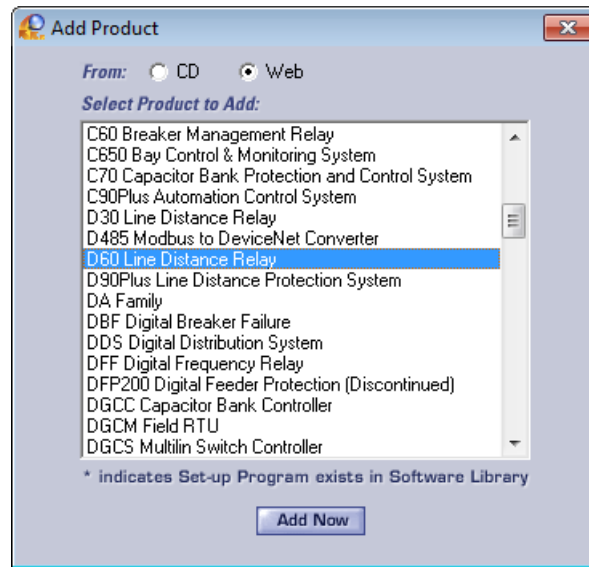
1. Insert the DVD into the DVD drive of your computer.
2. Click the **Install Now** button and follow the instructions.
3. When installation is complete, start the EnerVista Launchpad application.
4. Click the **IED Setup** section of the **Launch Pad** window.

Figure 3-59: Adding a UR device in Launchpad window



5. In the EnerVista Launch Pad window, click the **Add Product** button and select the appropriate product as follows. Select the **Web** option to ensure the most recent software release, or select **CD** if you do not have an Internet connection, then click the **Add Now** button to list software items for the product. EnerVista Launchpad obtains the software from the Internet or DVD and automatically starts the installation program after prompting about updates. From the web, the software is downloaded. A wizard opens.

Figure 3-60: Identifying the UR device type



- In the wizard, click the **Next** button and complete the process. The files are installed in the directory indicated, and the installation program automatically creates icons and adds an entry to the Windows start menu. The UR device is added to the EnerVista Launchpad window, as shown.

Figure 3-61: UR device added to Launchpad window



- For other than English, configure the language for the front panel in the EnerVista software under **Settings > Product Setup > Display Properties**. User-entered strings are not translated, for example relay names, so setting the language now ensures that the names are entered/displayed in the required language. For the EnerVista software language, access the **View > Language** menu item.

3.7 Add device to software

You connect remotely to the L30 through the rear RS485 or Ethernet port with a computer running the EnerVista UR Setup software. The L30 also can be accessed locally with a computer through the front panel RS232 or USB port or the rear Ethernet port using the Quick Connect feature.

The following procedures are outlined:

- Add device for serial access; see the Configure Serial Connection section
- Add device for the rear Ethernet port; see the Configure Ethernet Connection section
- Add device for access using a modem; see the Configure Modem Connection section

- Connect locally with a computer through either the front RS232 or USB port or rear Ethernet port; see the Connect to the L30 section
- Discover automatically UR devices within a network; see the Automatic Discovery of UR Devices section

Devices in the Device Setup window are listed in the order entered.

Devices in the main software window are listed alphabetically. Use the **Device Name** to order them as required, for example B30 Odessa, B30 Truro, B90, T35.

You cannot import a file to add a device to the software. You can import settings as outlined at the end of the chapter.

The Quick Connect button also can be used to add devices. The device is added to a Quick Connect menu item in the Online Window area, cannot be moved from it to another grouping, and needs to be renamed in the Device Setup window. GE instead recommends using the Device Setup window to add devices, as outlined here.

3.7.1 Set IP address in UR

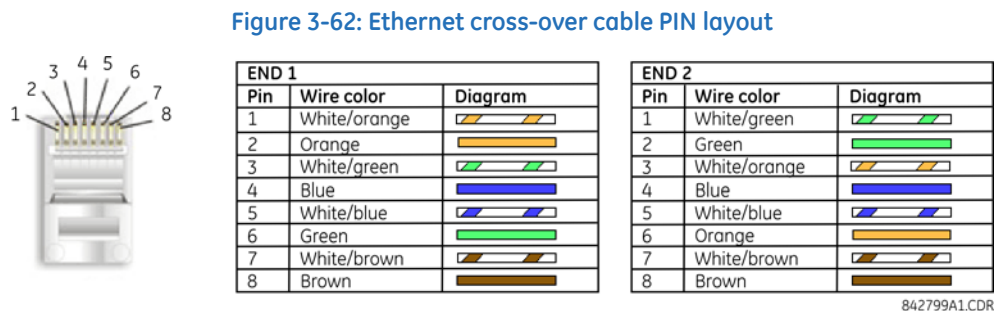
The IP and subnet addresses need to be added to the UR for Ethernet communication.

For serial communication, for example using the front RS232 port and the Quick Connect feature, the addresses are not required, but typically they are entered to add/configure devices for regular use.

1. On the front of the L30, press the **MENU** key until the **SETTINGS** menu displays.
2. Navigate to **SETTINGS** ⇒ **PRODUCT SETUP** ⇄ **COMMUNICATIONS** ⇄ **NETWORK** ⇒ **IP ADDRESS SETTING**.
3. Enter an IP address, for example “1.1.1.1,” and press the **ENTER** key to save the value.
4. In the same menu, select the **SUBNET IP MASK** setting.
5. Enter a subnet IP address, for example “255.0.0.0,” and press the **ENTER** key to save the value.

If using a blue or grey Ethernet cable, skip the rest of this section. If using an orange cross-over Ethernet cable, the computer needs to be set up as follows.

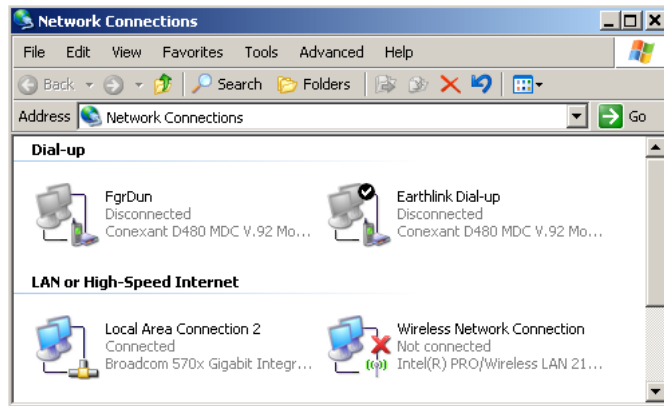
1. Use an orange Ethernet cross-over cable to connect the computer to the rear Ethernet port. In case you need it, the following figure shows the pinout for an Ethernet cross-over cable.



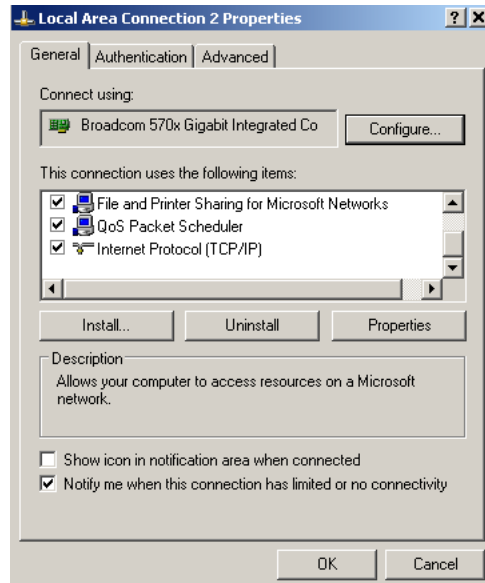
Next, assign the computer an IP address compatible with the relay's IP address.

1. From the Windows desktop, right-click the **My Network Places** icon and select **Properties** to open the network

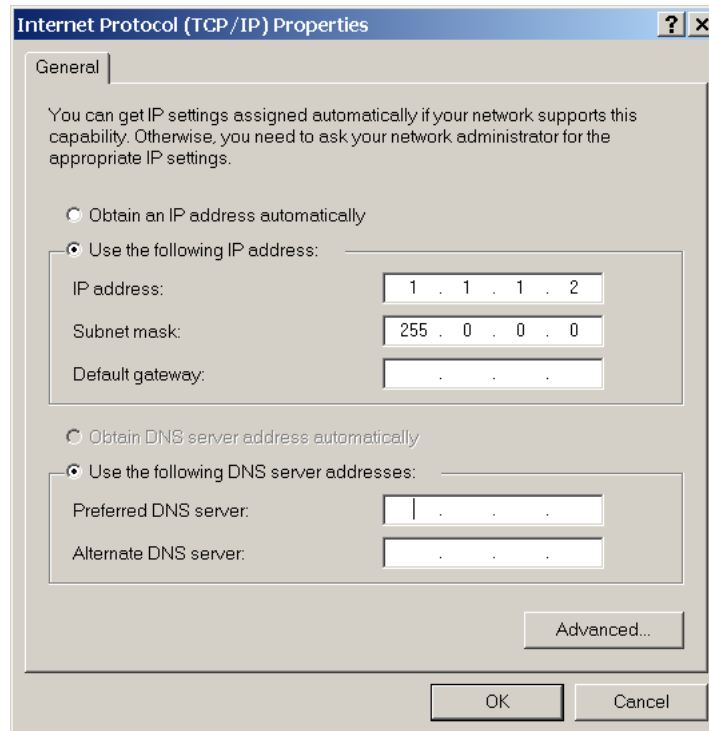
connections window. Or in Windows 7, access the **Network and Sharing Center** in the Control Panel.



2. Right-click the **Local Area Connection** icon and select **Properties**.



3. Select the **Internet Protocol (TCP/IP)** item from the list, and click the **Properties** button.



4. Click the "Use the following IP address" box.
5. Enter an **IP address** with the first three numbers the same as the IP address of the L30 relay and the last number different (in this example, 1.1.1.2).
6. Enter a subnet mask equal to the one set in the L30 (in this example, 255.0.0.0).
7. Click the **OK** button to save the values.

Before continuing, test the Ethernet connection.

1. Open a Windows console window, for example by selecting **Start > Run** from the Windows **Start** menu and typing "cmd" or clicking the **Start** button and entering "cmd".
2. Type the following command, substituting the IP address of 1.1.1.1 with yours:

```
C:\WINNT>ping 1.1.1.1
```

3. If the connection is successful, the system returns four replies similar to the following:

```
Pinging 1.1.1.1 with 32 bytes of data:
Reply from 1.1.1.1: bytes=32 time<10ms TTL=255
Reply from 1.1.1.1: bytes=32 time<10ms TTL=255
Reply from 1.1.1.1: bytes=32 time<10ms TTL=255
Reply from 1.1.1.1: bytes=32 time<10ms TTL=255
Ping statistics for 1.1.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip time in milliseconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0 ms
```

4. Note that the values for **time** and **TTL** vary depending on local network configuration.
5. If the following sequence of messages appears when entering the `C:\WINNT>ping 1.1.1.1` command:

```
Pinging 1.1.1.1 with 32 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.
```

```

Ping statistics for 1.1.1.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
    Approximate round trip time in milliseconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0 ms
    Pinging 1.1.1.1 with 32 bytes of data:

```

verify the physical connection between the L30 and the computer, and double-check the programmed IP address in the **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **NETWORK** ⇒ **IP ADDRESS** setting, then repeat step 2.

6. If the following sequence of messages appears when entering the `C:\WINNT>ping 1.1.1.1` command:

```

Pinging 1.1.1.1 with 32 bytes of data:
Hardware error.
Hardware error.
Hardware error.
Hardware error.
Ping statistics for 1.1.1.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
    Approximate round trip time in milliseconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0 ms
    Pinging 1.1.1.1 with 32 bytes of data:

```

verify the physical connection between the L30 and the computer, and double-check the programmed IP address in the **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **NETWORK** ⇒ **IP ADDRESS** setting, then repeat step 2.

7. If the following sequence of messages appears when entering the `C:\WINNT>ping 1.1.1.1` command:

```

Pinging 1.1.1.1 with 32 bytes of data:
Destination host unreachable.
Destination host unreachable.
Destination host unreachable.
Destination host unreachable.
Ping statistics for 1.1.1.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
    Approximate round trip time in milliseconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0 ms
    Pinging 1.1.1.1 with 32 bytes of data:

```

verify the IP address is programmed in the local computer by entering the `ipconfig` command in the command window.

```

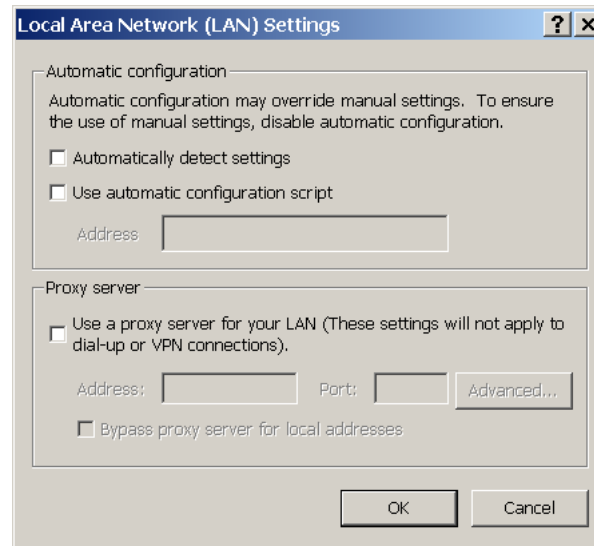
C:\WINNT>ipconfig
Windows IP Configuration
Ethernet adapter <F4FE223E-5EB6-4BFB-9E34-1BD7BE7F59FF>:
    Connection-specific DNS suffix. . . :
    IP Address. . . . . : 0.0.0.0
    Subnet Mask . . . . . : 0.0.0.0
    Default Gateway . . . . . :
Ethernet adapter Local Area Connection:
    Connection-specific DNS suffix . . :
    IP Address. . . . . : 1.1.1.2
    Subnet Mask . . . . . : 255.0.0.0
    Default Gateway . . . . . :
C:\WINNT>

```

Before using the Quick Connect feature through the Ethernet port, disable any configured proxy settings in Internet Explorer.

1. Start the Internet Explorer software.
2. Select the **Tools > Internet Options** menu item and click the **Connections** tab.

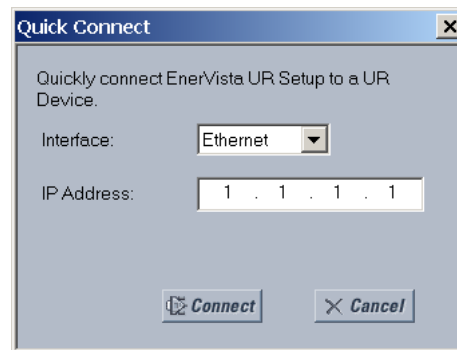
- Click on the **LAN Settings** button to open the following window.



- Ensure that the “Use a proxy server for your LAN” box is not checked.

If this computer is used to connect to the Internet, re-enable any proxy server settings after the computer has been disconnected from the L30 relay.

- Start the Internet Explorer software.
- Select the UR device from the EnerVista Launchpad to start EnerVista UR Setup.
- Click the **Quick Connect** button to open the window.



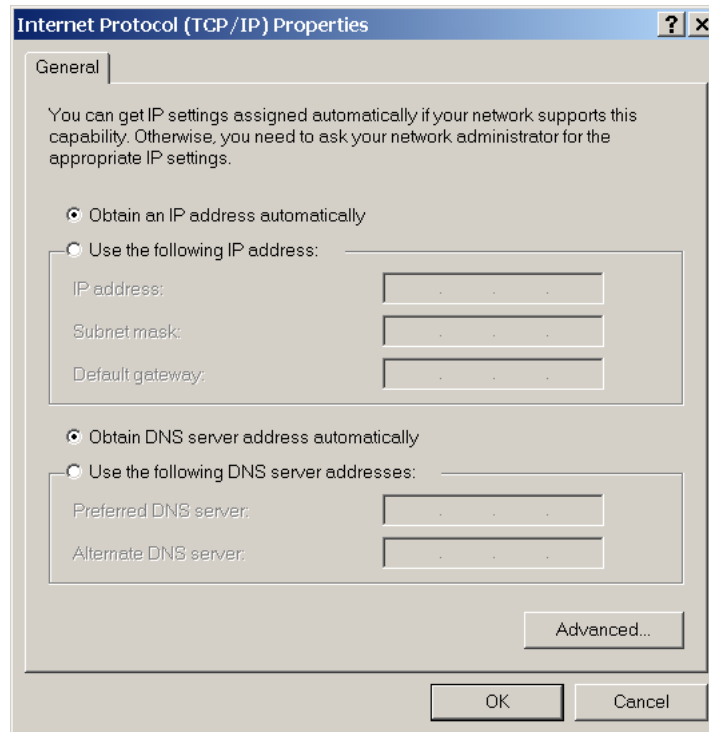
- Select the **Ethernet** interface and enter the IP address assigned to the L30, then click the **Connect** button. The EnerVista UR Setup software creates a site named “Quick Connect” with a corresponding device also named “Quick Connect” and displays them on the left side of the screen.
- Expand the sections to view data directly from the L30 device.

Each time that the EnerVista UR Setup software is initialized, click the **Quick Connect** button to establish direct communications to the L30. This ensures that configuration of the EnerVista UR Setup software matches the L30 model number.

When direct communications with the L30 via Ethernet is complete, make the following changes:

- From the Windows desktop, right-click the **My Network Places** icon and select **Properties** to open the network connections window.
- Right-click the **Local Area Connection** icon and select the **Properties** item.

3. Select the **Internet Protocol (TCP/IP)** item from the list provided and click the **Properties** button.
4. Set the computer to “Obtain a relay address automatically” as shown.



If the computer is used to connect to the Internet, re-enable any proxy server settings after the computer has been disconnected from the L30 relay.

3.7.2 Configure serial connection

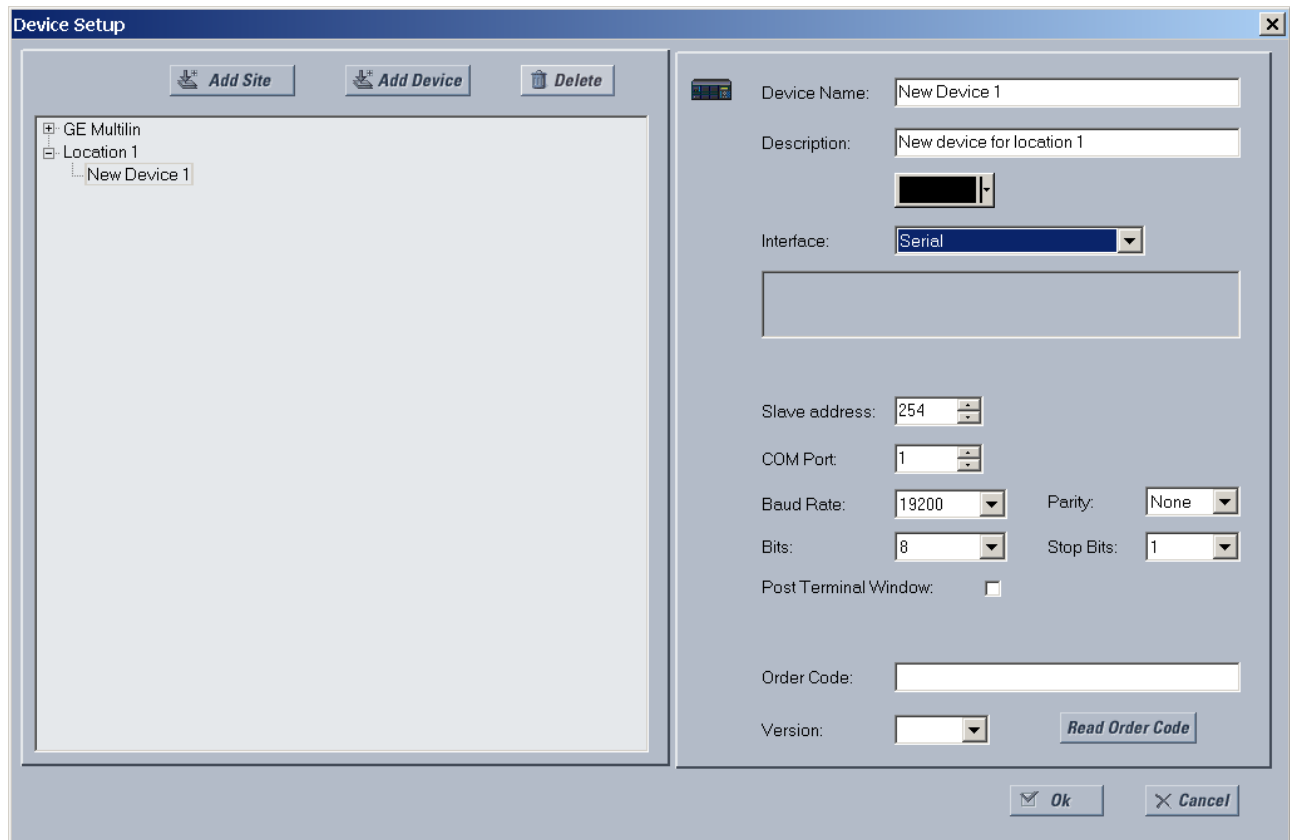
Two options are possible: local connection between computer and front RS232 port, and remote connection using the rear RS485 terminals.

For the RS232 connection, a computer with an RS232 port and a serial cable are required.

To use the RS485 terminals at the back of the relay, a GE Grid Solutions F485 converter (or compatible RS232-to-RS485 converter) is required. See the F485 instruction manual for details.

1. Connect the computer to the F485 and the F485 to the RS485 terminal on the back of the UR device. Or connect the computer to the RS232 port on the front of the relay.
2. Start the EnerVista UR Setup software, or in EnerVista Launchpad select the UR device to start the software.
3. Click the **Device Setup** button. The window opens.
4. Click the **Add Site** button. A new category is added. Enter a site name in the **Site Name** field. Optionally add a short **Description** of the site. This example uses “Location 1” as the site name.
5. Click the **Add Device** button. A new device is added.
6. Enter a name in the **Device Name** field, up to 15 characters, and optionally add a **Description** of the site. The **Color** is for the text in the device list in the Online Window.
7. Select “Serial” from the **Interface** drop-down list. Interface parameters display that must be entered for serial communications. Try to load automatically the fields by clicking the **Read Order Code** button.

Figure 3-63: Configuring serial communication



- Enter the COM port used by the computer, the baud rate, and parity settings from the front panel **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **SERIAL PORTS** menu, and the relay slave address setting from the front panel **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **MODBUS PROTOCOL** ⇒ **MODBUS SLAVE ADDRESS** menu in their respective fields.

Baud Rate — Typically 19200 bits per second (bps) for RS232, and higher for RS485. Both modems need to use the same rate.

Parity — Set to None if unsure

Bits — Set to 8 if unsure

Stop Bits — Set to 1 if unsure

Post Terminal Window — Enable this option if you have a Schweitzer Engineering (SEL) SEL-203x Communications Processor, such as an SEL-2030 or SEL-2032. This option enables display of a terminal window to allow interaction with the other device.

- Click the **Read Order Code** button to connect to the L30 and upload the order code to the software. If a communications error occurs, ensure that the EnerVista software serial communications values entered in the previous step correspond to the relay setting values, and also ensure that the same IP address is not assigned to multiple L30 ports.
- Click the **OK** button when the relay order code has been received. The new site and device are added to the Online Window.

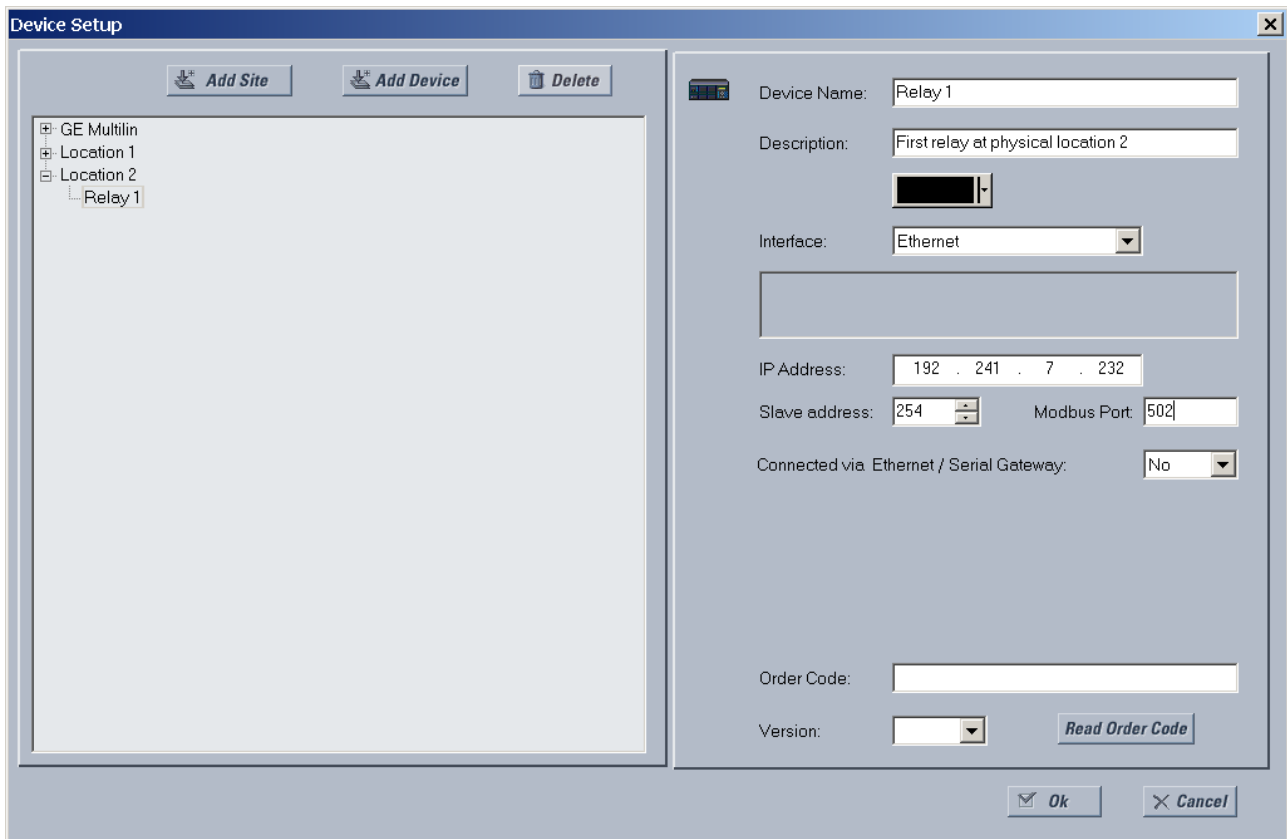
The device has been configured for serial communications. Proceed to the Connect to the L30 section to begin communication.

3.7.3 Configure Ethernet connection

You connect the Ethernet cable, define a site in the software, then add the relay as a device for the site. The computer and UR device must be on the same subnet.

1. Connect the Ethernet network cable to the Ethernet port on the back of the device.
2. Start the EnerVista UR Setup software, or in EnerVista Launchpad select the UR device to start the software.
3. Click the **Device Setup** button. The window opens.
4. Click the **Add Site** button. A new category is added. Enter a site name in the **Site Name** field. Optionally add a short **Description** of the site. This example uses "Location 1" as the site name.
5. Click the **Add Device** button. A new device is added.
6. Enter a name in the **Device Name** field, up to 15 characters, and optionally add a **Description** of the site. The **Color** is for the text in the device list in the Online Window.
7. Select "Ethernet" from the **Interface** drop-down list. This displays a number of interface parameters that must be entered for Ethernet functionality.

Figure 3-64: Configuring Ethernet communication



8. Enter the relay **IP Address**, which can be viewed on the device front panel under **SETTINGS** ⇒ **PRODUCT SETUP** ⇄ **COMMUNICATIONS** ⇄ **NETWORK** ⇒ **IP ADDRESS**. Once the IP address is entered, try to load automatically the fields by clicking the **Read Order Code** button.
9. Enter the relay **Slave address** and **Modbus Port** address values from the settings in the front panel **SETTINGS** ⇒ **PRODUCT SETUP** ⇄ **COMMUNICATIONS** ⇄ **MODBUS PROTOCOL** menu.
10. If using a gateway to connect to the device, select **Yes** from the drop-down list.
11. Click the **Read Order Code** button to connect to the L30 device and upload the order code. If the device was entered already, a message displays "Device 'X' is also using IP address..." If a communications error occurs, ensure that the values entered in the previous steps correspond to the relay setting values, and also ensure that the same IP address

is not assigned to multiple L30 ports.

12. Click the **OK** button when the relay order code has been received. The new site and device are added to the Online Window.

The device has been configured for Ethernet communications. Proceed to the Connect to the L30 section to begin communications.

3.7.4 Configure modem connection

A modem connection allows a computer to communicate with a UR device over phone lines.

Two modems are required. One modem is connected to the UR device, either by connecting the serial cable to the front panel port or through a RS485 box to the rear terminals of the UR device. The second modem is connected to the computer that initiates the connection.

To add a UR device for modem connections:

1. Connect the modems to the computer and UR.
2. Start the EnerVista UR Setup software, or in EnerVista Launchpad select the UR device to start the software.
3. Click the **Device Setup** button. The window opens.
4. Click the **Add Site** button. A new category is added. Enter a site name in the **Site Name** field, such as London East. Optionally add a short **Description** of the site, such as the address or intersection.
5. Click the **Add Device** button. A new device is added.
6. Enter a name in the **Device Name** field, up to 15 characters, and optionally add a **Description** of the site. The **Color** is for the text in the device list in the Online Window.
7. Select "Modem" from the **Interface** drop-down list. This displays a number of interface parameters that must be entered.
8. Select "Generic Modem" from the **Modem Name** drop-down list, then enter the **Phone Number** to dial to establish communication with the remote modem.
Post Terminal Window — Enable this option if you have a SEL-203x Communications Processor, such as an SEL-2030 or SEL-2032. It enables display of a terminal window to allow interaction with the other device.
9. Once the phone number is entered, try to load automatically the device information by clicking the **Read Order Code** button.
10. Click the **OK** button when the relay order code has been received. The new device is added to the Online window.

The UR device has been added to the software.

3.7.5 Automatic discovery of UR devices

The EnerVista UR Setup software can find and communicate to all UR-family devices located on an Ethernet network.

Using the **Discover** button in the **Device Setup** window, a single click of the mouse triggers the software to detect any URs located on the network. This is done by searching a range of IP addresses based on the subnet mask of the computer. When a UR device is detected, the EnerVista UR Setup software proceeds to configure all settings and order code options in the window. This feature allows the user to identify and interrogate all UR devices at a location.

Examples of address ranges are as follows:

- If the host has an IP address of 3.94.247.10 and its subnet mask is 255.255.252.0, then the host's subnet is 3.94.244.0, and the possible IP addresses in this subnet are
 - 3.94.244.1 to 254
 - 3.94.245.1 to 254
 - 3.94.246.1 to 254
 - 3.94.247.1 to 254

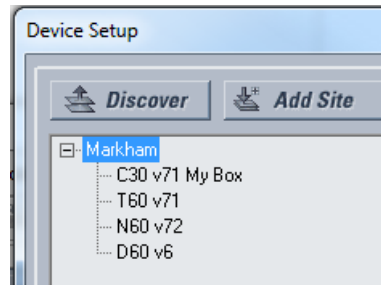
The discover function scans all those possible IP addresses to detect UR relays.

- If the host has an IP address of 3.94.247.145 and its subnet mask is 255.255.255.128, then the host's subnet is 3.94.247.128, and the discover function scans IP addresses of 3.94.247.128 to 3.94.248.254 for UR relays

To automatically add UR devices:

1. In the EnerVista software, click the **Device Setup** button. The window opens.
2. Click the **Discover** button. The software searches for UR devices on the computer subnet and adds any found to the Online Window area. If a required device is not found, add it manually as outlined earlier.

Figure 3-65: Discover button to detect UR devices in network



3.8 Connect to the L30

There are four ways to the connect to the device, as follows:

- RS232 or USB port (outlined here)
- RS485 port
- Ethernet port (outlined here)
- LAN

When unable to connect because of an "ACCESS VIOLATION," access **Device Setup** and refresh the order code for the device.

When unable to connect, ensure that the same IP address is not assigned to multiple L30 ports, for example under **Settings > Product Setup > Communications > Network**.



When multiple computers are connected to a L30 device, EnerVista settings windows are not updated automatically. They are refreshed when re-opened. If a user changes a setting on one computer, the other users need to refresh the display by closing and opening the settings window to see the change. To ensure that current settings are always viewed, close settings windows when not in use so that they are up-to-date when next accessed.

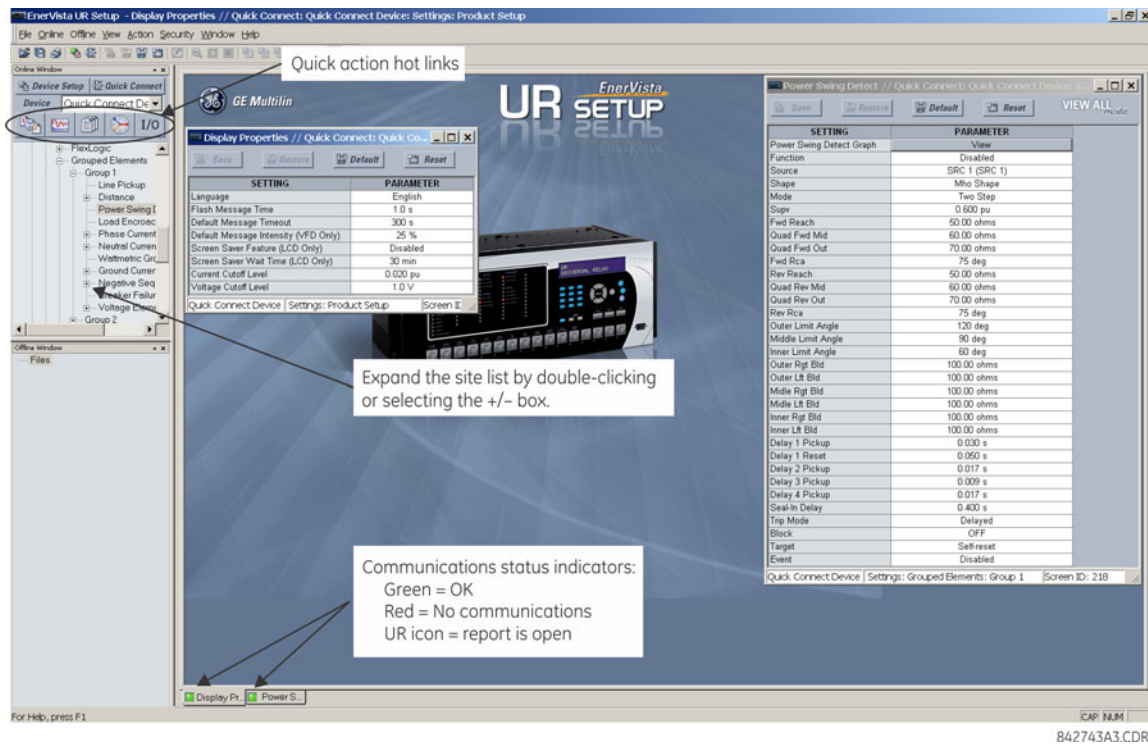
3.8.1 Connect to the L30 in EnerVista

For information on using the EnerVista software, see the Interfaces chapter.

To access the relay in EnerVista:

1. Open the **Settings > Product Setup > Display Properties** window as shown. The window opens with a status indicator on the lower left of the EnerVista UR Setup window.

Figure 3-66: EnerVista window



2. If the status indicator is red, verify that the Ethernet network cable is properly connected to the Ethernet port on the back of the relay and that the relay has been properly set up for communication.
3. If a relay icon appears in place of the status indicator, then a report (such as an oscillography or event record) is open. Close the report to re-display the green status indicator.
4. The Display Properties settings can now be viewed, edited, or printed.

3.8.1.1 Quick action hot links

The EnerVista UR Setup software has several quick action buttons to provide instant access to several functions that are performed often when using URs. From the online window, users can select the relay to interrogate from a pull-down window, then click the button for the action to perform. The following quick action functions are available:

- View the event record
- View the last recorded oscillography record
- View the L30 protection summary
- View all of the L30 metering values
- View the status of all L30 inputs and outputs
- Generate a service report

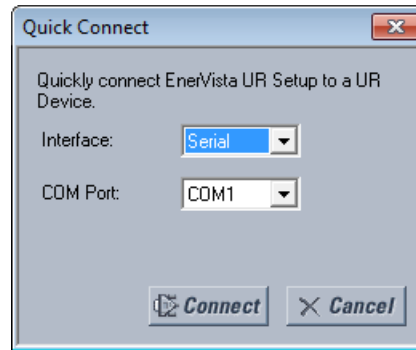
3.8.2 Use Quick Connect via front RS232 port

This feature applies to the enhanced and standard front panels.

To connect to the UR from a computer using a serial cable:

1. Connect an RS232 serial cable to the computer and the front panel RS232 port.
2. Start the EnerVista UR Setup software, or in EnerVista Launchpad select the UR device to start the software.
3. Click the **Quick Connect** button. The window opens.

Figure 3-67: Quick Connect window to access a device



3

4. Select the serial **Interface** and the communications port (**COM Port**) from the drop-down lists, then click **Connect**. The COM Port is that of the computer.
5. The EnerVista software creates a site named "Quick Connect" with a corresponding device also named "Quick Connect" and displays them in the Online Window. Expand the sections to view data directly from the UR device. Use the **Device Setup** button to change the site name.

Each time that the EnerVista UR Setup software is initialized, click the **Quick Connect** button to establish direct communications to the L30. This ensures that configuration of the EnerVista UR Setup software matches the L30 model number.

3.8.3 Use Quick Connect via front USB port

This feature applies to the graphical front panel.

To connect to the UR from a computer using a USB cable:

1. Connect the cable to the computer and the front panel USB port (square connector).
2. Start the EnerVista UR Setup software, or in EnerVista Launchpad select the UR device to start the software.
3. Click the **Quick Connect** button to open the window.
4. Select the USB **Interface** and the "GE Virtual Serial Port" driver from the drop-down list, then click **Connect**. If the GE driver does not display, it means that the USB cable was connected on Windows 10 when upgrading the UR software. You need to re-install the EnerVista software with the USB cable disconnected.
5. The EnerVista software creates a site named "Quick Connect" with a corresponding device also named "Quick Connect" and displays them in the Online Window. Expand the sections to view data directly from the UR device. Use the **Device Setup** button to change the site name.

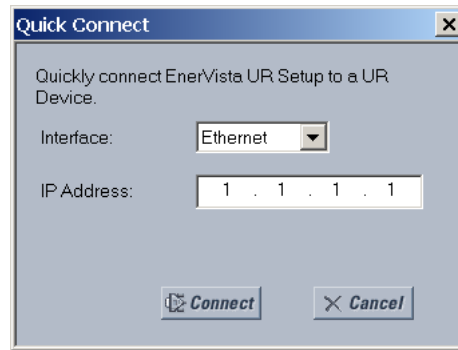
Each time that the EnerVista UR Setup software is initialized, click the **Quick Connect** button to establish direct communications to the L30. This ensures that configuration of the EnerVista UR Setup software matches the L30 model number.

3.8.4 Use Quick Connect via a rear Ethernet port

To connect to a UR using an Ethernet cable:

1. In the EnerVista software, click the **Quick Connect** button. The window opens.

Figure 3-68: Quick Connect window for Ethernet connection



2. Select the **Ethernet** interface and enter the IP address assigned to the L30, then click the **Connect** button. The EnerVista UR Setup software creates a site named "Quick Connect" with a corresponding device also named "Quick Connect" and displays them in the Online Window.
3. Expand the sections to view data directly from the L30 device. Use the **Device Setup** button to change the site name. Each time that the EnerVista software is initialized, click the **Quick Connect** button to establish direct communications to the L30. This ensures that configuration of the EnerVista UR Setup software matches the L30 model number.

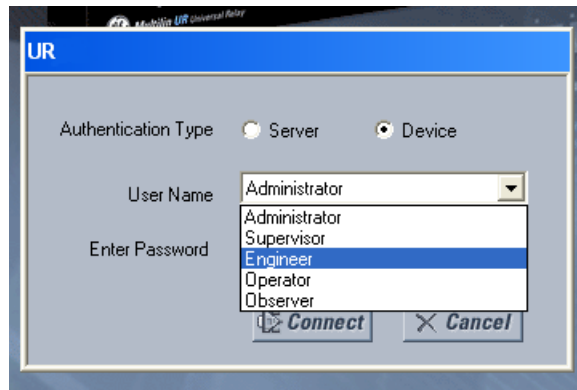
3.9 Set up CyberSentry and change default password

If and when first using CyberSentry security, use the following procedure for set up.

1. Log in to the relay as Administrator by using the **VALUE** keys on the front panel or through EnerVista connected serially (so that no IP address is required). If logging in through EnerVista choose Device authentication (see figure). Enter the default password "ChangeMe1#". Note that the "Lock relay" setting needs to be disabled in the **Security > Supervisory** menu. When this setting is disabled, configuration and firmware upgrade are possible. By default, this setting is disabled.
2. Enable the Supervisor role if you have a need for it.
3. Make any required changes in configuration, such as setting a valid IP address for communication over Ethernet.
4. Log out of the Administrator account by choosing None.

Next, device or server authentication can be chosen on the login screen, but the choice is available only in EnerVista. Use Device authentication to log in using the five pre-configured roles (Administrator, Supervisor, Engineer, Operator, Observer, or Administrator and Supervisor when Device authentication is disabled). When using a serial connection, only Device authentication is supported. When Server authentication is required, characteristics for communication with a RADIUS server must be configured on the UR. This is possible only through the EnerVista software. The RADIUS server itself also must be configured. At the end of this instruction manual, the appendix called RADIUS Server Configuration gives an example of how to set up a simple RADIUS server. Once both the RADIUS server and the parameters for connecting the UR to the server have been configured, you can choose Server authentication on the login screen of EnerVista.

Figure 3-69: Login screen for CyberSentry



3

During the commissioning phase, you have the option to bypass the use of passwords. Do so by enabling the **Bypass Access** setting under **Settings > Product Setup > Security > Supervisory**. Be sure to disable this bypass setting after commissioning the device.

You can change the password for any role either from the front panel or through EnerVista. If using EnerVista, navigate to **Settings > Product Setup > Security**. Change the **Local Administrator Password**, for example. It is strongly recommended that the password for the Administrator be changed from the default. Changing the passwords for the other three roles is optional.

3.10 Import settings

The following file types can be imported:

- URS — UR settings file (firmware version 7.3x or earlier)
- IID — Instantiated IED capability description file — Actual settings on UR
- CID — Configured IED description file — Settings sent to the UR (may or may not be actual settings)

The import is done in the Offline Window area.

To import a settings file:

1. In the Offline Window area, right-click the device and select the **Add Device from File** option. The device is that from which you want to import settings.
2. If required, change the **Files of type** drop-down list.
3. Select the file to import.

To apply the settings to a live device:

1. Drag-and-drop the device entry from the Offline Window area to its entry in the Online Window area. Individual settings also can be dragged and dropped between Online and Offline Window areas. The order codes must match.

This is what happens:

- CID — For version 7.30 or later, a new URS file generates and moves into a new device folder, generating SCL files from the new URS file. Files in the folder have new time stamps. The CID file retains its time stamp.
- URS — When not IEC 61850 and version is lower than 7.30, the file is added and time stamp is unchanged. When clicking in the software on the tree element, a device folder is created, the original file moves into it, and time stamp on the URS file is retained.

When EIC 61850 and version is 7.30 or later, the file is added and time stamp is unchanged. When clicking in the software on the tree element, a device folder is created, the original file moves into it, SCL files are generated there, and the "Last modified" time stamp on the URS file changes.

3.11 Connect to D400 gateway

A GE Multilin D400 Substation Gateway can be used to collect data from UR devices in a local area network (LAN). It collects metering, status, event, and fault report data from serial or LAN-based intelligent substation devices, and it pre-processes the data. The D400 supports up to 16 serial and eight network connections, with multiple devices possible on each serial connection. Up to 10 concurrent file transfer sessions are possible, meaning data for up to 10 URs can be transferred at the same time and any additional IEDs are queued on a first-come-first-served basis. The D400 can then upload files to a demilitarized zone (DMZ) server at the enterprise level.

Setup is as follows. For UR devices with the CyberSentry software option, when there is a need to retrieve periodically the logs from the UR securely without a human interface, the following approach can be used. See the D400 manual for configuration details to achieve it.

A UR in the substation can authenticate a user either connecting to a RADIUS server or on the device itself. This depends on the user name used for authentication on a connection. The D400 connects to the UR device using an Ethernet, USB, or serial port on the UR. The Ethernet connection can be ST or RJ-45 type. The serial connection can be RS232 or RS485. At the other end, a cable attaches to the rear of D400. Use the D400 software to configure a serial or network communication/connection for the UR, then to configure the IED device blocks/clients for the UR, and then to configure record retrieval. Once configured, the UR and D400 use a keyfile authentication mechanism to establish communication.

For UR devices with the IEC 61850 software option, also use the D400 IEC 61850 Loader software.

When a D400 detects new files available for download from a UR, it connects to the UR and reads the files via sFTP protocol. The following files can be transferred:

- Oscillography files
- Event records
- Log files
- Configuration (setting) files

The D400 information is viewable in its software and in a web browser.

3.11.1 Oscillography files

These are stored in COMTRADE format in the D400 folder system using the UR site and device name.

3.11.2 Event records

These are stored as the EVT.TXT file in the D400 folder system using the UR site and device name.

3.11.3 Log files

Log files can be retrieved for UR 7.0 and later. The following file types are possible, stored in the D400 folder system using the UR site and device name:

- `factory_event.txt` — Information about change methods and origins. Saved with a "_YYMMDDhhmmss" retrieval time stamp, for example `FACTORY_EVENT_170525183124.TXT`.
- `setting_changes.log` — Information on what settings have been changed. Saved with a "_YYMMDDhhmmss" retrieval time stamp, for example `SETTING_CHANGES_170525183124.TXT`.

3.11.4 Setting files

These are the configuration/settings files in the IEC 61850 SCL/IID format. The ur.iid file is saved with a "_YYMMDDhhmmss" retrieval time stamp, for example ur_170525183124.iid. It is stored in the D400 folder system using the UR site and device name.

L30 Line Current Differential System

Chapter 4: Interfaces

This chapter explains the EnerVista software interface, the front panel interface, logic diagrams, and Engineer interface for logic design and monitoring.

4.1 EnerVista software interface

4.1.1 Introduction

The EnerVista UR Setup software provides a single facility to configure, monitor, maintain, and troubleshoot relays connected over local or wide-area networks. It can be used while disconnected (offline) or connected (online) to a UR device. In offline mode, settings files can be created for eventual downloading to the device. In online mode, communication with the device is real-time.

The EnerVista UR Setup software is provided with every L30. This chapter outlines the EnerVista software interface. The EnerVista UR Setup help file in the software also provides details for getting started and using the software interface.

4.1.2 Settings files

The EnerVista software supports the following three ways of handling changes to relay settings:

- In offline mode (relay disconnected) to create or edit relay settings files for later transfer to relays
- While connected to a relay to modify relay settings, and then save the settings to the relay
- Create/edit settings files and then write them to the relay while connected to the relay

See the back up section in the Maintenance chapter for instructions on how to create a settings file either offline or online.

Settings files are organized on the basis of file names assigned by the user. A settings file contains data pertaining to the following types of relay settings:

- Device definition
- Product setup
- System setup
- FlexLogic
- Grouped elements
- Control elements
- Inputs/outputs

- Remote resources
- Testing

Factory default values are supplied and can be restored after any changes.

The following communications settings are not transferred to the L30 with settings files:

- Modbus Slave Address
- Modbus TCP Port Number
- RS485 COM2 Baud Rate
- RS485 COM2 Parity
- COM2 Minimum Response Time
- COM2 Selection
- RRTD Slave Address
- RRTD Baud Rate
- IP Address
- IP Subnet Mask
- IP Routing

When a settings file is loaded to a L30 that is in-service, the following sequence occurs:

1. The L30 takes itself out of service.
2. The L30 issues a UNIT NOT PROGRAMMED major self-test error.
3. The L30 closes the critical fail contact.

The Maintenance chapter outlines how to use a settings file in the .urs format for backup and restore.

4.1.3 Event viewing

In online or offline mode, you can view and analyze data generated by triggered parameters as follows:

- **Event recorder** — The event recorder captures contextual data associated with the last 1024 events, listed chronologically from most recent to oldest
- **Oscillography** — The oscillography waveform traces and digital states are used to provide a visual display of power system and relay operation data captured during specific triggered events

Event records are viewable at software and device-specific levels. Access the former under **Admin > Event Log > View**. Access the latter under **Actual Values > Records > Event Record**.

Event record entries for CyberSentry are explained in the next chapter. The following table outlines some software-level entries.

Table 4-1: Event record descriptions

Event	Description
EnerVista UR Setup SESSION STARTED	The EnerVista software was launched
Language was changed.	The user changed the software language using the View > Language menu item
DEFAULT USERS CREATED	The user management window was launched using the Admin > User Management menu item
: Successful upload of firmware END Firmware verified Firmware uploaded Firmware erased START: Upload new firmware	The firmware on a device was upgraded
EnerVista UR Setup EVENT LOG CLEARED	The event record was cleared. All event records were deleted using the Admin > Event Log > Clear menu item.

4.1.4 File support

The following support applies, where the Settings List is at the bottom left and the Site List is at the top left of the EnerVista window:

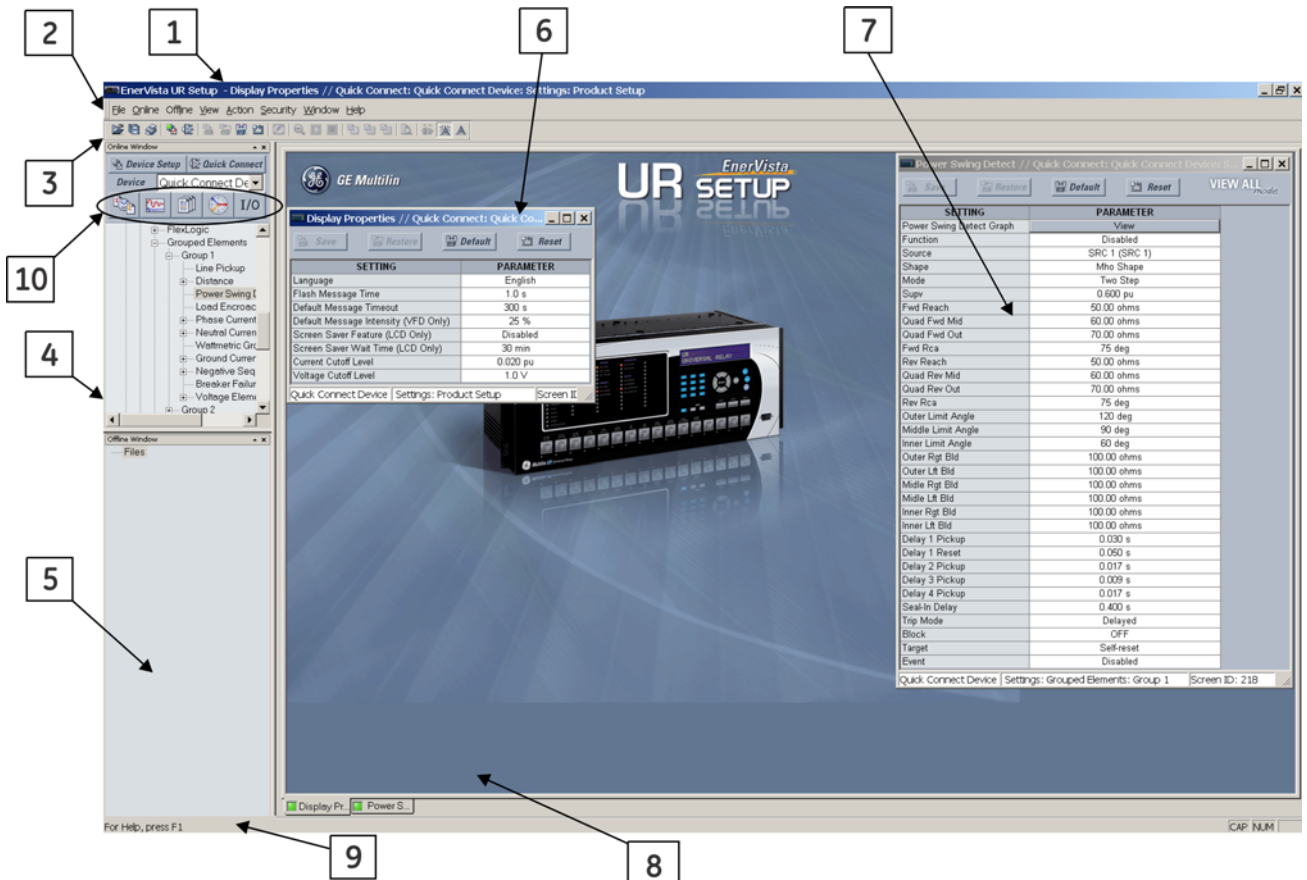
- **Execution** — Any EnerVista UR Setup file that is opened launches the application or provides focus to the already opened application. If the file was a settings file (has a .urs extension) that had been removed from the Settings List navigation menu, it is added back to the menu.
- **Drag and Drop** — The device settings and individual settings can be dragged and dropped between the Online and Offline Window areas. Also, any Windows Explorer directory folder is a file drag source and drop target.
New files that are dropped into the Offline Window are added to the tree, which is automatically sorted alphabetically with respect to settings file names. In the Online Window, files or individual menu items that are dropped in the selected device menu are sent automatically to the online device.

4.1.5 EnerVista main window

The EnerVista UR Setup software window has the following components:

1. Title bar that shows the pathname of the active data view or the name of the software
2. Main window menu bar
3. Main window toolbar
4. Site list / online window area
5. Settings list / offline window area
6. Software windows, with common toolbar
7. Settings file data view windows, with common toolbar
8. Workspace area with data view tabs
9. Status bar
10. Quick action hot links

Figure 4-1: EnerVista UR Setup software window

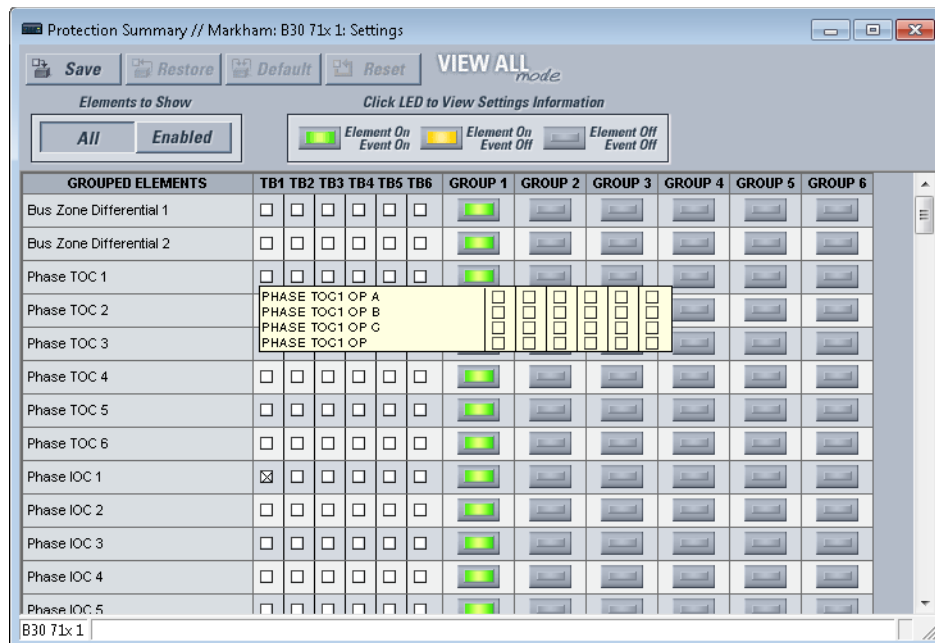


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4.1.6 Protection summary window

The Protection Summary is a graphical user interface to manage elements, such as enabling and disabling them. Access it under **Settings > Protection Summary**. See the Settings chapter for information on use.

Figure 4-2: Protection Summary interface (B30 example shown)



4.1.7 Settings templates

Settings file templates simplify the configuration and commissioning of multiple relays that protect similar assets. An example is a substation that has 10 similar feeders protected by 10 UR F60 relays.

In these situations, typically 90% or greater of the settings are identical among devices. The templates allow engineers to configure and test these common settings, then lock them so that they are not available to users. For example, locked settings can be hidden from view for field engineers, allowing them to quickly identify and concentrate on specific settings.

The remaining settings (typically 10% or less) can be specified as editable and made available to field engineers installing the devices. These are settings such as protection element pickup values and CT and VT ratios.

The settings template mode allows the user to define which settings are visible in the software. Settings templates can be applied to both settings files (settings file templates) and online devices (online settings templates). The functionality is identical for both purposes.



Template mode is available in English only.

Settings file conversion from previous firmware versions is supported.

4.1.7.1 Enable the settings template

The settings file template feature is disabled by default. It can be enabled in offline or online mode.

The procedure outlines how to enable in offline mode the settings template for UR settings files.

1. Locate the settings file in the Offline Window area of the EnerVista UR Setup software. If not there, a file can be added from an online device by right-clicking it and selecting the **Add Device to Offline Window** option.
2. In the Offline Window area, right-click the selected device or settings file and select the **Template Mode > Create Template** option.

The settings file template is now enabled and the file menus display in light blue. The settings file is now in template editing mode. To undo the action, select **Template Mode > Remove Template**.

Alternatively, the settings template can be applied to online settings, as follows.

1. Locate the device in the Online Window area of the EnerVista UR Setup software.
2. Right-click the device and select the **Template Mode > Create Template** option. The software prompts for a template password. This password is required to use the template feature and must be at least four characters in length.

Figure 4-3: Entering a settings file password

3. Enter and re-enter the new password, then click **OK** to continue.
The online settings template is now enabled. The device is now in template editing mode.

4

4.1.7.2 Edit the settings template

The settings template editing feature allows the user to specify which settings are available for viewing and modification in EnerVista UR Setup. By default, all settings except the FlexLogic equation editor settings are locked.

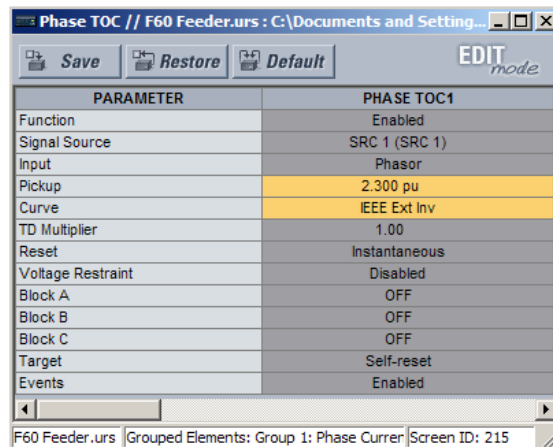
1. With the template already enabled, locate the device or settings file in the Online or Offline Window area in the software.
2. Right-click the device or file and select the **Template Mode > Edit Template** option to verify or place the device in template editing mode (check mark beside option). If prompted, enter the template password then click **OK**.
3. Open the relevant settings window that contains settings to be specified as viewable.
By default, all settings are specified as locked and displayed against a grey background. The icon on the upper right of the settings window indicates that the EnerVista software is in **EDIT mode**. The following example shows the phase time overcurrent settings window in edit mode.

Figure 4-4: Settings template with all settings specified as locked

PARAMETER	PHASE TOC1
Function	Enabled
Signal Source	SRC 1 (SRC 1)
Input	Phasor
Pickup	2.300 pu
Curve	IEEE Ext Inv
TD Multiplier	1.00
Reset	Instantaneous
Voltage Restraint	Disabled
Block A	OFF
Block B	OFF
Block C	OFF
Target	Self-reset
Events	Enabled

4. Specify the settings to make viewable by clicking them.
A setting available to view displays with a yellow background.

Figure 4-5: Settings template with two settings specified as editable



- Click the **Save** button to save changes to the settings template.
- Continue through any other settings window to specify all viewable settings. The next time that the device/settings are accessed, only those specified as viewable/editable display in the menu hierarchy.

4.1.7.3 Add password protection to a template

GE recommends that templates be saved with password protection to maximize security.



When templates are created for online settings, the password is added during the initial template creation step. It does not need to be added after the template is created.

To add password protection to a settings file template:

- In the Offline Window area, right-click the device and select the **Template Mode > Password Protect Template** option.

The software prompts for a template password. This password must be at least four characters in length.

- Enter and re-enter the new password, then click **OK** to continue.

The settings file template is now secured with password protection.

4.1.7.4 View the settings template

Once all necessary settings are specified for viewing, users are able to view the settings template on the online device or settings file. There are two ways to specify the settings view with the settings template feature:

- Display only those settings available for editing
- Display all settings, with settings not available for editing greyed-out

To display only the settings available for editing:

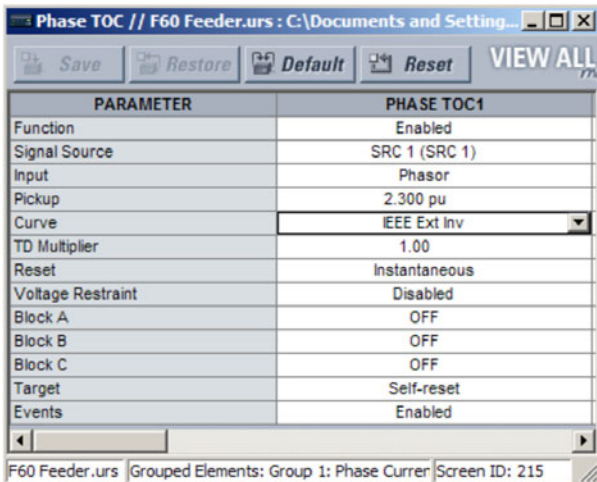
- Right-click the device in the Online or Offline Window area and apply the template by selecting the **Template Mode >**

View In Template Mode option.

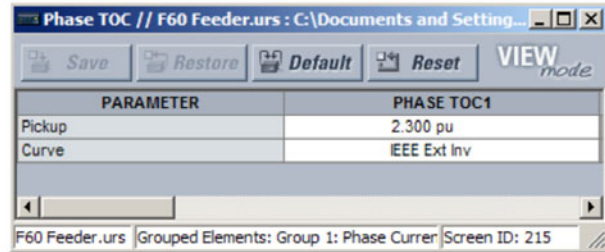
2. Enter the template password if prompted, then click **OK** to apply the template.

Once the template has been applied, users are limited to view and edit the settings specified by the template. The effect of applying the template to the phase time overcurrent settings is shown.

Figure 4-6: Applying templates using the View in Template Mode command



Phase time overcurrent settings window without template applied.

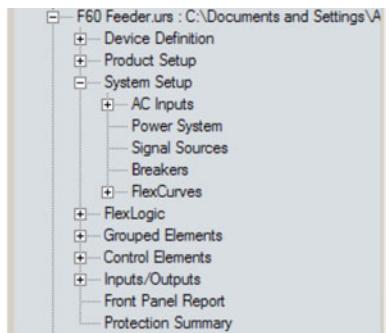


Phase time overcurrent window with template applied via the **Template Mode > View In Template Mode** command. The template specifies that only the Pickup and Curve settings be available.

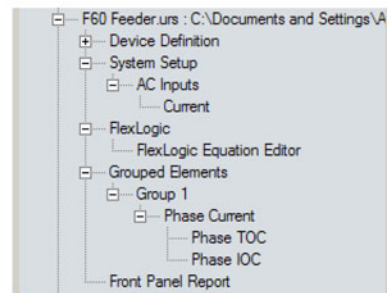
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Viewing the settings in template mode also modifies the settings menu, showing only the settings categories that contain editable settings. The effect of applying the template to a typical settings menu is shown as follows.

Figure 4-7: Applying templates using the View in Template Mode settings command



Typical settings tree view without template applied.



Typical settings tree view with template applied via the **Template Mode > View In Template Mode** command.

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Use the following procedure to display settings available for editing and settings locked by the template.

1. Right-click the device in the Online or Offline Window area and apply the template by selecting the **Template Mode > View All Settings** option.
2. Enter the template password then click **OK** to apply the template.

Once the template has been applied, users are limited to edit the settings specified by the template, but all settings are shown. The effect of applying the template to the phase time overcurrent settings is shown as follows.

Figure 4-8: Applying templates using the View All Settings command

PARAMETER	PHASE TOC1
Function	Enabled
Signal Source	SRC 1 (SRC 1)
Input	Phasor
Pickup	2.300 pu
Curve	IEEE Ext Inv
TD Multiplier	1.00
Reset	Instantaneous
Voltage Restraint	Disabled
Block A	OFF
Block B	OFF
Block C	OFF
Target	Self-reset
Events	Enabled

Phase time overcurrent settings window without template applied.

PARAMETER	PHASE TOC1
Function	Enabled
Signal Source	SRC 1 (SRC 1)
Input	Phasor
Pickup	2.300 pu
Curve	IEEE Ext Inv
TD Multiplier	1.00
Reset	Instantaneous
Voltage Restraint	Disabled
Block A	OFF
Block B	OFF
Block C	OFF
Target	Self-reset
Events	Enabled

Phase time overcurrent window with template applied via the **Template Mode > View All Settings** command. The template specifies that only the Pickup and Curve settings be available.

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4.1.7.5 Remove the settings template

Once a settings template is removed, it cannot be reapplied and a new settings template needs to be defined before use.

1. Right-click the device in the Online or Offline Window area and select the **Template Mode > Remove Template** option.
2. Enter the template password if prompted and click **OK** to continue.
3. Confirm that you want to remove the template by clicking **Yes**.

The EnerVista software removes all template information and all settings are available.

4.1.8 Secure and lock FlexLogic equations

The UR allows users to secure some or all FlexLogic equations, preventing unauthorized viewing or modification of critical FlexLogic applications. This is accomplished using the settings template feature to lock individual entries within FlexLogic equations.

Secured FlexLogic equations remain secure when files are sent to and retrieved from any UR-series device.

Locking can be tied to the serial number too.

4.1.8.1 Lock FlexLogic equations

To lock individual entries of a FlexLogic equation:

1. Right-click the settings file or online device and select the **Template Mode > Create Template** item to enable the settings template feature.
2. If prompted, enter the template password.
3. Select the **FlexLogic > FlexLogic Equation Editor** settings menu item.

By default, all FlexLogic entries are specified as viewable and display against a yellow background. The icon on the upper right of the window also indicates that EnerVista UR Setup is in **EDIT mode**.

4. Specify the entries to lock by clicking them.

The locked entries display a grey background as shown in the example.

Figure 4-9: Locking FlexLogic equation entries in Edit Mode

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Inputs On	Close HMI On (V11)
FlexLogic Entry 2	Virtual Inputs On	Close SCADA On (V12)
FlexLogic Entry 3	Contact Inputs On	Manual Close On(H5A)
FlexLogic Entry 4	OR	3 Input
FlexLogic Entry 5	Assign Virtual Output	= Close 52-1 (VO1)
FlexLogic Entry 6	Contact Inputs On	52-1 Closed On(H5C)
FlexLogic Entry 7	Contact Inputs On	52-1 Rack In On(H6A)
FlexLogic Entry 8	AND	2 Input
FlexLogic Entry 9	Protection Element	PHASE IOC1 OP
FlexLogic Entry 10	Protection Element	PHASE TOC1 OP
FlexLogic Entry 11	Protection Element	GROUND IOC1 OP
FlexLogic Entry 12	Protection Element	NEUTRAL IOC1 OP
FlexLogic Entry 13	OR	4 Input
FlexLogic Entry 14	AND	2 Input
FlexLogic Entry 15	Assign Virtual Output	= Trip 52-1 (VO2)
FlexLogic Entry 16	Protection Element	ANY MAJOR ERROR
FlexLogic Entry 17	POSITIVE ONE SHOT	1 Input
FlexLogic Entry 18	Protection Element	ANY MAJOR ERROR

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- Click the **Save** button to save and apply changes to the settings template.
- Select the **Template Mode > View In Template Mode** option to view the template.
- Optionally apply a password to the template by right-clicking the device and selecting the **Template Mode > Password Protect Template** option.

Once the template has been applied, users are limited to view and edit the FlexLogic entries not locked by the template. The effect of applying the template to the FlexLogic entries is shown here.

Figure 4-10: Locking FlexLogic entries through settings templates

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Inputs On	Close HMI On (V11)
FlexLogic Entry 2	Virtual Inputs On	Close SCADA On (V12)
FlexLogic Entry 3	Contact Inputs On	Manual Close On(H5A)
FlexLogic Entry 4	OR	3 Input
FlexLogic Entry 5	Assign Virtual Output	= Close 52-1 (VO1)
FlexLogic Entry 6	Contact Inputs On	52-1 Closed On(H5C)
FlexLogic Entry 7	Contact Inputs On	52-1 Rack In On(H6A)
FlexLogic Entry 8	AND	2 Input
FlexLogic Entry 9	Protection Element	PHASE IOC1 OP
FlexLogic Entry 10	Protection Element	PHASE TOC1 OP
FlexLogic Entry 11	Protection Element	GROUND IOC1 OP
FlexLogic Entry 12	Protection Element	NEUTRAL IOC1 OP
FlexLogic Entry 13	OR	4 Input
FlexLogic Entry 14	AND	2 Input
FlexLogic Entry 15	Assign Virtual Output	= Trip 52-1 (VO2)
FlexLogic Entry 16	Protection Element	ANY MAJOR ERROR
FlexLogic Entry 17	POSITIVE ONE SHOT	1 Input

Typical FlexLogic™ entries without template applied.

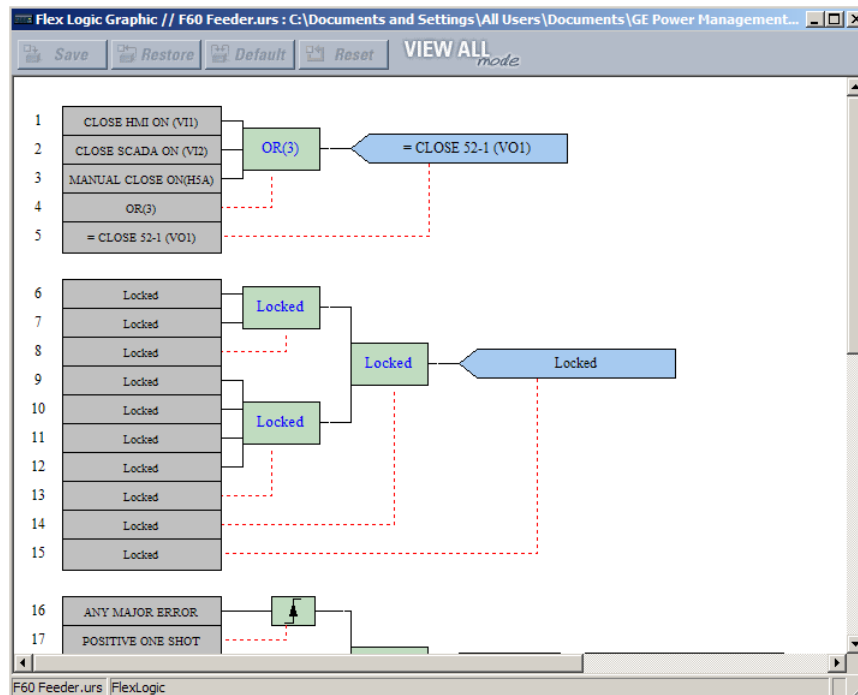
FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Inputs On	Close HMI On (V11)
FlexLogic Entry 2	Virtual Inputs On	Close SCADA On (V12)
FlexLogic Entry 3	Contact Inputs On	Manual Close On(H5a)
FlexLogic Entry 4	OR	3 Input
FlexLogic Entry 5	Assign Virtual Output	= Close 52-1 (VO1)
FlexLogic Entry 6	Locked	Locked
FlexLogic Entry 7	Locked	Locked
FlexLogic Entry 8	Locked	Locked
FlexLogic Entry 9	Locked	Locked
FlexLogic Entry 10	Locked	Locked
FlexLogic Entry 11	Locked	Locked
FlexLogic Entry 12	Locked	Locked
FlexLogic Entry 13	Locked	Locked
FlexLogic Entry 14	Locked	Locked
FlexLogic Entry 15	Locked	Locked
FlexLogic Entry 16	Protection Element	ANY MAJOR ERROR
FlexLogic Entry 17	POSITIVE ONE SHOT	1 Input
FlexLogic Entry 18	Protection Element	ANY MAJOR ERROR

Typical FlexLogic™ entries locked with template via the **Template Mode > View In Template Mode** command.

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The FlexLogic entries are also shown as locked in the graphical view and on the front panel display.

Figure 4-11: Secured FlexLogic in graphical view



4.1.8.2 Lock FlexLogic equations to the serial number

A settings file and associated FlexLogic equations also can be locked to a UR serial number. Once FlexLogic entries in a settings file have been secured, use the following procedure to lock the settings file to a serial number. A serial number is viewable under **Actual Values > Product Info > Model Information**, the inside front panel, and the rear of the device.

1. Right-click the setting file in the Offline Window area and select the **Edit Device Properties** item. The window opens.

Figure 4-12: Settings file properties window

Edit Device Properties

Device Name: B30_test_v7.3_T

Path: B30_test_v7.3_T.urs : D:\Users\420001756\Desktop\UI

Relay Name: Relay-1

Order Code: B30-TD4-HLH-F8N-H6L-L8N-N6L-S8L-U6L-WXX-___

Version: 7.3x

Description:

Serial # Lock:

Associate Device with Relay: No Device(s) found

Ok Cancel

2. Enter the serial number of the L30 device to lock to the settings file in the **Serial # Lock** field.
3. Click the **OK** button to apply the change. The serial number is not validated.

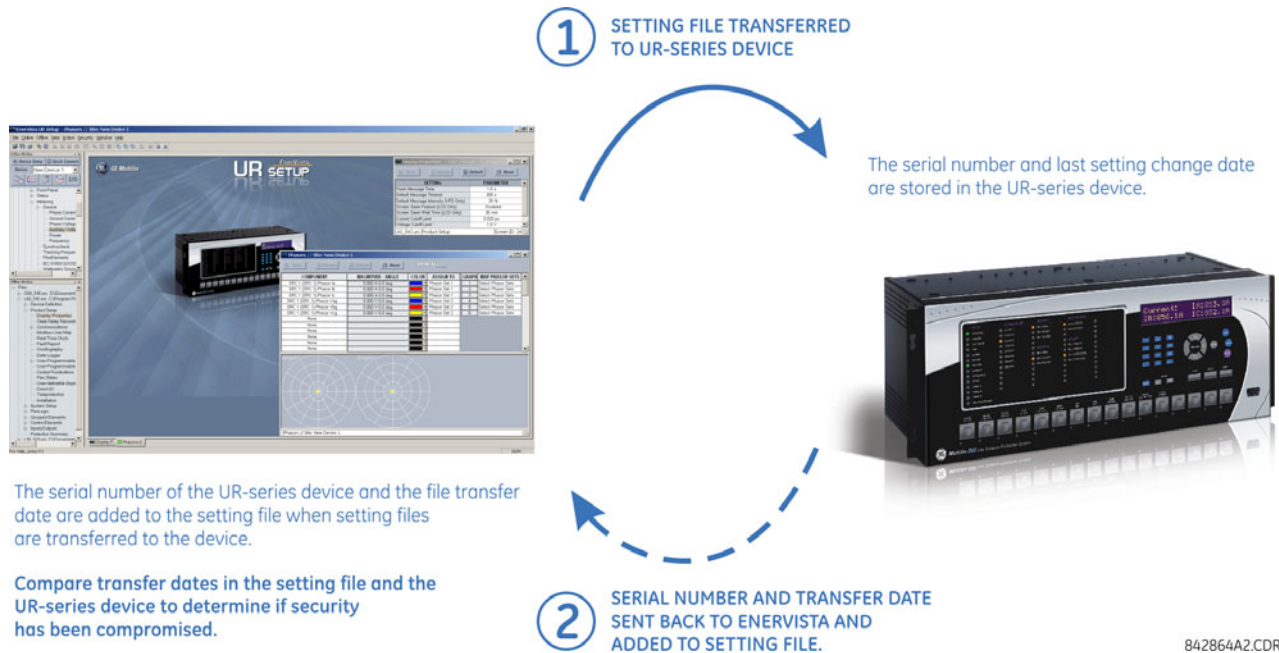
The settings file and corresponding secure FlexLogic equations are now locked to the L30 device specified by the serial number.

4.1.9 Settings file traceability

A traceability feature for settings files allows the user to quickly determine if the settings in a L30 device have been changed since the time of installation from a settings file. When a settings file is transferred to a L30 device, the date, time, and serial number of the L30 are sent back to EnerVista UR Setup and added to the settings file on the local computer. This information can be compared with the L30 actual values at any later date to determine if security has been compromised.

The traceability information is only included in the settings file if a complete settings file is either transferred to the L30 device or obtained from the L30 device. Any partial settings transfers by way of drag and drop do not add the traceability information to the settings file.

Figure 4-13: Settings file traceability



With respect to the figure, the traceability feature is used as follows.

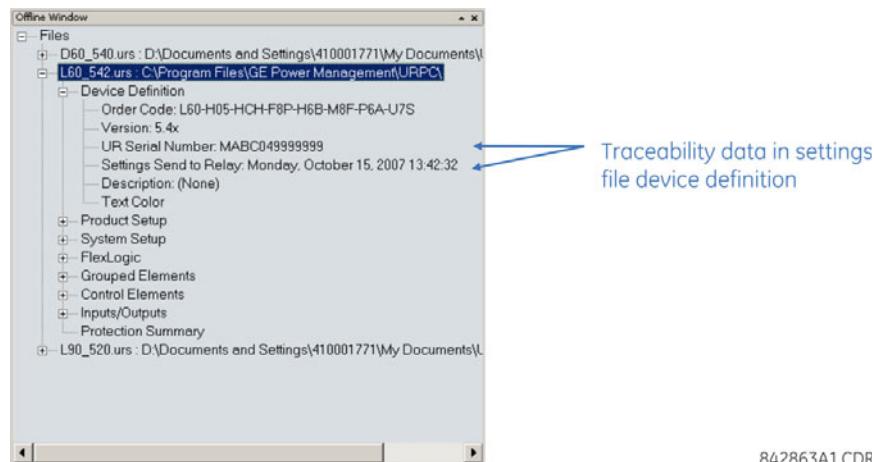
- The transfer date of a settings file written to a L30 is logged in the relay and can be viewed in the EnerVista software or the front panel display. Likewise, the transfer date of a settings file saved to a local computer is logged in the EnerVista software.
- Comparing the dates stored in the relay and on the settings file at any time in the future indicates if any changes have been made to the relay configuration since the settings file was saved.

4.1.9.1 Settings file traceability information

The serial number and file transfer date are saved in the settings files when they are sent to a L30 device.

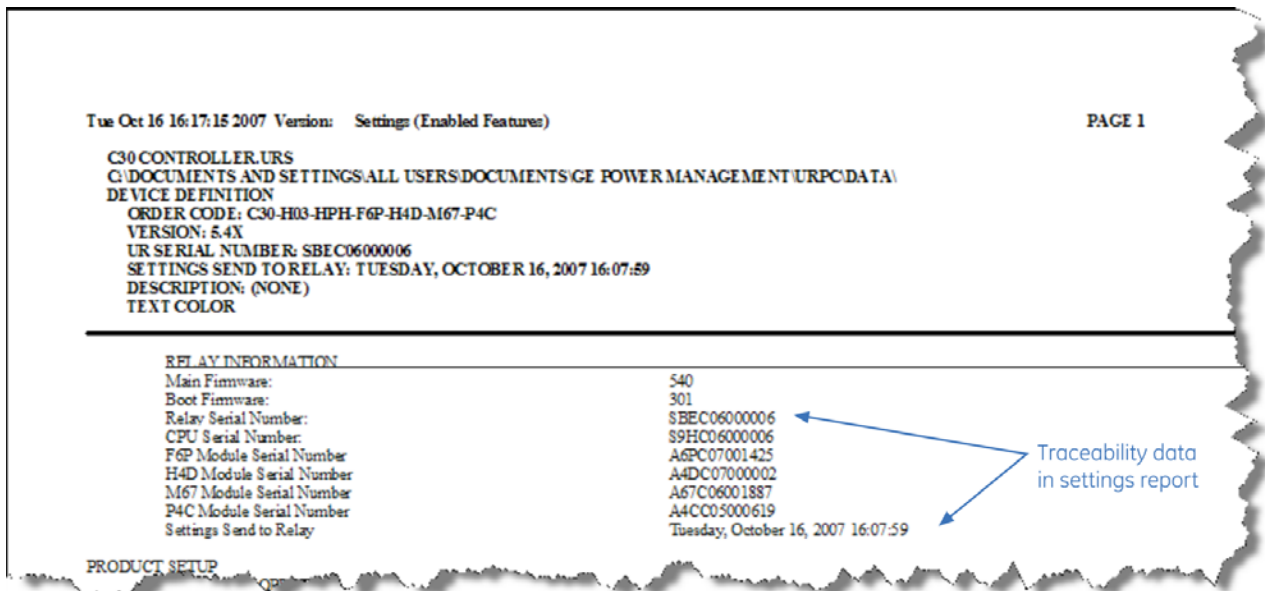
The L30 serial number and file transfer date are included in the settings file device definition within the EnerVista UR Setup offline window as shown in the example.

Figure 4-14: Device definition showing traceability data



This information is also available in printed settings file reports as shown in the example. A report is generated by right-clicking and selecting the **Print Settings** option.

Figure 4-15: Settings file report showing traceability data

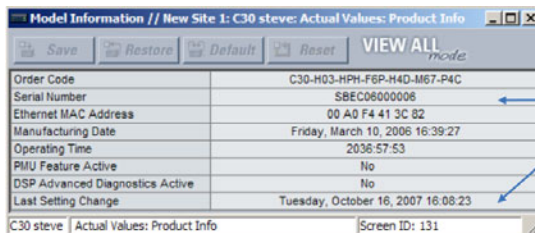


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4.1.9.2 Online device traceability information

The L30 serial number and file transfer date are available for an online device through the actual values. Select the **Actual Values > Product Info > Model Information** menu item within the EnerVista online window as shown in the example.

Figure 4-16: Traceability data in Actual Values window



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This information is also available from the front panel display through the following actual values:

ACTUAL VALUES ⇌ PRODUCT INFO ⇌ MODEL INFORMATION ⇌ SERIAL NUMBER

ACTUAL VALUES ⇌ PRODUCT INFO ⇌ MODEL INFORMATION ⇌ LAST SETTING CHANGE

4.1.9.3 Additional traceability rules

The following additional rules apply for the traceability feature:

- If the user changes any settings within the settings file in the offline window, then the traceability information is removed from the settings file
- If the user creates a new settings file, then no traceability information is included in the settings file
- If the user converts an existing settings file to another revision, then any existing traceability information is removed from the settings file
- If the user duplicates an existing settings file, then any traceability information is transferred to the duplicate settings file

4.2 Front panel interface

This section explains use of the enhanced, standard, and graphical front panels.

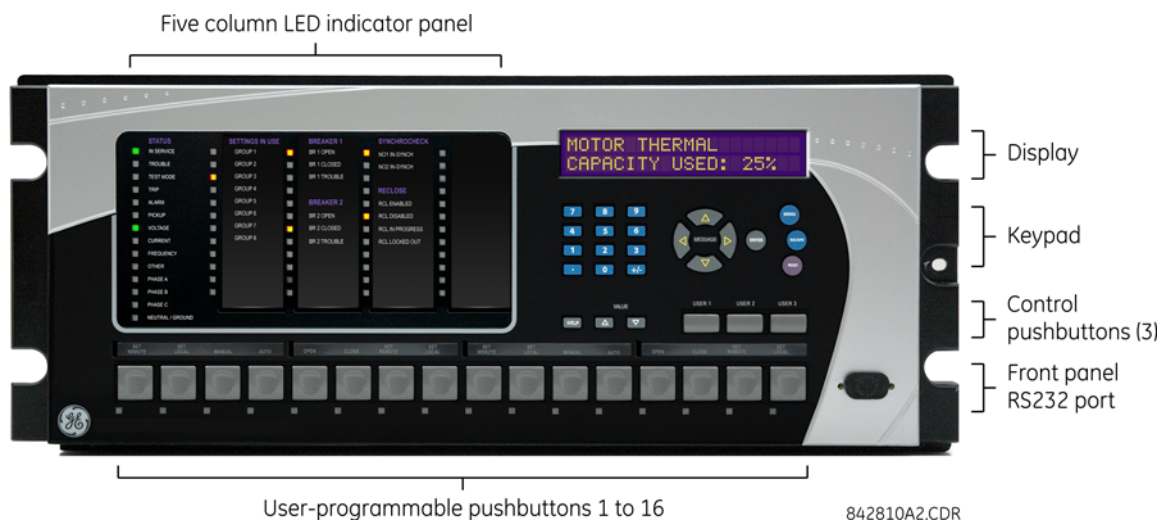
4.2.1 Front panel

4.2.1.1 Enhanced front panel

The enhanced front panel consists of LED panels, an RS232 port, keypad, LCD display, control pushbuttons, and optional user-programmable pushbuttons.

The front panel is hinged to allow access to removable modules inside the chassis. The L30 enhanced front panel can be horizontal or vertical. The following figure shows the horizontal front panel.

Figure 4-17: Enhanced horizontal front panel

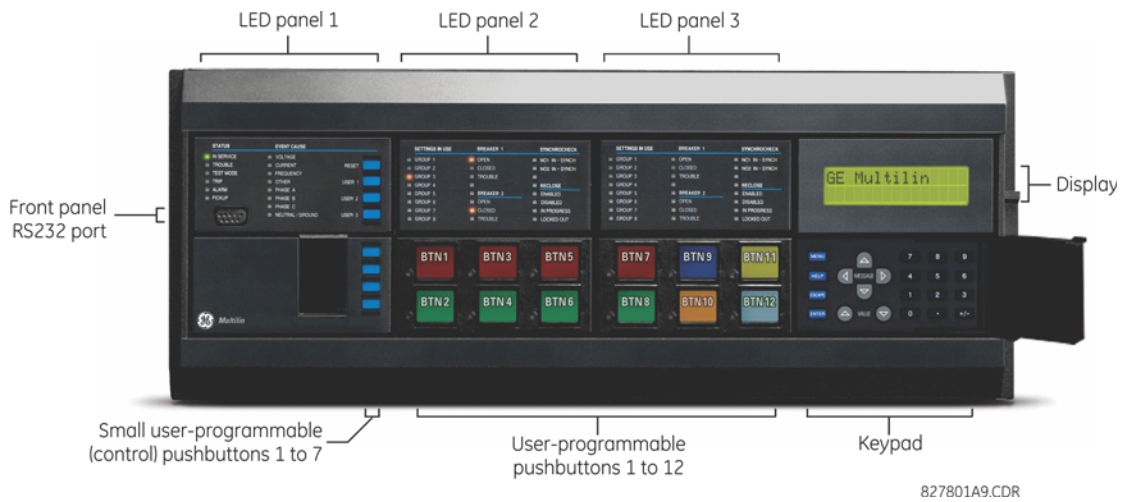


4.2.1.2 Standard front panel

The standard front panel consists of LED panels, an RS232 port, keypad, LCD display, control pushbuttons, and optional user-programmable pushbuttons.

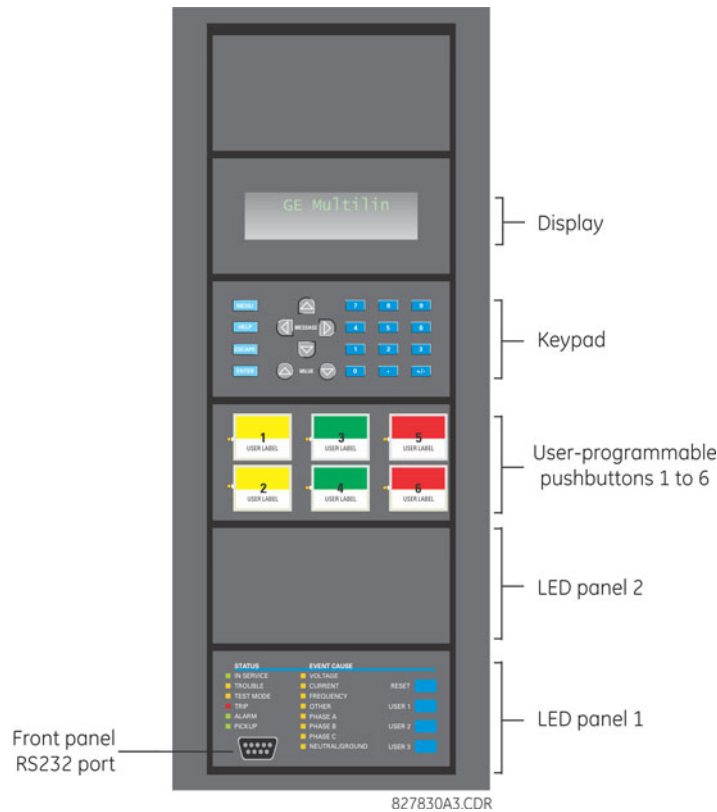
The front panel is hinged to allow easy access to removable modules inside the chassis. There is also a removable dust cover that is to be removed when accessing the keypad. The L30 standard front panel can be horizontal or vertical. The following figure shows the horizontal front panel.

Figure 4-18: Standard horizontal front panel



The following figure shows the vertical front panel for relays ordered with the vertical option.

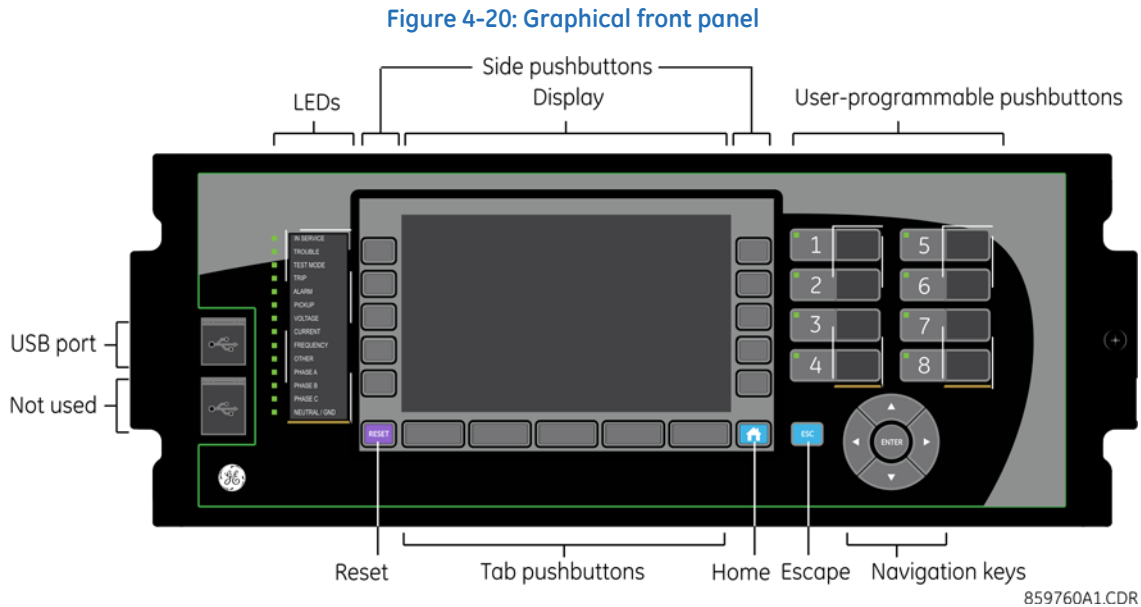
Figure 4-19: Standard vertical front panel



4.2.1.3 Graphical front panel

The graphical front panel consists of a USB port, LED panel, color screen display, user-programmable pushbuttons, and navigation keys. The screen is used to read data, such as metering actual values, alarms, self-test messages, and event records, and for viewing single-line diagrams. Settings can be changed on the front panel, except for the graphical front panel itself and for IEC 61850. The USB port connects to a computer with the EnerVista software and can be used to upgrade the relay and to transfer files and settings. The USB port is the square type B.

User-programmable pushbuttons 9 to 16 can be programmed among the 10 pushbuttons on the left and right sides of the display.



4.2.2 Front panel display

4.2.2.1 Enhanced and standard front panels

Messages display on a backlit liquid crystal display (LCD) to make them visible under poor lighting conditions. When the keypad and display are not actively being used, the display defaults to user-defined messages. Any high-priority event-driven message overrides the default messages.

Up to 20 characters can be used to configure some setting names in the software, while up to 12 characters display on the front panel. A tilde ~ symbol is used for the twelfth character on the front panel when a name extends beyond the 12 character limit. An example is shown for a Virtual Input.

Figure 4-21: Tilde symbols displays with names 12 or more characters long

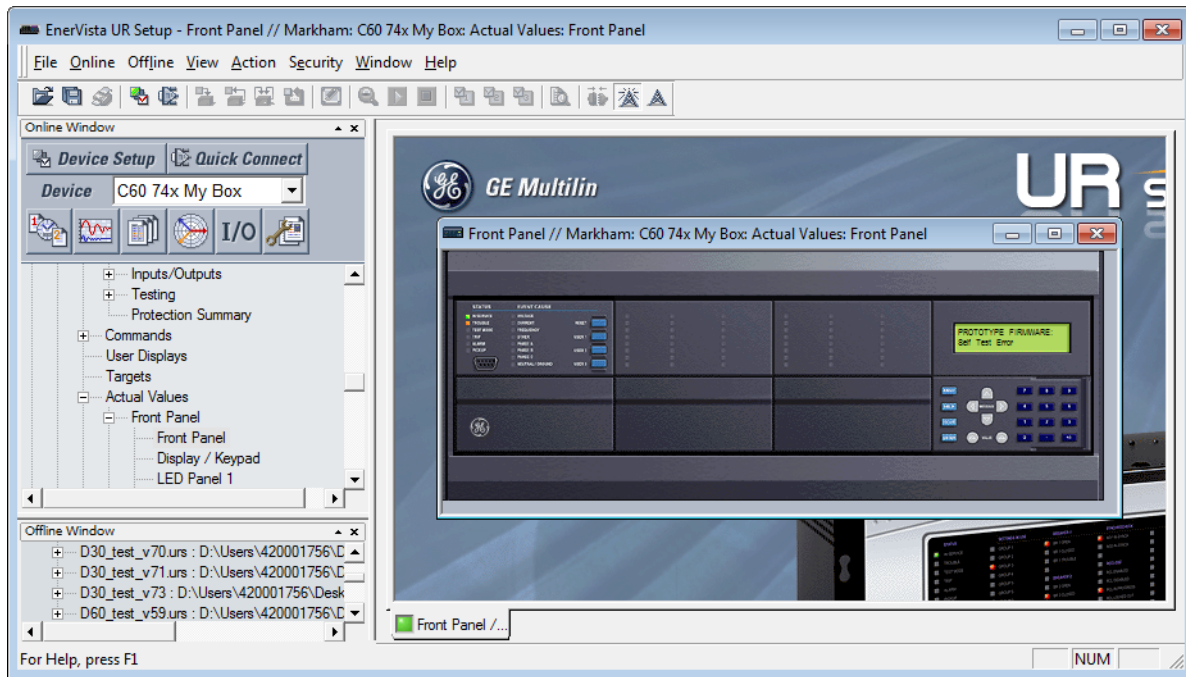


The front panel can be viewed and used in the EnerVista software, for example to view an error message displayed on the front panel or the LEDs.

To view the front panel in EnerVista software:

1. Click **Actual Values > Front Panel**, then any option.

Figure 4-22: Front panel use in the software (C60 shown)



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4.2.2.2 Graphical front panel

The graphical front panel has a seven-inch (17.8 cm) color liquid crystal display (LCD). The display provides convenient access to operational data generated by the relay, enables local control of power system devices, and allows display/editing of settings.

Header content varies by page. The home page displays any active icons, such as security status, active setting group, and active target messages. It shows the date and time of the relay. If the relay synchronizes to an external time source via PTP, IRIG-B, SNTP, and so on, the date/time is shown in white, and otherwise in yellow. On pages other than the home page, the header displays the name of the page.

The footer dynamically labels the Tab, or control, pushbuttons immediately below.

Page content displays between the header and footer.

Figure 4-23: Home page example with default content (product information)

Setting Group	Alarm	Target	Relay Date and Time
1			11-May-17 12:39:59
Relay ID:	Relay-1	Remaining Connections	
Last Setting Change:	01-Jan-70 00:00:00	MMS TCP:	5
Order Code:	F60-U03-HEH-F8L-H6H	Modbus TCP:	4
Relay Serial Number:	MBEC159999#9	DNP TCP:	2
Firmware Version:	7.60	IEC-104 TCP:	0
Modbus Slave Address:	254	SFTP:	4
Modbus TCP Port:	502		
	Port 1	Port 2	Port 3
IP Address:	192.168.2.3	10.14.22.7	127.0.0.1
Subnet Mask:	255.255.255.0	255.255.255.0	255.0.0.0
MAC Address:	00A0F4000000	00A0F4000001	00A0F4000002
Link Status:	Fail	OK	Fail
SLDs	Annunciator	Metering	Event Record
			Menu

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There are multiple ways to navigate pages, by using the pushbuttons and the menu hierarchy. The menu hierarchy is similar to the other front panels whereby you select a submenu using Up and Down arrow pushbuttons, and press the **ENTER** or Right pushbutton. On setting pages, opening a setting for editing is done by highlighting the setting using Up and Down pushbuttons, and pressing the **ENTER** or Right pushbutton.

Home page

Press the **Home** pushbutton to display the root page no matter the state. Any edit, control, or password entry sessions are cancelled. The header shows several relay/system status icons. The default content of the home page is the product information page and can be user-configured to show the content of any single-line diagram page, annunciator page, metering page, or event records page for example. The Tab pushbuttons on the bottom row each navigate to their page. The home page displays for a user-configured time period, then scrolls through user-configured pages, a feature referred to as rolling.

Holding the **Home** pushbutton for one second displays the product information page. The Home page also can display when settings are saved.



Security indicator, showing how many people are logged in, including local and remote users. The lock is red when one or more users are logged in and otherwise green. When no users are logged in because login is not required, an icon does not display.



Identifies the active setting group number (not shown)



Displays when an abnormal annunciator alarm is present. Navigate to the Annunciator for details. When there are no such alarms, the icon does not display. Even when you acknowledge/reset an alarm, the icon displays as long as the condition remains. For example, a breaker trouble alarm displays, you acknowledge it, but the icon remains because the breaker trouble remains.



Active targets symbol, where targets are error messages. View error messages by pressing the **Menu** Tab pushbutton, then accessing the **TARGETS** menu. Pressing the **RESET** button clears those messages that can be.

Configure the home page in the software under **Settings > Product Setup > Graphical Panel > Home Page**. The menu does not display when there is no graphical front panel.

Rolling mode

After a user-defined period of inactivity, the graphical front display rolls among up to 10 user-selected pages. The roll-to-pages are selected in the EnerVista software, with the defaults being the product information page. Each page displays for less than five seconds. Also, the display backlight intensity is lowered after a configurable period to a user-defined level (0, 10, 20, or 30%); lower intensity extends the life of the display.

Configure rolling mode in the software under **Settings > Product Setup > Graphical Panel > Rolling Mode**.

Operation works as follows:

- Press the **Home** pushbutton or **ESCAPE** pushbutton twice to cancel rolling, restore full backlight intensity, and return to the Home page
- Press the **ENTER**, **ESCAPE**, or a pushbutton to pause rolling once and restore full backlight intensity

Rolling is disabled by setting the delay to 0.

The following buttons display at the top of the window:

- **Save** — Updates the connected device if online or the open setting file if offline with changes made
- **Restore** — Undoes changes that have not been saved
- **Default** — Changes all rolling mode settings to their factory default values
- **Reset** — Displays factory default values. Previous changes are not lost unless you save the reset window.

4

Single-line diagrams

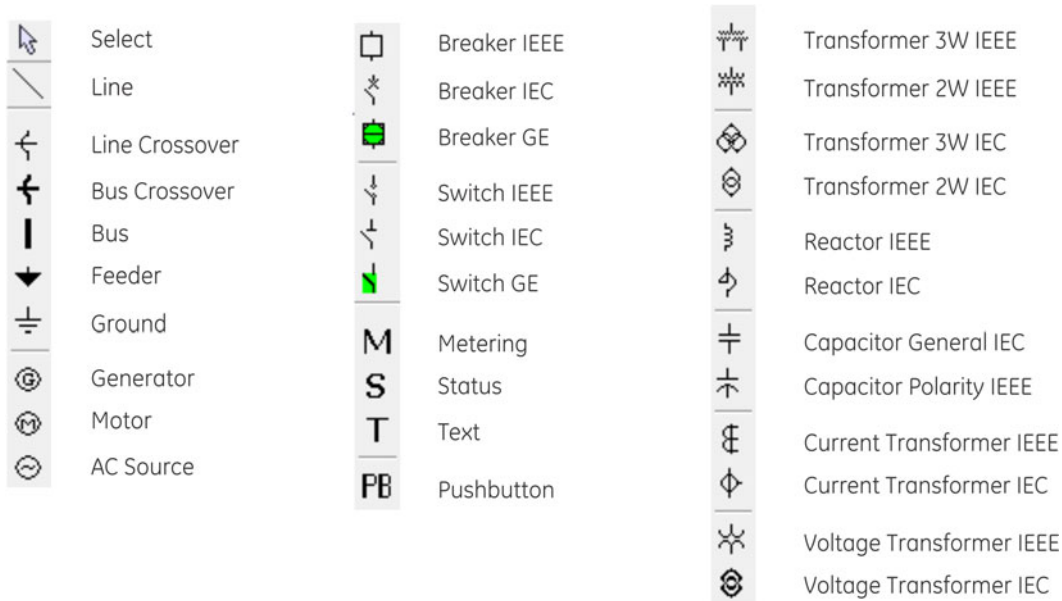
A single-line diagram, or mimic diagram, is a line drawing of elements in an electrical system. The graphical front panel displays up to five single-line diagrams. Each can be configured to show the arrangement of a portion of the power system, the status of circuit breakers and of ground and disconnect switches, user-programmable pushbuttons, and metering and status values. Each also enables control of the displayed power system devices.

One diagram is provided by default, single_bus_line_dsc.mif, which can be modified.

Configure the diagrams under **Settings > Product Setup > Graphical Panel > Single Line Diagram Editor**.

Each single-line diagram page has a user-configurable name that appears in the header and in the footer Tab pushbutton label. Factory default names are SLD 1 to SLD 5. Pages that have no configured content have a blank Tab pushbutton label, and the Tab pushbutton does nothing. The label for the current page has a blue background.

Figure 4-24: Toolbar options for single-line diagram



859875A1.cdr

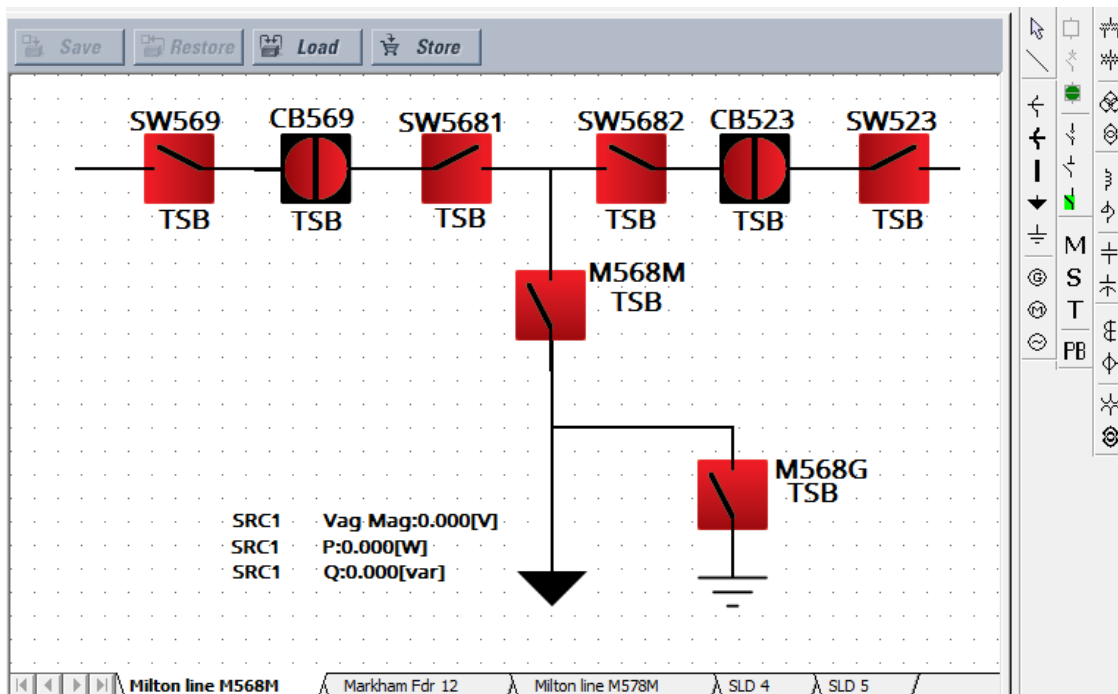
The letters T, S, B, R, and X next to a controllable element have the following meaning. An example (TSB) is shown in the next figure.

- T — The element is "tagged." Local and remote control of the device are inhibited, both open and close. Tripping is unaffected unless additional logic has been configured.
- S — The position indication of the device is substituted with a manually entered value
- B — Blocking open/close command is bypassed
- R — Autoreclose is enabled and not blocked
- X — The device is out-of-service and control is not available

Single-line diagram example

The following example outlines how to create a circuit breaker diagram, then how to close the second circuit breaker. The figure shows six switches (SW, M), two breakers (CB), feeder (arrow), and ground (lined arrow).

Figure 4-25: Single-line diagram of open circuit breakers



Under **Settings > System Setup > Switches and Breakers**, enable and name the six switches and two breakers. Switch 6, M568G, has the A/3 Pole Opened setting on.

Figure 4-26: Configure Breaker and Switch settings

SETTING	PARAMETER
Switch 1 Function	Enabled
Switch 1 Name	SW569
Switch 1 Mode	3-Pole
Switch 1 Open	OFF
Switch 1 Block Open	OFF
Switch 1 Close	OFF
Switch 1 Block Close	OFF
Switch 1 Phase A/3 Pole Closed	ON
Switch 1 Phase A/3 Pole Opened	OFF
Switch 1 Phase B Closed	OFF

SETTING	PARAMETER
Switch 6 Function	Enabled
Switch 6 Name	M568G
Switch 6 Mode	3-Pole
Switch 6 Open	OFF
Switch 6 Block Open	OFF
Switch 6 Close	OFF
Switch 6 Block Close	OFF
Switch 6 Phase A/3 Pole Closed	OFF
Switch 6 Phase A/3 Pole Opened	ON
Switch 6 Phase B Closed	OFF
Switch 6 Phase B Opened	OFF

SETTING	PARAMETER
Breaker 1 Function	Enabled
Breaker 1 Push Button Control	Enabled
Breaker 1 Tagging	Enabled
Breaker 1 Substitution	Enabled
Breaker 1 Bypass	Enabled
Breaker 1 AR Block	Enabled
Breaker 1 Name	CB569
Breaker 1 Mode	3-Pole
Breaker 1 Open	OFF
Breaker 1 Block Open	OFF
Breaker 1 Close	OFF
Breaker 1 Block Close	OFF
Breaker 1 Phase A/3-Pole Closed	ON
Breaker 1 Phase A/3-Pole Opened	OFF
Breaker 1 Phase B Closed	OFF

4

In the EnerVista software, open the single-line diagram editor under **Settings > Product Setup > Graphical Panel > Single Line Diagram Editor**.

Add the four switches for the top line by clicking the GE switch symbol in the toolbar, then clicking in the window. (If the UR device is not online, the software attempts to connect.) Right-click to edit properties. Rotate switches SW569 and SW5682 to 270 degrees. Rotate switches 5681 and SW523 to 90 degrees. Ignore the TSB text.

Add the two lower switches. Leave rotation at 0 degrees.

Add the two breakers by clicking the GE breaker symbol in the toolbar, then click in the window. Right-click to edit properties, rotating 90 degrees and setting the color to red (open).

Draw lines to fill in the gaps between the switches and breakers by clicking the line symbol in the toolbar, then clicking and dragging on the canvas to draw a line. Do not draw a single line for the top line, but instead draw several small lines.

Add the feeder arrow head by clicking the symbol in the toolbar, then clicking the end of the line.

Add the ground symbol by clicking the symbol in the toolbar, then clicking the end of the line.

Add three metered values by clicking the M symbol in the toolbar, then clicking near the feeder arrow. Double-click to edit. The three metered values are SRC1 Vag Mag, SRC 1 P, and SRC 1 Q.

Name the page by right-clicking the bottom tab. Here, page 1 is renamed "Milton line M568M."

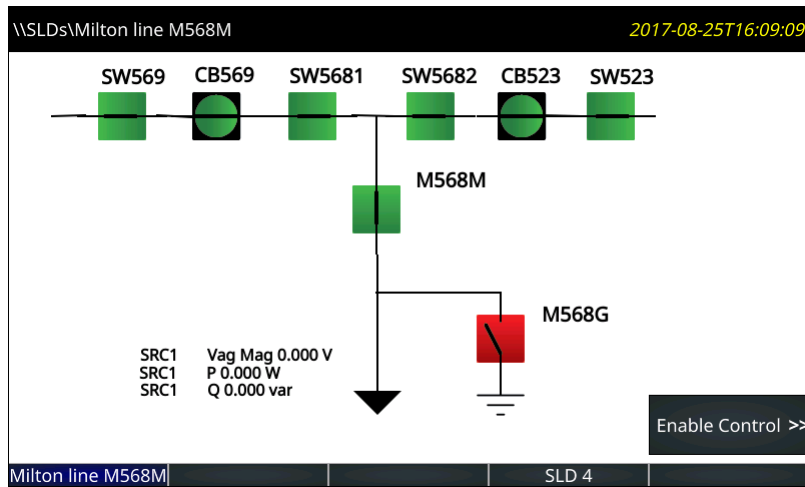
Note that active symbols in the toolbar display and those that are inactive are greyed-out.

The diagram has been created. Save it by clicking the **Save** button.

Next is to close circuit breaker CB523. This circuit breaker is shown at the top right of the figure. A vertical line means that it is open, and the color can be set as red or green.

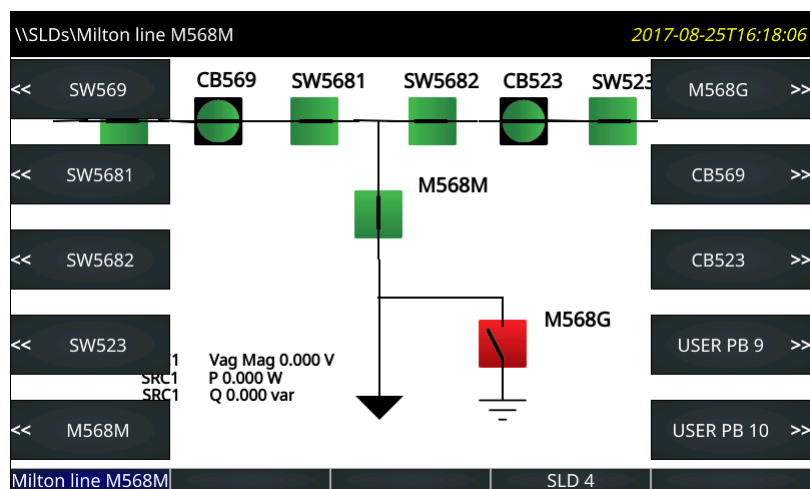
On the graphical front panel, press the **Home** pushbutton, then press the **SLDs** pushbutton to activate the first single-line diagram page.

Figure 4-27: Single-line diagram on graphical front panel



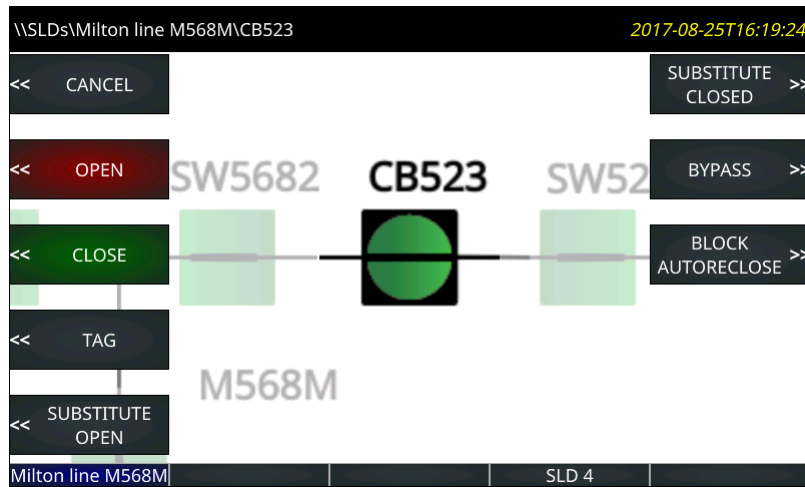
Press the **Enable Control** pushbutton. The side pushbutton labels display.

Figure 4-28: Side pushbutton display on graphical front panel



Press the **CB523** breaker pushbutton. Its menu displays.

Figure 4-29: Pushbuttons to control the breaker



4

Press the pushbutton to close the breaker, confirming the action at the prompt.

In this diagram, the two circuit breakers have hard-coded actions available to them. No action is possible on the switches. Note the USER PB 9 and 10 entries in the earlier figure. As outlined later, these are activated by clicking the PB icon on the software toolbar. These two pushbuttons can be configured under **Settings > Product Setup > User-Programmable Pushbuttons**.

Single-line diagram editor use

Start the application in the EnerVista software under **Settings > Product Setup > Graphical Panel > Single Line Diagram Editor**.

The following buttons display at the top of the window:

- **Save** — Updates the connected device if online or the open setting file if offline with changes made
- **Restore** — Undoes changes that have not been saved
- **Load** — Opens single-line diagram files, which replaces one or all five windows with that in the file selected
- **Store** — Saves all five single-line diagrams as a .mif file

On the right side of the window is a toolbox containing the components that can be added to the window. These include line, breaker, disconnect, metering value, status value, text, and miscellaneous power system elements. To create the single-line diagram, click the symbol, then click in the window. Once in the window, the component can be positioned and its properties modified. When using the pointing device to position a component, the component can snap to the nearest snap point. Snap points are in a 4 x 4 rectangular grid. The keyboard arrow keys move the selected component(s) in one pixel increments when snap locations are inadequate. Multiple components can be selected and moved or deleted as a group, or copied and pasted to another location. Right- or double-clicking a component opens the properties window.

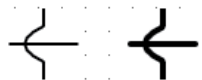
Ctrl+A selects all objects in a diagram.

Lines

Line components represent power system buses or electrical connections between power system elements. They can also be used as visual dividers and underline.

To add a line component, click it in the toolbox, then click in the window. Double-click a line to open its properties window to set orientation.

Figure 4-30: Line and bus crossover symbols



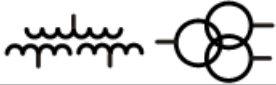
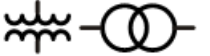

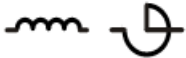


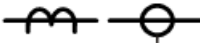
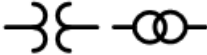
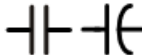
Static symbols

Static symbols depicting power system elements are available. For information, see the ANSI/IEEE 315A and IEC 60617 standards.

Up to 32 static symbols can be used per single-line diagram.

To add a symbol, click it in the toolbox, then click in the window. Double-click the symbol to open its properties window to set orientation.

Figure 4-31: IEEE and IEC static symbols

Device	Symbols
3W Transformer	
2W Transformer	
Rotating machines	
Reactor	
Ground	
Connector, Bus, Feeder, Crossover	
CT	
VT / PT	
Capacitor	

Breaker and disconnect components

Breaker components and disconnect components are interfaces to the UR breaker control elements and disconnect switch elements. On a UR device they show dynamically the breaker or disconnect status as calculated by the element, and provide means to open, close, tag, bypass interlock, and substitute (force status of) the element. Breaker components in addition provide means to enable/disable breaker autoreclose.

Each breaker and disconnect component can be configured to use UR-style symbols, IEC symbols, or simple square/slash symbols as shown in the following figure. The symbols assume horizontal symbol orientation, red - closed color, and green - open scheme. With vertical orientation, they are rotated 90 degrees.

Figure 4-32: Single-line diagram symbols

	IEEE style (IEEE 315)	IEC Style (IEC 60617)	GE Style
Disconnect Switch (Open)			(1)
Disconnect Switch (Intermediate)			
Disconnect Switch (Closed)			(1)
Disconnect Switch (Bad Status/Disabled)			
Breaker (Open)			(1)
Breaker (Closed)			(1)
Breaker (Bad Status/Disabled)			
Breaker racked-out (Open)			(1)
Breaker racked-out (Closed)			(1)
Breaker racked-out (Bad Status)			
Breaker racked-in (Open)			(1)
Breaker racked-in (Closed)			(1)
Breaker racked-in (Bad Status)			

(1) Red/Green color scheme for closed/open is configurable by the user.

(2) 3-position disconnect switches can be represented by grouping two 2-position disconnects switches.

To add a breaker or disconnect component, click it in the toolbox, then click in the window. Up to 10 dynamic components can be added to each single-line diagram.

Breaker and disconnect components have three different parts: label, symbol, and flags. Drag each of its parts to their final locations. Double or right-click any of these parts to open the properties window. Properties that can be edited are label text, breaker control element or disconnect switch element number, symbol orientation (horizontal or vertical), color scheme (red - closed, or red - open), and assigned side button (if any). If the selected breaker or disconnect element does

not exist in the target relay or has not been enabled, then the component is displayed in the graphical front panel and in the drawing edit window in grey. The color scheme selection has no effect when an IEC style symbol is used because IEC style symbols do not use color.

Symbol orientation

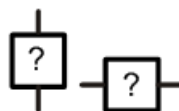
The figure shows the orientation available for the breaker and disconnect switch (taking Open status as examples). The default position is 0 degrees.

Figure 4-33: Single-line diagram symbol orientation

		0 degree	90 degrees	180 degrees	270 degrees
IEEE Style	Disconnect Switch (Open)				
	Breaker (Open)				
IEC Style	Disconnect Switch (Open)				
	Breaker (Open)				
GE Style	Disconnect Switch (Open)				
	Breaker (Open)				

A question mark displays in a symbol on the graphical front panel when status is bad. The question mark does not rotate with orientation.

Figure 4-34: Symbols when status is bad



The following figures show the orientation available for the static components. The default position is 0 degrees.

Figure 4-35: Single-line diagram static symbol orientation (sheet 1 of 2)

	0 degree	90 degrees	180 degrees	270 degrees
3W Transformer				
2W Transformer			0 degree	90 degrees
3W Transformer				
2W Transformer			0 degree	90 degrees
Rotating machines		0 degree	0 degree	0 degree
Reactor			0 degree	90 degrees
Reactor				
Capacitor				
Capacitor			0 degree	90 degrees

4

Figure 4-36: Single-line diagram static symbol orientation (sheet 2 of 2)

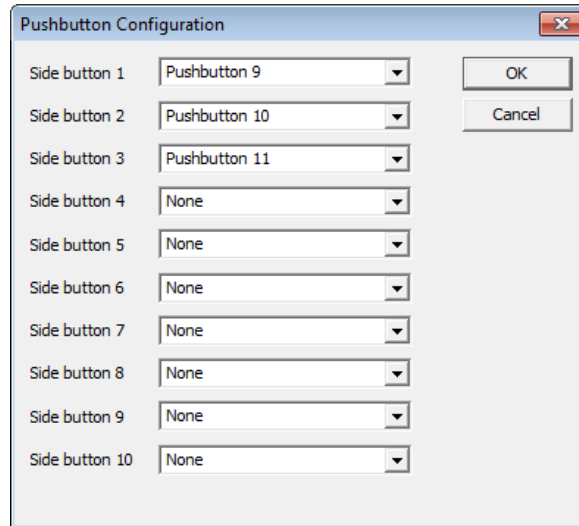
	0 degree	90 degrees	180 degrees	270 degrees
Ground				
Connector			0 degree	90 degrees
Bus			0 degree	90 degrees
Feeder				
Crossover			0 degree	90 degrees
CT				
CT				
VT / PT			0 degree	90 degrees
VT / PT			0 degree	90 degrees

User-programmable pushbuttons

User-programmable pushbuttons 1 to 8 are physical pushbuttons on the right side of the graphical front panel, numbering down the two columns.

User-programmable pushbuttons 9 to 16 can be programmed among the 10 pushbuttons on the left and right sides of the screen display. They show dynamically and provide a means to perform the same control as the other pushbuttons.

Figure 4-37: Assigning pushbuttons 9 to 16 to the display



4

As an example, if you set up a single-line diagram with two breakers and six switches, then eight of the side pushbuttons are used automatically for control of the breakers and switches. Side pushbuttons 9 and 10 are available. In the single-line diagram, let us set side pushbutton 9 to clear event records as follows:

- Show side pushbutton 9 on the graphical front panel — Click the PB symbol in the toolbar, then set **Side button 9** to pushbutton 9 in the drop-down list. This pushbutton then displays when appropriate on the right side of the screen display.
- Program event record clearing — Set **Settings > Product Setup > Clear Relay Records > Clear Event Records** to FlexLogic operand [PUSHBUTTON 9 ON](#)
- Program pushbutton 9 — Set **Settings > Product Setup > User-Programmable Pushbuttons > Pushbutton 9 Function** to "Self-reset." When pressed, pushbutton 9 clears the event records.

To instead set the second user pushbutton (not a side pushbutton) to clear events, follow the second and third bullet points, selecting settings of [PUSHBUTTON 2 ON](#) and Pushbutton 2.

Metering components

Metering components show dynamically the value of a FlexAnalog operand or actual value. Up to 16 metering components can be added to each single-line diagram.

To add a metering component, click the M symbol in the toolbox, then click in the window. Drag it to its final location. Double-click it to open the properties window. The figure shows the properties that can be edited.

Figure 4-38: Metering properties

Status components

Status components show dynamically the value of a FlexLogic operand. Up to 16 can be used in a diagram and 30 in all single-line diagrams.

An example is to show the Off or On state of the **ANY MAJOR ERROR** FlexLogic operand. The name of the operand displays in the single-line diagram editor, then as Off or On on the graphical front panel.

To add a status component, click the S symbol in the toolbox, then click in the window. Drag it to its final location. Double-click it to open the properties window. Properties that can be edited include parameter (any FlexLogic operand), text color background color, and on and off text.

Optionally add a text label to display beside the status.

Text

Text components show a single line of user-configured text.

Up to 16 text components can be used per single-line diagram.

To add a text component, click the T symbol in the toolbox, then click in the window. Drag it to its final location. Double-click it to open the properties window. Properties that can be edited are text, color, and size.

Annunciator

An annunciator is a grid of small windows for alarms, actual values, self-test messages, and product information.

The graphical front panel emulates a conventional annunciator panel. The annunciator has 96 windows, each with a description of the alarm condition that lights the window. The windows are arranged in rows and columns of 3 x 4, 4 x 6, or 6 x 8 over several pages. Each window can have up to three lines of configurable text, and one line can instead be a metered value. Normally the window background is dark, and when the configured FlexLogic operand becomes On, the window lights up.

The figure shows that two alarms are active. One alarm is configured red and the other alarm is configured blue. The red alarm type is Self Reset, so the alarm displays in a solid color. The blue alarm type is Acknowledgeable, so the alarm flashes until it is acknowledged, for example by navigating with the arrow keys and pressing the **ENTER** button. The alarm then remains blue until the trigger condition is eliminated.

Figure 4-39: 3x4 annunciator page with two active windows

\\Annunciator\Fdr 12 Alarms			23-Jun-17 12:35:08 PM	
Breaker 1 Failure	Breaker 2 Failure	Autoreclos Lockout	Fuse Failure	
Setting Group 2 Active	Breaker 1 Arc Phs A 0.000 kA2-cyc	Breaker 1 Arc Phs B 0.000 kA2-cyc	Breaker 1 Arc Phs C 0.000 kA2-cyc	
Fault Report	Breaker 1 Flashover	Breaker 2 Flashover		
M568M Alarms		Fdr 12 Alarms	Station Alarms	Misc Alarms
				Next

4

To display the annunciator, press the **Home** pushbutton, then the **Annunciator** Tab pushbutton. If there is one or more window in alarm or requiring reset, the annunciator page showing the first of these opens. Otherwise the first annunciator page opens.

Alarms do not display automatically. Set the Home page and/or rolling pages to display annunciator pages.

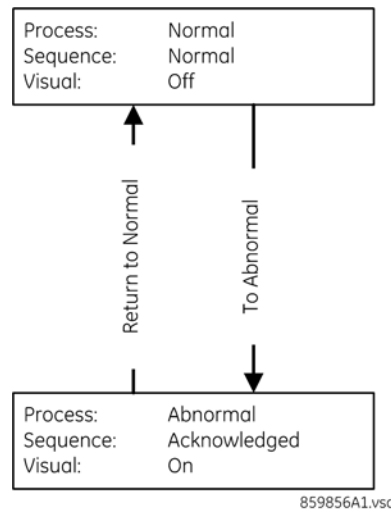
The Tab pushbutton labels populate with the annunciator pages. The label text for each annunciator page is configurable and displays in the header and Tab label. The current page has a blue Tab label. Tab labels for annunciator pages that have an active window (that is, on, latched, or unacknowledged) are red. Pages where alarms are not triggered have a grey Tab label. Pages that have no configured windows do not have Tab pushbuttons and do not display.

The Up, Down, Left, and Right pushbuttons cause the selection to move one window in the indicated direction. Pressing the Right pushbutton past the last window in a row scrolls the display to any next annunciator page, not the next row. The behavior is similar for the other pushbuttons, for example pressing the Up pushbutton while in the top row goes to any previous page. If no previous page exists, no action occurs.

Annunciator windows are positioned statically, so that all windows are visible no matter their state.

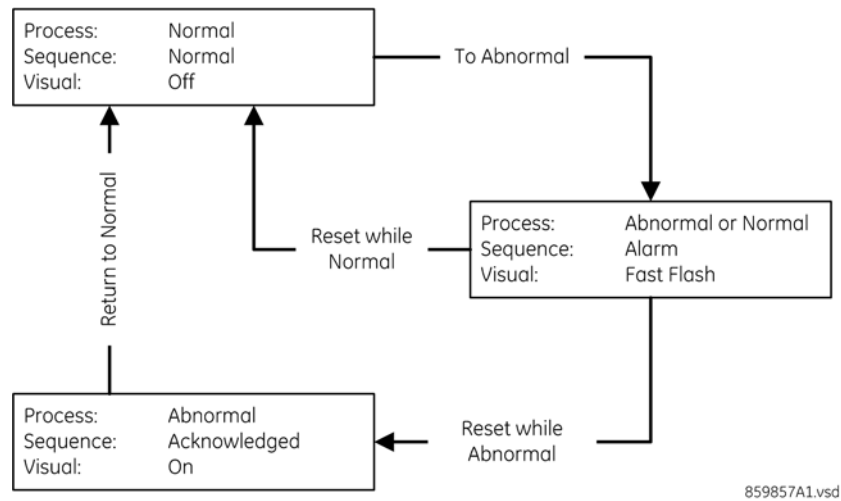
Alarm types of each window can be configured as Self Reset, Latched, or Acknowledgeable. In Self Reset mode, the window lighting follows the state of the configured FlexLogic operand. The self-reset mode alarm sequence conforms to ISA-18.1-1979 (R2004) standard type A 4 5 6.

Figure 4-40: Annunciator alarm sequence in Self Reset mode



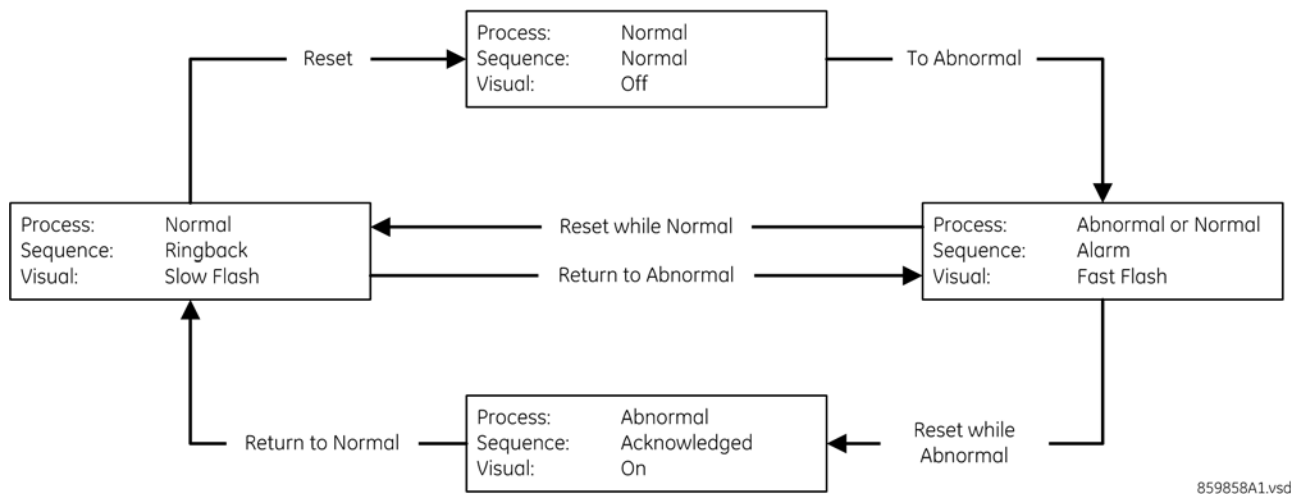
Latched mode is intended for transient signals such as trip, and it conforms to ISA-18.1-1979 (R2004) standard type M 6.

Figure 4-41: Annunciator alarm sequence in Latched mode



In Acknowledgeable mode, both Off to On and On to Off state changes in the configured operand cause the background to flash; the window must be acknowledged/reset to cancel flashing. This mode conforms to ISA-18.1-1979 (R2004) standard type R-6.

Figure 4-42: Annunciator alarm sequence in Acknowledgeable mode



To acknowledge/reset all annunciator windows on a page:

1. On the graphical front panel, press the **RESET** pushbutton with none of the annunciator windows selected. The flashing stops.

To acknowledge/reset a specific annunciator window:

1. On the graphical front panel, press the Up, Down, Left, and Right pushbuttons to select the window, so that it has a yellow outline. Press the **RESET** or **ENTER** pushbutton. While a window is selected, if that window has activated since the last restart, the date/time of the last activation of that window displays in the header.

Or in the software, access **Actual Values > Graphical Panel > Annunciator Panel**.

An alarm remains in an alarm state (for example, displays red) when the condition remains. That is, if you acknowledged a flashing alarm but the alarm condition remains, the background color remains red.

The **SETTINGS > INPUTS/OUTPUTS > RESETTING > RESET ANNUNCIATOR** setting can be used to select a FlexLogic operand that when activated acknowledges/resets all annunciator windows.

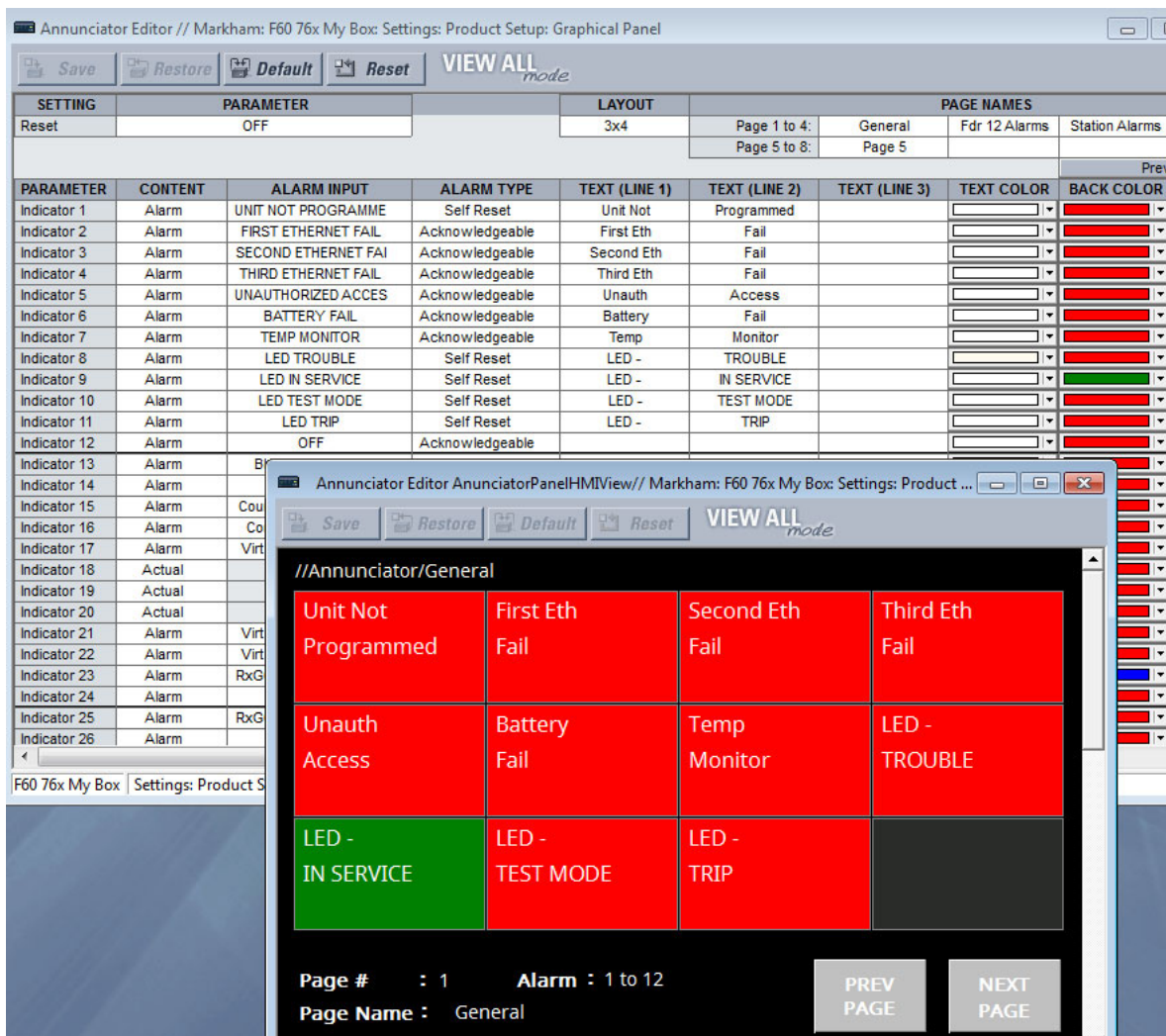
Annunciator editor

The annunciator editor is used to configure alarms and actual value displays for the graphical front panel.

The path in the EnerVista software is **Settings > Product Setup > Graphical Panel > Annunciator Editor**.

The figure shows the annunciator editor and its preview window. The page name is entered as General at the top right. Acknowledgeable and self-resetting alarms are set for basic functions, such as online/offline, Ethernet ports, unauthorized access/failed logins, and battery failure. The text to display in the annunciator window is entered. The IN SERVICE LED is set to be green because when the device is on, this LED is green. The preview shows what the annunciator looks like with all alarms triggered. The last window is not configured and displays blank/grey. In order for the Ethernet and battery alarms to work, the corresponding self-test alarms have been enabled under **Settings > Product Setup > User-Programmable Self Tests** (not shown). The LEDs can be viewed on the front panel, so adding them to the annunciator is for illustrative purposes only.

Figure 4-43: Annunciator editor and preview window



The three page layouts (3 × 4, 4 × 6, and 6 × 8) select the number of rows x columns of windows that appear in a page. Annunciator window size and text size shrink as the number of annunciator windows in a page increases.

Properties that can be edited include alarm type (acknowledgeable, latched, self-reset), alarm input (any FlexLogic operand), text color, and alarm background color.

The following buttons display at the top of the window:

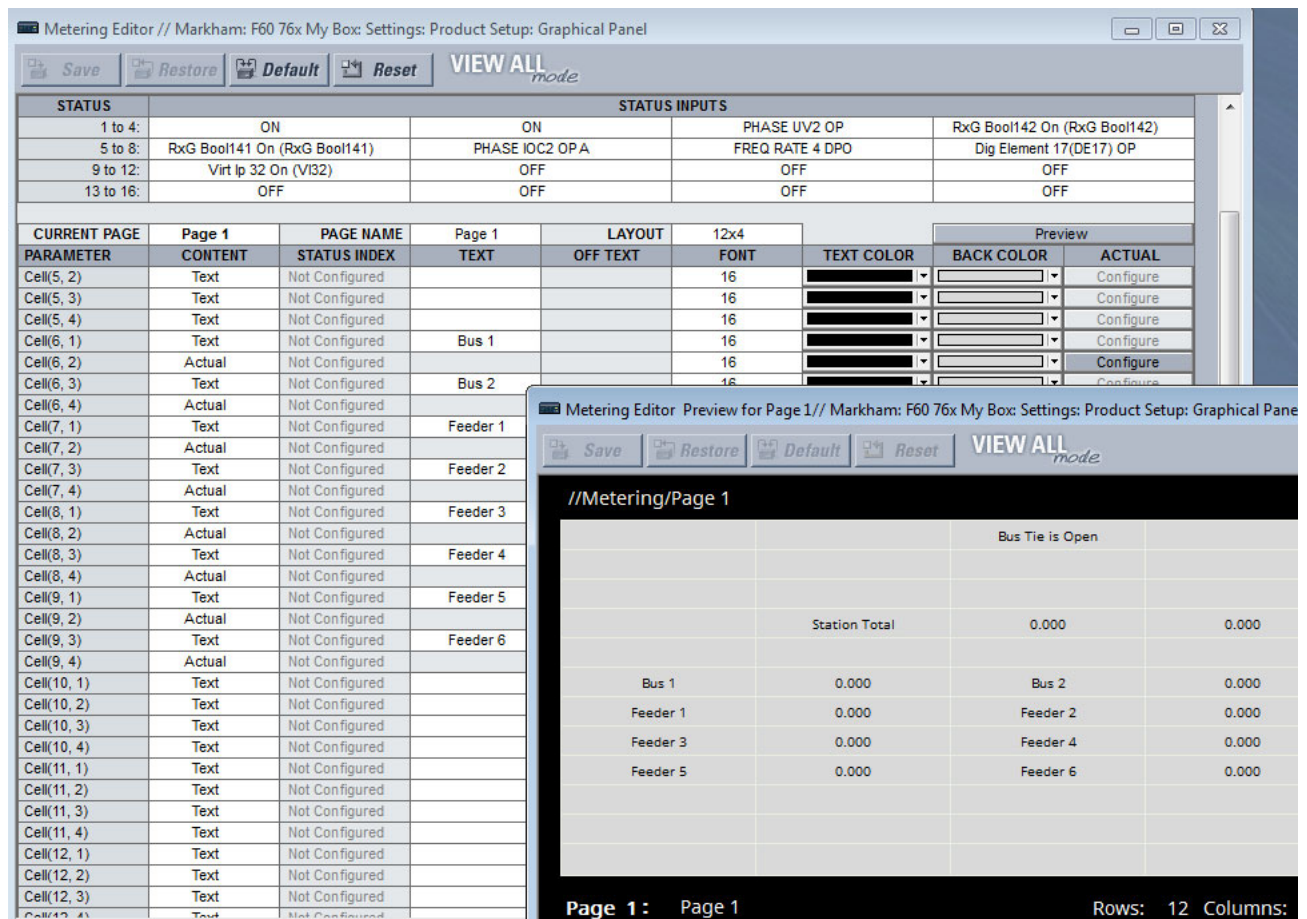
- **Save** — Updates the connected device if online or the open setting file if offline with changes made
- **Restore** — Undoes changes that have not been saved
- **Default** — Changes all annunciator settings to their factory default values
- **Reset** — Displays factory default values. Previous settings are not lost unless you save the reset window.

Metering editor

The metering editor is an actual values display tool. It creates pages of actual values for the graphical front panel. There are two types: tables and phasor diagrams. Tabular actual values pages have settings to configure, while phasor actual values pages have no settings. Five tabular metering pages can be configured, while there can be a phasor page for each configured AC source. They display on the graphical front panel using the **Metering** Tab pushbutton.

The path to the editor is **Settings > Product Setup > Graphical Panel > Metering Editor**.

Figure 4-44: Metering editor with preview window



The inputs are selected at the top. Select from the drop-down list or start typing in the field.

The page, page name, and grid layout are set below the inputs.

Content to display is configured with the cell lines. The content can be actual values, a status indicator, or text.

- **Actual value** — Select from the FlexAnalog applicable to the L30, where a FlexAnalog is an analog parameter

- **Status** — Select from the FlexLogic operands identified in the Status Inputs at the top of the window. An example is to display text to indicate whether the BATTERY FAIL operand is on or off.
- **Text** — Enter text to display in the table, for example name of table or column heading

If the metering input is other than OFF, the value of the selected metering input displays, formatted according to the size, text color, units, multiplier, and decimal configuration. Otherwise either the Text or the Off Text displays depending on the value of the operand selected by setting Status Input/Index.

A maximum of eight Status Inputs/Indexes can be used per metering page and 16 in all metering pages.

The following buttons display at the top of the window:

- **Save** — Updates the connected device if online or the open setting file if offline with changes made
- **Restore** — Undoes changes that have not been saved
- **Default** — Changes all actual value settings to their factory default values
- **Reset** — Displays factory default values. Previous settings are not lost unless you save the reset window.

Configurable navigation editor

Configurable Navigation is a feature that opens specified pages when specific FlexLogic operands are activated. This feature is useful to open the annunciator page containing an annunciator window that has entered its abnormal state.

In the example shown, failure of any of the three Ethernet ports triggers the Product Information page to display. With unauthorized access (such as wrong password), IRIG-B clock failure, or breaker trouble, the Event Records display. When a breaker opens, a single-line diagram displays. For the Ethernet and IRIG-B failure pages to work, these functions also have been enabled under **Settings > Product Setup > User-Programmable Self Tests**. For the breaker trouble, the single-line diagram has been configured.

Figure 4-45: Navigation editor

SETTING	CONDITION	ACTIVATE PAGE
Configurable Navigation Condition 1	FIRST ETHERNET FAIL	Product Information
Configurable Navigation Condition 2	SECOND ETHERNET FAIL	Product Information
Configurable Navigation Condition 3	THIRD ETHERNET FAIL	Product Information
Configurable Navigation Condition 4	UNAUTHORIZED ACCESS	Event Records
Configurable Navigation Condition 5	IRIG-b FAILURE	Event Records
Configurable Navigation Condition 6	BREAKER 1 TROUBLE	Event Records
Configurable Navigation Condition 7	BREAKER 2 TROUBLE	Event Records
Configurable Navigation Condition 8	BREAKER 1 OPEN	SLD 1
Configurable Navigation Condition 9	BREAKER 2 OPEN	SLD 1
Configurable Navigation Condition 10	OFF	Product Information
Configurable Navigation Condition 11	OFF	Product Information
Configurable Navigation Condition 12	OFF	Product Information

The path is **Settings > Product Setup > Graphical Panel > Configurable Navigation**.

The settings consist of 64 field pairs, each with a condition and an activation page. The condition selects any FlexLogic operand. The activation page selection is the standard set, such as product information, event records, annunciator pages, and single-line diagrams.

To use the feature, select a **CONDITION**, select its **ACTIVATE PAGE** option, then save. When selecting the condition operand, open the drop-down list and start typing in the field to auto-fill. For example, typing F displays FIRST ETHERNET FAIL.

The following buttons display at the top of the window:

- **Save** — Updates the connected device if online or the open setting file if offline with changes made
- **Restore** — Undoes changes that have not been saved
- **Default** — Changes all settings in the window to factory default values

- **Reset** — Displays factory default values. Previous settings are not lost unless you save the reset window.

4.2.3 Front panel navigation keys

4.2.3.1 Enhanced and standard front panels

Display messages are organized into pages under the following headings: actual values, settings, commands, and targets. The **MENU** key navigates through these pages. Each heading page is divided further into further submenus.

The **MESSAGE** keys navigate through the submenus. The **VALUE** keys increment or decrement numerical setting values when in programming mode. These keys also scroll through alphanumeric values in the text edit mode. Alternatively, values can be entered with the numeric keypad.

The decimal key initiates and advances to the next character in text edit mode or enters a decimal point.

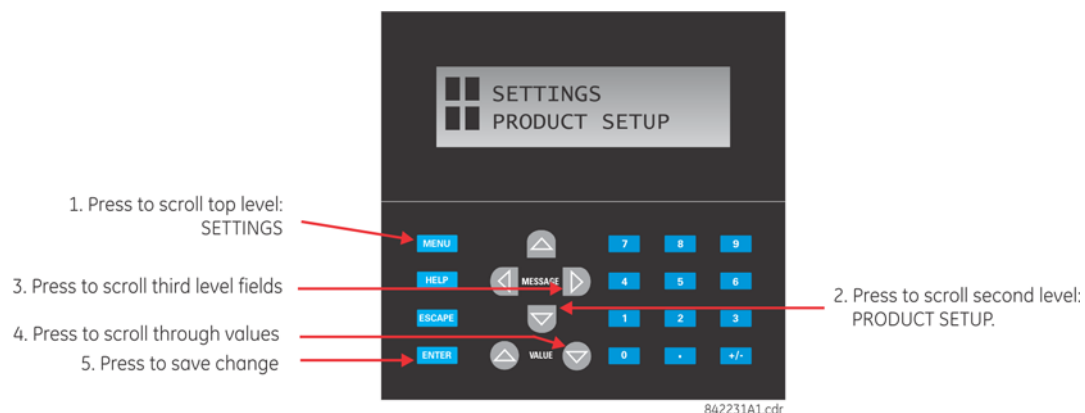
The **HELP** key can be pressed at any time for context-sensitive help messages.

The **ENTER** key stores setting values.

When entering an IP address on the front panel, key in the first sequence of the number, then press the **•** key for the decimal place. For example, for 127.0.0.1, press 127, then **•**, then 0, then **•**, then 0, then **•**, then 0, then **•**, then 1. To save the address, press the **ENTER** key.

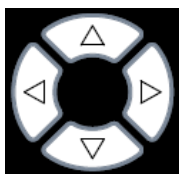
The figure shows the sequence to use to enter a setting. Subsequent sections provide more detail.

Figure 4-46: Front panel keypad use (standard front panel shown)



4.2.3.2 Graphical front panel

These keys and pushbuttons navigate and select items.



Up/Down/Left/Right — These pushbuttons move the selector among the options on a page. The selection is indicated by a yellow background or a yellow border. On menu pages, the Right pushbutton activates the selected submenu drilling down the menu hierarchy, and the Left pushbutton backs up the menu hierarchy. These pushbuttons have a typematic feature on some pages: after a short pause, the pushbutton repeats as long as it is pressed.



ENTER — Activates the selection on the display, for example a submenu, a control, a keypad key, or a setting. Also stores updated settings.



ESCAPE — If a setting is open for edit, this pushbutton closes the setting without saving. If a popup menu is open, this pushbutton closes it. If an item is selected, this pushbutton deselects it. Otherwise this pushbutton activates the previous page in the page hierarchy.



RESET — Clears all latched LED indications and target messages. When a page with acknowledgeable/resettable items is displayed, it instead resets/acknowledges all items on that page, or if an item on that page is selected, it resets/acknowledges that item.
If you reset/acknowledge alarms, they stop flashing but remain in the alarm state as long as that state remains. In other words, a red alarm does not switch off just because you acknowledged the alarm.



Home — Activates the home page, which is the root page. The page displays product information by default and is configurable.



Side pushbutton — Five pushbuttons on the left side of the display and five pushbuttons on the right side of the display. They perform various functions depending on the displayed page, such as switchgear controls. The display dynamically shows its label next to each side pushbutton when the pushbutton has an assigned function. These pushbuttons can also be programmed to function as user-programmable pushbuttons 9 to 16.



Tab pushbutton — Five pushbuttons under the display. They navigate through the page hierarchy, and on some pages activate other actions. The display footer dynamically labels the page or action that is activated by the Tab pushbutton.



User-programmable pushbutton — Eight physical pushbuttons are associated with the first eight user-programmable pushbutton elements. Numbering is down, that is, 1 to 4 down the left column and 5 to 8 down the right column. These elements control a set of FlexLogic operands that can be used to initiate outputs or select modes. Each physical pushbutton has an integrated LED indicator that can be user-configured to display the appropriate status. These pushbuttons have clear covers behind which custom labels can be mounted. A utility is available to print the labels, under **File > Front Panel Report** in the software.

4.2.4 LED indicators

4.2.4.1 Enhanced front panel

The enhanced front panel display provides five columns of LED indicators. The first column contains 14 status and event-cause LEDs. The next four columns contain the 48 user-programmable LEDs.

The **RESET** key is used to reset any latched LED indicator or target message, once the condition has been cleared (these latched conditions can also be reset via the **SETTINGS** ⇌ **INPUT/OUTPUTS** ⇌ **RESETTING** menu).

The **USER** keys are used by the breaker control feature.

Figure 4-47: Typical LED panel for enhanced front panel



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The status indicators in the first column are as follows:

- **IN SERVICE** — Indicates that control power is applied, all monitored inputs/outputs and internal systems are fine, and the relay is in (online) Programmed mode (under **Settings > Product Setup > Installation**)

- **TROUBLE** — Indicates that the relay has detected an internal problem. Check the self-test messages outlined at the end of the Commands and Targets chapter, and view the event records under **Actual Values > Records**. For a beta / pre-release, this LED is always on.
- **TEST MODE** — Indicates that the relay is in test mode. For information, see the Test Mode section in the Settings chapter.
- **TRIP** — Indicates that the selected FlexLogic operand serving as a trip input has operated. Set the operand under **Settings > Product Setup > User-Programmable LEDs > Trip & Alarm LEDs**. This indicator latches; initiate the reset command to reset the latch.
- **ALARM** — Indicates that the FlexLogic operand serving as an alarm switch has operated. Set the operand under **Settings > Product Setup > User-Programmable LEDs > Trip & Alarm LEDs**. This indicator never latches.
- **PICKUP** — Indicates that an element is picked up. This indicator never latches.

The event-cause indicators in the first column are as follows.

Event-cause LEDs are below the status LEDs. They are turned on or off by protection elements that have their respective target setting selected as either “Enabled” or “Latched.” If a protection element target setting is “Enabled,” then the corresponding event-cause LEDs remain on as long as the operand associated with the element remains asserted. If a protection element target setting is “Latched,” then the corresponding event-cause LEDs turn on when the operate operand associated with the element is asserted and remains on until the **RESET** button on the front panel is pressed after the operand is reset.

All elements that are able to discriminate faulted phases can independently turn off or on the phase A, B, or C LEDs. This includes phase instantaneous overcurrent, phase undervoltage, and so on. This means that the phase A, B, and C operate operands for individual protection elements are ORed to turn on or off the phase A, B, or C LEDs.

- **VOLTAGE** — This LED indicates voltage was involved
- **CURRENT** — This LED indicates current was involved
- **FREQUENCY** — This LED indicates frequency was involved
- **OTHER** — This LED indicates a composite function was involved
- **PHASE A** — This LED indicates phase A was involved
- **PHASE B** — This LED indicates phase B was involved
- **PHASE C** — This LED indicates phase C was involved
- **NEUTRAL/GROUND** — This LED indicates that neutral or ground was involved

The user-programmable LEDs consist of 48 amber LED indicators in four columns. The operation of these LEDs is user-defined. Support for applying a customized label beside every LED is provided. Default labels are shipped in the label package of every L30, together with custom templates. The default labels can be replaced by user-printed labels.

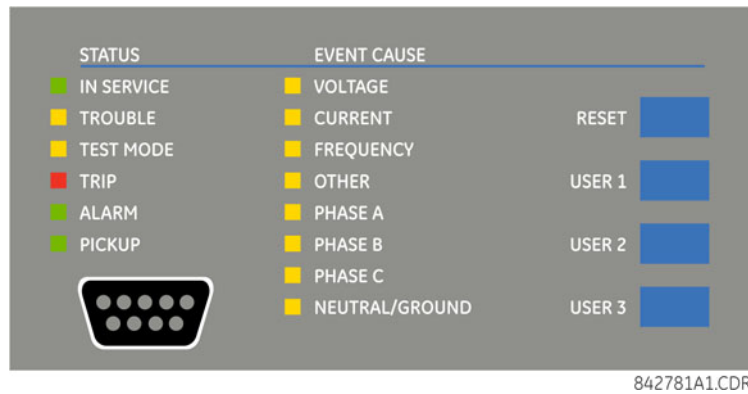
User customization of LED operation is of maximum benefit in installations where languages other than English are used to communicate with operators. See the User-Programmable LEDs section in chapter 5 for the settings used to program the operation of the LEDs on these panels.

4.2.4.2 Standard front panel

The standard front panel consists of three panels with LED indicators, keys, and a communications port. The **RESET** key is used to reset any latched LED indicator or target message, once the condition has been cleared (these latched conditions can also be reset via the **SETTINGS** ⇒ **INPUT/OUTPUTS** ⇒ **RESETTING** menu). The RS232 port is for connection to a computer.

The **USER** keys are used by the breaker control feature.

Figure 4-48: LED panel 1



Status indicators

- **IN SERVICE** — Indicates that control power is applied, all monitored inputs/outputs and internal systems are fine, and the relay is in (online) Programmed mode (under **Settings > Product Setup > Installation**)
- **TROUBLE** — Indicates that the relay has detected an internal problem. Check the self-test messages outlined at the end of the Commands and Targets chapter, and view the event records under **Actual Values > Records**. For a beta / pre-release, this LED is always on.
- **TEST MODE** — Indicates that the relay is in test mode. For information, see the Test Mode section in the Settings chapter.
- **TRIP** — Indicates that the selected FlexLogic operand serving as a trip switch has operated. This indicator always latches; initiate the reset command to reset the latch.
- **ALARM** — Indicates that the selected FlexLogic operand serving as an alarm switch has operated. This indicator never latches.
- **PICKUP** — Indicates that an element is picked up. This indicator never latches.

Event-cause indicators

Event-cause LEDs are turned on or off by protection elements that have their respective target setting selected as either “Enabled” or “Latched.” If a protection element target setting is “Enabled,” then the corresponding event cause LEDs remain on as long as the operand associated with the element remains asserted. If a protection element target setting is “Latched,” then the corresponding event cause LEDs turn on when the operate operand associated with the element is asserted and remains on until the **RESET** button on the front panel is pressed after the operand is reset.

All elements that are able to discriminate faulted phases can independently turn off or on the phase A, B, or C LEDs. This includes phase instantaneous overcurrent, phase undervoltage, and so on. This means that the phase A, B, and C operate operands for individual protection elements are ORed to turn on or off the phase A, B, or C LEDs.

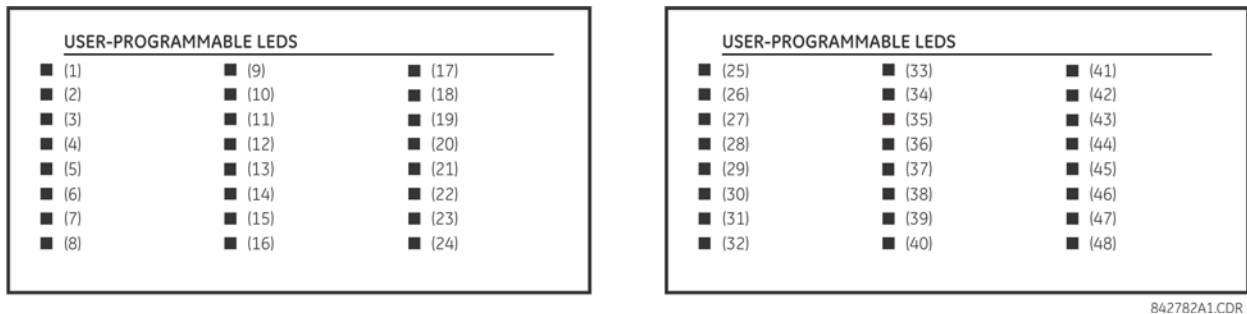
- **VOLTAGE** — Indicates voltage was involved
- **CURRENT** — Indicates current was involved
- **FREQUENCY** — Indicates frequency was involved
- **OTHER** — Indicates a composite function was involved
- **PHASE A** — Indicates phase A was involved
- **PHASE B** — Indicates phase B was involved
- **PHASE C** — Indicates phase C was involved
- **NEUTRAL/GROUND** — Indicates that neutral or ground was involved

User-programmable indicators

The second and third panels provide 48 amber LED indicators whose operation is controlled by the user. Custom labelling can be done.

User customization of LED operation is of maximum benefit in installations where languages other than English are used to communicate with operators. See the User-programmable LEDs section in chapter 5 for the settings used to program the operation of the LEDs on these panels.

Figure 4-49: LED panels 2 and 3 (index template)



Default labels for LED panel 2

The default labels are intended to represent the following:

- **GROUP 1...6** — The illuminated GROUP is the active settings group
- **BREAKER 1(2) OPEN** — The breaker is open
- **BREAKER 1(2) CLOSED** — The breaker is closed
- **BREAKER 1(2) TROUBLE** — A problem related to the breaker has been detected
- **SYNCHROCHECK NO1(4) IN-SYNCH** — Voltages have satisfied the synchrocheck element
- **RECLOSE ENABLED** — The recloser is operational
- **RECLOSE DISABLED** — The recloser is not operational
- **RECLOSE IN PROGRESS** — A reclose operation is in progress
- **RECLOSE LOCKED OUT** — The recloser is not operational and requires a reset

The relay is shipped with the default label for the LED panel 2. The LEDs, however, are not pre-programmed. To match the pre-printed label, the LED settings must be entered as shown in the User-programmable LEDs section of chapter 5. The LEDs are fully user-programmable. The default labels can be replaced by user-printed labels for both panels as explained in the next section.

Figure 4-50: LED panel 2 (default labels)

SETTINGS IN USE	BREAKER 1	SYNCHROCHECK
■ GROUP 1	■ OPEN	■ NO1 IN-SYNCH
■ GROUP 2	■ CLOSED	■ NO2 IN-SYNCH
■ GROUP 3	■ TROUBLE	
■ GROUP 4		■ <u>RECLOSE</u>
■ GROUP 5	■ <u>BREAKER 2</u>	■ ENABLED
■ GROUP 6	■ OPEN	■ DISABLED
■ GROUP 7	■ CLOSED	■ IN PROGRESS
■ GROUP 8	■ TROUBLE	■ LOCKED OUT

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4.2.4.3 Graphical front panel

The graphical front panel has 14 LEDs. LEDs 1 to 5 are fixed status LEDs, and LEDs 6 to 14 are programmable.

Status indicators

- **IN SERVICE** — Indicates that control power is applied, all monitored inputs/outputs and internal systems are fine, the relay's test mode is disabled, and the relay is in (online) Programmed mode (under **Settings > Product Setup > Installation**)
- **TROUBLE** — Indicates that the relay has detected an internal problem. Check the self-test messages outlined at the end of the Commands and Targets chapter, and view the event records under **Actual Values > Records**. For a beta / pre-release, this LED is always on.
- **TEST MODE** — Indicates that the relay is in Isolated (solid) or Forcible (flashing) test mode. For information, see the Test Mode section in the Settings chapter.
- **TRIP** — Indicates that the selected FlexLogic operand serving as a trip input has operated. Set the operand under **Settings > Product Setup > User-Programmable LEDs > Trip & Alarm LEDs**. This indicator latches; initiate the reset command to reset the latch.
- **ALARM** — Indicates that the selected FlexLogic operand serving as an alarm input has operated. Set the operand under **Settings > Product Setup > User-Programmable LEDs > Trip & Alarm LEDs**.

Figure 4-51: Example of LEDs on graphical front panel



User-programmable event-cause indicators

Event-cause LEDs are below the status LEDs. They are turned on or off by protection elements that have their respective target setting selected as “Self-Reset” or “Latched.” If set to “Self-Reset,” then the corresponding event cause LED remains on as long as the operand associated with the element remains asserted. If set to “Latched” and asserted, then it remains on until the operand is reset and then a reset command initiated.

All elements that are able to discriminate faulted phases can independently turn on or off the phase A, B, or C LEDs. This includes phase instantaneous overcurrent, phase undervoltage, and so on. This means that the phase A, B, and C operate operands for individual protection elements are ORed to turn on or off the phase A, B, or C LEDs.

The LEDs have defaults and can be configured to show instead the status of any FlexLogic operand.

The labelling area has a clear cover for custom labels. A utility is available to print stick-on labels, as outlined later in this chapter.

These LEDs are programmed by default as follows:

- **PICKUP — LED 6** — Indicates that an element is picked up, and hence a trip can be imminent
- **VOLTAGE — LED 7** — Indicates voltage was involved
- **CURRENT — LED 8** — Indicates current was involved
- **FREQUENCY — LED 9** — Indicates frequency was involved

- **OTHER — LED 10** — Indicates a composite function was involved
- **PHASE A — LED 11** — Indicates phase A was involved
- **PHASE B — LED 12** — Indicates phase B was involved
- **PHASE C — LED 13** — Indicates phase C was involved
- **NEUTRAL/GROUND — LED 14** — Indicates that neutral or ground was involved

4.2.5 Front panel labelling

4.2.5.1 Enhanced front panel

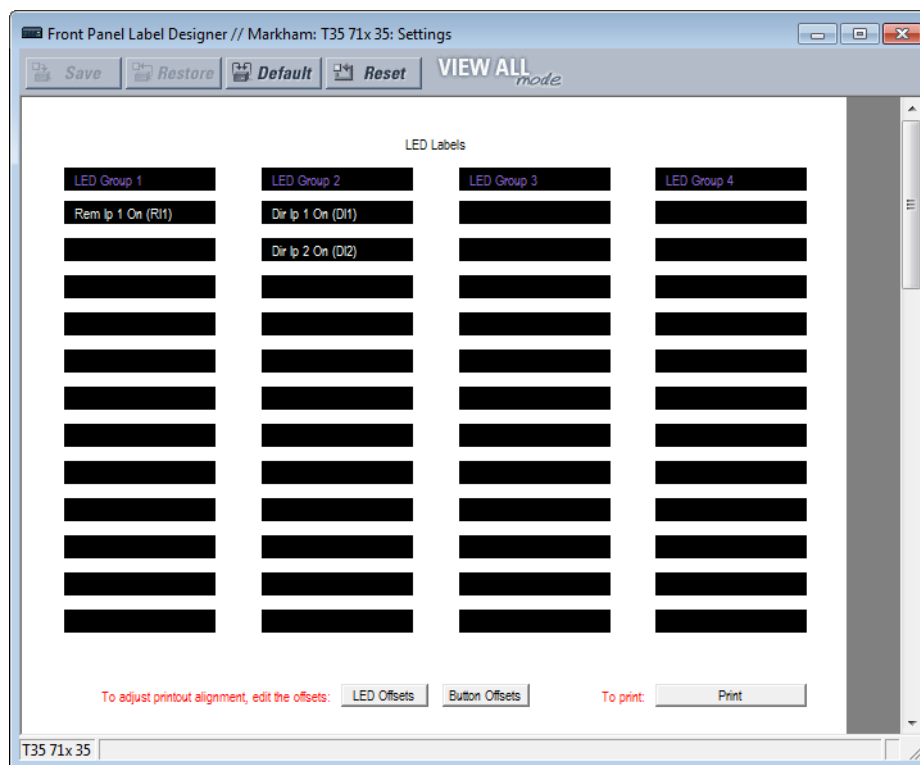
The following procedure requires these pre-requisites:

- The UR front panel label cutout sheet (GE part number 1006-0047) has been downloaded from <http://www.gegridsolutions.com/products/support/ur/URLEDenhanced.doc> and printed
- Small-bladed knife

To create custom LED and pushbuttons labels for the enhanced front panel:

1. Start the EnerVista UR Setup software.
2. If not already copied to the Offline Window area, right-click the online device and select the **Add Device to Offline Window** option. Click the **Receive** button in the window that opens to save the settings file to the Offline Window area.
3. Type labels as follows. Select the **File > Front Panel Report**. The window opens.

Figure 4-52: Enhanced front panel label designer



4. Enter the text to appear next to each LED and above each user-programmable pushbutton in the fields provided. The **LED Offsets** and **Button Offsets** buttons move all labels left/right and up/down on the page (they both do the same action, so use either button). The **Button Offsets** button does not display when there are no pushbuttons to customize.
5. Feed the UR front panel label cutout sheet into a printer and press the **Print** button in the front panel report window.
6. When printing is complete, fold the sheet along the perforated lines and punch out the labels.

- Remove the UR label insert tool from the package and bend the tabs as described in the following procedures. These tabs are used for removal of the default and custom LED labels.



Use the tool with the printed side containing the GE part number facing the user.

The label package shipped with every L30 contains the three default labels, the custom label template sheet, and the label removal tool.

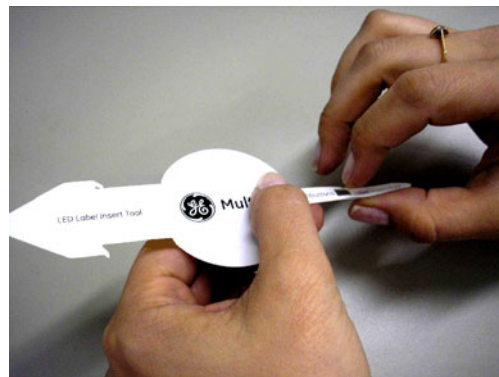
If the default labels are suitable for your application, insert them in the appropriate slots and program the LEDs to match them. If you require custom labels, use the following procedures to remove the original labels and insert the new ones.

To set up and use the label removal tool:

- Bend the tabs at the left end of the tool upwards as shown.



Bend the tab at the center of the tool tail as shown.



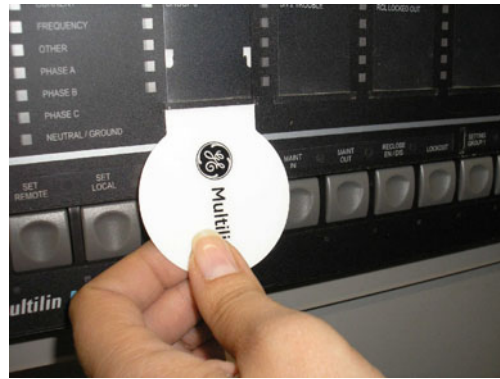
To remove the LED labels from the L30 front panel and insert the custom labels:

- Use the knife to lift the LED label and slide the label tool underneath. Ensure that the bent tabs are pointing away from

the relay.



- Slide the label tool under the LED label until the tabs snap out as shown. This attaches the label tool to the LED label.



- Remove the tool and attached LED label as shown.



- Slide the new LED label inside the pocket until the text is properly aligned with the LEDs, as shown.



To remove the user-programmable pushbutton labels from the L30 front panel and insert the custom labels:

- Use the knife to lift the pushbutton label and slide the tail of the label tool underneath, as shown. Ensure that the bent tab points away from the relay.



- Slide the label tool under the user-programmable pushbutton label until the tabs snap out as shown. This attaches the label tool to the user-programmable pushbutton label.



- Remove the tool and attached user-programmable pushbutton label.



- Slide the new user-programmable pushbutton label inside the pocket until the text is properly aligned with the buttons.



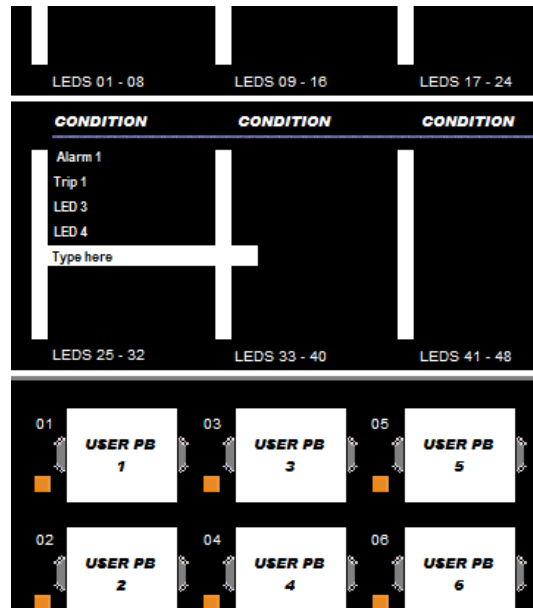
4.2.5.2 Standard front panel

After programming LEDs and pushbuttons under **Settings > Product Setup > User-Programmable Leds** and **User-Programmable Pushbuttons**, labels can be created for the front panel.

To create LED and pushbutton labels for a standard front panel:

- In the EnerVista software, if the L30 is not already listed in the Offline Window area, add it by right-clicking it and selecting the **Add Device to Offline Window** option.
- Click the **File > Front Panel Report** menu item and select the device.
- In the Front Panel Report window, double-click an LED or pushbutton slot and type a label. If you need to see the existing front panel remotely, access **Actual Values > Front Panel** for the online device. In the figure, note that labelling is being done for the third set of LEDs because the second panel of LEDs was factory-labelled.

Figure 4-53: Standard front panel label designer (LEDs shown)



4. Optionally save the changes by clicking the **Save** icon on the toolbar.
5. Click the **Print** icon on the toolbar. Consider printing to PDF format and adjusting the zoom for appropriate label size, then print on a physical printer.
6. Cut labels as a block or individually, for example with scissors or an Exacto knife.
7. If there is a plastic cover over the front panel, remove it by gently pushing in on the right side and lifting off the cover.
8. Remove the plastic cover over the LEDs or pushbutton(s) using a screw driver.
9. Insert the labels.
10. Re-attach the plastic covers.

4.2.5.3 Graphical front panel

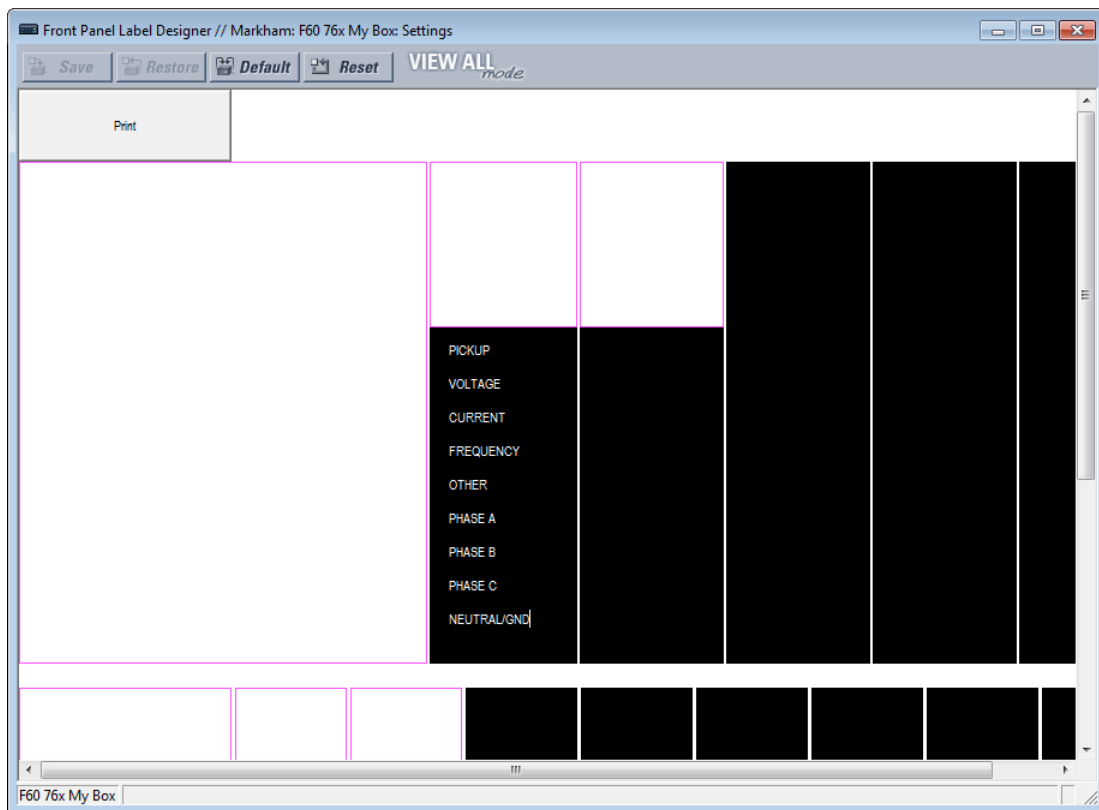
The L30 includes software for labelling the LEDs and pushbuttons on the graphical front panel and a sticker sheet with pre-printed and blank labels. The pre-printed labels are on the top-left of the template sheet, and the blank labels are on the bottom-right. Use the pre-printed labels, or use the designer provided in the software and print labels onto the template. One sheet is provided.

The example shows LED labeling, with pushbutton labeling below it (cut off).

To create LED and pushbutton labels for the front panel:

1. In the EnerVista software, in the Online or Offline Window area, access **Settings > Front Panel Label Designer** or **Front Panel Label Designer** (at the product root level). The designer window opens with pre-configured labels.
2. Under **File > Print Setup**, change the page orientation to **Landscape**.
3. In the label designer window, delete all labels not wanted for printing. This can be done by clicking the **Reset** button to clear all labels, or by selecting each unwanted label and deleting it. Otherwise, all labels displayed print on the template and use up the template. If you make a mistake, exit the window and open it again to view the default labels.
4. Based on the location on the template on which to print, create the labels by typing in the appropriate slots.

Figure 4-54: Front panel label designer for graphical front panel



5. Click the **Print** button in the window and select the printer.
6. Once printed, peel the labels off the template and stick them on the front panel. For the enhanced and graphical front panels, they go over the clear plastic inserts, not under. For the standard front panel, they go under or over the plastic covers.

Any changes are not saved. Each time that the label designer window opens, the original template displays. Any labels deleted are not lost.

4.2.6 Menu navigation

Press the **MENU** key to display selections or home page. Each press of the key advances through the following main headings:

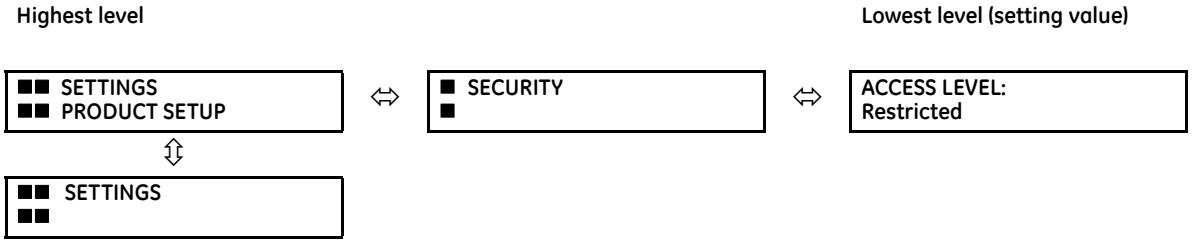
- Actual Values
- Settings
- Commands
- Targets
- Factory Service
- User displays (when enabled)

4.2.6.1 Enhanced and standard front panels

The setting and actual value pages are arranged hierarchically. Header display pages are indicated by double scroll bars (■■), while sub-header pages are indicated by a single scroll bar (■). The header display pages represent the highest level of the hierarchy and the sub-header display pages fall below this level. Use the down, right, left, and up arrows to navigate the menu. The **MESSAGE** up and down arrow keys move within a group of headers, sub-headers, setting values, or actual

values. Continually pressing the **MESSAGE** right arrow from a header display displays specific information for the category. Conversely, continually pressing the **MESSAGE** left arrow from a setting value or actual value display returns to the header display.

Default values are indicated in this instruction manual in mixed case. In the example shown here, the default access level is Restricted.



Example

■■ ACTUAL VALUES ■■ STATUS	Press the MENU key until the Actual Values header page appears. This page contains system and relay status information.
↓	
■■ SETTINGS ■■ PRODUCT SETUP	Press the MENU key until the Settings header page appears. This category contains settings to configure the relay.
↓	
■ SECURITY ■	Press the MESSAGE right arrow once to display the first sub-header (Security).
↓	
ACCESS LEVEL: Restricted	Press the MESSAGE right arrow once to display the first setting for Security.
↓	
■ SECURITY ■	Press the MESSAGE left arrow to return to the Security heading.
↓	
■ DISPLAY ■ PROPERTIES	Press the MESSAGE down arrow to display the second setting sub-header associated with the Product Setup header.
↓	
LANGUAGE: English	Press the MESSAGE right arrow once to display the first setting for Display Properties.
↓	
■■ SETTINGS ■■	Press the MESSAGE left arrow to return to the Display Properties page, then again to return to the Product Setup Page. Press the MESSAGE down arrow to move to the next Settings page. This page contains settings for .

4.2.6.2 Graphical front panel

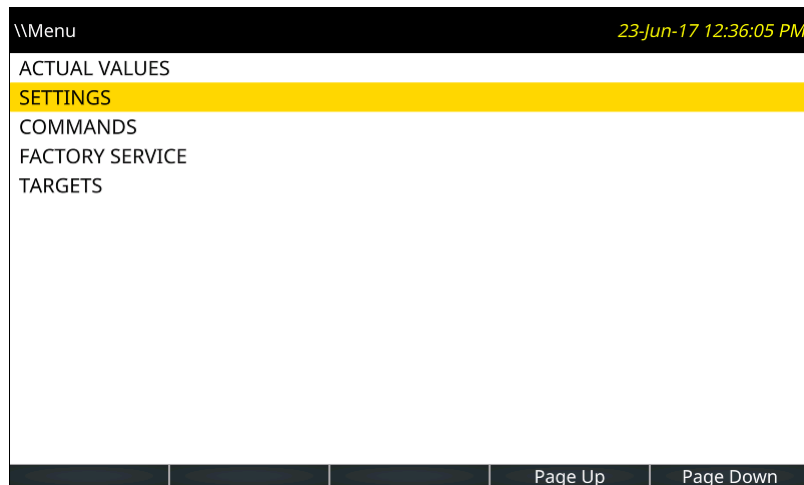
Access the main menu by pressing the **Home** pushbutton, then the **Menu** Tab pushbutton.

Use the Up and Down arrow pushbuttons to select a submenu, then press the Right or **ENTER** pushbutton to drill into that submenu. The Left and **ESCAPE** pushbuttons back up the menu hierarchy.

The **Page Up** and **Page Down** Tab pushbuttons also navigate through the list. When there is only a single page of options, they jump to the first and last entries.

The options displayed depend on order code.

Figure 4-55: Main menu on graphical front panel



4.2.7 Change settings

4.2.7.1 Enhanced and standard front panels

Numerical data

Each numerical setting has its own minimum, maximum, and increment value associated with it. These parameters define what values are acceptable for a setting.

FLASH MESSAGE TIME: 10.0 s For example, select the **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **DISPLAY PROPERTIES** ⇒ **FLASH MESSAGE TIME** setting.



MINIMUM: 0.5
MAXIMUM: 10.0 Press the **HELP** key to view the minimum and maximum values. Press the key again to view the next context sensitive help message.

Two methods of editing and storing a numerical setting value are available.

- **0 to 9 and decimal point** — The relay numeric keypad works the same as a calculator. A number is entered one digit at a time. The leftmost digit is entered first and the rightmost digit is entered last. Pressing the **MESSAGE** left arrow or pressing the **ESCAPE** key, returns the original value to the display.
- **VALUE keys** — The **VALUE** up arrow increments the displayed value by the step value, up to the maximum value allowed. While at the maximum value, pressing the **VALUE** up arrow again allows the setting selection to continue upward from the minimum value. The **VALUE** down arrow decrements the displayed value by the step value, down to the minimum value. While at the minimum value, pressing the **VALUE** down arrow again allows the setting selection to continue downward from the maximum value.

FLASH MESSAGE TIME: 2.5 s As an example, set the flash message time setting to 2.5 seconds. Press the appropriate numeric keys in the sequence "2 . 5". The display message changes as the digits are being entered.



NEW SETTING HAS BEEN STORED Until **ENTER** is pressed, editing changes are not registered by the relay. Press **ENTER** to store the new value in memory. This flash message momentarily appears as confirmation of the storing process. Numerical values that contain decimal places are rounded-off if more decimal place digits are entered than specified by the step value.

Enumeration data

Enumeration settings have data values that are part of a set, whose members are explicitly defined by a name. A set has two or more members.

ACCESS LEVEL: Restricted	For example, the selections available for ACCESS LEVEL are "Restricted," "Command," "Setting," and "Factory Service."
------------------------------------	--

Enumeration type values are changed using the **VALUE** keys. The **VALUE** up arrow displays the next selection while the **VALUE** down arrow displays the previous selection.

ACCESS LEVEL: Setting	If the ACCESS LEVEL needs to be "Setting," press the VALUE keys until the proper selection displays. Press HELP at any time for the context sensitive help messages.
---------------------------------	---



NEW SETTING HAS BEEN STORED	Changes are not registered by the relay until the ENTER key is pressed. Pressing ENTER stores the new value in memory. This flash message momentarily appears as confirmation.
--	--

4

Alphanumeric text

Text settings have data values that are fixed in length, but user-defined in characters. They can be upper-case letters, lower-case letters, numerals, and a selection of special characters.

There are several places where text messages can be programmed to allow the relay to be customized for specific applications. One example is the Message Scratchpad. Use the following procedure to enter alphanumeric text messages.

For example, enter the text "Breaker #1".

1. Press the decimal point to enter text edit mode.
2. Press the **VALUE** keys until the character 'B' appears; press the decimal key to advance the cursor to the next position.
3. Repeat step 2 for the remaining characters: r,e,a,k,e,r, #,1.
4. Press **ENTER** to store the text.
5. If you have any problem, press **HELP** to view context sensitive help. Flash messages appear sequentially for several seconds each. For the case of a text setting message, pressing **HELP** displays how to edit and store new values.

4.2.7.2 Graphical front panel

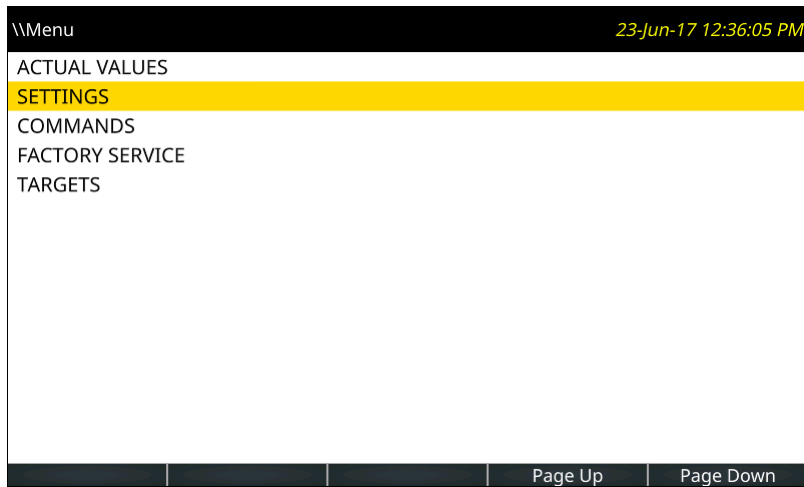
When enabling an element in the EnerVista software that outputs to an actual value, the actual values menu is not updated on the graphical front panel via Ethernet connection when that menu is active on the graphical front panel. Navigate out and back into the menu for activation.

Numerical data

This example outlines how to change the FLASH MESSAGE TIME setting. Flash messages are status, warning, error, and information messages displayed in response to certain key presses during settings programming. An example is a confirmation message upon saving settings. This setting specifies how long to display the message.

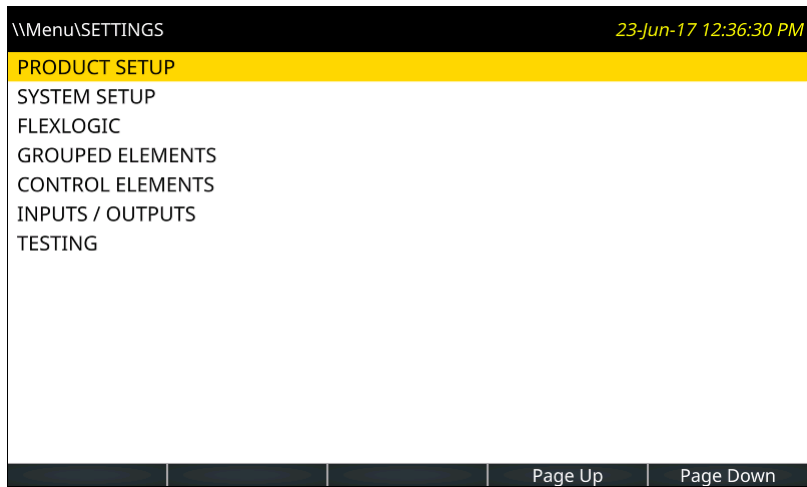
Press the **Menu** pushbutton to display the main menu.

Figure 4-56: Main menu



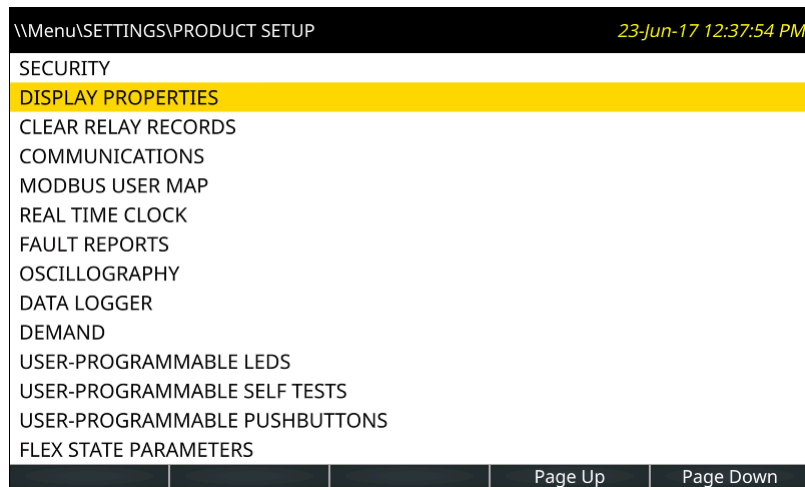
Use the Up or Down pushbutton to select **SETTINGS**, then press the Right or **ENTER** pushbutton.

Figure 4-57: Settings menu



With **PRODUCT SETUP** selected, press the Right or **ENTER** pushbutton.

Figure 4-58: Product Setup menu



Use the Up or Down pushbutton to select **DISPLAY PROPERTIES**, then press the Right or **ENTER** pushbutton.

Figure 4-59: Display Properties menu



Use the Up or Down pushbutton to select **FLASH MESSAGE TIME**, then press the Right or **ENTER** pushbutton. If the relay is configured to require login to edit settings, and the user is not already logged in, the login page displays. When the user has successfully logged in, the setting is opened for edit. As the **FLASH MESSAGE TIME** setting accepts a numerical value, a keypad displays. The time is to be changed to 4.0 seconds.

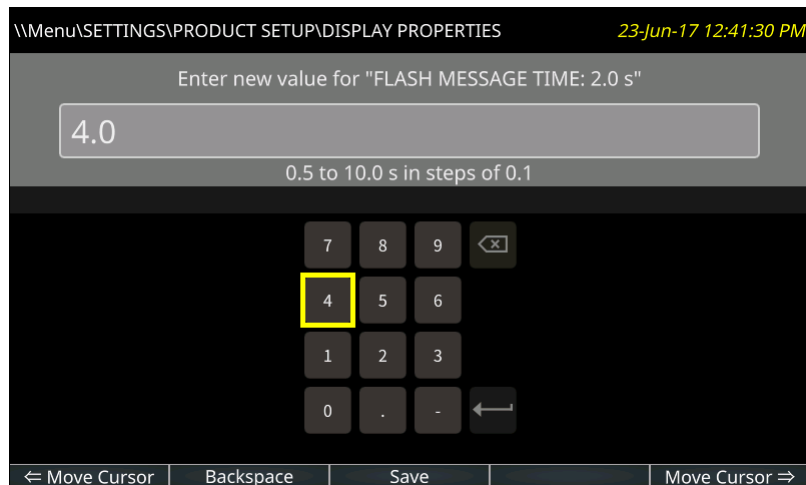
The current setting displays. A flashing cursor line marks the insertion point, initially positioned after the last character of the setting. The setting range displays under the text.

Press the **<-- Move Cursor** and **Move Cursor -->** Tab pushbuttons to move the insertion point. Place it after the 2.

Press the **Backspace** Tab pushbutton to remove the character to the left of the cursor, in this case the 2.

Using the arrow keys, enter another time, for example 4 for four seconds. These Up, Down, Left, and Right pushbuttons move the keypad key selector. Pressing the **ENTER** pushbutton with the - key selected inverts the sign. Pressing the **ENTER** pushbutton with the decimal point selected enters that character at the insertion point. Push **ENTER** now to accept the 4.

Figure 4-60: Settings page with numeric keypad



Press the **Save** Tab pushbutton, which does a range check on the value, saves the setting when valid, closes the page, and displays the previous page.

When a setting is not saved due to an invalid value, a message flashes, for example being out of range. In cases where the relay needs to be restarted for settings to take effect, the flash message advises.

Setting entry can be cancelled without impact on the original value by pressing the **ESCAPE** or **Home** pushbutton.

Alphanumeric text

Settings that accept alphanumeric values display a keyboard. An example is a pushbutton name.

The **&123** key toggles between text and numbers.

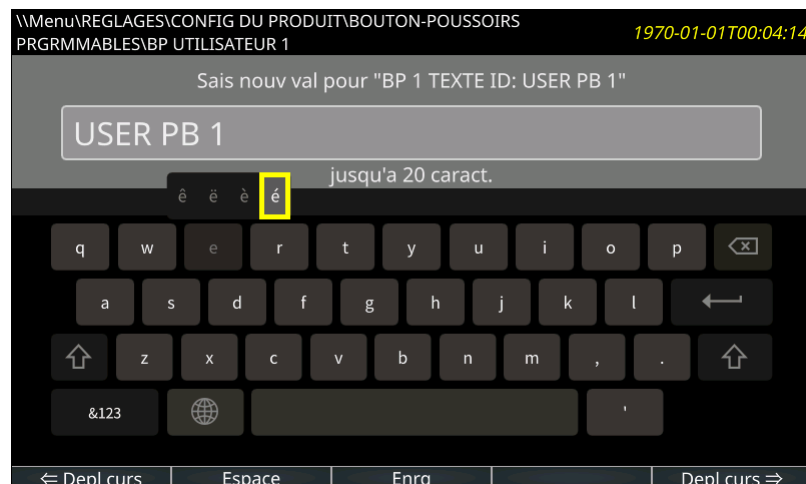
The shift key (up arrow on keyboard) is green upon activation, while the keyboard letters switch to upper case. Double-click the shift key to lock capital lettering, or full capitals.

The globe key (shown greyed-out) toggles the keyboard language between English and another display language selected, for example between English and French. (The second language needs to be activated under **Settings > Product Setup > Display Properties**.)

For Japanese and Chinese, up to 10 characters can be input in a field, not 20.

To add accents, highlight a key and hold the **ENTER** pushbutton on the graphical front panel. Any special characters associated with the key display.

Figure 4-61: Settings page with keyboard and accents



4.2.8 View actual values

4.2.8.1 Graphical front panel

In addition to data viewable in the **Actual Values** menu on the front panel, phasor diagrams and metered data can be displayed. The metered data can be arranged as a table.

The update rate of metered values is 500 ms.

A phasor page for each configured AC Source and up to five user-configurable metering pages can be displayed. The phasor pages are not configurable. Each phasor page shows a phasor plot and numerical values of all currents, voltages, and symmetrical components of a single AC source.

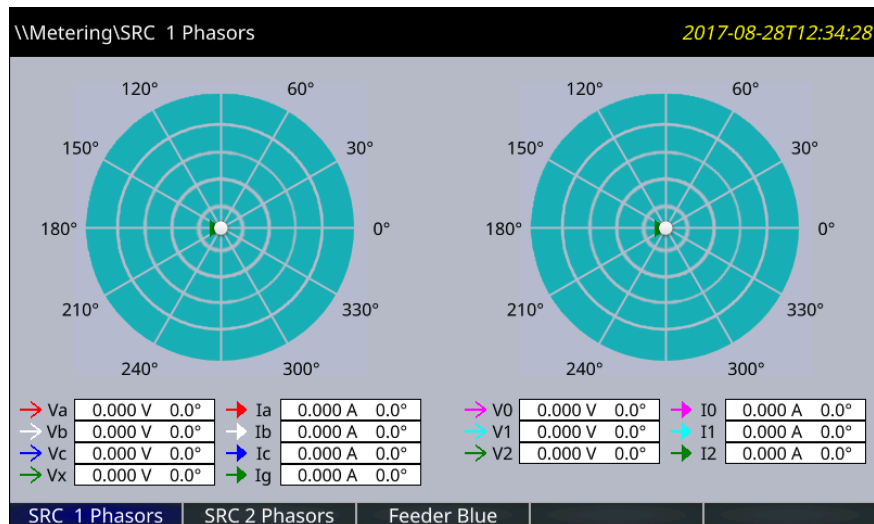
The Annunciator and Metering pages can be configured to display data. Each has a user-configured number of rows and columns. Each cell can include either configurable static text or the value of a selected FlexLogic operand, FlexAnalog operand, or actual value.

To display a metering page, press the **Home** pushbutton, then the **Metering** Tab pushbutton. The first metering page opens, with phasor pages listed before tabular pages. The Tab pushbuttons display any other metering page, as do the Up, Down, Left and Right pushbuttons. The current page is highlighted with a blue Tab pushbutton.

Each phasor page has a name, which consists of the value of the SOURCE NAME # setting appended with " Phasors." Phasor pages that have no configured CTs or VTs do not have a Tab pushbutton, and phasor pages that have no configured cells cannot be displayed.

4

Figure 4-62: Phasor display



The configurable name displays in the header and Tab pushbutton label. Factory default names are Page 1, Page 2, and so on.

Figure 4-63: Metered actual values

\\Metering\Feeder Blue			2017-08-28T12:35:43
Phase AB	Phase BC	Phase CA	
0.000	0.000	0.000	V
Phase A	Phase B	Phase C	
0.000	0.000	0.000	A
0.000	0.000	0.000	W
0.000	0.000	0.000	VAR
0.000	0.000	0.000	PF

SRC 1 Phasors SRC 2 Phasors Feeder Blue

The phasor sources are configured under **Settings > System Setup > Signal Sources**. The tables to display the actual values are configured in the software under **Settings > Product Setup > Graphical Panel > Metering Editor**.

4.2.9 Breaker control

The L30 can interface with associated circuit breakers. In many cases the application monitors the state of the breaker, that can be presented on front panel LEDs, along with a breaker trouble indication. Breaker operations can be manually initiated from the front panel keypad or automatically initiated from a FlexLogic operand. A setting is provided to assign names to each breaker; this user-assigned name is for the display of related flash messages. These features are provided for two breakers; the user can use only those portions of the design relevant to a single breaker, which must be breaker 1.

It is assumed in the following discussion that the **SETTINGS ⇒ SYSTEM SETUP ⇒ BREAKERS ⇒ BREAKER 1(2) ⇒ BREAKER FUNCTION** setting is "Enabled" for each breaker.

4.2.9.1 Control mode selection and monitoring

Installations can require that a breaker be operated in the three-pole only mode (3-pole), or in the one and three-pole (1-pole) mode, selected by setting. If the mode is selected as three-pole, a single input tracks the breaker open or closed position. If the mode is selected as one-pole, all three breaker pole states must be input to the relay. These inputs must be in agreement to indicate the position of the breaker.

For the following discussion it is assumed that the **SETTINGS ⇒ SYSTEM SETUP ⇒ BREAKERS ⇒ BREAKER 1(2) ⇒ BREAKER 1(2) PUSH BUTTON CONTROL** setting is "Enabled" for each breaker.

4.2.9.2 Front panel (user key) control

After the 30 minute interval during which command functions are permitted after a correct command password, the user cannot open or close a breaker via the keypad. The following discussions begin from the not-permitted state.

4.2.9.3 Control of two breakers

For the following setup example, the **(Name)** field represents the user-programmed variable name.

For this example, the relay is connected and programmed for both breaker 1 and breaker 2. The **USER 1** key performs the selection of which breaker is to be operated by the **USER 2** and **USER 3** keys. The **USER 2** key manually closes the breaker, and the **USER 3** key manually opens the breaker.

ENTER COMMAND PASSWORD	This message appears when the USER 1 , USER 2 , or USER 3 key is pressed and a COMMAND PASSWORD is required, that is, if COMMAND PASSWORD is enabled and no commands have been issued within the last 30 minutes.
Press USER 1 To Select Breaker	This message appears if the correct password is entered or if none is required. This message displays for 30 seconds or until the USER 1 key is pressed again.
BKR1-(Name) SELECTED USER 2=CLS/USER 3=OP	This message displays after the USER 1 key is pressed for the second time. Three possible actions can be performed from this state within 30 seconds as per the following items (1), (2) and (3).
(1) USER 2 OFF/ON To Close BKR1-(Name)	If the USER 2 key is pressed, this message appears for 20 seconds. If the USER 2 key is pressed again within that time, a signal is created that can be programmed to operate an output relay to close breaker 1.
(2) USER 3 OFF/ON To Open BKR1-(Name)	If the USER 3 key is pressed, this message appears for 20 seconds. If the USER 3 key is pressed again within that time, a signal is created that can be programmed to operate an output relay to open breaker 1.
(3) BKR2-(Name) SELECTED USER 2=CLS/USER 3=OP	If the USER 1 key is pressed at this step, this message appears showing that a different breaker is selected. Three possible actions can be performed from this state as per (1), (2) and (3). Repeatedly pressing the USER 1 key alternates between available breakers. Pressing keys other than USER 1 , 2 , or 3 at any time cancels the breaker control function.

4.2.9.4 Control of one breaker

For this application, the relay is connected and programmed for breaker 1 only. Operation for this application is identical to that described in the previous section for two breakers.

4.2.10 Change passwords

The information in this section refers to password security. For information on how to set the password for the first time or change CyberSentry passwords, see the previous chapter or the Settings > Product Setup > Security > CyberSentry section in the next chapter.

The L30 supports password entry from a local or remote connection.

Local access is defined as access to settings or commands via the front panel. This includes both keypad entry and the RS232 port. Remote access is defined as access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. Any change to the local or remote password enables this functionality.

When entering a settings or command password via EnerVista or any serial interface, the user must enter the corresponding connection password. If the connection is to the back of the L30, the remote password must be used. If the connection is to the RS232 port of the front panel, the local password must be used.

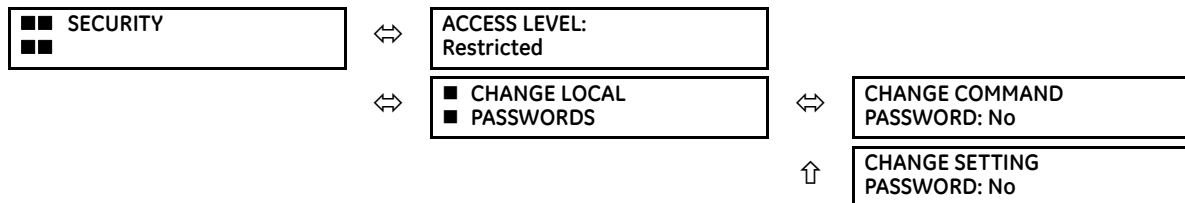
There are two user security access levels, setting and command, for which you can set a password for each. Use of a password for each level controls whether users can enter commands or change settings. Another option is to specify setting and/or command access for individual user accounts.

- **Setting** — Allows the user to make any changes to any of the setting values:
 - Changing any setting
 - Test mode operation
- **Command** — Restricts the user from making any settings changes, but allows the user to perform the following operations:
 - Operating the breakers via front panel keypad
 - Changing the state of virtual inputs

- Clearing the event records
- Clearing the oscillography records
- Clearing fault reports
- Changing the date and time
- Clearing the breaker arcing current
- Clearing the data logger
- Clearing the user-programmable pushbutton states

To enter the initial setting or command password:

1. Press the **MENU** key until the **SETTINGS** header flashes momentarily and the **PRODUCT SETUP** message appears on the display.
2. Press the **MESSAGE** right arrow until the **ACCESS LEVEL** message appears on the display.
3. Press the **MESSAGE** down arrow until the **CHANGE LOCAL PASSWORDS** message appears on the display.
4. Press the **MESSAGE** right arrow until the **CHANGE SETTING PASSWORD** or **CHANGE COMMAND PASSWORD** message appears on the display.



5. After the **CHANGE...PASSWORD** message appears on the display, press the **VALUE** up or down arrow to change the selection to "Yes."
6. Press the **ENTER** key and the display prompts you to **ENTER NEW PASSWORD**.
7. Type in a password and press the **ENTER** key.
8. When **VERIFY NEW PASSWORD** displays, re-type the password and press **ENTER**.



9. When the **NEW PASSWORD HAS BEEN STORED** message appears, your new Setting (or Command) password is active.

4.2.11 Invalid password entry

By default, when an incorrect Command or Setting password has been entered via the front panel three times within five minutes, the **LOCAL ACCESS DENIED** FlexLogic operand is set to "On" and the L30 does not allow settings or command level access via the front panel for five minutes.

By default, when an incorrect Command or Setting password has been entered via any external communications interface three times within five minutes, the **REMOTE ACCESS DENIED** FlexLogic operand is set to "On" and the L30 does not allow settings or command access via the any external communications interface for five minutes. The **REMOTE ACCESS DENIED** FlexLogic operand is set to "Off" after five minutes for a Command password or 30 minutes for a Settings password.

These default settings can be changed in EnerVista under **Settings > Product Setup > Security**.

4.3 Logic diagrams

Logic diagrams in this instruction manual provide an overview of function and settings. A logic diagram is based on

- Inputs-on the left side, which are setting and operands
- Logical gates, which is Boolean algebra to combine logical lines using AND, OR, NOT, and other gates to get a new logical state
- Logical operators, which are timers, one-shot operations, latches, and so on
- Outputs-on the right side, which are products of the manipulations with inputs, logical gates, and logical operators to produce new operands and define the output state of the element

True and false values are denoted by 1 and 0 respectively. A function usually is high/on/enabled when 1.

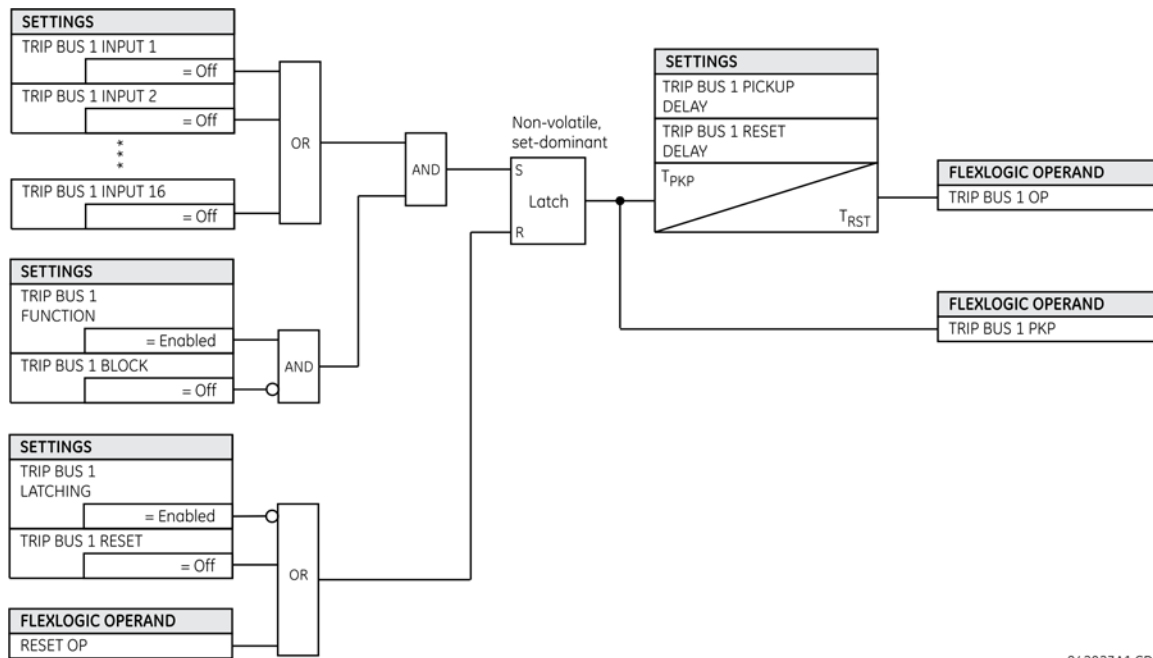
Reading from right to left in the following diagram, the **TRIP BUS 1 OP** and **TRIP BUS 1 PKP** FlexLogic operands on the right side are triggered when either the settings or reset latch in the middle of the diagram is triggered. When this applies, the **TRIP BUS 1 OP** operand is triggered after the delay set by the **TRIP BUS 1 PICKUP DELAY** or **TRIP BUS 1 RESET DELAY** setting, while the **TRIP BUS 1 PKP** operand initiates immediately. The settings or reset latch in the middle of the diagram is triggered as follows.

- For the reset, one of three conditions are required to meet the OR requirement shown at the bottom left. That is, the **TRIP BUS 1 LATCHING** setting must be 0=Disabled (which is negated by the NOT function to become 1=Enabled), output from the **TRIP BUS 1 RESET** FlexLogic operand must be 1, or output from the **RESET OP** FlexLogic operand must be 1.
- For the settings, one of 16 input conditions at the top left must be met for the OR, the **TRIP BUS 1 FUNCTION** must be Enabled, and the **TRIP BUS 1 BLOCK** output must output as 0, which is then negated/reversed by NOT to become 1.

Table 4-2: Logic diagram symbols

Symbol	Description
= Off	Output from FlexLogic operand, so user-defined
= Enabled	1 = Enabled and 0 = Disabled
OR	Any function input on the left side satisfies the condition
AND	All functions input on the left side are required to satisfy the condition
○	Not. Negates/reverses the output, for example 0 becomes 1.
●	Connection
S, R	Set, Reset
T _{PKP}	Timer pickup. Triggered by the settings latch in the diagram.
T _{RST}	Timer reset. Triggered by the reset latch in the diagram.

Figure 4-64: Logic diagram



842023A1.CDR

4.4 FlexLogic design using Engineer

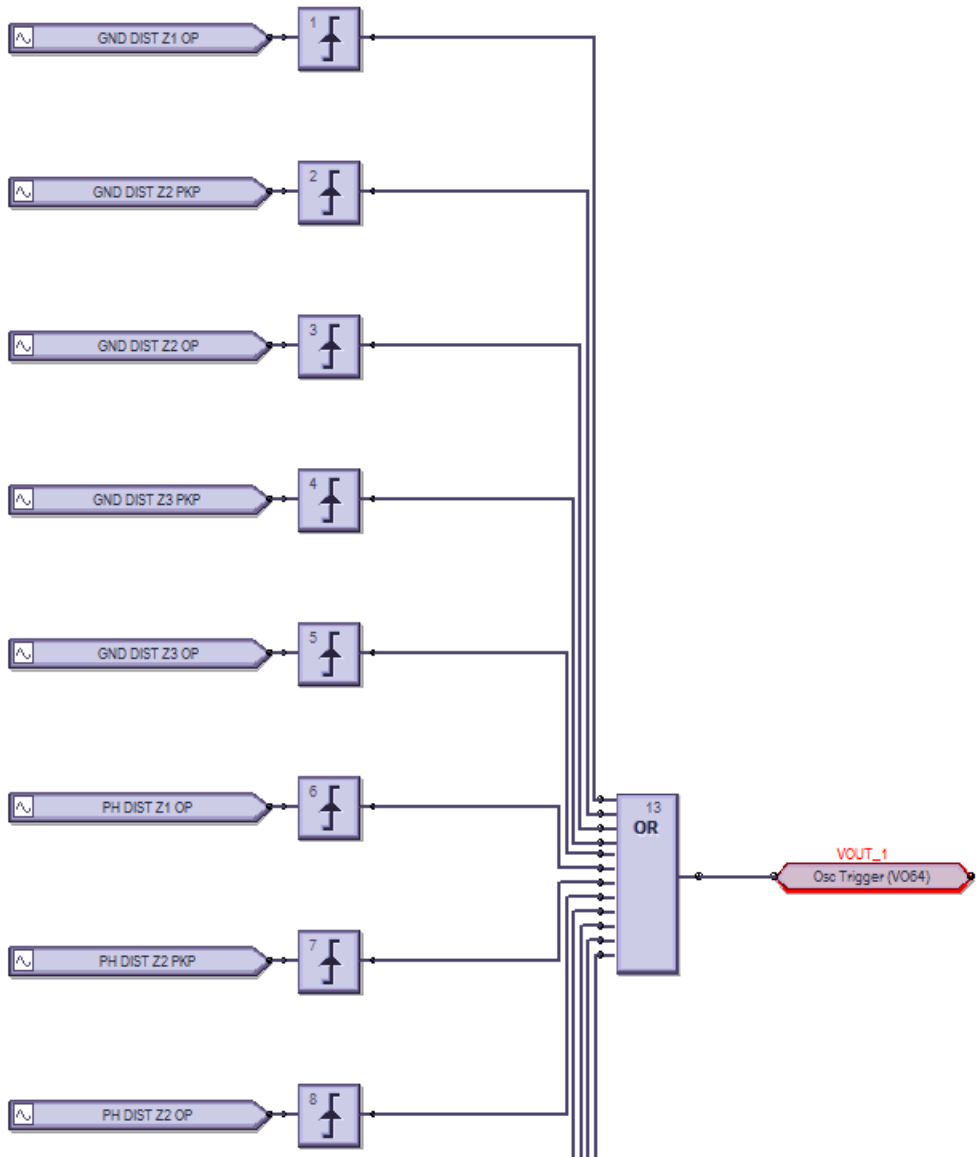
Parts of EnerVista Viewpoint Engineer software are integrated in the EnerVista UR Setup software. Engineer can be used to create and modify FlexLogic that is used by a device, such as to monitor output, monitor triggers, and create self-tests.

Features include

- Automatically displays existing FlexLogic
- Drag-and-drop interface
- Open multiple tabs and edit simultaneously
- Display symbols in IEC, ISO, or UR formats
- Export a diagram as BMP file or copy it to the clipboard for import into other applications
- Scale and print files in various paper sizes
- Works with all UR firmware versions

The figure shows an example where several inputs are used to trigger an output. With the OR function, any one of the inputs can trigger the output.

Figure 4-65: Inputs triggering output in Engineer



The process is as follows:

- Modify or create a logic diagram in the Offline Window area of the EnerVista UR Setup software
- Compile it and troubleshoot any errors
- The logic populates automatically into the FlexLogic Equation Editor
- Upload the file to the live device
- Monitor the output

This section explains how to use Engineer. It outlines the following topics:

- Design logic
- Send file to and from device
- Monitor logic
- View front panel
- Generate connectivity report
- Preferences

- Toolbars

4.4.1 Design logic

FlexLogic can be created with a block diagram. Note that although work is completed in the Offline Window area of the software, communication occurs with the online device, for example when switching to monitoring mode.

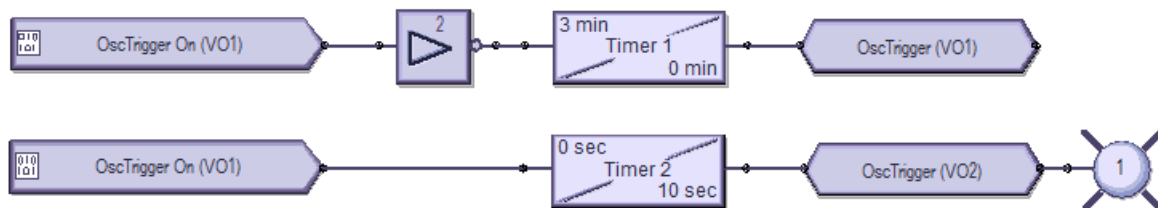
The following procedures are outlined:

- Examples
- Add existing FlexLogic equations
- Create a logic diagram/sheet
- Rapidly add logic blocks in sequence
- Connect two logic diagrams/sheets
- Optimize the logic
- Change logic order
- Search logic
- Exclude sheet from compile

4.4.1.1 Examples

Create oscillography trigger every three minutes

Figure 4-66: Three-minute timer turns on LED for 10 seconds



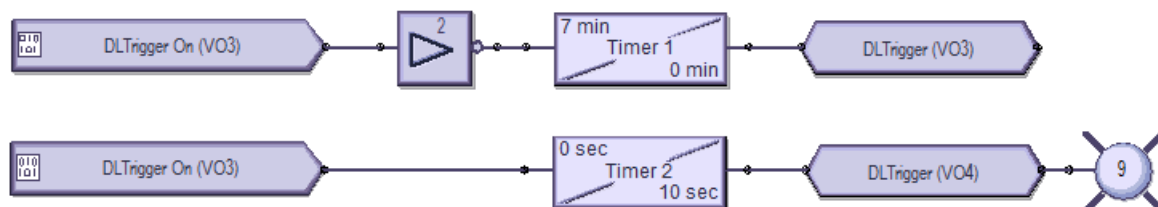
Preparation — Under **Settings > Inputs/Outputs > Virtual Outputs**, the first and second virtual outputs are named OscTrigger

Top logic — Three-minute timer trigger

Bottom logic — Turn on LED 1 for 10 seconds when the trigger starts

Create data logger trigger every seven minutes

Figure 4-67: Seven-minute timer turns on LED for 10 seconds



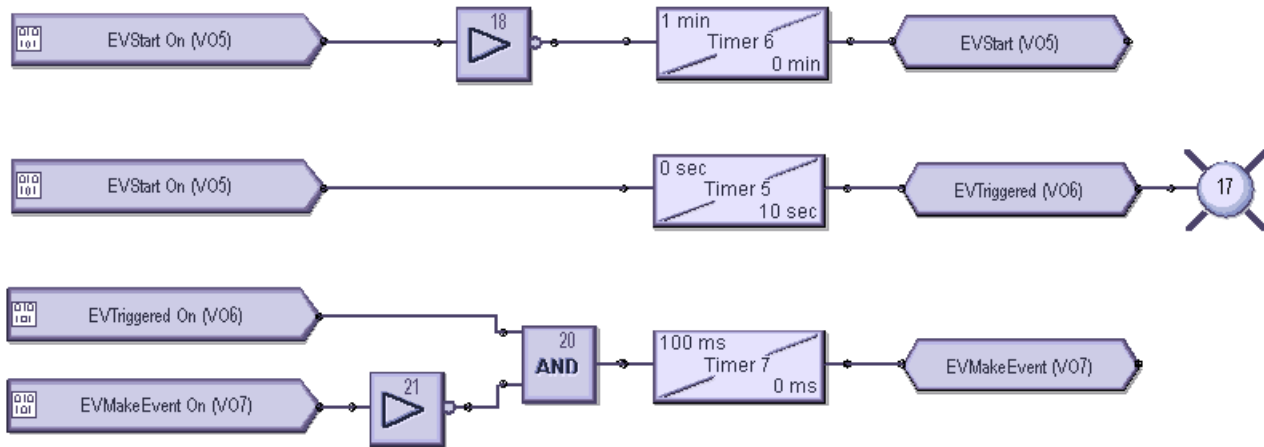
Preparation — Under **Settings > Inputs/Outputs > Virtual Outputs**, virtual outputs 3 and 4 are named DLTrigger

Top logic — Seven-minute timer trigger

Bottom logic — Turn on LED 9 for 10 seconds when the trigger starts

Create events every minute, then every 100 ms

Figure 4-68: One-minute timer turns on LED and creates events every 100 ms



4

Preparation — Under **Settings > Inputs/Outputs > Virtual Outputs**, virtual output 5 is named EVStart, 6 is named EVTriggered, and 7 is named EVMakeEvent

Top logic — One-minute timer trigger

Middle logic — Turn on LED 17 for 10 seconds when trigger starts

Bottom logic — Create events at 100 ms intervals for the same 10 second period

4.4.1.2 Add existing FlexLogic equations

A logic diagram can be created using existing FlexLogic equations (this section) or by creating new ones (next section).

When using existing equations, you modify them in the FlexLogic Equation Editor in the Offline Window area, then apply them.



The FlexLogic Equation Editor window is in view-only mode when the Logic Designer is open. To instead work in the FlexLogic Equation Editor, close the Logic Designer window, then re-open the FlexLogic Equation Editor.

To create a logic diagram using existing FlexLogic equations:

1. In the Offline Window area, modify the FlexLogic for the device under **FlexLogic > FlexLogic Equation Editor**. If the device is not listed, right-click the device in the Online Window area and select the **Add Device to Offline Window** option.
Upon saving the modified FlexLogic, a yellow icon appears for the device in the Offline Window area to indicate that the logic differs from the Online device.
2. In the Offline Window area, access **Engineer** for the device, then **Logic Designer**. The logic opens.
3. Click the **Edit > Auto Populate Workbook** menu item. If the software prompts if you want to keep or discard existing sheets, either is acceptable, with the older excluded sheeted being denoted by brackets, such as < Sheet 1 >. The logic displays in the various tabs. The FlexLogic created in the equation editor appears in Sheet 1, for example.

4.4.1.3 Create logic diagram

Upon access of the Logic Designer, the FlexLogic equations of the device display. You can create new logic in new sheets or modify the ones that display.

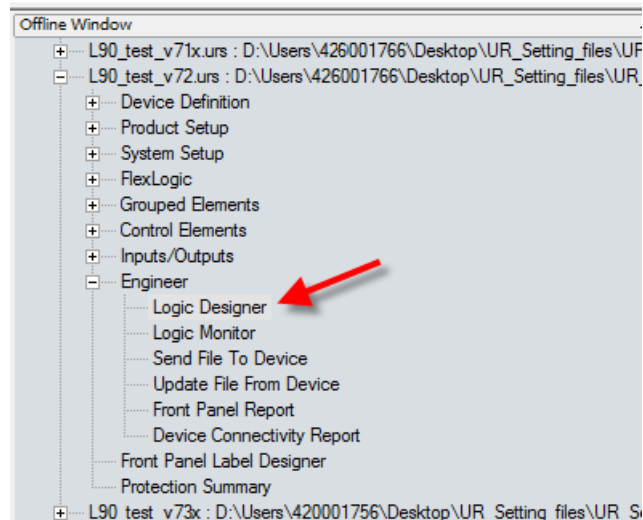
This procedure uses input / output logic as an example.

To create a logic diagram:

1. In the Offline Window area, access **Engineer** for the device, then **Logic Designer**. If the device is not listed, right-click

the device in the Online Window area and select the **Add Device to Offline Window** option.

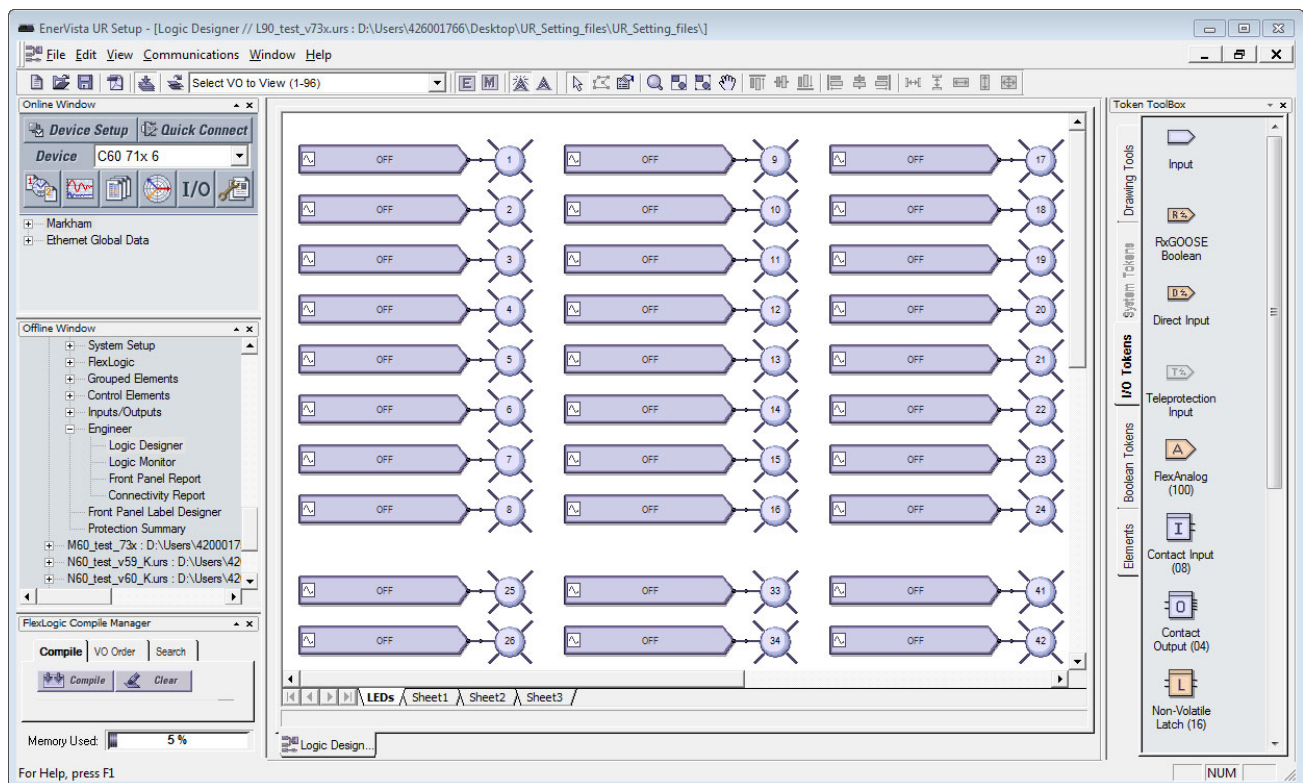
Figure 4-69: Access Engineer in the Offline Window area



A blank window opens (graphical front panel), or a default block diagram opens that shows 48 inputs (boxes) and 48 user-programmable LEDs (circles).

For the graphical front panel, no LEDs can be added to the window and the LEDs are removed when opening any existing files. For these existing files with the LEDs removed, save the file without them.

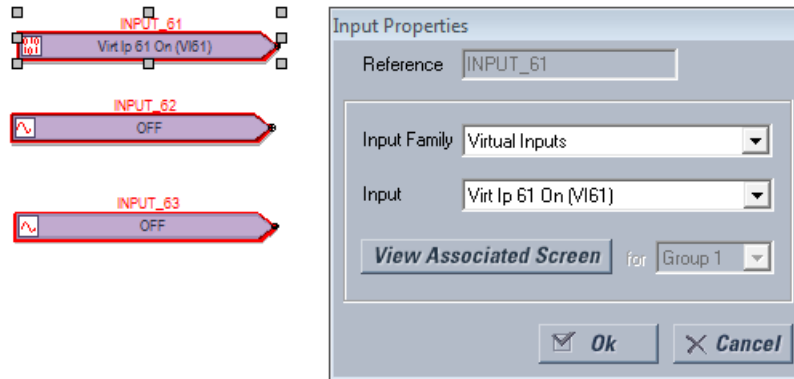
Figure 4-70: Default view of FlexLogic designer



2. Optionally delete the default logic diagram by right-clicking its tab at the bottom of the window and selecting **Delete**.
3. To add a blank sheet, click **Edit > Add Sheet**. A new tab displays. Or use the last tab displayed, which is a blank sheet.

4. Optionally right-click the new tab and **Rename** it.
5. Add the input blocks to the logic diagram. For example, click the **I/O Tokens** tab on the right, click the **Input** element, then click in the logic sheet to add it. Or drag-and-drop it.
6. Double-click the block on the sheet to configure it, selecting from the two drop-down lists. The figure shows that virtual input 61 is being added. The **View Associated Screen** button opens its settings window.

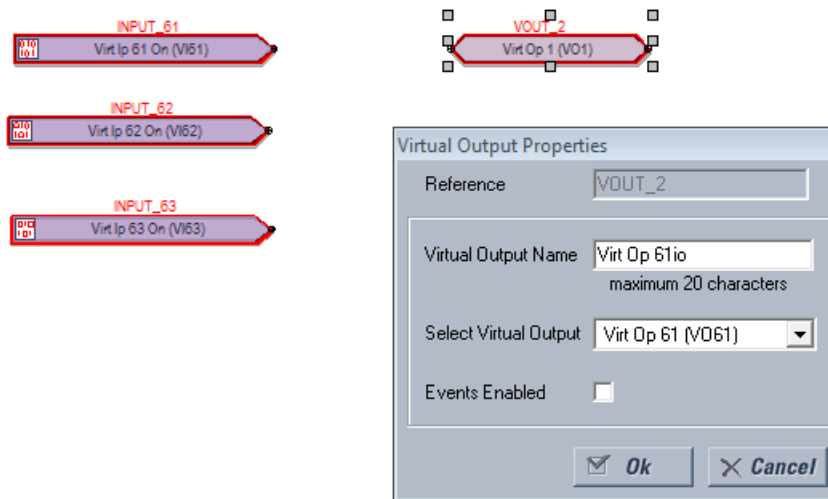
Figure 4-71: Configuring an input block



4

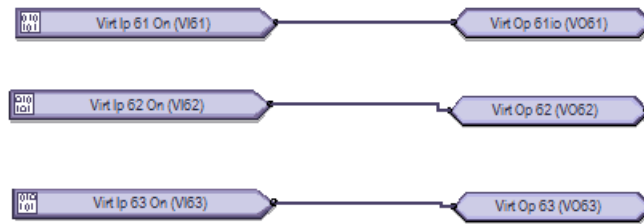
7. Add the output blocks to the logic diagram. For example, click the **I/O Tokens** tab, click the **Virtual Output** element, then click in the logic sheet to add it. Double-click the block on the sheet to configure it. For the name, make it unique. The figure shows virtual output 61 is being added, with a suffix of "io" added to the name to make it unique. Note that the outline color of a block is red until it is configured, and that this properties window varies by block and the selectable options by order code.

Figure 4-72: Configuring an output block



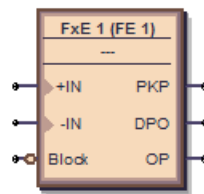
8. Connect the input blocks to the output blocks by drawing a line as follows. Click the **Drawing Tools** tab, then select the **Line** option. The cursor needs to be at the connection point to end the line, not elsewhere on the block. Note that the outline color is no longer red on the blocks.

Figure 4-73: Completed inputs and outputs



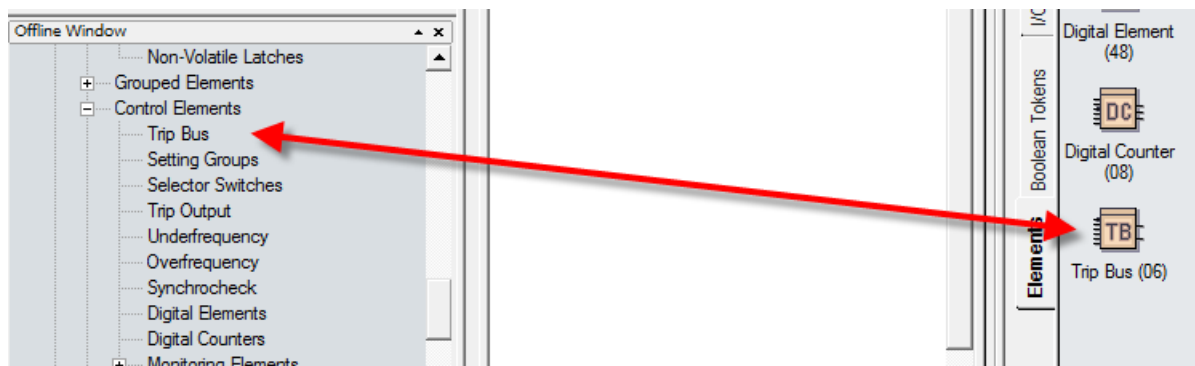
9. Add any remaining blocks or information. Right-click a block to copy and paste it. Notes are as follows.
 Add a text box — Drawing Tools > Text
 Add a FlexElement — Elements > FlexElement. An analog input is expected where a small arrow head shows in the box.

Figure 4-74: FlexElement accepts analog inputs on left side where arrow heads display



Add an Element — **Elements** tab. Available elements reflect the product, for example the **Control Elements** category.

Figure 4-75: Elements reflect Control Elements



10. Check for any blocks that have a red outline. These are invalid. Fix them before continuing, for example by configuring them.
11. Compile the logic diagram to check for errors by clicking the **Compile** button at the bottom left or by pressing the **F7** key.

If prompted about a message about sorting, click **Yes** to apply the default (for this example), which can be automatic sorting based on an algorithm that applies fastest execution time.

With successful compiling, the file is saved and the FlexLogic equations populate automatically. Scroll up through the compile messages, with the red errors being the only messages that require fixing before proceeding.

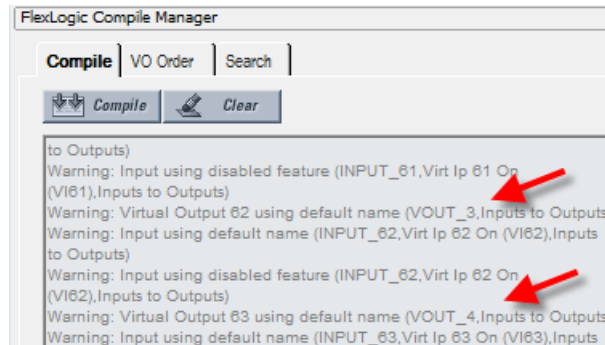
The figure shows that we forgot to add the "Io" suffix to the names of virtual outputs 62 and 63, as indicated by "Warning: Virtual output xx using default name." This warning is a minor warning.

The warning "input using disabled feature" means that input needs to be enabled. Double-click the block, click the **View Associated Screen** button, enable the setting, save, and recompile.

The output and messages are explained in the next section.

Some information displayed in the compile messages updates automatically, for example messages after a device is unplugged.

Figure 4-76: Compile and check the logic



- View the FlexLogic equations by navigating in the Offline Window area to **FlexLogic > FlexLogic Equation Editor**. The window opens with the entries displayed in the next tab.

Figure 4-77: Logic displayed in FlexLogic Equation Editor

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Inputs On	Virt Ip 61 On (VI61)
FlexLogic Entry 2	Assign Virtual Output	= Virt Op 61io (VO61)
FlexLogic Entry 3	Virtual Inputs On	Virt Ip 62 On (VI62)
FlexLogic Entry 4	Assign Virtual Output	= Virt Op 62io (VO62)
FlexLogic Entry 5	Virtual Inputs On	Virt Ip 63 On (VI63)
FlexLogic Entry 6	Assign Virtual Output	= Virt Op 63io (VO63)

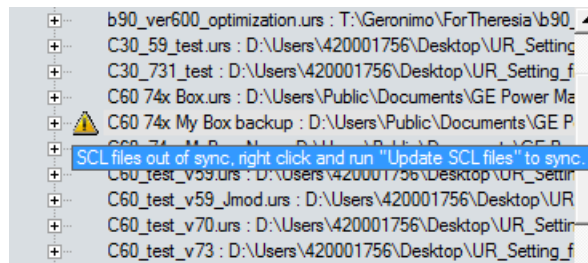
- Save the work.

The logic diagram has been created and the FlexLogic equations populated. The next steps are to upload the file to the device and to monitor the device.

4.4.1.4 Compiled results and warning messages

When a yellow caution icon displays in the Offline Window area, it means that the settings file is not synchronized with the online device. Right-click the device in the Offline Window area, and select the **Update SCL files** option. SCL refers to the Substation Configuration Language. An Instantiated IED capability description (IID) file is an example of an SCL file and contains the actual settings on a UR device.

Figure 4-78: Settings files not synchronized between offline and online files

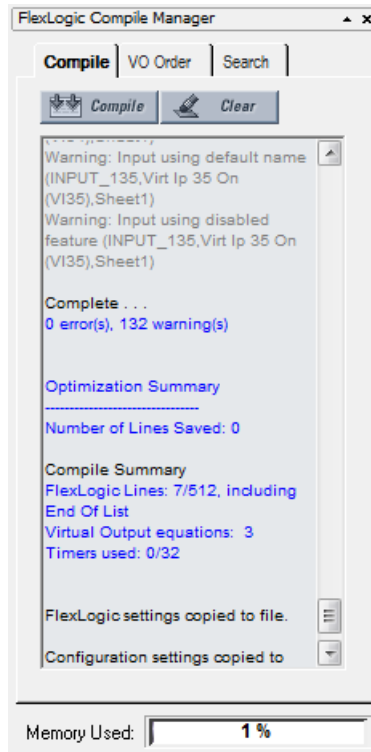


When the **Update SCL files** option is selected, the CID and IID files in the device folder are updated by the user configuration in the IEC 61850 panel and thereby become synchronized. The CID file and the IID file (depending on the preference 'Do not update IID file when updating SCL files') are updated. If the CID file is not already there, it is generated.

The location of these files is C:\ProgramData\GE Power Management\urpc, for example, in the Offline and Online folders. Any FlexLogic equations entered in the Offline Window area are erased. The logic drawn in the Logic Designer window in Engineer in the Offline Window area remain. The warning icon disappears after updating.

The following information is contained in the compile window.

Figure 4-79: Compiled results



Number of Lines Saved — The number of compiled logic lines eliminated by using the optimization algorithm, as set in the **Optimize Compiled Output** option of the Preferences. In the example shown, no lines were saved because the optimizer is disabled.

FlexLogic Lines — The number of lines that the compiled logic uses, for example seven of 512 available.

Virtual Output equations — The number of FlexLogic equations used in the Logic Designer window.

Timers used — The number of timers used in the Logic Designer window.

Memory Used — The percent of memory used in the Logic Designer window.

Errors

Table 4-3: Errors from compiling

Category	Block or gate affected	Message	Description
Error	All	Number of lines (nnn) exceeds maximum limit of 512	The compiled result exceeds the limit of 512. Reduce the number of equations to 512 or less.
Error	Tag-In	Tag-in not configured (TAG_ID, SheetReference)	A Tag-In is connected to a circuit but the Tag-In is not referencing an existing Tag-Out
Error	1 Shots	One Shot is over limit (SYMBOL_ID, SheetReference)	The number of One-Shots contained within all of the VO blocks has exceeded the maximum allowed for the firmware revision. This value can either be 0 or 32.
Error	=VO	VO has no inputs (VO_ID, SheetReference)	A Virtual Output block is located within the FlexLogic diagram and there is no block connected as input to it. Connect and identify the inputs.

Category	Block or gate affected	Message	Description
Error	Timer	Timer used more than once (TIMER_ID, SheetReference)	The same timer is used in more than one place in the editor. This means either the circuit that the Timer belongs to has been branched, or the Timer has been duplicated.
Error	Input	Unrecognized Parameter (SYMBOL_ID,Name,SheetReference)	An Input symbol is configured for an item that is not recognized by the current order code and version. Possible cause: The order code and/or version of the settings file was converted causing the input parameter to become unavailable.

Warnings

When using the 'Reset OP' operand, a warning can appear indicating that this is a disabled feature. This means that the Reset Setting's FlexLogic operand is set to OFF. Resetting of the relay can be done by pressing the reset button on the front panel of the relay or by sending a Reset command through communications.

Table 4-4: Warning messages from compiling

Category	Block or gate affected	Message	Description
Minor warning	Input	Input set to unused VO (SYMBOL_ID,Name,Sheet)	An Input symbol is using an unassigned Virtual Output
Major warning	Tag-Out	Tag-out not connected (TAG_ID,Sheet)	A Tag-Out symbol has no input
Major warning	All	Symbol not connected (SYMBOL_ID,Name,Sheet)	A symbol's input and/or output is not connected and is not part of a VO block. Draw the input and/or output to the block.
Minor warning	=VO	Virtual Output n using default name (VO_ID,Sheet)	The Assigned Virtual Output is using the default name. Change the name.
Minor warning	Input	Input using default name (SYMBOL_ID,Name,Sheet)	An Input symbol is using a Contact Input, Contact Output, Digital Element, FlexElement, or Digital Counter set to the default name. Change the name so that it is unique.
Setting warning	Input	Input using disabled feature (SYMBOL_ID,Name,Sheet)	An Input symbol is using a disabled Virtual Input, Contact Input, Digital Element, FlexElement, Digital Counter, Control Pushbutton, Programmable Pushbutton, Contact Output, or Protection/Monitoring Element. Enable it and try again.
Major warning	Input	Input set to OFF (SYMBOL_ID,Sheet)	An Input symbol is set to OFF
Major warning	Input	Input set to ON (SYMBOL_ID,Sheet)	An Input symbol is set to ON
Setting warning	Input	Contact Output Operate is OFF (SYMBOL_ID, Contacts)	The symbol block is using the default setting of OFF
Setting warning	Input	Contact Output Seal-In is OFF (SYMBOL_ID, Contacts)	The symbol block is using the default setting of OFF

4.4.1.5 Rapidly add logic blocks in sequence

Blocks are added by clicking an element then clicking in the drawing area, or by dragging and dropping the element onto the canvas. Blocks can be added rapidly in sequence, for example when you have inputs 1 to 10, without having to select the element each time.

To rapidly add logic blocks:

1. In Engineer, click **File > Preferences**. The window opens.
2. Click the **Editor** entry.
3. Enable the **Repeat Symbol** check box.
4. Click the **Ok** button to save and exit from the window.
5. In the logic diagram, select an element, then click in the drawing area to add it, click again to add a second box, and so on.



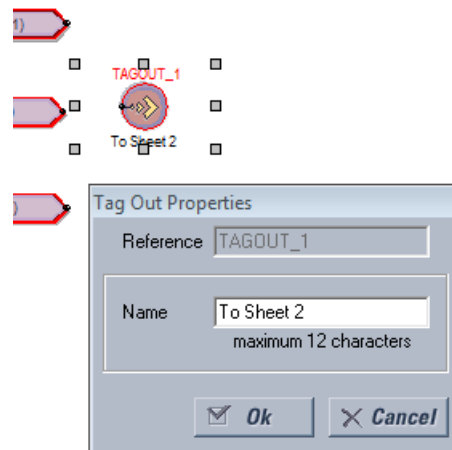
4.4.1.6 Connect two logic diagrams

When the logic is complex and requires two sheets, for example, these two sheets can be connected. By connecting them, the logic is continuous from one sheet to the next.

To connect two logic diagrams:

1. In the first sheet, click the **I/O Tokens** tab.
2. Scroll to the bottom, and click and drag the **Tag Out** element to the sheet where the next sheet is to connect.
3. Double-click the element and in the window that opens, give it a name, such as "To Sheet 2" or "To IO Sheet 2."

Figure 4-80: Connecting sheet 1 to sheet 2



4. In the second sheet, click and drag the **Tag In** element to the sheet where the first sheet is to connect.
5. Double-click the element and in the window that opens, select the first sheet from the drop-down list to connect the two sheets.
6. Save the work.

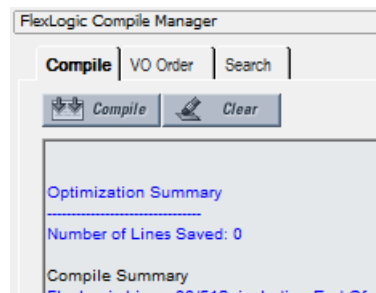
4.4.1.7 Optimize the logic

The number of available FlexLogic entries depends on firmware, for example 515 or 1024 lines. The software can automatically optimize a logic diagram to reduce space and free up entries.

To optimize the logic:

1. In Engineer, under **File > Preferences**, select the **Compiler** option. Ensure that the **Optimize Compiled Output** option is enabled.
2. Run the compiler again, for example by clicking the **Compile** button at the bottom left of the software. The results display in the Optimization Summary. Changes also display when the FlexLogic Equation Editor is accessed. The logic diagram does not change. In the example shown, no lines were saved to free up space.

Figure 4-81: Code optimization results



4.4.1.8 Change logic order

The order in which the FlexLogic is populated in the FlexLogic Equation Editor window depends on settings.

First, when automatic sorting is not enabled, the sequence in which the blocks were drawn is followed.

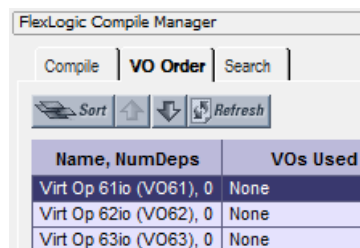
Second, the order in which equations are executed can be manually changed, as outlined here.

Third, automatic sorting can be set in preferences, as outlined here. It is enabled by default and means that an algorithm is implemented to give best results and quickest performance. For example, the block with the fastest execution time is entered first in the FlexLogic. When two block functions have the same execution time the block drawn first displays first in the FlexLogic. For example, drawing input 61 to output 61, then input 62 to output 62 causes the input/output 61 to be entered into the FlexLogic first. Automatic sorting takes precedence over manual sort; if you enable this option, manual sorting is not implemented.

To manually change logic order:

1. In the compile area, click the **VO Order** tab.
2. If the window is blank, click the **Refresh** button.
3. Select an entry and click the up or down arrow. To cancel any manual changes, click the **Sort** or **Refresh** button.
4. Recompile. The change is not executed or saved if automatic sorting is enabled.

Figure 4-82: Ordering FlexLogic entries



To set automatic sorting:

1. In Engineer, under **File > Preferences**, select the **Compiler** option. The **Automatically Sort VOs** option means that the block with the fastest execution time is entered first in the FlexLogic. When two block functions have the same execution time the block drawn first displays first in the FlexLogic. For example, drawing input 61 to output 61, then input 62 to output 62 causes the input/output 61 to be entered into the FlexLogic first.

4.4.1.9 Search logic

Items that can be searched in a logic diagram include gates, Input, Contact Input, Contact Output, Timer, Virtual Output, Tag In, Tag Out, and User-programmable LED. A search can be performed while designing or monitoring.

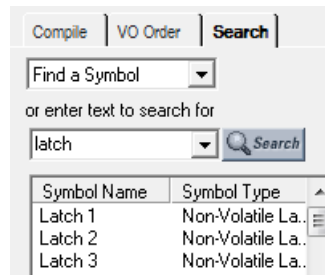
To search:

1. In the compiler area of Engineer, click the **Search** tab.
2. Use one of the following methods to set search criteria:
 - Select an element from the first drop-down list. Results display automatically.
 - Type in the second text string box, or select any of the 32 previous searches from the drop-down list. Click the **Search** button. Any results display.

The search applies to all tabs, not just the active tab.

3. Double-click a search result to view the item.

Figure 4-83: Search function



You can also select an element from the drop-down list on the toolbar. It is then highlighted in the logic diagram.



4.4.1.10 Exclude sheet from compile

While designing the FlexLogic equations, entire sheets can be removed from the compile logic. This allows the user to test various schemes by placing schemes on separate sheets and including either sheet at compile time.

To exclude a sheet:

1. In the Logic Designer window, right-click the tab and select the **Exclude from Compile** option so that the check mark displays. When sheets are excluded, a message displays with each compile that "excluded sheets will not be reflected in the RPN." An excluded sheet is denoted with end brackets, similar to < Sheet 1 >.

Figure 4-84: Excluding a tab from compiling

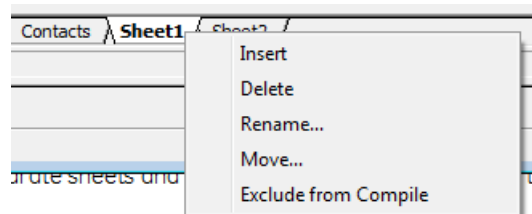
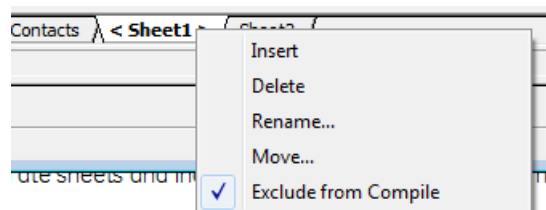


Figure 4-85: Tab excluded from compiling



4.4.2 Send file to and from device

With the logic diagram created, compiled, and errors eliminated, the FlexLogic can be sent to a live device. And, conversely, a file from a live device can be added to the Offline Window area for additional work.

To send a file to a device:

1. In the Offline Window area of the software, right-click the device name and select the **Write Settings to Device** option. A prompt can appear that the URS file has been repaired; acknowledge the message.
2. When a window opens, select the device to which you want to send the file, then click the **Send** button and confirm. The order codes must match. The file is sent to the live device. Any errors can be viewed in the log file at the prompt.

To import a file from a device:

1. Close all open files in Engineer that relate to the device, else a message displays to that effect, for example to close the FlexLogic view associated with the file. When the file is not associated with a live device, a message displays to that effect; you need to identify the device to which you want to send the file. The order codes must match.
2. Right-click the device in the Online Window area and select the **Add Device to Offline Window** option. After you enter a name for the file, it is written to the Offline Window area.

4.4.3 Monitor logic

After creating the logic diagram, validating it, and uploading the FlexLogic to a device, the results from the device can be viewed.

The following checks are performed automatically when switching from design to monitoring, and prompts display when necessary:

- Verify that the order code of the linked relay matches the settings file
- Verify that the version of the linked relay matches the settings file
- Verify that the FlexLogic Equation Editor of the linked relay matches the settings file. Solution: Compile the FlexLogic logic diagram and send the settings file to the relay.
- Verify that the FlexLogic Timers of the linked relay match the settings file. Solution: Compile the FlexLogic logic diagram and send the settings file to the relay.
- If the settings file contains a serial number lock, then verify that the serial number of the linked relay matches the settings file

To view results:

1. In the Offline Window area of the software, expand the **Engineer** entry for the device.
2. Double-click the **Logic Designer** entry and **Compile** the logic.
3. Double-click the **Logic Monitor** entry, or click the **M** button in the toolbar at the top of the window. With successful launch, the logic displays and a green indicator displays at the bottom of the tab.

When the file is not associated with a live device, a message displays to that effect; you need to identify the device to which you want to send the file. The order codes must match between the Offline Window and the Online Window.

When the device is offline, a message indicates problems communicating with the device.

When the devices are not synchronized, a message indicates the FlexLogic does not match the settings file. To send the offline file to the device, right-click the device name and select the **Write Settings to Device** option.

When the state of a symbol is OFF, the symbol is shown in the default color or no color.

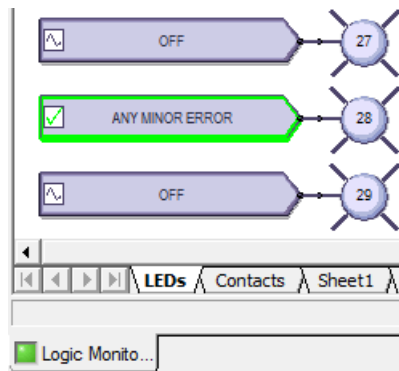
When a symbol's state changes to ON, the symbol and connection line turns green.

The state of some symbols can either be unknown or the state transitions faster than the update interval. For these two cases, the state of the symbol is considered 'UNKNOWN' and the symbol is outlined in red.

The colors for the ON and Unknown state can be customized in the Preferences.

The figure shows that the software is communicating with devices (square green indicator) and that a minor error is present (green box outline). In this case, the battery is weak and needs to be replaced. This can be viewed as the Replace Battery message on the front panel of the device and in the EnerVista software under **Actual Values > Front Panel > Front Panel** or **Display/Keypad**.

Figure 4-86: Monitoring a device, with minor error caused by weak battery



4.4.4 View front panel and print labels

This window displays the LEDs that are on the front panel. You can create labels and print them for the device. You do not use the window to add text labels and upload them to the device. Custom labelling is also outlined earlier in this chapter; see the Front Panel Labelling section.

To view the front panel:

1. In the Offline Window area of the software, expand the **Engineer** entry for the device.
2. Double-click the **Front Panel Report** entry. The report displays. The Device Summary is read from the settings file and cannot be changed. The LEDs and pushbuttons display below the summary.
3. To save the report, click **File > Save As**, enter a file name, and select the front panel report (FPR), JPG, or PDF format.

Figure 4-87: Front panel display in Engineer

Device Summary	
Device Name	Relay-1
Description	none
Order Code	B30-TD4-HLH-F8N-H6L-L8N-N6L-S8L-U6L-WXX
Firmware Version	7.30
Serial Number	No serial number lock - See File Properties
Communications	0. 0. 0. 0 : 502, Slave 254
Setting File Name	B30_test_v73_T.urs

March 17, 2016 11:04

Page 1 of 2

CONDITION	CONDITION	CONDITION
Virt Op 2 On (V02)		
Label one		
Label two		
LEDS 01 - 08	LEDS 09 - 16	LEDS 17 - 24
CONDITION	CONDITION	CONDITION

To print labels:

1. In the **Front Panel Report** window, double-click an LED or pushbutton and enter text.
2. To print the labels, click the **Print** icon on the toolbar.
3. To save the report and labels, click **File > Save As**, enter a file name, and select the FPR, JPG, or PDF format.
4. Use the instructions in the second tab of the window to add the labels to the physical device.

4.4.5 Generate connectivity report

This report displays basic information about a device, such as order code, port numbers, inputs and outputs. You can use it to create a PDF file of basic information. The report is based on CID and/or IID files, and not the system or full SCD. All device details including Remote Inputs, Remote Outputs, and Analog Inputs/Outputs are indicated, including quantities used and available.


To display a device report:

1. In the Offline Window area of the software, expand the **Engineer** entry for the device.
2. Double-click the **Device Connectivity Report** entry. The report displays.
3. To save as a PDF file, click **File > Save As**.

Figure 4-88: Device Connectivity Report

4

Device Connectivity Report



Device Information		
Filename / Device Name	Order Code / Revision / Serial Nr.	File Details
D30_test_v73.urs Relay-1	D30-U03-HLH-F8L-H6L 7.3x No serial number lock - See File Properties	Size: 2683 KB Last Modified Date: 15.11.2016 23:29:41 Path: D:\Users\... \Desktop\JR_Setting_files\JR_Setting_files\D30_test_v73\

Device Details		
Physical Ports Available	Port Settings	Services / Protocols
RS232	RS232 Baud Rate: 115200	DNP 3.0
RS485	RS485 Baud Rate: 115200	IEC 60870-5-104
2 * 100BaseFX Eth, Multimode, SFP with LC	Port1 IP: 3. 94.244.210	IEC 61850
1 * 100BaseT Eth, Multimode, SFP with RJ-45	Port2 IP: 127. 0. 0. 1	EGD

4.4.6 Preferences

Preferences determine functionality. As such, you are encouraged to review them. This section outlines some options available in the menus and preference panels.

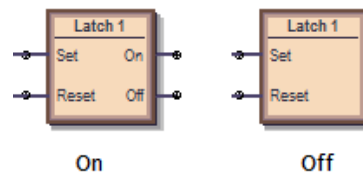
Access them in the **Logic Designer** panel under the **View** menu and under **File > Preferences**. The Logic Designer and Logic Monitor preferences are outlined here, not all preferences for a device.

4.4.6.1 View menu

View > Toolbar > Advanced Actions — Active when in Logic Designer. Toggles a toolbar to nudge, rotate, flip, or change the order of an element.

View > Show Unused Pins — Enable to display unconnected pins. Disable to eliminate unconnected pins from the view, for example when printing.

Figure 4-89: Unused pins on and off



4.4.6.2 Logic designer

The path is **File > Preferences > Logic Designer**.

Workbook Setup

Size and Units

Size and Units — Changes the size of diagram area displayed in Engineer. If you set the size to be smaller than an existing logic diagram, the content is cut off.

WorkBook

Print Scale — The scale for logic diagram when printing. Scaling a large diagram to 200 percent, for example, results in the diagram being cut off.

Orphan Protection — When enabled, the printing output prevents Virtual Output circuits from spanning more than a single page. The largest Virtual Output circuit is scaled to fit on a single page and all remaining Virtual Output circuits are scaled so that all circuits are printed using the same scale.

Show Title Block — When enabled, places an information box at the bottom right of the diagram when printing. Enter the information in the **File Information** panel.

Show Sheet Name — When enabled, shows Sheet 1, Sheet 2, or any other name at the top of the logic diagram when printing.

Start Sheet On New Page — Places the sheet on the next page when printing.

Show Notes Selection — When other than None, prints the text from any information notes added to the document (under **Drawing Tools** tab > **Note**). The text is printed after the logic diagram.

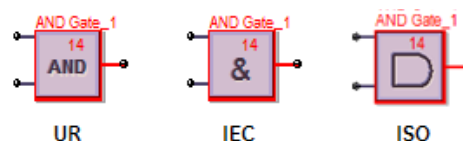
File Information

The text entered here displays at the bottom right of a diagram when printing, provided that the **Show Title Block** option is enabled. Note the option to change the logo from the GE logo to your company logo.

Display

The panel sets how the element boxes display. The figure shows how an AND gate displays when the UR default, IEC, or ISO symbol type is selected.

Figure 4-90: AND gate varies by standard selected



Symbol Style — IEC, ISO, UR Setup — Sets how the gates display in the logic diagram.

Symbol Color — When set to Black & White, only logic blocks with issues continue to display red.

Zoom Operation — Determines what happens when the **View > Zoom** functions are used. When set to Sheet Only and the zoom is changed, the single tab changes. When set to Workbook, all tabs change.

Editor

Repeat Symbol — Enable this feature to add element blocks rapidly in sequence, for example when you have inputs 1 to 10, without having to select the element each time. Select the element block from the toolbox, click the diagram, then continue to click to add additional blocks.

Use first available VO / Timer — When enabled and you copy and paste a virtual output or timer element, the numbering continues in sequence. For example, you copy timer 5 and paste it as timer 6. When disabled and you copy and paste a virtual output or timer element, the same number is used. For example, you copy timer 5 and paste it as timer 5.

Auto-Save Logic Designer every x minutes — Logic diagrams with changes are saved automatically according to this interval. The range is 5 minutes (default) to 30 minutes. With auto-save, the file extension of the saved file is .auto. This file remains until you save the file manually.

Auto Populate

These options work in the **Edit > Auto Populate Workbook** function.

VOs per Worksheet — When an existing settings file is opened in the Logic Designer, the Logic Designer populates the canvas and attempts to evenly distribute the Virtual Output circuits across multiple sheets. A value of 100 in this setting places all FlexLogic equations on a single sheet until there are 100, then the next ones are placed on another sheet. A value of 1 places each Virtual Output circuit on a separate sheet.

Show / FlexLogic Merge / Show Unused — If Show Contact Outputs and Show LEDs are selected, for example, the function places Contact Output and User-programmable LED symbols for settings that are configured. If you disable the LED check boxes, then the LED tab/sheet does not display when you next open the Logic Designer window. The settings apply to all products, not just the active window when it is next opened. Close then reopen the Logic Designer window for the setting to take effect.

Compiler

Show Warnings — Options to filter the messages that display when logic compiles.

Minor — Enable to display minor errors. An example is using the default values of an element added to the diagram, such as the name of the element. An example is "Warning: Virtual output xx using default name," for which you simply click into the element to rename it.

Major — Enable to display major errors. Examples are an input that does not have a corresponding output, using disabled features, and failing to connect a symbol. Fix these errors.

Setting — Enable to display error message related to settings, such as an improperly configured setting, such as using ON or OFF.

Automatically Sort VOs — When enabled, the logic is compiled with an algorithm to give best results and quickest performance, for example the fastest logic first. The fastest logic displays in the FlexLogic Equation Editor output as the first entries in the table. Use sorting when virtual outputs have dependencies on other virtual outputs. This setting takes precedence over order set manually in the **VO Order** tab in the compiler. When disabled, the sequence in which the blocks were drawn is followed.

Optimize Compiled Output — With this option enabled, the software automatically optimizes a logic diagram to reduce space and free up FlexLogic entries. Run the compiler again, for example by clicking the **Compile** button at the bottom left of the software. The number of saved lines displays in the Optimization Summary. Changes also display when the FlexLogic Equation Editor is accessed. The logic diagram does not change.

4.4.6.3 Logic monitor

Display

The software displays the color specified when an element is on. There is no color when the element is off.

The software displays another color when the status cannot be determined and is unknown.

Timing

Timing Information can be displayed in the monitoring window. This timing information is only an approximate representation of how Engineer sees transitions. Use the device's Event Record to view accurate timing information.

The timing information can also be streamed to a comma-separated values (CSV) spreadsheet.

The timing information displayed and recorded can be filtered based on six categories. If a category is not selected, any timing information related to that category does not display and is not recorded to the CSV file.

Show Timing Information in Output Window — Enable to display times in the monitoring window.

Because of the update rate of the Logic Monitoring, the timing information cannot be used as an accurate representation of the events that occur within the relay. Use instead the device's event record. Timing information can be delayed by 30 seconds.

Save Timing Information to CSV File — Enable to write timing information in a spreadsheet. The timing information is recorded in a text file that uses commas to separate each of the fields. This file uses the extension CSV that is supported by any spreadsheet application.

Every change written to the CSV file requires a timestamp.

The format for the timing information in the output window is as follows:

```

yyy/mm/dd hh:dd:ss
  devicename offline
yyy/mm/dd hh:dd:ss
  devicename ONLINE
yyy/mm/dd hh:dd:ss
  VO1: Virt Out 1- 0
  VI4: Virt In 4- 1
  DI3: Direct In 3- 0
  RI2: Remote In 2- 1
  H5a: Contact In 1- 1
  H1: Contact Output 1- 0

```

Data is only appended to the CSV file. The format for the data is as follows:

```

yyy/mm/dd hh:dd:ss, devicename, offline
yyy/mm/dd hh:dd:ss, devicename, ONLINE
yyy/mm/dd hh:dd:ss, VO1: Virt Out 1, 0
yyy/mm/dd hh:dd:ss, VI4: Virt In 4, 1
yyy/mm/dd hh:dd:ss, DI3: Direct In 3, 0
yyy/mm/dd hh:dd:ss, RI2: Remote In 2, 1
yyy/mm/dd hh:dd:ss, H5a: Contact In 1, 1
yyy/mm/dd hh:dd:ss, H1: Contact Output 1, 0

```

Options display for filtering, such as recording timing for Virtual Inputs and Outputs, but not Communications Status.

4.4.6.4 COMTRADE waveforms

Waveform files are viewable in the EnerVista software. The preferences are unrelated to Engineer and are outlined in the UR Family Communications Guide.

4.4.7 Toolbars

These are toggled in the **View > Toolbar** menu.

The UR symbols are displayed for the toolbox icons. They change when the default setting is changed to IEC or ISO symbols. The symbols displayed in the toolbox also vary by firmware version, reflecting what is supported for each release.

4.4.7.1 FlexLogic Editor toolbar











	New Device	Create a new settings file
	Open File	Open an existing settings file in the URS, CID, or IID format
	Save FlexLogic	Save the Logic Designer diagram
	PDF Report	Create a PDF document from Logic Designer diagram(s). Settings can be changed under File > Preferences > Workbook Setup .
	Toggle Compile Window	Display or hide the compile window area
	Sort Order	Select to change the sort order of the Virtual Output list to the right of the icon. Virtual Outputs can be sorted numerically in ascending and descending order based on numbers and names.
	Select VO to View (x - x)	Select a Virtual Output to locate and select it in the workbook. Each Virtual Output listed also contains the name of the sheet where the Virtual Output is located.
	Edit Mode Logic Designer	Switch to Logic Designer mode
	Monitor Mode Logic Monitor	Switch to Logic Monitor mode
	Turn On ALL Communications	Turn on all communications to all Logic Designer diagrams that are in the monitoring mode. Default upon each launch of Engineer.
	Turn Off All Communications	Turn off all communications to all Logic Designer diagrams that are in the monitoring mode. This is a legacy function for serial communication to turn off communication to devices. Turning off communication applies to the current session only. When you re-launch the EnerVista software, communication is on by default.

4.4.7.2 Token Toolbox

Drawing Tools

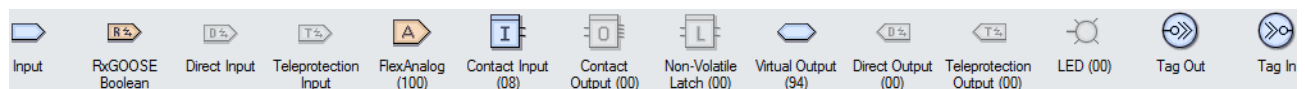






	Draw a line. Click and drag to draw.
	Draw multiple joined lines. Click and drag for each line. Double-click to finish.

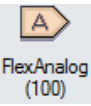
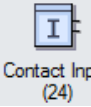
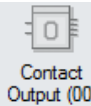
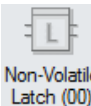

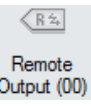
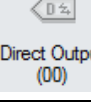
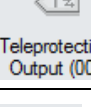
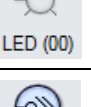

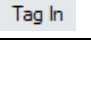
 Polygon	Draw multi-sided object. Click for each line. Double-click to finish.
 Rectangle	Draw four-sided object. Click and drag to draw.
 Polycurve	Draw multiple curves. Click for each line. Double-click to finish.
 Closed Curve	Draw multiple, closed curves. Click for each line. Double-click to finish.
 Ellipse	Draw oval or circle. Click and drag to draw.
 Text	Add text box with rectangle around it. Click to add. Double-click it to change text.
 Image	Add figure. Select file in the window that opens, then click on diagram canvas to add figure.
 Note	Add note icon and text. Click to add. Double-click to edit the title and text.

I/O Tokens

These are parts used in FlexLogic equations. They are the inputs and outputs of the Virtual Output equations. The display can vary from that shown here.













 Input	Input symbol that can be configured to any FlexLogic operand value
 RxGOOSE Boolean	Remote inputs from other devices
 Direct Input	Input from another UR device. Teleprotection inputs/outputs and direct inputs/outputs are mutually exclusive and cannot be used simultaneously.
 Teleprotection Input	Teleprotection inputs/outputs and direct inputs/outputs are mutually exclusive and cannot be used simultaneously.

	FlexAnalog symbol that can be used as the input to a FlexElement or use the FlexAnalog symbol to monitor an actual value when in logic Monitoring mode
	Contact Input Gate is similar to the Input symbol but is restricted to the operands associated with a Contact Input
	Contact Output Gate is similar to the Input symbol but is restricted to the operands associated with a Contact Output. The Operate and Seal-In settings can be configured graphically.
	The Non-Volatile Latch is similar to the Input symbol but is restricted to the operands associated with a Non-Volatile Latch. The Set and Reset settings can be configured graphically.
	The final output of an equation is a numbered register called a virtual output. Virtual outputs can be used as an input operand in any equation, including the equation that generates the output, as a seal-in or other type of feedback.
	Place and configure a Remote Output. The UR's order code and firmware version then determine the availability of the Remote Output.
	Place and configure a Direct Output. The UR's order code and firmware version then determine the availability of the Direct Output to another UR device.
	Place and configure a Teleprotection Output. The UR's order code and firmware version then determine the availability of the Teleprotection Output.
	Place a User Programmable LED in the Logic Designer diagram. Not applicable when using a graphical front panel.
	A Tag Out can be used in 1 of 2 ways. The first use of the Tag Out is to break up logic that needs to span several sheets. The second use of the Tag Out is to associate a frequently used block of code with the Tag Out and then repeatedly use the same block of code using a Tag In. When a Tag Out is referenced more than once, the Tag Out is replaced with a Virtual Output during the compile phase.
	Tag-In can be used to reference an existing Tag-Out. It joins another diagram to a previous diagram.

Boolean Tokens

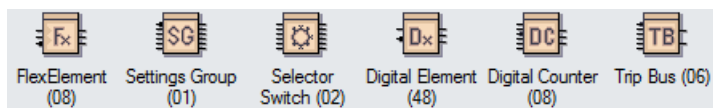
These symbols are used to create FlexLogic Equations. Use them as intermediate logic for the Virtual Output equations. The display can vary from that shown here.








 OR Gate	Place an OR gate in the Logic Designer diagram. Only one action needs to occur. Any function input on the left side satisfies the condition. The number of inputs is configurable from two to 16.
 AND Gate	Place an AND gate in the Logic Designer diagram. Multiple actions need to occur. All functions input on the left side are required to satisfy the condition. The number of inputs is configurable from two to 16.
 NOR Gate	Place a NOR gate in the Logic Designer diagram. Gives the value of one when all input operands have a value of zero and otherwise gives a value of zero. It gives an output signal when there are no input signals. An inverter that reverses the logic state. The number of inputs is configurable from two to 16.
 NAND Gate	Place a NAND gate in the Logic Designer diagram. Gives the value of zero when all input operands have a value of one and otherwise gives a value of one. It gives an output signal until all signals are present on its inputs. An inverter that reverses the logic state. The number of inputs is configurable from two to 16.
 XOR Gate	Place a XOR gate in the Logic Designer diagram, which is two exclusive OR gates. Only one action needs to occur. If there are two inputs or there is no input, there is no output.
 NOT Gate	Place a NOT gate in the Logic Designer diagram. Gives the value of one when the input operand has a value of zero and otherwise gives a value of zero. It gives an output signal when there is no input signal. An inverter that reverses the logic state.
 Latch	Place a latch in the Logic Designer diagram. A latch has two inputs and one output. One input is the Set input, and other input is the Reset input.
 Positive One Shot	Place a positive one shot symbol that responds to a positive going edge in the Logic Designer diagram. A "one shot" is a single input gate that generates a pulse ins response to an edge on the input.
 Negative One Shot	Place a negative one shot symbol that responds to a negative going edge in the Logic Designer diagram
 Dual One Shot	Place a positive one shot and a negative one shot symbol in the Logic Designer diagram
 Timer (32)	Place a timer in the Logic Designer diagram

Elements














These blocks configure properties of the element or use element operands as input to FlexLogic equations.




 FlexElement (08)	Place and configure a FlexElement. A FlexElement is a universal comparator used to monitor any analog actual value calculated by the relay or a net difference of any two analog actual values of the same type.
 Settings Group (01)	Place and configure the Settings Group settings
 Selector Switch (02)	Place and configure a Selector Switch element. Firmware version determines feature availability. The Selector Switch element is intended to replace a mechanical selector switch. Typical applications include setting group control or control of multiple logic sub-circuits in user-programmable logic. The element provides for two control inputs.
 Digital Element (48)	Place and configure a Digital Element. A Digital Element can monitor any FlexLogic operand and present a target message and/or enable events recording depending on the output operand state.
 Digital Counter (08)	Place and configure a Digital Counter element. A Digital Counter counts the number of state transitions from Logic 0 to Logic 1. The counter is used to count operations such as the pickups of an element.

4.4.7.3 Basic Actions toolbar



	Select	Select components. Click one component and hold down the CTRL key to select others. Or click and drag an area that contains multiple components to select.
	Edit Vertices	Shows vertices points for the component selected (if the component support vertices manipulation)
	Properties	Shows the properties of the selected component
	Zoom Normal	Zoom in and center the screen to the spot selected
	Zoom to Fit	Zoom in to a magnitude that fits your entire schema layout on your entire screen
	Zoom Custom	Zoom in on the components that you have selected
	Pan	Move the viewable area of your screen around the schema. To activate, select this tool and then place the hand icon over and part of your schema. Click and drag the hand in a direction to move around the schema.
	Align Top, Middle, Bottom	Align the selected components to the top, middle, or bottom of the reference component
	Align Left, Center, Right	Align the selected components to the left, middle, or right of the reference component
	Space Across	Evenly space the selected components across a horizontal axis, starting from the far left component and ending at the far right component
	Space Down	Evenly space the selected components across a vertical axis, starting from the top component and ending at the bottom component
	Same Width	Set the width of the selected components to the same width as the reference component
	Same Height	Set the height of the selected components to the same height as the reference component









	Same Size	Set the width and height of the selected components to the same width and height of the reference component
---	-----------	---

4.4.7.4 Advanced Actions toolbar



Only basic objects (lines, rectangles, ellipses) can be rotated and flipped.

Only objects from the Drawing Toolbar can be structured (grouped, ungrouped, forward, backward).

	Nudge Up, Down, Left, Right	Moves selected component one pixel upward, downward, left, right
	Rotate	Rotates selected component freely. Once selected, put your mouse cursor over the component and move the component clockwise or counter-clockwise depending on what you need.
	Rotate Left, Right	Rotates selected component 90 degrees counter-clockwise or clockwise
	Flip Vertical	Flips the selected component on the vertical axis
	Flip Horizontal	Flips the selected component on the horizontal axis
	Group, Ungroup	Combines all selected components into one combined entity. Ungroups them into separate components.
	Front, Back	Moves current components to the absolute front or back of all viewable layers
	Forward, Backward	Moves current components on layer higher or lower than its original layer hierarchy

4

L30 Line Current Differential System

Chapter 5: Settings

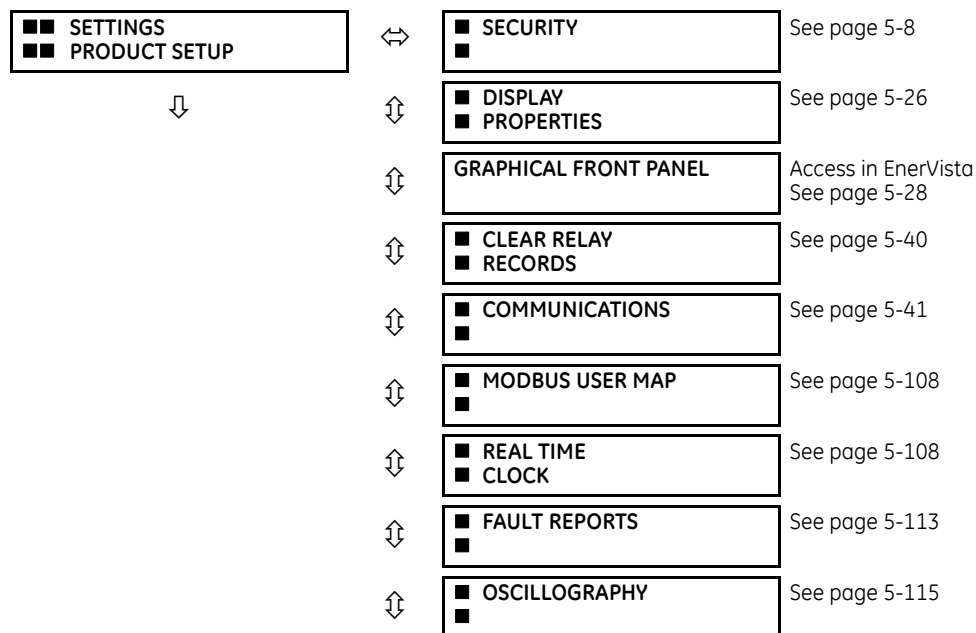
This chapter outlines front panel and/or software settings. The relay is not taken out of service when saving settings; the relay is taken out of service when a settings file is written to it.

Settings can be viewed remotely in a web browser by entering the IP address of the relay, accessing the **Device Information Menu** option, then the **Front-Panel Display Report** option.

When indicated that a restart is required for a setting change to take effect, use the **Maintenance > Reboot Relay Command** in the software.

Settings file conversion from previous firmware versions is supported. See the Maintenance chapter.

5.1 Settings menu



	↑			
		↑	■ ■ DATA LOGGER ■	See page 5-117
		↑	■ ■ USER-PROGRAMMABLE ■ ■ LEDS	See page 5-119
		↑	■ ■ USER-PROGRAMMABLE ■ ■ SELF TESTS	See page 5-123
		↑	■ ■ CONTROL ■ ■ PUSHBUTTONS	See page 5-123
		↑	■ ■ USER-PROGRAMMABLE ■ ■ PUSHBUTTONS	See page 5-125
		↑	■ ■ FLEX STATE ■ ■ PARAMETERS	See page 5-131
		↑	■ ■ USER-DEFINABLE ■ ■ DISPLAYS	See page 5-132
	↑	↑	■ ■ INSTALLATION ■	See page 5-133
■ ■ REMOTE RESOURCES ■ ■	↔	↔	■ ■ ■ ■	Access in EnerVista See page 5-134
■ ■ SETTINGS ■ ■ SYSTEM SETUP	↔	↔	■ ■ AC INPUTS ■ ■	See page 5-135
	↓	↑	■ ■ POWER SYSTEM ■ ■	See page 5-136
		↑	■ ■ SIGNAL SOURCES ■ ■	See page 5-137
		↑	■ ■ 87L POWER SYSTEM ■ ■	See page 5-140
		↑	■ ■ BREAKERS ■ ■	See page 5-146
		↑	■ ■ SWITCHES ■ ■	See page 5-152
		↑	■ ■ FLEXCURVES ■ ■	See page 5-157
	↑	↑	■ ■ PHASOR MEASUREMENT ■ ■ UNIT	See page 5-164
■ ■ SETTINGS ■ ■ FLEXLOGIC	↔	↔	■ ■ FLEXLOGIC ■ ■ EQUATION EDITOR	See page 5-202
	↓	↑	■ ■ FLEXLOGIC ■ ■ TIMERS	See page 5-202
		↑	■ ■ FLEXELEMENTS ■ ■	See page 5-202
	↑	↑	■ ■ NON-VOLATILE ■ ■ LATCHES	See page 5-206
■ ■ SETTINGS ■ ■ GROUPED ELEMENTS	↔	↔	■ ■ SETTING GROUP 1 ■ ■	See page 5-207
	↓	↑	■ ■ SETTING GROUP 2 ■ ■	
		↑	■ ■ SETTING GROUP 3 ■ ■	

	⇅	■ ■ SETTING GROUP 4 ■	
	⇅	■ ■ SETTING GROUP 5 ■	
↑	↑	■ ■ SETTING GROUP 6 ■	
■ ■ SETTINGS ■ ■ CONTROL ELEMENTS	↔	■ ■ TRIP BUS ■	See page 5-258
↓	⇅	■ ■ SETTING GROUPS ■	See page 5-260
	⇅	■ ■ SELECTOR SWITCH ■	See page 5-261
	⇅	■ ■ UNDERFREQUENCY ■	See page 5-268
	⇅	■ ■ FREQUENCY RATE ■ OF CHANGE	See page 5-269
	⇅	■ ■ SYNCHROCHECK ■	See page 5-271
	⇅	■ ■ AUTORECLOSE ■	See page 5-276
	⇅	■ ■ DIGITAL ELEMENTS ■	See page 5-282
	⇅	■ ■ DIGITAL COUNTERS ■	See page 5-285
↑	↑	■ ■ MONITORING ■ ■ ELEMENTS	See page 5-287
■ ■ SETTINGS ■ ■ INPUTS / OUTPUTS	↔	■ ■ CONTACT INPUTS ■	See page 5-301
↓	⇅	■ ■ VIRTUAL INPUTS ■	See page 5-303
	⇅	■ ■ CONTACT OUTPUTS ■	See page 5-304
	⇅	■ ■ VIRTUAL OUTPUTS ■	See page 5-307
	⇅	■ ■ RESETTING ■	See page 5-307
	⇅	■ ■ DIRECT INPUTS ■	See page 5-308
↑	↑	■ ■ DIRECT OUTPUTS ■	See page 5-309
■ ■ SETTINGS ■ ■ TRANSDUCER I/O	↔	■ ■ DCMA INPUTS ■	See page 5-310
↓	⇅	■ ■ RTD INPUTS ■	See page 5-311
↑	↑	■ ■ DCMA OUTPUTS ■	See page 5-312
■ ■ SETTINGS ■ ■ TESTING	↔	TEST MODE FUNCTION: Disabled	Range: Disabled, Isolated, Forcible See page 5-316

↓	⇅	TEST MODE FORCING: On	Range: FlexLogic operand See page 5-316
	⇅	■ PMU ■ TEST VALUES	See page 5-317
	⇅	■ FORCE CONTACT ■ INPUTS	See page 5-318
	⇅	■ FORCE CONTACT ■ OUTPUTS	See page 5-318
↑	↑	■ CHANNEL TESTS ■	See page 5-319

5.2 Overview

5.2.1 Introduction to elements

For URs, the term *element* is used to describe a feature that is based around a comparator. The comparator is provided with an input (or set of inputs) that is tested against a programmed setting (or group of settings) to determine if the input is within the defined range that sets the output to logic 1, also referred to as *setting the flag*. A single comparator can make multiple tests and provide multiple outputs. For example, the time overcurrent comparator sets a pickup flag when the current input is above the setting and sets an operate flag when the input current has been at a level above the pickup setting for the time specified by the time-current curve settings. All comparators use analog actual values as the input.

5



An exception to this rule is digital elements, which use logic states as inputs.

Elements are arranged into two classes, *grouped* and *control*. Each element classed as a grouped element is provided with six alternate sets of settings, in setting groups numbered 1 through 6. The performance of a grouped element is defined by the setting group that is active at a given time. The performance of a control element is independent of the selected active setting group.

The main characteristics of an element are shown on a logic diagram. This includes the inputs, settings, fixed logic, and the output operands generated. The previous chapter explains how to read a logic diagram, and the abbreviations used in a diagram are defined in the Abbreviations chapter.

Some settings are specified in per-unit (pu) calculated quantities:

$$\text{pu quantity} = (\text{actual quantity}) / (\text{base quantity})$$

Where the current source is from a single current transformer (CT), the *base quantity* is the nominal secondary or primary current of the CT. Use the secondary current base to convert per-unit settings to/from a secondary current value, and use the primary current base to convert to/from a primary current value.

Where the current source is the sum of two or more CTs with different nominal primary current, the primary base quantity is the largest nominal primary current. For example, if CT1 = 300 / 5 A and CT2 = 100 / 1 A, then in order to sum these, CT2 is scaled to the CT1 ratio. In this case, the base quantity is 300 A primary, 5 A secondary for CT1, and 300/(100/1) = 3 A secondary for CT2.

For voltage elements, the primary base quantity is the nominal phase-to-phase primary voltage of the protected system provided that the VT ratio setting is set to the nominal ratio of the VTs and the secondary voltage setting is set to the phase-to-phase voltage seen by the relay when the voltage of the protected system is nominal. The UR uses the convention that nominal voltages in a three-phase system are phase-to-phase voltages.

For example, on a system with a 13.8 kV nominal primary voltage, the base quantity is 13800 V. With 14400:120 V delta-connected VTs, the secondary base quantity and secondary voltage setting is:

$$\frac{13800}{14400} \times 120 = 115 \text{ V} \tag{Eq. 5-1}$$

For wye-connected VTs, the primary and secondary base quantities are as before, but the secondary voltage setting (here a phase-to-ground value) is:

$$\frac{13800}{14400} \times \frac{120}{\sqrt{3}} = 66.4 \text{ V} \quad \text{Eq. 5-2}$$

Many settings are common to most elements, outlined as follows:

- **FUNCTION setting** — This setting programs the element to operate when selected as “Enabled.” The factory default is “Disabled.” Once “Enabled,” any element associated with the function becomes active and all options become available.
- **NAME setting** — This setting is used to uniquely identify the element.
- **SOURCE setting** — This setting is used to select the AC source to be monitored. See the Introduction to AC Sources section later.
- **PICKUP setting** — For simple elements, this setting is used to program the level of the measured parameter above or below which the pickup state is established. In more complex elements, a set of settings can be provided to define the range of the measured parameters that cause the element to pick up.
- **PICKUP DELAY setting** — This setting sets a time-delay-on-pickup, or on-delay, for the duration between the pickup and operate output states.
- **RESET DELAY setting** — This setting is used to set a time-delay-on-dropout, or off-delay, for the duration between the operate output state and the return to logic 0 after the input transits outside the defined pickup range.
- **BLOCK setting** — The default output operand state of all comparators is a logic 0 or “flag not set.” The comparator remains in this default state until a logic 1 is asserted at the RUN input, allowing the test to be performed. If the RUN input changes to logic 0 at any time, the comparator returns to the default state. The RUN input is used to supervise the comparator. The BLOCK input is used as one of the inputs to RUN control.
- **TARGET setting** — This setting is used to define the operation of an element target message. When set to “Disabled,” no target message or illumination of a front panel LED indicator is issued upon operation of the element. When set to “Self-Reset,” the target message and LED indication follow the operate state of the element and self-resets once the operate element condition clears. When set to “Latched,” the target message and LED indication remains visible after the element output returns to logic 0 until a RESET command is received by the relay.
- **EVENTS setting** — This setting is used to control whether the pickup, dropout, or operate states are recorded by the event recorder. When set to “Disabled,” element pickup, dropout, or operate are not recorded as events. When set to “Enabled,” events are created for
 - <Element> PKP (pickup)
 - <Element> DPO (dropout)
 - <Element> OP (operate)

The DPO event is created when the measure and decide comparator output transits from the pickup state (logic 1) to the dropout state (logic 0). This can happen when the element is in the operate state if the reset delay time is not zero.

Not every operand of a given element in a UR relay generates events, only the major output operands. Elements, asserting output per phase, log operating phase output only, without asserting the common three-phase operand event.

5.2.2 Introduction to AC sources

5.2.2.1 Background

The L30 can be used on systems with breaker-and-a-half or ring bus configurations.

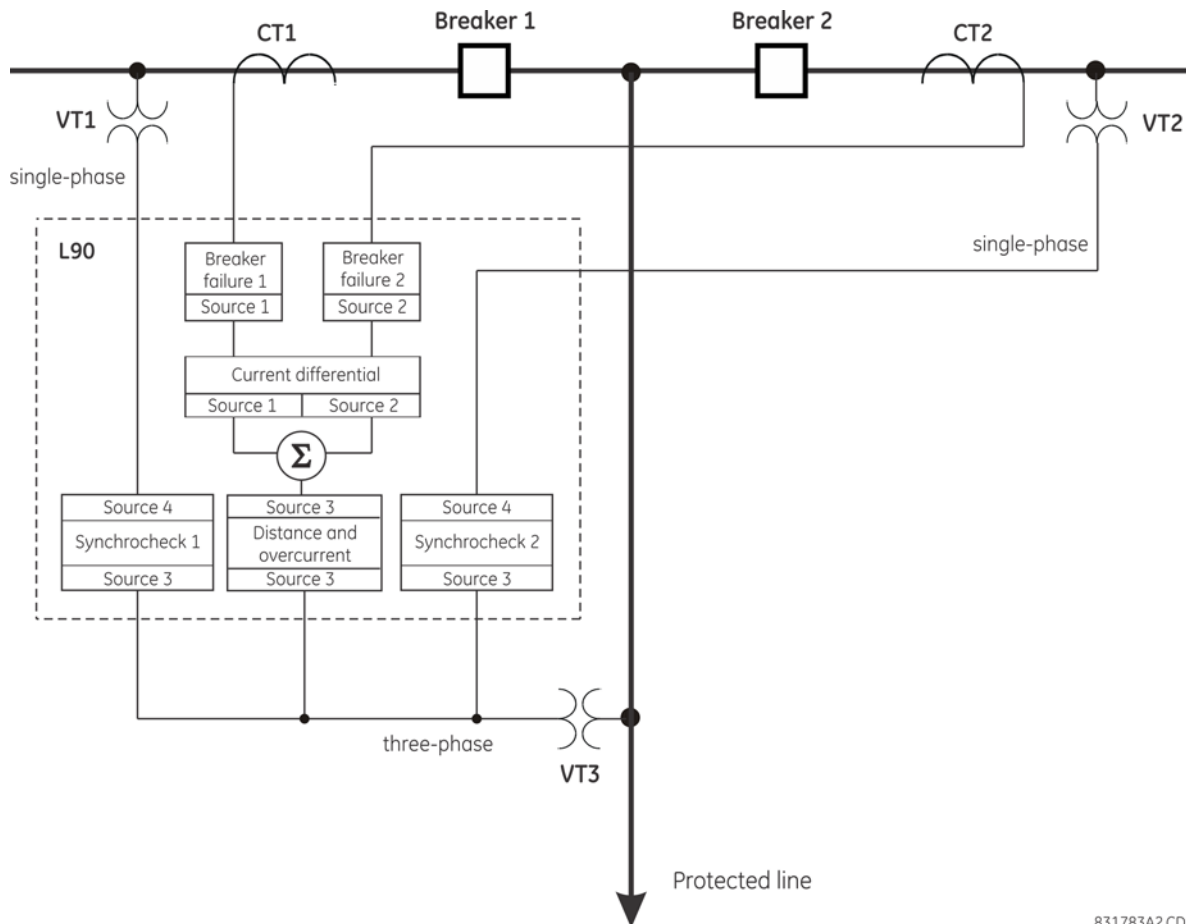
In these applications, each of the two three-phase sets of individual phase currents (one associated with each breaker) can be used as an input to a breaker failure element. The sum of both breaker phase currents and 3I₀ residual currents can be required for the circuit relaying and metering functions. Two separate synchrocheck elements can be programmed to check synchronization between two different buses VT and the line VT. These requirements can be satisfied with a single L30, equipped with sufficient CT and VT input channels, by selecting proper parameter to measure. A mechanism is provided to specify the AC parameter (or group of parameters) used as the input to protection/control comparators and

some metering elements. Selection of the measured parameters is partially performed by the design of a measuring element or protection/control comparator by identifying the measured parameter type (fundamental frequency phasor, harmonic phasor, symmetrical component, total waveform RMS magnitude, phase-phase or phase-ground voltage, and so on). The user completes the process by selecting the instrument transformer input channels to use and some parameters calculated from these channels. The input parameters available include the summation of currents from multiple input channels. For the summed currents of phase, 3I₀, and ground current, current from CTs with different ratios are adjusted to a single ratio before summation. A mechanism called a source configures the routing of CT and VT input channels to measurement sub-systems.

Sources, in the context of L30 relays, refer to the logical grouping of current and voltage signals such that one source contains all the signals required to measure the load or fault in a particular power apparatus. A given source can contain all or some of the following signals: three-phase currents, single-phase ground current, three-phase voltages and an auxiliary voltages from a single-phase VT for checking for synchronism.

To illustrate the concept of Sources, as applied to current inputs only, consider the breaker-and-a-half scheme shown. Some protection elements, like breaker failure, require individual CT current as an input. Other elements, like distance, require the sum of both current as an input. The line differential function requires the CT currents to be processed individually to cope with a possible CT saturation of one CT during an external fault on the upper bus. The current into protected line is the phasor sum (or difference) of the currents in CT1 and CT2, depending on the current distribution on the upper bus.

Figure 5-1: Breaker-and-a-half scheme



831783A2.CDR

In conventional analog or electronic relays, the sum of the currents is obtained from an appropriate external connection of all CTs through which any portion of the current for the element being protected could flow. Auxiliary CTs are required to perform ratio matching if the ratios of the primary CTs to be summed are not identical. In the L30, provisions have been included for all the current signals to be brought to the device where grouping, CT ratio correction, and summation are

applied internally via configuration settings. Up to four currents can be brought into the L30; current summation and CT ratio matching is performed internally. A major advantage of internal summation is that individual currents are available to the protection device (for example, as additional information to apply a restraint current properly, or to allow the provision of additional features that operate on the individual currents, such as breaker failure). Given the flexibility of this approach, it becomes necessary to add configuration settings to the platform to allow the user to select which sets of CT inputs are added to form the net current into the protected device. The internal grouping of current and voltage signals forms an internal source. This source can be assigned a specific name and becomes available to protection and metering elements in the relay. Individual names can be given to each source to identify them for later use. For example, in the scheme shown, three different sources are be configured as inputs for separate elements:

- Source 1 — CT1 current, for the breaker failure 1 element and first current source for the line differential element
- Source 2 — CT2 current, for breaker failure 2 element and second current source for the line differential element
- Source 3 — The sum of the CT1 and CT2 currents for the distance function

In addition, two separate synchrocheck elements can be programmed to check synchronization between line voltage and two different bus voltages (SRC3–SRC1 and SRC3–SRC2).

5.2.2.2 CT/VT module configuration

CT and voltage transformer (VT) input channels are contained in CT/VT modules. The type of input channel can be phase/neutral/other voltage, phase/ground current, or sensitive ground current. The CT/VT modules calculate total waveform RMS levels, fundamental frequency phasors, symmetrical components, and harmonics for voltage or current, as allowed by the hardware in each channel. These modules can calculate other parameters as directed by the CPU module.

A CT/VT module contains up to eight input channels, numbered 1 through 8. The channel numbering corresponds to the module terminal numbering 1 through 8 and is arranged as follows. Channels 1, 2, 3, and 4 are always provided as a group, hereafter called a “bank,” and all four are either current or voltage, as are channels 5, 6, 7, and 8. Channels 1, 2, 3 and 5, 6, 7 are arranged as phase A, B, and C respectively. Channels 4 and 8 are either another current or voltage.

Banks are ordered sequentially from the block of lower-numbered channels to the block of higher-numbered channels, and from the CT/VT module with the lowest slot position letter to the module with the highest slot position letter, as follows.

The UR platform allows for a maximum of six sets of three-phase voltages and six sets of three-phase currents. The result of these restrictions leads to the maximum number of CT/VT modules in a chassis to three. The maximum number of sources is six. A summary of CT/VT module configurations is as follows.

Item	Maximum number
CT/VT Module	1
CT Bank (3 phase channels, 1 ground channel)	2
VT Bank (3 phase channels, 1 auxiliary channel)	1

5.2.2.3 CT/VT input channel configuration

Upon relay startup, configuration settings for every bank of current or voltage input channels in the relay are generated automatically from the order code. Within each bank, a channel identification label is assigned automatically to each bank of channels in a given product. The *bank* naming convention is based on the physical location of the channels, required by the user to know how to connect the relay to external circuits. Bank identification consists of the letter designation of the slot in which the CT/VT module is mounted as the first character, followed by numbers indicating the channel, either 1 or 5. See the HardFiber instruction manual for designations of HardFiber voltage and current banks.

For three-phase channel sets, the number of the lowest numbered channel identifies the set. For example, F1 represents the three-phase channel set of F1/F2/F3, where F is the slot letter and 1 is the first channel of the three channels.

Upon startup, the CPU configures the settings required to characterize the current and voltage inputs, and it displays them in the appropriate section in the sequence of the banks (as described earlier) as follows for a maximum configuration: F1, F5, L1, L5, S1, and S5.

5.3 Product setup

5.3.1 Security

5.3.1.1 Security overview

The following security features are available:

- Password security — Basic security present by default
- EnerVista security — Role-based access to various EnerVista software screens and configuration elements. The feature is present by default in the EnerVista software.
- CyberSentry security — Advanced security available using a software option. When purchased, the option is automatically enabled, and the default Password security and EnerVista security are disabled.

Lost password

If all passwords are lost, recovery is possible by resetting the unit to default values. Note that the relay is reset to default values, not just the passwords.

To reset the unit after a lost password:

1. Email GE customer service at multilin.tech@ge.com with the serial number and using a recognizable corporate email account. Customer service provides a code to reset the relay to the factory defaults.
2. Enter the reset code on the front panel, under **COMMANDS** ⇒ **RELAY MAINTENANCE** ⇒ **SERVICE COMMAND**.
3. Change the default password of ChangeMe1# as outlined in the Set Up CyberSentry and Change Default Password section at the end of the Installation chapter.

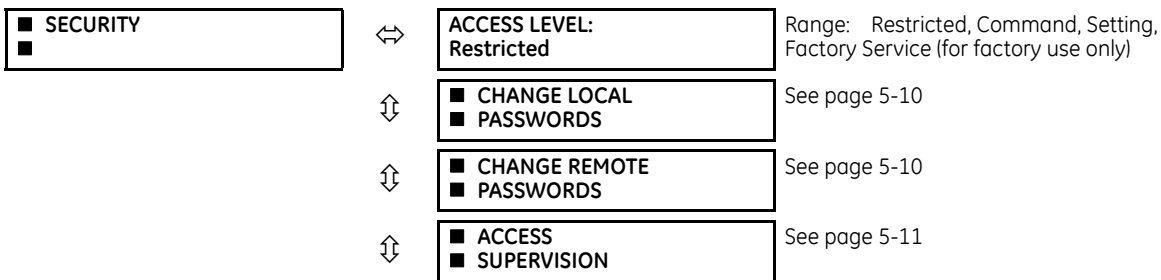
Password requirements

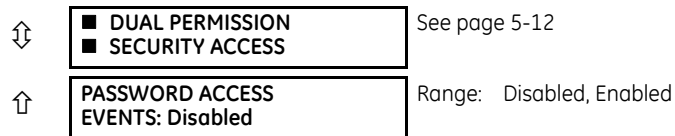
A user account requires an alpha-numeric password that meets the following requirements:

- Password is case-sensitive
- Password cannot contain the user account name or parts of the user account that exceed two consecutive characters
- Password must be 8 to 20 characters in length
- Password must contain characters from all of the following categories:
 - English uppercase characters (A through Z)
 - English lowercase characters (a through z)
 - Base 10 digits (0 through 9)
 - Non-alphabetic characters (for example, ~, !, @, #, \$, %, &)

5.3.1.2 Password security

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY





The L30 supports password entry from a local or remote connection.

Local access is defined as access to settings or commands via the front panel. This includes both keypad entry and the RS232 port. Remote access is defined as access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. Any change to the local or remote password enables this functionality.

ACCESS LEVEL — The "Restricted" option means that settings and commands can be accessed, but there is no access to factory configuration. Access automatically reverts to the Restricted level according to the access level timeout setting values. The access level is set to Restricted when control power is cycled.

The "Factory Service" level is not available and intended for factory use only.

There are two user security access levels, setting and command, for which you can set a password for each. Use of a password for each level controls whether users can enter commands or change settings. Another option is to specify setting and/or command access for individual user accounts.

- **Setting** — Allows the user to make any changes to any of the setting values:
 - Changing any setting
 - Test mode operation
- **Command** — Restricts the user from making any settings changes, but allows the user to perform the following operations:
 - Operating the breakers via front panel keypad
 - Changing the state of virtual inputs
 - Clearing the event records
 - Clearing the oscillography records
 - Clearing fault reports
 - Changing the date and time
 - Clearing the breaker arcing current
 - Clearing the data logger
 - Clearing the user-programmable pushbutton states

When entering a settings or command password via EnerVista or any serial interface, the user must enter the corresponding connection password. If the connection is to the back of the L30, the remote password must be used. If the connection is to the RS232 port of the front panel, the local password must be used.

The local setting and command sessions are initiated by the user through the front panel display and are disabled either by the user or by timeout (via the setting and command level access timeout settings). The remote setting and command sessions are initiated by the user through the EnerVista software and are disabled either by the user or by timeout.

The state of the session (local or remote, setting or command) determines the state of the following FlexLogic operands:

- **ACCESS LOC SETG OFF** — Asserted when local setting access is disabled
- **ACCESS LOC SETG ON** — Asserted when local setting access is enabled
- **ACCESS LOC CMND OFF** — Asserted when local command access is disabled
- **ACCESS LOC CMND ON** — Asserted when local command access is enabled
- **ACCESS REM SETG OFF** — Asserted when remote setting access is disabled
- **ACCESS REM SETG ON** — Asserted when remote setting access is enabled
- **ACCESS REM CMND OFF** — Asserted when remote command access is disabled
- **ACCESS REM CMND ON** — Asserted when remote command access is enabled



A command or setting write operation is required to update the state of the remote and local security operands listed.

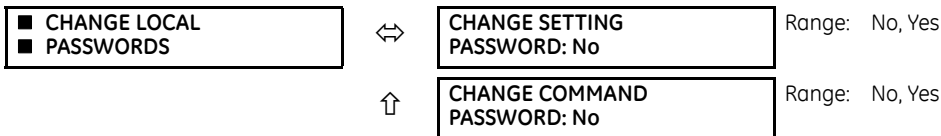
When a setting password or command password is set or updated, user access with a graphical front panel is removed. Simply log in again on the graphical front panel.

When the setting password is set or updated, the graphical front panel Access Level displays as Command. This is because the graphical front panel is a Modbus client and it does not have automatic access to the password change.

PASSWORD ACCESS EVENTS — This setting allows recording of password access events in the event recorder.

Change local passwords

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ CHANGE LOCAL PASSWORDS



As outlined in the previous section, there are two user security access levels, setting and command. Use of a password for each level controls whether users can enter commands or change settings.

Proper password codes are required to enable each access level. When a **CHANGE COMMAND PASSWORD** or **CHANGE SETTING PASSWORD** setting is programmed to “Yes” via the front panel interface, the following message sequence is invoked:

1. ENTER NEW PASSWORD: _____.
2. VERIFY NEW PASSWORD: _____.
3. NEW PASSWORD HAS BEEN STORED.

To gain write access to a “Restricted” setting, program the **ACCESS LEVEL** setting in the main security menu to “Setting” and then change the setting, or attempt to change the setting and follow the prompt to enter the programmed password. If the password is correctly entered, access is allowed. Access automatically reverts to the “Restricted” level according to the access level timeout setting values and when power is cycled.



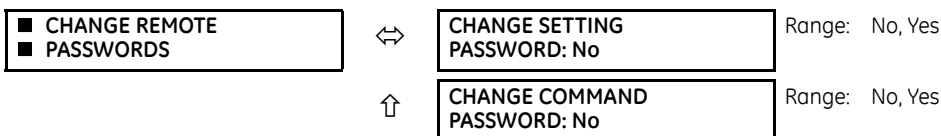
If the setting and command passwords are identical, then this one password allows access to both commands and settings.

If a remote connection is established, local passcodes are not visible.

Change remote passwords

Proper passwords are required to enable each command or setting level access, which are explained in the previous section.

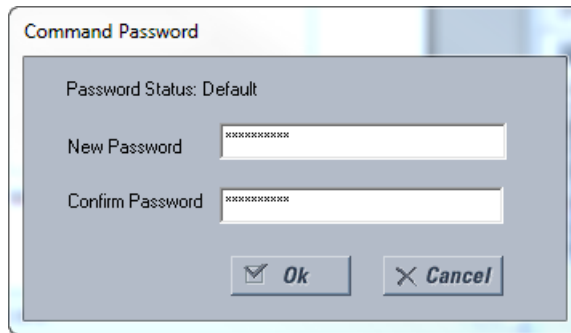
SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ CHANGE REMOTE PASSWORDS



To set the command or setting password in EnerVista:

1. In the EnerVista software or from the front panel, navigate to **Settings > Product Setup > Security** menu item to open the remote password settings window.
2. Click the command or setting password **Change** button.
3. Enter the new password in the **New Password** field. Requirements are outlined in the Password Requirements section earlier in this chapter. When an original password has already been used, enter it in the **Enter Password** field and click

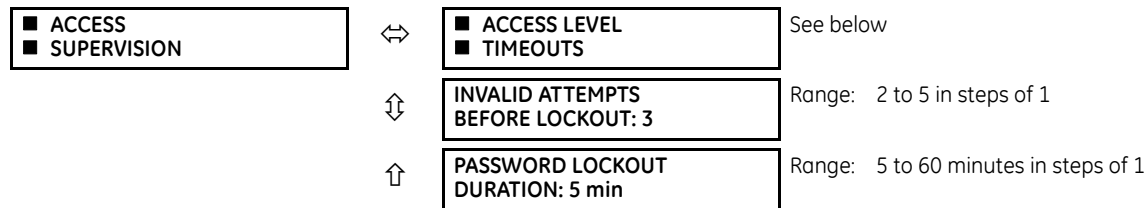
- the **Send Password to Device** button.
- 4. Re-enter the password in the **Confirm Password** field.
- 5. Click the **OK** button. The password is checked to ensure that it meets requirements.



If you establish a local (serial) connection to the relay, you cannot view remote passcodes.

Access supervision

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ACCESS SUPERVISION



The following access supervision settings are available.

INVALID ATTEMPTS BEFORE LOCKOUT — This setting specifies the number of times that an incorrect password can be entered within a three-minute time span before lockout occurs. When lockout occurs, the [LOCAL ACCESS DENIED](#) or [REMOTE ACCESS DENIED](#) FlexLogic operands are set to “On.” These operands are returned to the “Off” state upon expiration of the lockout.

PASSWORD LOCKOUT DURATION — This setting specifies the time that the L30 locks out password access after the number of invalid password entries specified by the **INVALID ATTEMPTS BEFORE LOCKOUT** setting has occurred.

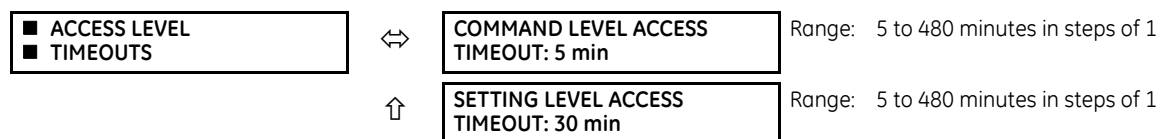
The L30 provides a means to raise an alarm upon failed password entry. If password verification fails while accessing a password-protected level of the relay (either settings or commands), the [UNAUTHORIZED ACCESS](#) FlexLogic operand is asserted. The operand can be programmed to raise an alarm via contact outputs or communications. This feature can be used to protect against both unauthorized and accidental access attempts.

The [UNAUTHORIZED ACCESS](#) operand is reset with the **COMMANDS ⇒ CLEAR RECORDS ⇒ RESET UNAUTHORIZED ALARMS** command. Therefore, to apply this feature with security, password-protect the Command level. The operand does not generate events or targets.

If events or targets are required, the [UNAUTHORIZED ACCESS](#) operand can be assigned to a digital element programmed with event logs or targets enabled.

The following table outlines access level timeout settings.

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ACCESS SUPERVISION ⇒ ACCESS LEVEL TIMEOUTS



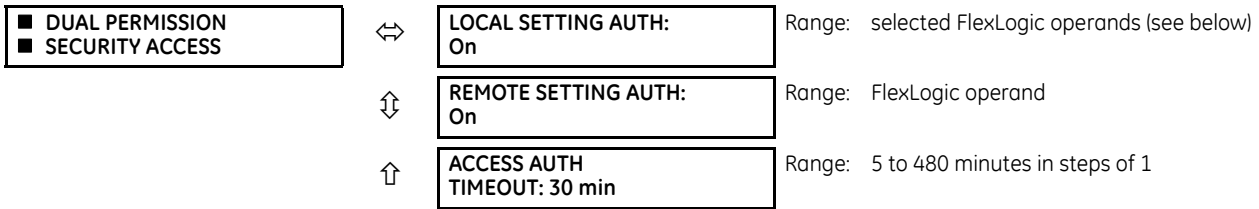
These settings allow the user to specify the length of inactivity required before returning to the Restricted access level. Note that the access level is set to Restricted when control power is cycled.

COMMAND LEVEL ACCESS TIMEOUT — This setting specifies the length of inactivity (no local or remote access) required to return to Restricted access from the Command password level.

SETTING LEVEL ACCESS TIMEOUT — This setting specifies the length of inactivity (no local or remote access) required to return to Restricted access from the Command password level.

Dual permission security access

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ DUAL PERMISSION SECURITY ACCESS



This feature provides a mechanism to prevent unauthorized or unintended upload of settings to a relay through the local or remote interface.

The following settings are available through the local (front panel) interface only.

- LOCAL SETTING AUTH** — This setting is used for local (front panel or RS232 interface) setting access supervision. Valid values for the FlexLogic operands are either “On” (default) or any physical “Contact Input ~~ On” value.

If this setting is “On,” then local setting access functions as normal; that is, a local setting password is required. If this setting is any contact input on FlexLogic operand, then the operand must be asserted (on) prior to providing the local setting password to gain setting access.

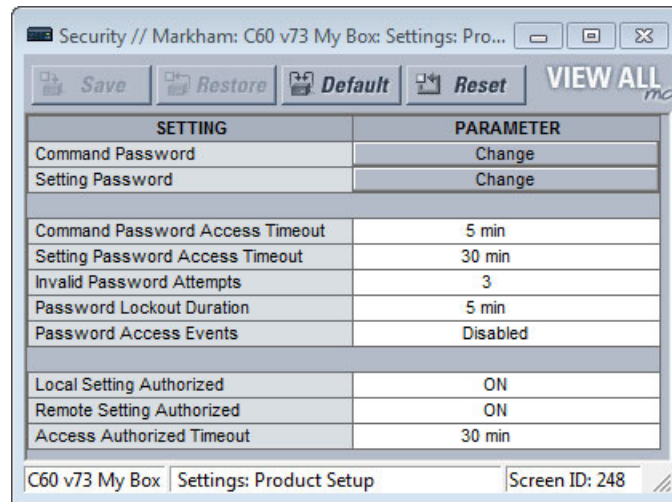
If setting access is *not* authorized for local operation (front panel or RS232 interface) and the user attempts to obtain setting access, then the UNAUTHORIZED ACCESS message displays on the front panel.

If this setting is “Off,” firmware upgrades are blocked. If this setting is “On,” firmware upgrades are allowed.
- REMOTE SETTING AUTH** — This setting is used for remote (Ethernet or RS485 interface) setting access supervision.

If this setting is “On” (the default setting), then remote setting access functions as normal; that is, a remote password is required. If this setting is “Off,” then remote setting access is blocked even if the correct remote setting password is provided. If this setting is any other FlexLogic operand, then the operand must be asserted (set as on) prior to providing the remote setting password to gain setting access.

If this setting is “Off,” firmware upgrades are blocked. If this setting is “On,” firmware upgrades are allowed.
- ACCESS AUTH TIMEOUT** — This setting represents the timeout delay for local setting access. This setting is applicable when the **LOCAL SETTING AUTH** setting is programmed to any operand except “On.” The state of the FlexLogic operand is monitored continuously for an off-to-on transition. When this occurs, local access is permitted and the timer programmed with the **ACCESS AUTH TIMEOUT** setting value is started. When this timer expires, local setting access is immediately denied. If access is permitted and an off-to-on transition of the FlexLogic operand is detected, the timeout is restarted. The status of this timer updates every five seconds.

The following settings are available through the remote (EnerVista UR Setup) interface only. Select the **Settings > Product Setup > Security** menu item to display the security settings window.



The **Remote Settings Authorized** setting is used for remote (Ethernet or RS485 interface) setting access supervision. If this setting is “On” (the default setting), then remote setting access functions as normal; that is, a remote password is required. If this setting is “Off,” then remote setting access is blocked even if the correct remote setting password is provided. If this setting is any other FlexLogic operand, then the operand must be asserted (on) prior to providing the remote setting password to gain setting access.

The **Access Authorized Timeout** setting represents the timeout delay remote setting access. It applies when the **Remote Settings Authorized** setting is programmed to any operand except “On” or “Off.” The state of the FlexLogic operand is continuously monitored for an off-to-on transition. When this occurs, remote setting access is permitted, and the timer programmed with the **Access Authorized Timeout** setting value is started. When this timer expires, remote setting access is denied immediately. If access is permitted and an off-to-on transition of the FlexLogic operand is detected, the timeout is restarted. The status of this timer updates every five seconds.

5.3.1.3 EnerVista security

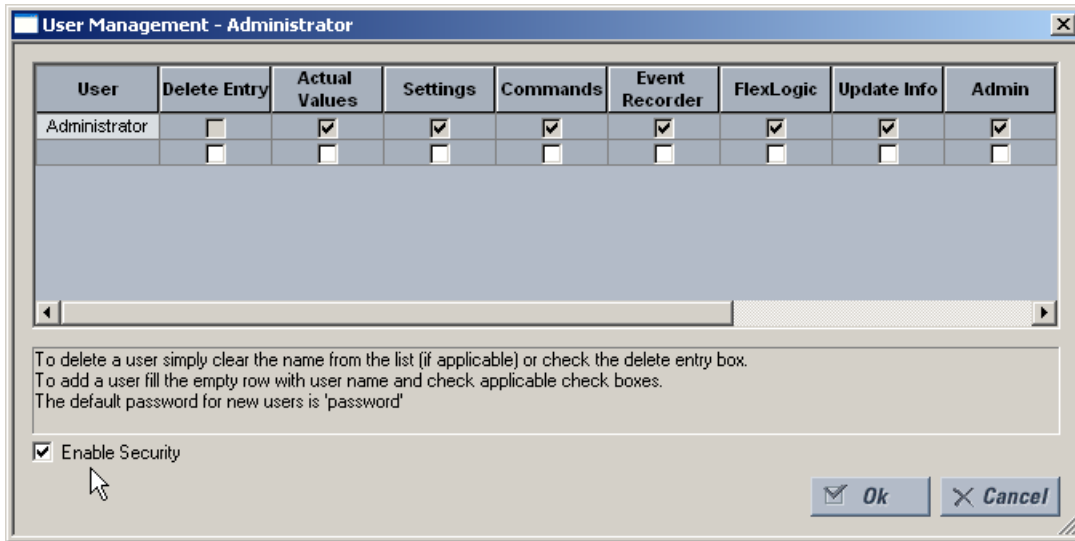
Enable the security management system

The EnerVista security system allows an administrator to manage access privileges of multiple users of EnerVista.

It is disabled by default to allow access to the device immediately after installation. When security is disabled, all users have administrator access. GE recommends enabling the EnerVista security before placing the device in service.

To enable the security system and require password use:

1. Select the **Security > User Management** menu to open the user management window.



2. Enable the **Enable Security** check box in the lower-left corner to enable the security management system.
3. Click the **Ok** button.

5



If you force password entry by using this feature, ensure that you know the Administrator password. If you do not know the password and are locked out of the software, contact GE Grid Solutions for the default password of a UR device. When using CyberSentry, the default password is "ChangeMe1#".

Security is now enabled for the EnerVista UR Setup software. Upon starting the software, users are now required to enter a username and password.

Add a new user

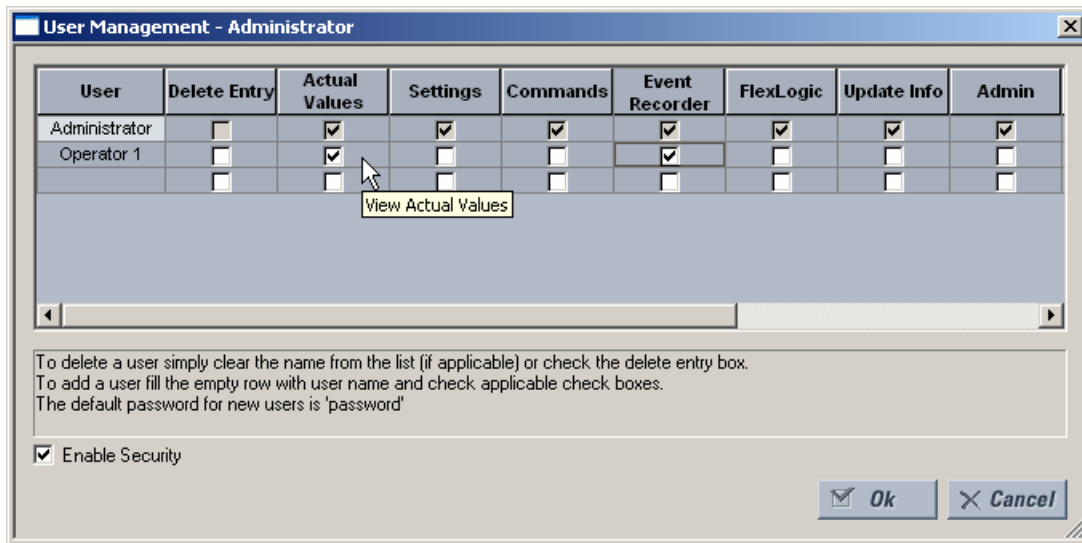
The following pre-requisites are required to add user accounts to the EnerVista security management system:

- The user adding the account must have administrator rights
- The EnerVista security management system must be enabled (previous section)

To add a user account:

1. Select the **Security > User Management** item from the top menu to open the user management window.
2. Enter a username in the **User** field. The username must be four to 20 characters in length.

3. Select the user access rights by enabling the check box of one or more fields.



The table outlines access rights.

Table 5-1: Access rights summary

Field	Description
Delete Entry	Deletes the user account when exiting the user management window
Actual Values	Allows the user to read Actual Values
Settings	Allows the user to read Settings values
Commands	Allows the user to execute Commands
Event Recorder	Allows the user to use the Event Recorder
FlexLogic	Allows the user to read FlexLogic values
Update Info	Allows the user to write to any function to which they have read privileges. When any of the Settings , Event Recorder , and FlexLogic check boxes are enabled by themselves, the user is granted read access. When any of them are enabled in conjunction with the Update Info box, they are granted read and write access. The user is not granted write access to functions that are not enabled, even if the Update Info field is enabled.
Admin	When the check box is enabled, the user becomes an EnerVista UR Setup administrator and has all administrative rights. Exercise caution when granting administrator rights.

4. Click **OK** to add the user account to the system.

Modify user privileges

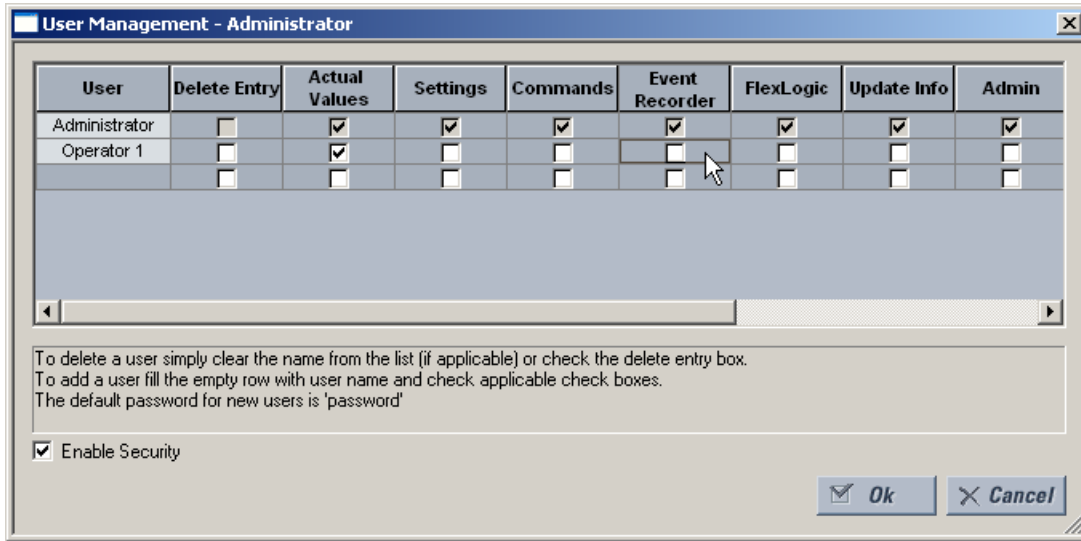
The following pre-requisites are required to modify user privileges in the EnerVista security management system:

- The user modifying the privileges must have administrator rights
- The EnerVista security management system must be enabled (the **Enable Security** check box enabled)

To modify user privileges:

1. Select the **Security > User Management** item from the top menu to open the user management window.
2. Locate the username in the **User** field.

- Modify the user access rights by enabling or disabling one or more of the check boxes.



The table outlines access rights.

Table 5-2: Access rights summary

Field	Description
Delete Entry	Deletes the user account when exiting the user management window
Actual Values	Allows the user to read actual values
Settings	Allows the user to read setting values
Commands	Allows the user to execute commands
Event Recorder	Allows the user to use the digital fault recorder
FlexLogic	Allows the user to read FlexLogic values
Update Info	Allows the user to write to any function to which they have read privileges. When any of the Settings , Event Recorder , and FlexLogic check boxes are enabled by themselves, the user is granted read access. When any of them are enabled in conjunction with the Update Info box, they are granted read and write access. The user is not granted write access to functions that are not enabled, even if the Update Info field is enabled.
Admin	When this check box is enabled, the user becomes an EnerVista UR Setup administrator and has all administrative rights. Exercise caution when granting administrator rights.

- Click **OK** to save the changes.

5.3.1.4 CyberSentry security

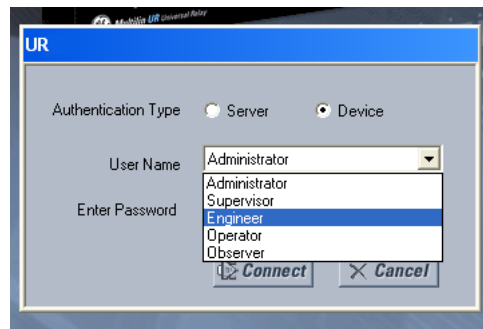


This feature requires a CyberSentry software option. See the Order Codes section in chapter 2 for details.

The EnerVista software provides the means to configure and authenticate the L30 access using either a server or the device. Access to functions depends on user role.

The login screen of EnerVista has two options for access to the L30, these being Server and Device authentication.

Figure 5-2: Login screen for CyberSentry



When the "Server" **Authentication Type** is selected, the L30 uses the RADIUS server and not its local authentication database to authenticate the user.

When the "Device" button is selected, the L30 uses its local authentication database and not the RADIUS server to authenticate the user. In this case, it uses built-in roles (Administrator, Engineer, Supervisor, Operator, Observer, or Administrator and Supervisor when Device Authentication is disabled), as login accounts and the associated passwords are stored on the L30 device. In this case, access is not user-attributable. In cases where user-attributable access is required, especially for auditable processes for compliance reasons, use server authentication (RADIUS) only.

No password or security information is displayed in plain text by the EnerVista software or the UR device, nor are they ever transmitted without cryptographic protection.



Only (TCP/UDP) ports and services that are needed for device configuration and for customer enabled features are open. All the other ports are closed. For example, Modbus is on by default, so its TCP port 502, is open. But if Modbus is disabled, port 502 is closed. This function has been tested and no unused ports have been found open.

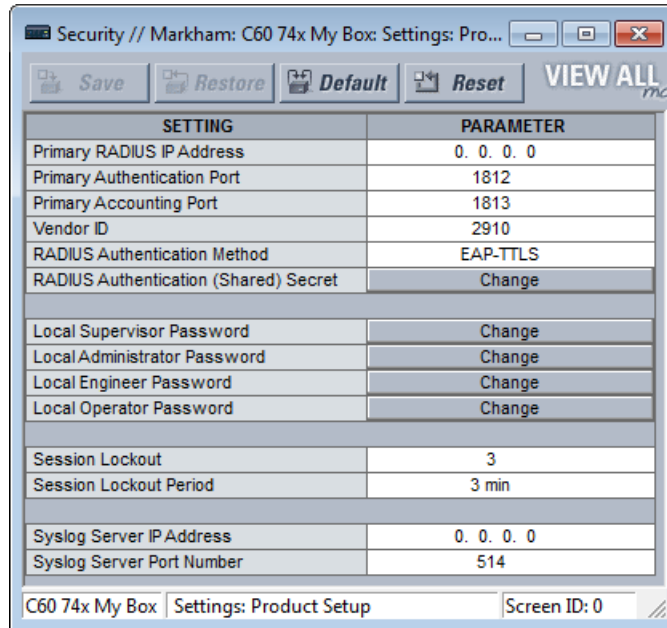
When CyberSentry is enabled, Modbus communications over Ethernet is encrypted, which is not always tolerated by SCADA systems. The UR has a bypass access feature for such situations, which allows unencrypted Modbus over Ethernet. The **Bypass Access** setting is available on the **SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ SUPERVISORY** screen. Note that other protocols (DNP, 101, 103, 104, EGD) are not encrypted, and they are good communications options for SCADA systems when CyberSentry is enabled.

When using the rear RS485 port and CyberSentry, registers can be read with a maximum buffer of 64 bytes. Settings may not be written, so use another port.

CyberSentry settings through EnerVista

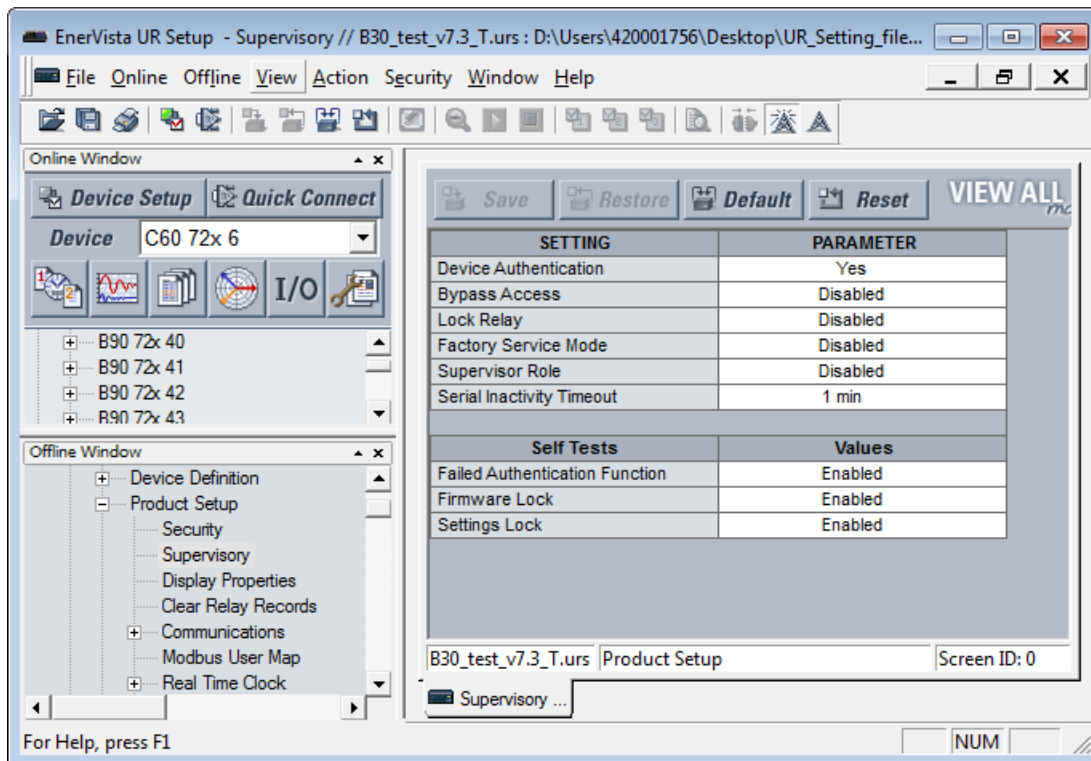
CyberSentry security settings are configured under **Device > Settings > Product Setup > Security**.

Figure 5-3: Security panel when CyberSentry installed



For the **Device > Settings > Product Setup > Supervisory** option, the panel looks like the following.

Figure 5-4: Supervisory panel



For the Security panel, the following settings are available.

Table 5-3: RADIUS server settings

Setting name	Description	Minimum	Maximum	Default	Units	Minimum permission
Primary RADIUS IP Address	IP address of the main RADIUS server. Default value indicates no Primary RADIUS server is configured, and hence RADIUS is disabled. Restart the relay for any change to take effect.	0.0.0.0	223.255.255.254	0.0.0.0	-	Administrator
Primary Authentication Port	RADIUS authentication port	1	65535	1812	-	Administrator
Primary Accounting Port	RADIUS accounting port	1	65535	1813	-	Administrator
Vendor ID	An identifier that specifies RADIUS vendor-specific attributes used with the protocol			Value that represents General Electric		Administrator
RADIUS Authentication Method	Authentication method used by RADIUS server. Can use EAP-TTLS, PEAP-GTC, or PAP. Selecting the PEAP-GTC option disables RADIUS authentication.	EAP-TTLS	PAP	EAP-TTLS	-	Administrator
RADIUS Authentication (Shared) Secret	Shared secret used in authentication. It displays as asterisks. This setting must meet the CyberSentry password requirements.	See the Password Requirements section earlier in this chapter	See the following password section for requirements	N/A	-	Administrator
Timeout	Timeout in seconds between re-transmission requests	0	9999	10	sec	Administrator
Retries	Number of retries before giving up	0	9999	3	-	Administrator
Confirm RADIUS Authentication (Shared) Secret	Confirmation of the shared secret. The entry displays as asterisks.	See the Password Requirements section	245 characters	N/A	-	Administrator

Table 5-4: General security settings

Setting name	Description	Minimum	Maximum	Default	Units	Minimum permission
Session Lockout	Number of failed authentications before the device blocks subsequent authentication attempts for the lockout period	0 (lockout disabled)	99	3	-	Administrator
Session Lockout Period	The period in minutes that a user is prevented from logging in after being locked out	0 (no period)	9999	3	min	Administrator
Syslog Server IP Address	The IP address of the target Syslog server to which all security events are transmitted	0.0.0.0	223.255.255.254	0.0.0.0	-	Administrator
Syslog Server Port Number	The UDP port number of the target syslog server to which all security events are transmitted	1	65535	514	-	Administrator
Device Authentication	When enabled, local Device authentication with roles is allowed. When disabled, the UR only authenticates to the AAA server (RADIUS). NOTE: Administrator and Supervisor (if still enabled) remain active even after Device authentication is disabled. The only permission for local Administrator is to re-enable Device authentication when Device authentication is disabled. To re-enable Device authentication, the Supervisor unlocks the device for setting changes, and then the Administrator can re-enable Device authentication.	Disabled	Enabled	Enabled	-	Administrator

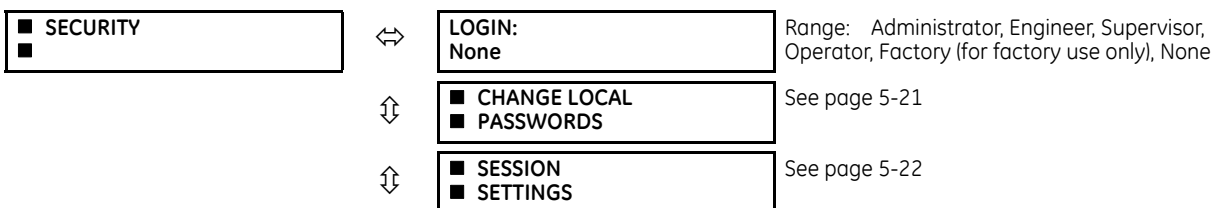
Setting name	Description	Minimum	Maximum	Default	Units	Minimum permission
Firmware Lock (via Lock Relay)	Indicates if the device receives firmware upgrades. If Enabled and the firmware upgrade attempt is made, the device denies the upgrade and displays an error message that the lock is set. On each firmware upgrade, this setting goes back to the default. The Lock Relay setting blocks settings and firmware updates.	Disabled	Enabled	Enabled	-	Administrator
Factory Service Mode	When enabled, the device can go into factory service mode. To enable, Supervisor authentication is necessary.	Disabled	Enabled	Disabled	-	Supervisor (Administrator when Supervisor is disabled)
Restore to Defaults	Sets the device to factory defaults	No	Yes	No	-	Administrator
Supervisor Role	When enabled, the Supervisor role is active. To enable, Administrator authentication is necessary. When disabled, the Supervisor role is inactive. To disable, Supervisor authentication is necessary.	Disabled	Enabled	Enabled	-	Administrator to enable and Supervisor to disable
RADIUS user names	Ensures that RADIUS user names are not the same as local/device role names	See RADIUS server documents	See RADIUS server documents		-	Administrator
Password	Local/device roles except for Observer are password-protected. All RADIUS users are password-protected.	See the Password Requirements section earlier in this chapter	See the following password section for requirements	Change Me1#	Text	The specified role and Administrator, except for Supervisor, where it is only itself

Table 5-5: Security alarm settings

Setting name	Description / Details	Min	Max	Default	Units	Minimum permissions
Failed Authentications	A threshold number indicating when an alarm is set off to indicate too many failed authentication attempts	0 (disabled)	99	3	-	Administrator
Firmware Lock	A value indicating if the device can receive a firmware upgrade. If Enabled and a firmware upgrade attempt is made, the device alarm activates. If Disabled, the device alarm does not activate. On each firmware upgrade this setting goes back to the default.	Disabled	Enabled	Enabled	-	Administrator
Settings Lock	A value indicating if the device can accept any settings changes. If Enabled and a settings change attempt is made, the device alarm activates. If Disabled, the device alarm does not activate.	Disabled	Enabled	Enabled	-	Supervisor (Administrator if Supervisor has been disabled)

CyberSentry settings through the front panel

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY



↕	■ RESTORE DEFAULTS ■	See page 5-22
↕	■ SUPERVISORY ■	See page 5-22
↕	SYSLOG IP ADDRESS: 0.0.0.0	Range: 0.0.0.0, 255.255.255.255
↑	SYSLOG PORT NUMBER: 514	Range: 1 to 65535

LOGIN — This setting is applicable for Device authentication only. This setting allows a user to log in with a specific role, as outlined here. For the Supervisor role, enable the “Supervisor Role” setting. Log out by right-clicking the device in EnerVista and selecting the **Disconnect** option.

Whenever a new role is logged in, the user is prompted to enter a password. Passwords must obey the requirements specified earlier in the chapter in the Password Requirements section. The UR device supports five roles. Roles have their corresponding passwords, except the Observer role, which does not require a password. There are no time-outs for the Administrator, Engineer, Operator, and Supervisor when logged in using the front panel; log out manually or use the **Command > Security** commands in the software.

The roles are defined as follows:

- Administrator — Complete read/write access to all settings and commands. This role does not allow concurrent access. This role has an operand to indicate when it is logged on.
- Engineer — Complete read/write access to all settings and commands except configuring Security settings and firmware upgrades. This role does not allow concurrent access.
- Operator — The Operator has read/write access to all settings under the Commands menu/section. This role does not exist offline.
- Supervisor — This is only an approving role. This role’s authentication commits setting changes submitted by Administrator or Engineer. The Supervisor role authenticates to unlock the UR relay for setting changes and not approve changes after the fact. Only a Supervisor can set the Settings Lock and Firmware Lock in the Security settings. This role also has the ability to forcefully log off any other role and clear the security event log. This role can also be disabled, but only through a Supervisor authentication. When this role is disabled its permissions are assigned to the Administrator role.
- Observer — This role has read-only access to all L30 settings. This role allows unlimited concurrent access but it has no download access to any files on the device. Observer is the default role if no authentication has been done to the device. This role displays as “None” on the front panel. When local authentication is used, no password is required for this role. When RADIUS server authentication is used, a password is required.



The Factory service role is not available. It is for factory use only.

The Local Access Denied message on the front panel can mean that you need to log in to the UR in order to complete the action.

Change local passwords

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ↕ CHANGE LOCAL PASSWORDS

■ CHANGE LOCAL ■ PASSWORDS	↔	LOGIN: None	Range: 20 alphanumeric characters
	↕	NEW PASSWORD:	Range: 20 alphanumeric characters
	↑	CONFIRM PASSWORD:	Range: 20 alphanumeric characters

The menu is shown on the front panel upon successful login of the Administrator role.

The **LOGIN** setting in this menu is similar to that described in **SETTINGS > PRODUCT SETUP > SECURITY** except for the factory role.

Passwords are stored in text format. No encryption is applied.



In Device authentication mode, the Observer role does not have a password associated with it. In Server authentication mode the Observer role requires a password.

NOTE

If you are locked out of the software, contact GE Grid Solutions for the default password. When using CyberSentry, the default password is "ChangeMe1#".

Once the passwords are set, the Administrator with Supervisor approval can change the role-associated password.

In CyberSentry, password encryption is not supported.

Session settings

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ↓ SESSION SETTINGS

<input checked="" type="checkbox"/> SESSION <input checked="" type="checkbox"/> SETTINGS	↔	SESSION LOCKOUT: 3	Range: 0 to 99
	↑	SESSION LOCKOUT PERIOD: 3 min	Range: 0 to 9999 minutes

SESSION LOCKOUT — This setting specifies the number of failed authentications before the device blocks subsequent authentication attempts for the lockout period. A value of zero means lockout is disabled.

SESSION LOCKOUT PERIOD — This setting specifies the period of time in minutes of a lockout period. A value of 0 means that there is no lockout period.

Restore defaults

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ↓ RESTORE DEFAULTS

<input checked="" type="checkbox"/> RESTORE DEFAULTS	↔	LOAD FACTORY DEFAULTS: No	Range: Yes, No
--	---	------------------------------	----------------

LOAD FACTORY DEFAULTS — This setting is used to reset all the settings, communication, and security passwords. An Administrator role is used to change this setting and a Supervisor role (if not disabled) approves it.

Supervisory

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ↓ SUPERVISORY

<input checked="" type="checkbox"/> SUPERVISORY	↔	DEVICE AUTHENTICATION: Yes	Range: Yes, No
	↕	BYPASS ACCESS: Disabled	Range: Local, Remote, Local and Remote, Disabled, Pushbuttons
	↕	LOCK RELAY: Disabled	Range: Enabled, Disabled
	↕	FACTORY SERVICE MODE: Disabled	Range: Enabled, Disabled
	↕	<input checked="" type="checkbox"/> SELF TESTS	See below
	↕	SUPERVISOR ROLE: Disabled	Range: Enabled, Disabled
	↑	SERIAL INACTIVITY TIMEOUT: 1 min	Range: 1 to 9999 minutes

The Supervisory menu settings are available for Supervisor role only, or if the Supervisor role is disabled then for the Administrator role only.

DEVICE AUTHENTICATION — This setting is enabled by default, meaning "Yes" is selected. When enabled, Device authentication with roles is enabled. When this setting is disabled, the UR only authenticates to the AAA server (RADIUS). However, the Administrator and Supervisor (when enabled) remain active even after device authentication is disabled and their only permission is to re-enable Device authentication. To re-enable Device authentication, the Supervisor unlocks the device for settings changes, then the Administrator re-enables device authentication.

BYPASS ACCESS — The bypass security feature provides an easier access, with no authentication and encryption for those special situations when this is considered safe. Only the Supervisor, or the Administrator when the Supervisor role is disabled, can enable this feature.

Mode	Front panel or serial (RS232, RS485)	Ethernet
Normal mode	Authentication — Role Based Access Control (RBAC) and passwords in clear	Authentication — RBAC and passwords encrypted SSH tunneling
Bypass access mode	No passwords for allowed RBAC levels	No passwords for allowed RBAC levels No SSH tunneling

The bypass options are as follows:

- Local — Bypasses authentication for push buttons, keypad, RS232, and RS485
- Remote — Bypasses authentication for Ethernet
- Local and Remote — Bypasses authentication for push buttons, keypad, RS232, RS485, and Ethernet
- Pushbuttons — Bypasses authentication for front panel push buttons only. On the graphical front panel, the authentication for side pushbuttons to control breakers and disconnects also is bypassed.

LOCK RELAY — This setting uses a Boolean value (Enabled/Disabled) to indicate if the device accepts settings changes and whether the device can receive a firmware upgrade. This setting can be changed by the Supervisor role, if it is enabled, or by the Administrator if the Supervisor role is disabled. The Supervisor role disables this setting for the relay to start accepting settings changes, command changes, or firmware upgrade. After all the setting changes are applied or commands executed, the Supervisor enables to lock settings changes.

Example: If this setting is enabled and an attempt is made to change settings or upgrade the firmware, the UR device denies the settings changes or denies upgrading the firmware. If this setting is disabled, the UR device accepts settings changes and firmware upgrade.

This role is disabled by default.

FACTORY SERVICE MODE — When Enabled, the device can go into factory service mode. For this setting to become enabled a Supervisor authentication is necessary. The default value is Disabled.

SUPERVISOR ROLE — When Enabled, the Supervisor role is active. To Disable this setting a Supervisor authentication is necessary. If disabled, the Supervisor role is not allowed to log in. In this case, the Administrator can change the settings under the Supervisory menu.

If enabled, Supervisor authentication is required to change the settings in the Supervisory menu. If the Supervisor disables their role after authentication, the Supervisor session remains valid until they switch to another role using MMI or until they end the current Supervisor session if using communications.

This role is disabled by default.

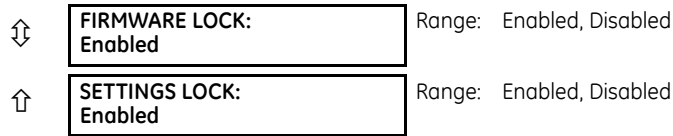
SERIAL INACTIVITY TIMEOUT — The role logged via a serial port is auto logged off after the Serial Inactivity timer times out. A separate timer is maintained for RS232 and RS485 connections. The default value is 1 minute.

GE recommends setting this value to at least 3 minutes for the following scenario: while connected to a CyberSentry device, with serial or USB cable connected to the front panel, and performing "Add Device to Offline Window" or an online/offline comparison. With less than the recommended 3 minutes, the serial activity timeout interrupts the connection and the security role login window appears. Upon login, the process resumes.

Self-tests

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ⬇️ SUPERVISORY ⇒ SELF TESTS





FAILED AUTHENTICATE — If this setting is Enabled then the number of failed authentications is compared with the Session Lockout threshold. When the Session Lockout threshold is exceeded, this minor alarm indication comes up.

FIRMWARE LOCK — If this setting is Enabled, then any firmware upgrade operation attempt when the Lock Relay setting is enabled brings up this self test alarm.

SETTINGS LOCK — If this setting is Enabled then an unauthorized write attempt to a setting for a given role activates this self test.

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ↓ SUPERVISORY ⇒ SELF TESTS ⇒ FAILED AUTHENTICATE



CyberSentry setup

When first using CyberSentry security, use the following procedure for setup.

1. Log in to the relay as Administrator by using the **VALUE** keys on the front panel to enter the default password "ChangeMe1#". Note that the Lock Relay setting needs to be disabled in the **Security > Supervisory** menu. When this setting is disabled, configuration and firmware upgrade are possible. By default, this setting is disabled.
2. Enable the Supervisor role if you have a need for it.
3. Make any required changes in configuration, such as setting a valid IP address for communication over Ethernet.
4. Log out of the Administrator account by choosing None.
5. Next, Device or Server authentication can be chosen on the login screen, but the choice is available only in EnerVista. Use Device authentication to log in using the five pre-configured roles (Administrator, Supervisor, Engineer, Operator, Observer). When using a serial connection, only Device authentication is supported. When Server authentication is required, characteristics for communication with a RADIUS server must be configured. This is possible only in the EnerVista software. The RADIUS server itself also must be configured. The appendix called RADIUS Server at the end of this instruction manual gives an example of how to set up a simple RADIUS server. Once both the RADIUS server and the parameters for connecting the UR to the server have been configured, you can choose Server authentication on the login screen of EnerVista.

NOTICE

The use of CyberSentry for devices communicating through an Ethernet-to-RS485 gateway is not supported. Because these gateways do not support the secure protocols necessary to communicate with such devices, the connection cannot be established. Use the device as a non-CyberSentry device.

Users logged in through the front panel are not timed out and cannot be forcefully logged out by a supervisor. Roles logged in through the front panel that do not allow multiple instances (Administrator, Supervisor, Engineer, Operator) must switch to None (equivalent to a logout) when they are done in order to log out.

For all user roles except Observer, only one instance can be logged in at a time, for both login by front panel and software.

To configure Server authentication:

1. In the EnerVista software, choose Device authentication and log in as Administrator.
2. Configure the following RADIUS server parameters: IP address, authentication port, shared secret, and vendor ID.
3. On the RADIUS server, configure the user accounts. Do not use the five pre-defined roles as user names (Administrator, Supervisor, Engineer, Operator, Observer) in the RADIUS server. If you do, the UR relay automatically provides the authentication from the device.
4. In the EnerVista software, choose Server authentication and log in using the user name and password configured on the RADIUS server for Server authentication login.

- After making any required changes, log out.

NOTICE

When changing settings offline, ensure that only settings permitted by the role that performs the settings download are changed because only those changes are applied.

Pushbuttons (both user-control buttons and user-programmable buttons) located on the front panel can be pressed by an Administrator or Engineer role. This also applies to the **RESET** button, which resets targets, where targets are errors displayed on the front panel or the Targets panel of the EnerVista software. The **RESET** button has special behavior in that it allows these two roles to press it even when they are logged in through the RS232 port and not through the front panel.

To reset the security event log and self-test operands:

- Log in as Supervisor (if the role is enabled) or Administrator (if the Supervisor role is disabled) and execute a clear security command under **Commands > Security > Clear Security**.

Security events

The security events produced when the CyberSentry option is purchased are sent as system log (syslog) messages to a syslog server, if one is configured. The format is as follows.

Security log	Event Number	Date & Timestamp	Username	IP address	Role	Activity Value
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Event Number — Event identification number (index)

Date & Timestamp — UTC date and time

Username — 255 chars maximum, but in the security log it is truncated to 20 characters

IP address — Device IP address

Role — 16 bit unsigned, of type format F617

Enumeration	Role
0	None
1	Administrator
2	Supervisor
3	Engineer
4	Operator
5	Factory

Activity Value — 16 bit unsigned

Enumeration	Description
1	Authentication Failed
2	User Lockout
3	FW Upgrade
4	FW Lock
5	Settings Lock
6	Settings Change. Because this can fill the entire event log, it is supported by the already existing Settings_Change.log file. This event is not required.
7	Clear Oscillography command
8	Clear Data Logger command (not applicable to all UR products)
9	Clear Demand Records command (not applicable to all UR products)
10	Clear Energy command (not applicable to all UR products)
11	Clear Unauthorized Access command
12	Clear Teleprotection Counters command (not applicable to all UR products)
13	Clear All Relay Records command
14	Role Log in

Enumeration	Description
15	Role Log off

In addition to supporting syslog, a L30 with CyberSentry also saves the security events in two local security files, these being SECURITY_EVENTS.CSV and SETTING_CHANGES.LOG. Details on these files and how to retrieve them are available in the EnerVista software under **Maintenance > Retrieve File**. Depending on the level of criticality/severity, a syslog server or a reporting tool gathering information from a syslog server can produce reports, charts, and so on. All severity levels are per RFC 5424.

Table 5-6: CyberSentry system events recorded

Event	Severity	Description
FAILED_AUTH, ORIGIN, TIMESTAMP	Warning (4)	A failed authentication with origin information (username and IP:MAC address), a time stamp in UTC time when it occurred
AUTH_LOCKOUT, ORIGIN, TIMESTAMP	Error (3)	An authentication lockout has occurred because of too many failed authentication attempts
FIRMWARE_UPGD, ORIGIN, TIMESTAMP	Warning (4)	Indicates that a change of firmware has occurred
FIRMWARE_LOCK, ORIGIN, TIMESTAMP	Critical (1)	An attempt was made to change firmware while the firmware lock was enabled
SETTING_CHG, ORIGIN, TIMESTAMP	Notice (5)	Indicates setting changes
SETTING_LOCK, ORIGIN, TIMESTAMP	Critical (1)	An attempt was made to change settings while the settings lock was enabled
LOGIN, ORIGIN, TIMESTAMP	Warning (4)	Indicates when a certain role logged in
LOGOUT, ORIGIN, TIMESTAMP	Notice (5)	Indicates when a certain role logged out or timed out
CLEAR_OSCILLOGRAPHY	Notice (5)	Clear oscillography command was issued
CLEAR_DATA_LOGGER	Notice (5)	Clear data logger command was issued
CLEAR_DEMAND_RECS	Notice (5)	Clear demand records command was issued
CLEAR_ENERGY	Notice (5)	Clear energy command was issued
RESET_UNAUTH_ACCESS	Warning (4)	Reset Unauthorized access command was issued
CLEAR_TELEPROTECTION_CNT	Notice (5)	Clear teleprotection counters command was issued
CLEAR_ALL_RECS	Warning (4)	Clear all records command was issued

5

5.3.2 Display properties

SETTINGS ⇒ PRODUCT SETUP ⇒ DISPLAY PROPERTIES

<ul style="list-style-type: none"> ■ DISPLAY ■ PROPERTIES 	↔	LANGUAGE: English	Range: English; English, French; English, Russian; English, Chinese; English, German (examples; depends on order code) Visible when language other than English purchased
	↕	FLASH MESSAGE TIME: 1.0 s	Range: 0.5 to 10.0 s in steps of 0.1
	↕	DEFAULT MESSAGE TIMEOUT: 300 s	Range: 10 to 900 s in steps of 1
	↕	DEFAULT MESSAGE INTENSITY: 25 %	Range: 25%, 50%, 75%, 100% Visible when a VFD is installed
	↕	SCREEN SAVER FEATURE: Disabled	Range: Disabled, Enabled Visible when an LCD is installed
	↕	SCREEN SAVER WAIT TIME: 30 min	Range: 1 to 65535 min. in steps of 1 Visible when an LCD is installed
	↕	CURRENT CUT-OFF LEVEL: 0.020 pu	Range: 0.002 to 0.020 pu in steps of 0.001
	↑	VOLTAGE CUT-OFF LEVEL: 1.0 V	Range: 0.1 to 1.0 V secondary in steps of 0.1

Some relay messaging characteristics can be modified to suit different situations using the display properties settings.

LANGUAGE — This setting selects the language used to display settings, actual values, and targets. This setting displays when a language other than English was purchased, and the range depends on the order code of the relay.

For Japanese, the settings display in Japanese on the graphical front panel, while the keys printed on the panel are in English.

For Japanese and Chinese, up to 10 characters can be input in a field on the graphical front panel, not 20.

With the graphical front panel, the language can be changed regardless of the language purchased. That is, all languages can be used. If you select a language with which you are unfamiliar and want to switch back to English for example, the menu order remains the same. That is, Settings is always second, Product Setup is always first, Display Properties is always second, and Language is always first.

If the language is changed after entering user-configured names, such as relay names, the strings are not translated. For example, a relay name is entered in English, the language is changed to Japanese, and the relay name remains in English. Set the language before changing settings.

The language can be selected also for the front panel in EnerVista under **Maintenance > Change Front Panel**.

The language of the EnerVista software can be changed under **View > Language**.

FLASH MESSAGE TIME — Flash messages are status, warning, error, and information messages displayed in response to certain key presses during settings programming. These messages override any normal messages. Use this setting to change the duration of flash messages on the display.

DEFAULT MESSAGE TIMEOUT — If the keypad is inactive for a period of time, the relay automatically reverts to a default message. The inactivity time is modified using this setting to ensure that messages remain on the screen long enough during programming or reading of actual values. This setting is not supported on the graphical front panel.

DEFAULT MESSAGE INTENSITY — To extend phosphor life in the vacuum fluorescent display, the brightness can be attenuated during default message display. During keypad interrogation, the display always operates at full brightness. This setting is not supported on the graphical front panel.

SCREEN SAVER FEATURE and **SCREEN SAVER WAIT TIME** — These settings are only visible if the L30 has a liquid crystal display (LCD) and control its backlighting. When the **SCREEN SAVER FEATURE** is “Enabled,” the LCD backlighting turns off after the **DEFAULT MESSAGE TIMEOUT** followed by the **SCREEN SAVER WAIT TIME**, provided that no keys have been pressed and no target messages are active. When a keypress occurs or a target becomes active, the LCD backlighting turns on. These settings are not supported on the graphical front panel.

CURRENT CUT-OFF LEVEL — This setting modifies the current cut-off threshold. Very low currents (1 to 2% of the rated value) are very susceptible to noise. Some customers prefer very low currents to display as zero, while others prefer the current to display even when the value reflects noise rather than the actual signal. The L30 applies a cut-off value to the magnitudes and angles of the measured currents. If the magnitude is below the cut-off level, it is substituted with zero. This applies to phase and ground current phasors as well as true RMS values and symmetrical components. The cut-off operation applies to quantities used for metering, protection, and control, as well as those used by communications protocols. Note that the cut-off level for the sensitive ground input is 10 times lower than the **CURRENT CUT-OFF LEVEL** setting value. Raw current samples available via oscillography are not subject to cut-off.

This setting does not affect the 87L metering cutoff, which is constantly at 0.02 pu.

VOLTAGE CUT-OFF LEVEL — This setting modifies the voltage cut-off threshold. Very low secondary voltage measurements (at the fractional volt level) can be affected by noise. Some customers prefer these low voltages to be displayed as zero, while others prefer the voltage to be displayed even when the value reflects noise rather than the actual signal. The L30 applies a cut-off value to the magnitudes and angles of the measured voltages. If the magnitude is below the cut-off level, it is substituted with zero. This operation applies to phase and auxiliary voltages, and symmetrical components. The cut-off operation applies to quantities used for metering, protection, and control, as well as those used by communications protocols. Raw samples of the voltages available via oscillography are not subject to cut-off.

The **CURRENT CUT-OFF LEVEL** and the **VOLTAGE CUT-OFF LEVEL** are used to determine the metered power cut-off levels. The power cut-off level is calculated using the following equations. For Delta connections:

$$\text{3-phase power cut-off} = \frac{\sqrt{3} \times \text{CURRENT CUT-OFF LEVEL} \times \text{VOLTAGE CUT-OFF LEVEL} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}} \quad \text{Eq. 5-3}$$

For Wye connections:

$$\text{3-phase power cut-off} = \frac{3 \times \text{CURRENT CUT-OFF LEVEL} \times \text{VOLTAGE CUT-OFF LEVEL} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}} \tag{Eq. 5-4}$$

$$\text{per-phase power cut-off} = \frac{\text{CURRENT CUT-OFF LEVEL} \times \text{VOLTAGE CUT-OFF LEVEL} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}} \tag{Eq. 5-5}$$

where VT primary = VT secondary × VT ratio and CT primary = CT secondary × CT ratio.

For example, given the following settings:

- CURRENT CUT-OFF LEVEL:** "0.02 pu"
- VOLTAGE CUT-OFF LEVEL:** "1.0 V"
- PHASE CT PRIMARY:** "100 A"
- PHASE VT SECONDARY:** "66.4 V"
- PHASE VT RATIO:** "208.00 : 1"
- PHASE VT CONNECTION:** "Delta"


We have:

- CT primary = "100 A", and
- VT primary = PHASE VT SECONDARY × PHASE VT RATIO = 66.4 V × 208 = 13811.2 V


The power cut-off is therefore:

$$\begin{aligned} \text{power cut-off} &= (\text{CURRENT CUT-OFF LEVEL} \times \text{VOLTAGE CUT-OFF LEVEL} \times \text{CT primary} \times \text{VT primary}) / \text{VT secondary} \\ &= (\sqrt{3} \times 0.02 \text{ pu} \times 1.0 \text{ V} \times 100 \text{ A} \times 13811.2 \text{ V}) / 66.4 \text{ V} \\ &= 720.5 \text{ watts} \end{aligned}$$

Any calculated power value below this cut-off does not display. As well, the three-phase energy data do not accumulate if the total power from all three phases does not exceed the power cut-off.

 Lower the **VOLTAGE CUT-OFF LEVEL** and **CURRENT CUT-OFF LEVEL** with care as the relay accepts lower signals as valid measurements. Unless dictated otherwise by a specific application, the default settings of "0.02 pu" for **CURRENT CUT-OFF LEVEL** and "1.0 V" for **VOLTAGE CUT-OFF LEVEL** are recommended.

5.3.3 Graphical front panel

 The graphical front panel is a hardware option. See the Order Codes section in chapter 2 for details.

Use the EnerVista software to configure the graphical front panel. The settings are not accessible from the graphical front panel.

The following screens are available:

- Home page
- Rolling mode
- Metering editor
- Single-line diagram editor
- Annunciator editor
- Configurable navigation

The settings menu itself and the event record pages are not configurable.

Multiple screens can be opened in the EnerVista software, but the first remains active and the others can be read-only. For example, the Annunciator Editor and Single Line Diagram Editor can be open and active, then subsequently opened Rolling Mode and Home Page screens are read-only. Close the windows, then re-open the one required.

5.3.3.1 Home page

This window sets the home page displayed on the graphical front panel and the date and time formats for all pages. Home page options include display of product information, alarms, actual values, and event records.

The path is **Settings > Product Setup > Graphical Panel > Home Page**. The menu does not display when there is no graphical front panel.

Figure 5-5: Home page with product information

Setting Group		Alarm	Target	Relay Date and Time	
1				11-May-17 12:39:59	
Relay ID:	Relay-1			Remaining Connections	
Last Setting Change:	01-Jan-70 00:00:00			MMS TCP:	5
Order Code:	F60-U03-HEH-F8L-H6H			Modbus TCP:	4
Relay Serial Number:	MBEC159999#9			DNP TCP:	2
Firmware Version:	7.60			IEC-104 TCP:	0
Modbus Slave Address:	254			SFTP:	4
Modbus TCP Port:	502				
	Port 1	Port 2	Port 3		
IP Address:	192.168.2.3	10.14.22.7	127.0.0.1		
Subnet Mask:	255.255.255.0	255.255.255.0	255.0.0.0		
MAC Address:	00A0F4000000	00A0F4000001	00A0F4000002		
Link Status:	Fail	OK	Fail		
	SLDs	Annunciator	Metering	Event Record	Menu

859850A1.cdr

5

Figure 5-6: Home page settings

SETTING	PARAMETER
Home Page Content	Product Information
Date Format	yyyy-mm-dd
Time Format	hh:mm:ss

F60 76x My Box | Settings: Product Setup: Graphical F | Screen ID: 24

Home Page Content

Range: Product Information, SLD 1...5, Annunciator, Annunciator 1...8, Phasors 1...6, Tabular 1...5, Event Records, Targets
Default: Product Information

This setting specifies the page to display between the home page header and footer. Pressing the **Home** button returns the display to this page. The home page displays for the rolling mode delay specified, then changes to the rolling mode pages.

The "Annunciator" option without a page number specifies the first annunciator page in the following sequence:

- The first annunciator page that contains an annunciator window that is in alarm (fast flash)
- The first annunciator page that contains an annunciator window that is in ringback. Ringback is a "return alert." Visual and audible signals are given when conditions return to normal, then the sequence returns to normal by pushing the **RESET** button.
- The first annunciator page that contains an annunciator window that is in abnormal state
- Annunciator page 1

Whenever an annunciator window changes state this list is re-evaluated, which can result in the home page displaying a different annunciator page.

The Tabular option displays a configured actual values/metering page.

The Targets option displays error messages, such as wrong transceiver, similar to event record entries.

Date Format

Range: yyyy-mm-dd, dd-mmm-yy, yyyy/mm/dd, m/d/yyyy, m/d/yy, mm/dd/yy, mm/dd/yyyy, yy/mm/dd

Default: yyyy-mm-dd

This setting specifies the format for dates on the graphical front panel. It applies to the page header, the events records, the annunciator, and everywhere else a date displays on the panel. If the relay is synchronized to an external time source via PTP, IRIG-B, SNTP, and so on, the date/time is shown in white, and otherwise in yellow.

yyyy — four-digit year, for example 2017

yy — two-digit year, for example 17 for 2017

mmm — abbreviation of month name, for example Jan for January

mm — two-digit month, for example 01 for January

m — one or two-digit month, for example 1 for January and 10 for October

dd — two-digit day, for example 08

d — one or two-digit day, for example 8 and 28

To set the date and time, access **Synchronize Devices** in the software, synchronize to a time source using **Settings > Product Setup > Real Time Clock**, or synchronize to the computer using **Commands > Set Date and Time**.

Time Format

Range: hh:mm:ss, h:mm:ss tt

Default: hh:mm:ss

This setting specifies the format for time on the graphical front panel. It applies to the page header and everywhere else a time displays on the panel. When the Date Format and the Time Format use the defaults, the date and time are separated by the character "T" per the ISO convention, such as "2017-09-24T10:58:31". Otherwise the date and time are separated by a space. If the relay is synchronized to an external time source via PTP, IRIG-B, SNTP, and so on, the date/time is shown in white, and otherwise in yellow.

hh — two-digit hour, for example 02 for two o'clock

h — one or two-digit hour, for example 2 for two o'clock

mm — two-digit minute, for example 51 minutes

ss — two-digit second (can have a decimal and further digits appended), for example 16 seconds

tt — AM or PM based on 12 hour clock

If microseconds have to be displayed, for example, in the event records, the 24-hour clock is adopted. The representation of an accumulated period (for example hh:mm) is not affected by the selected time format.

To set the date and time, access **Synchronize Devices** in the software or synchronize to a time source using **Settings > Product Setup > Real Time Clock**.

5.3.3.2 Rolling mode

After a user-defined period of inactivity, the graphical front panel changes, or rolls, to user-selected pages. Up to 10 pages can be specified. Similarly, the display backlight intensity is lowered to a specified level; lower intensity extends the life of the display.

Each rolling page displays for a few seconds; duration cannot be set.

The path is **Settings > Product Setup > Graphical Panel > Rolling Mode**.

Figure 5-7: Rolling mode settings

SETTING	PARAMETER
Rolling Mode Delay	900 s
Automatic Annunciator Recall	Enabled
Screen Saver Delay	800 s
Screen Saver Intensity	30 %
Number of Rolling Mode Pages	5
Rolling Mode Page 1	Product Information
Rolling Mode Page 2	SLD 1
Rolling Mode Page 3	SLD 2
Rolling Mode Page 4	SLD 3
Rolling Mode Page 5	Event Records
Rolling Mode Page 6	Product Information
Rolling Mode Page 7	Product Information
Rolling Mode Page 8	Product Information
Rolling Mode Page 9	Product Information
Rolling Mode Page 10	Product Information

Rolling Mode Delay

Range: 0 to 900 s in steps of 1

Default: 300 s

Set this delay to 0 to disable the rolling mode feature.

Otherwise, after no pushbutton has been pressed for the amount of time specified by this setting, the display automatically enters rolling mode. While in the rolling mode, the Rolling Mode Pages display. Rolling mode can be interrupted when a setting changes, such as changing the home page, then resumes rolling.

Automatic Annunciator Recall

Range: Enabled, Disabled

Default: Enabled

When Enabled, an annunciator window changes state, and the display is in rolling mode, this setting terminates rolling mode and displays the annunciator page containing the changed state.

The Configurable Navigation feature takes precedence over this setting when the Automatic Annunciator Recall and Configurable Navigation are activated by the same input.

Screen Saver Delay

Range: 0 to 900 s in steps of 1

Default: 300 s

The screen saver mode extends the life of the display. After the amount of time set here, the screen saver activates and the display intensity is reduced to the level set by the **Screen Saver Intensity** setting. When in rolling mode, rolling continues while the screen saver is active. The screen saver terminates when rolling mode terminates. To disable the screen saver, set the delay to 0.

Screen Saver Intensity

Range: 0, 10, 20, or 30 %

Default: 30 %

This setting sets the brightness of the display while the screen saver is active. For example, 0% means that the screen is dark and nothing displays. Pressing a pushbutton or changing a setting in the software, for example, re-activates the display.

Number of Rolling Mode Pages

Range: 1 to 10 in steps of 1

Default: 1

This setting specifies the number of rolling pages. During rolling mode, the graphical front panel displays pages from 1 to the selected number.

Rolling Mode Page 1 to 10

Range: Product Information, SLD 1...5, Annunciator, Annunciator 1...8, Phasors 1...6, Tabular 1...5, Event Records, Targets
Default: Product Information

These settings specify the pages to display on the graphical front panel while in rolling mode.

The "Annunciator" selection without a page number specifies the first annunciator page in the following sequence:

- The first annunciator page that contains an annunciator window that is in alarm (fast flash)
- The first annunciator page that contains an annunciator window that is in ringback. Ringback is a "return alert." Visual and audible signals are given when conditions return to normal, then the sequence returns to normal by pushing the **RESET** button.
- The first annunciator page that contains an annunciator window that is in abnormal state
- Annunciator page 1

Whenever an annunciator window changes state the list is re-evaluated, which can result in the display of a different annunciator page in the rolling sequence.

The Tabular option displays a configured actual values/metering page.

The Targets option displays error messages, such as wrong transceiver, similar to event record entries.

5.3.3.3 Metering editor

This feature creates tables of actual/metered values for the graphical front panel. It configures the content that displays in the Metering Tab pushbutton. An actual value, status, or text can be displayed. Five tabular metering pages can be configured. There also can be a phasor page for each configured AC source, and these pages are not configurable.

The path is **Settings > Product Setup > Graphical Panel > Metering Editor**.

Set the Current Page, Page Name, Layout, configure the top inputs, then the cells. The 16 inputs at the top of the page are used as inputs for the **Status Index** fields. Click the **Preview** button to view the page.

For a phasor diagram, configure the source under **Settings > System Setup > Signal Sources**. The diagram is then viewable by pushing the **Metering** Tab pushbutton on the graphical front panel. The Metering Editor is not used for these phasor diagrams.

The figures show setup and table preview.

Figure 5-8: Metering Editor window

STATUS		STATUS INPUTS			
1 to 4:	87L DIFF OP	87L DIFF OP G	87L DIFF BLOCKED	OFF	
5 to 8:	PH DIST Z1 OP	GND DIST Z1 OP	PH DIST Z2 OP	GND DIST Z2 OP	
9 to 12:	PH DIST Z3 OP	GND DIST Z3 OP	OFF	OFF	
13 to 16:	OFF	OFF	OFF	OFF	

CURRENT PAGE	Page 1	PAGE NAME	87L DIFF	LAYOUT	6x4	Preview		
PARAMETER	CONTENT	STATUS INDEX	TEXT	OFF TEXT	FONT	TEXT COLOR	BACK COLOR	ACTUAL
Cell(1, 1)	Text	Select One	DIFF OPERANDS		20	█		Configure
Cell(1, 2)	Status	1	87L DIFF OP	87LP NOT OP	16	█		Configure
Cell(1, 3)	Status	2	87L DIFF OP G	87LG NOT OP	16	█		Configure
Cell(1, 4)	Status	3	87L BLOCKED	87L NOT BLK	16	█		Configure
Cell(2, 1)	Text	Select One	DIFF CURRENT		20	█		Configure
Cell(2, 2)	Actual	Select One			16	█		Configure
Cell(2, 3)	Actual	Select One			16	█		Configure
Cell(2, 4)	Actual	Select One			16	█		Configure
Cell(3, 1)	Text	Select One	RESTRAINT CURR		20	█		Configure
Cell(3, 2)	Actual	Select One			16	█		Configure
Cell(3, 3)	Actual	Select One			16	█		Configure
Cell(3, 4)	Actual	Select One			16	█		Configure
Cell(4, 1)	Text	Select One	LOCAL CURRENT		20	█		Configure
Cell(4, 2)	Actual	Select One			16	█		Configure
Cell(4, 3)	Actual	Select One			16	█		Configure
Cell(4, 4)	Actual	Select One			16	█		Configure
Cell(5, 1)	Text	Select One	REM CURRENT		20	█		Configure
Cell(5, 2)	Actual	Select One			16	█		Configure
Cell(5, 3)	Actual	Select One			16	█		Configure
Cell(5, 4)	Actual	Select One			16	█		Configure
Cell(6, 1)	Text	Select One	GND DIFF		20	█		Configure
Cell(6, 2)	Actual	Select One			16	█		Configure
Cell(6, 3)	Text	Select One	GND RESTRAINT		20	█		Configure
Cell(6, 4)	Actual	Select One			16	█		Configure

Figure 5-9: Preview for graphical front panel

//Metering/87L DIFF			
DIFF OPERANDS	87L DIFF OP	87L DIFF OP G	87L BLOCKED
DIFF CURRENT	000000.000 A	000000.000 A	000000.000 A
RESTRAINT CURR	000000.000 A	000000.000	000000.000 A
LOCAL CURRENT	000000.000 A	000000.000 A	000000.000 A
REM CURRENT	000000.000 A	000000.000 A	000000.000 A
GND DIFF	000000.000 A	GND RESTRAINT	000000.000 A

Page 1: 87L DIFF Rows: 6 Columns: 4

STATUS INPUTS 1 to 16

Range: OFF, ON, any FlexLogic operand

Default: OFF

This setting identifies the potential inputs for use in the STATUS INDEX fields, for display of the status of FlexLogic operands.

A maximum of eight Status Inputs can be used per metering page, and 16 in all metering pages.

Select the metering input from the drop-down list. The options reflect the FlexLogic operands applicable to the L30. They are inputs for all five metering pages, not just the current page.

CURRENT PAGE*Range: Page 1...Page 5**Default: Page 1*

Select the metering page to configure from the drop-down list. There are five pages possible, viewable with the Tab pushbuttons on the graphical front panel.

PAGE NAME*Range: Page 1...Page 5**Default: Page 1*

Up to 20 characters can be input here as the name of each metering page. The name displays for the Tab pushbutton on the graphical front panel.

LAYOUT*Range: 3x4, 4x6, 6x8, 6x4, 8x6, 12x8, 12x4, 16x6, 18x8**Default: 6x4*

This setting determines how many rows and columns display on the graphical front panel with the metering information. The configurable rows in the settings window change dynamically based on this setting.

CONTENT*Range: Actual, Status, Text**Default: Text*

Select the type of content to display.

- Actual — an actual value/data. The **Configure** button becomes active for the actual value to be selected.
- Status — one of the operands selected from the STATUS INPUTS fields. Select it in the **STATUS INDEX** field.
- Text — indicates that text is to display instead of a metered value

STATUS INDEX*Range: 1...16**Default:*

This field becomes active when the **CONTENT** field is set to Status. It selects the input from the STATUS INPUTS to display the on/off status of the selected operand.

A maximum of eight Status Inputs can be used per metering page, and 16 in all metering pages.

TEXT*Range: up to 20 alphanumeric characters**Default:*

Enter the text to display on the graphical front panel. This field is active when the **CONTENT** field is set to Text or Status. When Status is selected, the text displays when the status input is in the "on" state.

OFF TEXT*Range: up to 20 alphanumeric characters**Default:*

Enter the text to display on the graphical front panel when the element being monitored is in an off/closed state. This field is active when the **CONTENT** field is set to Status. The text displays when the status input is in the "off" state.

FONT*Range: 16, 18, 20**Default: 16*

Set the font size to display on the graphical front panel.

TEXT COLOR*Range: 24-bit color selector**Default: Black*

Set the text color to display in the specified cell.

BACK COLOR

Range: 24-bit color selector

Default: Grey

Set the background color to display in the specified cell.

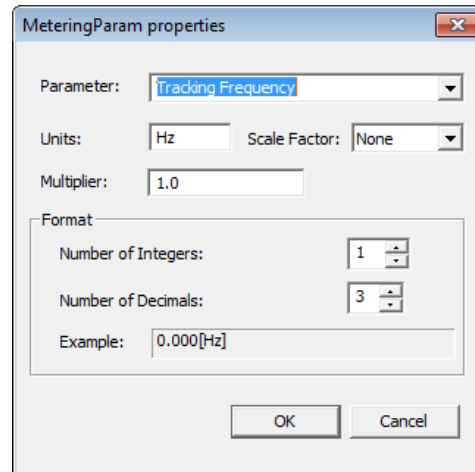
ACTUAL (Configure)

Range: Configure

Default: Configure

The **Configure** button becomes active when the **CONTENT** field is set to "Actual." The window specifies the metering data to display.

Figure 5-10: Metering value properties window

**Parameter**

Range: any FlexAnalog parameter

Default:

This setting selects a FlexAnalog parameter that specifies the metered value to display in the metering window. A FlexAnalog is an analog parameter.

Units

Range: up to eight alphanumeric characters

Default:

This setting specifies the units of measurement for the metered value and is populated based on the Parameter selected. The field can be left blank when units of measure do not apply.

Scale Factor

Range: G Giga, M Mega, k Kilo, None

Default: None

This setting allows the user to specify the scaling factor for the metering units value. Options depend on the Parameter.

Multiplier

Range: -1000000 to 1000000

Default: 1.0

This setting allows the user to specify a multiplier for the metering parameter value. The multiplier must be in compliance with the 32-bit floating-point format per IEEE 754, otherwise, the input value is represented as per the IEEE standard. For example, 1234.56789 is represented as 1234.567871094, and 9876.54321 as 9876.54296875.

Number of Integers

Range: 1 to 12 in steps of 1

Default: 1

This setting specifies the number of integers in the displayed metered value. It can be used to provide for leading character spacing of the display value.

For example, setting the number to 2 displays 00.000[V] and setting it to 3 displays 000.000[V].

Number of Decimals

Range: 0 to 10 in steps of 1

Default: 3

This setting specifies the number of decimal places in the displayed metered value. For example, setting the number to 1 displays 0.0 and setting it to 2 displays 0.00.

5.3.3.4 Single-line diagram editor

The path is **Settings > Product Setup > Graphical Panel > Single Line Diagram Editor**. Use is explained in the Interfaces chapter.

5.3.3.5 Annunciator editor

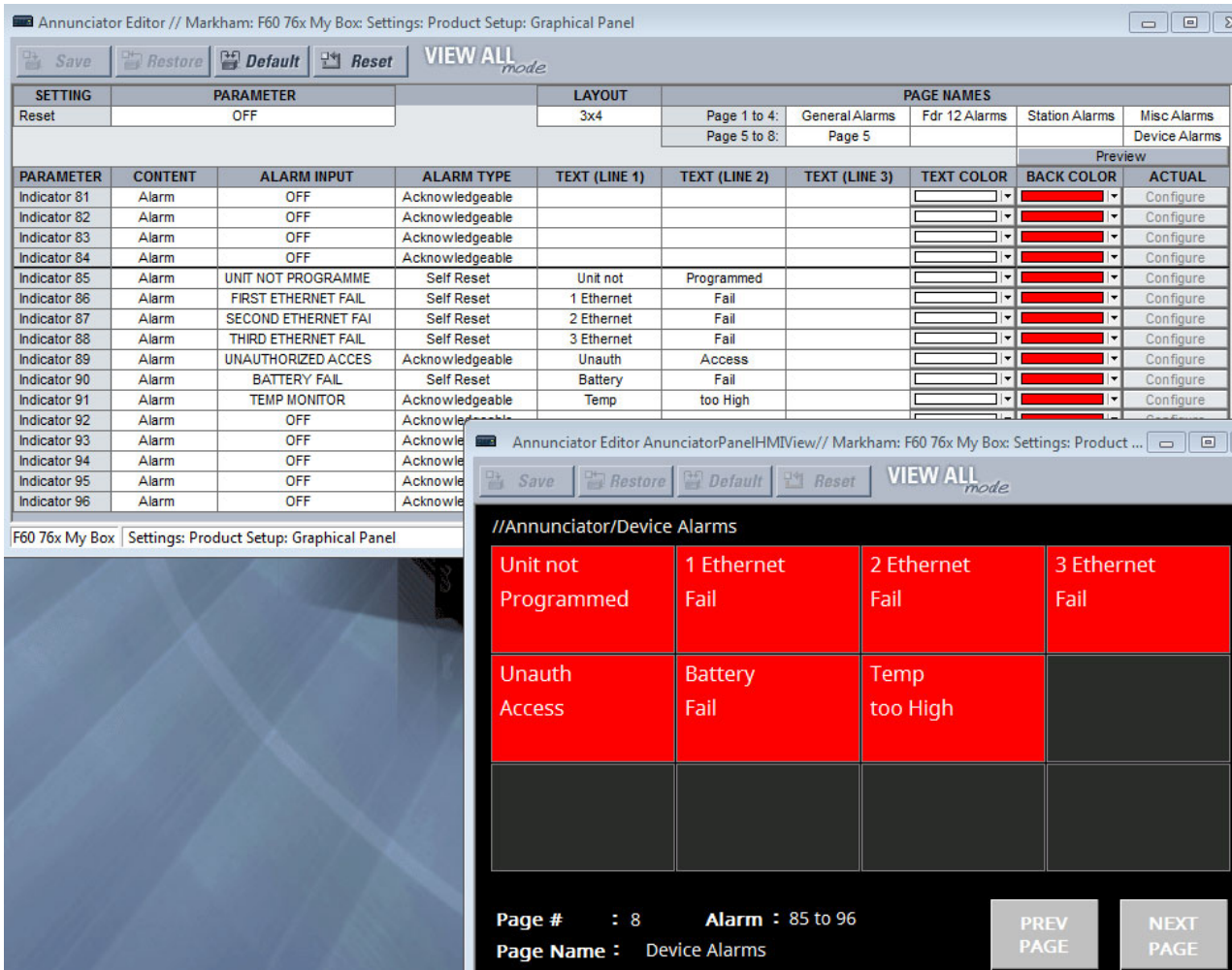
The annunciator editor is used to create annunciator content for the graphical front panel, including alarms and actual values. Use is explained in the Interfaces chapter.

The path is **Settings > Product Setup > Graphical Panel > Annunciator Editor**.

To add an alarm, access the Annunciator Editor, configure the Layout and Page Name, configure the alarm or actual value, set the text and color, then save. On the graphical front panel, view the content by pressing the **Annunciator** Tab pushbutton at the bottom of the **Home** page. (Alarms do not display automatically.) Acknowledge or reset the alarm by navigating to it with the arrow pushbuttons, then pressing the **ENTER** or **RESET** pushbutton.

The figure shows alarms for basic functions. The last annunciator page is named Device Alarms. Alarms are set for the device being offline, Ethernet cable issues, unauthorized access, battery failure, and high ambient temperature. They can reset themselves when conditions return to normal, except for unauthorized access and temperature monitoring, which require the alarms to be acknowledged. The self-test error functions, here for Ethernet and battery failures, also have been enabled under **Settings > Product Setup > User-Programmable Self Tests** (not shown). When the alarms are triggered, they display with a red background. An alarm is acknowledged by using the arrow keys on the graphical front panel then pressing the **ENTER** button.

Figure 5-11: Annunciator editor with preview shown



Reset

Range: ON, OFF, any FlexLogic operand
 Default: OFF

This setting selects a FlexLogic operand that when activated acknowledges/resets all annunciator windows in the graphical front panel. For example, to have the first user pushbutton resets all alarms, set this to **PUSHBUTTON 1 ON** and turn on the pushbutton under **Settings > Product Setup > User-Programmable Pushbuttons**. This setting is the same as the one defined in **Settings > Inputs/Outputs > Resetting > Reset Annunciator**. See the Resetting section later in this chapter.

LAYOUT

Range: 3x4, 4x6, 6x8
 Default: 3x4

Selects the number of rows and columns to display on the annunciator pages. For example, 3x4 means 12 windows display per page over eight pages. Up to 96 entries are possible.
 To view the layout, click the **Preview** button.

PAGE NAMES

Range: up to 20 alphanumeric characters
 Default: Page 1...Page 8

Up to 20 characters can be input as the name of each annunciator page. The number of pages depends on the Layout. The name displays for the Tab pushbutton on the graphical front panel.

PARAMETER

Range: Indicator 1...Indicator 96

Default: Indicator 1...Indicator 96

Read-only field. Up to 96 windows are possible.

CONTENT

Range: Actual, Alarm, Mixed

Default: Alarm

Select if the cell is to be an alarm, an actual value, or a combination thereof, for example consists of a single metered value (set to "Actual"), contains a single alarm indication (set to "Alarm"), or contains both a metered value and an alarm indication (set to "Mixed").

ALARM INPUT

Range: OFF, ON, any FlexLogic operand

Default: OFF

Select a trigger for the alarm, or the input signal connected to the alarm. For example, when set to "FIRST ETHERNET FAIL" and the Ethernet cable connected to port 1 is removed, the alarm is triggered. (Note that when the Ethernet cable is inserted into an SFP connector and the SFP connector is removed, the alarm is not triggered.) The field is read-only for an actual value.

The selectable options are the FlexLogic operands specific to the product.

ALARM TYPE

Range: Acknowledgeable, Self Reset, Latched

Default: Acknowledgeable

Set the alarm type. The field is read-only for an actual value.

Acknowledgeable — Follow the state transitions, as outlined in the Annunciator section of the Interfaces chapter. The alarm blinks until acknowledged, then remains on until the condition clears.

Self Reset — Track the state of the input operand. The alarm turns on when the trigger activates and off when the trigger clears.

Latched — Alarm is on until acknowledged/reset individually or until the **RESET** button is pressed.

To acknowledge/reset/unlatch an alarm, use the arrow buttons on the graphical front panel and press the **ENTER** button.

TEXT (LINE 1 to 3)

Range: up to 10 alphanumeric characters

Default:

The text that displays in the annunciator cell. Three lines can be displayed. Note that a specified metering value replaces the text for the selected line. This means that a line can display text or be set to show an actual metered value. If the text does not display it is because an actual metered value is over-riding it; change the line for the text or for the actual value.

TEXT COLOR

Range: 24-bit color selector

Default: White

The color to display for the three text or actual value lines specified.

BACK COLOR

Range: 24-bit color selector

Default: Red

The background color to display for any triggered cell, for example when an alarm is triggered.

ACTUAL (Configure)

Range: Configure

Default: Configure

The **Configure** button becomes active when the **CONTENT** field is set to "Actual" or "Mixed." The window specifies the metering data to display.

Parameter

Range: any FlexAnalog parameter

Default:

This setting selects a FlexAnalog parameter that specifies the metered value to display in the annunciator alarm.

Units

Range: up to eight alphanumeric characters

Default:

This setting specifies the units of measurement for the metered value and is populated based on the Parameter selected. The field can be left blank when units of measure do not apply.

Scale Factor

Range: G Giga, M Mega, k Kilo, None

Default: None

This setting allows the user to specify the scaling factor for the metering units value. Options depend on the Parameter.

Multiplier

Range: -1000000 to 1000000

Default: 1.0

This setting allows the user to specify a multiplier for the metering parameter value. The multiplier must be in compliance with the 32-bit floating-point format per IEEE 754, otherwise, the input value is represented as per the IEEE standard. For example, 1234.56789 is represented as 1234.567871094, and 9876.54321 as 9876.54296875.

Number of Integers

Range: 1 to 12 in steps of 1

Default: 1

This setting specifies the number of integers in the displayed analog value. It can be used to provide for leading character spacing of the display value.

For example, setting the number to 2 displays 00.000[V] and setting it to 3 displays 000.000[V].

Number of Decimals

Range: 0 to 10 in steps of 1

Default: 3

This setting specifies the number of decimal places in the displayed analog value. For example, setting the number to 1 displays 0.0 and setting it to 2 displays 0.00.

Display in Line

Range: 1, 2, 3

Default: 1

This setting specifies the line in the annunciator alarm window to display the metered value. The actual value replaces the text for the selected line. For example, 2 means the value displays in line 2 of the text; any text configured to display in that line does not display.

5.3.3.6 Configurable navigation

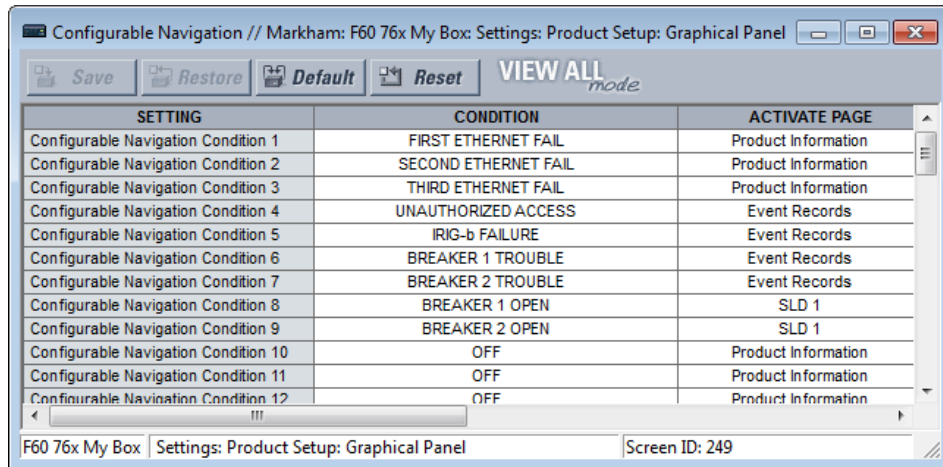
The path is **Settings > Product Setup > Graphical Panel > Configurable Navigation**.

This feature allows FlexLogic operands to trigger page display on the graphical front panel. It consists of 64 setting pairs, each with a condition and an activation page. The condition selects any FlexLogic operand. The activation page selects any page available for the graphical front panel. The page opens whenever the selected operand transitions from Off to On. The page remains open until rolling mode initiates, another trigger initiates from Configurable Navigation, or the **Home** button is pressed.

Avoid selecting condition operands that are likely to operate simultaneously but activate different pages, as only one page can be opened at a time. For example, do not select a single-line diagram page for breaker status open and select an annunciator page for a trip alarm.

In the example shown, failure of any of the three Ethernet ports triggers the Product Information page to display. With unauthorized access (such as wrong password), IRIG-B clock failure, or breaker trouble, the Event Records display. When a breaker opens, a single-line diagram displays. For the Ethernet and IRIG-B failure operation to work, these functions also have been enabled under **Settings > Product Setup > User-Programmable Self Tests**.

Figure 5-12: Configurable navigation editor



To use the feature, select a **CONDITION**, select an **ACTIVATE PAGE**, then save.

CONDITION

Range: OFF, ON, any FlexLogic operand

Default: OFF

Select the FlexLogic operand for the trigger. When it transitions from Off to On, it opens the page specified by the **ACTIVATE PAGE** setting. The FlexLogic operands selectable depend on product. Select it from the drop-down list. Or click or select the field and start typing to auto-fill. For example, typing F displays FIRST ETHERNET FAIL, while typing BR displays the first breaker option.

ACTIVATE PAGE

Range: Product Information, SLD 1...5, Annunciator, Annunciator 1...8, Actual Values Phasors 1...6, Tabular 1...5, Event Records, Targets

Default: Product Information

This setting specifies the page to display on the graphical front panel when the FlexLogic operand selected by its **CONDITION** setting transitions from Off to On.

The "Annunciator" option without a page number specifies the first annunciator page in the following sequence:

- The first annunciator page that contains an annunciator window that is in alarm (fast flash)
- The first annunciator page that contains an annunciator window that is in ringback. Ringback is a "return alert." Visual and audible signals are given when conditions return to normal, then the sequence returns to normal by pushing the **RESET** button.
- The first annunciator page that contains an annunciator window that is in abnormal state
- Annunciator page 1

The Tabular option displays a configured actual values/metering page.

The Targets option displays error messages, such as wrong transceiver, similar to event record entries.

5.3.4 Clear relay records

SETTINGS ⇒ PRODUCT SETUP ⇒ CLEAR RELAY RECORDS

CLEAR RELAY RECORDS

↔

CLEAR FAULT REPORTS:
Off

Range: FlexLogic operand

⇕	CLEAR EVENT RECORDS: Off	Range: FlexLogic operand
⇕	CLEAR OSCILLOGRAPHY: Off	Range: FlexLogic operand
⇕	CLEAR DATA LOGGER: Off	Range: FlexLogic operand
⇕	CLEAR ARC AMPS 1: Off	Range: FlexLogic operand
⇕	CLEAR ARC AMPS 2: Off	Range: FlexLogic operand
⇕	CLEAR CHNL STATUS: Off	Range: FlexLogic operand
↑	RESET UNAUTH ACCESS: Off	Range: FlexLogic operand

RESET UNAUTH ACCESS — Resets the access restriction counter.

Selected records can be cleared from user-programmable conditions with FlexLogic operands. Assigning user-programmable pushbuttons to clear specific records is a typical application for these commands. Since the L30 responds to rising edges of the configured FlexLogic operands, they must be asserted for at least 50 ms to take effect.

Clearing records with user-programmable operands is not protected by the command password. However, user-programmable pushbuttons are protected by the command password. Thus, if they are used to clear records, the user-programmable pushbuttons can provide extra security if required.

For example, to assign user-programmable pushbutton 1 to clear demand records, apply the following settings.

1. Assign the clear demand function to pushbutton 1 by making the following change in the **SETTINGS ⇒ PRODUCT SETUP ⇒ CLEAR RELAY RECORDS** menu:
CLEAR DEMAND: "PUSHBUTTON 1 ON"
2. Set the properties for user-programmable pushbutton 1 by making the following changes in the **SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE PUSHBUTTONS ⇒ USER PUSHBUTTON 1** menu:
PUSHBUTTON 1 FUNCTION: "Self-reset"
PUSHBTN 1 DROP-OUT TIME: "0.20 s"

5.3.5 Communications

5.3.5.1 Menu

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS

<div style="background-color: #f0f0f0; padding: 2px;">■ COMMUNICATIONS</div> <div style="background-color: #f0f0f0; padding: 2px;">■</div>	↔	<div style="background-color: #f0f0f0; padding: 2px;">■ SERIAL PORTS</div> <div style="background-color: #f0f0f0; padding: 2px;">■</div>	See below
	⇕	<div style="background-color: #f0f0f0; padding: 2px;">■ NETWORK</div> <div style="background-color: #f0f0f0; padding: 2px;">■</div>	See page 5-42
	⇕	<div style="background-color: #f0f0f0; padding: 2px;">■ IPv4 ROUTE TABLE</div> <div style="background-color: #f0f0f0; padding: 2px;">■</div>	See page 5-48
	⇕	<div style="background-color: #f0f0f0; padding: 2px;">■ MODBUS PROTOCOL</div> <div style="background-color: #f0f0f0; padding: 2px;">■</div>	See page 5-50
	⇕	<div style="background-color: #f0f0f0; padding: 2px;">■ PROTOCOL</div> <div style="background-color: #f0f0f0; padding: 2px;">■</div>	See page 5-51
	⇕	<div style="background-color: #f0f0f0; padding: 2px;">■ DNP PROTOCOL</div> <div style="background-color: #f0f0f0; padding: 2px;">■</div>	See page 5-52

⇕	<input type="checkbox"/> DNP / IEC104 <input type="checkbox"/> POINT LISTS	See page 5-55
⇕	<input type="checkbox"/> IEC 61850 PROTOCOL <input type="checkbox"/>	Access in EnerVista See page 5-56
⇕	<input type="checkbox"/> WEB SERVER <input type="checkbox"/> HTTP PROTOCOL	See page 5-100
⇕	<input type="checkbox"/> TFTP PROTOCOL <input type="checkbox"/>	See page 5-101
⇕	<input type="checkbox"/> IEC 60870-5-104 <input type="checkbox"/> PROTOCOL	See page 5-101
⇕	<input type="checkbox"/> IEC103 <input type="checkbox"/> PROTOCOL	See page 5-103
↑	<input type="checkbox"/> USB 2.0 PORT <input type="checkbox"/>	See page 5-108

5.3.5.2 Serial ports

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ SERIAL PORTS

<input type="checkbox"/> SERIAL PORTS <input type="checkbox"/>	↔	RS232 BAUD RATE: 115200	Range: 19200, 115200
	⇕	RS485 COM2 BAUD RATE: 19200	Range: 300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 57600, 115200 bit/s
	⇕	RS485 COM2 PARITY: Even	Range: None, Odd, Even
	↑	RS485 COM2 RESPONSE MIN TIME: 0 ms	Range: 0 to 1000 ms in steps of 10

The front RS232 port applies to enhanced and standard front panels.

RS232 BAUD RATE, RS485 COM2 BAUD RATE, and PARITY — The L30 is equipped with two independent serial communication ports. The front panel RS232 port (USB port with graphical front panel) is intended for local use. The rear COM2 port is RS485 and has settings for baud rate and parity. It is important that these parameters agree with the settings used on the computer or other equipment that is connected to these ports. Any of these ports can be connected to a computer running the EnerVista software, for example to download and upload setting files, view measured parameters, and upgrade the relay firmware. A maximum of 32 relays can be daisy-chained and connected to a DCS, PLC, or computer using the RS485 ports. If IEC 60870-103 is chosen as the protocol, valid baud rates are 9600 and 19200 bit/s, and valid parity is Even.

RS485 COM2 RESPONSE MIN TIME — This setting specifies the minimum time before the rear RS485 port transmits after receiving data from a host. This feature allows operation with hosts that hold the RS485 transmitter active for some time after each transmission.

5.3.5.3 Ethernet network topology

The L30 has three Ethernet ports. Each Ethernet port must belong to a different network or subnetwork. Configure the IP address and subnet to ensure that each port meets this requirement. Two subnets are different when the bitwise AND operation performed between their respective IP address and mask produces a different result. Communication becomes unpredictable when more than one port is configured to the same subnet.

Example 1

IP1/Mask1: 10.1.1.2/255.255.255.0 (where LAN 1 is 10.1.1.x/255.255.255.0)

IP2/Mask2: 10.2.1.2/255.255.255.0 (where LAN2 is 10.2.1.x/255.255.255.0)

IP3/Mask3: 10.3.1.2/255.255.255.0 (where LAN3 is 10.3.1.x/255.255.255.0)

Example 2

IP1/Mask1: 10.1.1.2/255.0.0.0 (where LAN1 is 10.x.x.x/255.0.0.0)

IP2/Mask2: 11.1.1.2/255.0.0.0 (where LAN2 is 11.x.x.x/255.0.0.0)

IP3/Mask3: 12.1.1.2/255.0.0.0 (where LAN3 is 12.x.x.x/255.0.0.0)

Example 3 – Incorrect

IP1/Mask1: 10.1.1.2/255.0.0.0

IP2/Mask2: 10.2.1.2/255.0.0.0

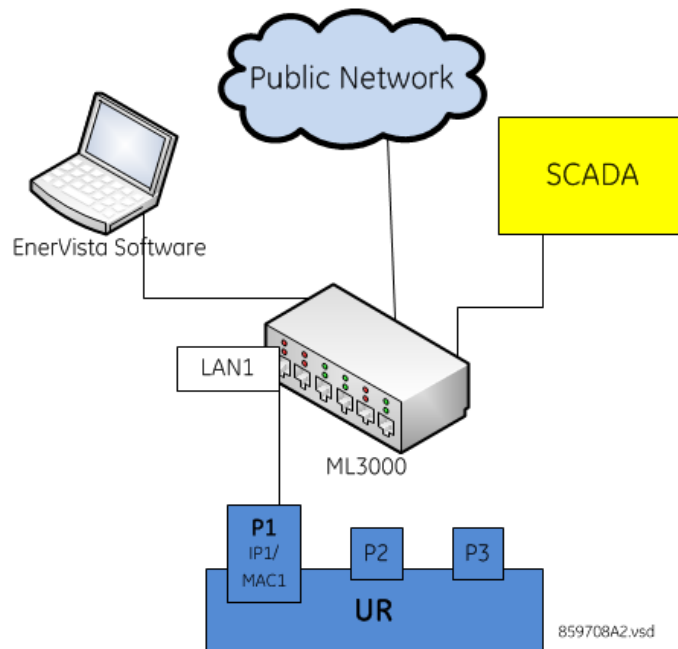
IP3/Mask3: 10.3.1.2/255.0.0.0

This example is incorrect because the mask of 255.0.0.0 used for the three IP addresses makes them belong to the same network of 10.x.x.x.

Single LAN, no redundancy

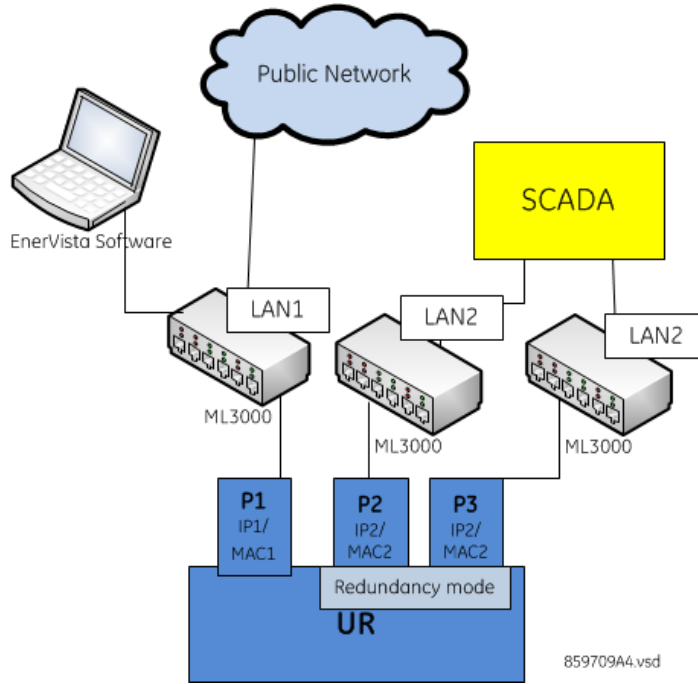
The topology shown in the following figure allows communications to SCADA, local configuration/monitoring through EnerVista, and access to the public network shared on the same LAN. No redundancy is provided.

Figure 5-13: Network configuration for single LAN

**Multiple LANS, with redundancy**

The following topology provides local configuration/monitoring through EnerVista software and access to the public network shared on LAN1, to which port 1 (P1) is connected. There is no redundancy provided on LAN1. Communications to SCADA is provided through LAN2. P2 and P3 are connected to LAN2, where P2 is the primary channel and P3 is the redundant channel. In this configuration, P3 uses the IP and MAC addresses of P2.

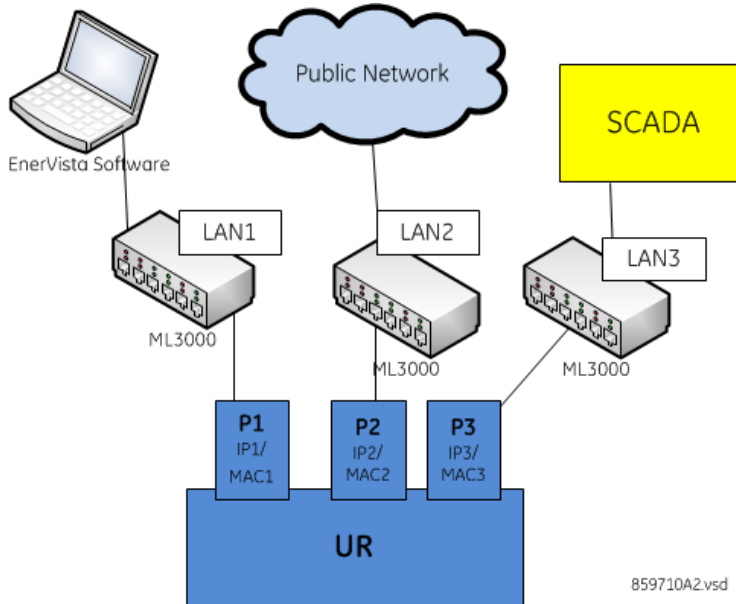
Figure 5-14: Multiple LANs, with redundancy



5 Multiple LANs, no redundancy

The following topology provides local configuration/monitoring through EnerVista software on LAN1, to which port 1 (P1) is connected, access to the public network on LAN2, to which port 2 (P2) is connected, and communications with SCADA on LAN3, to which port 3 (P3) is connected. There is no redundancy.

Figure 5-15: Multiple LANs, no redundancy



5.3.5.4 Network

As outlined in the previous section, when using more than one Ethernet port, configure each to belong to a different network or subnet using the IP addresses and mask. Configure the network IP and subnet settings before configuring the routing settings.

To obtain a list of all port numbers used, for example for audit purposes, contact GE technical support with substantiating information, such as the serial number and order code of your device.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ NETWORK 1(3)

<div style="border: 1px solid black; padding: 2px;"> ■ NETWORK PORT 1 ■ </div>	↔	<div style="border: 1px solid black; padding: 2px;"> PRT1 IP ADDRESS: 127.0.0.1 </div>	Range: standard IPV4 address format
	⇕	<div style="border: 1px solid black; padding: 2px;"> PRT1 SUBNET IP MASK: 255.0.0.0 </div>	Range: standard IPV4 address format
	↑	<div style="border: 1px solid black; padding: 2px;"> PRT1 FUNCTION: Enabled </div>	Range: Enabled, Disabled
<div style="border: 1px solid black; padding: 2px;"> ■ NETWORK PORT 2 ■ </div>	↔	<div style="border: 1px solid black; padding: 2px;"> PRT2 IP ADDRESS: 127.0.0.1 </div>	Range: standard IPV4 address format
	⇕	<div style="border: 1px solid black; padding: 2px;"> PRT2 SUBNET IP MASK: 255.0.0.0 </div>	Range: standard IPV4 address format
	⇕	<div style="border: 1px solid black; padding: 2px;"> PRT2 REDUNDANCY: None </div>	Range: None, Failover, PRP Range if no PRP license: None, Failover
	⇕	<div style="border: 1px solid black; padding: 2px;"> PRP MCST ADDR: 01154E000100 </div>	Range: 01-15-4E-00-01-00 to 01-15-4E-00-01-FF
	↑	<div style="border: 1px solid black; padding: 2px;"> PRT2 FUNCTION: Enabled </div>	Range: Enabled, Disabled
<div style="border: 1px solid black; padding: 2px;"> ■ NETWORK PORT 3 ■ </div>	↔	<div style="border: 1px solid black; padding: 2px;"> PRT3 IP ADDRESS: 127.0.0.1 </div>	Range: standard IPV4 address format
	↑	<div style="border: 1px solid black; padding: 2px;"> PRT3 SUBNET IP MASK: 255.0.0.0 </div>	Range: standard IPV4 address format
	↑	<div style="border: 1px solid black; padding: 2px;"> PRT3 FUNCTION: Enabled </div>	Range: Enabled, Disabled

The IP addresses are used with the DNP, Modbus/TCP, IEC 61580, IEC 60870-5-104, TFTP, HTTP, and PRP protocols. PRP is explained in its own section later.

Use the front panel to change these settings. When online, the EnerVista software can be used to enable/disable each port only. In the Offline Window area, all settings can be changed except port 2 redundancy (depending on firmware version).

When using GOOSE, in failover or PRP mode, port 3 configuration in the CID file is ignored. The Port 3 ConnectedAP elements has no meaning, as ports 2 and 3 use the port 2 MAC address, IP address, and mask.

PRT1 (2 or 3) IP ADDRESS — This setting sets the port's IPv4 address in standard IPV4 format. This setting is valid on port 3 if port 2 **REDUNDANCY** is set to None.

PRT1 (2 or 3) SUBNET MASK — This setting sets the port's IPv4 subnet mask in standard IPV4 format. This setting is valid on port 3 if port 2 **REDUNDANCY** is set to None.

PRT1 (2 or 3) FUNCTION — This setting enable/disable network communication on the respective port. When the port function is Disabled, the network traffic on this port is disabled. The PRT2 redundancy setting has no effect on this functionality. The change takes effect upon relay restart.

PRT2 REDUNDANCY — Determines if ports 2 and 3 operate in redundant or independent mode. If a license for PRP was purchased, the options are None, Failover, and PRP. If a license for PRP was not purchased, the options are None and Failover. In non-redundant mode (**REDUNDANCY** set to None), ports 2 and 3 operate independently with their own MAC, IP, and mask addresses. If **REDUNDANCY** is set to Failover, the operation of ports 2 and 3 is as follows:

- Ports 2 and 3 use the port 2 MAC address, IP address, and mask
- The configuration fields for IP address and mask on port 3 are hidden
- Port 3 is in standby mode and does not actively communicate on the Ethernet network but monitors its link to the Multilink switch. If port 2 detects a problem with the link, communications is switched to Port 3. Port 3 is, in effect, acting as a redundant or backup link to the network for port 2. Once port 2 detects that the link between itself and the switch is good and that communication is healthy for five minutes, then switching back to port 2 is performed. The delay in switching back ensures that rebooted switching devices connected to the L30, which signal their ports as active prior to being completely functional, have time to completely initialize themselves and become active. Once port 2 is active again, port 3 returns to standby mode.

If **REDUNDANCY** is set to PRP, the operation of ports 2 and 3 is as follows:

- Ports 2 and 3 use the port 2 MAC address, IP address, and mask
- The configuration fields for IP address and mask on port 3 are overwritten with those from port 2. This is visible on the front panel but not displayed in the EnerVista software.
- Port 2 **MCST ADDRESS** field is visible
- The port 2 PTP function still uses only port 2 and the port 3 PTP function still uses only port 3. The relay still synchronizes to whichever port has the best master. When ports 2 and 3 see the same master, as is typically the case for PRP networks, the port with the better connectivity is used.

Behavior for GOOSE messages is as follows:

- If **REDUNDANCY** is set to Failover or PRP, In order to transmit a GOOSE message on port 2, the CID file must be configured to have the corresponding GSE element in both ConnectedAPs S2 and S3. In the EnerVista software, the **TxGOOSE PORT ASSIGNMENT** needs to be "Ports-1,2,3" to transmit GOOSE on both ports 1 and 2, or "Ports-2,3" to have GOOSE only on port 2, with failover/ PRP.
- If **REDUNDANCY** is set to PRP, the port 2 configured GOOSE message is simultaneously transmitted on ports 2 and 3
- If **REDUNDANCY** is set to failover and the port 2 link fails, then only the port 2 configured GOOSE message is transmitted on port 3



The two ports must be connected to completely independent LANs with no single point of failure, such as common power supplies that feed switches on both LANs.

For any changes to this setting to take effect, restart the unit.

PRT2 PRP MCST ADDR — This setting allows the user to change the multicast address used by the PRP supervision frames. This setting is available if **REDUNDANCY** is set to PRP. All devices in the same PRP network need to have the same multicast address. Choose an address that does not conflict with another multicast protocol.

5.3.5.5 Far-End Fault Indication (FEFI)

Since 100BASE-FX does not support Auto-Negotiation, a Far-End Fault Indication (FEFI) feature is included since UR 7 that allows for detection of link failures.

The purpose of the Far-End Fault feature is to allow the stations on both ends of a pair of fibers to be informed when there is a problem with one of the fibers. Without the Far-End Fault feature, it is impossible for a fiber interface to detect a problem that affects only its transmit fiber.

When the Far-End Fault feature is supported, a loss of receive signal (link) causes the transmitter to generate a Far-End Fault pattern in order to inform the device at the far end of the fiber pair that a fault has occurred.

When the local receiver again detects a signal, the local transmitter automatically returns to normal operation.

If a Far-End Fault pattern is received by a fiber interface that supports the Far-End Fault feature and it is enabled, it reacts by dropping the link as if there were no signal at all.

If the receiving interface does not support the Far-End Fault feature or has it disabled, an incoming Far-End Fault pattern is ignored.

It is strongly recommended to have switches used for substation automation that support the Far-End Fault feature, especially when UR 7 redundancy Failover is selected for redundancy.

5.3.5.6 Parallel Redundancy Protocol (PRP)

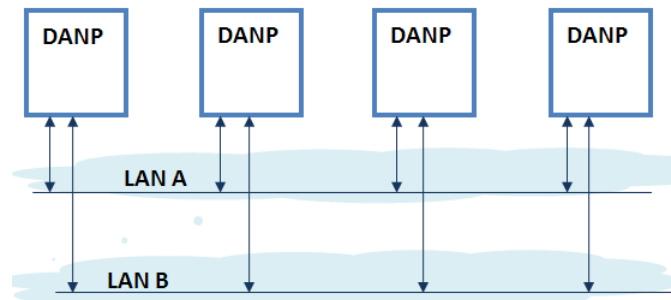


The L30 is provided with optional PRP capability. This feature is specified as a software option at the time of ordering. See the Order Codes section in chapter 2 for details.

The Parallel Redundancy Protocol (PRP) defines a redundancy protocol for high availability in substation automation networks. It applies to networks based on Ethernet technology (ISO/IEC 8802-3) and is based on the second edition (July 2012) of IEC 62439-3, clause 4.

PRP is designed to provide seamless recovery in case of a single failure in the network, by using a combination of LAN duplication and frame duplication. Identical frames are sent on two completely independent networks that connect source and destination. Under normal circumstances both frames reach the destination and one of them is sent up the OSI stack to the destination application, while the second one is discarded. If an error occurs in one of the networks and traffic is prevented from flowing on that path, connectivity is provided through the other network to ensure continuous communication. Take care when designing the two LANs, so that no single point of failure (such as a common power supply) is encountered, as such scenarios can bring down both LANs simultaneously.

Figure 5-16: Example of parallel redundant network



PRP uses specialized nodes called doubly attached nodes (DANPs) for handling the duplicated frames. DANP devices have an additional module, called a Link Redundancy Entity (LRE). LRE is responsible for duplicating frames and adding the specific PRP trailer when sending the frames out on the LAN, as well as making decisions on received frames as to which one is sent up the OSI stack to the application layer and which one is discarded. LRE is responsible for making PRP transparent to the higher layers of the stack.

In addition, there is a second type of specialized device used in PRP networks, called RedBox, with the role of connecting Single Attached Nodes (SANs) to a redundant network.

UR relays implement the DANP functionality. The RedBox functionality is not implemented.

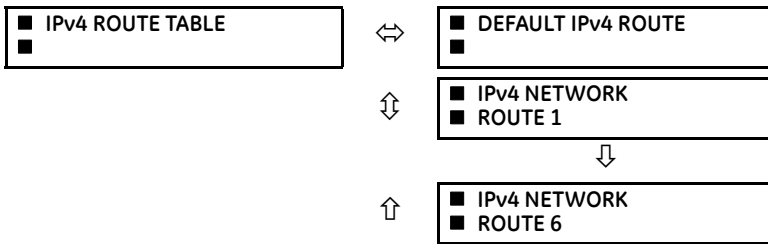
The original standard IEC 62439-3 (2010) was amended to align PRP with the High-availability Seamless Redundancy (HSR) protocol. To achieve this, the original PRP was modified at the cost of losing compatibility with the PRP 2010 version. The revised standard IEC 62439-3 (2012) is commonly referred to as PRP-1, while the original standard is PRP-0. The UR relays support PRP-1.

The relay implements PRP on two of its Ethernet ports, specifically Ports 2 and 3 of the CPU module. Use the previous section (network port configuration) to configure PRP.

PRP is purchased as a separate option. If purchased (valid order code), PRP can be enabled in configuration through a setting available on the network configuration menu, REDUNDANCY, which already has the capability of enabling failover redundancy. The options on this setting must be changed to accommodate two types of redundancy: failover and PRP. When REDUNDANCY is set to either failover or PRP, the ports dedicated for PRP (Ports 2 and 3) operate in redundant mode. In this mode, Port 3 uses the MAC, IP address, and mask of Port 2.

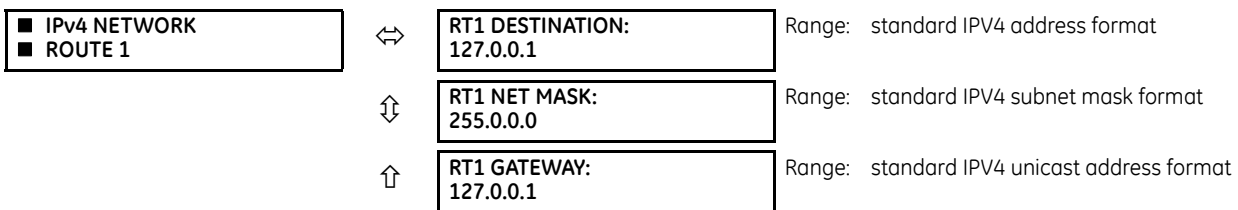
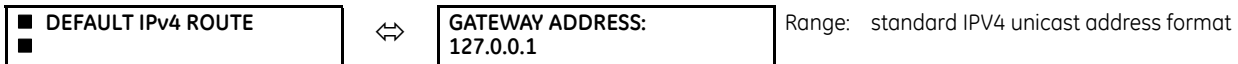
5.3.5.7 IPv4 route table

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IPv4 ROUTE TABLE 1(6)



A default route and up to six static routes can be configured.

The default route is used as the last choice when no other route towards a given destination is found.



Configure the network IP and subnet settings before configuring the routing settings.

Add and delete static routes

Host routes are not supported at present.

The routing table configuration is available on the serial port and front panel. This is a deliberate decision, to avoid loss of connectivity when remotely configuring the L30.

By default, the value of the destination field is 127.0.0.1 for all static routes (1 to 6). This is equivalent to saying that the static routes are not configured. When the destination address is 127.0.0.1, the mask and gateway also must be kept on default values.

By default, the value of the route gateway address is 127.0.0.1. This means that the default route is not configured.

To add a route:

1. Use any of the static network route entries numbered 1 to 6 to configure a static network route. Once a route destination is configured for any of the entries 1 to 6, that entry becomes a static route and it must meet all the rules listed in the next section, General Conditions to be Satisfied by Static Routes.
2. To configure the default route, enter a default gateway address. Once a default gateway address is configured, it must be validated against condition 2 of the General Conditions to be Satisfied by Static Routes, where the route gateway must be on a connected network.

To delete a route:

1. Replace the route destination with the default loopback address of 127.0.0.1. When deleting a route, the mask and gateway also must be brought back to default values.
2. Delete the default route by replacing the default gateway with the default value of 127.0.0.1.

General conditions to be satisfied by static routes

The following rules are validated internally:

- The route mask has IP mask format. In binary this needs to be a set of contiguous bits of 1 from left to right, followed by one or more contiguous bits of 0.
- The route destination and mask must match. This can be verified by checking that $RtDestination \text{ AND } RtMask = RtDestination$
Example of good configuration: $RtDestination = 10.1.1.0$; $RtMask = 255.255.255.0$
Example of bad configuration: $RtDestination = 10.1.1.1$; $RtMask = 255.255.255.0$

The following rules must be observed when you configure static routes:

- The route destination must not be a connected network
- The route gateway must be on a connected network. This rule applies to the gateway address of the default route as well. This can be verified by checking that:
 $(RtGwy \text{ AND } Prt1Mask) == (Prt1IP \text{ AND } Prt1Mask) \text{ OR } (RtGwy \text{ AND } Prt2Mask) == (Prt2IP \text{ AND } Prt2Mask) \text{ OR } (RtGwy \text{ AND } Prt3Mask) == (Prt3IP \text{ AND } Prt3Mask)$

where

& is the bitwise-AND operator

== is the equality operator

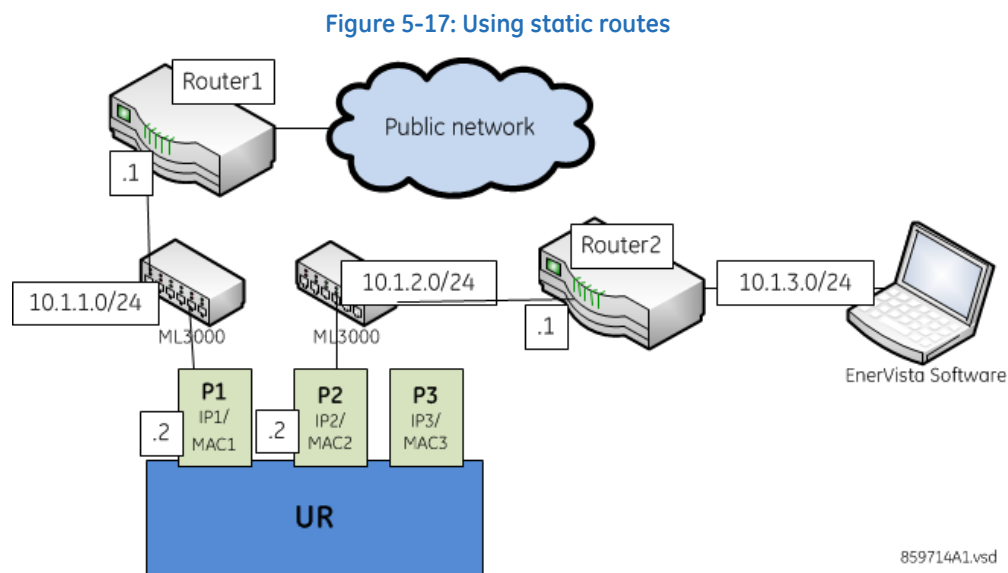
|| is the logical OR operator

Routing behavior compared to previous releases

Prior to release 7.10, UR devices did not have an explicit manner of configuring routes. The only available route was the default route configured as part of the network settings (port gateway IP address). This limited the ability to route to specific destinations, particularly if these destinations were reachable through a different interface than the one on which the default gateway was.

Starting with UR 7.10, up to six static network routes can be configured in addition to a default route. The default route configuration was also moved from the network settings into the routing section.

The figure shows an example of topology that benefits from the addition of static routes.



In the figure, the UR connects through the following two Ethernet ports:

- Port 1 (IP address 10.1.1.2) connects the UR to LAN 10.1.1.0/24 and to the Internet through Router1. Router1 has an interface on 10.1.1.0/24 and the IP address of this interface is 10.1.1.1.
- Port 2 (IP address 10.1.2.2) connects the UR to LAN 10.1.2.0/24 and to the EnerVista software through Router2. Router2 has an interface on 10.1.2.0/24 and the IP address of this interface is 10.1.2.1.

The configuration before release 7.10 was as follows:

- PRT1 IP ADDRESS = 10.1.1.2
PRT1 SUBNET IP MASK = 255.255.255.0
PRT1 GWY IP ADDRESS = 10.1.1.1
PRT2 IP ADDRESS = 10.1.2.2
PRT2 SUBNET IP MASK = 255.255.255.0

The behavior before release 7.10 was as follows. When sending packets to EnerVista, the UR noticed that the destination was not on a connected network and it tried to find a route to destination. Since the default route was the only route it knew, it used it. Yet EnerVista was on a private network, which was not reachable through Router1. Hence a destination unreachable message was received from the router.

The configuration starting with release 7.10 is as follows:

- PRT1 IP ADDRESS = 10.1.1.2
PRT1 SUBNET IP MASK = 255.255.255.0
PRT2 IP ADDRESS = 10.1.2.2
PRT2 SUBNET IP MASK = 255.255.255.0
IPV4 DEFAULT ROUTE: GATEWAY ADDRESS = 10.1.1.1
STATIC NETWORK ROUTE 1: RT1 DESTINATION = 10.1.3.0/24; RT1 NET MASK = 255.255.255.0; and RT1 GATEWAY = 10.1.2.1

The behavior since release 7.10 is as follows. There is one added static network route to the destination 10.1.3.0/24, where a computer running EnerVista is located. This static route uses a different gateway (10.1.2.1) than the default route. This gateway is the address of Router2, which has knowledge about 10.1.3.0 and is able to route packets coming from the UR and destined to EnerVista.

Show routes and ARP tables

This feature is available on the Web interface, where the main menu contains an additional Communications menu and two submenus:

- Routing Table
- ARP Table

The tables outline the information displayed when the two submenus are selected.

Table 5-7: Routing table information

Field	Description
Destination	The IP address of the remote network to which this route points
Mask	The network mask for the destination
Gateway	The IP address of the next router to the remote network
Interface	Interface through which the specified network can be reached

Table 5-8: IP ARP information

Field	Description
IP Address	The network address that corresponds to Hardware Address
Age (min)	Age, in minutes, of the cache entry. A hyphen (-) means the address is local.
Hardware Address	LAN hardware address, a MAC address that corresponds to network address
Type	Dynamic or Static
Interface	Interface to which this address mapping has been assigned

5.3.5.8 Modbus protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ ⚙ COMMUNICATIONS ⇒ ⚙ MODBUS PROTOCOL

MODBUS PROTOCOL

↔

MODBUS SLAVE ADDRESS: 254
 Range: 1 to 254 in steps of 1

↑

MODBUS TCP PORT NUMBER(502): 502
 Range: 0 to 65535 in steps of 1

The serial communication ports utilize the Modbus protocol, unless the port is configured for DNP or IEC 60870-5-103 operation. This allows the EnerVista UR Setup software to be used on the port. UR devices operate as Modbus slave devices only.

For more information on the protocol, including the memory map table, see the UR Family Communications Guide.

MODBUS SLAVE ADDRESS — When using the Modbus protocol on the RS232 port, the L30 responds regardless of the **MODBUS SLAVE ADDRESS** programmed. For the RS485 port, each device on the serial bus must have a unique slave address from 1 to 254. Address 0 and addresses from 248 and up are reserved by the Modbus protocol specification, and so their use here is not recommended. Address 0 is the broadcast address to which all Modbus slave devices listen. Addresses do not have to be sequential, but no two devices can have the same address or conflicts resulting in errors occur. Generally, starting at 1, set each device added to the link to use the next higher address. When using Modbus TCP/IP, the client must use the programmed **MODBUS SLAVE ADDRESS** value in the Unit Identifier field.

MODBUS TCP PORT NUMBER — Modbus over TCP/IP can also be used on any of the Ethernet ports. The listening TCP port 502 is reserved for Modbus communications, and only in exceptional cases when **MODBUS TCP PORT NUMBER** is set to any other port. The **MODBUS TCP PORT NUMBER** setting sets the TCP port used by Modbus on Ethernet. A **MODBUS TCP PORT NUMBER** of 0 disables Modbus over TCP/IP, meaning closes the Modbus TCP port. When the port number is changed to 0, the change takes effect when the L30 is restarted. When it is set to 0, use the front panel or serial port to communicate with the relay.



Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

5.3.5.9 Protocol selection

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ PROTOCOL

■ PROTOCOL ■	↔	SCADA PROTOCOL: DNP 3.0	Range: DNP 3.0, IEC 60870-5-104, IEC 60870-5-103
	↑	MMS CONNECTION TIMEOUT: 120 s	Range: 10 to 7200 in steps of 10

The **PROTOCOL** menu allows selection of one of the following protocols: DNP 3.0, IEC60870-104, or IEC60870-103.

SCADA PROTOCOL — This setting selects the SCADA protocol on which the unit communicates, among DNP3.0, IEC 60870-104, and IEC 60870-103, with DNP being the default. Options depend on order code. For any change to take effect, restart the unit.

MMS CONNECTION TIMEOUT — This setting specifies a time delay for the detection of network TCP connection lost. If there is no data traffic on the TCP connection for greater than the time specified by this setting, the connection is terminated. This frees up the connection to be re-used by a client. A setting of 10 seconds disables this timer. The TCP connection then is managed by a standard TCP KeepAlive message sequence. These messages are transmitted every 20 seconds when there is no MMS communication between the relay and the client. If there are no responses to the TCP KeepAlive messages, the connection is closed. For any change to this setting to take effect, restart the unit. The change takes effect for a new connection. For any existing open connection when the change is made, close and re-open the connection. Cycling power to the relay also applies the new setting.

The table shows which of DNP 3.0, IEC 60870-5-104, IEC 60870-5-103, and IEC 61850 protocols are operational on the RS232, RS485, and Ethernet ports. It shows all possible combinations of the **PROTOCOL** and **DNP CHANNEL 1(2) PORT** settings.

Table 5-9: Port and protocol combinations

PROTOCOL setting	DNP CHANNEL 1(2) PORT settings	RS232	RS485	Ethernet
DNP	Channel 1: Eth TCP Channel 2: Eth TCP	Modbus	Modbus	DNP, Modbus, IEC 61850
	Channel 1: Eth TCP Channel 2: none	Modbus	Modbus	DNP, Modbus, IEC 61850
	Channel 1: none Channel 2: Eth TCP	Modbus	Modbus	DNP, Modbus, IEC 61850
	Channel 1: Eth UDP Channel 2: none	Modbus	Modbus	DNP, Modbus, IEC 61850
	Channel 1: Eth TCP Channel 2: RS485	Modbus	DNP	DNP, Modbus, IEC 61850
	Channel 1: Eth TCP Channel 2: RS232	DNP	Modbus	DNP, Modbus, IEC 61850
	Channel 1: Eth UDP Channel 2: RS485	Modbus	DNP	DNP, Modbus, IEC 61850
	Channel 1: Eth UDP Channel 2: RS232	DNP	Modbus	DNP, Modbus, IEC 61850
	Channel 1: RS485 Channel 2: Eth TCP	Modbus	DNP	DNP, Modbus, IEC 61850
	Channel 1: RS232 Channel 2: Eth TCP	DNP	Modbus	DNP, Modbus, IEC 61850
	Channel 1: RS485 Channel 2: RS232	DNP	DNP	Modbus, IEC 61850
	Channel 1: RS232 Channel 2: RS485	DNP	DNP	Modbus, IEC 61850
Channel 1: RS485 Channel 2: none	Modbus	DNP	Modbus, IEC 61850	
IEC 104		Modbus	Modbus	IEC 104, Modbus, IEC 61850
IEC 103		Modbus	IEC 103	Modbus, IEC 61850

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5.3.5.10 DNP protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ DNP PROTOCOL

<input checked="" type="checkbox"/> DNP PROTOCOL <input type="checkbox"/>	⇔	<input checked="" type="checkbox"/> DNP CHANNELS <input type="checkbox"/>	See below
	⇕	DNP ADDRESS: 1	Range: 0 to 65535 in steps of 1
	⇕	<input checked="" type="checkbox"/> DNP NETWORK <input checked="" type="checkbox"/> CLIENT ADDRESSES	See below
	⇕	DNP TCP/UDP PORT NUMBER(20000): 20000	Range: 0 to 65535 in steps of 1
	⇕	DNP UNSOL RESPONSE FUNCTION: Disabled	Range: Enabled, Disabled
	⇕	DNP UNSOL RESPONSE TIMEOUT: 5 s	Range: 0 to 60 s in steps of 1
	⇕	DNP UNSOL RESPONSE MAX RETRIES: 10	Range: 1 to 255 in steps of 1
	⇕	DNP UNSOL RESPONSE DEST ADDRESS: 1	Range: 0 to 65519 in steps of 1
	⇕	DNP CURRENT SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000, 1000000, 10000000, 100000000

↕	DNP VOLTAGE SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000, 1000000, 10000000, 100000000
↕	DNP POWER SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000, 1000000, 10000000, 100000000
↕	DNP ENERGY SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000, 1000000, 10000000, 100000000
↕	DNP PF SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000, 1000000, 10000000, 100000000
↕	DNP OTHER SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000, 1000000, 10000000, 100000000
↕	DNP CURRENT DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP VOLTAGE DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP POWER DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP ENERGY DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP PF DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP OTHER DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP TIME SYNC IIN PERIOD: 1440 min	Range: 1 to 10080 min. in steps of 1
↕	DNP MESSAGE FRAGMENT SIZE: 240	Range: 30 to 2048 in steps of 1
↕	DNP OBJECT 1 DEFAULT VARIATION: 2	Range: 1, 2
↕	DNP OBJECT 2 DEFAULT VARIATION: 2	Range: 1, 2, 3
↕	DNP OBJECT 20 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6
↕	DNP OBJECT 21 DEFAULT VARIATION: 1	Range: 1, 2, 9, 10
↕	DNP OBJECT 22 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6
↕	DNP OBJECT 23 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6
↕	DNP OBJECT 30 DEFAULT VARIATION: 1	Range: 1, 2, 3, 4, 5
↕	DNP OBJECT 32 DEFAULT VARIATION: 1	Range: 1, 2, 3, 4, 5, 7
↕	DNP NUMBER OF PAIRED CONTROL POINTS: 0	Range: 0 to 32 in steps of 1
↕	DNP TCP CONNECTION TIMEOUT: 120 s	Range: 10 to 7200 s in steps of 1
↑	DNP EVENT TIME BASE: LOCAL	Range: UTC, LOCAL

The Distributed Network Protocol (DNP) allows for the optimization of control and data acquisition between the equipment in the substation and the central control center. The protocol is scalable; that is, it is designed to be compatible with the latest high speed LAN technology yet still be implemented over slower speed serial links.

The DNP improves upon many master-slave protocols by improving overall communication performance requirements and provides time-stamping with millisecond accuracy.

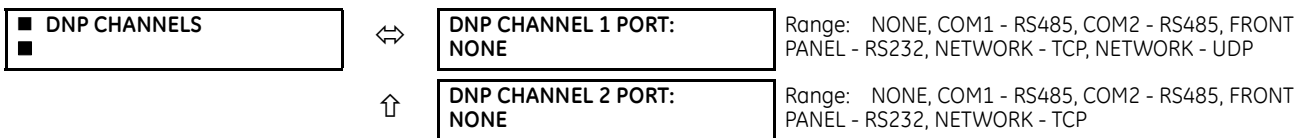
The L30 supports the Distributed Network Protocol (DNP) version 3.0. DNP is enabled when the **SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ PROTOCOL** setting is set to DNP 3.0. The L30 can be used as a DNP slave device connected to multiple DNP masters (usually an RTU or a SCADA master station). Since the L30 maintains two sets of DNP data change buffers and connection information, two DNP masters can actively communicate with the L30 at one time.

DNP is not available using the USB port on the graphical front panel.

See the UR Family Communications Guide for more information on DNP.


The DNP Channels sub-menu is shown.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ DNP PROTOCOL ⇒ DNP CHANNELS



The **DNP CHANNEL 1 PORT** and **DNP CHANNEL 2 PORT** settings select the communications port assigned to the DNP protocol for each channel. Once DNP is assigned to a serial port, DNP is the only protocol running on that port; Modbus or IEC 60870-5-103 are disabled. If DNP is assigned to RS485, the protocol must be set to DNP on the serial port configuration as well, for the change to take effect. When the **DNP CHANNEL 1(2) PORT** setting is set to "Network - TCP," the channel 1(2) DNP protocol can be used over TCP/IP on the Ethernet ports. When this value is set to "Network - UDP," the DNP protocol can be used over UDP/IP on channel 1 only. The "Front Panel - RS232" setting does not apply to the graphical front panel; when selected the DNP client cannot establish a connection on a USB port.

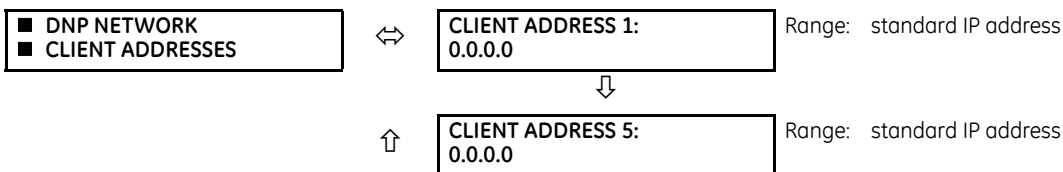
For any change to take effect, restart the relay.

 Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

The **DNP ADDRESS** setting is the DNP slave address. This number identifies the L30 on a DNP communications link. Assign a unique address to each DNP slave.

The L30 can specify a maximum of five clients for its DNP connections. These are IP addresses for the controllers to which the L30 can connect. The settings follow.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ DNP PROTOCOL ⇒ DNP NETWORK CLIENT ADDRESSES



The **DNP TCP/UDP PORT NUMBER** setting is for normal DNP operation. To close the port, set the port number to 0. The change takes effect when the L30 is restarted.

The **DNP UNSOL RESPONSE FUNCTION** is set to "Disabled" for RS485 applications since there is no collision avoidance mechanism. The **DNP UNSOL RESPONSE TIMEOUT** sets the time the L30 waits for a DNP master to confirm an unsolicited response. The **DNP UNSOL RESPONSE MAX RETRIES** setting determines the number of times the L30 retransmits an unsolicited response without receiving confirmation from the master; a value of "255" allows infinite re-tries. The **DNP UNSOL RESPONSE DEST ADDRESS** is the DNP address to which all unsolicited responses are sent. The IP address to which solicited responses are sent is determined by the L30 from the current TCP connection or the most recent UDP message.

The DNP scale factor settings are numbers used to scale analog input point values. These settings group the L30 analog input data into the following types: current, voltage, power, energy, power factor, and other. Each setting represents the scale factor for all analog input points of that type. For example, if the **DNP VOLTAGE SCALE FACTOR** setting is set to “1000,” all DNP analog input points that are voltages are returned with values 1000 times smaller (for example, a value of 72000 V on the L30 is returned as 72). These settings are useful when analog input values must be adjusted to fit within certain ranges in DNP masters. Note that a scale factor of 0.1 is equivalent to a multiplier of 10 (that is, the value is 10 times larger).

The **DNP DEFAULT DEADBAND** settings determine when to trigger unsolicited responses containing analog input data. These settings group the L30 analog input data into the following types: current, voltage, power, energy, power factor, and other. Each setting represents the default deadband value for all analog input points of that type. For example, to trigger unsolicited responses from the L30 when any current values change by 15 A, the **DNP CURRENT DEFAULT DEADBAND** setting is set to “15.” Note that these settings are the deadband default values. DNP object 34 points can be used to change deadband values, from the default, for each individual DNP analog input point. For any change to take effect, restart the relay. Whenever power is removed and re-applied to the L30, the default deadbands are in effect.



The L30 relay does not support energy metering. As such, the **DNP ENERGY SCALE FACTOR** and **DNP ENERGY DEFAULT DEADBAND** settings are not applicable.

The **DNP TIME SYNC IIN PERIOD** setting determines how often the Need Time Internal Indication (IIN) bit is set by the L30. Changing this time allows the DNP master to send time synchronization commands more or less often, as required.

The **DNP MESSAGE FRAGMENT SIZE** setting determines the size, in bytes, at which message fragmentation occurs. Large fragment sizes allow for more efficient throughput; smaller fragment sizes cause more application layer confirmations to be necessary, which provides more robust data transfer over noisy communication channels.



Check the “DNP Points Lists” L30 web page to view the analog inputs and/or binary inputs points lists. This page can be viewed with a web browser by entering the IP address of the L30 Ethernet port employed to access the L30 Main Menu, then by clicking the **Device Information Menu** item, then the **DNP Points Lists** item.

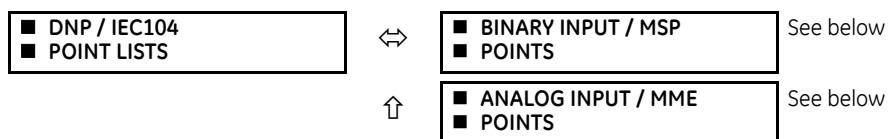
The **DNP OBJECT 1 DEFAULT VARIATION** to **DNP OBJECT 32 DEFAULT VARIATION** settings select the DNP default variation number for object types 1, 2, 20, 21, 22, 23, 30, and 32. The default variation refers to the variation response when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. See the DNP Implementation section in the UR Family Communications Guide.

The DNP binary outputs typically map one-to-one to IED data points. That is, each DNP binary output controls a single physical or virtual control point in an IED. In the L30 relay, DNP binary outputs are mapped to virtual inputs. However, some legacy DNP implementations use a mapping of one DNP binary output to two physical or virtual control points to support the concept of trip/close (for circuit breakers) or raise/lower (for tap changers) using a single control point. That is, the DNP master can operate a single point for both trip and close, or raise and lower, operations. The L30 can be configured to support paired control points, with each paired control point operating two virtual inputs. The **DNP NUMBER OF PAIRED CONTROL POINTS** setting allows configuration of 0 to 32 binary output paired controls. Points not configured as paired operate on a one-to-one basis.

The **DNP TCP CONNECTION TIMEOUT** setting specifies a time delay for the detection of dead network TCP connections. If there is no data traffic on a DNP TCP connection for greater than the time specified by this setting, the connection is aborted by the L30. This frees up the connection to be re-used by a client. For any change to take effect, restart the relay.

5.3.5.11 DNP / IEC 60870-5-104 point lists

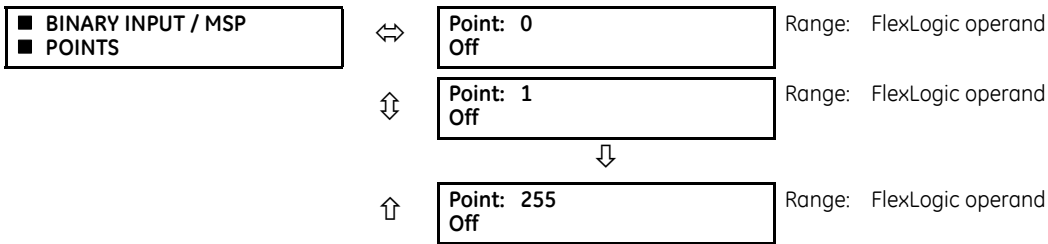
SETTINGS ⇌ PRODUCT SETUP ⇌ COMMUNICATIONS ⇌ DNP / IEC104 POINT LISTS



Up to 256 binary and up to 256 analog input points for the DNP protocol, or the MSP and MME points for IEC 60870-5-104 protocol, can be configured. The value for each point is user-programmable and can be configured by assigning FlexLogic operands for binary inputs / MSP points or FlexAnalog parameters for analog inputs / MME points.

The menu for the binary input points (DNP) or MSP points (IEC 60870-5-104) follows.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ DNP / IEC104 POINT LISTS ⇒ BINARY INPUT / MSP POINTS

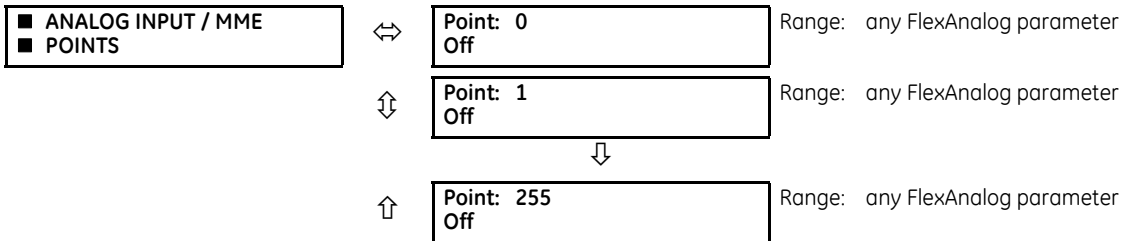


Up to 256 binary input points can be configured for the DNP or IEC 60870-5-104 protocols. The points are configured by assigning an appropriate FlexLogic operand. See the Introduction to FlexLogic section in this chapter for the range of assignable operands.

Changes to the DNP / IEC 60870-5-104 point lists take effect when the L30 is restarted.


The menu for the analog input points (DNP) or MME points (IEC 60870-5-104) follows.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ DNP / IEC104 POINT LISTS ⇒ ANALOG INPUT / MME POINTS




Up to 256 analog input points can be configured for the DNP or IEC 60870-5-104 protocols. The analog point list is configured by assigning an appropriate FlexAnalog parameter to each point. See the FlexAnalog Parameters section in Appendix A for the range of assignable parameters.


Changes to the DNP / IEC 60870-5-104 point lists take effect when the L30 is restarted.

 The DNP / IEC 60870-5-104 point lists always begin with point 0 and end at the first “Off” value. Since DNP / IEC 60870-5-104 point lists must be in one continuous block, any points assigned after the first “Off” point are ignored.

5.3.5.12 IEC 61850 protocol

 The L30 is provided with optional IEC 61850 communications. This feature is specified as a software option at the time of ordering. See the Order Codes section in chapter 2 for details.

The IEC 61850 settings are accessible in EnerVista software or a substation configuration language (SCL) generating tool. The path is **Settings > Product Setup > Communications > IEC 61850** or **Settings > IEC 61850**. The settings are not accessible from the front panel of the device.

 IEC 61850 messaging can form part of protection schemes. Consider IEC 61850 settings with the same criticality as protection element settings. To ensure reliable performance of protection schemes utilizing IEC 61850 messaging, route IEC 61850 traffic on a separate port from SCADA communications, or use redundant, independent ports, and a high-speed network recovery method, such as PRP.

Overview

IEC 61850 is a series of international standards and technical reports applicable to power utility automation systems. It includes semantics, abstract communication services, specific communication services, performance specifications, network engineering guidelines, configuration description methodologies, and engineering processes. The standard enables interoperability among intelligent electronic devices (IEDs) from different suppliers and interoperability among software configuration tools from different suppliers. Interoperability in this case is the ability for IEDs to operate on the same network or communication path sharing information and commands, and for configuration tools to understand each other's configuration files.

The UR family supports a large subset of IEC 61850 features. These are detailed in the UR Family Communications Guide and include the information model, GOOSE publish, GOOSE subscribe, buffered report server, unbuffered report server, and Manufacturing Message Specification (MMS) query, read, write, and control services. In addition, the URs and their EnerVista UR Setup software support IEC 61850 Substation Configuration Language (SCL) file import/export and merging.

Whereas prior UR releases used edition 1.0 of IEC 61850, this release uses edition 2.0, with certain modifications according to IEC/TR 61850-90-5. Only edition 2.0 61850 configuration tools can interoperate with edition 2.0 devices, such as the UR 7.3x release. This UR release uses edition 2.0 SCL, which differs from edition 1.0 SCL. GSSE, fixed GOOSE, and fixed report services of previous releases are no longer supported, and thus UR devices of previous releases using these features have to be converted to configurable GOOSE to communicate with a 7.3x or later device.

Many settings of UR protection, control, and monitoring elements, that is to say elements that are not concerned with the IEC 61850 protocol, can nevertheless be accessed via IEC 61850. These settings are documented elsewhere in this Settings chapter. This section of the Settings chapter deals solely with the settings that configure the IEC 61850 protocol itself.

The maximum number of simultaneous clients supported by the UR family is five.

EnerVista setup for IEC 61850

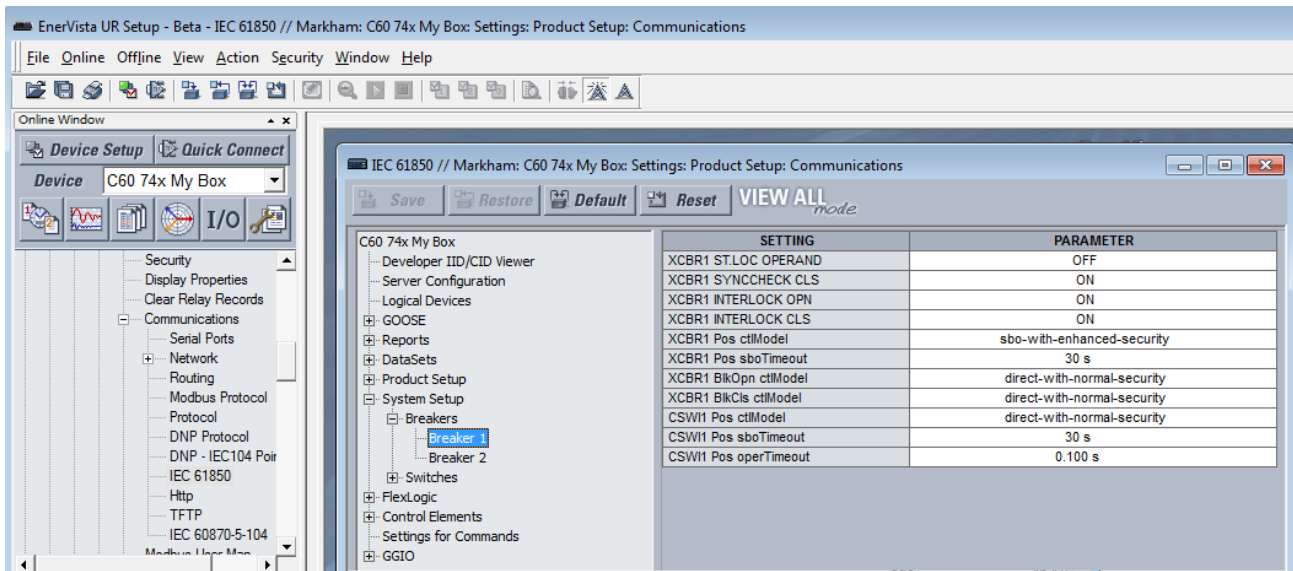
The EnerVista UR Setup software provides the interface to configure L30 settings for the IEC 61850 protocol. This section describes this interface. The software also supports import/export and merging of IEC 61850 Substation Configuration Language (SCL) files as documented in the UR Family Communications Guide.

The IEC 61850 protocol configuration settings cannot be accessed through the UR front panel and are instead accessible with the EnerVista software, via MMS query, read, and write services, or via 61850 SCL file transfer. Accordingly, whereas other settings are presented in this manual as they appear on the front panel, IEC 61850 settings are presented as they appear in the software. See the UR Family Communications Guide for MMS and SCL access. Note that if you update the IEC 61850 settings in the EnerVista software by writing to them by MMS while the corresponding IEC 61850 panel is open in EnerVista, you need to close then open the panel in EnerVista for the correct readings to display.

IEC 61850 protocol configuration settings are accessed through software panels that are selected either in the **Online Window** area (see figure) or the **Offline Window** area in the EnerVista software.

The EnerVista software also includes an interface that is compatible with firmware versions 5.0 to 7.2 to configure subscribers. Use the Simplified GOOSE Configurator in the Offline Window area.

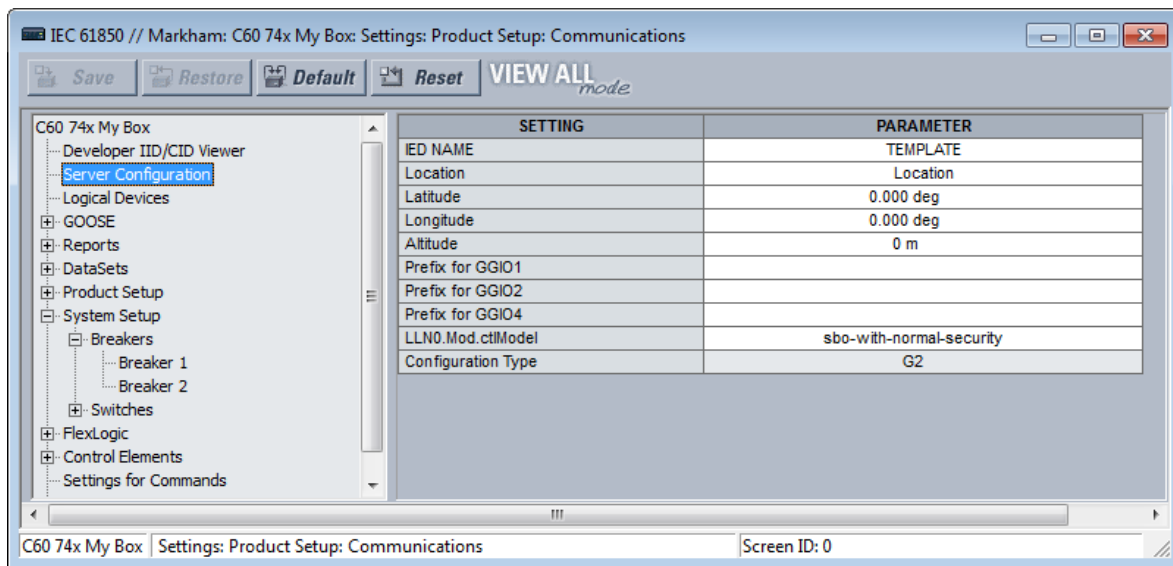
Figure 5-18: IEC 61850 protocol panel in EnerVista software



The IEC 61850 window is divided into a navigation pane on the left and a settings panel on the right. You expand and click an option on the left to display its panel on the right. The following figure shows an example for Server Configuration. The **SETTING** column contains the names of the settings, and the **PARAMETER** column is used to enter the settings. Hovering the mouse over a setting name displays a tool-tip showing the 61850 information model name of the setting or its location in SCL files.

5

Figure 5-19: IEC 61850 panel



Opening the IEC 61850 window while online causes the UR Setup software to retrieve and import an SCL file from the L30. This System Configuration Description (SCD) file contains all the settings in the UR at the time of the file request, both those that are mapped into the IEC 61850 information model (that is, the "public" sections) and those that are not in the model (that is, the "private" section). The UR EnerVista Setup software imports all of these settings into the current session, not just those in the IEC 61850 window. To avoid loss of any unsaved setting changes made in other panels during the current session, all other panels for the L30 must be closed before the IEC 61850 panel can be opened, and the software prompts for this when applicable. Panels for other devices can be open concurrently to facilitate parameter coordination.

When CyberSentry security is enabled, editable settings depend on the user role logged in. For example, an Administrator and Engineer can change settings. If prompted for a "Settings password," it means the Administrator or Engineer password.

The **Restore** button restores settings in the window to their last saved values. The **Default** button reverts settings in the window to factory default values or Oscillography, Data Logger, or FlexLogic Equation Editor pre-configured values. The **Reset** button reverts all IEC 61850 settings to the factory default values, not just the current window. (In other settings windows, the button reverts settings in the window to factory default values.)

When a setting is enabled, its panel continues to read Disabled until relaunched. There is no polling capability to update automatically the IEC 61860 readings, so the panel needs to be closed then opened for the correct status to display. Good practice is to close any panel not in use because changes being made by other users too are reflected only upon relaunch of the panel.

Some of the IEC 61850 settings use floating point data, which guarantees accurate representation of real numbers up to seven digits. Numbers with more than seven digits are approximated within a certain precision. This can result in differences between what is entered and what is saved, and for example results in differences shown on a settings comparison report.

Create CID and settings files

When the **Save** button is clicked in the online IEC 61850 window, UR Setup software prepares a configured IED description (CID) file containing all the settings of the UR and sends the CID file to the L30. Upon receipt, the L30 checks the CID file for correctness, going out of service, then back into service when the CID file is accepted. The software displays a message when the L30 is running the new settings, confirming successful transfer. This process can take a minute or so due to the amount of processing required by the software and the L30.

When the **Save** button is clicked in the offline IEC 61850 window, UR Setup software saves to local storage, for example the hard drive, a .urs file containing all settings of the UR.

View IID/CID files

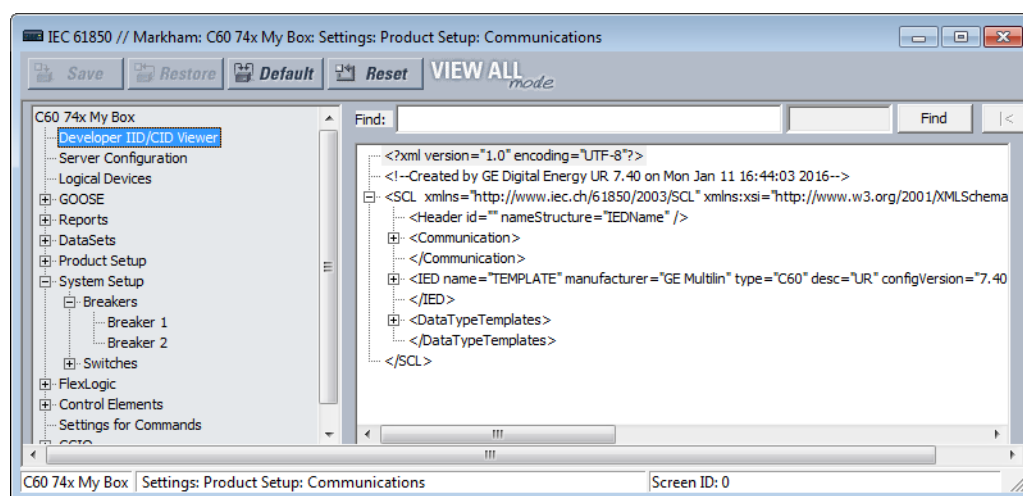
The file types are described as follows:

- IID — Instantiated IED capability description file — Actual settings on UR
- CID — Configured IED description file — Settings sent to the UR (may or may not contain the present settings)

IID and CID files are viewable. For example, after modifying settings in the IEC 61850 panels and clicking **Developer IID/CID Viewer** in the software, a CID file generates and an SCL Viewer shows the updated CID file content. There are no edit or save functions; use instead the Back Up and Restore Settings instructions later in this document to save the files.

Searches are case insensitive.

Figure 5-20: View CID settings file



Server configuration

The Server Configuration panel contains IEC 61850 settings relevant to the server functions of the IED implementation.

The path is **Settings > Product Setup > Communications > IEC 61850 > Server Configuration**.

The following settings are available, where <iedName> is a syntactic variable representing the present value of the IED NAME setting.

IED NAME

Range: 1 to 58 VisibleString characters

Default: TEMPLATE

The value entered sets the IED name used by IEC 61850 for the L30. An IED name unique within the network must be entered for proper operation. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter.

The **IED NAME** and the **Product LD inst name** comprise the <LDName> for a product. The longest LD inst are "Master" and "System" at six characters, with Master being fixed and the others configurable with the configurable Logical device feature. So the IED NAME needs to be restricted to 58 characters to meet a 64 character limit.

Location

Range: 0 to 255 ASCII characters

Default: Location

The value entered sets the value of the data attribute <LDName>/LPHD1.PhyNam.location. This data attribute is provided by the protocol to allow the user to declare where the equipment is installed.

Latitude

Range: -90.000 to 90.000 degrees in steps of 0.001 degree

Default: 0.000 deg

The value entered sets the value of the data attribute <LDName>/LPHD1.PhyNam.latitude. This data attribute is provided by the protocol to declare the geographical position of the device in WGS84 coordinates -latitude. Negative values indicate a southern latitude. WGS refers to the world geodetic system, which is used in global positioning systems (GPS), and 84 is the current version of the standard.

Longitude

Range: -180.000 to 180.000 degrees in steps of 0.001 degree

Default: 0.000 deg

The value entered sets the value of the data attribute <LDName>/LPHD1.PhyNam.longitude. This data attribute is provided by the protocol to declare the geographical position of the device in WGS84 coordinates -longitude. Negative values indicate a western longitude.

Altitude

Range: 0 to 10,0000 m in steps of 1 m

Default: 0 m

The value entered sets the value of the data attribute <LDName>/LPHD1.PhyNam.altitude. This data attribute is provided by the protocol to declare the geographical position of the device in WGS84 coordinates - altitude.

Prefix for GGIO1

Range: 0 to 11 VisibleString characters

Default:

This setting sets the LN Prefix of the FlexLogic operand interface logical node GGIO1 that is described in the GGIO1 section later. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter. UR Setup software does not allow entry of a prefix that duplicates any other GGIO1 prefix that is used by the product, such as ConIn and ConOut.

Prefix for GGIO2*Range: 0 to 11 VisibleString characters**Default:*

This setting sets the LN Prefix of the Virtual Inputs Interface logical node GGIO2 that is described in the GGIO2 section later. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter. UR Setup software does not allow entry of a prefix that duplicates any other GGIO2 prefix that is used by the product.

Prefix for GGIO4*Range: 0 to 11 VisibleString characters**Default:*

This setting sets the LN Prefix of the FlexAnalog operand interface logical node GGIO4 that is described in the GGIO4 section later. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter. UR Setup software does not allow entry of a prefix that duplicates any other GGIO4 prefix that is used by the product.

LLN0.ModctlModel*Range: status-only, direct-with-normal-security, sbo-with-normal-security**Default: sbo-with-normal-security*

This setting specifies the control service that clients must use to control the TEST MODE FUNCTION of the L30. An "on" control to <LDName>/LLN0.Mod changes TEST MODE FUNCTION to Disabled, an "on-blocked" control changes it to Forcible, and a "test/blocked" changes it to Isolated.

Configuration Type*Range: G2, E3-2.0**Default: G2*

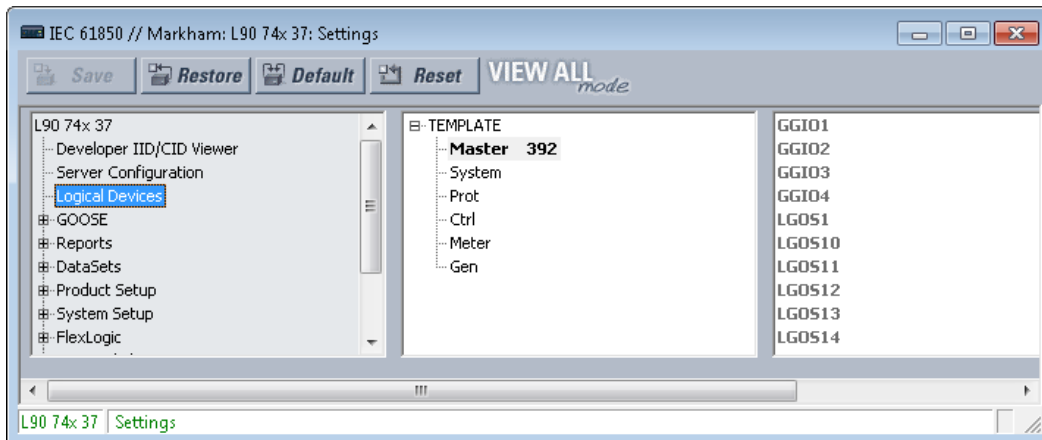
This setting is read only. It specifies the method used to describe GOOSE subscription configuration in SCL. See the UR Family Communications Guide for details. In the G2 mode, the CID file contains IED elements for IEDs subscribed to by this IED containing GOOSE subscription information. In the E3 2.0 mode, the CID file has only one IED element and GOOSE subscription information is coded in data objects in the standard LGOS logical node used to monitor reception of the subscribed GOOSE. UR 7.30 or later accepts either mode. The set value is for the entire EnerVista installation and is preserved between sessions. To change this global field, click **File > Preferences** and access the IEC 61850 panel; you do not need to be connected to the device.

Logical devices

The Logical Devices panel contains IEC 61850 settings relevant to the configurable logical devices feature, wherein logical device naming can be reconfigured and logical nodes re-assigned.

The path is **Settings > Product Setup > Communications > IEC 61850 > Logical Devices**.

Figure 5-21: Default IEC 61850 Logical Devices panel with devices middle and nodes right



To configure logical devices and nodes:

1. Right-click an entry and edit an existing device, add a new one, or move a logical node. The rest of this section explains the window and how to perform these actions.

The default logical device ID/categories are as follows:

- **Master** — Communications, including GOOSE, reports, Remote I/O, Virtual Inputs, Modbus, DNP, and setting group control
- **System** — Power system devices: breakers, switches, CTs, VTs, and so on, including interfaces to these, such as AC inputs, contact I/O, transducer I/O, HardFiber I/O
- **Prot** — Protection and protection-related functions
- **Ctrl** — Control and monitoring functions
- **Meter** — Metering and measurement functions
- **Gen** — FlexLogic, Virtual Outputs, non-volatile latches, FlexElements, recording (for example oscillography), security, front panel, clock

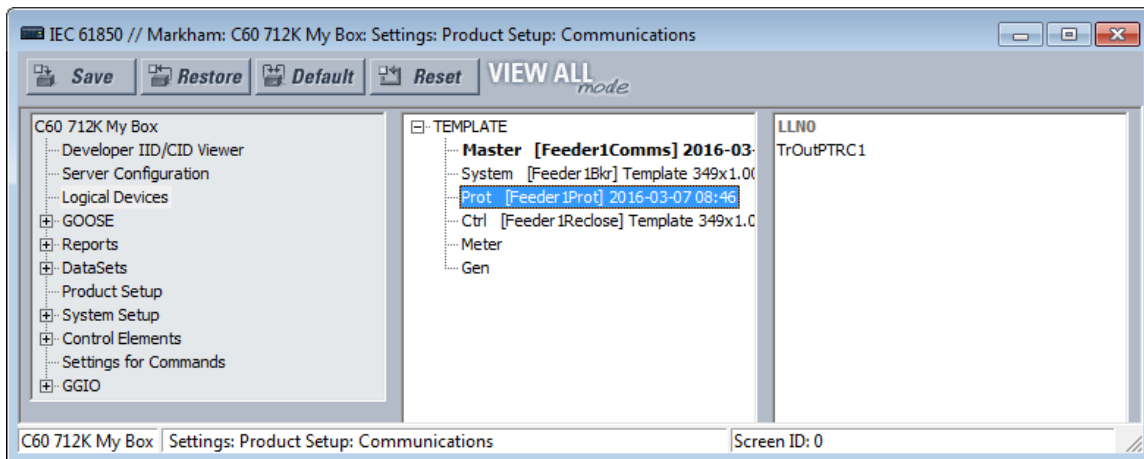
For the Master logical device, the following logical nodes have fixed assignment:

- The LLN0 in the Master logical device, which includes setting group, GOOSE and report control blocks, and datasets
- LPHD1 — Models common issues for physical devices
- GGI01 — For unmapped FlexLogic operands
- GGI02 — For Virtual Input control
- GGI03 — For RxGOOSE Inputs
- GGI04 — For unmapped FlexAnalog operands
- LGOS logical nodes — For GOOSE subscription

The Logical Devices panel has middle and right panes. The middle pane has a list of the instantiated logical devices in the sequence that they appear in SCL, with one device selected. The right pane has a list of the logical nodes presently assigned to the selected logical device in lexicographic order by logical node name.

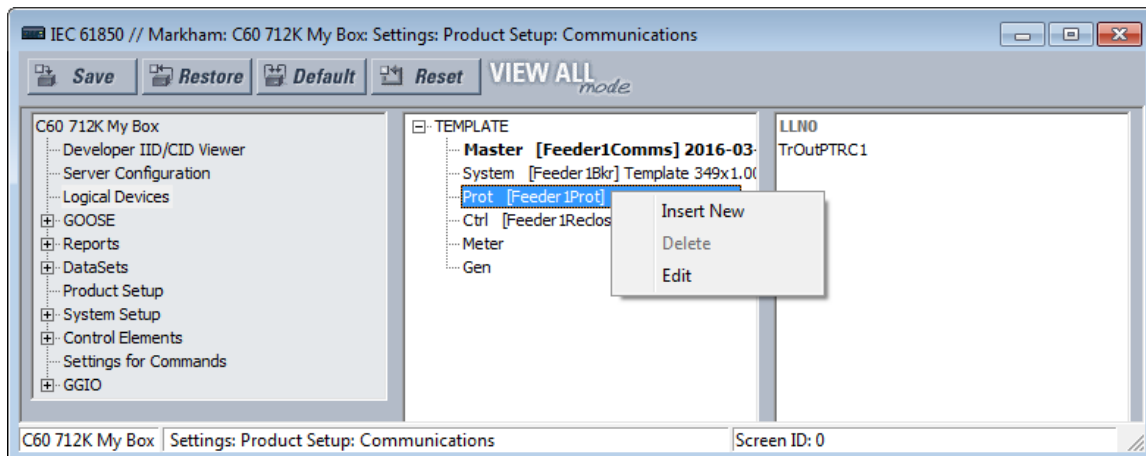
In the middle pane logical devices are shown with their product-related name, followed in brackets by their function-related IdName, and followed by the value of their confRev. In the following example, by right-clicking and editing, the Protection logical device has been set to instance name "Prot", the function-related name "Feeder1Prot" and the configuration revision "2016-03-07 08:46." The text is clipped on the right if the line is longer than the available width. The next paragraphs explain how to do this setup.

Figure 5-22: Protection logical node selected



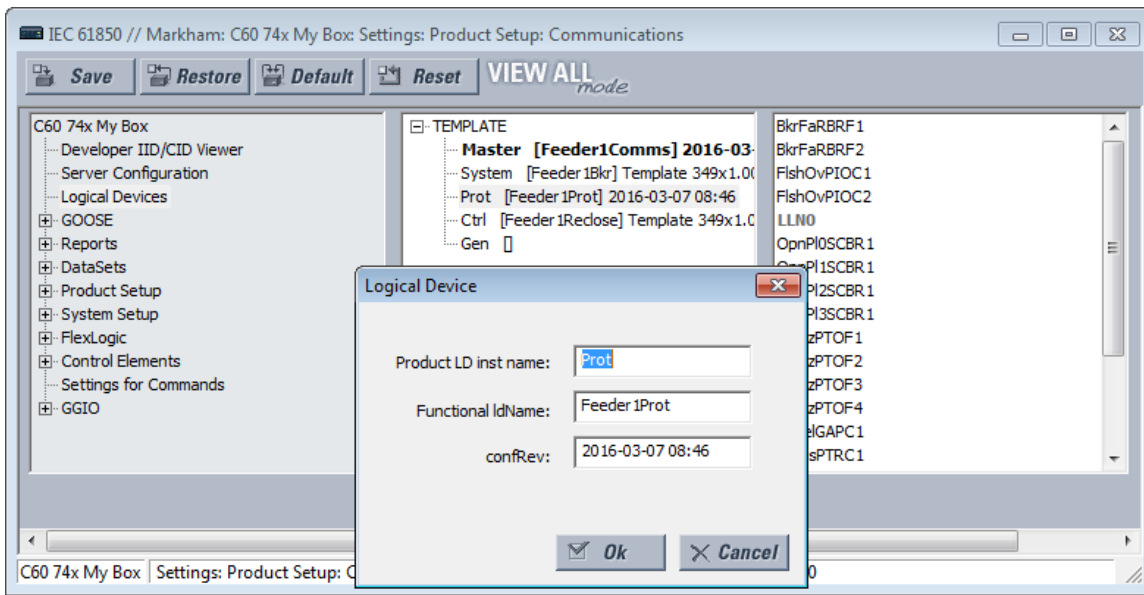
Right-clicking a logical device displays the menu that allows insertion of a new logical device immediately below the selected one, deletion of the selected logical device, or editing the selected logical device's parameters. The insert option is disabled and greyed-out if there are already 16 logical devices instantiated. The delete option is disabled and greyed-out if the selected logical device is Master or it contains any logical nodes other than LLN0.

Figure 5-23: Menu for logical node



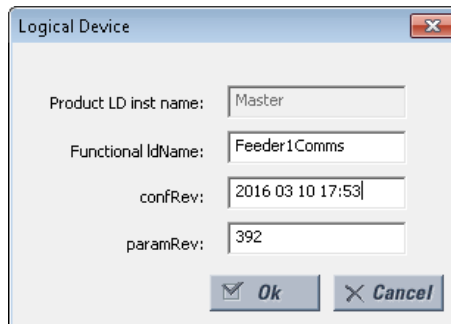
If the insert option is selected, or the edit option is selected for other than the Master logical device, a logical device parameters edit dialog opens.

Figure 5-24: Insert new logical node



If the edit option is selected for the Master logical device, the **Product LD inst name** setting is not editable.

Figure 5-25: Edit logical node



When the **Ok** button is clicked, the entered values for **Product LD inst name** and **Functional IdName** are checked for uniqueness within the UR, and they are updated in the pane.

The settings are explained as follows, where <iedName> is a syntactic variable representing the present value of the IED NAME setting. When adding or editing a logical device entry, these are the fields that need to be completed.



Customized logical nodes are not saved in the URS file.

Product LD inst name

Range: 1 to 64 VisibleString characters

Default: as per the following table

Each logical device has this setting. The value is fixed at "Master" in the first logical device and configurable in all others. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The entered value sets the logical device inst name. Each logical device inst name is required to be unique within the device, and it cannot be blank. Also, if the corresponding functional IdName setting is blank, the concatenation of the IED name and the logical device

inst name must form an LDName that is unique within the network for proper operation. It is recommended that the length of the IED NAME plus the length of this setting be not greater than 64 to respect the requirements of IEC 61850 7 2:2010 22.2 for LDName.

The factory default configuration is for six logical devices with Product LD inst name settings and logical node assignments as per the following table.

Table 5-10: Factory default logical nodes

Default logical device inst name	Contains logical nodes modeling...
Master (root logical device; name is fixed)	communications, including GOOSE, reports, Remote I/O, Virtual Inputs, Modbus, DNP, and so on. Setting group control. This is the root logical device. To comply with IEC 61850 7 1 Ed2 clause 6.4.5.1, all group L logical nodes (logical nodes with class names begin with "L"), except LLN0, belonging to this IED are in this logical device.
Protection (Prot)	protection functions
Control (Ctrl)	control and monitoring functions
System	power system devices: breakers, switches, CTs, VTs, and so on, including interface to these such as AC inputs, contact I/O, transducer I/O, HardFiber I/O
Metering (Meter)	metering and measurement (other than PMU), including Signal Sources
General (Gen)	FlexLogic, virtual outputs, non-volatile latches, FlexElements, FlexMath, recording (for example oscillography), security, front panel, clock

Functional IdName

Range: 0 to 64 VisibleString characters

Default: empty string

Each logical device has this setting. The value is configurable in all logical devices. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. If the number of characters entered is greater than zero, the setting sets the value of the function-related name used in communications. If an IdName is entered, it must form an LDName that is unique within the network for proper operation. The standard recommends choosing this name according to IEC 81346-1. If the number of characters entered is zero, no function-related name is defined.



NOTE

Throughout the remainder of this IEC 61850 section, <LDName> is a syntactic variable representing the present LDName of the master logical device. In other contexts LDName can refer to some other logical device. Depending on its context, <LDName> can be a product-related name or a function-related name.

configRev

Range: 0 to 255 ASCII characters

Default:

This data attribute is provided by the protocol to declare changes to the semantic of the data model of the UR. The intent is that the user changes Master configRev each time that the semantic or data model changes, so that clients can readily detect the change. A semantic change is a logical node getting a new semantic use; for example, an instance of logical node CSWI is now serving a different physical switch, or an instance of a logical node PDIS is now used for another zone. A data model change is a change in the presence of logical nodes, data objects, data attributes, or instance names.

The scope of Maser configRev is the entire relay configuration, as the Master logical device is the root logical device. Similar settings are provided for the other logical nodes; the scope of these other configRev settings is limited to the corresponding logical device configuration.

paramRev

Range: -2,147,483,648 to 2,147,483,647

Default: 0

The configurable data attribute paramRev has a scope that includes the entire device, and thus is modified whenever any setting in the device changes. The UR increments the value of paramRev by one whenever one or multiple setting changes occurs in one Modbus write request by any means (front panel, Modbus, or MMS) other than by SCL file

download. Incrementing occurs whether or not the setting is represented in the information model. When a UR device or EnerVista UR Setup accepts an SCL file, paramRev is set to the value in that SCL file. When EnerVista UR Setup changes one or more settings, and prepares an SCL file, it increments paramRev to the next higher multiple of 10 000.



Each logical device has a name: LDName. (Note the upper case LD.) LDName has both a product-related form and a function-related form as per IEC 61850 6:2009 8.5.3.

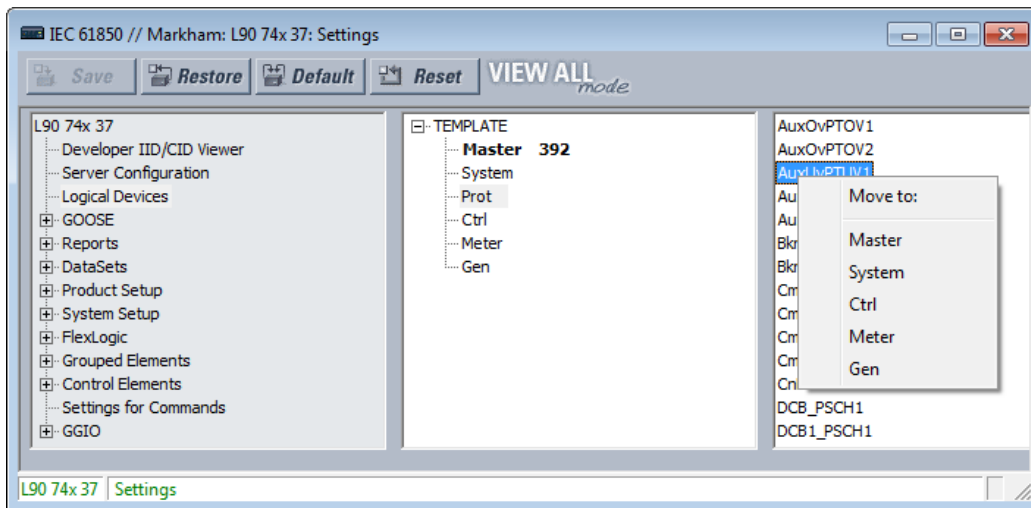
SCL files invariably use the product-related form of LDName. The product-related form is the concatenation of the IED name of the device and the individual logical device's inst name. The IED name is the value of the "IED NAME" setting on the Server Configuration panel, and the logical device inst names are each the value of the corresponding "Product LD inst name" setting here. The "Product LD inst name" of the first logical device is fixed at "Master".

Communications use the function-related form of LDName if a function-related name is defined, otherwise communications use the product-related name. The function-related name is the value of the corresponding "Functional ldName" setting if this setting is not empty, if empty the function-related name is not defined.

In SCL, the function-related name is specified by the LDevice element attribute ldName (note the lower case ld). Absence of this attribute indicates the function-related name is not defined. In SCL the product-related name is specified by the name attribute of the IED element and the inst attribute of the LDevice element.

In the right pane, logical nodes assigned permanently to the Master logical device and LLN0 in all logical devices are greyed-out as shown earlier. These are not movable. Any other logical node can be dragged to any of the logical devices in the middle pane, which causes that logical device to be re-assigned to that logical device. Right-clicking a logical node device displays a menu that lists the logical devices that this logical node can be moved to. Clicking one of these re-assigns the logical node. Other common keyboard and/or mouse action can be used to select one or more logical nodes and move the selected nodes together.

Figure 5-26: Move logical node



GOOSE

The path is **Settings > Product Setup > Communications > IEC 61850 > GOOSE**.

Support for Routable GOOSE

Routable GOOSE (R-GOOSE) is supported in firmware release 7.4 and later. Routable GOOSE allows UR and other devices to be located in separate networks. Encryption/decryption of messages is performed by a separate gateway device. Messages are routed using a separate router, using IP addresses.

Note the following behavior:

- A v7.4 device can send an R-GOOSE message to another v7.4 device when both have R-GOOSE active as the protocol
- A v7.4 device can send a GOOSE message to another v7.4 device when both have GOOSE active as the protocol

- A v7.4 device cannot send an R-GOOSE message to non-R-GOOSE devices, such as v7.3 or v5.9 UR device
- UR devices with firmware below v7.3 can send a GOOSE message to a v7.4 device that has GOOSE as the active protocol



R-GOOSE is available through the IEC 61850 software option. If R-GOOSE security is required, the CyberSentry software option also must be purchased.

TxGOOSE

IEC 61850 GOOSE is an efficient method for simultaneous high-speed delivery of generic substation event information by a publishing device to more than one subscribing device. A TxGOOSE is a UR element implementing a single IEC 61850 GOOSE message publishing service. The subscribing function in URs is performed by RxGOOSE elements, as described in the next section. Each UR with IEC 61850 order code options has 16 TxGOOSE elements. Each TxGOOSE can either use the original format specified in IEC 61850 8 1:2011 or the routable GOOSE (R-GOOSE) format specified in IEC TR 61850-90-5:2012. Each TxGOOSE element can publish the values of up to 64 attributes of the IEC 61850 nodes in the UR.

Published TxGOOSE messages configured in the EnerVista UR Setup software can be subscribed by and the published operand values understood by other UR devices. Furthermore, they can be subscribed to and understood by any device of any manufacturer that implements the IEC 61850 edition 1.0 or 2.0 GOOSE subscription mechanism. The messages are published with a multicast address so that the network sends the messages to all devices; any number of devices that want to subscribe can.

For wide area protection, control, and monitoring schemes, R-GOOSE wraps the proven original format GOOSE in IP/UDP to multicast (or unicast) the data over a Wide Area Network (WAN). Sample applications are Wide area Remedial Action Scheme (RAS) and Under Voltage/ Frequency Load Shedding Schemes (UVLS/UFLS). R GOOSE uses IGMPv3 (Internet Group Management Protocol version-3, RFC 3376) for multicasting.

The entities whose values are published in GOOSE messages are known as members. The members are itemized in an ordered list known as a data set. Each TxGOOSE can use any one of the configured data sets. (See the DataSets section later for details.) The performance of a TxGOOSE is determined by its dataset. Booleans in fast GOOSE datasets are designed for the TT6 transfer time class (3 ms), while Booleans in the Normal datasets are designed for the TT3 class (100 ms). Due to the significant amount of CPU time required to compose a TT6 TxGOOSE message and the limited amount of time allowed by the TT6 class, at most four of these can be configured in a given UR. So only four fast GOOSE are allowed to be configured, and the UR software has a check to disallow the use of more than four fast datasets in GOOSE. If six fast datasets are configured outside of UR software and the file sent directly to the relay, the relay rejects the file. The design does allow six fast datasets to be used in report control blocks, which allows fast scanned data in reports.

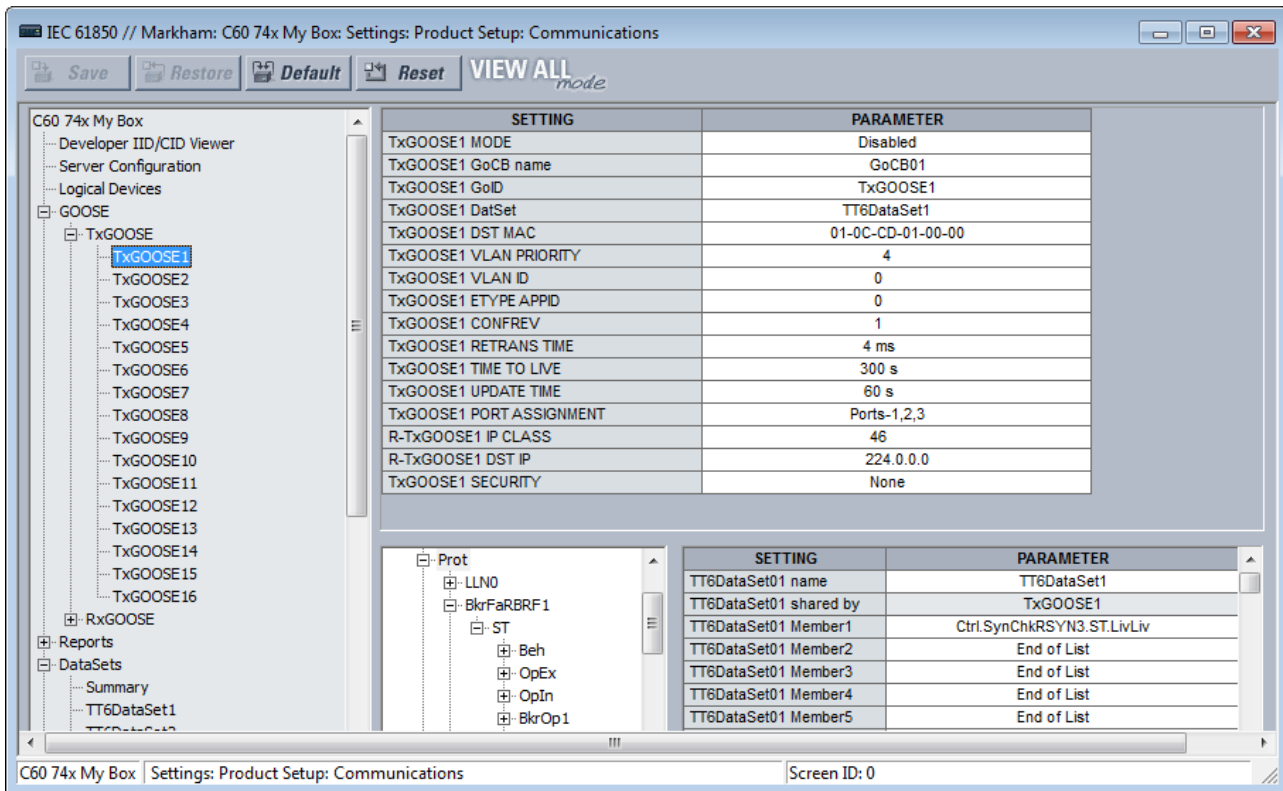
Each enabled TxGOOSE transmits its message whenever a value change is detected in one or more of its members. If the changed value is a Boolean in a fast dataset, then the change detect occurs in the TT6 detection time of 3 ms or less. If the member is an analog value in a fast dataset, the change detect occurs in the TT3 time of 100 ms. In Normal GOOSE Datasets, change detection for all dataset members occurs in the TT3 time of 100 ms. To guard against the possibility that such a message is lost in the network before it reaches all subscribers, the message is quickly retransmitted several times. To allow subscribers to verify that their link to the publisher and the publisher itself are healthy, each message is also retransmitted periodically even while the values are unchanging. These latter messages are known as heartbeat messages, while the former are known as event messages. Heartbeat messages also provide means for a subscriber newly online to receive the published values in the absence of an event.

The details of TxGOOSE message construction are contained in the UR Family Communications Guide. Knowledge of these details is not required to configure GOOSE.

The UR does not implement the Fixed-Length encoded GOOSE messages option specified in IEC 61850-8-1:2011 clause A.3; the UR always uses the ASN.1 Basic encoding rules (as specified in ISO/IEC 8825-1) as specified in IEC 61850 edition 1.0 and as optional in IEC 61850 edition 2.0.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > TxGOOSE > TxGOOSE1** to access the settings for the first TxGOOSE. The settings and functionality for the others are similar.

Figure 5-27: IEC 61850 TxGOOSE panel



5

A data set needs to be set up and selected in the **TxGOOSEx DataSet** field for all content to display.

When saving changes, when a "dataset member is empty" message displays, you need to set the member in the bottom right of the window.

TxGOOSE1 MODE

Range: Disabled, GOOSE, R-GOOSE

Default: Disabled

When set to Disabled, TxGOOSE1 messages are not published. When set to GOOSE, TxGOOSE1 messages are published in IEC 61850 8 1:2011 GOOSE format. When set to R-GOOSE, TxGOOSE1 messages are published in Routable GOOSE format according to IEC 61850 90-5, and the **TxGOOSE1 DST MAC** address is set to 00 00 00 00 00 00 and cannot be changed.

TxGOOSE1 GoCB name

Range: 0 up to 32 VisibleString characters

Default: GoCB01

The entered value sets the GOOSE control block (GoCB) name value for TxGOOSE1.

An ObjectReference to the control block, which consists of the concatenation of the string "<LDName>/LLN0." and the control block name, is published in the gocbRef field of TxGOOSE1 messages and is used by subscribers to discriminate TxGOOSE1 messages from other GOOSE messages. <LDName> is a syntactic variable that is set to the value of setting Master functional ldName if one or more characters have been entered to that setting, otherwise the value of setting IED NAME suffixed with "Master".

TxGOOSE1 GoID

Range: 0 to 129 VisibleString characters

Default: TxGOOSE1

The entered value sets the goID value published in TxGOOSE1 messages, and can be used by subscribers to discriminate the TxGOOSE1 messages from other GOOSE messages.

TxGOOSE1 DataSet

Range: None, TT6DataSet1, TT6 DataSet2, ... TT3DataSet01, TT3 DataSet02, ...

Default: None

This setting selects the published data set using the UR Setup software designator for the data set. If None is selected, no TxGOOSE1 messages are sent.

The IEC 61850 name of the data sets are configured in the Datasets panel, as described later.

Some datasets are designed for the TT6 transfer time class (3 ms), while others are designed for the TT3 class (100 ms). The performance of a TxGOOSE is determined by its dataset. Use TT6 datasets for trips and blocking applications, TT3 datasets for slow automatic interactions. The 61850 name of the datasets are configured in the Datasets panel.

An ObjectReference to the data set, which consists of the concatenation of the string "<LDName>/LLN0." and the data set name, is published in the datSet field of TxGOOSE1 messages and can be used by subscribers to discriminate TxGOOSE1 messages from other GOOSE messages. <LDName> is a syntactic variable that is set to the value of setting Master functional ldName if one or more characters have been entered to that setting, otherwise the value of setting IED NAME suffixed with "Master".

To configure a DataSet, select it at the top of the window from the drop-down list. In the lower part of the window, drag and drop configuration items to the right side. Dataset members configured here affect other Report or TxGOOSE control blocks that use the same DataSet.

The performance of the TxGOOSE is determined by the performance of the selected dataset. When the selection is TT3DataSet01, TT3DataSet02, ... it is possible that transient events can be missed.

TxGOOSE1 DST MAC

Range: any 12 digit hexadecimal number

Default: 01-0C-CD-01-00-00

When the **TxGOOSE1 MODE** setting is R-GOOSE, the **TxGOOSE1 DST MAC** address is set to 00 00 00 00 00 00 and cannot be changed. Otherwise, the value entered here sets the Ethernet destination Media Access Control (MAC) address in published TxGOOSE1 messages. As the standard requires that the address have the multicast bit set TRUE, that is to say the second digit is set to an odd number, messages transmitted have the multicast bit set TRUE no matter its value in this setting.

The destination MAC address can be used by the network to restrict message delivery to selected devices that need to receive them, reducing network load. This address also can be used by hardware in receiving devices to filter out messages that are of no interest to them, reducing processor burden. Different filtering algorithms are implemented by different devices. The standard recommends that the algorithm used by hardware of the receiving device be considered when assigning destination multicast addresses.

Subscribers can use this address to discriminate TxGOOSE1 messages from other GOOSE messages.

TxGOOSE1 VLAN PRIORITY

Range: 0, 1, 2, 3, 4, 5, 6, 7, 5-4, 6-4, 6-5, 7-4, 7-5, 7-6

Default: 4

When the value entered is 0, 1, 2, 3, 4, 5, 6, or 7, the User Priority value in the IEEE 802.1Q VLAN tag included in published TxGOOSE1 messages is set to that value. When one of the two-digit values is entered, the dynamic priority feature is selected: the first event message has the User Priority value of the first digit, and User Priority is decremented in each following message until reaching the value of the second digit. For instance, if the selected value is 7-5, then the User Priority values in successive messages beginning with the message triggered by an event is 7, 6, 5, 5, 5, 5, and so on. Do not make a dynamic priority selection when standard behavior is required.

Network devices can forward a message with a higher priority value before a message with a lower priority value, which speeds delivery of high-priority messages in heavily loaded networks. The standard recommends that higher-priority messages, such as GOOSE, have priority values in the range of 4 to 7.

TxGOOSE1 VLAN ID

Range: 0 to 4095 in steps of 1

Default: 0

The value entered sets the VID value in the IEEE 802.1Q VLAN tag included in published TxGOOSE1 messages. VID can be used by network devices to direct messages to only selected devices, reducing network burden. VID values of 0 and 1 are assigned by IEEE 802.1Q to other functions and are not to be used for GOOSE.

TxGOOSE1 ETYPE APPID

Range: 0 to 65535 in steps of 1

Default: 0

The value entered sets the APPID value in published GOOSE messages and can be used by subscribers to discriminate TxGOOSE1 messages from other GOOSE messages.

The standard reserves the value range 0 to 16383 for GOOSE Type 1 (Fast messages), and reserves the value range 32768 to 41151 for GOOSE Type 1A (Trip messages). Some subscribers can process messages in the Type 1A range faster than messages in the Type 1 range. The standard reserves the default value (0) to indicate lack of configuration. The standard strongly recommends unique, source-orientated APPIDs within a given system.

TxGOOSE1 CONFREV

Range: 0 to 4294967295 in steps of 1

Default: 1

The entered value sets the confRev value in published GOOSE messages and can be used by subscribers to discriminate TxGOOSE messages of the expected configuration revision from messages of a different revision. The standard requires that CONFREV be incremented each time the members or the order of the members published is changed. The standard states that the value of 0 is reserved.

TxGOOSE1 RETRANS TIME

Range: 0 to 100 ms in steps of 1 ms

Default: 4 ms

If the entered time is non-zero, when a member value change is detected, four event transmissions are sent, then heartbeat transmissions resume. The interval between the first and second event transmissions, and between the second and third, is the time set here. The interval between the third and the fourth event transmission is double the set time. If the entered time is zero, only a single event transmission occurs, then heartbeat transmissions resume.

TxGOOSE1 TIME TO LIVE

Range: 1 to 300 s in steps of 1 s

Default: 300 s

The value entered sets the timeAllowedtoLive value in published TxGOOSE1 messages. The standard requires subscribers to assume a failure has occurred when another TxGOOSE1 message is not received within the published timeAllowedtoLive time.

Base this setting on the **TxGOOSE UPDATE TIME** and the tolerable number of contiguous message delivery misses. For example, if the heartbeat time is 10 s, and missing up to three successive messages is tolerable, make the setting $10 * 3 + 1 = 31$ s. The extra second is to ensure that arrival of the third heartbeat transmission beats the timeAllowedtoLive timer.

TxGOOSE1 UPDATE TIME

Range: 1 to 60 s in steps of 1 s

Default: 60 s

This setting specifies the time interval between heartbeat messages, meaning messages that are sent periodically while no events are detected.

TxGOOSE1 PORT ASSIGNMENT

Range: Disabled, Port-1; Port-2; Port-3; Ports-1,2; Ports-2,3; Ports-1,3; Ports-1,2,3

Default: Ports-1, 2, 3

This setting specifies the Ethernet ports for transmission of TxGOOSE1. When set to disabled, TxGOOSE1 messages are not transmitted on any port no matter the state of GoEna. When set to Port-1, TxGOOSE1 is published over Ethernet Port-1 only; while selecting Ports-1, 3 option, the same TxGOOSE1 is published to both Ports 1 and 3; and similarly if set to Ports-1, 2, 3, all ports publish TxGOOSE1.



When setting **PRT2 REDUNDANCY** to Failover or to PRP, the TxGOOSE 1 port assignment needs to be set to ports 2 and 3 (Ports-2,3).

Also, Port 3 configuration in the CID file is ignored. The Port 3 ConnectedAP elements has no meaning, as ports 2 and 3 use the port 2 MAC address, IP address, and mask.

R-TxGOOSE1 IP CLASS

Range: 0 to 256 in steps of 1

Default: 46

When the **TxGOOSE1 MODE** setting is other than R-GOOSE, the value of this setting is not used. Otherwise this setting selects the IPv4 Differentiated Services Code Point-DSCP (formerly called TypeOfService-TOS) value. This value provides priority routing, when supported in the routers. The default value is for Expedited Forwarding (101110B, 46 or 2EH).

R-TxGOOSE1 DST IP

Range: 0.0.0.0 to 255.255.255 in steps of 1

Default: 224.0.0.0

When the **TxGOOSE1 MODE** setting is other than R-GOOSE, the value of this setting is not used. Otherwise this setting specifies destination IP address for the R-TXGOOSE1 that is entered in Standard IPV4 address format. The destination IP address needs to be a valid multicast or unicast IP address. The value specified in this setting is mapped to IPv4 header 32 bit field for Destination IP Address while publishing R-GOOSE1.

The default IP address 224.0.0.0 is reserved, and hence not a valid multicast IP address.

The source IP address is that of the UR port from which the R-GOOSE messages are transmitted.

R-TxGOOSE1 SECURITY

Range: None, Signature, SignatureAndEncryption

Default: None

This setting specifies level of security (authentication/encryption) used for TxGOOSE1. None specifies no security mechanisms are to be used. Signature specifies only signature (no encryption) is to be used. SignatureAndEncryption specifies that both signature and encryption are to be used.

RxGOOSE

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > RxGOOSE > RxGOOSE Messages**.

IEC 61850, GOOSE is an efficient method for simultaneous high-speed delivery of the same generic substation event information by a publishing device to more than one subscribing device. An RxGOOSE is a UR element implementing a single IEC 61850 GOOSE message subscribing service. The publishing function in URs is performed by TxGOOSE elements, as described in the previous section.

Each UR with the IEC 61850 order code option has 64 RxGOOSE elements. Each RxGOOSE element can subscribe to GOOSE messages from a specified publisher. Each RxGOOSE can either use the original format specified in IEC 61850 8 1:2011 or the routable GOOSE (R-GOOSE) format specified in IEC TR 61850-90-5:2012. Subscribed message members can be DataObjects, SubDataObjects, DataAttributes or SubAttributes. In E2-2.0 mode members are restricted to basic types BOOLEAN, FLOAT32, INT32, Dbpos, TimeStamp or Quality. Each subscribed message can contain up to 64 values. A member can be a structure containing several values; note that it is the number of values rather than the number of members that are limited to 64.

GOOSE messages from any device of any manufacturer that implements the IEC 61850 edition 1.0 or 2.0 GOOSE publish service or the 61850-90-5 R GOOSE service can be subscribed to. The UR accepts both the variable length encoded GOOSE messages specified IEC 61850 8 1:2004 and the Fixed-Length encoded GOOSE messages as specified in IEC 61850 8 1:2011 clause A.3.

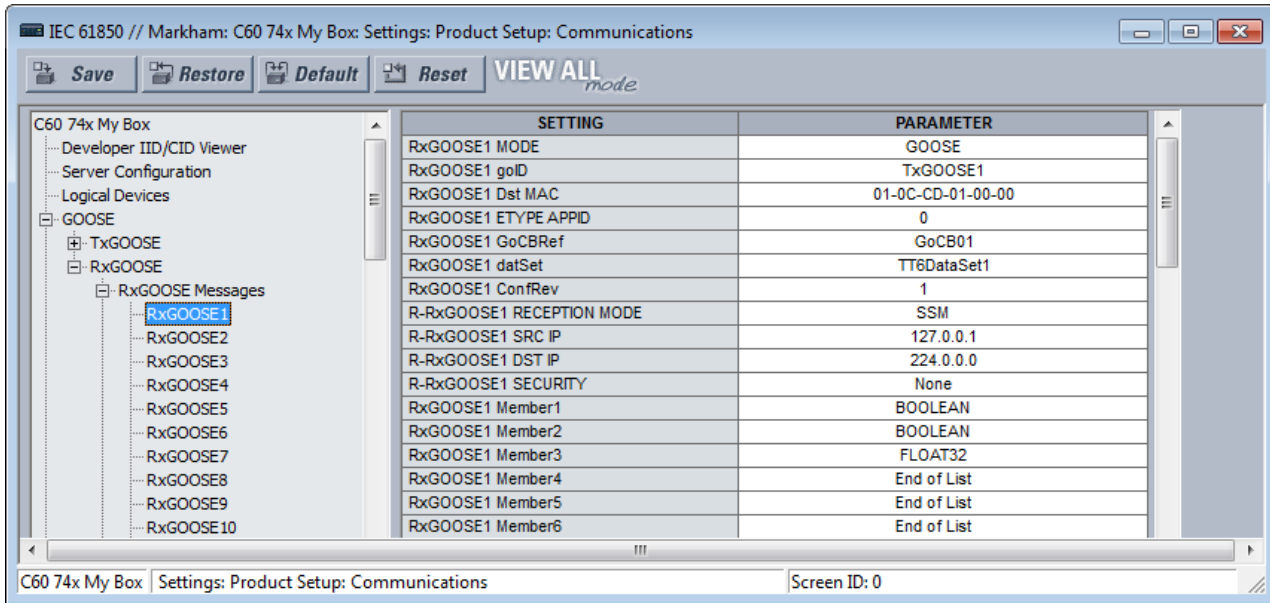
Each enabled RxGOOSE monitors for interruption of the GOOSE messages it subscribes to based on the value in the timeAllowedtoLive field of the last message received. If a new message is not received within that time interval, the RxGOOSE assumes that connectivity is lost. FlexLogic operands (for example RxGOOSE1 On, RxGOOSE1 Off) reflect the status of each RxGOOSE connectivity. An RxGOOSE connection is also considered lost after the UR finishes restart until a message is received. While any RxGOOSE connectivity is lost, a common RxGOOSE Fail self-test is activated.

Messages that contain the value true in the ndsCom field are never accepted. Messages that contain the value true in the simulation field (test field in edition 1.0 messages) are accepted only when the UR **Test Mode Function** setting is set to Forcible or Isolated.

RxGOOSE messages can be received through any UR Ethernet port.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > RxGOOSE > RxGOOSE Messages > RxGOOSE1** to access the settings that specify the messages to be accepted by the first RxGOOSE element. The settings and functionality for the other RxGOOSE are similar. The following settings are available. They allow RxGOOSE1 to recognize the GOOSE messages it is to accept. Most of these settings are automatically configured by UR Setup software when an association to an RxGOOSE Boolean Input, RxGOOSE DPS Input, and/or RxGOOSE Analog Input is made as described in the sections following this. Only settings **R-RxGOOSE1 RECEPTION MODE**, **R-RxGOOSE1 SECURITY**, and **R-RxGOOSE SRC IP** need to be manually completed as the information is not contained in publisher SCL.

Figure 5-28: IEC 61850 RxGOOSE Messages panel



5

RxGOOSE1 MODE

Range: GOOSE, R-GOOSE
 Default: GOOSE

When set to GOOSE, TxGOOSE1 messages are published in IEC 61850 8 1:2011 GOOSE format. When set to R-GOOSE, TxGOOSE1 messages are published in Routable GOOSE format according to IEC 61850 90-5. When set to R-GOOSE, the **R-RxGOOSE DST IP** needs to be a valid multicast or unicast IP address.

RxGOOSE1 goID

Range: 0 to 129 Visible String characters
 Default: empty string

If the entered value has one or more characters, the goID field of incoming GOOSE messages must exactly match this value for the message to be accepted as a valid RxGOOSE1 message. If the entered value is the empty string, RxGOOSE1 does not check the value received in the goID field.

If the publisher is a UR 7.3x series device, this setting needs match the value of the publisher's **TxGOOSE GoID** setting.

RxGOOSE1 Dst MAC

Range: any 12 digit hexadecimal number
 Default: 01-0C-CD-01-00-00

When the **RxGOOSE1 MODE** setting is R-GOOSE, the value of this setting is not used, the destination Media Access Control (MAC) address for RxGOOSE1 messages is calculated based on the **RxGOOSE DST IP** address. Otherwise, set this setting to the MAC address of the publisher. Only received GOOSE messages having a MAC address equal to this value are accepted as valid RxGOOSE1 messages. An entered address of zero disables RxGOOSE1.

If the publisher is a UR series 7.3x device, the setting needs to match the value of the publisher's **TxGOOSE DST MAC** setting.

RxGOOSE1 ETYPE APPID

Range: 0 to 65535 in steps of 1

Default: 0

If the value entered is non-zero, the APPID field of incoming GOOSE messages must exactly match this value for the message to be accepted as a valid RxGOOSE1 message. If the value entered is zero, RxGOOSE1 does not check the value received in the APPID field.

If the publisher is a UR series 7.3x device, the setting needs to match the value of the publisher's **TxGOOSE ETYPE APPID** setting.

RxGOOSE1 GoCBRef

Range: 0 to 129 alphanumeric, underscore, slash and period characters, beginning with an alpha character

Default: empty string

The gocbRef field of incoming GOOSE messages must match this value for the message to be accepted as a valid RxGOOSE1 message. If the entered value is the empty string, RxGOOSE1 is disabled. If not the empty string, the entry needs to be an ACSI ObjectReference to the publishing control block in the format:

<LDName>/LLN0.<GoCBName>

where <LDName> is the function-related name if the logical device containing the publishing control block has "ldName" configured, otherwise the product-related name of that logical device, and <GoCBName> is the name of the publishing control block.

The L30 translates the ACSI format required for this setting to the MMS format used in GOOSE messages:

<LDName>/LLN0\$GO\$<GoCBName>

If the publisher is a UR 7.3x or 7.40 series device, <LDName> is the value of the publisher's Master functional ldName setting if that setting is not empty, otherwise it is the value of the publisher's IED NAME suffixed with "Master". If the publisher is a UR 7.3x series device, <GoCBName> is "GoCB" suffixed with the two digit TxGOOSE instance number, for example "GoCB01". If the publisher is a UR 7.40 series device, <GoCBName> is as specified earlier in the TxGOOSE section of this chapter.

RxGOOSE1 datSet

Range: 0 to 32 alphanumeric and underscore characters, beginning with an alpha character

Default: empty string

If the entered value has one or more characters, the datSet field of incoming GOOSE messages must exactly match this value prefixed by <LDName>/LLN0\$ for the message to be accepted as a valid RxGOOSE1 message. <LDName> is as specified in the RxGOOSE GoCBRef setting above. If the entered value is the empty string, RxGOOSE1 does not check the value received in the datSet field.

If the publisher is a UR 7.3x series device, set this setting to the value of the publisher's DataSetxx name setting, where xx is the instance number of the data set selected by the publisher's **TxGOOSE datSet** setting. If the publisher is a UR 7.40 series device, datSet is as specified in the DataSets section of this chapter.

RxGOOSE1 ConfRev

Range: 0 to 4294967295 in steps of 1

Default: 1

If the value entered is non-zero, the confRev field of incoming GOOSE messages must exactly match this value for the message to be accepted as a valid RxGOOSE1 message. If the entered value is zero, RxGOOSE1 does not check the value received in the confRev field.

If the publisher is a UR 7.3x series device, set this setting to match the value of the publisher's **TxGOOSE ConfRev** setting.

R-RxGOOSE1 RECEPTION MODE

Range: SSM, ASM, Unicast

Default: SSM

When the **RxGOOSE1 MODE** setting is other than R-GOOSE the value of this setting is not used. Otherwise it selects the R-GOOSE reception mode.

R-RxGOOSE RECEPTION MODE specifies the **R-RxGOOSE DST IP** range. When set to SSM, **R-RxGOOSE DST IP** must be in the range of 232.0.0.1 to 232.255.255.255. When set to ASM, **R-RxGOOSE DST IP** must be in the range of 224.0.0.1 to 239.255.255.255, excluding the SSM range. Note that the SSM range is inside the ASM range and therefore the ASM use excludes the SSM range. The default destination IP address 224.0.0.0 is reserved, and hence not a valid multicast IP address.

The reception modes are related to Layer-3 R-GOOSE reception from routers/WAN. The subscription to multicasting of R-GOOSE is supported using IGMP Protocol Independent Multicast (PIM). It is made available in either Source Specific Multicast (SSM) mode or Any Source Multicast (ASM) mode. Unicast (over UDP) mode can also be used. In case of multicasting (IGMPv3 based SSM or ASM), the R-GOOSE subscriber device requests the Last Hop Router (LHR) to subscribe to a specific multicasting group.

If the publisher is using a unicast destination IP address for this R-GOOSE, then set **R-RxGOOSE1 RECEPTION MODE** to Unicast. Otherwise set **R-RxGOOSE1 RECEPTION MODE** to the SSM or ASM mode used by the local routers/firewalls.

R-RxGOOSE1 SRC IP

Range: 0.0.0.0 to 255.255.255 in steps of 1

Default: 127.0.0.1

When the **RxGOOSE1 MODE** setting is other than R-GOOSE, the value of this setting is not used. When the **RxGOOSE1 MODE** setting is R-GOOSE and the **R-RxGOOSE RECEPTION MODE** setting is ASM, the value of this setting is not used. Otherwise the Source IP Address field of incoming R-GOOSE messages must exactly match this value for the message to be accepted as a valid RxGOOSE1 message. Set this setting to the value of the source IP address used by the publisher. For UR publishers, this value is in setting PRT# IP ADDRESS.

The UR does not validate the address entered. The default IP address 127.0.0.1 is a reserved, not a valid IP address. Enter a valid IP source address.

R-RxGOOSE1 DST IP

Range: 0.0.0.0 to 255.255.255 in steps of 1

Default: 224.0.0.0

When the **RxGOOSE1 MODE** setting is other than R-GOOSE, the value of this setting is not used. Otherwise the Destination IP Address field of incoming R GOOSE messages must exactly match this value for the message to be accepted as a valid RxGOOSE1 message. Set this setting to the same value as the R-GOOSE publisher's Destination IP Address. For UR publishers, this value is in setting R-TxGOOSE# DST IP.

The destination IP address needs to be a valid multicast or unicast IP address. The UR does not validate the address entered. The default IP address 224.0.0.0 is reserved, and hence not a valid multicast IP address.

R-RxGOOSE1 SECURITY

Range: None, Signature, SignatureAndEncryption

Default: None

This setting specifies the level of security (authentication/encryption) used for RxGOOSE1. None indicates no security mechanisms are in use. Signature indicates only signature (no encryption) is in use. SignatureAndEncryption indicates that both signature and encryption are in use. Normally this setting is set to match the GOOSE publisher's security method.

RxGOOSE1 Member 1

Range: End of List, BOOLEAN, FLOAT32, INT32, Dbpos (DPS), Quality, TimeStamp, Struct

Default: End of List

This setting specifies the type that the first member of incoming GOOSE messages must be for the message to be accepted as a valid RxGOOSE1 message. There are similar settings for each of the up to 64 members that the UR is able to subscribe to in a given GOOSE message. The member before the first member setting set to "End of List" must be the last member of the message for the message to be accepted as a valid RxGOOSE1 message.

If the publisher is a UR 7.3x or 7.40 series device, set these settings to match the basic type of the members of the publisher's data set selected by the publisher's **TxGOOSE dataSet** setting.

If the publisher dataset includes members with structured data, that is, data attributes, sub-data objects, and/or data attributes with sub-data attributes, configuration must use one of the new 7.40 UR Setup RxGOOSE Inputs pages. In this case the Member setting displays as the product-related name used by the publishing IED of the data object or data attribute, in standard SCSM format (e.g. Publisher1LD1/LLN0\$ST\$Off\$stVal).

Note that a dataset can hold at most 64 basic data attribute values, and that a single structured data object or attribute can contain multiple basic data attribute values. UR Setup software does not allow more than 64 basic data attribute values to be entered, in which case the last several members settings cannot be changed from End of List.

Note that the publisher's name alone does not contain all the information required for subscription, additional publisher information model information is stored elsewhere. For this reason, manual entry of the name is not supported.

RxGOOSE inputs

The values received by RxGOOSE elements need to be converted to FlexLogic or FlexAnalog operands so that they can be used by other UR elements. This conversion is done by RxGOOSE Boolean, RxGOOSE DPS, and RxGOOSE Analog elements. Each RxGOOSE Boolean can convert the value of a specified Boolean value received by a specified RxGOOSE to a FlexLogic operand. Each RxGOOSE DPS can convert the value of a specified Dbpos (Double bit position) value to four FlexLogic operands, one for each of the four possible Dbpos states. Each RxGOOSE Analog can convert the value of a specified FLOAT32 member to a FlexAnalog operand. Each of these operands reverts to its default state when the RxGOOSE connectivity is lost. Other types of values can be present in subscribed GOOSE messages, but cannot be converted to operands. An RxGOOSE Input that is mapped to a value that in the GOOSE message is a child of a data object reverts to its configured default value while the Quality value in that data object is invalid, and also while the Quality value is test and this relay's **TEST MODE FUNCTION** setting is other than Forcible or Isolated.

RxGOOSE Boolean, RxGOOSE DPS, and RxGOOSE Analog elements are mapped to various data objects in <iedName>Master/GGIO3. This is to allow reading of their values via MMS and to allow references to them in SCL files. GGIO3 has no settings, nor is it visible in the UR Setup software. See the UR Family Communications Guide for more information on GGIO3.

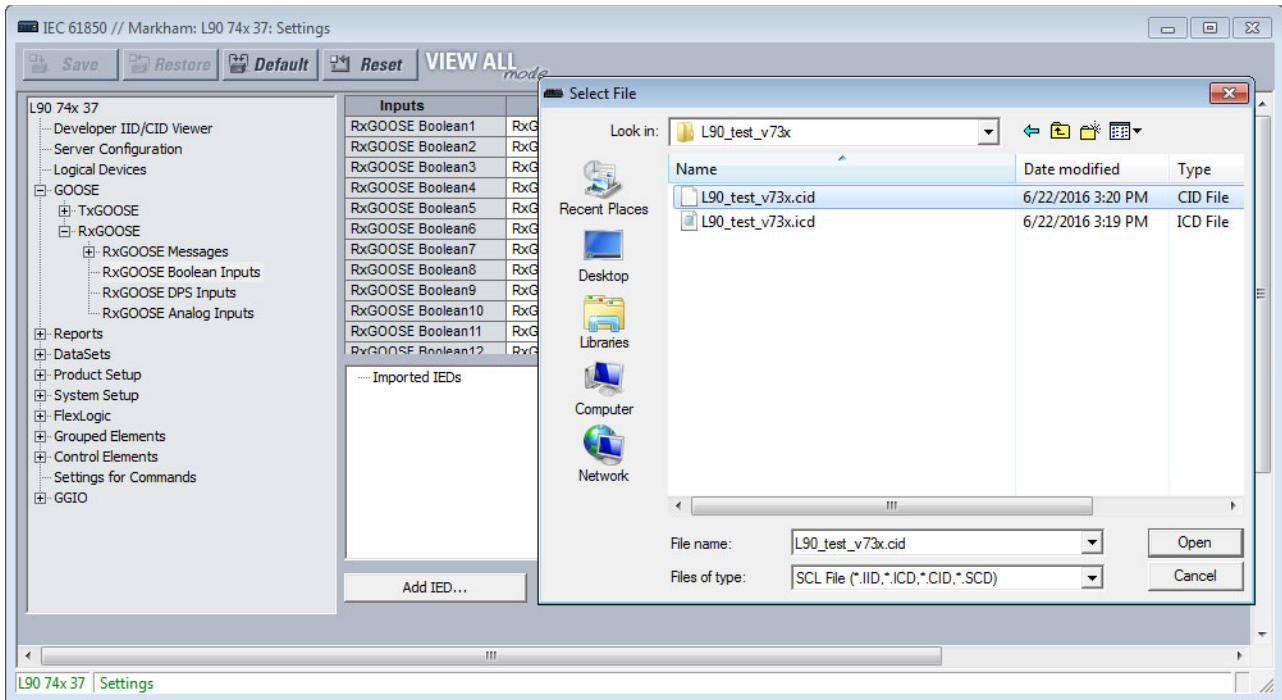
RxGOOSE Boolean inputs

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > RxGOOSE > RxGOOSE Boolean Inputs**.

The number of RxGOOSE Boolean (remote inputs) is 256.

There are **Add IED** and **Remove IED** buttons. The **Add IED** button allows SCL files to be used, including ICD, CID, and SCD (supported in version 7.40 and later). When the file format is SCD, the system lists all IEDs inside the SCD file and lets the user select the ones to add. The figure shows a selection being made by importing a CID file using the **Add IED** function.

Figure 5-29: RxGOOSE Boolean panel



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Most of the settings are configured by drag-and-drop. However the ID, DEFAULT STATE, and EVENTS settings must be individually entered when the factory default values are not acceptable.

RxGOOSE Boolean1 ID

Range: 0 to 20 characters

Default: RxG Bool1

This setting allows the user to assign descriptive text to the name of the RxGOOSE Boolean1 FlexLogic operand. The full operand name is the value of this setting appended with " On". The standard and enhanced front panels display the first 17 characters of this setting plus " On" to fit the 20 character display.

RxGOOSE Boolean1 RxGOOSE

Range: None, RxGOOSE1, RxGOOSE2, and so on

Default: None

This setting selects the RxGOOSE containing the value that drives the RxGOOSE Boolean1 FlexLogic operand. If set to None, the RxGOOSE Boolean1 FlexLogic operand assumes its default state.

RxGOOSE Boolean1 Member

Range: 1 to 64 in steps of 1

Default: 1

This setting selects the GOOSE message member that drives the RxGOOSE Boolean1 FlexLogic operand. A setting of 1 selects the first member, 2 selects the second member, and so on. Entering a number greater than the number of members in the message and entering the number of a member which does not contain a BOOLEAN results in the RxGOOSE Boolean1 FlexLogic operand assuming its default state. The Subscribed to column identifies the particular Boolean subscribed to even if the member is a structure containing more than one Boolean.

RxGOOSE Boolean1 DEFAULT STATE

Range: On, Off, Latest/On, Latest/Off

Default: Off

This setting selects the logic state for the RxGOOSE Boolean1 FlexLogic operand if the UR has just completed startup and the selected RxGOOSE has not yet received a message, or the selected RxGOOSE has lost its connectivity with the publisher. The following choices are available:

- "On" value defaults the input to logic 1
- "Off" value defaults the input to logic 0
- "Latest/On" freezes the input in case of lost connectivity. If the latest state is unknown, such as after UR power-up but before the first communication, the input defaults to logic 1. When communication resumes, the input becomes fully operational.
- "Latest/Off" freezes the input in case of lost connectivity. If the latest state is unknown, such as after UR power-up but before the first communication, the input defaults to logic 0. When communication resumes, the input becomes fully operational.

RxGOOSE Boolean1 EVENTS

Range: Disabled, Enabled

Default: Disabled

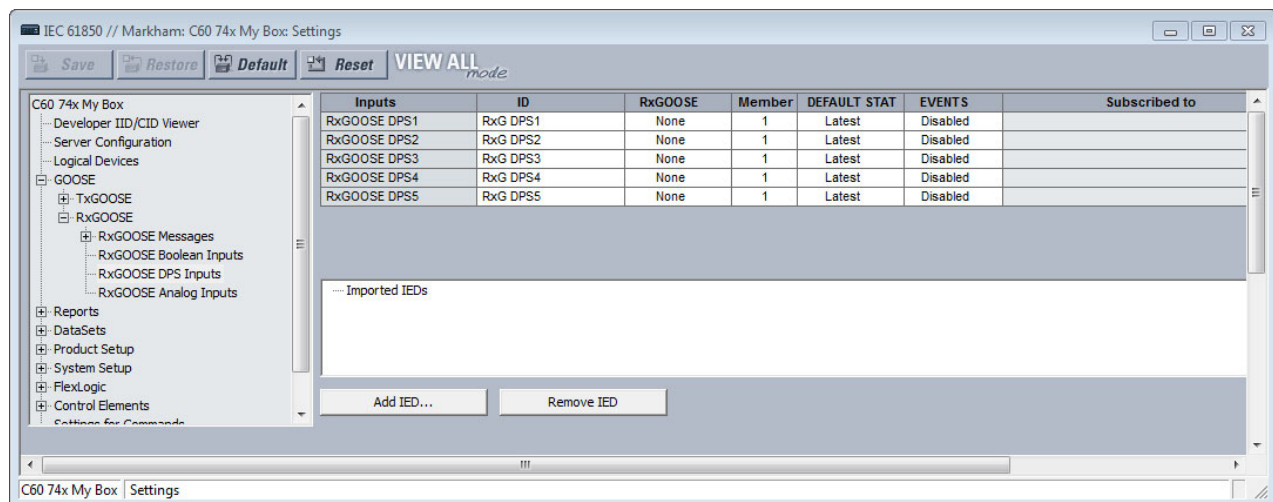
This setting selects whether Off to On transitions of the RxGOOSE Boolean1 FlexLogic operand are recorded by the event recorder. If set to Enabled, Off to On transitions are recorded. On to Off transitions are never recorded, even if events are enabled.

RxGOOSE DPS inputs

Navigate to **Settings > Product Setup > Communications > IEC 618560 > GOOSE > RxGOOSE > RxGOOSE DPS Inputs**.

There are **Add IED** and **Remove IED** buttons. The **Add IED** button allows SCL files to be used, including ICD, CID, and SCD (supported in version 7.40 and later). When the file format is SCD, the system lists all IEDs inside the SCD file and lets the user select the ones to add.

Figure 5-30: RxGOOSE DPS Inputs panel



RxGOOSE DPS1 ID

Range: 0 to 20 characters

Default: RxG DPS1

This setting allows the user to assign descriptive text to the names of the four RxGOOSE DPS1 FlexLogic operands. The full operand name is the value of this setting appended with "Interm," "On," "Off," or "Bad." The standard and enhanced front panels display the first 13 characters of this setting plus the state suffix to fit the 20 character display.

RxGOOSE DPS1 RxGOOSE

Range: None, RxGOOSE1, RxGOOSE2, and so on

Default: None

This setting selects the GOOSE message containing the value that drives the RxGOOSE DPS1 FlexLogic operand. If set to None, the RxGOOSE DPS1 FlexLogic operand assumes its default state.

RxGOOSE DPS1 Member

Range: 1 to 64 in steps of 1
 Default: 1

This setting selects the GOOSE message member that drives the RxGOOSE DPS1 FlexLogic operand. A setting of 1 selects the first member, 2 selects the second member, and so on. Entering a number greater than the number of members in the message and entering the number of a member that is not a Dbpos results in the RxGOOSE DPS1 FlexLogic operand assuming its default state. In the case that the member is a structure containing more than one Dbpos, the Subscribed to column identifies the particular Dbpos subscribed to.

RxGOOSE DSP1 DEFAULT STATE

Range: Intermediate-state, Off, On, Bad-state, Latest
 Default: Latest

This setting selects the logic state for the data attribute @Master/GGIO3.IndPos01.stVal and the DPS FlexLogic operands when the UR has just completed start-up and the selected RxGOOSE has not yet received a message, and when the RxGOOSE has lost its connection with the publisher. When this setting is selected to Latest, the value of @Master/GGIO3.IndPosψψ.stVal is Intermediate-state when the UR has just completed start-up and the selected RxGOOSE has not yet received a message, and the latest received value when the RxGOOSE loses its connectivity with the publisher.

RxGOOSE DPS1 EVENTS

Range: Disabled, Enabled
 Default: Disabled

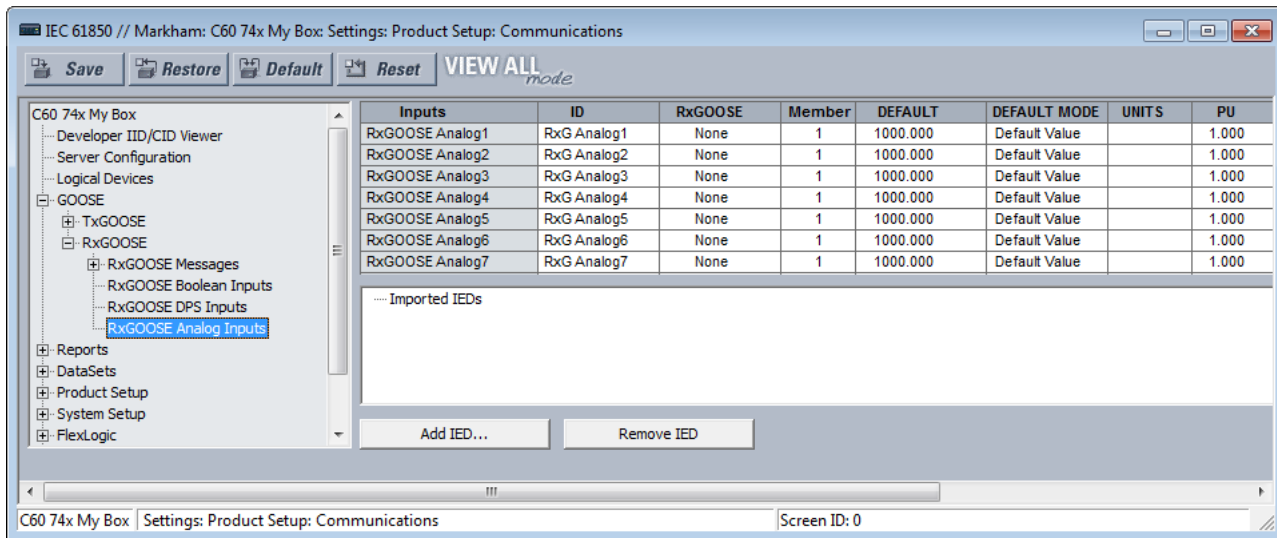
This setting selects whether Off to On transitions of the RxGOOSE DPS1 FlexLogic operands are recorded by the event recorder. If set to Enabled, Off to On transitions are recorded. On to Off transitions are never recorded, even if events are enabled.



RxGOOSE analog inputs

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > RxGOOSE > RxGOOSE Analog Inputs**. There are **Add IED** and **Remove IED** buttons. The **Add IED** button allows SCL files to be used, including ICD, CID, and SCD (supported in version 7.40 and later). When the file format is SCD, the system lists all IEDs inside the SCD file and lets the user select the ones to add.

Figure 5-31: RxGOOSE Analog Inputs panel



There are 32 RxGOOSE analog inputs.

RxGOOSE Analog1 ID*Range: 0 to 20 characters**Default: RxG Analog1*

This setting allows the user to assign descriptive text to RxGOOSE Analog1. Unlike RxGOOSE Booleans and RxGOOSE DPS, the RxGOOSE Analog operands have fixed names, for example RxGOOSE Analog1.

RxGOOSE Analog1 RxGOOSE*Range: None, RxGOOSE1, RxGOOSE2, and so on**Default: None*

This setting selects the GOOSE message that drives the RxGOOSE Analog1 FlexAnalog operand. If set to None, the RxGOOSE Analog1 FlexAnalog operand assumes its default state.

RxGOOSE Analog1 Member*Range: 1 to 64 in steps of 1**Default: 1*

This setting selects the GOOSE message member that drives the RxGOOSE Analog1 FlexAnalog operand. A setting of 1 selects the first member, 2 selects the second member, and so on. Entering a number greater than the number of members in the message and entering the number of a member that does not contain a FLOAT32 results in the RxGOOSE Analog1 FlexAnalog operand assuming its default state. The Subscribed to column identifies the particular FLOAT32 subscribed to even if the member is a structure containing more than one FLOAT32.

RxGOOSE Analog1 DEFAULT*Range: -1000000.000 to 1000000.000 in steps of 0.001**Default: 1000.000*

This setting specifies the value of the GOOSE analog input when the selected RxGOOSE has lost its connectivity with the publisher and the RxGOOSE Analog1 DEFAULT MODE is set to "Default Value." Otherwise this setting has no effect. This setting is stored as an IEEE 754 / IEC 60559 floating point number. Because of the large range of this setting, not all possible values can be stored. Some values can be rounded to the closest possible floating point number.

RxGOOSE Analog1 DEFAULT MODE*Range: Default Value, Last Known**Default: Default Value*

When the selected RxGOOSE has lost its connectivity with the publisher and this setting is "Last Known," the value of the RxGOOSE Analog1 FlexLogic operand remains at the last received value. When the selected RxGOOSE has lost its connectivity with the publisher and this setting value is "Default Value," then the RxGOOSE Analog1 FlexLogic operand is defined by the RxGOOSE Analog1 DEFAULT setting. After restart, until a message is received, the operand value is the default value.

RxGOOSE Analog1 UNITS*Range: up to 4 characters**Default: empty string*

This setting specifies a four-character string that is used in the actual values display of RxGOOSE Analog1.

RxGOOSE Analogs are floating-point values, with no units. The RxGOOSE UNIT and PU base settings allow the user to configure RxGOOSE Analog, so that it can be used in a FlexElement.

RxGOOSE Analogs that represent current, voltage, power, frequency, angles, or power factor can be used in a FlexElement. The following text must be used in the UNITS setting, to represent these types of analogs: A, V, W, var, VA, Hz, deg, and no text (blank setting) for power factor.

RxGOOSE Analogs can be compared to other RxGOOSE Analogs with any character string or no string.

RxGOOSE Analog1 PU Base in kilo*Range: 0.000 to 1000000000.000 in steps of 0.001**Default: 1.000*

This setting specifies the per-unit base value for other L30 features to use with the RxGOOSE Analog1 operand. A FlexElement for instance subtracts two quantities after converting their values to integers rescaled to a common base, the common base being the largest of the base values of the two quantities. If one of quantities is RxGOOSE Analog1 and its per-unit base value is not appropriate, the rescaling operation can result in unnecessary loss of precision or overflow

in the integer result. The FlexElement Base Units table in the Settings > FlexLogic > FlexElements section later, which tabulates the per-unit base value used by its pickup setting and implies the per-unit base used by other FlexAnalog, can be of use in selecting a value for the **RxGOOSE Analog1 PU** setting.

Some UR elements have requirements for the type of input operands, for instance current type or voltage type. These elements assume that RxGOOSE Analog operands are of whatever type is necessary to meet these requirements.

The per-unit base setting represents thousands, not single units. For example, a PU base of 1.000 is actually 1000 and a PU base of 0.001 is 1.

When using RxGOOSE Analogs and PU base in FlexElements, the largest value that can be displayed in the FlexElement actual values is 2,140,000.000.

Reports

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Reports**.

Report settings

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Reports > Report Settings**.

ReportSettings rptID

Range: Dyn, Conf

Default: Dyn

When set to Dyn, the RptID attribute in any buffered and unbuffered report control block can be modified by an MMS client while the control block's RptEna attribute is false. The RptID is the name of the report.

ReportSettings optFields

Range: Dyn, Conf

Default: Dyn

When set to Dyn, the OptFlds attribute in any buffered and unbuffered report control block can be modified by an MMS client while the control block's RptEna attribute is false.

ReportSettings bufTime

Range: Dyn, Conf

Default: Dyn

When set to Dyn, the BufTm attribute in any buffered and unbuffered report control block can be modified by an MMS client while the control block's RptEna attribute is false.

ReportSettings trgOps

Range: Dyn, Conf

Default: Dyn

When set to Dyn, the TrgOps attribute in any buffered and unbuffered report control block can be modified by an MMS client while the control block's RptEna attribute is false.

ReportSettings intgPd

Range: Dyn, Conf

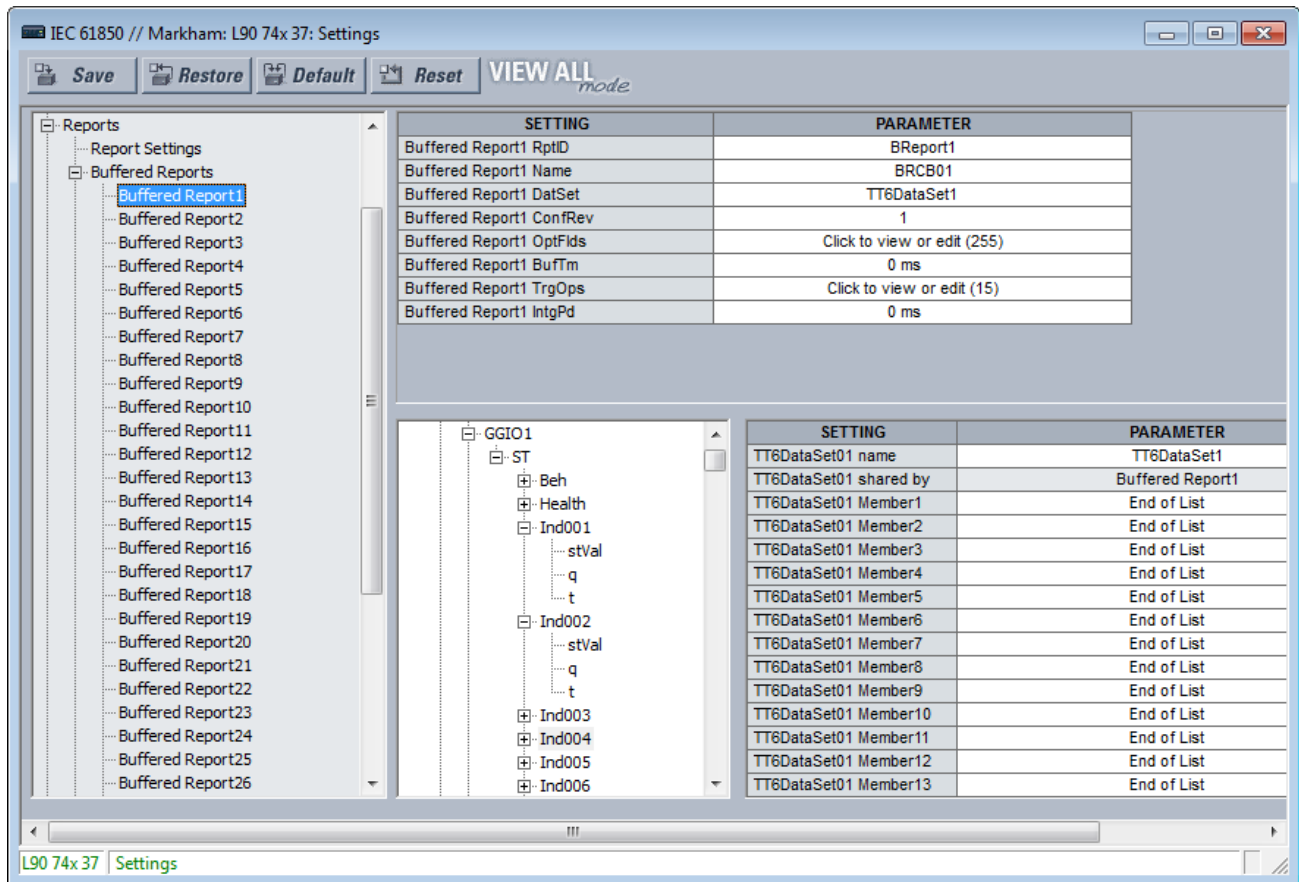
Default: Dyn

When set to Dyn, the IntgPd attribute in any buffered and unbuffered report control block can be modified by an MMS client while the control block's RptEna attribute is false.

Buffered and unbuffered reports

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Reports > Buffered Reports** or **Unbuffered Reports**.

Figure 5-32: IEC 61850 buffered report panel



An IEC 61850 Report server is an efficient method to deliver generic substation event information from a single server to a single client, such as a supervisory control IED. A Configurable Report is a UR element implementing an IEC 61850 Report server, either of the buffered or unbuffered kind. The following table lists the number of Configurable Report elements. Each Configurable Report element can report the values of up to 64 FlexLogic or FlexAnalog operands. Buffered report elements queue value changes that occur while the client is offline and delivered when the client re-connects. Up to 512 events can be queued. Unbuffered control blocks purge all value change events when the connection to the client is lost; any events that occur while the client is not connected are lost.

Table 5-11: Number of report elements

	Number
Buffered reports	30
Unbuffered reports	18

Configurable Reports interoperate with any client device of any manufacturer that conforms to the IEC 61850 edition 1.0 or 2.0 report client requirements.

The entities whose values are reported by a Configurable Report are known as members. The members are itemized in an ordered list known as a data set. Each Configurable Report can use any one of the data sets provided that no more than four data sets are used for reports. This restriction is to limit the amount of processing power that can be allocated to reporting.

Each enabled Configurable Report transmits an update to its client whenever a value change is detected in one or more of its members. Also, the control block can be configured to send integrity reports containing the present value of all members either on demand from the client or periodically. A TCP handshaking mechanism causes messages that are not read and acknowledged by the client to be retransmitted.

For a Configurable Report to operate, its members must be selected (that is, its data set configured) and a client must open a connection to, configure, and enable its report control block. Control blocks and data sets can be pre-configured by sending the L30 a CID file. See the UR Family Communications Guide for details. EnerVista UR Setup also can be used to select the data set members and to pre-configure the control blocks.

Each buffered report has the following settings.

Buffered Report1 RptID

Range: 0 to 129 VisibleString characters

Default: empty string

The name of the report. The entered value sets the RptID value in Buffered Report1 messages, and it can be used by the client to discriminate Buffered Report1 messages from other messages. If the number of characters entered is zero, the value used for RptID in messages is an ObjectReference to the report's control block, that is, "<LDName>/LLN0\$BR\$"BRCB01".

Buffered Report1 Name

Range: 0 to 32 VisibleString characters

Default: BRCB01

The entered value sets the report control block name value for Buffered Report1.

Buffered Report1 DatSet

Range: None, TT6DataSet1, TT6 DataSet2, ..., TT3DataSet01, TT3DataSet02, ...

Default: None

This setting selects the data set whose members' status is reported in Buffered Report1 messages using the UR Setup software designator for the data set. The IEC 61850 name of the data sets are configured in the Datasets panel, as described later.

An ObjectReference to the data set, which consists of the concatenation of the string "<LDName>/LLN0\$" and the data set name, is used in the datSet field of report messages, and it can be used by the client to discriminate Buffered Report1 messages from other messages.

The performance of the report is determined by the performance of the selected dataset. When the selection is TT3DataSet01, TT3DataSet02, ... it is possible that transient events can be missed.

To configure a DataSet, select it at the top of the window from the drop-down list, for example DataSet02 shown in the previous figure. In the lower part of the window, drag and drop configuration items to the right side. For example select the **ST Ind001 stVal** item and drag it to DataSet Member 1. Dataset members configured here affect other Report or TxGOOSE control blocks that use the same DataSet.

Buffered Report1 ConfRev

Range: 0 to 4294967295 in steps of 1

Default: 1

The entered value sets the confRev value in Buffered Report1 messages, and it can be used by clients to discriminate report messages of the expected configuration revision from messages of a different revision. The standard requires that confRev be incremented each time the members or the order of the members is changed, and each time the data set name is changed. The standard states that the value of 0 is reserved.

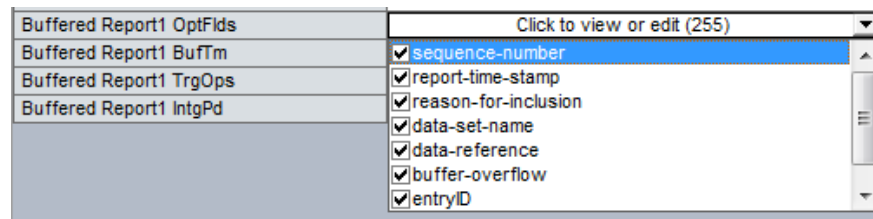
Buffered Report1 OptFlds

Range: The check box for each individual bit can be enabled or not (see figure)

Default: All bits enabled/ true

The OptFlds setting is bitstring that controls which of the optional fields are included in report messages. The figure shows the available option bits. To reduce message size, uncheck any fields that are not needed.

Figure 5-33: Options for buffered report messages

**Buffered Report1 BufTm**

Range: 0 to 4294967295 in steps of 1

Default: 0 ms

The entered value sets the time interval in milliseconds for the buffering of events for inclusion in a single report.

Buffered Report1 TrgOps

Range: The check box for an individual bit can be enabled or not

Default: All bits enabled / true

The TrgOps setting is bitstring that controls which trigger conditions are monitored in this report. The options are as follows. Uncheck any trigger conditions that are not needed.

- data-change
- quality-change
- integrity
- general interrogation

Buffered Report1 IntgPd

Range: 0 to 4294967295 in steps of 1

Default: 0 ms

The entered value sets the period in milliseconds for generating Buffered Report1 integrity reports. An integrity report includes the values of all members of the referenced data set, whether a change has occurred or not.

Each unbuffered report has the following settings.

Unbuffered Report1 RptID

Range: 0 to 129 VisibleString characters

Default: empty string

The name of the report. The entered value sets the RptID value in Unbuffered Report1 messages, and it can be used by the client to discriminate Unbuffered Report1 messages from other messages. If the number of characters entered is zero, the value used for RptID in messages is an ObjectReference to the report's control block, that is, "<LDName>/LLN0\$RP\$"URCB01".

Unbuffered Report1 Name

Range: 0 up to 32 VisibleString characters

Default: URCB01

The entered value sets the report control block name value for Unbuffered Report1.

Unbuffered Report1 DatSet

Range: None, TT6DataSet1, TT6 DataSet2, ..., TT3DataSet01, TT3DataSet02, ...

Default: None

This setting selects the data set whose members' status is reported in Unbuffered Report1 messages using the UR Setup software designator for the data set. The IEC 61850 name of the data sets are configured in the Datasets panel, as described later.

An ObjectReference to the data set, which consists of the concatenation of the string "<LDName>/LLN0\$" and the data set name, is used in the datSet field of report messages, and it can be used by the client to discriminate Unbuffered Report1 messages from other messages.

The performance of the report is determined by the performance of the selected dataset. When the selection is TT3DataSet01, TT3DataSet02, ... it is possible that transient events can be missed.

Unbuffered Report1 ConfRev

Range: 0 to 4294967295 in steps of 1

Default: 1

The entered value sets the confRev value in Unbuffered Report1 messages, and it can be used by clients to discriminate report messages of the expected configuration revision from messages of a different revision. The standard requires that confRev be incremented each time the members or the order of the members is changed, and each time the data set name is changed. The standard states that the value of 0 is reserved.

Unbuffered Report1 OptFlds

Range: The check box for an individual bit can be enabled or not

Default: All bits enabled / true

The OptFlds setting is bitstring that controls which of the optional fields are included in report messages. The options are as follows. To reduce message size, uncheck any fields that are not needed.

- sequence-number
- report-time-stamp
- reason-for-inclusion
- data-set-name
- data-reference
- conf-revision

The OptFlds bits buffer-overflow and entryID also listed are not applicable to unbuffered reports even though the bits exist in the protocol. They are unchecked by default.

Unbuffered Report1 BufTm

Range: 0 to 4294967295 in steps of 1

Default: 0 ms

The entered value sets the time interval in milliseconds for the buffering of events for inclusion into a single report.

Unbuffered Report1 TrgOps

Range: The check box for an individual bit can be enabled or not

Default: All bits enabled / true

The TrgOps setting is bitstring that controls which trigger conditions are monitored in this report. The options are as follows. Uncheck any trigger conditions that are not needed.

- data-change
- quality-change
- integrity
- general interrogation

Unbuffered Report1 IntgPd

Range: 0 to 4294967295 in steps of 1

Default: 0 ms

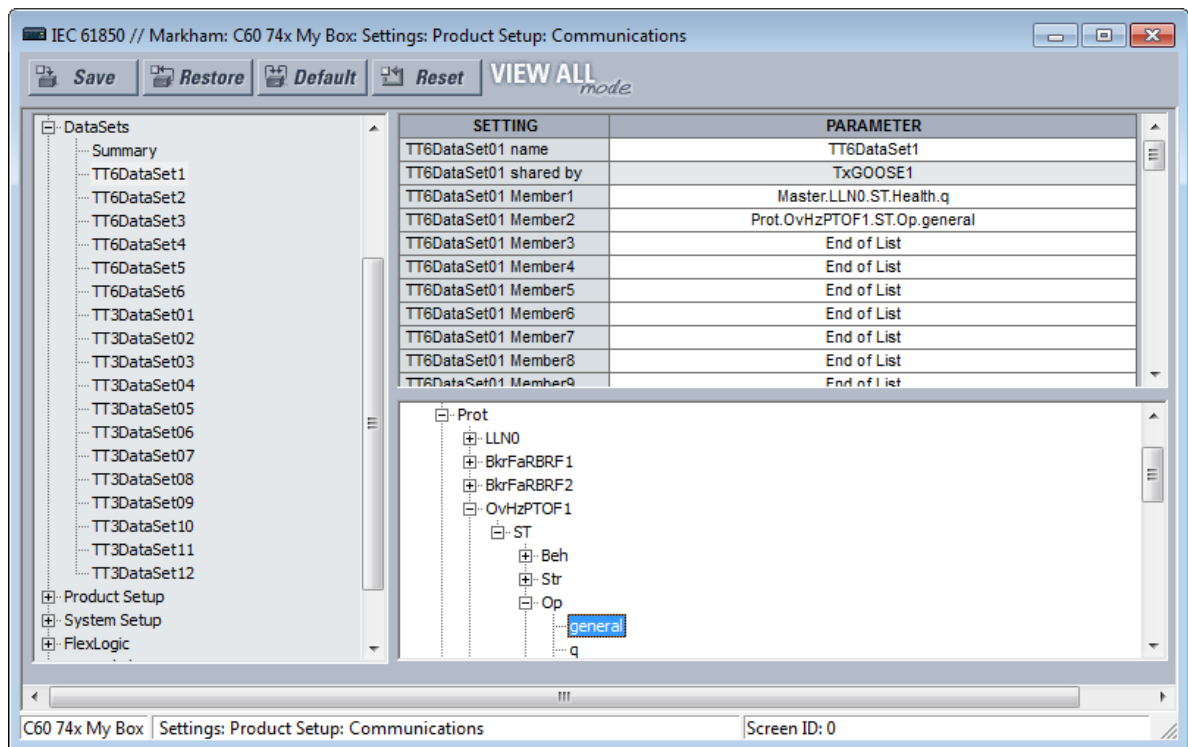
The entered value sets the period in milliseconds for generating Unbuffered Report1 integrity reports. An integrity report includes the values of all members of the referenced data set, whether a change has occurred or not.

DataSets

Navigate to **Settings > Product Setup > Communications > IEC 61850 > DataSets**.

As mentioned in the preceding GOOSE and Reports sections, the members whose values are communicated by these services are itemized in an ordered list known as a data set. Each UR with the IEC 61850 option has 18 data sets (six fast and 12 slow). Each data set can contain as many as 64 members. Any data set can be used simultaneously by any number of TxGOOSE elements and/or by any number of Configurable Report elements. UR Setup software can configure any FlexLogic operands and any FlexAnalog operands as members.

Figure 5-34: IEC 61850 DataSets



UR Setup software requires data set members to be IEC 61850 data objects or data attributes with Functional Constraint ST or MX. Certain FlexLogic and FlexAnalog operands have factory-assigned data attributes as tabulated in the UR Family Communications Guide. All FlexLogic and FlexAnalog operands can be user-assigned to GGIO1 or GGIO4 data attributes, so that operands without factory-assigned data attributes can still have their values published. See the GGIO1 and GGIO4 sections later for details.

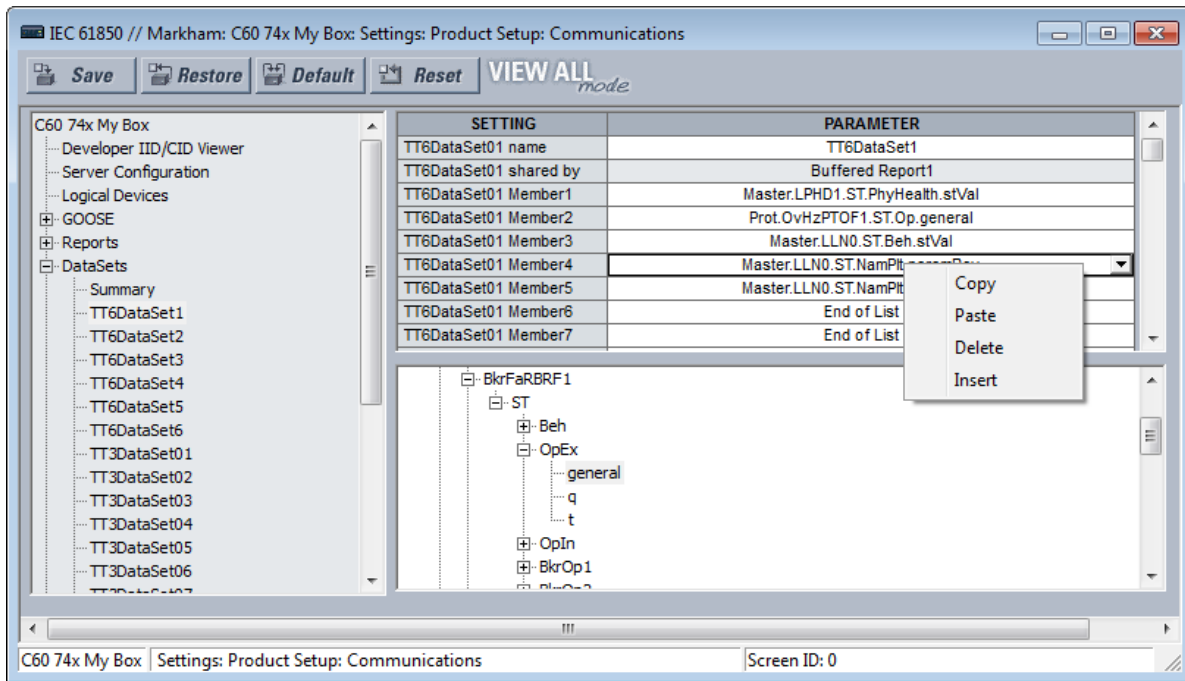
Datasets used by TxGOOSE1, TxGOOSE2, and/or by reports also provide a chatter suppression service for their Boolean members. Oscillation in a value, also known as chatter, can be caused by errors in logic programming, inadequate hysteresis (deadband) on a threshold, or a failed station component. Chatter can flood a communications network with GOOSE messages, degrading response time for all users. If chatter is detected in a Boolean member, TxGOOSE suspends GOOSE event message triggering and report message triggering from that member for as long as the condition exists, and for a minimum period of one second. While sending is suspended, a self-test message identifying the specific data item detected as oscillating is activated.

For a summary of the panels in which the data sets are used, the path is **Settings > Product Setup > Communications > IEC 61850 > DataSets > Summary**.

For the settings, navigate to **Settings > Product Setup > Communications > IEC 61850 > DataSets > TT6DataSet1** for the first data set.

Copy and paste functions are available when right-clicking a DataSet. They allow the target dataset to be configured based on its order code. If some dataset items are not supported, they are not pasted, and a warning message shows a list of dataset items that were not supported and not pasted. The **DataSet name** is not copied or pasted. In short, use this feature to copy a **DataSet Member** setting and paste it into another Member setting, a text file, or Word, as examples.

Figure 5-35: Member right-click



5

DataSet01 name

Range: 0 to 32 VisibleString characters
 Default: DataSet01

The value entered sets the name of the data set, which is required to be unique within the UR for proper operation. The value entered sets the name of the data set, which is required to be unique within the UR for proper operation. Fast datasets start with TT6, and slow datasets start with TT3. Up to six fast datasets are allowed. Up to four fast GOOSE datasets are allowed.

An ObjectReference to the data set consists of a string that is the concatenation of "<LDName>/LLN0\$" and the DataSet01 name setting value. An ObjectReference to the data set is published in the datSet field of TxGOOSE messages, and it can be used by subscribers to discriminate the messages of that TxGOOSE from other GOOSE messages. An ObjectReference to the data set is optionally published in the DatSet field of Report messages. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter.

DataSet01 shared by

Range: 0 to 32 VisibleString characters
 Default:

Names of all control blocks that use this DataSet. Read-only field.

DataSet01 Member1

Range: End of List or any instantiated 61850 data object or data attribute with Functional Constraint ST or MX
 Default: End of List

This setting specifies the first member in TxGOOSE1 messages. There is a similar setting for each of the up to 64 members that the UR allows in a Dataset. Only values of members before the first set to End of List are published. Select the member from the drop-down list. Or right-click an entry to copy, paste, delete, or insert.

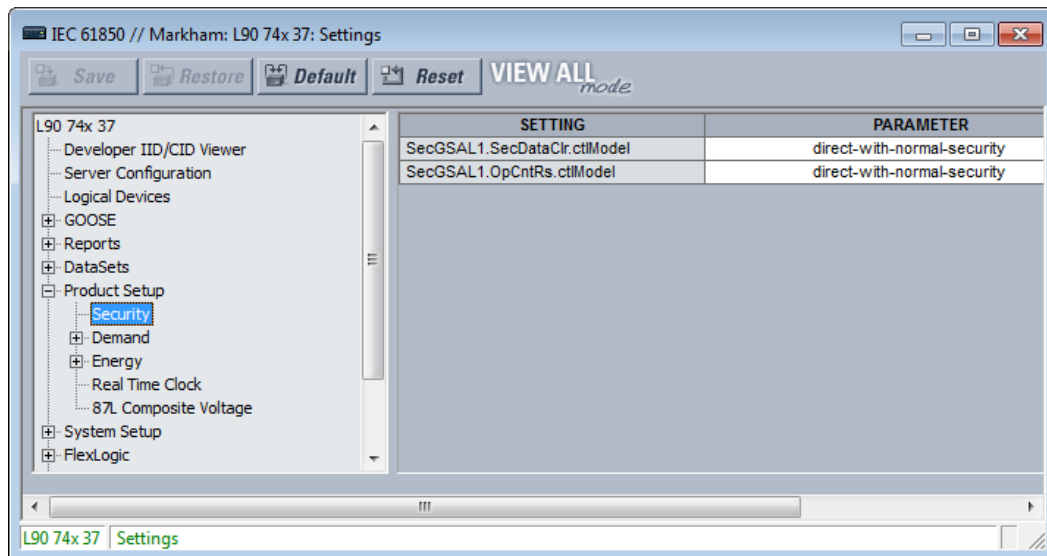
Product setup

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Product Setup.**

Security

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Product Setup > Security**.

Figure 5-36: IEC 61850 Security



SecGSAL1.SecDataClr.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model that clients must use to clear security data via commands to SecGSAL1.SecDataClr. "sbo" here is select-before-operate.

SecGSAL1.OpCntRs.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model that clients must use to clear security data via commands to SecGSAL1.OpCntRs. "sbo" here is select-before-operate.

Demand

Deadband parameters of measured values related to the Demand metering are configured here.

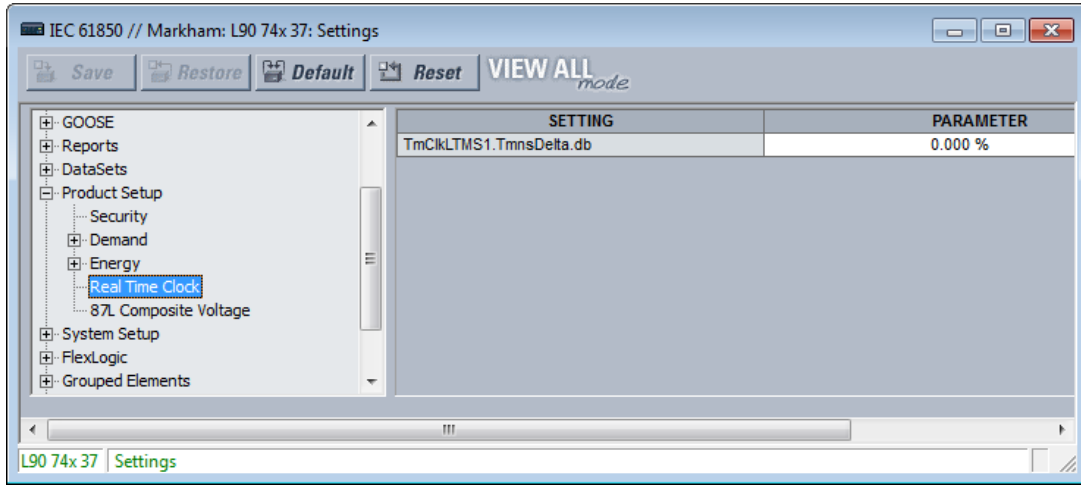
Energy

Deadband parameters of measured values related to the Energy metering are configured here.

Real Time Clock

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Product Setup > Real Time Clock**.

Figure 5-37: IEC 61850 Real Time Clock



TmClkLTMS1.TmnsDelta.db

Range: 0.000 to 100.000 %

Default: 0.000 %

This setting is a deadband setting and is used by the relay to determine when to update the "mag" and "cVal" values from the associated "instMag" and "instCVal" values. The value shall represent the percentage of difference between maximum and minimum in units of 0.001%. The minimum and maximum values for TmnsDelta data object are -500000000 ns and 500000000 ns respectively and for example, a setting value of 0.002% results in the dead banded value of $(500000000 - (-500000000)) * 0.002 / 100 = 20000$ ns. The default setting value of 0.000% does not update the "mag" and "cVal" values.

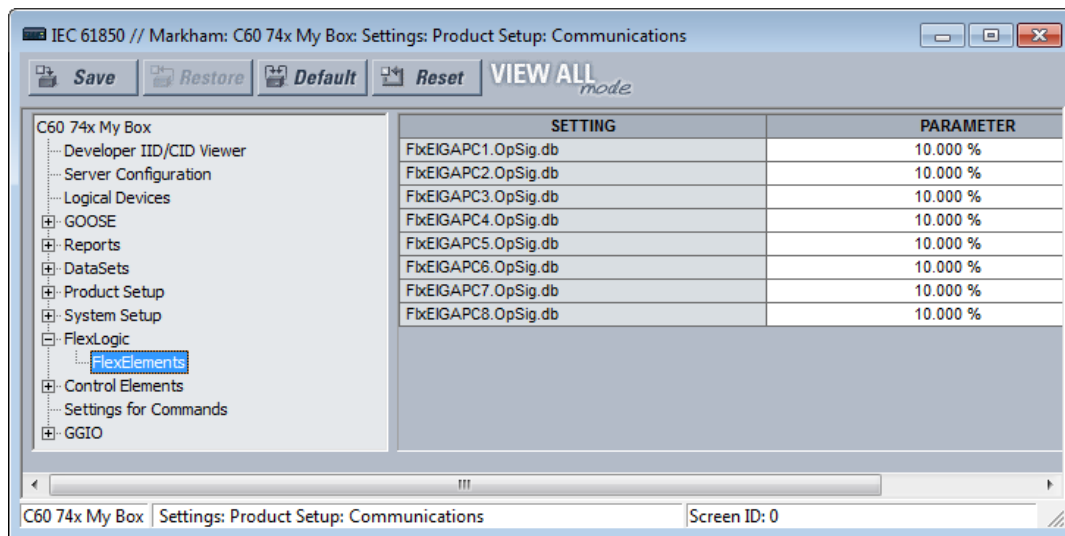
Deadband settings

A deadband is a range in which no action occurs, usually expressed as a percentage.

The IEC 61850 panels contain hundreds of deadband settings, such as in the following panels: Product Setup > Real Time Clock, FlexLogic, Control Elements, and GGIO4. Each panel is not outlined here.

Deadband setting names all end either with "DB" or .db. As they all work the same way, but each on a different analog value, a single description applicable to all deadband settings is given here. The analog value that each deadband setting applies is usually obvious from the name of the setting. However, a tabulation of the analog values and their associated deadband setting can be found in the UR Family Communications Guide.

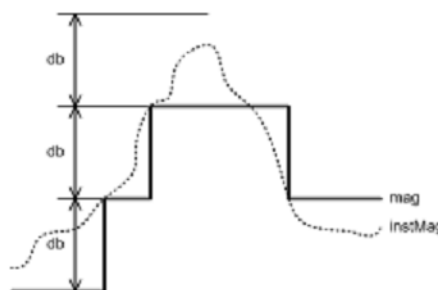
Figure 5-38: Deadband settings with .db suffix



GOOSE, buffered report, and unbuffered report messages are for the most part transmitted only when there is a value change in one or more of their members. Most analog values continuously dither by an amount that is not significant. Were a report to be sent each time an insignificant analog value change occurred, then the communications network floods with GOOSE and report messages, degrading response time for all users.

To control this, a deadband setting is provided for each analog value. Also, in addition to the present actual value of each analog ("instMag" in the following figure), there is a deadbanded value ("mag" in the figure), which is updated with the present value only when the difference between the two exceeds the deadband setting (db in the figure). Changes to this deadbanded value trigger transmissions when included in GOOSE and report data sets.

Figure 5-39: Deadband settings



Deadband settings are entered in UR Setup software in units of percent of the difference between the "max." and "min." of the associated analog value. A zero deadband setting suppresses transmission triggering. The range of deadband settings is 0.000 to 100.000% in steps of 0.001. The default value is 0.000%.

GGIO4 elements have individual settings for "min." and "max." The min. and max. for FlxEIGAPC#.OpSig.db (FLEXELEMENT # OpSig) are -50 pu and +50 pu respectively. The min. value for all other quantities is 0. The max. values are as follows:

- Phase current — 46 x phase CT primary setting
- Neutral current — 46 x ground CT primary setting
- Ground current (sensitive ground CT) — 4.6 x sensitive ground CT primary setting
- Phase, phase-to-phase, and sequence voltage — 275 x phase VT ratio setting
- Auxiliary voltage — 275 x auxiliary VT ration setting
- Power (real, reactive, apparent, 3-phase, and 1-phase) — 4 x phase CT primary setting x 1.5 x VT Secondary setting x VT ratio setting

- Energy (real or imaginary) — $4 \times \text{phase CT primary setting} \times 1.5 \times \text{VT Secondary setting} \times \text{VT ratio setting} \times 1 \text{ hour}$
- Frequency — 90 Hz
- Frequency rate of change — 90 Hz/s
- Power factor — 2
- Angle — 360 degrees

Select the deadband settings from knowledge of the characteristics of the power system quantity measured and knowledge of the demands of the applications receiving the measurement via GOOSE or report such that changes of significance to the application are promptly reported, yet the network is not overly burdened with event messages.

Signal sources

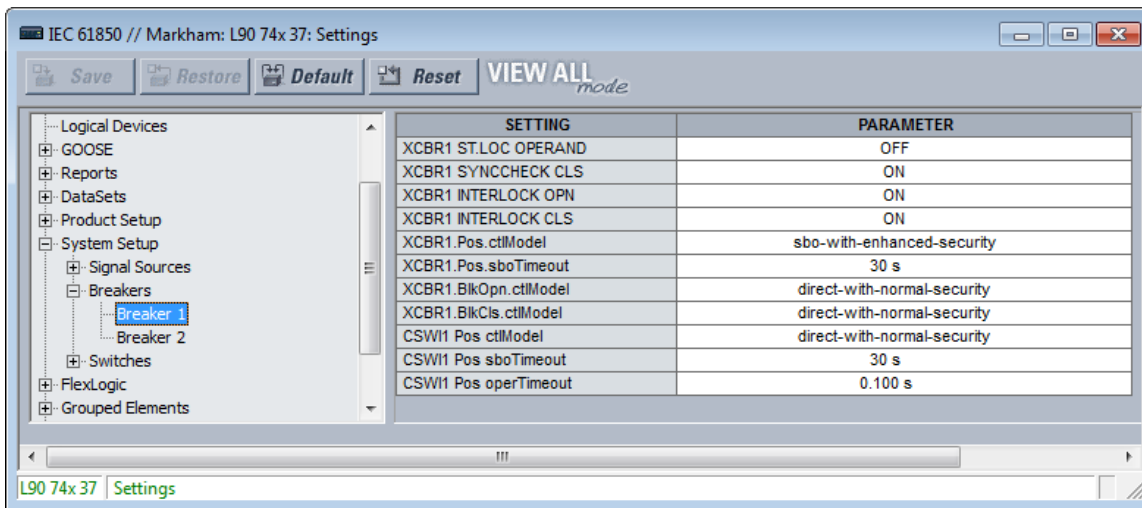
Deadband parameters of measured values related to the signal sources are configured here.

Breakers

The UR breaker control and status monitoring elements have certain settings that configure how the IEC 61850 protocol interacts with these elements. These settings are described in this section. See the Breakers section in the System Setup section of this chapter for details on the operation of breaker control elements.

Navigate to **Settings > Communications > IEC 61850 > System Setup > Breakers > Breaker 1** to access the settings that configure the IEC 61850 protocol interface with the first breaker control and status monitoring element. The settings and functionality for the others are similar.

Figure 5-40: IEC 61850 Breaker panel



XCBR1 ST.LOC OPERAND

Range: any FlexLogic operand

Default: OFF

This setting is used to select a FlexLogic operand that declares to IEC 61850 services that breaker 1 is selected for local control. While the selected operand is asserted, Bkr0XCBR1.Loc.stVal is true and IEC 61850 commands to BkrCSWI1.Pos and Bkr0XCBR1.Pos are not accepted, and a Negative Response (-Rsp) is issued with the REASON CODE of Blocked-by-switching-hierarchy.

XCBR1 SYNCHECK CLS*Range: any FlexLogic operand**Default: ON*

This setting is used to select a FlexLogic operand that declares to IEC 61850 services that synchrocheck conditions are acceptable for closing breaker 1. If a SelectWithValue or Operate service with `ctlVal` true and with `Check.SynchroCheck` true is requested of either `BkrCSWI1.Pos` or `Bkr0XCBR1.Pos` and the selected operand is not asserted, a Negative Response (-Rsp) is issued with the REASON CODE of Blocked-by-synchrocheck.

XCBR1 INTERLOCK OPN*Range: any FlexLogic operand**Default: ON*

This setting is used to select a FlexLogic operand that declares to IEC 61850 services that interlocking conditions are not acceptable for opening breaker 1. While the selected operand is asserted, the value of `BkrCILO.EnaOpn.stVal` is false. If a SelectWithValue or Operate service with `ctlVal` false and with `Check.Interlock-check` true is requested of either `BkrCSWI1.Pos` or `Bkr0XCBR1.Pos`, and the selected operand is not activated, a Negative Response (-Rsp) is issued with the REASON CODE of Blocked-by-interlocking.

XCBR1 INTERLOCK CLS*Range: any FlexLogic operand**Default: ON*

This setting is used to select a FlexLogic operand that declares to IEC 61850 services that interlocking conditions are not acceptable for closing breaker 1. While the selected operand is asserted, the value of `BkrCILO.EnaCls.stVal` is false. If a SelectWithValue or Operate service with `ctlVal` true and with `Check.Interlock-check` true is requested of either `BkrCSWI1.Pos` or `Bkr0XCBR1.Pos` and the selected operand is not activated, a Negative Response (-Rsp) is issued with the REASON CODE of Blocked-by-interlocking.

XCBR1 Pos ctlModel*Range: status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security**Default: sbo-with-enhanced-security*

This setting selects the control model clients must use to successfully control the breaker 1 signals marked `Bkr0XCBR1.PosOpn.ctlVal` and `Bkr0XCBR1.PosCls.ctlVal` on the Breaker Control Logic (Sheet 1 of 2) diagram in the Settings > System Setup section later in this chapter. These signals force a breaker 1 three-phase trip or close control while the operand selected by setting `XCBR1 ST.LOC OPERAND` is not active.

"sbo" here is select-before-operate. Enhanced security means that the UR reports to the client the breaker 1 position at the end of the command sequence.

XCBR1 Pos sboTimeout*Range: 2.000 to 60.000 s in steps of 1 s**Default: 30.000 s*

This setting specifies the maximum time between a select and an operate command to breaker 1 signals marked `Bkr0XCBR1.PosOpn.ctlVal` and `Bkr0XCBR1.PosCls.ctlVal` in order for the operand to be successful. This setting is only relevant when `XCBR1 Pos ctlModel` is `sbo-with-normal-security` or `sbo-with-enhanced-security`.

XCBR1 BlkOpn ctlModel*Range: status-only, direct-with-normal-security, sbo-with-normal-security**Default: direct-with-normal-security*

This setting selects the control model clients must use to successfully control the breaker 1 signal marked `Bkr0XCBR1.BlkOpn.ctlVal` signal on the Breaker Control Logic (Sheet 1 of 2) diagram in the Settings > System Setup section later. This signal when true blocks breaker 1 trip control while the operand selected by setting `XCBR1 ST.LOC OPERAND` is not active.

XCBR1 BlkCls ctlModel

Range: status-only, direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the breaker 1 signal marked BkrOXCBR1.BlkCls.ctlVal signal on the Breaker Control Logic (Sheet 1 of 2) diagram in the Settings > System Setup section later. This signal when true blocks breaker 1 close control while the operand selected by setting XCBR1 ST.LOC OPERAND is not active.

CSWI1 Pos ctlModel

Range: status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the breaker 1 signals marked BkrCSWI1.PosOpn.ctlVal and BkrCSWI1.PosCls.ctlVal on the Breaker Control Logic (Sheet 1 of 2) diagram in the Settings > System Setup section earlier. These signals force a breaker 1 three-phase trip or close control while the operand selected by setting XCBR1 ST.LOC OPERAND is not active.

CSWI1 Pos sboTimeout

Range: 2 to 60 s in steps of 1 s

Default: 30 s

This setting specifies the maximum time between a select and an operate command to breaker 1 via BkrCSWI1.Pos in order for the operand to be successful. This setting is only relevant when CSWI1 Pos ctlModel is sbo-with-normal-security or sbo-with-enhanced-security.

CSWI1 Pos operTimeout

Range: 0.000 to 2.000 s in steps of 0.001s

Default: 0.100 s

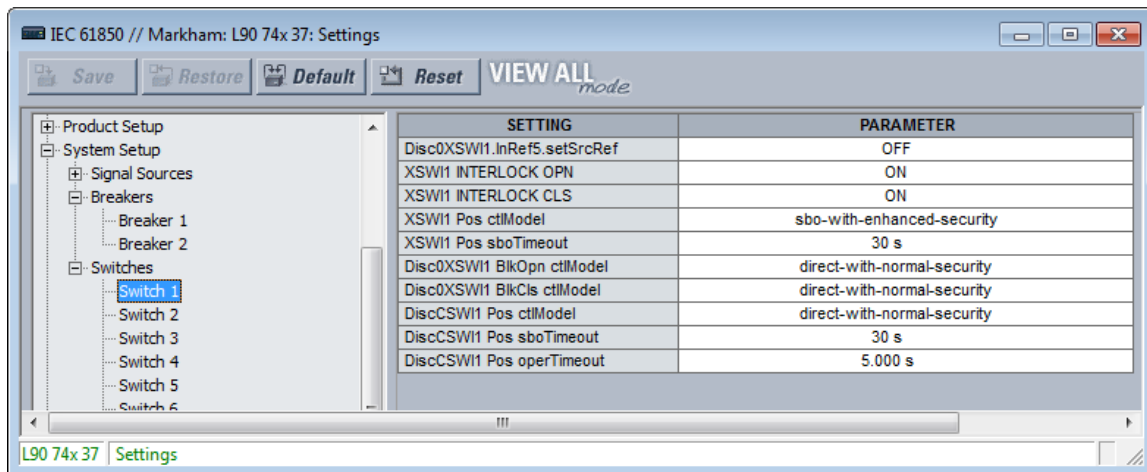
This setting specifies the maximum time between an operate command to breaker 1 via BkrCSWI1.Pos until BkrCSWI1.Pos.stVal enters the commanded state. The command terminates if the commanded state is not reached in the set time.

Switches

The UR disconnect switch control and status monitoring elements have certain settings that configure how the IEC 61850 protocol interacts with these elements. These settings are described in this section. See the Settings > System Setup > Disconnect Switches section later in this chapter for details on the operation of the disconnect switch control elements.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > System Setup > Switches > Switch 1** to access the settings that configure the IEC 61850 protocol interface with the first disconnect switch control and status monitoring element. The settings and functionality for the others are similar.

Figure 5-41: Switch panel



Disc0XSWI1.InRef5.setSrcRef OPERAND

Range: any FlexLogic operand

Default: OFF

This setting is used to select a FlexLogic operand that declares to IEC 61850 services that disconnect switch 1 is selected for local control. While the selected operand is asserted, Disc0XSWI1.Loc.stVal is true and IEC 61850 commands to DiscCSWI1.Pos and Disc0XSWI1.Pos are not accepted, and a Negative Response (-Rsp) is issued with the REASON CODE of Blocked-by-switching-hierarchy.

XSWI1 INTERLOCK OPN

Range: any FlexLogic operand

Default: ON

This setting is used to select a FlexLogic operand that declares to IEC 61850 services that interlocking conditions are not acceptable for opening disconnect switch 1. While the selected operand is asserted, the value of DiscCILO.EnaOpn.stVal is false. If a SelectWithValue or Operate service with ctlVal false and with Check.Interlock-check true is requested of DiscCSWI1.Pos or Disc0XSWI1.Pos and the selected operand is not activated, a Negative Response (-Rsp) is issued with the REASON CODE of Blocked-by-interlocking.

XSWI1 INTERLOCK CLS

Range: any FlexLogic operand

Default: ON

This setting is used to select a FlexLogic operand that declares to IEC 61850 services that interlocking conditions are not acceptable for closing disconnect switch 1. While the selected operand is asserted, the value of DiscCILO.EnaCls.stVal is false. If a SelectWithValue or Operate service with ctlVal true and with Check.Interlock-check true is requested of DiscCSWI1.Pos or Disc0XSWI1.Pos and the selected operand is not activated, a Negative Response (-Rsp) is issued with the REASON CODE of Blocked-by-interlocking.

XSWI1 Pos ctlModel

Range: status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security

Default: sbo-with-enhanced-security

This setting selects the control model that clients must use to successfully control the disconnect switch 1 signals marked Disc0XCBR1.PosOpn.ctlVal and Disc0XCBR1.PosCls.ctlVal on the Disconnect Switch Logic diagram in the Settings > System Setup section later. These signals force a disconnect switch trip or close control while the operand selected by setting XSWI1 ST.LOC OPERAND is not active.

"sbo" here is select-before-operate. Enhanced security means that the L30 reports to the client the disconnect switch 1 position the end of the command sequence.

XSWI1 Pos sboTimeout

Range: 2 to 60 s in steps of 1 s

Default: 30 s

This setting specifies the maximum time between a select and an operate command to disconnect switch 1 signals marked Disc0XCBR1.PosOpn.ctlVal and Disc0XCBR1.PosCls.ctlVal in order for the operand to be successful. This setting is only relevant when XSWI1 Pos ctlModel is sbo-with-normal-security or sbo-with-enhanced-security.

Disc0XSWI1 BlkOpn ctlModel

Range: status-only, direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the disconnect switch 1 signal marked DiscCSWI1.BlkOpn.ctlVal signal on the Disconnect Switch Logic diagram in the Settings > System Setup section later. This signal when true blocks disconnect switch 1 trip control while the operand selected by setting XSWI1 ST.LOC OPERAND is not active.

Disc0XSWI1 BlkCls ctlModel

Range: status-only, direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the disconnect switch 1 signal marked DiscCSWI1.BlkCls.ctlVal signal on the Disconnect Switch Logic diagram in the Settings > System Setup section later. This signal when true blocks disconnect switch 1 close control while the operand selected by setting XSWI1 ST.LOC OPERAND is not active.

Disc0CSWI1 Pos ctlModel

Range: status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the disconnect switch 1 signals marked DiscCSWI1.PosOpn.ctlVal and DiscCSWI1.PosCls.ctlVal on the Disconnect Switch Logic diagram in the Settings > System Setup section later. These signals force a disconnect switch trip or close control while the operand selected by setting XSWI1 ST.LOC OPERAND is not active.

Disc0CSWI1 Pos sboTimeout

Range: 2 to 60 s in steps of 1 s

Default: 30 s

This setting specifies the maximum time between a select and an operate command to disconnect switch 1 via BkrCSWI1.Pos in order for the operand to be successful. This setting is only relevant when CSWI1 Pos ctlModel is sbo-with-normal-security or sbo-with-enhanced-security.

Disc0CSWI1 Pos operTimeout

Range: 0.000 to 65.535 s in steps of 0.001s

Default: 5.000 s

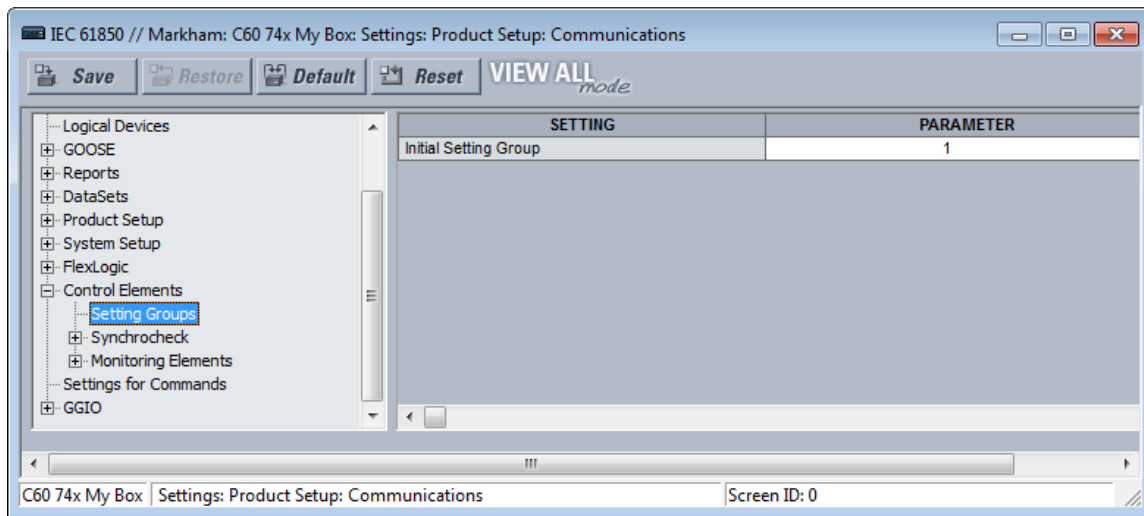
This setting specifies the maximum time between an operate command to disconnect switch 1 via BkrCSWI1.Pos until BkrCSWI1.Pos.stVal enters the commanded state. The command terminates if the commanded state is not reached in the set time.

Setting Groups

The UR implements a setting groups element as detailed in the Control Elements > Setting Groups section of this chapter. The active setting group and the setting group open for edits can be selected via MMS commands SelectActiveSG and SelectEditSG. The setting related to these IEC 61850 commands are described here.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Control Elements > Setting Groups** to access the setting that configures the IEC 61850 setting group commands.

Figure 5-42: Setting Groups panel



Initial Setting Group

Range: 1 to 6 in steps of 1

Default: 1

The entered value sets the initial value of the non-volatile register normally controlled by the service SelectActiveSG. This initialization occurs only on the UR reboot immediately following the receipt of a valid CID file.

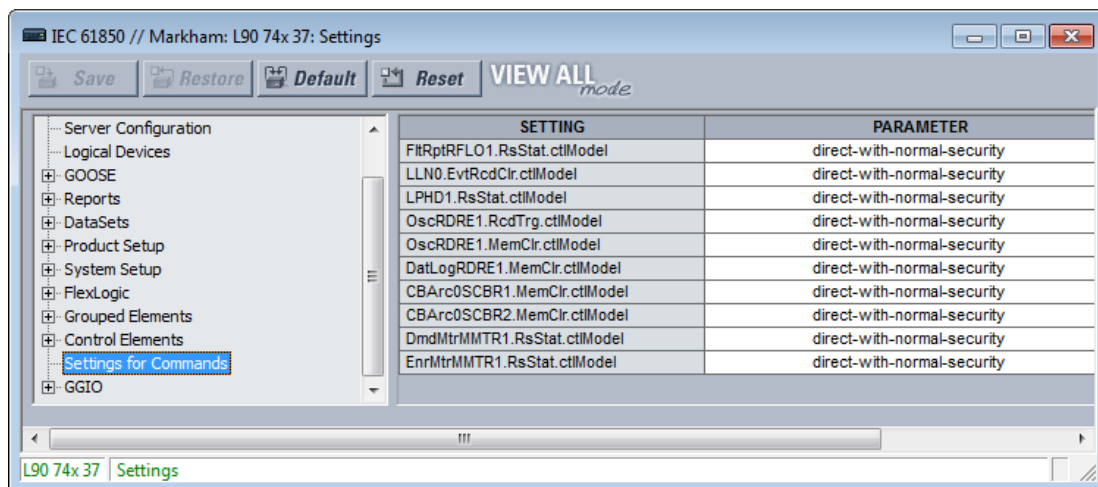
This setting is not mapped into the IEC 61850 information model, but sets the value of SettingControl element attribute actSG in SCL files.

Commands

The UR implements a number of clear records commands as detailed in the Commands and Targets chapter of this manual. Several of these commands also can be issued via IEC 61850. The settings related to these IEC 61850 commands are described here.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Settings for Commands** to access the settings that configure the IEC 61850 protocol interface for record clear commands.

Figure 5-43: Commands panel



FltRptRFLO1.RsStat.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR FAULT REPORTS. "sbo" here is select-before-operate. Enhanced security means that the L30 reports to the client the breaker 1 position at the end of the command sequence.

LLN0.EvtRcdClr.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR EVENT RECORDS.

LPHD1.RsStat.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR ALL RELAY RECORDS.

OscRDRE1.RcdTrg.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command FORCE TRIGGER.

OscRDRE1.MemClr.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR OSCILLOGRAPHY.

DatLogRDRE1.MemClr.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR DATA LOGGER.

CBArc0SCBR1.MemClr.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

DmdMtrMMTR1.RsStat.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

EnrMtrMMTR1.RsStat.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

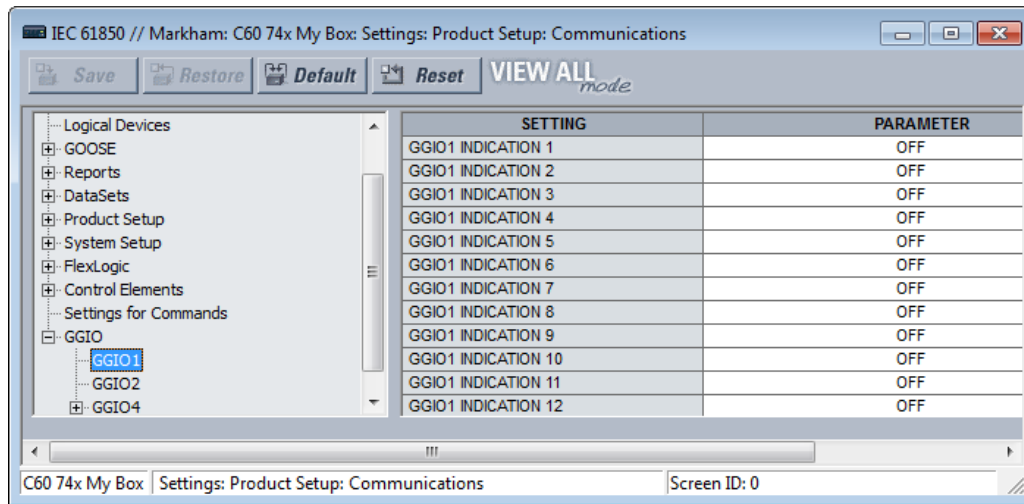
GGIO1

GGIO1 is a UR feature that allows up to 128 UR FlexLogic operands to be user-mapped to IEC 61850 information model data attributes.

For the value of a FlexLogic operand to be read via MMS, included in TxGOOSE messages, or included in buffered/unbuffered reports, the value must be assigned to a data attribute. GGIO1 allows those FlexLogic operands that have not yet been factory-assigned to a data attribute to be user-assigned to a generic data attribute, and thus have their values included in IEC 61850 communications.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GGIO > GGIO1** to access the settings for GGIO1.

Figure 5-44: IEC 61850 GGIO1 panel

**GGIO1 INDICATION 1**

Range: any FlexLogic operand

Default: OFF

This setting selects the FlexLogic operand whose value is mapped into the IEC 61850 data attribute <LDName>/GGIO1.Ind001.stVal. See the FlexLogic section in this chapter for a list of FlexLogic operands.

GGIO1 INDICATION 2

Range: any FlexLogic operand

Default: OFF

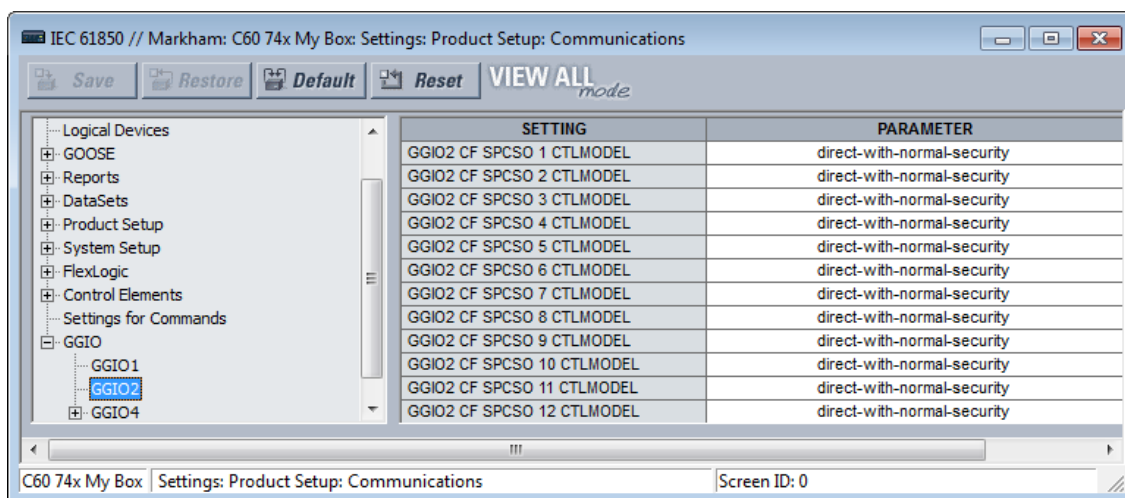
Selects the FlexLogic operand mapped to <LDName>/GGIO1.Ind002.stVal, and so on.

GGIO2

Virtual Inputs are controllable FlexLogic operands that can be controlled via IEC 61850 commands to GGIO2, by DNP, by Modbus, and by the UR front panel. The settings related to these IEC 61850 commands are described here.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GGIO > GGIO2** to access the settings that configure the IEC 61850 protocol interface for Virtual Input commands.

Figure 5-45: GGIO2 panel



GGIO2 CF SPCSO 1 CTLMODEL

Range: status-only, direct-with-normal-security, sbo-with-normal-security
 Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control Virtual Input 1. "sbo" here is select-before-operate.

GGIO2 CF SPCSO 2 CTLMODEL

Range: status-only, direct-with-normal-security, sbo-with-normal-security
 Default: direct-with-normal-security

Selects the control model for Virtual Input 2, and so on.

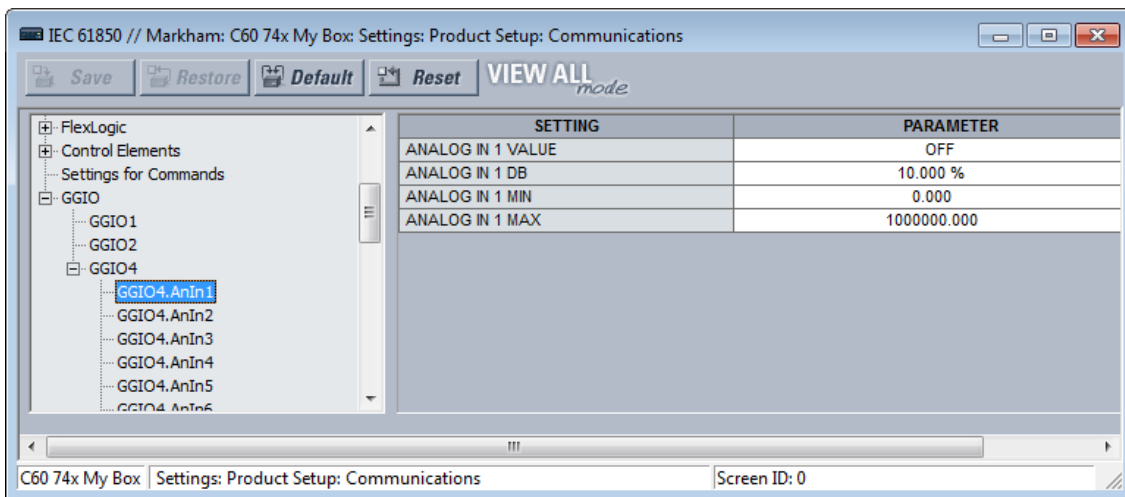
GGIO4

GGIO4 is a UR feature that allows up to 32 UR FlexAnalog operands to be user-mapped to an IEC 61850 information model data attribute.

For the value of a FlexAnalog operand to be read via MMS, included in TxGOOSE messages, or included in buffered/unbuffered reports, the value must be assigned to a data attribute. GGIO4 allows those FlexAnalog operands that have not yet been factory-assigned to a data attribute to be user-assigned to a generic data attribute, and thus have their values included in IEC 61850 communications.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GGIO > GGIO4 > GGIO4.AnIn1** to access the settings for the first GGIO4 value. The settings and functionality for the others are similar.

Figure 5-46: GGIO4 panel



ANALOG IN 1 VALUE

Range: any FlexAnalog operand
 Default: OFF

This setting selects the FlexAnalog operand whose value is mapped into the IEC 61850 data attribute <LDName>/GGIO4.AnIn01.instMag.f. The value of the FlexAnalog operand is converted automatically to the format and scaling required by the standard, that is to say primary amperes, primary volts, and so on. See Appendix A for a list of FlexAnalog operands.

ANALOG IN 1 DB

Range: 0.000 to 100.000% in steps of 0.001

Default: 0.000%

This setting specifies the deadband for the **ANALOG IN 1 VALUE**. The deadband is used to determine when to update the deadbanded magnitude from the instantaneous magnitude. The deadband is a percentage of the difference between the "max." and "min." values. Here, the "max." and "min." are as specified by the settings **ANALOG IN 1 MAX** and **ANALOG IN 1 MIN**.

See the Deadband Settings section earlier for a description of deadbanded values.

ANALOG IN 1 MIN

Range: -1000000000.000 to 1000000000.000 in steps of 0.001

Default: 0.000

This setting specifies the "min." value used in deadband calculations. The scaling of this setting is the same as used by <LDName>/GGIO4.AnIn01.instMag.f. This setting is stored as an IEEE 754 / IEC 60559 floating point number. Because of the large range of this setting, not all possible values can be stored. Some values are rounded to the closest possible floating point number.

ANALOG IN 1 MAX

Range: -1000000000.000 to 1000000000.000 in steps of 0.001

Default: 1000000.000

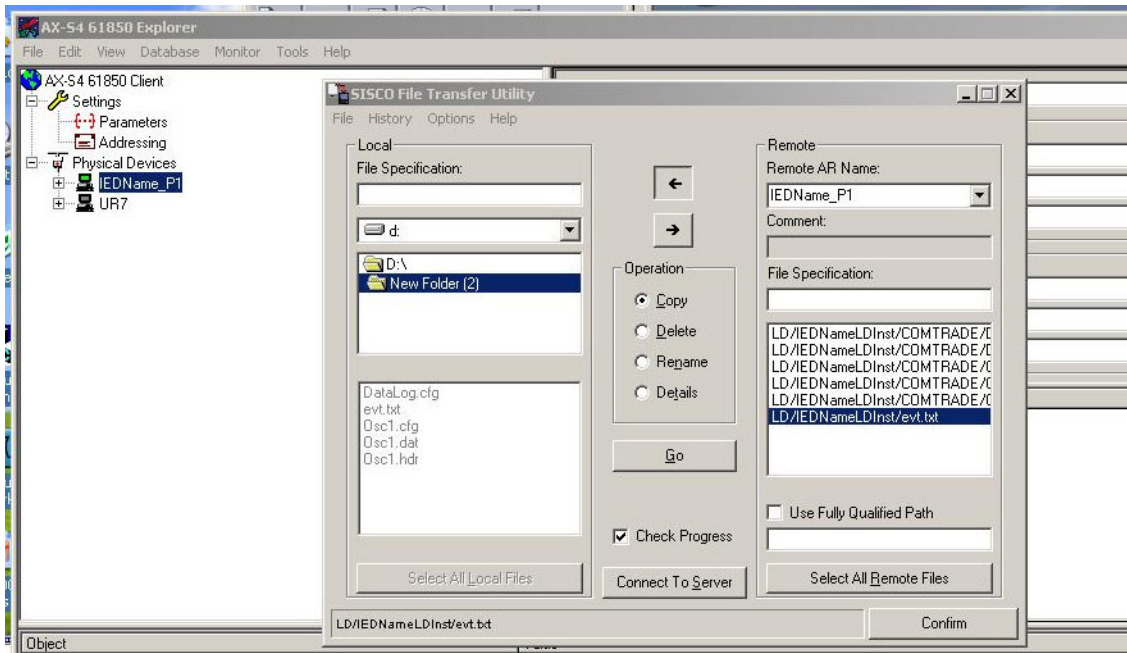
This setting specifies the "max." value used in deadband calculations. The scaling of this setting is the same as used by <LDName>/GGIO4.AnIn01.instMag.f. This setting is stored as an IEEE 754 / IEC 60559 floating point number. Because of the large range of this setting, not all possible values can be stored. Some values are rounded to the closest possible floating point number.

File transfer by IEC 61850

The L30 supports file transfer by IEC 61850. The approach is as follows, using the SISCO AX-S4 61850 client software as an example.

1. In the AX-S4 61850 Explorer window, click the **Tools** menu and access the SISCO File Transfer Utility.
2. Select the **Remote AR Name** from the drop-down list. Available files appear in the **File Specification** area on the right side of the window.
3. With the **Copy** option active, select a file to transfer and click the **Go** button. The file is copied and displays in the **Local** list on the left side of the window.
4. Repeat the process to transfer any other files.

Figure 5-47: File transfer by IEC 61850



5

5.3.5.13 Web server HTTP protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ WEB SERVER HTTP PROTOCOL

<ul style="list-style-type: none"> ■ WEB SERVER ■ HTTP PROTOCOL 	↔	HTTP TCP PORT NUMBER(80): 80	Range: 0 to 65535 in steps of 1
---	---	-------------------------------------	---------------------------------

The L30 contains an embedded web server and can display pages in a web browser. The web pages are organized as a series of menus that can be accessed starting at the L30 “Main Menu.” Web pages are read-only and are available showing DNP and IEC 60870-5-104 points lists, Modbus registers, event records, fault reports, and so on. First connect the L30 and a computer to an Ethernet network, then enter the IP address of the L30 Ethernet port in a web browser.

To close the port, set the port number to 0.

Any change takes effect when the L30 is restarted.

Figure 5-48: Example of UR web page showing event records

Event Number	Time and Date	Event Cause
214	Nov 04 2014 14:02:56.062087	PROTOTYPE FIRMWARE
213	Nov 04 2014 14:02:56.062087	POWER ON
212	Nov 03 2014 14:00:20.364906	POWER OFF
211	Nov 03 2014 13:55:15.061866	PROTOTYPE FIRMWARE
210	Nov 03 2014 13:55:15.061866	POWER ON
209	Nov 03 2014 13:10:59.733179	POWER OFF
208	Nov 03 2014 13:06:11.062104	PROTOTYPE FIRMWARE
207	Nov 03 2014 13:06:11.062104	POWER ON
206	Oct 31 2014 10:07:25.078203	POWER OFF
205	Oct 31 2014 10:00:44.062027	PROTOTYPE FIRMWARE



Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

5.3.5.14 TFTP protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ TFTP PROTOCOL

<input checked="" type="checkbox"/> TFTP PROTOCOL	↔	TFTP MAIN UDP PORT NUMBER(69): 69	Range: 0 to 65535 in steps of 1
<input checked="" type="checkbox"/>	↕	TFTP DATA UDP PORT 1 NUMBER: 0	Range: 0 to 65535 in steps of 1
	↑	TFTP DATA UDP PORT 2 NUMBER: 0	Range: 0 to 65535 in steps of 1

The Trivial File Transfer Protocol (TFTP) can be used to transfer files from the L30 over a network. The L30 operates as a TFTP server. TFTP client software is available from various sources, including Microsoft Windows NT. The dir.txt file obtained from the L30 contains a list and description of all available files, for example event records and oscillography.

The "put" function is not for security reasons. You can enter a "get" command but not a "put" command.

TFTP MAIN UDP PORT NUMBER – To close the port, set the port number to 0. Any change takes effect when the L30 is restarted.



Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

5.3.5.15 IEC 60870-5-104 protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 60870-5-104 PROTOCOL

<input checked="" type="checkbox"/> IEC 60870-5-104 <input checked="" type="checkbox"/> PROTOCOL	↔	IEC TCP PORT NUMBER: 2404	Range: 0 to 65535 in steps of 1
	↕	<input checked="" type="checkbox"/> IEC NETWORK <input checked="" type="checkbox"/> CLIENT ADDRESSES	See below

⇅	IEC COMMON ADDRESS OF ASDU: 0	Range: 0 to 65535 in steps of 1
⇅	IEC CYCLIC DATA PERIOD: 60 s	Range: 1 to 65535 s in steps of 1
⇅	IEC CURRENT DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
⇅	IEC VOLTAGE DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
⇅	IEC POWER DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
⇅	IEC ENERGY DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
⇅	IEC PF DEFAULT THRESHOLD: 1.00	Range: 0.00 to 1.00
⇅	IEC OTHER DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
⇅	IEC REDUNDANCY ENABLED: No	Range: No, Yes

IEC 60870-5-104 is a transmission protocol for network access, specifically for communication between a control station and substation over a TCP/IP network.

5

The L30 supports the IEC 60870-5-104 protocol. This protocol is enabled when the **SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ PROTOCOL** setting is set to IEC 60870-5-104. The L30 can be used as an IEC 60870-5-104 slave device connected to a maximum of two masters (usually either an RTU or a SCADA master station). Since the L30 maintains two sets of IEC 60870-5-104 data change buffers, ideally no more than two masters actively communicate with the L30 at one time.

The **IEC ----- DEFAULT THRESHOLD** settings are used to determine when to trigger spontaneous responses containing M_ME_NC_1 analog data. These settings group the L30 analog data into types: current, voltage, power, energy, and other. Each setting represents the default threshold value for all M_ME_NC_1 analog points of that type. For example, to trigger spontaneous responses from the L30 when any current values change by 15 A, the **IEC CURRENT DEFAULT THRESHOLD** setting is set to 15. Note that these settings are the default values of the deadbands. P_ME_NC_1 (parameter of measured value, short floating point value) points can be used to change threshold values, from the default, for each individual M_ME_NC_1 analog point. Whenever power is removed and re-applied to the L30, the default thresholds are in effect.

The **IEC REDUNDANCY** setting decides whether multiple client connections are accepted or not. If redundancy is set to Yes, two simultaneous connections can be active at any given time.

IEC TCP PORT NUMBER — To close the port, set the port number to 0. Any change takes effect when the L30 is restarted.

IEC COMMON ADDRESS OF ASDU — The change takes effect when the L30 is restarted.

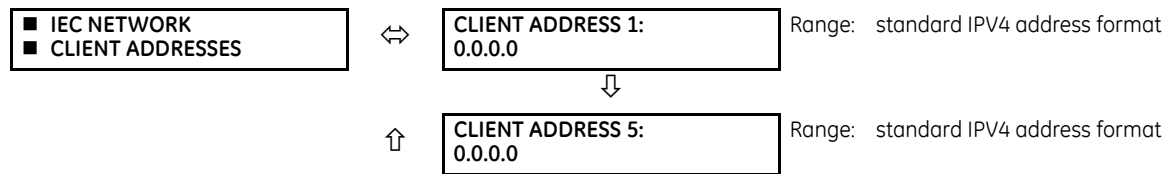
IEC CYCLIC DATA PERIOD — The change takes effect when the L30 is restarted.



The L30 relay does not support energy metering. As such, the **IEC ENERGY DEFAULT THRESHOLD** setting is not applicable.

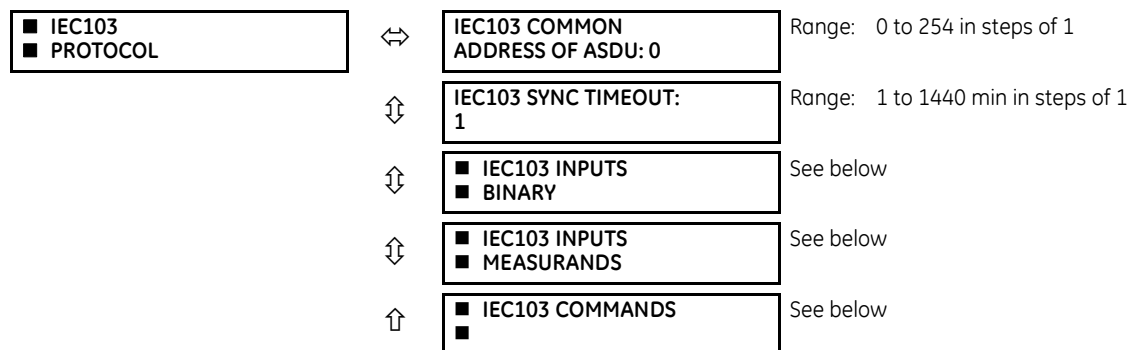


Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 60870-5-104 PROTOCOL ⇒ IEC NETWORK CLIENT ADDRESSES


The L30 can specify a maximum of five clients for its IEC 104 connections. These are IP addresses for the controllers to which the L30 can connect. A maximum of two simultaneous connections are supported at any given time.

5.3.5.16 IEC 60870-5-103 protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 60870-5-103


The L30 is provided with optional IEC 60870-5-103 communications capability. This feature is specified as a software option at the time of ordering. See the Order Codes section in chapter 2 for details.

IEC 60870-5-103 is a companion standard to the IEC 60870-5 suite of standards for transmission protocols. It defines messages and procedures for interoperability between protection equipment and devices of a control system in a substation for communicating on a serial line.

The IEC 60870-5-103 protocol is enabled when the **SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ PROTOCOL** setting is set to IEC 60870-5-103.

The IEC 60870-5-103 is an unbalanced (master-slave) protocol for coded-bit serial communication, exchanging information with a control system. In the context of this protocol, the protection equipment is the slave and the control system is the master. The communication is based on a point-to-point principle. The master must be able to interpret the IEC 60870-5-103 communication messages.

The UR implementation of IEC 60870-5-103 consists of the following functions:

- Report binary inputs
- Report analog values (measurands)
- Commands
- Time synchronization

The RS485 port supports IEC 60870-5-103.

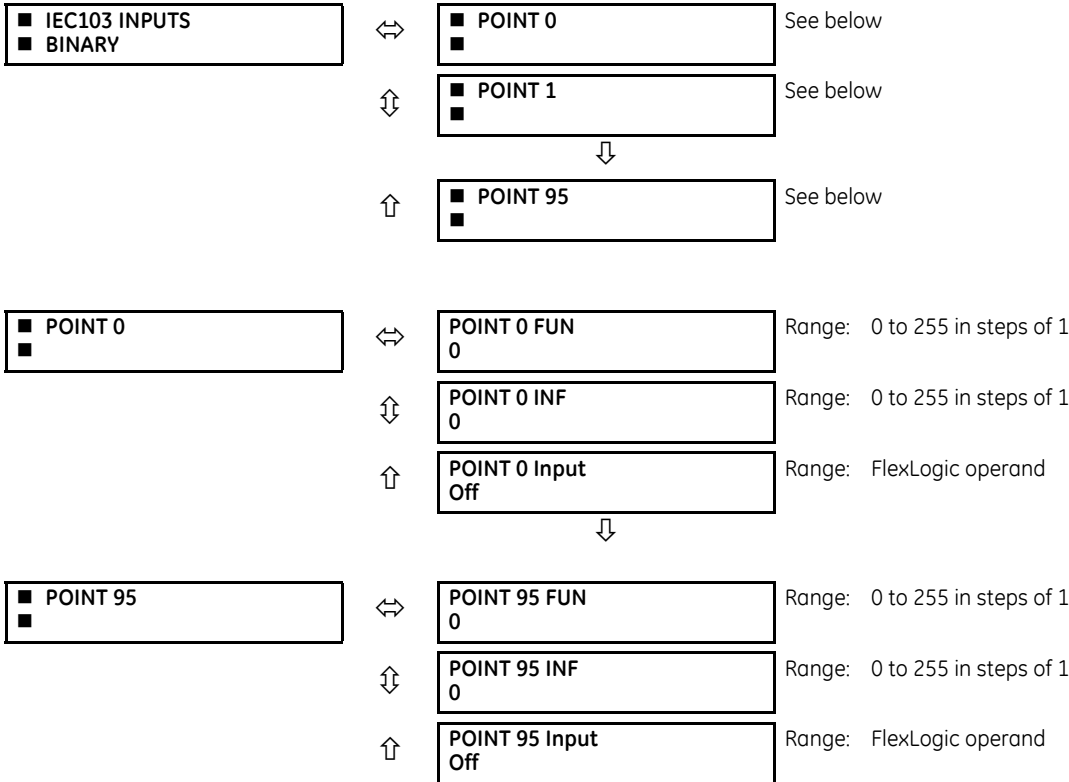
The UR Family Communications Guide contains more information on the protocol.

IEC103 COMMON ADDRESS OF ASDU — This setting uniquely defines this L30 on the serial line. Select an ID between 0 and 254. This ID does not need to be in sequential order for all stations that communicate with a controller, but it is recommended. Note that RS485 only allows a maximum of 32 slave stations on a communication line, so the entire range of 254 addresses is never exhausted.

IEC103 SYNC TIMEOUT — This setting defines the time that the L30 waits for a synchronization message. The L30 synchronizes its clock using all available sources, with the source syncing more frequently overwriting the time of the other sources. Since the synchronization message received from the IEC 60870-5-103 master is less frequent than IRIG-B, PTP, or SNTP, its time is overwritten by these three sources, if any of them is active. If the synchronization timeout occurs and none of IRIG-B, PTP, or SNTP is active, the L30 sets the invalid bit in the time stamp of a time-tagged message.

The settings for the remaining menus are outlined as follows.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 60870-5-103 ⇒ IEC103 INPUTS BINARY



The binary input points are mapped using elements from a list of possible FlexLogic operands. A maximum of 96 binary inputs (points) can be mapped this way.

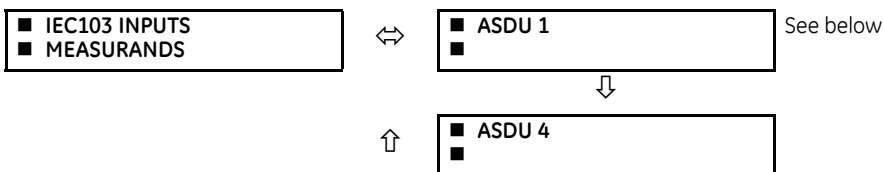
The IEC 60870-5-103 point list always starts with point 0 and ends at the first "Off" value. Since the IEC 60870-5-103 point list must be in a continuous block, any points assigned after the first "Off" point are ignored.

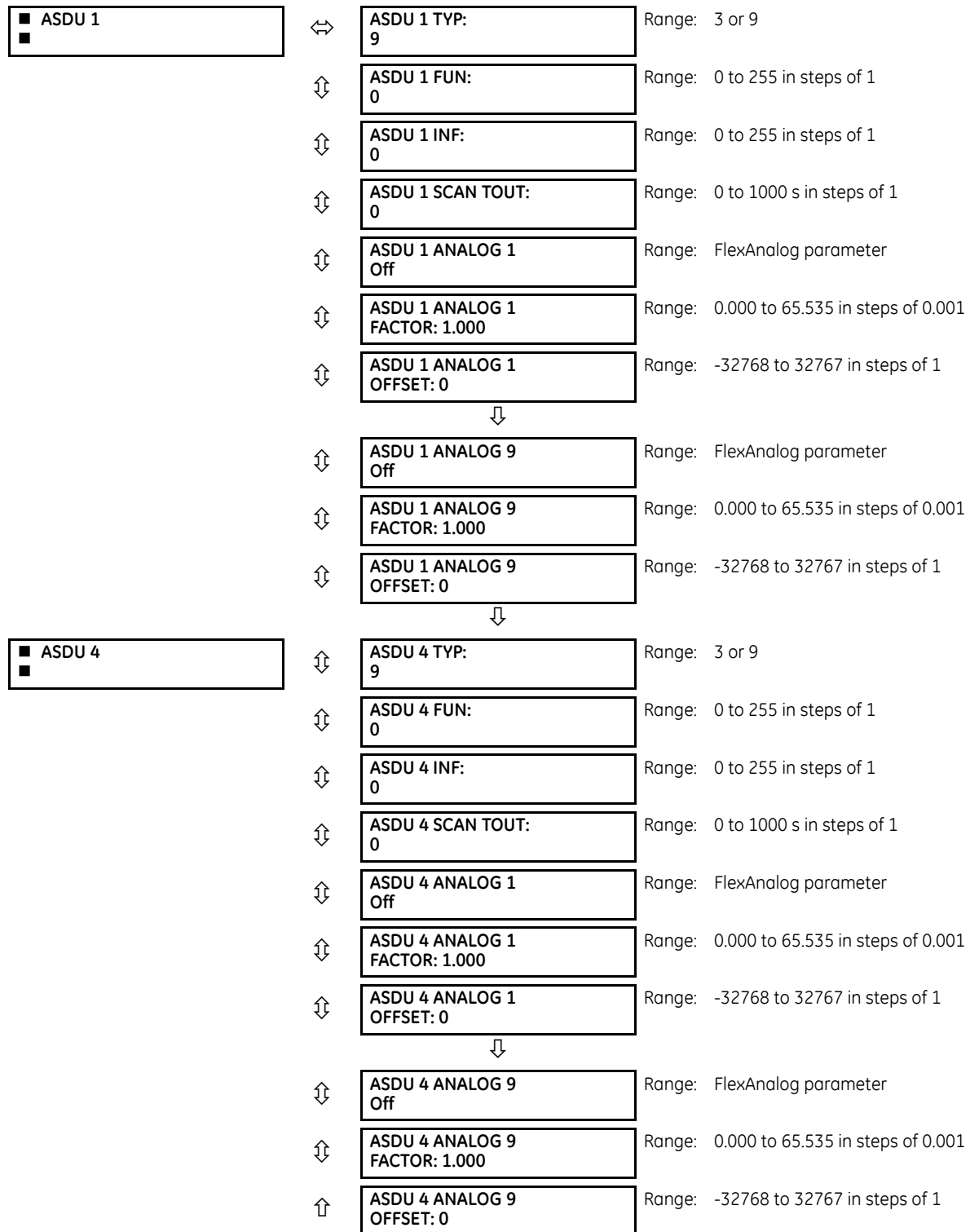
For each defined point, set appropriate values for the Function Type (FUN) and Information Number (INF), which form the Information Object Identifier field of the ASDU, as defined in IEC 60870-5-103.

The binary input points are sent as Class 1 data. They are sent either as a response to a general interrogation received from the controller or reported spontaneously. Spontaneous transmission occurs as a response to cyclic Class 2 requests. If the L30 wants to transmit Class 1 data at that time, it demands access for Class 1 data transmission (ACD=1 in the control field of the response).

For any change to take effect, restart the relay.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 60870-5-103 ⇒ IEC103 INPUTS MEASURANDS





The configuration menu allows a maximum of four ASDUs containing measurands. Measurands are sent as a response to Class 2 requests, which are cyclic requests coming from the master.

TYPE IDENTIFICATION (TYP) — The configuration field TYP indicates how many measurands are present in the corresponding ASDU. Each ASDU can take either 4 or 9 measurands maximum, depending on the type identification (3 respectively 9). For any change to take effect, restart the relay.

FUNCTION TYPE (FUN) and **INFORMATION NUMBER (INF)** — These two fields form the Information Object Identifier of the ASDU as defined in IEC 60870-103. For any change to take effect, restart the relay.

SCAN TIMEOUT (SCAN TOUT) — This is the cyclic period used by the L30 to decide when a measurand ASDU is included in a response. The measurand is sent as response to a Class 2 request when the corresponding timeout expires. The default value 0 means 500 ms.

ANALOG # — This field contains the actual measurand to be sent in the response to the master. The measurands can be mapped using elements from a list of FlexAnalog operands. The measurands sent are voltage, current, power, power factor, and frequency. If any other FlexAnalog is chosen, the L30 sends 0 instead of its value. Note that the power is transmitted in KW, not W. Measurands are transmitted as ASDU 3 or ASDU 9 (type identification value set to measurands I, respectively measurands II).

Each IEC 60870-5-103 measurands list ends at the first unconfigured ("Off") value. Any measurand assigned after the first "Off" value is ignored.

At least one measurand per ASDU must be configured in order to configure the following ASDU. For example, the user can configure only one measurand for each ASDU, but the user is not allowed to skip ASDU 2 and configure measurands in ASDU 3.

For any change to take effect, restart the relay.

ANALOG # FACTOR and **OFFSET** — For each measurand included in the ASDU, a factor and offset also can be configured. The factor and offset allow for scaling to be performed on measurands. The final measurement sent to the IEC 60870-103 master is then "a*x + b," where x is the measurand, a is the multiplying factor and b is the offset. The master has to perform the reversed operation in order to retrieve the actual value if such scaling is done. By default a = 1 and b = 0, so no scaling is done if these values are left at their defaults. Examples of when scaling is appropriate are as follows:

- If the measured value contains decimals and it is important to preserve the resolution. Since the format for transmitting the measurand does not permit decimals, a factor a>1 can be applied before transmission. For example, a frequency F=59.9Hz can be transmitted as $F_t = 10 * F = 10 * 59.9 = 599$. In this case a = 10, b = 0. The master receives 599 and has to divide by 10 to retrieve the real value 59.9.
- If the measured value is larger than what fits in the format defined in IEC 103. The format defined in the standard allows for signed integers up to 4095. By offsetting, unsigned integers up to $4096 + 4095 = 8191$ are supported. Scaling using factors <1 can be required in such cases. The calculation is outlined in the IEC 60870-5-103 chapter of the UR Family Communications Guide. Two examples follow, where you decide factors a and b.

Example 1: Nominal power $P_n = 100 \text{ MW} = 100000 \text{ KW}$ (power is transmitted in KW)

Since P can be both positive and negative:

$$\begin{aligned} \text{Transmitted power } P_t &= (4095/(P_n * 2.4)) * P = (4095/(100000 * 2.4)) * P \\ &= 0.017 * P \end{aligned}$$

$$a = 0.017$$

$$b = 0$$

$$P_t = 0.017 * P$$

For a max power $100000 \text{ KW} * 2.4 = 240000 \text{ KW}$, we transmit

$$P_t = 0.017 * 240000 = 4080$$

A value above 240 MW is indicated by overflow.

Example 2: Nominal voltage $V_n = 500000 \text{ V}$

Since RMS voltage V can be only positive:

$$\begin{aligned} \text{Transmitted voltage } V_t &= (8191/(V_n * 2.4)) * V - 4096 = \\ &= (8191/(500000 * 2.4)) * V - 4096 = 0.0068 * V - 4096 \\ a &= 0.0068 \end{aligned}$$

Since the step is in increments of 0.001, we round it at:

a = 0.006

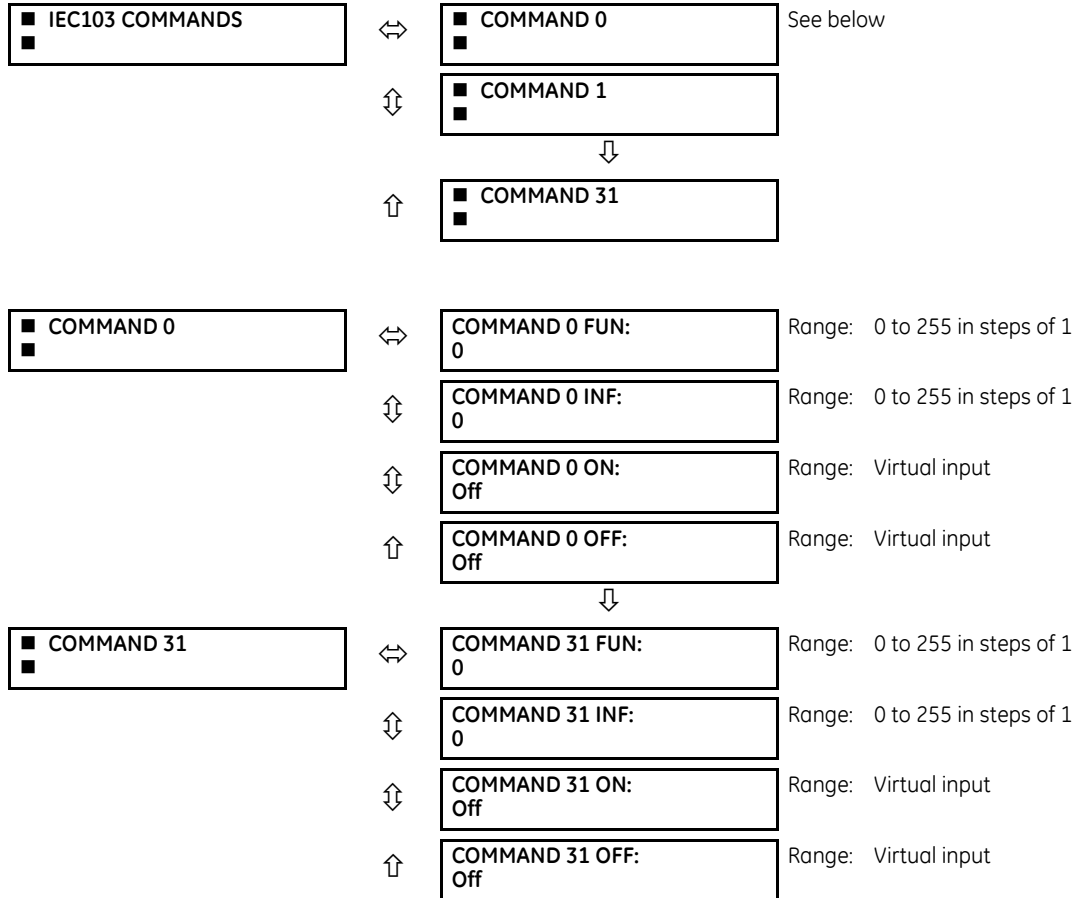
b = -4096

$V_t = 0.006 * V - 4096$

For max voltage $500000 \text{ V} * 2.4 = 1200000 \text{ V}$, we transmit

$V_t = 0.006 * 1200000 - 4096 = 7200 - 4096 = 3104$

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 60870-5-103 ⇒ IEC103 COMMANDS



Commands are received as General Command (Type Identification 20). The user can configure the action to perform when an ASDU command comes.

A list of available mappings is provided on the L30. This includes 64 virtual inputs (see the following table). The ON and OFF for the same ASDU command can be mapped to different virtual inputs.

Each command is identified by the unique combination made by the function type (FUN) and information number (INF). If the master sends an ASDU command that does not have the FUN and INF of any configured command, the relay rejects it.

Table 5-12: Commands mapping table

Description	Value
Off	0
Virtual Input 1	1
Virtual Input 2	2
...	...
Virtual Input 64	64

For any change to take effect, restart the relay.

5.3.5.17 USB port

SETTINGS ⇒ PRODUCT SETUP ⇅ USB 2.0

<input checked="" type="checkbox"/> USB 2.0 <input checked="" type="checkbox"/>	⇅	USB DEVICE PORT FUNCTION: Enabled	Range: Disabled, Enabled
--	---	--------------------------------------	--------------------------



This setting applies to the USB port on the graphical front panel.

This setting enables/disables the USB port on the graphical front panel. When the port function is "Enabled," a standard USB serial cable allows a computer running the EnerVista UR Setup software to retrieve, display, and write settings either individually or collectively, to display status and actual values, to initiate controls, and to retrieve and display event records, oscillography records, data logger records, and disturbance records. Installation of the EnerVista software automatically installs the drivers required to use this USB port.

DNP is not available using the USB port on the graphical front panel.

5.3.6 Modbus user map

SETTINGS ⇒ PRODUCT SETUP ⇅ MODBUS USER MAP

<input checked="" type="checkbox"/> MODBUS USER MAP <input checked="" type="checkbox"/>	⇅	ADDRESS 1: 0 VALUE: 0	Range: 0 to 65535 in steps of 1
		↓	
	⇅	ADDRESS 256: 0 VALUE: 0	Range: 0 to 65535 in steps of 1

The Modbus user map provides read-only access for up to 256 registers. To obtain a memory map value, enter the address in the **ADDRESS** line (converted from hex to decimal format). The corresponding value (if programmed) displays in the **VALUE** line. A value of "0" in subsequent register **ADDRESS** lines automatically returns values for the previous **ADDRESS** lines incremented by 1. An address value of "0" in the initial register means "none" and values of "0" display for all registers. Different **ADDRESS** values can be entered as required in any of the register positions.

The UR Family Communications Guide outlines the Modbus memory map. The map is also viewable in a web browser; enter the IP address of the L30 in a web browser and click the option.

5.3.7 Real-time clock

5.3.7.1 Menu

SETTINGS ⇒ PRODUCT SETUP ⇅ REAL TIME CLOCK

<input checked="" type="checkbox"/> REAL TIME <input checked="" type="checkbox"/> CLOCK	⇅	SYNCHRONIZING SOURCE: None	Range: None, PP/IRIG-B/PTP/Other, IRIG-B/PP/PTP/Other, PP/PTP/IRIG-B/Other
	⇅	REAL TIME CLOCK EVENTS: Disabled	Range: Enabled, Disabled
	⇅	IRIG-B SIGNAL TYPE: None	Range: None, DC Shift, Amplitude Modulated
	⇅	<input checked="" type="checkbox"/> PRECISION TIME <input checked="" type="checkbox"/> PROTOCOL (1588)	See below
	⇅	<input checked="" type="checkbox"/> SNTP PROTOCOL <input checked="" type="checkbox"/>	See below



The relay contains a real time clock (RTC) to create time stamps for communications protocols as well as for historical data, such as event records and oscillography. When the relay restarts, the RTC initializes from an onboard battery-backed clock, which has the same accuracy as an electronic watch, approximately ± 1 minute per month (~ 23 ppm). Once the RTC is synchronized with the Precision Time Protocol (PTP), IRIG-B, or SNTP, its accuracy approaches that of the synchronizing time delivered to the relay. While the RTC is not synchronized via PTP or IRIG-B, or the relay determines that it has an offset possibly greater than $10 \mu\text{s}$ from the international time standard, the **CLOCK UNSYNCHRONIZED** FlexLogic operand is activated. When the L30/L90 channel asymmetry function is used, the relay's real time clock must be synchronized to an external time source using PTP or IRIG-B, typically from a global positioning system (GPS) receiver.

The **SYNCHRONIZING SOURCE** setting displays when the relay includes the IEEE 1588 software option. The setting configures the priority sequence of the time synchronization source, to determine which of the available external time sources to use for time synchronization. A setting of None causes the RTC and the synchrophasor clock to free-run, and the clock can be changed from the front panel or from communications protocols. A setting of PP/IRIG-B/PTP/Other, IRIG-B/PP/PTP/Other, or PP/PTP/IRIG-B/Other causes the relay to track the first source named that is enabled and operational, or free-run if none of these are available. Here, PP means a time source that is strictly compliant with PP, PTP means a time source that is not strictly compliant with PP, and Other means any less precise source (SNTP, IEC 103, IEC 104, Modbus, or DNP). When a time source fails or recovers, the relay automatically transfers synchronization as required by this setting.

When the relay does not have the IEEE 1588 software option and this setting does not display, it uses IRIG-B when enabled and operational, then failing that SNTP when configured and operational, and otherwise it free-runs unless the clock is changed from the front panel or from communications protocols.

Setup for IRIG-B is illustrated in the Installation chapter.

For the Other protocols, whenever a time synchronization message is received through any of the active protocols, the L30 clock updates. However, given that IEC 60870-5-103, IEC 60870-5-104, Modbus, and DNP are low-accuracy time synchronization methods, avoid their use for synchronization when better accuracy time protocols, such as IRIG-B and PTP, are active in the system. If IRIG-B or PTP is used to update the relay clock, the other protocols (such as SNTP) are not allowed to update, even if active.

See the **COMMANDS** \Rightarrow **SET DATE AND TIME** menu section of this manual to manually set the RTC.

The **REAL TIME CLOCK EVENTS** setting allows changes to the date and/or time to be captured in the event record. The event records the RTC time before the adjustment. A Date/Time Changed event is generated when:

- The real time clock changed from SNTP/PTP/IRIG-B and the time difference is more than one second
- The real time clock changed from the front panel or via Modbus register. The relay always generates this event regardless of the time difference.
- The Daylight Saving Time (DST) setting gets enabled and the current relay time is already in the DST zone
- The real time clock enters or leaves DST

To enable IRIG-B synchronization, the input **IRIG-B SIGNAL TYPE** must be set to DC Shift or Amplitude Modulated. IRIG-B synchronization can be disabled by making this setting None.

Clocks can be synchronized locally among several relays using the computer time. When using a time source, such as IRIG-B, the time is overwritten eventually by the time source. To synchronize clocks among UR devices:

1. In the EnerVista software, expand the main menu in the Online Window area and select the **Synchronize Devices** entry. The window opens. The software prompts to acknowledge any offline devices.
2. Click the **Synchronize Devices** button at the top of the window, and confirm the action at the prompt. The devices assume the time of the computer being used.

To configure and enable PTP and/or SNTP, or to set local time parameters (for example time zone, daylight savings), use the following sections.

5.3.7.2 Precision time protocol (1588)

SETTINGS ⇒ PRODUCT SETUP ⇒ REAL TIME CLOCK ⇒ PRECISION TIME PROTOCOL (1588)

<input checked="" type="checkbox"/> PRECISION TIME <input checked="" type="checkbox"/> PROTOCOL (1588)	↔	STRICT POWER PROFILE: Disabled	Range: Enabled, Disabled
	↕	PTP DOMAIN NUMBER: 0	Range: 0 to 255
	↕	PTP VLAN PRIORITY: 4	Range: 0 to 7
	↕	PTP VLAN ID: 0	Range: 0 to 4095
	↑	<input checked="" type="checkbox"/> PTP PORT 1 <input checked="" type="checkbox"/>	See below

SETTINGS ⇒ PRODUCT SETUP ⇒ REAL TIME CLOCK ⇒ PRECISION TIME PROTOCOL (1588) ⇒ PTP PORT 1(3)

<input checked="" type="checkbox"/> PTP PORT 1 <input checked="" type="checkbox"/>	↕	PORT 1 PTP FUNCTION: Disabled	Range: Enabled, Disabled
	↕	PORT 1 PATH DELAY ADDER: 0 ns	Range: 0 to 60000 ns in steps of 1
	↑	PORT 1 PATH DELAY ASYMMETRY: 0 ns	Range: -1000 to +1000 ns in steps of 1

5



The L30 is provided with optional Precision Time Protocol capability. This feature is specified as the IEEE 1588 software option at the time of ordering. See the Order Codes section in chapter 2 for details.

The L30 supports the Precision Time Protocol (PTP) specified in IEEE Std 1588 2008 using the Power Profile (PP) specified in IEEE Std C37.238 2011. This enables the relay to synchronize to the international time standard over an Ethernet network that implements PP.

The relay can be configured to operate on some PTP networks that are not strictly PP. Time accuracy can be less than specified for a PP network. Tolerated deviations from strict PP include 1) missing declaration of PP compliance in the messages, 2) connection to a network device that does not support the PTP peer delay mechanism, 3) jitter substantially greater than 1 μs in received event messages, and 4) certain non-compliant announce and sync message update rates.

The relay implements PTP according to IEEE Std 1588 2008 and the equivalent IEC 61588:2009(E), sometimes referred to as version 2 PTP. It does not support the previous version of the standard (version 1).

PTP is a protocol that allows multiple clocks in a network to synchronize with one another. It permits synchronization accuracies better than 1 ns, but this requires that each and every component in the network achieve very high levels of accuracy and a very high baud rate, faster than normally used for relay communications. When operating over a generic Ethernet network, time error can amount to 1 ms or more. PP is a profile of PTP which specifies a limited subset of PTP suitable for use in power system protection, control, automation, and data communication applications, and thereby facilitates interoperability between different vendor’s clocks and switches. PP specifies a worst-case delivered time error of less than 1 μs over a 16-hop network.

In a PTP system and in a PP system, the clocks automatically organize themselves into a master-slave synchronization hierarchy with the “best” clock available making itself the “grandmaster” at the top of the hierarchy; all others make themselves “slaves” and track the grandmaster. Typically the grandmaster clock receives its time from GPS satellites or some other link to the international time standard. If the grandmaster fails, the next “best” clock available in the domain assumes the grandmaster role. When a clock on start-up discovers that it is “better” than the present grandmaster, it assumes the grandmaster role and the previous grandmaster reverts to slave. The L30 qualification mechanism accepts a potential master clock as a new grandmaster, when in a four-second interval it has received three announce messages from it, all better than the present grandmaster clock and better than any other announce in this interval.

Time messages issued by the grandmaster are delayed as they pass through the network both due to the finite speed of the signal in the interconnecting fiber or wire, and due to processing delays in the Ethernet switches. Each clock and switch implementing PP measures the propagation delay to each of its PP neighbors, and compensates for these delays in the time received. Each network device implementing PP measures the processing delay it introduces in each time message and compensates for this delay in the time it transmits. As a result, the time delivered to end-devices such as the UR are virtually identical to the grandmaster time. If one of the network devices in the hierarchy does not fully implement PP, the associated propagation delay and/or latency may not be compensated for, and the time received at the end-device can be in error by more than 100 μ s.

See the preceding Real Time Clock section for a description of when time values received via PTP are used to update the relay's real time clock.

The following settings are available for configuring the relay for PTP. The PTP menu displays only when the option was purchased.

STRICT POWER PROFILE — Power profile (IEEE Std C37.238 2011) requires that the relay only select a power profile compliant clock as a grandmaster, that the delivered time have worst-case error of $\pm 1 \mu$ s, and that the peer delay mechanism be implemented. With the strict power profile setting enabled, the relay only selects as master the clocks displaying the IEEE_C37_238 identification codes. It uses a port only when the peer delay mechanism is operational. With the strict power profile setting disabled, the relay uses clocks without the power profile identification when no power profile clocks are present, and uses ports even if the peer delay mechanism is non-operational. This setting applies to all of the relay's PTP capable ports.

PTP DOMAIN NUMBER — Set this setting to the domain number of the grandmaster-capable clock(s) to be synchronized to. A network can support multiple time distribution domains, each distinguished with a unique domain number. More commonly, there is a single domain using the default domain number zero.

This setting applies to all of the relay's PTP capable ports.

PTP VLAN PRIORITY — This setting selects the value of the priority field in the 802.1Q VLAN tag in request messages issued by the relay's peer delay mechanism. In compliance with PP the default VLAN priority is 4, but it is recommended that it be set to 7 in accordance with PTP. Depending on the characteristics of the device to which the relay is linked directly, VLAN Priority can have no effect.

This setting applies to all of the relay's PTP capable ports.

PTP VLAN ID — This setting selects the value of the ID field in the 802.1Q VLAN tag in request messages issued by the relay's peer delay mechanism. It is provided in compliance with PP. As these messages have a destination address that indicates they are not to be bridged, their VLAN ID serves no function, and so can be left at its default value. Depending on the characteristics of the device to which the relay is linked directly, VLAN ID can have no effect. This setting applies to all of the relay's PTP capable ports.

PORT 1 ... 3 FUNCTION — While this port setting is selected to disabled, PTP is disabled on this port. The relay does not generate or listen to PTP messages on this port.

PORT 1 ... 3 PATH DELAY ADDER — The time delivered by PTP is advanced by the time value in this setting prior to the time being used to synchronize the relay's real time clock. This is to compensate to the extent practical for time delivery delays not compensated for in the network. In a fully compliant PP network, the peer delay and the processing delay mechanisms compensate for all the delays between the grandmaster and the relay. In such networks, make this setting zero.

In networks containing one or more switches and/or clocks that do not implement both of these mechanisms, not all delays are compensated, so the time of message arrival at the relay is later than the time indicated in the message. This setting can be used to approximately compensate for this delay. However, as the relay is not aware of network switching that dynamically changes the amount of uncompensated delay, there is no setting that always and completely corrects for uncompensated delay. A setting can be chosen that reduces the worst-case error to half of the range between minimum and maximum uncompensated delay, if these values are known.

PORT 1 ... 3 PATH DELAY ASSYMMETRY — This setting corresponds to "delayAsymmetry" in PTP, which is used by the peer delay mechanism to compensate for any difference in the propagation delay between the two directions of a link. Except in unusual cases, the two fibers are of essentially identical length and composition, so make this setting zero.

In unusual cases where the length of the link is different in different directions, set this setting to the number of nanoseconds the Ethernet propagation delay to the relay is longer than the mean of path propagation delays to and from the relay. For instance, if it is known say from the physical length of the fibers and the propagation speed in the fibers that the delay from the relay to the Ethernet switch it is connected to is 9000 ns and that the delay from the switch to the relay is 11000 ns, then the mean delay is 10000 ns, and the path delay asymmetry is 11000 - 10000 = +1000 ns.

5.3.7.3 SNTP protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ REAL TIME CLOCK ⇒ SNTP PROTOCOL

<div style="border: 1px solid black; padding: 2px;"> <input checked="" type="checkbox"/> SNTP PROTOCOL </div>	↔	<div style="border: 1px solid black; padding: 2px;"> SNTP FUNCTION: Disabled </div>	Range: Enabled, Disabled
	⇕	<div style="border: 1px solid black; padding: 2px;"> SNTP SERVER IP ADDR: 0.0.0.0 </div>	Range: standard IP address format
	↑	<div style="border: 1px solid black; padding: 2px;"> SNTP UDP PORT NUMBER: 123 </div>	Range: 1 to 65535 in steps of 1

The L30 supports the Simple Network Time Protocol specified in RFC-2030. With SNTP, the L30 can obtain clock time over an Ethernet network. The L30 acts as an SNTP client to receive time values from an SNTP/NTP server, usually a dedicated product using a GPS receiver. UR family relays support unicast, broadcast, multicast, and anycast SNTP functionality.


The **SNTP FUNCTION** setting enables or disables the SNTP feature on the L30.

To use SNTP in unicast mode, set **SNTP SERVER IP ADDR** to the SNTP/NTP server IP address. Once this address is set and **SNTP FUNCTION** is “Enabled,” the L30 attempts to obtain time values from the SNTP/NTP server. Since many time values are obtained and averaged, it generally takes three to four minutes until the L30 clock is closely synchronized with the SNTP/NTP server. It takes up to two minutes for the L30 to signal an SNTP self-test error if the server is offline.

To use SNTP in broadcast mode, set the **SNTP SERVER IP ADDR** setting to “0.0.0.0” and **SNTP FUNCTION** to “Enabled.” The L30 then listens to SNTP messages sent to the “all ones” broadcast address for the subnet. The L30 waits up to 18 minutes (>1024 seconds) without receiving an SNTP broadcast message before signaling an SNTP self-test error.

The **SNTP UDP PORT NUMBER** is 123 for normal SNTP operation. The change takes effect when the L30 is restarted.

After enabling and waiting for the synchronization, verify that there is no SNTP Failure message in the Event Records.

 Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

5.3.7.4 Local time

SETTINGS ⇒ PRODUCT SETUP ⇒ REAL TIME CLOCK ⇒ LOCAL TIME

<div style="border: 1px solid black; padding: 2px;"> <input checked="" type="checkbox"/> LOCAL TIME </div>	↔	<div style="border: 1px solid black; padding: 2px;"> LOCAL TIME OFFSET FROM UTC: 0.0 hr </div>	Range: -24.0 to 24.0 hr in steps of 0.5
	⇕	<div style="border: 1px solid black; padding: 2px;"> DAYLIGHT SAVINGS TIME: Disabled </div>	Range: Disabled, Enabled
	⇕	<div style="border: 1px solid black; padding: 2px;"> DST START MONTH: January </div>	Range: January to December (all months)
	⇕	<div style="border: 1px solid black; padding: 2px;"> DST START DAY: Sunday </div>	Range: Sunday to Saturday (all days of the week)
	⇕	<div style="border: 1px solid black; padding: 2px;"> DST START DAY INSTANCE: First </div>	Range: First, Second, Third, Fourth, Last
	⇕	<div style="border: 1px solid black; padding: 2px;"> DST START HOUR: 2:00 </div>	Range: 0:00 to 23:00 in steps of one hour
	⇕	<div style="border: 1px solid black; padding: 2px;"> DST STOP MONTH: January </div>	Range: January to December (all months)

⇅	DST STOP DAY: Sunday	Range: Sunday to Saturday (all days of the week)
⇅	DST STOP DAY INSTANCE: First	Range: First, Second, Third, Fourth, Last
↑	DST STOP HOUR: 2:00	Range: 0:00 to 23:00 in steps of one hour

The L30 maintains two times: local time and Universal Coordinated Time (UTC). Local time can be provided by IRIG-B signals. UTC time is provided by SNTP servers.

The real-time clock (RTC) and time stamps reported in historical records and communication protocols can be incorrect if the Local Time settings are not configured properly.

See the IRIG-B section in the Installation chapter for guidance on these settings when using an IRIG-B source that sets the IRIG-B control bits according to IEEE Std 1344-1995.

LOCAL TIME OFFSET FROM UTC — Used to specify the local time zone offset from UTC (Greenwich Mean Time) in hours. Time zones in the eastern hemisphere have positive values; time zones in the western hemisphere have negative values. A value of zero causes the relay to use UTC for local time. This setting has two uses. When the system RTC is synchronized with a communications protocol providing only local time or it is free-running, the offset setting is used to calculate UTC from the local time these provide. When the RTC is synchronized with a communications protocol providing only UTC (such as PTP or SNTP), the time offset setting is used to determine local time from the UTC provided. PTP ALTERNATE_TIME_OFFSET_INDICATOR TLVs are not used to calculate local time.

DAYLIGHT SAVINGS TIME and DST — Can be used to allow the relay to follow the DST rules of the local time zone. Note that when IRIG-B time synchronization is active, the local time in the IRIG-B signal contains any daylight savings time offset and so the DST settings are ignored.

5.3.8 Fault reports

SETTINGS ⇒ ⇅ PRODUCT SETUP ⇒ ⇅ FAULT REPORTS ⇒ ⇅ FAULT REPORT 1(2)

■ FAULT REPORT 1 ■	↔	FAULT REPORT 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
	⇅	FAULT REPORT 1 TRIG: Off	Range: FlexLogic operand
	⇅	FAULT REPORT 1 Z1 MAG: 3.00 Ω	Range: 0.01 to 250.00 ohms in steps of 0.01
	⇅	FAULT REPORT 1 Z1 ANGLE: 75°	Range: 25 to 90° in steps of 1
	⇅	FAULT REPORT 1 Z0 MAG: 9.00 Ω	Range: 0.01 to 650.00 ohms in steps of 0.01
	⇅	FAULT REPORT 1 Z0 ANGLE: 75°	Range: 25 to 90° in steps of 1
	⇅	FAULT REPORT 1 Z0M MAG: 0.00 Ω	Range: 0.00 to 650.00 ohms in steps of 0.01
	⇅	FAULT REPORT 1 Z0M ANGLE: 0°	Range: 25 to 90° in steps of 1
	⇅	FAULT REPORT 1 LINE LENGTH UNITS: km	Range: km, miles
	⇅	FAULT REP 1 LENGTH (km): 100.0	Range: 0.0 to 2000.0 in steps of 0.1
	⇅	FAULT REPORT 1 VT SUBSTITUTION: None	Range: None, I0, V0

⇅	FAULT REP 1 SYSTEM Z0 MAG: 2.00 Ω	Range: 0.01 to 650.00 ohms in steps of 0.01
⇅	FAULT REP 1 SYSTEM Z0 ANGLE: 75°	Range: 25 to 90° in steps of 1
↑	FAULT REPORT 1 Z0M MAG: 0.00 Ω	Range: 0.00 to 650.00 ohms in steps of 0.01

The L30 relay supports one fault report and an associated fault locator per CT bank to a maximum of two. The signal source and trigger condition, as well as the characteristics of the line or feeder, are entered in this menu.

The fault report stores data, in non-volatile memory, pertinent to an event when triggered. The captured data contained in the FaultReport.txt file includes:

- Fault report number
- Name of the relay, programmed by the user
- Firmware revision of the relay
- Date and time of trigger
- Name of trigger (specific operand)
- Line or feeder ID via the name of a configured signal source
- Active setting group at the time of trigger
- Pre-fault current and voltage phasors (two cycles before either a 50DD disturbance associated with fault report source or the trigger operate). Once a disturbance is detected, pre-fault phasors hold for three seconds waiting for the fault report trigger. If trigger does not occur within this time, the values are cleared to prepare for the next disturbance.
- Fault current and voltage phasors (one cycle after the trigger)
- Elements operated at the time of triggering
- Events — Nine before trigger and seven after trigger (only available via the relay web page)
- Fault duration times for each breaker (created by the breaker arcing current feature)

The captured data also includes the fault type, the distance to the fault location, distance to the fault location, fault loop impedance, as well as the reclose shot number (when applicable). To include fault duration times in the fault report, enable and configure the breaker arcing current feature for each of the breakers. Fault duration is reported on a per-phase basis.

The relay allows locating faults, including ground faults, from delta-connected VTs. In this case, the missing zero-sequence voltage is substituted either by the externally provided neutral voltage (broken delta VT) connected to the auxiliary voltage channel of a VT bank, or by the zero-sequence voltage approximated as a voltage drop developed by the zero-sequence current, and user-provided zero-sequence equivalent impedance of the system behind the relay.

The trigger can be any FlexLogic operand, but in most applications it is expected to be the same operand, usually a virtual output, that is used to drive an output relay to trip a breaker. To prevent the overwriting of fault events, do not use the disturbance detector to trigger a fault report. A FAULT RPT TRIG event is automatically created when the report is triggered.

If a number of protection elements are ORed to create a fault report trigger, the first operation of any element causing the OR gate output to become high triggers a fault report. However, if other elements operate during the fault and the first operated element has not been reset (the OR gate output is still high), the fault report is not triggered again. Considering the reset time of protection elements, there is very little chance that a fault report can be triggered twice in this manner. As the fault report must capture a usable amount of pre and post-fault data, it cannot be triggered faster than every 20 ms.

Each fault report is stored as a file; the relay capacity is 15 files. A 16th trigger overwrites the oldest file.

Individual fault report features store their files in the same memory space. The sixteenth report overwrites the first one regardless of which fault report feature produced the sixteenth and the first records.

The EnerVista software is required to view all captured data. The relay faceplate display can be used to view the date and time of trigger, the fault type, the distance location of the fault, and the reclose shot number.

The **FAULT REPORT 1 SOURCE** setting selects the source for input currents and voltages and disturbance detection. For the application of entirely parallel lines, the fault report can be programmed to apply compensation for the zero sequence mutual coupling between parallel lines when calculating fault resistance and fault loop impedance. If this compensation is

required, the ground current (3I_0) from the parallel line must be connected to the ground input CT of the CT bank configured under the **FAULT REPORT 1 SOURCE** with the same polarity as the phase current input configured in the same source.

The **FAULT 1 REPORT TRIG** setting assigns the FlexLogic operand representing the protection element/elements requiring operational fault location calculations. The distance to fault calculations are initiated by this signal. The **FAULT REPORT 1 Z1 MAG**, **FAULT REPORT 1 Z0 MAG**, and **FAULT REPORT 1 Z0M MAG** impedances are entered in secondary ohms.

For the application of entirely parallel lines, Z0M MAG/ANG is the mutual zero-sequence impedance for the whole line, required to compensate the calculation of fault resistance and fault loop impedance.

The **FAULT REPORT 1 VT SUBSTITUTION** setting is set to "None" if the relay is fed from wye-connected VTs. If delta-connected VTs are used, and the relay is supplied with the neutral (3V0) voltage, this setting is set to "V0". The method is still exact, as the fault locator combines the line-to-line voltage measurements with the neutral voltage measurement to re-create the line-to-ground voltages. See the **ACTUAL VALUES ⇒ RECORDS ⇒ FAULT REPORTS** menu for details. It is required to configure the delta and neutral voltages under the source indicated as input for the fault report. Also, the relay checks if the auxiliary signal configured is marked as "Vn" by the user (under VT setup) and inhibits the fault location if the auxiliary signal is labeled differently.

If the broken-delta neutral voltage is not available to the relay, an approximation is possible by assuming the missing zero-sequence voltage to be an inverted voltage drop produced by the zero-sequence current and the user-specified equivalent zero-sequence system impedance behind the relay: $V0 = -Z0 \times I0$. In order to enable this mode of operation, the **FAULT REPORT 1 VT SUBSTITUTION** setting is set to "I0".

The **FAULT REP 1 SYSTEM Z0 MAG** and **FAULT REP 1 SYSTEM Z0 ANGLE** settings are used only when the **VT SUBSTITUTION** setting value is "I0". The magnitude is to be entered in secondary ohms. This impedance is an average system equivalent behind the relay. It can be calculated as zero-sequence Thevenin impedance at the local bus with the protected line/feeder disconnected. The method is accurate only if this setting matches perfectly the actual system impedance during the fault. If the system exhibits too much variability, this approach is questionable and the fault location results for single-line-to-ground faults is trusted accordingly. Keep in mind that grounding points in the vicinity of the installation impact the system zero-sequence impedance (grounded loads, reactors, zig-zag transformers, shunt capacitor banks, and so on).

5.3.9 Oscillography

5.3.9.1 Menu

SETTINGS ⇒ PRODUCT SETUP ⇒ OSCILLOGRAPHY

■ OSCILLOGRAPHY ■	↔	NUMBER OF RECORDS: 15	Range: 1 to 64 in steps of 1
	⇕	TRIGGER MODE: Automatic Overwrite	Range: Automatic Overwrite, Protected
	⇕	TRIGGER POSITION: 50%	Range: 0 to 100% in steps of 1
	⇕	TRIGGER SOURCE: Off	Range: FlexLogic operand
	⇕	AC INPUT WAVEFORMS: 16 samples/cycle	Range: Off, 8, 16, 32, 64 samples/cycle
	⇕	■ DIGITAL CHANNELS ■	See below
	↑	■ ANALOG CHANNELS ■	See below

Oscillography records contain waveforms captured at the sampling rate as well as other relay data at the point of trigger. Oscillography records are triggered by a programmable FlexLogic operand. Multiple oscillography records can be captured simultaneously.

The **NUMBER OF RECORDS** is selectable, but the number of cycles captured in a single record varies considerably based on other factors, such as sample rate and the number of operational modules. There is a fixed amount of data storage for oscillography; the more data captured, the less the number of cycles captured per record. See the **ACTUAL VALUES** ⇨ ⇩ **RECORDS** ⇨ ⇩ **OSCILLOGRAPHY** menu to view the number of cycles captured per record. The following table provides sample configurations with corresponding cycles/record. The minimum number of oscillographic records is three.

Table 5-13: Oscillography cycles/record example


Records	CT/VTs	Sample rate	Digital channels	Analog channels	Cycles per record
3	1	32	32	16	2399
3	1	64	32	16	1450
16	1	32	32	16	666
16	1	64	32	16	402
32	1	32	32	16	352
32	1	64	32	16	213
3	2	32	32	16	1516
3	2	64	32	16	851
16	2	32	32	16	421

TRIGGER MODE — A new record automatically overwrites an older record when **TRIGGER MODE** is set to “Automatic Overwrite.”

TRIGGER POSITION — Set this to a percentage of the total buffer size (for example, 10%, 50%, 75%, and so on). A trigger position of 25% consists of 25% pre- and 75% post-trigger data.

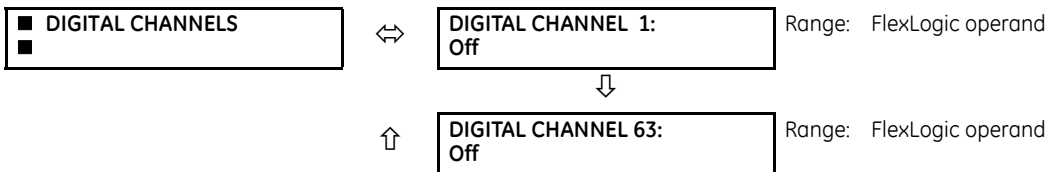
TRIGGER SOURCE — Always captured in oscillography and can be any FlexLogic parameter (element state, contact input, virtual output, and so on). The relay sampling rate is 64 samples per cycle.

AC INPUT WAVEFORMS — Determines the sampling rate at which AC input signals (that is, current and voltage) are stored. Reducing the sampling rate allows longer records to be stored. This setting has no effect on the internal sampling rate of the relay, which is always 64 samples per cycle. That is, it has no effect on the fundamental calculations of the device.

 When changes are made to the oscillography settings, all existing oscillography records are cleared.

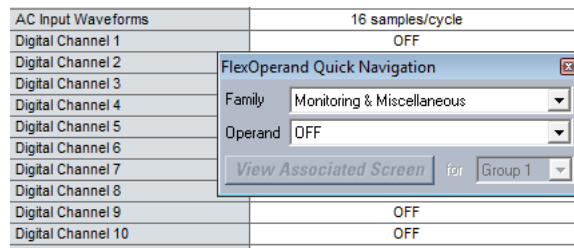
5.3.9.2 Digital channels

SETTINGS ⇨ PRODUCT SETUP ⇨ ⇩ OSCILLOGRAPHY ⇨ ⇩ DIGITAL CHANNELS



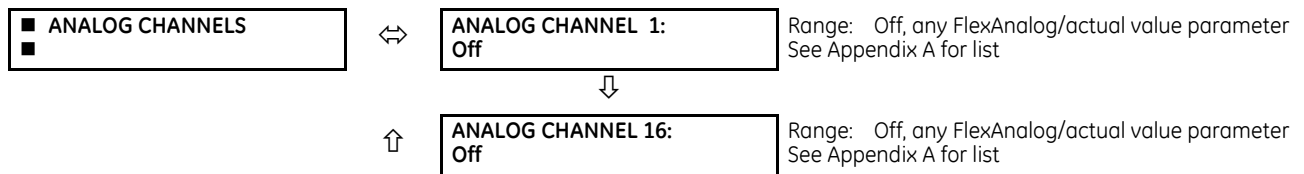
DIGITAL 1(63) CHANNEL — This setting selects the FlexLogic operand state recorded in an oscillography trace. The length of each oscillography trace depends in part on the number of parameters selected here. Parameters set to “Off” are ignored. To populate quickly the rows in the Offline Window, use Ctrl C/V to copy/paste, or click then double-click a row to display a quick selection window.

Figure 5-49: Quick selection window



5.3.9.3 Analog channels

SETTINGS ⇒ PRODUCT SETUP ⇒ OSCILLOGRAPHY ⇒ ANALOG CHANNELS



These settings select the metering actual value recorded in an oscillography trace. The length of each oscillography trace depends in part on the number of parameters selected here. Parameters set to “Off” are ignored. The parameters available in a given relay depend on

- the type of relay,
- the type and number of CT/VT hardware modules installed, and
- the type and number of analog input hardware modules installed

A list of all possible analog metering actual value parameters is presented in Appendix A: FlexAnalog Parameters. The parameter index number shown in any of the tables is used to expedite the selection of the parameter on the relay display. It can be time-consuming to scan through the list of parameters via the relay keypad and display — entering this number via the relay keypad causes the corresponding parameter to display.

All eight CT/VT module channels are stored in the oscillography file. The CT/VT module channels are named as follows:

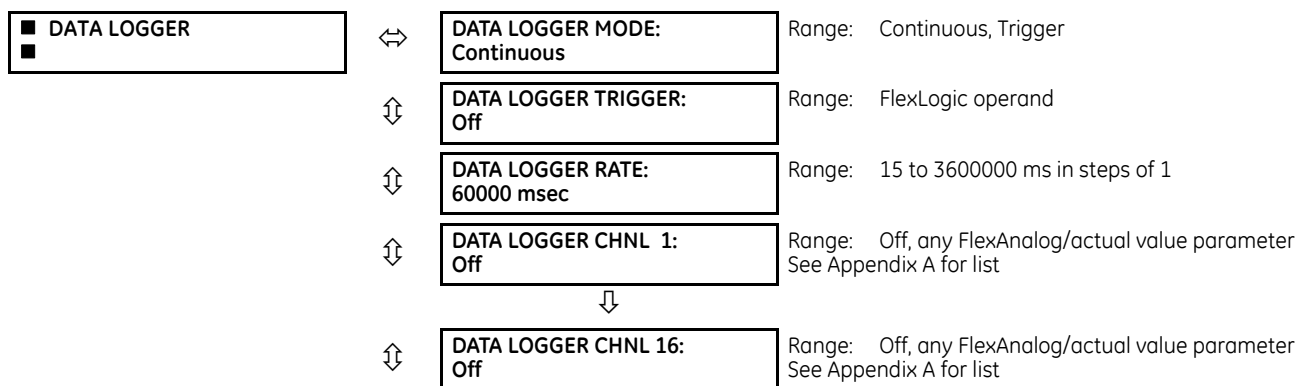
<slot_letter><terminal_number>—<I or V><phase A, B, or C, or 4th input>

The fourth current input in a bank is called IG, and the fourth voltage input in a bank is called VX. For example, F2-IB designates the IB signal on terminal 2 of the CT/VT module in slot F.

If there are no CT/VT modules and analog input modules, no analog traces appear in the file; only the digital traces appear.

5.3.10 Data logger

SETTINGS ⇒ PRODUCT SETUP ⇒ DATA LOGGER





DATA LOGGER CONFIG:
0 CHNL x 0.0 DAYS

Range: Not applicable - shows computed data only

The data logger samples and records up to 16 analog parameters at a user-defined sampling rate. This recorded data can be downloaded to EnerVista UR Setup and displayed with parameters on the vertical axis and time on the horizontal axis. All data is stored in non-volatile memory, so the information is retained when power to the relay is lost.

For a fixed sampling rate, the data logger can be configured with a few channels over a long period or a larger number of channels for a shorter period. The relay automatically partitions the available memory between the channels in use. The following table outlines examples of storage capacities for a system frequency of 60 Hz.

Table 5-14: Data logger storage capacity example

Sampling rate	Channels	Days	Storage capacity
15 ms	1	0.1	482 s
	8	0.1	60 s
	9	0.1	54 s
	16	0.1	30 s
1000 ms	1	0.3	32729 s
	8	0.1	4091 s
	9	0.1	3637 s
	16	0.1	2046 s
60000 ms	1	22.7	1963710 s
	8	2.8	245460 s
	9	2.5	218190 s
	16	1.4	127230 s
3600000 ms	1	1362.1	117822600 s
	8	170.2	14727600 s
	9	151.3	13091400 s



Changing any setting affecting data logger operation clears data in the log.

DATA LOGGER MODE — This setting configures the mode in which the data logger operates. When set to “Continuous,” the data logger actively records any configured channels at the rate as defined by the **DATA LOGGER RATE**. The data logger is idle in this mode when no channels are configured. When set to “Trigger,” the data logger records any configured channels at the instance of the rising edge of the **DATA LOGGER TRIGGER** source FlexLogic operand. The data logger ignores all subsequent triggers and continues to record data until the active record is full. Once the data logger is full, a CLEAR DATA LOGGER command is required to clear the data logger record before a new record can be started. Performing the CLEAR DATA LOGGER command also stops the current record and resets the data logger to be ready for the next trigger.

DATA LOGGER TRIGGER — This setting selects the signal used to trigger the start of a new data logger record. Any FlexLogic operand can be used as the trigger source. This setting only applies when the mode is set to “Trigger.”

DATA LOGGER RATE — This setting selects the time interval at which the actual value data is recorded.

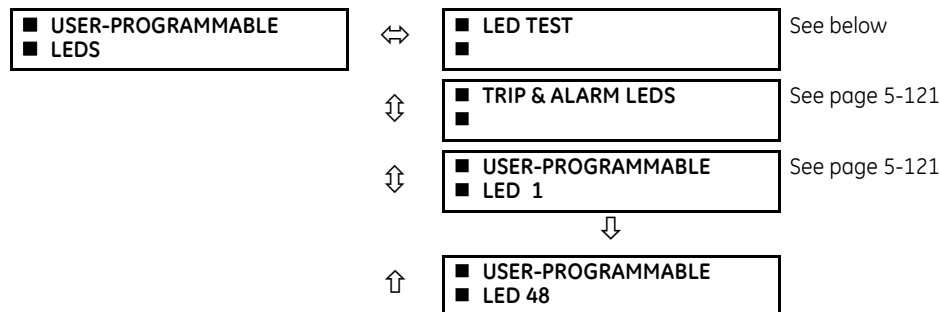
DATA LOGGER CHNL 1(16) — This setting selects the metering actual value that is to be recorded in Channel 1(16) of the data log. The parameters available in a given relay are dependent on: the type of relay, the type and number of CT/VT hardware modules installed, and the type and number of Analog Input hardware modules installed. Upon startup, the relay automatically prepares the parameter list. A list of all possible analog metering actual value parameters is shown in Appendix A: FlexAnalog Parameters. The parameter index number shown in any of the tables is used to expedite the selection of the parameter on the relay display. It can be time-consuming to scan through the list of parameters via the relay keypad/display—entering this number via the relay keypad causes the corresponding parameter to display.

DATA LOGGER CONFIG — This display presents the total amount of time that the Data Logger can record the channels not selected to “Off” without overwriting old data.

5.3.11 User-programmable LEDs

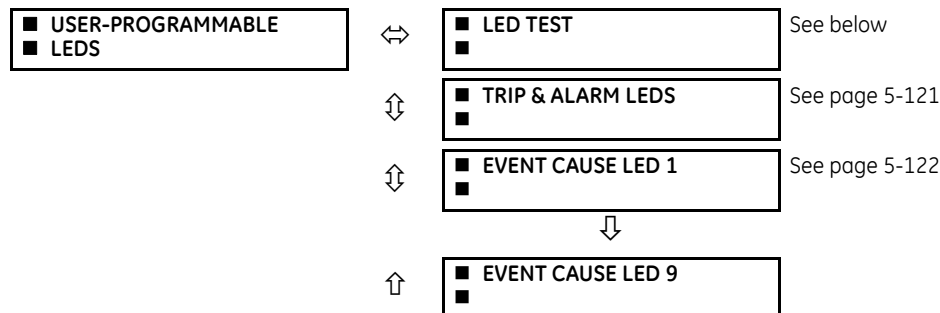
5.3.11.1 Menu - Enhanced and standard front panels

SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE LEADS



5.3.11.2 Menu - Graphical front panel

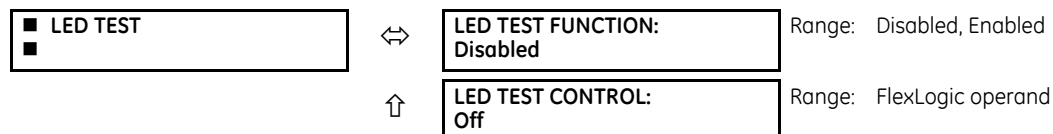
SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE LEADS



The LEDs can be customized to illuminate when a selected FlexLogic operand is in the logic 1 state. The trip and alarm LEDs can also be customized in a similar manner. To ensure correct functionality of all LEDs, an LED test feature is also provided.

5.3.11.3 LED test

SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE LEADS ⇒ LED TEST



When enabled, the LED test can be initiated from any digital input or user-programmable condition, such as a user-programmable pushbutton. The control operand is configured under the **LED TEST CONTROL** setting. The test covers all LEDs, including the LEDs of the optional user-programmable pushbuttons.

For the enhanced and standard front panels, the test consists of the following three stages:

1. All 62 LEDs on the relay are illuminated. This is a quick test to verify if any of the LEDs is “burned.” This stage lasts as long as the control input is on, up to a maximum of one minute. After one minute, the test ends.
2. All the LEDs are turned off, and then one LED at a time turns on for one second, then back off. The test routine starts at the top left panel, moving from the top to bottom of each LED column. This test checks for hardware failures that lead to more than one LED being turned on from a single logic point. This stage can be interrupted at any time.
3. All the LEDs are turned on. One LED at a time turns off for one second, then back on. The test routine starts at the top left panel moving from top to bottom of each column of the LEDs. This test checks for hardware failures that lead to more than one LED being turned off from a single logic point. This stage can be interrupted at any time.

For the graphical front panel, the test consists of the following stages:

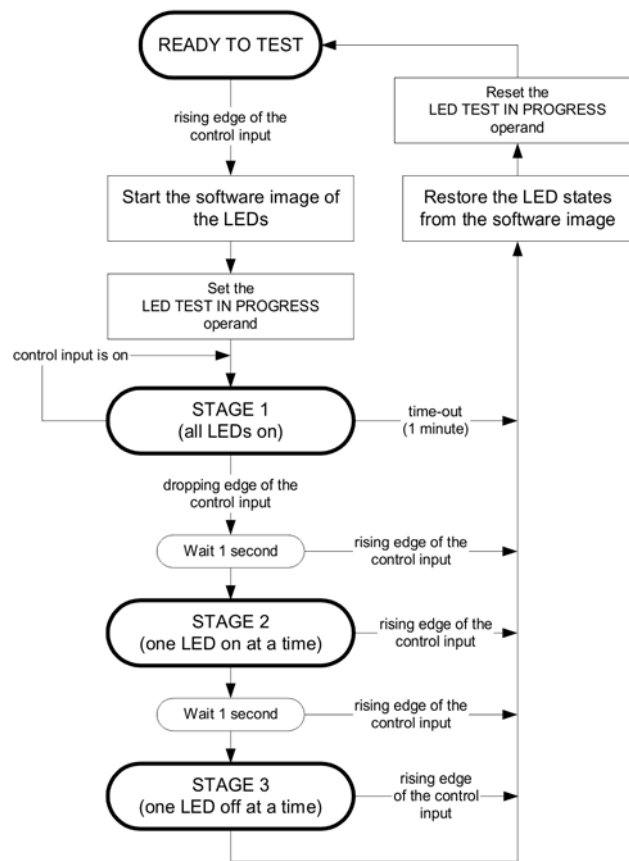
1. All 22 LEDs on the relay are illuminated. This is a quick test to verify if any of the LEDs is "burned." This stage lasts as long as the control input is on, up to a maximum of one minute. After one minute, the test ends.
2. All the LEDs are turned off, and then one LED at a time turns on with the orange color for one second, then back off. The test routine starts at the top left panel, moving from the top to bottom for all 14 LEDs. Then the eight pushbutton LEDs are tested in the same manner. This test checks for hardware failures that lead to more than one LED being turned on from a single logic point. This stage can be interrupted at any time.
3. All the LEDs are turned on with the orange color. One LED at a time turns off for one second, then back on. The test routine starts at the top left panel moving from top to bottom for all 14 LEDs. Then the eight pushbutton LEDs are tested in the same manner. This test checks for hardware failures that lead to more than one LED being turned off from a single logic point. This stage can be interrupted at any time.
4. Additionally, stages 2 and 3 are repeated twice for the five device status LEDs and nine event cause LEDs, one time with green color on and the other with red color on.

When testing is in progress, the LEDs are controlled by the test sequence, rather than the protection, control, and monitoring features. However, the LED control mechanism accepts all the changes to LED states generated by the relay and stores the actual LED states (on or off) in memory. When the test completes, the LEDs reflect the actual state resulting from relay response during testing. The reset pushbutton does not clear any targets when the LED Test is in progress.

A dedicated FlexLogic operand, **LED TEST IN PROGRESS**, is set for the duration of the test. When the test sequence is initiated, the LED TEST INITIATED event is stored in the event recorder.

The entire test procedure is user-controlled. In particular, stage 1 can last as long as necessary, and stages 2 and 3 can be interrupted. The test responds to the position and rising edges of the control input defined by the **LED TEST CONTROL** setting. The control pulses must last at least 250 ms to take effect. The following diagram explains how the test is executed.

Figure 5-50: LED test sequence



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Application example 1

Assume one needs to check if any of the LEDs is “burned” through user-programmable pushbutton 1. Apply the following settings.

Configure user-programmable pushbutton 1 by making the following entries in the **SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE PUSHBUTTONS ⇒ USER PUSHBUTTON 1** menu. (The option does not display when not purchased.)

PUSHBUTTON 1 FUNCTION: “Self-reset”

PUSHBTN 1 DROP-OUT TIME: “0.10 s”

Configure the LED test to recognize user-programmable pushbutton 1 by making the following entries in the **SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE LEDES ⇒ LED TEST** menu:

LED TEST FUNCTION: “Enabled”

LED TEST CONTROL: “PUSHBUTTON 1 ON”

The test is initiated when the user-programmable pushbutton 1 is pressed. Keep the pushbutton pressed for as long as the LEDs are being visually inspected. When finished, release the pushbutton. The relay then automatically starts stage 2. At this point, test can be cancelled by pressing the pushbutton.

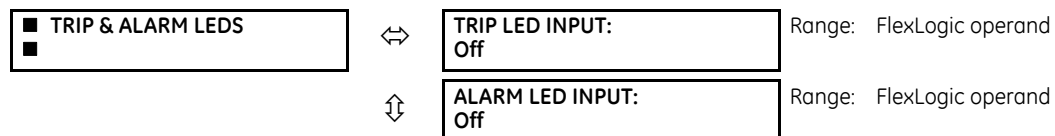
Application example 2

Assume one needs to check if any LEDs are “burned” as well as exercise one LED at a time to check for other failures. This is to be performed via user-programmable pushbutton 1.

After applying the settings in application example 1, hold down the pushbutton as long as necessary to test all LEDs. When finished, release the pushbutton so that the relay then automatically starts stage 2. When stage 2 is completed, stage 3 starts automatically. The test can be cancelled at any time by pressing the pushbutton.

5.3.11.4 Trip and alarm LEDs

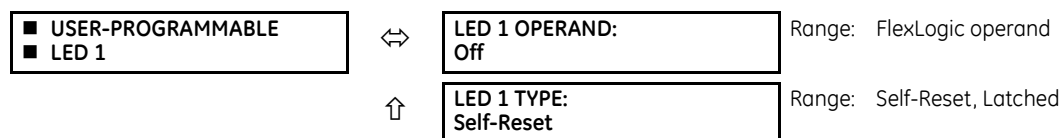
SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE LEDES ⇒ TRIP & ALARMS LEDES



The trip and alarm LEDs are in the first LED column (enhanced and graphical front panels) and on LED panel 1 (standard front panel). Each LED can be programmed to turn on when the selected FlexLogic operand is in the logic 1 state.

5.3.11.5 User-programmable LED 1(48)

SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE LEDES ⇒ USER-PROGRAMMABLE LED 1(48)



For the enhanced and standard front panels, there are 48 amber LEDs across the relay LED panels. Each of these indicators can be programmed to illuminate when the selected FlexLogic operand is in the logic 1 state.

For the standard front panel, the LEDs are located as follows:

- LED Panel 2 — User-programmable LEDs 1 through 24
- LED Panel 3 — User programmable LEDs 25 through 48

For the enhanced front panel, the LEDs are located as follows:

- LED column 2 — User-programmable LEDs 1 through 12
- LED column 3 — User-programmable LEDs 13 through 24
- LED column 4 — User-programmable LEDs 25 through 36
- LED column 5 — User-programmable LEDs 37 through 48

See the LED Indicators section in chapter 4 for information on the location of these indexed LEDs.

The user-programmable LED settings select the FlexLogic operands that control the LEDs. If the **LED 1 TYPE** setting is "Self-Reset" (the default setting), the LED illumination tracks the state of the selected LED operand. If the **LED 1 TYPE** setting is "Latched," the LED, once lit, remains so until reset by the front panel **RESET** button, from a remote device via a communications channel, or from any programmed operand, even if the LED operand state de-asserts.

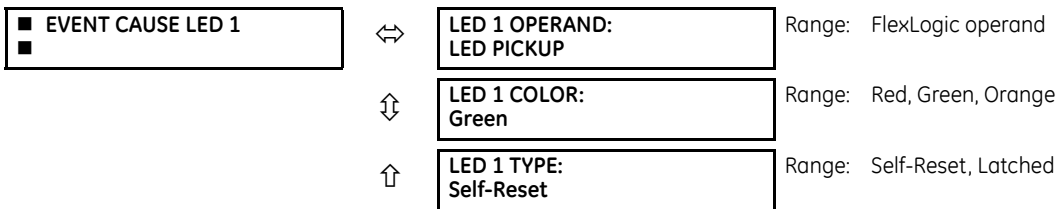
Table 5-15: Recommended settings for user-programmable LEDs

Setting	Parameter	Setting	Parameter
LED 1 operand	SETTING GROUP ACT 1	LED 13 operand	Off
LED 2 operand	SETTING GROUP ACT 2	LED 14 operand	BREAKER 2 OPEN
LED 3 operand	SETTING GROUP ACT 3	LED 15 operand	BREAKER 2 CLOSED
LED 4 operand	SETTING GROUP ACT 4	LED 16 operand	BREAKER 2 TROUBLE
LED 5 operand	SETTING GROUP ACT 5	LED 17 operand	SYNC 1 SYNC OP
LED 6 operand	SETTING GROUP ACT 6	LED 18 operand	SYNC 2 SYNC OP
LED 7 operand	Off	LED 19 operand	Off
LED 8 operand	Off	LED 20 operand	Off
LED 9 operand	BREAKER 1 OPEN	LED 21 operand	AR ENABLED
LED 10 operand	BREAKER 1 CLOSED	LED 22 operand	AR DISABLED
LED 11 operand	BREAKER 1 TROUBLE	LED 23 operand	AR RIP
LED 12 operand	Off	LED 24 operand	AR LO

5

5.3.11.6 Event cause LED 1(9)

SETTINGS ⇒ PRODUCT SETUP ⇒ ⇅ USER-PROGRAMMABLE LEADS ⇒ ⇅ EVENT CAUSE LED 1(9)



For the graphical front panel, the event cause LED settings select the FlexLogic operands that control the LEDs.

LED 1 TYPE — If set to "Self-Reset," the LED illumination tracks the state of the selected LED operand. If set to "Latched," the LED, once lit, remains so even the LED operand state already de-asserts, until reset by the front panel **RESET** button, from a remote device via a communications channel, or from any programmed operand.

The table outlines default input operand and output operands for each event cause LED.

Table 5-16: Default input and output operand for event cause LEDs

LED	Default input operand	Output operand	Default color
Event Cause LED 1	LED PICKUP	EVENT CAUSE LED 1	Green
Event Cause LED 2	LED VOLTAGE	EVENT CAUSE LED 2	Orange
Event Cause LED 3	LED CURRENT	EVENT CAUSE LED 3	Orange
Event Cause LED 4	LED FREQUENCY	EVENT CAUSE LED 4	Orange
Event Cause LED 5	LED OTHER	EVENT CAUSE LED 5	Orange
Event Cause LED 6	LED PHASE A	EVENT CAUSE LED 6	Orange
Event Cause LED 7	LED PHASE B	EVENT CAUSE LED 7	Orange
Event Cause LED 8	LED PHASE C	EVENT CAUSE LED 8	Orange
Event Cause LED 9	LED NEUTRAL/GROUND	EVENT CAUSE LED 9	Orange

5.3.12 User-programmable self-tests

SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE SELF TESTS

■ USER-PROGRAMMABLE ■ SELF TESTS	↔	RxGOOSE OFF FUNCTION: Enabled	Range: Disabled, Enabled
	⇅	FIRST ETHERNET FAIL FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	SEC. ETHERNET FAIL FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	THIRD ETHERNET FAIL FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	SFP MODULE FAIL FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	BATTERY FAIL FUNCTION: Enabled	Range: Disabled, Enabled
	⇅	SNTP FAIL FUNCTION: Enabled	Range: Disabled, Enabled
	⇅	IRIG-B FAIL FUNCTION: Enabled	Range: Disabled, Enabled
	↑	PTP FAIL FUNCTION: Enabled	Range: Disabled, Enabled

All major self-test alarms are reported automatically with their corresponding FlexLogic operands, events, and targets.

This settings menu allows enabling and disabling of most minor self-test alarms.

When in the Disabled mode, minor alarms do not assert a FlexLogic operand, write to the event recorder, or display target messages. Moreover, they do not trigger the ANY MINOR ALARM or ANY SELF-TEST messages. When in Enabled mode, minor alarms continue to function along with other major and minor alarms. See the Relay Self-tests section in chapter 7 for information on major and minor self-test alarms.

When using the graphical front panel and setting annunciator alarms, the function needs to be enabled here too, else the alarm is not triggered.

5.3.13 Control pushbuttons

SETTINGS ⇒ PRODUCT SETUP ⇒ CONTROL PUSHBUTTONS ⇒ CONTROL PUSHBUTTON 1(7)

■ CONTROL ■ PUSHBUTTON 1	↔	CONTROL PUSHBUTTON 1 ID CTRL PB 1	Range: up to 20 alphanumeric characters
	⇅	CONTROL PUSHBUTTON 1 FUNCTION: Disabled	Range: Disabled, Enabled
	↑	CONTROL PUSHBUTTON 1 EVENTS: Disabled	Range: Disabled, Enabled

This feature is supported with enhanced and standard front panels.

There are three standard control pushbuttons, labelled USER 1, USER 2, and USER 3, on the standard and enhanced front panels. These are user-programmable and can be used for various applications such as performing an LED test, switching setting groups, and invoking and scrolling through user-programmable displays.

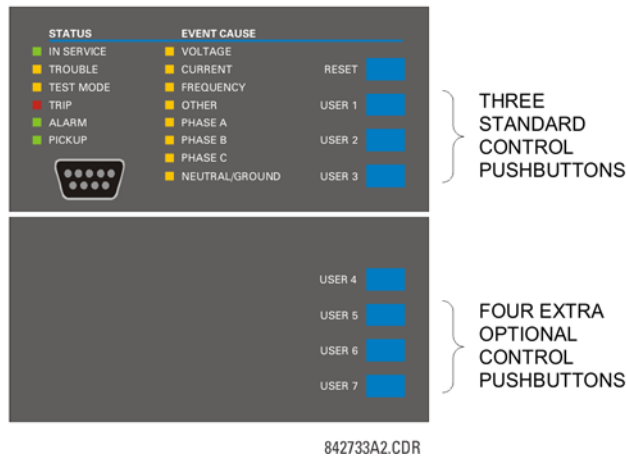
The location of the control pushbuttons are shown in the following figures.

Figure 5-51: Control pushbuttons (enhanced front panel)



An additional four control pushbuttons are included on the standard front panel when the L30 is ordered with the 12 user-programmable pushbutton option.

Figure 5-52: Control pushbuttons (standard front panel)



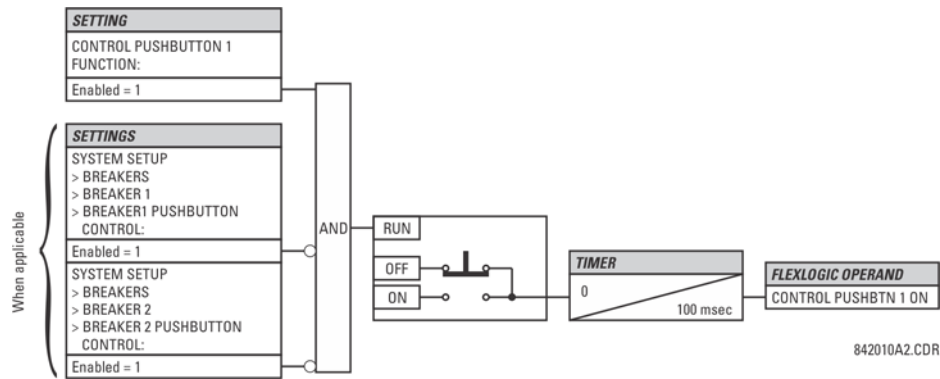
5

Control pushbuttons are not typically used for critical operations and are not protected by the control password. However, by supervising their output operands, the user can dynamically enable or disable control pushbuttons for security reasons. Each control pushbutton asserts its own FlexLogic operand. Each operand need to be configured appropriately to perform the required function. Each operand remains asserted as long as the pushbutton is pressed and resets when the pushbutton is released. A dropout delay of 100 ms is incorporated to ensure fast pushbutton manipulation is recognized by various features that can use control pushbuttons as inputs.

An event is logged in the event record (as per user setting) when a control pushbutton is pressed. No event is logged when the pushbutton is released. The front panel keys (including control keys) cannot be operated simultaneously—a given key must be released before the next one can be pressed.

The control pushbuttons become user-programmable only if the breaker control feature is not configured for manual control via the USER 1 through 3 pushbuttons as shown. If configured for manual control, breaker control typically uses the larger, optional user-programmable pushbuttons, making the control pushbuttons available for other user applications.

Figure 5-53: Control pushbutton logic



5.3.14 User-programmable pushbuttons

SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE PUSHBUTTONS ⇒ USER PUSHBUTTON 1(16)

■ USER PUSHBUTTON 1	↔	PUSHBUTTON 1 FUNCTION: Disabled	Range: Self-Reset, Latched, Disabled
	↕	PUSHBTN 1 ID TEXT: USER PB 1	Range: up to 20 alphanumeric characters
	↕	PUSHBTN 1 ON TEXT:	Range: up to 20 alphanumeric characters
	↕	PUSHBTN 1 OFF TEXT:	Range: up to 20 alphanumeric characters
	↕	PUSHBTN 1 HOLD: 0.0 s	Range: 0.0 to 10.0 s in steps of 0.1
	↕	PUSHBTN 1 SET: Off	Range: FlexLogic operand
	↕	PUSHBTN 1 RESET: Off	Range: FlexLogic operand
	↕	PUSHBTN 1 AUTORST: Disabled	Range: Disabled, Enabled
	↕	PUSHBTN 1 AUTORST DELAY: 1.0 s	Range: 0.2 to 600.0 s in steps of 0.1
	↕	PUSHBTN 1 REMOTE: Off	Range: FlexLogic operand
	↕	PUSHBTN 1 LOCAL: Off	Range: FlexLogic operand
	↕	PUSHBTN 1 DROP-OUT TIME: 0.00 s	Range: 0 to 60.00 s in steps of 0.05
	↕	PUSHBTN 1 LED CTL: Off	Range: FlexLogic operand
	↕	PUSHBTN 1 MESSAGE: Disabled	Range: Disabled, Normal, High Priority
	↑	PUSHBUTTON 1 EVENTS: Disabled	Range: Disabled, Enabled



The L30 is provided with this optional feature, specified as an option at the time of ordering. Using the order code for your device, see the order codes in chapter 2 for details.

User-programmable pushbuttons provide an easy and error-free method of entering digital state (on, off) information. The number depends on the front panel ordered.

- Enhanced horizontal front panel — 16 user-programmable pushbuttons
- Enhanced vertical front panel — 6 user-programmable pushbuttons
- Standard horizontal front panel — 12 user-programmable pushbuttons
- Graphical front panel — 16 user-programmable pushbuttons (eight physical pushbuttons, eight graphical interface pushbuttons)



NOTE

User-programmable pushbuttons require a front panel with that option. If the front panel was ordered separately, update the EnerVista software under **Maintenance > Change Front Panel**.

The digital state can be entered locally (by directly pressing the front panel pushbutton or optional graphical front panel interface) or remotely (via FlexLogic operands) into FlexLogic equations, protection elements, and control elements. Typical applications include breaker control, autorecloser blocking, and setting groups changes. For example, set pushbuttons 1 to 5 to select settings groups 1 to 5, or set pushbutton 1 to clear event records. The user-programmable pushbuttons are under the control level of password protection.

Example

To clear event records using pushbutton 1, set **Settings > Product Setup > Clear Relay Records > Clear Event Records** to FlexLogic operand **PUSHBUTTON 1 ON**. Then program the pushbutton by setting **Settings > Product Setup > User-Programmable Pushbuttons > Pushbutton 1 Function** to "Self-reset." For a graphical front panel, to use a side pushbutton 9 to 16 to clear the event records, it also needs to be programmed in a single-line diagram.

The figures show user-configurable pushbuttons for the front panels.

Figure 5-54: User-programmable pushbuttons (enhanced front panel)

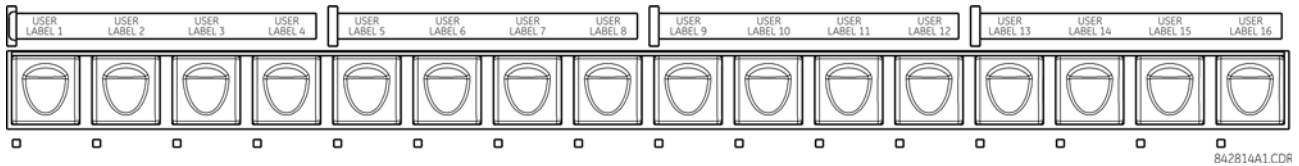


Figure 5-55: User-programmable pushbuttons (standard front panel)

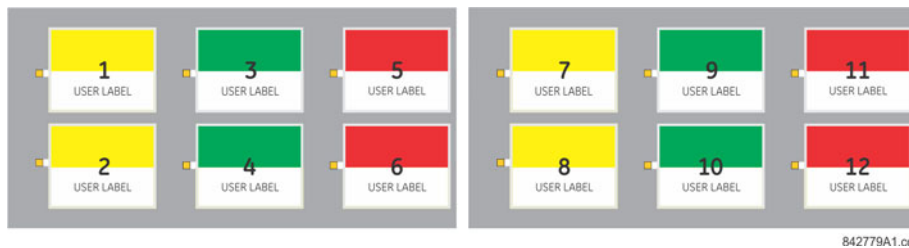
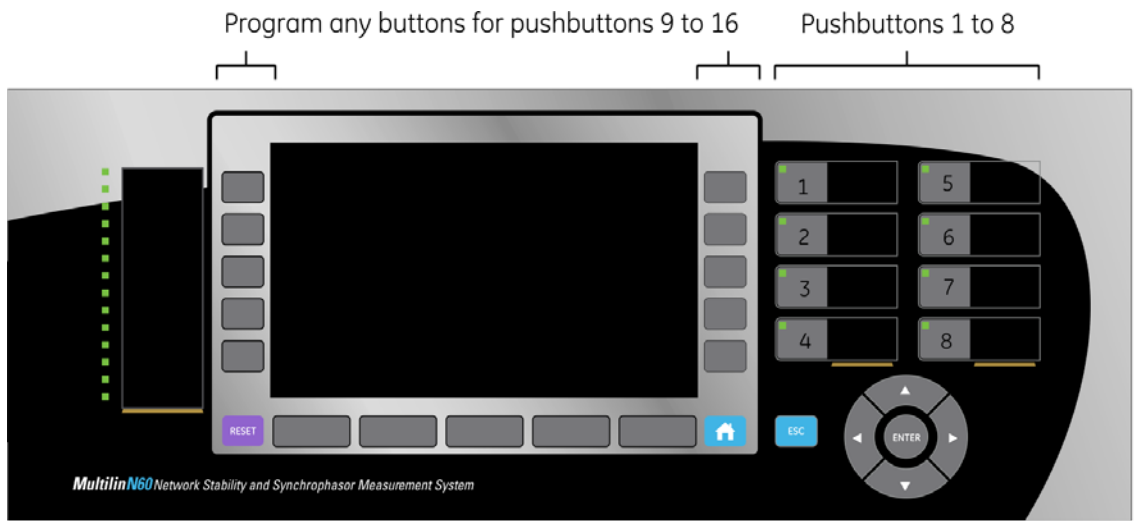


Figure 5-56: User-programmable pushbuttons (graphical front panel)



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Front panel pushbuttons and LEDs can be custom labelled as outlined in the Front Panel Labelling section in the previous chapter.

Each pushbutton asserts its own “On” and “Off” FlexLogic operands (for example, [PUSHBUTTON 1 ON](#) and [PUSHBUTTON 1 OFF](#)). These operands are available for each pushbutton and are used to program specific actions. If any pushbutton is active, the [ANY PB ON](#) operand is asserted.

Each pushbutton has an associated LED indicator. By default, this indicator displays the present status of the corresponding pushbutton (on or off). However, each LED indicator can be assigned to any FlexLogic operand through the [PUSHBTN 1 LED CTL](#) setting.

The activation and deactivation of user-programmable pushbuttons depends on whether latched or self-reset mode is programmed.

- **Latched mode** — In latched mode, a pushbutton can be set (activated) by asserting the operand assigned to the [PUSHBTN 1 SET](#) setting, by directly pressing the associated front panel pushbutton, or with the graphical front panel interface. The state of each pushbutton is stored in non-volatile memory and maintained through a loss of control power.

The pushbutton is reset (deactivated) in latched mode by asserting the operand assigned to the [PUSHBTN 1 RESET](#) setting, by directly pressing the active front panel pushbutton, or with the graphical front panel interface.

It can also be programmed to reset automatically through the [PUSHBTN 1 AUTORST](#) and [PUSHBTN 1 AUTORST DELAY](#) settings. These settings enable the autoreset timer and specify the associated time delay. The autoreset timer can be used in select-before-operate (SBO) breaker control applications, where the command type (close/open) or breaker location (feeder number) must be selected prior to command execution. The selection must reset automatically if control is not executed within a specified time period.

- **Self-reset mode** — In self-reset mode, a user-programmable pushbutton can be set (activated) by asserting the operand assigned to the [PUSHBTN 1 SET](#) setting, by pressing the front panel pushbutton, or by the graphical front panel interface. A pushbutton remains active for the time it is pressed physically or pressed in the graphical front panel interface, plus the dropout time specified in the [PUSHBTN 1 DROP-OUT TIME](#) setting. If the pushbutton is activated via FlexLogic, the pulse duration is specified by the [PUSHBTN 1 DROP-OUT TIME](#) only. The time the operand assigned to the [PUSHBTN 1 SET](#) setting remains On has no effect on the pulse duration.



The pulse duration of the remote set or local front panel pushbutton must be at least 50 ms to operate the pushbutton. This allows the user-programmable pushbuttons to properly operate during power cycling events and various system disturbances that can cause transient assertion of the operating signals.

The local and remote operation of each user-programmable pushbutton can be inhibited through the **PUSHBTN 1 LOCAL** and **PUSHBTN 1 REMOTE** settings. If local inhibit is applied, the pushbutton ignores set and reset commands executed through the front panel pushbuttons. If remote inhibit is applied, the pushbutton ignores set and reset commands executed through FlexLogic operands.

The inhibit functions are not applied to the autoreset feature. The inhibit function can be used in SBO control operations to prevent user-programmable pushbutton activation and ensuring “one-at-a-time” select operation.

The inhibit functions can also be used to prevent pushbutton activation from the accidental pressing of the front panel pushbuttons. The separate inhibit of the local and remote operation simplifies the implementation of local/remote control supervision.

Pushbutton states can be logged by the event recorder. User-defined messages can also be associated with each pushbutton and displayed on standard and enhanced front panels when the user-programmable pushbutton is activated, and when in the latched mode when the user-programmable pushbutton is deactivated. With the graphical front panel interface, instead of messages, the status of user-programmable pushbuttons can display on a single-line diagram and can also display in annunciator page windows and in actual values page cells.

For the graphical front panel, the pushbuttons 1 to 8 are linked to the eight physical pushbuttons, and pushbuttons 9 to 16 are mapped to the graphical interface pushbuttons. To set the buttons for pushbuttons 9 to 16, access **Settings > Product Setup > Graphical Panel > Single Line Diagram Editor**, click the PB symbol in the toolbox, then configure pushbuttons 9 to 16.

PUSHBUTTON 1 FUNCTION — This setting selects the mode of the pushbutton (Self-Reset, Latched, Disabled). If set to “Disabled,” the pushbutton is not active and the corresponding FlexLogic operands (both “On” and “Off”) are de-asserted. If set to “Latched,” the pushbutton remains on until reset.

PUSHBTN 1 ID TEXT — This setting specifies the top 20-character line of the user-programmable pushbutton message and is intended to provide ID information of the pushbutton. For example, the text displays in the Event Record. See the User-definable Displays section in this chapter for instructions on how to enter alphanumeric characters from the keypad. On a graphical front panel, this setting instead controls the label of the user-programmable pushbutton component on single-line diagrams.

PUSHBTN 1 ON TEXT — This setting specifies the bottom 20-character line of the user-programmable pushbutton message and is displayed when the pushbutton is in the “on” position. See the User-definable Displays section for instructions on entering alphanumeric characters from the keypad. On a graphical front panel, this setting instead controls the on status text of the user-programmable pushbutton component on single-line diagrams. This setting is not applied to the physical pushbuttons on the graphical front panel.

PUSHBTN 1 OFF TEXT — This setting specifies the bottom 20-character line of the user-programmable pushbutton message and displays when the pushbutton is deactivated and the **PUSHBUTTON 1 FUNCTION** is “Latched.” A message does not display when the **PUSHBUTTON 1 FUNCTION** is “Self-reset” as the pushbutton operand status is implied to be “Off” upon its release. The length of the “Off” message is configured with the **PRODUCT SETUP ⇒ DISPLAY PROPERTIES ⇒ FLASH MESSAGE TIME** setting. On a graphical front panel, this setting instead controls the off status text of the user-programmable pushbutton component on single-line diagrams. This setting is not applied to the physical pushbuttons on the graphical front panel.

PUSHBTN 1 HOLD — This setting specifies the time required for a front panel pushbutton to be pressed before it is deemed active. This timer is reset upon release of the pushbutton. Note that user-programmable pushbutton operation requires the front panel pushbutton to be pressed a minimum of 50 ms. This minimum time is required prior to activating the user-programmable pushbutton hold timer.

PUSHBTN 1 SET — This setting assigns the FlexLogic operand serving to activate the user-programmable pushbutton element. The duration of the incoming set signal must be at least 50 ms.

PUSHBTN 1 RESET — This setting assigns the FlexLogic operand serving to deactivate the user-programmable pushbutton element. This setting is applicable only if the user-programmable pushbutton is in “Latched” mode.

PUSHBTN 1 AUTORST — This setting enables the user-programmable pushbutton autoreset feature. This setting is applicable only if the pushbutton is in “Latched” mode.

PUSHBTN 1 AUTORST DELAY — This setting specifies the time delay for automatic reset of the pushbutton when in “Latched” mode.

PUSHBTN 1 REMOTE — This setting assigns the FlexLogic operand serving to inhibit user-programmable pushbutton operation from the operand assigned to the **PUSHBTN 1 SET** or **PUSHBTN 1 RESET** settings.

PUSHBTN 1 LOCAL — This setting assigns the FlexLogic operand serving to inhibit user-programmable pushbutton operation from the front panel pushbuttons. This inhibit functionality is not applicable to pushbutton autoreset.

PUSHBTN 1 DROP-OUT TIME — This setting applies only to "Self-Reset" mode and specifies the duration of the user-programmable pushbutton active status after the front panel pushbutton or graphical front panel interface pushbutton has been released. When activated remotely, this setting specifies the entire activation time of the pushbutton; the length of time the operand selected by **PUSHBTN 1 SET** remains on has no effect on the pulse duration.

PUSHBTN 1 LED CTL — This setting assigns the FlexLogic operand serving to drive the front panel pushbutton LED. If this setting is "Off," then LED operation is directly linked to the **PUSHBUTTON 1 ON** operand. This setting is not applied to Pushbuttons 9 to 16 on the graphical front panel, where the label background shows the orange glow color for the "on" state.

PUSHBTN 1 MESSAGE — This setting controls the behavior of the user-programmable pushbutton on message that is programmed in the **PUSHBTN 1 ID** and **PUSHBTN 1 ON TEXT** settings, and the behavior of the user-programmable pushbutton off message that is programmed in the **PUSHBTN 1 ID** and **PUSHBTN 1 OFF TEXT** settings. This settings has no effect on the graphical front panel.

When set to "Disabled", user-programmable pushbutton messages do not display. Otherwise the on message displays when the user-programmable pushbutton becomes activated, and if in the "Latched" mode the off message displays when the user-programmable pushbutton becomes deactivated.

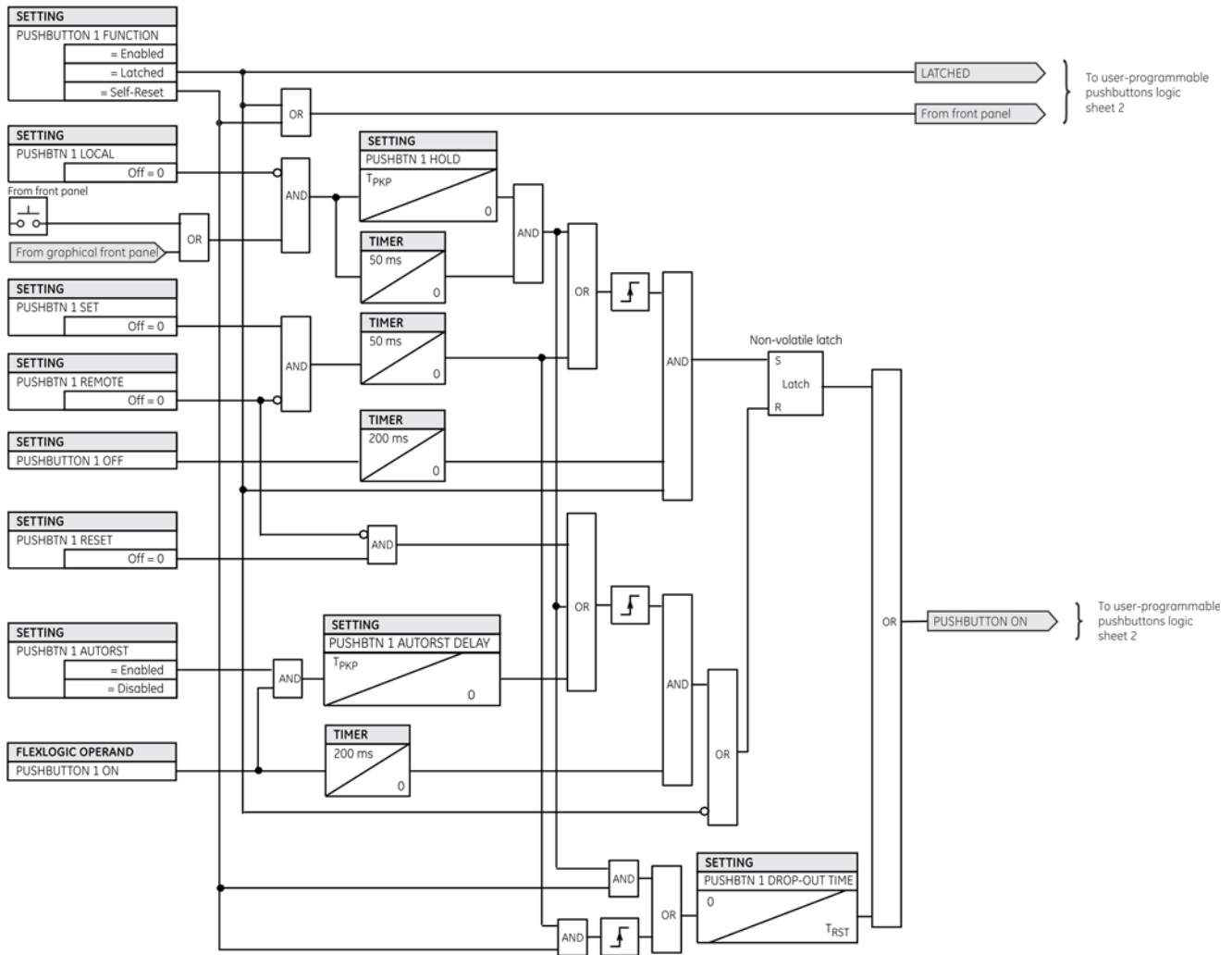
When set to "Normal", the duration the message displays is as specified by the **FLASH MESSAGE TIME** setting.

When set to "High Priority", the duration of the off message is as specified by the **FLASH MESSAGE TIME** setting, but the on message is displayed as long as the user-programmable pushbutton is activated. While activated, target and other messages are suppressed. To allow front panel keypad operation, when a keypad button is pressed the message is suppressed for 10 seconds.

PUSHBUTTON 1 EVENTS — If this setting is enabled, each user-programmable pushbutton state change is logged as an event into the event recorder.

The figures show the user-programmable pushbutton logic.

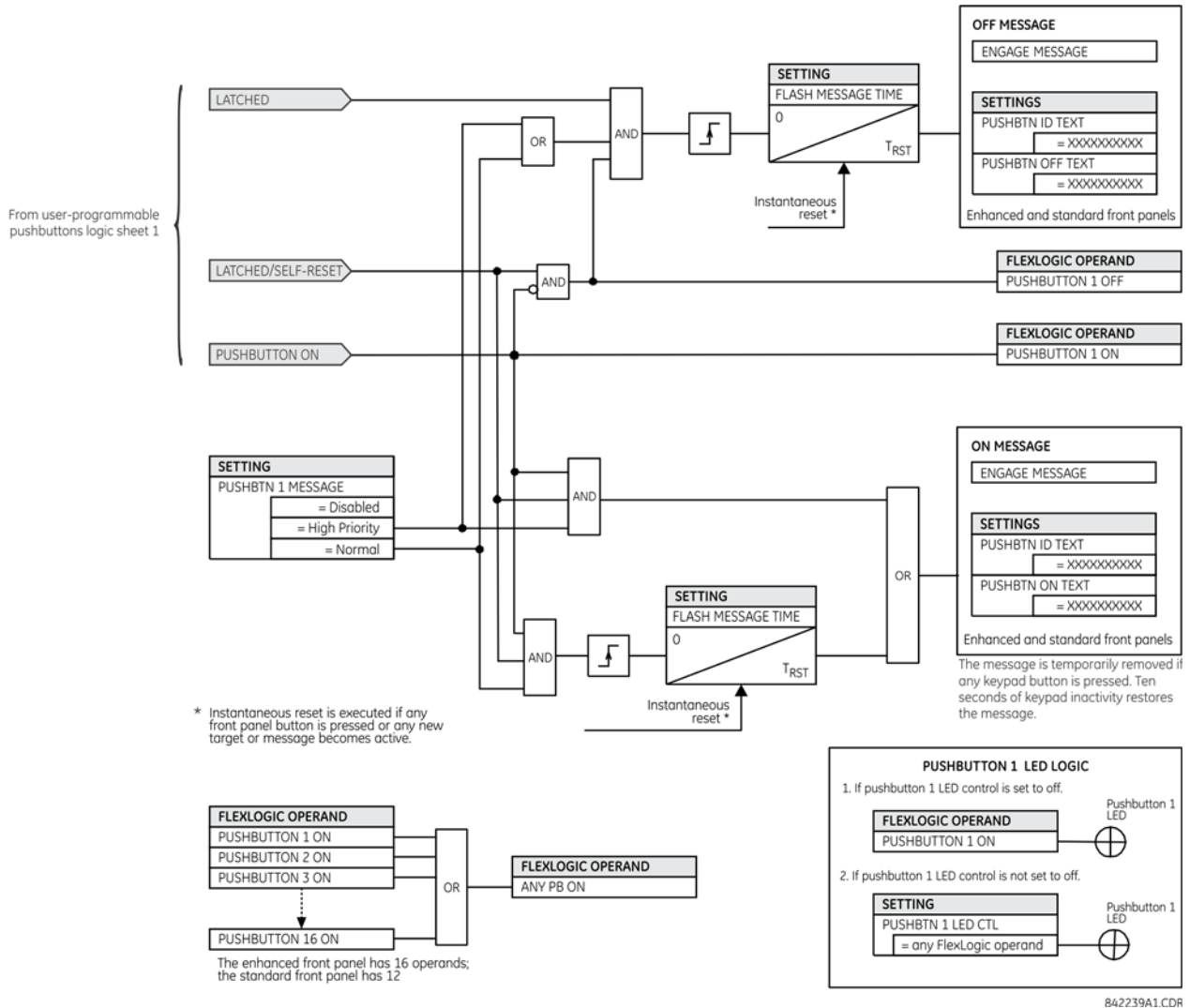
Figure 5-57: User-programmable pushbutton logic (Sheet 1 of 2)



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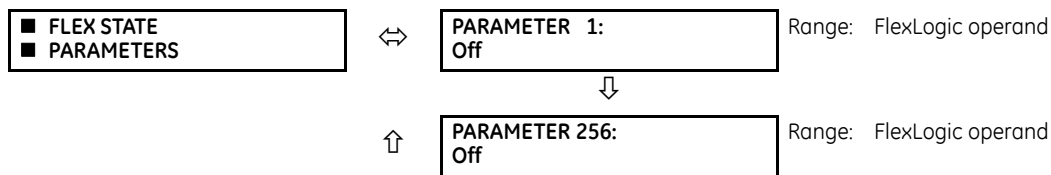
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Figure 5-58: User-programmable pushbutton logic (Sheet 2 of 2)



5.3.15 Flex state parameters

SETTINGS ⇒ PRODUCT SETUP ⇒ FLEX STATE PARAMETERS



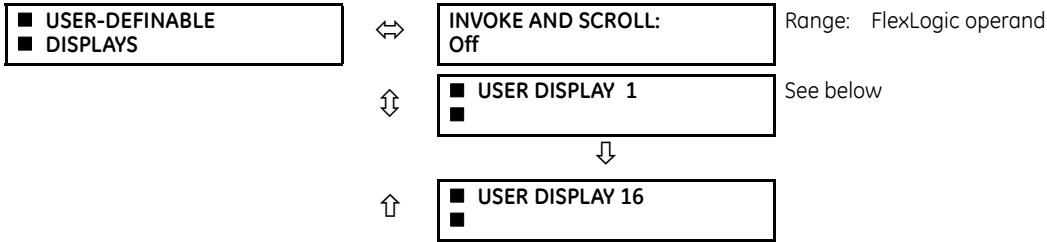
This feature provides a mechanism where any of 256 selected FlexLogic operand states can be used for efficient monitoring. The feature allows user-customized access to the FlexLogic operand states in the relay. The state bits are packed so that 16 states are readable in a single Modbus register. The state bits can be configured so that all states of interest are available in a minimum number of Modbus registers.

The state bits can be read out in the “Flex States” register array beginning at Modbus address 0900h. Sixteen states are packed into each register, with the lowest-numbered state in the lowest-order bit. Sixteen registers accommodate the 256 state bits.

5.3.16 User-definable displays

5.3.16.1 Menu

SETTINGS ⇒ PRODUCT SETUP ⇒⇅ USER-DEFINABLE DISPLAYS



This feature is supported with enhanced and standard front panels.

This menu provides a mechanism for manually creating up to 16 user-defined information displays in a convenient viewing sequence in the **USER DISPLAY** menu (between the **TARGETS** and **ACTUAL VALUES** top-level menus). The sub-menus facilitate text entry and Modbus register data pointer options for defining the user display content.

This feature is not supported with the optional graphical front panel.

Once programmed, the user-definable displays can be viewed in two ways.

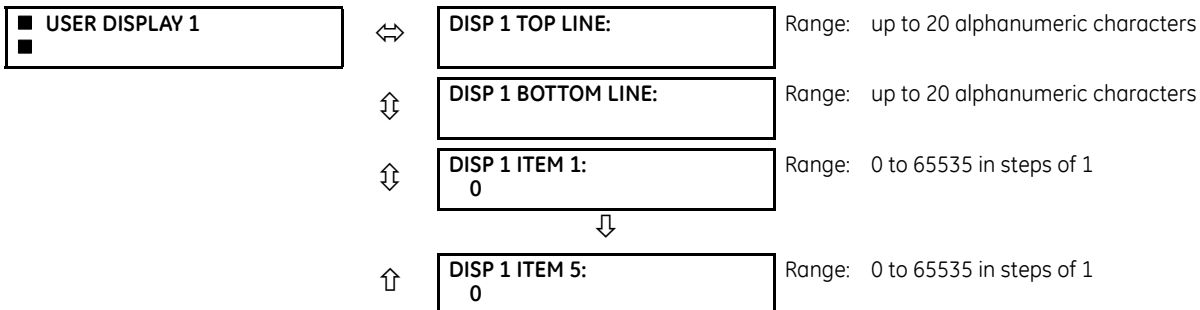
- **Keypad** — Use the **MENU** key to select the **USER DISPLAY** menu item to access the first user-definable display (note that only the programmed screens are displayed). The screens can be scrolled using the up and down arrow keys. The display disappears after the default message time-out period specified by the **PRODUCT SETUP ⇒⇅ DISPLAY PROPERTIES ⇒⇅ DEFAULT MESSAGE TIMEOUT** setting.
- **User-programmable control input** — The user-definable displays also respond to the **INVOKE AND SCROLL** setting. Any FlexLogic operand (in particular, the user-programmable pushbutton operands), can be used to navigate the programmed displays.

On the rising edge of the configured operand (such as when the pushbutton is pressed), the displays are invoked by showing the last user-definable display shown during the previous activity. From this moment onward, the operand acts exactly as the down key and allows scrolling through the configured displays. The last display wraps up to the first one. The **INVOKE AND SCROLL** input and the down arrow key operate concurrently.

When the default timer expires (set by the **DEFAULT MESSAGE TIMEOUT** setting), the relay starts to cycle through the user displays. The next activity of the **INVOKE AND SCROLL** input stops the cycling at the currently displayed user display, not at the first user-defined display. The **INVOKE AND SCROLL** pulses must last for at least 250 ms to take effect.

5.3.16.2 User display 1(16)

SETTINGS ⇒ PRODUCT SETUP ⇒⇅ USER-DEFINABLE DISPLAYS ⇒⇅ USER DISPLAY 1(16)



Any existing system display can be automatically copied into an available user display by selecting the existing display and pressing the **ENTER** key. The display then prompts with **ADD TO USER DISPLAY LIST?** After selecting “Yes,” a message indicates that the selected display has been added to the user display list. When this type of entry occurs, the sub-menus are automatically configured with the proper content—this content can be edited subsequently.

This menu is used to enter user-defined text and user-selected Modbus-registered data fields into the particular user display. Each user display consists of two 20-character lines (top and bottom). The tilde (~) character is used to mark the start of a data field – the length of the data field needs to be accounted for. Up to five separate data fields can be entered in a user display – the *n*th tilde (~) refers to the *n*th item.

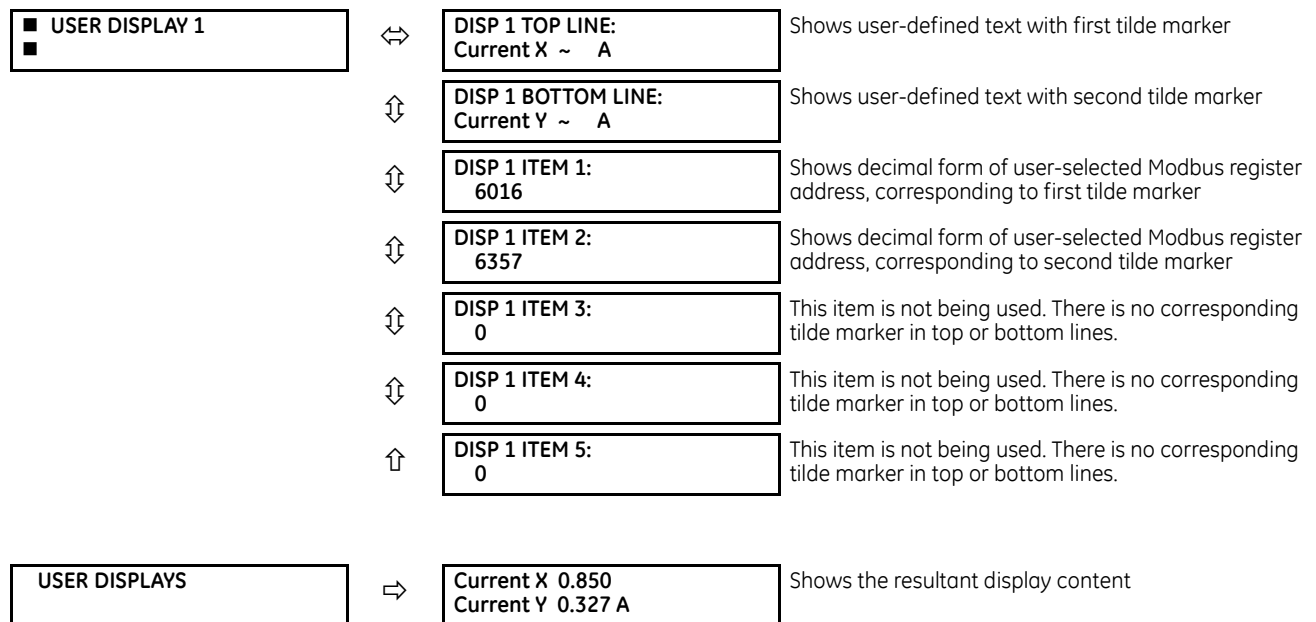
A user display can be entered from the front panel keypad or the EnerVista interface (preferred for convenience). The following procedure shows how to enter text characters in the top and bottom lines from the front panel keypad:

1. Select the line to be edited.
2. Press the decimal key to enter text edit mode.
3. Use either **VALUE** key to scroll through the characters. A space is selected like a character.
4. Press the decimal key to advance the cursor to the next position.
5. Repeat step 3 and continue entering characters until the desired text is displayed.
6. The **HELP** key can be pressed at any time for context sensitive help information.
7. Press the **ENTER** key to store the new settings.

To enter a numerical value for any of the five items (the *decimal form* of the selected Modbus address) from the front panel keypad, use the number keypad. Use the value of "0" for any items not being used. Use the **HELP** key at any selected system display (setting, actual value, or command) which has a Modbus address, to view the *hexadecimal form* of the Modbus address, then manually convert it to decimal form before entering it (EnerVista usage conveniently facilitates this conversion).

Use the **MENU** key to go to the user displays menu to view the user-defined content. The current user displays show in sequence, changing every four seconds. While viewing a user display, press the **ENTER** key and then select the 'Yes' option to remove the display from the user display list. Use the **MENU** key again to exit the user displays menu.

An example of user display setup and result is shown as follows.



If the parameters for the top line and the bottom line items have the same units, then the unit is displayed on the bottom line only. The units are only displayed on both lines if the units specified both the top and bottom line items are different.

5.3.17 Installation

SETTINGS ⇒ PRODUCT SETUP ⇕ INSTALLATION



↑ RELAY NAME:
Relay-1 Range: up to 20 alphanumeric characters

RELAY SETTINGS — To safeguard against the installation of a relay without any entered settings, the unit does not allow signaling of any output relay until **RELAY SETTINGS** is set to "Programmed." This setting is "Not Programmed" by default. The UNIT NOT PROGRAMMED self-test error message displays until the relay is put into the "Programmed" state.

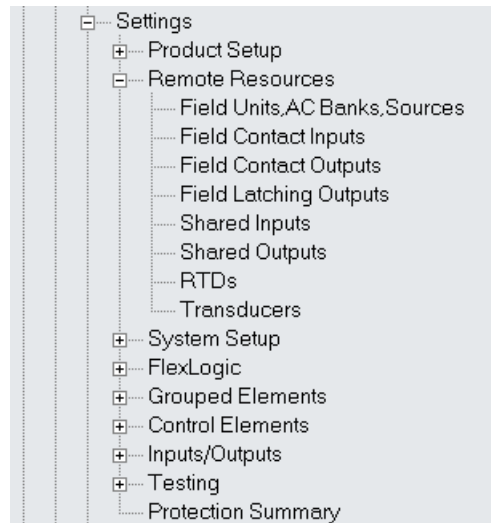
RELAY NAME — This setting allows the user to uniquely identify a relay. This name appears on generated reports.

5.4 Remote resources

5.4.1 Remote resources configuration

When the L30 is ordered with a process card module as a part of HardFiber system, an additional **Remote Resources** menu tree is available in the EnerVista software to allow configuration of the HardFiber system.

Figure 5-59: Remote Resources configuration menu



The remote resources settings configure a L30 with a process bus module to work with HardFiber Bricks. Remote resources configuration is only available through the EnerVista software, and is not available through the L30 front panel. A Brick provides eight AC measurements, along with contact inputs, DC analog inputs, and contact outputs, to be the remote interface to field equipment such as circuit breakers and transformers. The L30 with a process bus module has access to all of the capabilities of up to eight Bricks. Remote resources settings configure the point-to-point connection between specific fiber optic ports on the L30 process card and specific Brick. The relay is then configured to measure specific currents, voltages and contact inputs from those Bricks, and to control specific outputs.

The configuration process for remote resources is straightforward and consists of the following steps.

- Configure the field units. This establishes the point-to-point connection between a specific port on the relay process bus module, and a specific digital core on a specific Brick. This is a necessary first step in configuring a process bus relay.
- Configure the AC banks. This sets the primary and secondary quantities and connections for currents and voltages. AC bank configuration also provides a provision for redundant measurements for currents and voltages, a powerful reliability improvement possible with process bus.
- Configure signal sources. This functionality of the L30 has not changed other than the requirement to use currents and voltages established by AC bank configuration under the remote resources menu.
- Configure field contact inputs, field contact outputs, RTDs, and transducers as required for the application's functionality. These inputs and outputs are the physical interface to circuit breakers, transformers, and other

equipment. They replace the traditional contact inputs and outputs located at the relay to virtually eliminate copper wiring.

- Configure shared inputs and outputs as required for the application's functionality. Shared inputs and outputs are distinct binary channels that provide high-speed protection quality signaling between relays through a Brick.

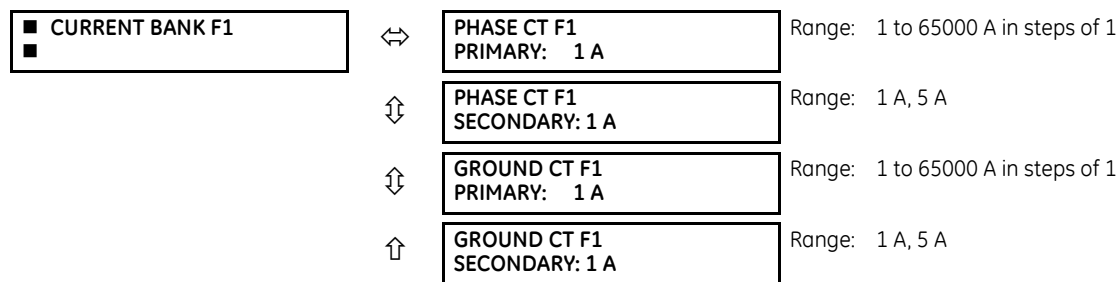
For additional information on how to configure a relay with a process bus module, see the HardFiber Process Bus System Instruction Manual.

5.5 System setup

5.5.1 AC inputs

5.5.1.1 Current banks

SETTINGS ⇒ SYSTEM SETUP ⇒ AC INPUTS ⇒ CURRENT BANK F1(F5)



Four banks of phase and ground CTs can be set, where the current banks are denoted in the following format (X represents the module slot position letter):

Xa , where $X = \{F\}$ and $a = \{1, 5\}$

See the Introduction to AC Sources section at the beginning of this chapter for details.

These settings are critical for all features that have settings dependent on current measurements. When the relay is ordered, the CT module must be specified to include a standard or sensitive ground input. As the phase CTs are connected in wye (star), the calculated phasor sum of the three phase currents ($I_A + I_B + I_C = \text{neutral current} = 3I_0$) is used as the input for the neutral overcurrent elements. In addition, a zero-sequence (core balance) CT which senses current in all of the circuit primary conductors, or a CT in a neutral grounding conductor can also be used. For this configuration, the ground CT primary rating must be entered. To detect low level ground fault currents, the sensitive ground input can be used. In this case, the sensitive ground CT primary rating must be entered. See chapter 3 for more details on CT connections.

Enter the rated CT primary current values. For both 1000:5 and 1000:1 CTs, the entry would be 1000. For correct operation, the CT secondary rating must match the setting (which must also correspond to the specific CT connections used).

The following example illustrates how multiple CT inputs (current banks) are summed as one source current. Given the following current banks:

- F1: CT bank with 500:1 ratio
- F5: CT bank with 1000:1 ratio

The following rule applies:

$$\text{SRC1} = \text{F1} + \text{F5} \quad \text{Eq. 5-6}$$

1 pu is the highest primary current. In this case, 1000 is entered and the secondary current from the 500:1 ratio CT is adjusted to that created by a 1000:1 CT before summation. If a protection element is set up to act on SRC 1 currents, then a pickup level of 1 pu operates on 1000 A primary.

The same rule applies for current sums from CTs with different secondary taps (5 A and 1 A).

5.5.1.2 Voltage banks

SETTINGS ⇒ SYSTEM SETUP ⇒ AC INPUTS ⇒ VOLTAGE BANK F5

<div style="border: 1px solid black; padding: 2px;"> <p>■ VOLTAGE BANK F5</p> <p>■</p> </div>	↔	<p>PHASE VT F5 CONNECTION: Wye</p>	Range: Wye, Delta
	↕	<p>PHASE VT F5 SECONDARY: 66.4 V</p>	Range: 25.0 to 240.0 V in steps of 0.1
	↕	<p>PHASE VT F5 RATIO: 1.00 :1</p>	Range: 1.00 to 24000.00 in steps of 0.01
	↕	<p>AUXILIARY VT F5 CONNECTION: Vag</p>	Range: Vn, Vag, Vbg, Vcg, Vab, Vbc, Vca
	↕	<p>AUXILIARY VT F5 SECONDARY: 66.4 V</p>	Range: 25.0 to 240.0 V in steps of 0.1
	↑	<p>AUXILIARY VT F5 RATIO: 1.00 :1</p>	Range: 1.00 to 24000.00 in steps of 0.01

Two banks of phase/auxiliary VTs can be set, where voltage banks are denoted in the following format (X represents the module slot position letter):

Xa, where X = {F} and a = {5}

See the Introduction to AC Sources section at the beginning of this chapter for details.

With VTs installed, the relay can perform voltage measurements as well as power calculations. Enter the **PHASE VT F5 CONNECTION** made to the system as “Wye” or “Delta.” An open-delta source VT connection is entered as “Delta.”

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The nominal **PHASE VT F5 SECONDARY** voltage setting is the voltage across the relay input terminals when nominal voltage is applied to the VT primary.

For example, on a system with a 13.8 kV nominal primary voltage and with a 14400:120 volt VT in a delta connection, the secondary voltage is 115; that is, $(13800 / 14400) \times 120$. For a wye connection, the voltage value entered must be the phase to neutral voltage, which is $115 / \sqrt{3} = 66.4$.

On a 14.4 kV system with a delta connection and a VT primary to secondary turns ratio of 14400:120, the voltage value entered is 120; that is, $14400 / 120$.

5.5.2 Power system

SETTINGS ⇒ SYSTEM SETUP ⇒ POWER SYSTEM

<div style="border: 1px solid black; padding: 2px;"> <p>■ POWER SYSTEM</p> <p>■</p> </div>	↔	<p>NOMINAL FREQUENCY: 60 Hz</p>	Range: 25 to 60 Hz in steps of 1
	↕	<p>PHASE ROTATION: ABC</p>	Range: ABC, ACB
	↕	<p>FREQUENCY AND PHASE REFERENCE: SRC 1</p>	Range: SRC 1, SRC 2
	↑	<p>FREQUENCYTRACKING: Enabled</p>	Range: Disabled, Enabled

The power system **NOMINAL FREQUENCY** value is used as a default to set the digital sampling rate if the system frequency cannot be measured from available signals. This can happen if the signals are not present or are heavily distorted. Before reverting to the nominal frequency, the frequency tracking algorithm holds the last valid frequency measurement for a safe period of time while waiting for the signals to reappear or for the distortions to decay.

The phase sequence of the power system is required to properly calculate sequence components and power parameters. The **PHASE ROTATION** setting matches the power system phase sequence and informs the relay of the actual system phase sequence, either ABC or ACB. CT and VT inputs on the relay, labelled as A, B, and C, must be connected to system phases A, B, and C for correct operation.

The **FREQUENCY AND PHASE REFERENCE** setting determines which signal source is used (and hence which AC signal) for phase angle reference. The AC signal used is prioritized based on the AC inputs configured for the signal source. Phase voltages takes precedence, followed by auxiliary voltage, then phase currents, and finally ground current.

For three phase selection, phase A is used for angle referencing ($V_{\text{ANGLE REF}} = V_A$), while Clarke transformation of the phase signals is used for frequency metering and tracking ($V_{\text{FREQUENCY}} = (2V_A - V_B - V_C) / 3$) for better performance during fault, open pole, and VT and CT fail conditions.

The phase reference and frequency tracking AC signals are selected based upon the source configuration, regardless of whether or not a particular signal is actually applied to the relay.

Phase angle of the reference signal always displays zero degrees and all other phase angles are relative to this signal. If the pre-selected reference signal is not measurable at a given time, the phase angles are not referenced.

The phase angle referencing is done via a phase locked loop, which can synchronize independent UR-series relays if they have the same AC signal reference. This results in very precise correlation of phase angle indications between different UR-series relays.

FREQUENCY TRACKING is set to “Disabled” only in unusual circumstances; consult GE Grid Solutions for special variable-frequency applications.



The frequency tracking feature functions only when the L30 is in the “Programmed” mode. If the L30 is “Not Programmed,” then metering values are available but can exhibit significant errors.



Select the nominal system frequency as 50 Hz or 60 Hz only. The **FREQUENCY AND PHASE REFERENCE** setting, used as a reference for calculating all angles, must be identical for all terminals. Whenever the 87L function is “Enabled,” the frequency tracking function is disabled, and frequency tracking is driven by the UR algorithm. Whenever the 87L function is “Disabled,” the frequency tracking mechanism reverts to the UR-series mechanism that uses the **FREQUENCY TRACKING** setting to provide frequency tracking for all other elements and functions.

5.5.3 Signal sources

SETTINGS ⇨ SYSTEM SETUP ⇨ SIGNAL SOURCES ⇨ SOURCE 1(2)

<div style="border: 1px solid black; padding: 2px;"> ■ SOURCE 1 ■ </div>	↔	<div style="border: 1px solid black; padding: 2px;"> SOURCE 1 NAME: SRC 1 </div>	Range: up to 20 alphanumeric characters
	⇅	<div style="border: 1px solid black; padding: 2px;"> SOURCE 1 PHASE CT: None </div>	Range: None, F1,... up to any 6 CTs. Only Phase CT inputs are displayed.
	⇅	<div style="border: 1px solid black; padding: 2px;"> SOURCE 1 GROUND CT: None </div>	Range: None, F1,... up to any 6 CTs. Only Ground CT inputs are displayed.
	⇅	<div style="border: 1px solid black; padding: 2px;"> SOURCE 1 PHASE VT: None </div>	Range: None, F5 Only phase voltage inputs are displayed
	↑	<div style="border: 1px solid black; padding: 2px;"> SOURCE 1 AUX VT: None </div>	Range: None, F5 Only auxiliary voltage inputs are displayed

Identical menus are available for each source. The “SRC 1” text can be replaced by with a user-defined name appropriate for the associated source.

The first letter in the source identifier represents the module slot position. The number directly following this letter represents either the first bank of four channels (1, 2, 3, 4) called “1” or the second bank of four channels (5, 6, 7, 8) called “5” in a particular CT/VT module. See the Introduction to AC Sources section at the beginning of this chapter for details.

It is possible to select the sum of all CT combinations. The first channel displayed is the CT to which all others are referred. For example, the selection "F1+F5" indicates the sum of each phase from channels "F1" and "F5," scaled to whichever CT has the higher ratio. Selecting "None" hides the associated actual values.

The approach used to configure the AC sources consists of several steps; first step is to specify the information about each CT and VT input. For CT inputs, this is the nominal primary and secondary current. For VTs, this is the connection type, ratio and nominal secondary voltage. Once the inputs have been specified, the configuration for each source is entered, including specifying which CTs are summed together.

5.5.3.1 User selection of AC parameters for comparator elements

CT/VT modules automatically calculate all current and voltage parameters from the available inputs. Users must select the specific input parameters to be measured by every element in the relevant settings menu. The internal design of the element specifies which type of parameter to use and provides a setting for source selection. In elements where the parameter can be either fundamental or RMS magnitude, such as phase time overcurrent, two settings are provided. One setting specifies the source, the second setting selects between fundamental phasor and RMS.

5.5.3.2 AC input actual values

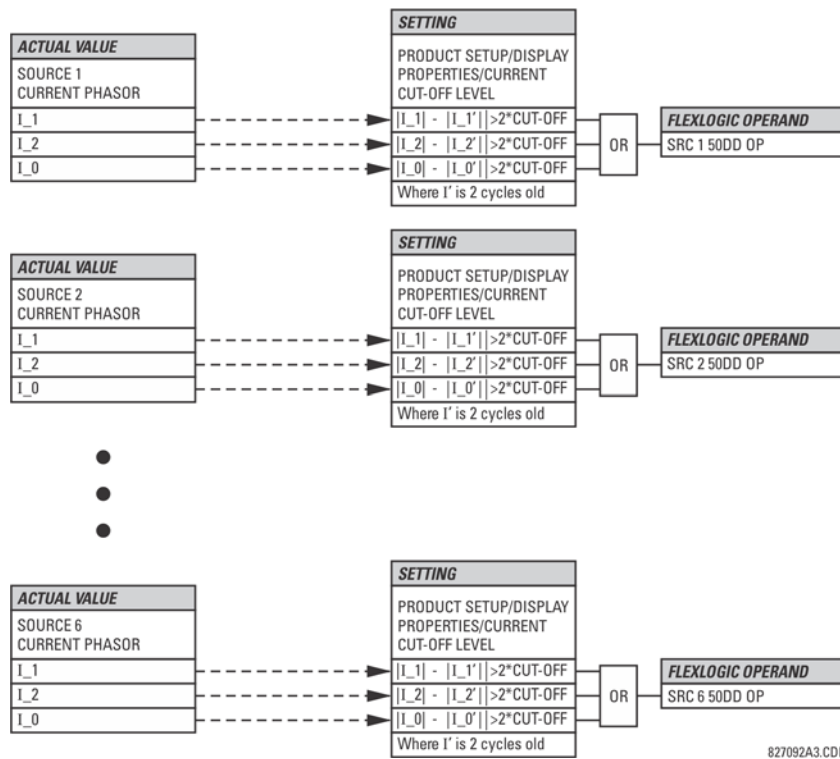
The calculated parameters associated with the configured voltage and current inputs are displayed in the current and voltage sections of actual values. Only the phasor quantities associated with the actual AC physical input channels display here. All parameters contained within a configured source are displayed in the sources section of the actual values.

5.5.3.3 Disturbance detectors (internal)

The disturbance detector (ANSI 50DD) element is a sensitive current disturbance detector that detects any disturbance on the protected system. The 50DD function is used directly in some elements in the relay, for example VT Fuse Failure detector or Fault Report. It can also be used to supervise current-based elements to prevent maloperation as a result of the wrong settings or external CT wiring problem. A disturbance detector is provided for each source.

The 50DD function responds to the changes in magnitude of the sequence currents. The disturbance detector logic is as follows.

Figure 5-60: Disturbance detector logic



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The disturbance detector responds to the change in currents of twice the current cut-off level. The default cut-off threshold is 0.02 pu; thus by default the disturbance detector responds to a change of 0.04 pu. The metering sensitivity setting (**PRODUCT SETUP** ⇒ **DISPLAY PROPERTIES** ⇒ **CURRENT CUT-OFF LEVEL**) controls the sensitivity of the disturbance detector accordingly.

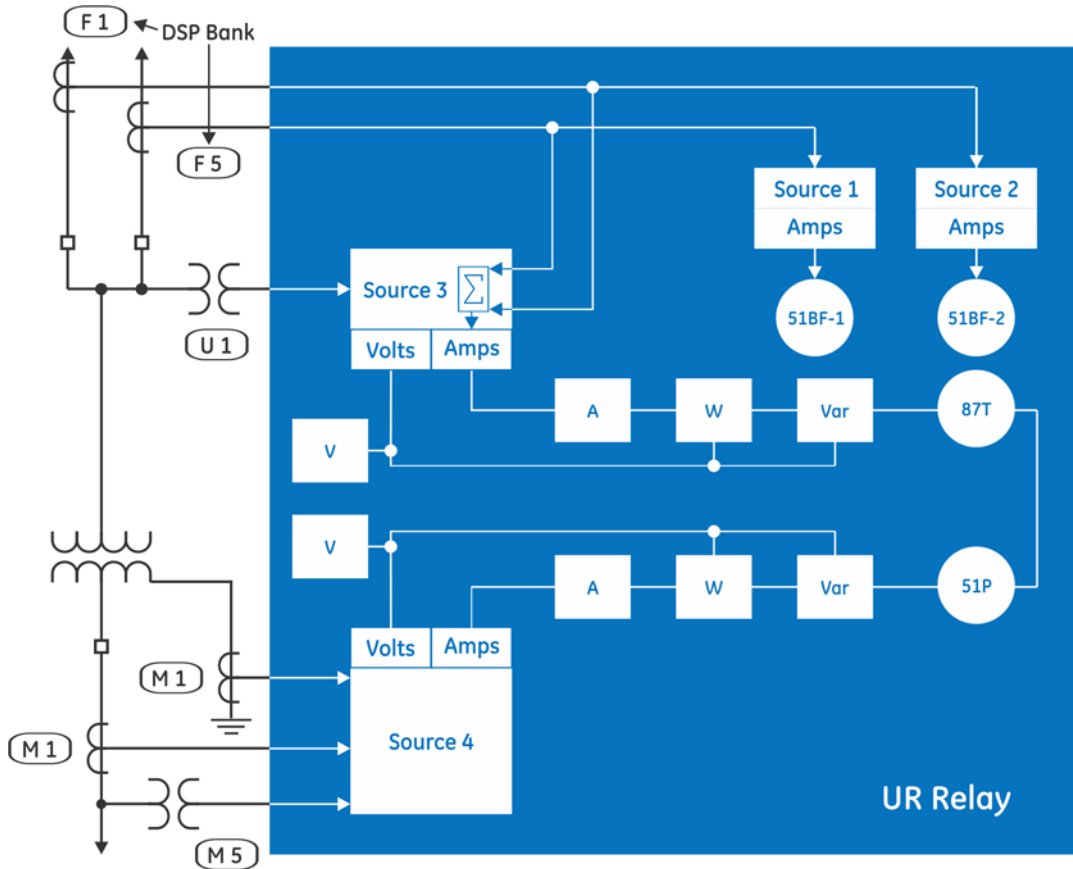
5.5.3.4 Example for use of sources

An example of the use of sources is shown in the following figure. A relay can have the following hardware configuration:

	Increasing slot position letter -->		
UR	CT/VT module 1	CT/VT module 2	CT/VT module 3
B30, B90, C70, F35, N60, T35	8 CTs	4 CTs, 4 VTs	4 CTs, 4 VTs
C60, D60, G30, G60, L30, L90, M60, T60	CTs	VTs	not applicable

This configuration can be used on a two-winding transformer, with one winding connected into a breaker-and-a-half system. The following figure shows the arrangement of sources used to provide the functions required in this application, and the CT/VT inputs that are used to provide the data.

Figure 5-61: Example of use of sources



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	Y LV	D HV	AUX
	SRC 1	SRC 2	SRC 3
Phase CT	M1	F1+F5	None
Ground CT	M1	None	None
Phase VT	M5	None	None
Aux VT	None	None	U1

5.5.4 87L power system

5.5.4.1 Menu

SETTINGS ⇄ SYSTEM SETUP ⇄ 87L POWER SYSTEM

<input checked="" type="checkbox"/> 87L POWER SYSTEM	⇄	NUMBER OF TERMINALS: 2	Range: 2, 3
	⇄	NUMBER OF CHANNELS: 1	Range: 1, 2
	⇄	CHARGING CURRENT COMPENSATN: Disabled	Range: Disabled, Enabled
	⇄	POS SEQ CAPACITIVE REACTANCE: 0.100 kΩ	Range: 0.100 to 65.535 kΩ in steps of 0.001

⇅	ZERO SEQ CAPACITIVE REACTANCE: 0.100 kΩ	Range: 0.100 to 65.535 kΩ in steps of 0.001
⇅	ZERO SEQ CURRENT REMOVAL: Disabled	Range: Disabled, Enabled
⇅	LOCAL RELAY ID NUMBER: 0	Range: 0 to 255 in steps of 1
⇅	TERMINAL 1 RELAY ID NUMBER: 0	Range: 0 to 255 in steps of 1
⇅	TERMINAL 2 RELAY ID NUMBER: 0	Range: 0 to 255 in steps of 1
⇅	CHNL ASYM COMP: Off	Range: FlexLogic operand
⇅	BLOCK GPS TIME REF: Off	Range: FlexLogic operand
⇅	MAX CHNL ASYMMETRY: 1.5 ms	Range: 0.0 to 10.0 ms in steps of 0.1
⇅	ROUND TRIP TIME CHANGE: 1.5 ms	Range: 0.0 to 10.0 ms in steps of 0.1
↑	<input type="checkbox"/> IN-ZONE <input type="checkbox"/> TRANSFORMER	See page 5-145



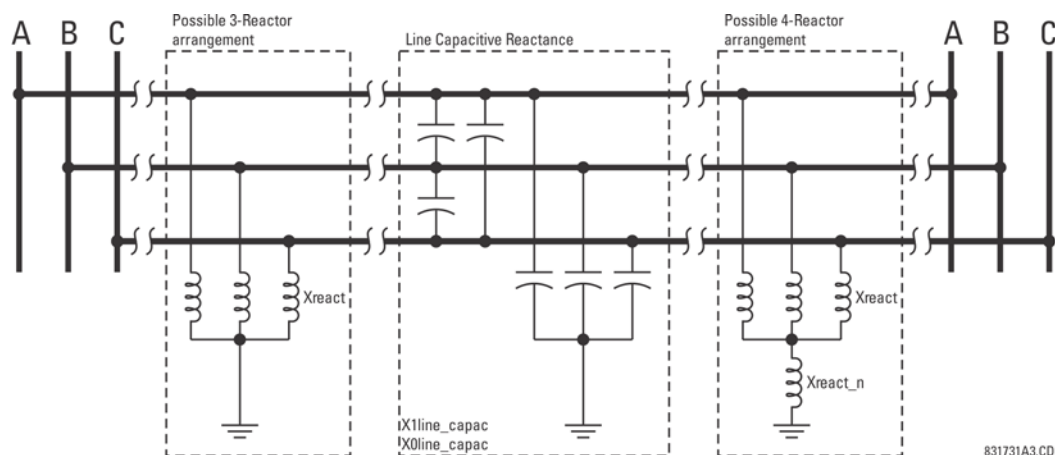
Any changes to the L30 power system settings change the protection system configuration. As such, the 87L protection at all L30 protection system terminals must be temporarily disabled to allow the relays to acknowledge the new settings.

NUMBER OF TERMINALS — This setting is the number of terminals of the protected line.

NUMBER OF CHANNELS — This setting corresponds to the communications module installed. If the relay is applied on two terminal lines with a single communications channel, select "1." For a two-terminal line with a second redundant channel for increased dependability, or for three terminal line applications, select "2."

CHARGING CURRENT COMPENSATION — This setting enables and disables the charging current calculations and corrections of current phasors. The voltage signals used for charging current compensation are taken from the source assigned with the **CURRENT DIFF SIGNAL SOURCE 1** setting. As such, it is critical to ensure that three-phase line voltage is assigned to this source. The figure shows possible configurations.

Figure 5-62: Charging current compensation configurations



POSITIVE and ZERO SEQUENCE CAPACITIVE REACTANCE — The values of positive and zero-sequence capacitive reactance of the protected line are required for charging current compensation calculations. The line capacitive reactance values are entered in primary kilo-ohms for the total line length.

If shunt reactors are also installed on the line, the resulting value entered in the **POS SEQ CAPACITIVE REACTANCE** and **ZERO SEQ CAPACITIVE REACTANCE** settings are calculated as follows:

Three-reactor arrangement — Three identical line reactors (X_{react}) solidly connected phase to ground:

$$X_{C1} = \frac{X_{1\text{line_capac}} \cdot X_{\text{react}}}{X_{\text{react}} - X_{1\text{line_capac}}}, X_{C0} = \frac{X_{0\text{line_capac}} \cdot X_{\text{react}}}{X_{\text{react}} - X_{0\text{line_capac}}} \quad \text{Eq. 5-7}$$

Four-reactor arrangement — Three identical line reactors (X_{react}) wye-connected with the fourth reactor (X_{react_n}) connected between reactor-bank neutral and the ground.

$$X_{C1} = \frac{X_{1\text{line_capac}} \cdot X_{\text{react}}}{X_{\text{react}} - X_{1\text{line_capac}}}, X_{C0} = \frac{X_{0\text{line_capac}} \cdot (X_{\text{react}} + 3X_{\text{react}_n})}{X_{\text{react}} + 3X_{\text{react}_n} - X_{0\text{line_capac}}} \quad \text{Eq. 5-8}$$

where

$X_{1\text{line_capac}}$ = the total line positive-sequence capacitive reactance

$X_{0\text{line_capac}}$ = the total line zero-sequence capacitive reactance

X_{react} = the total reactor inductive reactance per phase. If identical reactors are installed at both line ends, the value of the inductive reactance is divided by 2 (or 3 for a three-terminal line) before use in the previous equations. If the reactors installed at both ends of the line are different, the following equations apply:

For two terminal line:

$$X_{\text{react}} = 1 / \left(\frac{1}{X_{\text{react_terminal1}}} + \frac{1}{X_{\text{react_terminal2}}} \right) \quad \text{Eq. 5-9}$$

For three terminal line:

$$X_{\text{react}} = 1 / \left(\frac{1}{X_{\text{react_terminal1}}} + \frac{1}{X_{\text{react_terminal2}}} + \frac{1}{X_{\text{react_terminal3}}} \right) \quad \text{Eq. 5-10}$$

where

X_{react_n} = the total neutral reactor inductive reactance. If identical reactors are installed at both line ends, the value of the inductive reactance is divided by 2 (or 3 for a three-terminal line) before use in the previous equations. If the reactors installed at both ends of the line are different, the following equations apply:

For two terminal line:

$$X_{\text{react}_n} = 1 / \left(\frac{1}{X_{\text{react}_n\text{terminal1}}} + \frac{1}{X_{\text{react}_n\text{terminal2}}} \right) \quad \text{Eq. 5-11}$$

For three terminal line:

$$X_{\text{react}_n} = 1 / \left(\frac{1}{X_{\text{react}_n\text{terminal1}}} + \frac{1}{X_{\text{react}_n\text{terminal2}}} + \frac{1}{X_{\text{react}_n\text{terminal3}}} \right) \quad \text{Eq. 5-12}$$



Charging current compensation calculations need to be performed for an arrangement where the VTs are connected to the line side of the circuit. Otherwise, opening the breaker at one end of the line causes a calculation error.

Differential current is significantly decreased when **CHARGING CURRENT COMPENSATION** is “Enabled” and the proper reactance values are entered. The effect of charging current compensation is viewed in the **METERING** ⇒ **87L DIFFERENTIAL CURRENT** actual values menu. This effect is very dependent on CT and VT accuracy.

ZERO-SEQUENCE CURRENT REMOVAL — This setting facilitates application of the L30 to transmission lines with one or more tapped transformers without current measurement at the taps. If the tapped transformer is connected in a grounded wye on the line side, it becomes a source of the zero-sequence current for external ground faults. As the transformer current is not measured by the L30 protection system, the zero-sequence current creates a spurious differential signal and can cause a false trip.

If enabled, this setting forces the L30 to remove zero-sequence current from the phase currents prior to forming their differential signals, ensuring protection stability on external ground faults. However, zero-sequence current removal can cause all three phases to trip for internal ground faults. Consequently, a phase selective operation of the L30 is not retained if the setting is enabled. This does not impose any limitation, as single-pole tripping is not recommended for lines with tapped transformers. See the Application of Settings chapter for guidelines.

LOCAL (TERMINAL 1 and TERMINAL 2) ID NUMBER — In installations using multiplexers or modems for communication, it is desirable to ensure the data used by the relays protecting a given line comes from the correct relays. The L30 performs this check by reading the ID number contained in the messages sent by transmitting relays and comparing this ID to the programmed correct ID numbers by the receiving relays. This check is used to block the differential element of a relay, if the channel is inadvertently set to loopback mode, by recognizing its own ID on a received channel. If an incorrect ID is found on either channel during normal operation, the FlexLogic operand **87 CH1(2) ID FAIL** is set, driving the event with the same name. The result of channel identification is also available in **ACTUAL VALUES** ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **VALIDITY OF CHANNEL CONFIGURATION** for commissioning purposes. The default value “0” as the local relay ID setting indicates that the channel ID number is not to be checked. See the Current Differential section in this chapter for additional information.

For two-terminal applications, use the **LOCAL ID NUMBER** and **TERMINAL 1 ID NUMBER**. For three-terminal applications, also use the **TERMINAL 2 ID NUMBER**.

CHNL ASYM COMP — This setting enables/disables channel asymmetry compensation. The compensation is based on absolute time referencing provided by GPS-based clocks via the Precision Time Protocol or IRIG-B. Use this feature on multiplexed channels where channel asymmetry can be expected and which otherwise causes errors in current differential calculations. The feature takes effect when all terminals are provided with reliable GPS clock signals. If the GPS clock signal is lost at any terminal of the current differential protection system, or the real time clock not configured, then the compensation is not calculated. If the compensation is in place prior to losing the GPS time reference, the last (memorized) correction is applied as long as the value of **CHNL ASYM COMP** is “On.” See the Application of Settings chapter for information.

The GPS-based compensation for channel asymmetry can take three different effects:

- If the **CHNL ASYM COMP** selected FlexLogic operand is “Off,” compensation is not applied and the L30 uses only the ping-pong technique.
- If the **CHNL ASYM COMP** selected FlexLogic operand is “On” and all terminals have a valid time reference, then compensation is applied and the L30 effectively uses GPS time referencing tracking channel asymmetry if the latter fluctuates.
- If **CHNL ASYM COMP** is “On” and not all terminals have a valid time reference, then compensation is not applied (if the system was not compensated prior to the problem), or the memorized (last valid) compensation is used if compensation was in effect prior to the problem.

A terminal is considered to have a valid time reference while the **BLOCK GPS TIME REF** selected FlexLogic operand is Off and the internal signal **LOCAL GPS TROUBLE** is Off. The **LOCAL GPS TROUBLE** signal is On if the real time clock is not locked to global time via PP, PTP, or DC Shift IRIG-B. It is also On if locked via Amplitude Modulated IRIG-B, and if locked via PP or PTP and indicated clock accuracy is less than 250 μ s.

The **CHNL ASYM COMP** setting dynamically turns the GPS compensation on and off. A FlexLogic operand that combines several factors typically is used. The L30 protection system does not incorporate any pre-defined way of treating certain conditions, such as failure of the GPS receiver, loss of satellite signal, channel asymmetry prior to the loss of reference time, or change of the round trip time prior to loss of the time reference. Virtually any philosophy can be programmed by selecting the **CHNL ASYM COMP** setting. Factors to consider are:

- **Fail-safe output of the GPS receiver** — Some receivers can be equipped with the fail-safe output relay. The L30 system requires a maximum error of 250 μ s. The fail-safe output of the GPS receiver can be connected to the local L30 via an input contact. In the case of GPS receiver fail, the channel compensation function can be effectively disabled by using the input contact in conjunction with the **BLOCK GPS TIME REF** setting.
- **Channel asymmetry prior to losing the GPS time reference** — This value is measured by the L30 and a user-programmable threshold is applied to it. The corresponding FlexLogic operands are produced if the asymmetry is above the threshold (**87L DIFF 1 MAX ASYM** and **87L DIFF 2 MAX ASYM**). These operands can be latched in FlexLogic and combined with other factors to decide, upon GPS loss, if the relays continue to compensate using the memorized correction. Typically, one decides to keep compensating if the pre-existing asymmetry is low.
- **Change in the round trip travel time** — This value is measured by the L30 and a user-programmable threshold applied to it. The corresponding FlexLogic operands are produced if the delta change is above the threshold (**87L DIFF 1 TIME CHNG** and **87L DIFF 2 TIME CHNG**). These operands can be latched in FlexLogic and combined with other factors to decide, upon GPS loss, if the relays continue to compensate using the memorized correction. Typically, one decides to disable compensation if the round trip time changes.

BLOCK GPS TIME REF — This setting signals to the L30 that the time reference is not valid, for example due to problems with the GPS receiver. Be aware of the case when a GPS satellite receiver loses its satellite signal and reverts to its own calibrated crystal oscillator. In this case, accuracy degrades in time and can eventually cause relay misoperation. Verification from the receiver manufacturer of accuracy not worse than 250 μ s and the presence of an alarm contact indicating loss of the satellite signal is strongly recommended. If the time reference accuracy cannot be guaranteed, relay this to the L30 via contact inputs and block GPS compensation using the contact position in conjunction with the **BLOCK GPS TIME REF** setting. This setting is typically a signal from the GPS receiver signaling problems or time inaccuracy.

Some GPS receivers supply erroneous IRIG-B signals during power-up and before locking to satellites. If the receiver's failsafe contact opens during power-up (allowing for an erroneous IRIG-B signal), then set a dropout delay up to 15 minutes (depending on GPS receiver specifications) to the failsafe contact via FlexLogic to prevent incorrect relay response.

MAX CHNL ASYMMETRY — This setting detects excessive channel asymmetry. The same threshold is applied to both channels, while the per-channel **87L DIFF 1 MAX ASYM** and **87L DIFF 2 MAX ASYM** FlexLogic operands are generated. These operands can be used to alarm on problems with communication equipment and/or to decide whether channel asymmetry compensation remains in operation if the GPS-based time reference is lost. Channel asymmetry is measured if both terminals of a given channel have valid time reference.

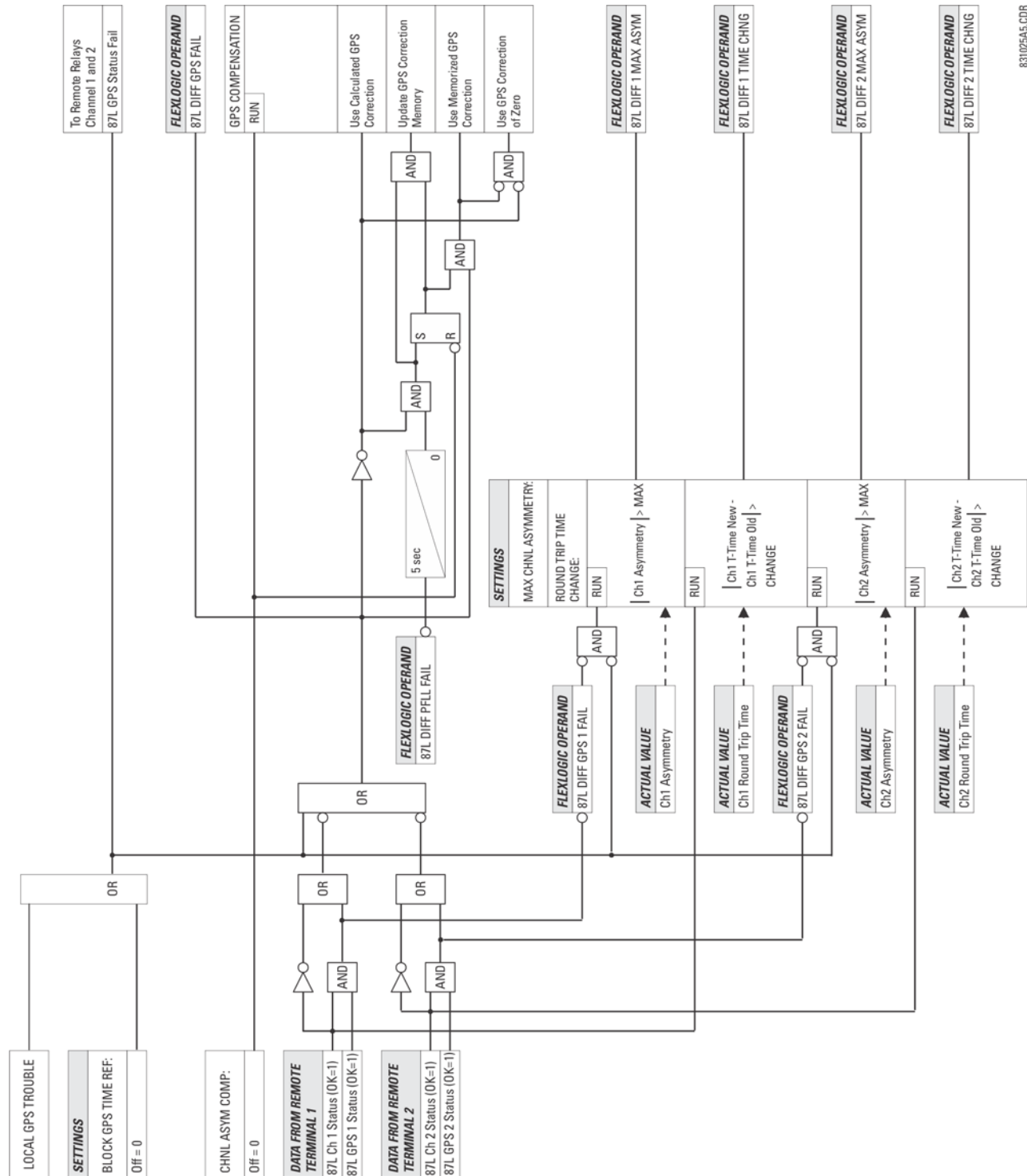
If the memorized asymmetry value is much greater than expected (indicating a significant problem with GPS clock timing), then this operand also can be used to block GPS compensation, forcing the relay to use the memorized asymmetry value.

ROUND TRIP TIME CHANGE — This setting detects changes in round-trip time. This threshold is applied to both channels, while the **87L DIFF 1 TIME CHNG** and **87L DIFF 2 TIME CHNG ASYM** per-channel FlexLogic operands are generated. These operands can be used to alarm on problems with communication equipment and/or to decide whether channel asymmetry compensation remains in operation if the GPS-based time reference is lost.

LOCAL GPS TROUBLE — This internal signal is On when any of the following conditions are present:

- The best clock selector (BCS) selection is none or SNTP
- The BCS selection is IRIG-B and the **IRIG-B SIGNAL TYPE** setting is Amplitude Modulated
- The RTC and/or the synchrophasor clock are not synchronized to the selected synchronizing source. This can possibly occur on power-up, when transferring between sources, and when the selected source's holdover timer times out.
- The quality bits in the messages from a PTP source used for synchronizing indicate worst-case error greater than 250 μ s, or accuracy less than 250 μ s, or unknown accuracy/error (that is, not locked to an international time standard). Apply two security counts (2 seconds) to both set and reset of this operand when change is based on accuracy. There is no corresponding quality test for IRIG-B sources here.

Figure 5-63: Channel asymmetry compensation logic



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5.5.4.2 In-zone transformer

SETTINGS ⇄ SYSTEM SETUP ⇄ 87L POWER SYSTEM ⇄ IN-ZONE TRANSFORMER

IN-ZONE
 TRANSFORMER



IN-ZONE TRANSFORMER CONNECTION: None

Range: None, 0 to 330° lag in steps of 30°

↑ **TRANSFORMER LOCATION:** LOCAL-TAP Range: LOCAL-TAP, REM1-TAP, REM2-TAP



The L30 is provided with this optional feature, specified as an option at the time of ordering. Using the order code for your device, see the order codes in chapter 2 for details.

These settings ensure that the 87L element correctly applies magnitude and phase compensation for the in-zone transformer. To accommodate for the difference in CT ratios at line terminals, use the **SETTINGS** ⇒ **GROUPED ELEMENTS** ⇒ **SETTING GROUP 1(6)** ⇒ **LINE DIFFERENTIAL ELEMENTS** ⇒ **CURRENT DIFFERENTIAL** ⇒ **CURRENT DIFF CT TAP** setting. It is important to properly program the in-zone transformer setting for all terminals to ensure correct 87L performance.

IN-ZONE TRANSFORMER CONNECTION — This setting indicates the presence and group connection of the in-zone transformer. The winding angle selection specifies the phase shift of the remote terminal side winding with respect to the local terminal side winding. For example, for the Dy1 group where the delta winding is connected to the local terminal side, and wye winding is connected to the remote terminal side, you select “30° lag” for the local terminal side. (At the remote terminal relay, select “330° lag” for this transformer group connection.) If there is no in-zone transformer connected, then program this setting as “None” (note that the “0° lag” value does not correspond to “None”). Only one in-zone transformer is allowed for both two-terminal and three-terminal applications. Enabling in-zone transformer functionality forces the L30 to automatically remove the zero-sequence component from all terminals currents. It also disables ground differential 87LG functionality and zero-sequence current removal functionality defined by the **ZERO SEQ CURRENT REMOVAL** setting.

Do not set the **IN-ZONE TRANSFORMER CONNECTION** setting to “None” at one terminal and set other terminals to a value other than “None.” 87L is blocked under these circumstances.

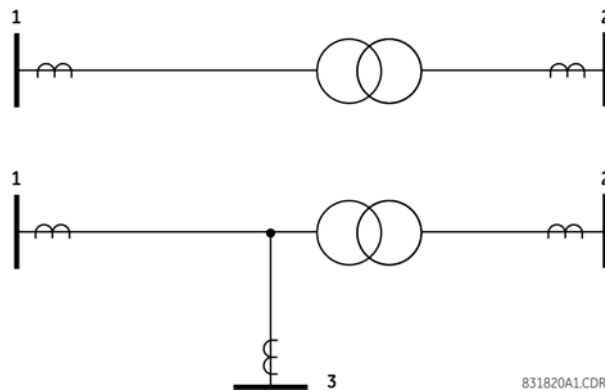
TRANSFORMER LOCATION — This setting selects the transformer location and applies only when the **IN-ZONE TRANSFORMER CONNECTION** setting is other than “None.”

Select the “LOCAL-TAP” value if the transformer is present between the local terminal and the tap point or for two-terminal applications.

Select “REM1-TAP” if the transformer is present between remote terminal 1 and the tap point.

Select “REM2-TAP” if the transformer is present between remote terminal 2 and the tap point.

Figure 5-64: Illustration of in-zone transformer for two-terminal and three-terminal lines



5.5.5 Breakers

SETTINGS ⇒ SYSTEM SETUP ⇒ BREAKERS ⇒ BREAKER 1(2)

<input checked="" type="checkbox"/> BREAKER 1	↔	BREAKER 1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	BREAKER1 PUSH BUTTON CONTROL: Disabled	Range: Disabled, Enabled

↕	BREAKER 1 TAGGING: Disabled	Range: Disabled, Enabled
↕	BREAKER 1 SUBSTITUTN: Disabled	Range: Disabled, Enabled
↕	BREAKER 1 BYPASS: Disabled	Range: Disabled, Enabled
↕	BREAKER 1 AR BLOCK: Disabled	Range: Disabled, Enabled
↕	BREAKER 1 NAME: Bkr 1	Range: up to six alphanumeric characters
↕	BREAKER 1 MODE: 3-Pole	Range: 3-Pole, 1-Pole
↕	BREAKER 1 OPEN: Off	Range: FlexLogic operand
↕	BREAKER 1 BLK OPEN: Off	Range: FlexLogic operand
↕	BREAKER 1 CLOSE: Off	Range: FlexLogic operand
↕	BREAKER 1 BLK CLOSE: Off	Range: FlexLogic operand
↕	BREAKER1 ΦA/3P CLSD: Off	Range: FlexLogic operand
↕	BREAKER1 ΦA/3P OPND: Off	Range: FlexLogic operand
↕	BREAKER 1 ΦB CLOSED: Off	Range: FlexLogic operand
↕	BREAKER 1 ΦB OPENED: Off	Range: FlexLogic operand
↕	BREAKER 1 ΦC CLOSED: Off	Range: FlexLogic operand
↕	BREAKER 1 ΦC OPENED: Off	Range: FlexLogic operand
↕	BREAKER 1 TOPERATE: 70 ms	Range: 0 to 65535 s in steps of 1
↕	BREAKER 1 EXT ALARM: Off	Range: FlexLogic operand
↕	BREAKER 1 ALARM DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	MANUAL CLOSE RECAL1 TIME: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	BREAKER 1 OPEN SEAL-IN: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	BREAKER 1 OUT OF SV: Off	Range: FlexLogic operand
↕	BREAKER 1 RACKED-IN: Off	Range: FlexLogic operand
↑	BREAKER 1 EVENTS: Disabled	Range: Disabled, Enabled

The breaker control element contains the auxiliary logic for status and serves as the interface for opening and closing of a circuit breaker from protection, autoreclose, SCADA, or through the front panel interface. The breaker control element can be used to create interlocking functionality. For greater security in determination of the breaker position, both the 52/a and 52/b auxiliary contacts are used with reporting of the discrepancy between them.

To use this element, configure the contact outputs that trip and close the breaker to use FlexLogic operands **BREAKER 1 OFF CMD** (or **BREAKER 1 TRIP A/B/C** in the case of single-pole tripping) and **BREAKER 1 ON CMD**, and configure the breaker control element inputs as described here.

A description of the operation of the breaker control and status monitoring features from the front panel is provided in chapter 4.

There are two breaker control elements for each CT/VT module installed. The following settings are available for each breaker control element.

BREAKER 1 FUNCTION — This setting enables and disables the operation of the breaker 1 control feature.

BREAKER1 PUSH BUTTON CONTROL — Set to "Enable" to allow front panel pushbutton open/close control operations.

BREAKER1 TAGGING — Set to "Enable" to allow the graphical front panel to tag breaker 1. When tagged, the following operations are disabled: pushbutton open/close, IEC 61850 open/close, and close command initiated by **BREAKER 1 CLOSE** setting. The trip command issued by the Trip Out element or **BREAKER 1 OPEN** setting is not affected.

BREAKER1 SUBSTITUTN — Set to "Enable" to allow the graphical front panel to substitute breaker 1 status. When substituted, breaker 1 control open/close status is forced to the substituted value.

BREAKER1 BYPASS — Set to "Enable" to allow the graphical front panel to bypass breaker 1 interlocking. When asserted, **BREAKER 1 BLK OPEN** and **BREAKER 1 BLK CLOSE** settings are bypassed.

BREAKER1 AR BLOCK —Set to "Enable" to generate an operand to block the Autoreclose element.

The Autoreclose element is not automatically inhibited by **BLOCK AR** from the front panel. If the autoreclose scheme needs to be inhibited, set setting **AR BLOCK** in the corresponding autoreclose element with the **BREAKER 1 BLK RCLS** operand.

BREAKER 1 NAME — Assign a user-defined name (up to six characters) to the breaker. This name is used in flash messages related to breaker 1.

BREAKER 1 MODE — Selects "3-Pole" mode, where all breaker poles are operated simultaneously, or "1-Pole" mode where all breaker poles are operated either independently or simultaneously.

BREAKER 1 OPEN — Selects an operand that when activated, and unless blocked, initiates the Breaker 1 open and individual phase trip commands.

BREAKER 1 BLK OPEN — Selects an operand that prevents initiation of Breaker 1 open and individual phase trip commands. This setting can be used for blocking circuit breaker tripping for instance when breaker monitoring detects conditions such as low SF₆ gas density during which breaker opening can cause damage.

BREAKER 1 CLOSE — Selects an operand that when activated, and unless blocked, initiates the Breaker 1 close commands.

BREAKER 1 BLK CLOSE — Selects an operand that prevents initiation of Breaker 1 close commands. This setting can be used for blocking circuit breaker closing, for instance to prevent closing into a closed ground switch.

BREAKER1 Φ A/3P CLSD — Selects an operand, usually a contact input connected to a breaker auxiliary position tracking mechanism. This input is for a normally-open 52/a status input that creates a logic 1 when the breaker is closed. If the **BREAKER 1 MODE** setting is selected as "3-Pole," this setting selects a single 52/a input as the operand used to track the breaker open or closed position. If the mode is selected as "1-Pole," the input mentioned is used to track phase A and the **BREAKER 1 Φ B** and **BREAKER 1 Φ C** settings select operands to track phases B and C, respectively.

BREAKER1 Φ A/3P OPND — Selects an operand, usually a contact input, that is for a normally-closed 52/b status input that creates a logic 1 when the breaker is open. If a separate 52/b contact input is not available, then the inverted 52/a status signal or the inverted **BREAKER 1 CLOSED** status signal can be used.

BREAKER 1 Φ B CLOSED — If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the breaker phase B closed position as outlined for phase A.

BREAKER 1 Φ B OPENED — If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the breaker phase B opened position as outlined for phase A.

BREAKER 1 Φ C CLOSED — If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the breaker phase C closed position as outlined for phase A.

BREAKER 1 Φ C OPENED — If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the breaker phase C opened position as outlined for phase A.

BREAKER 1 TOPERATE — This setting specifies the required interval to overcome transient disagreement between the 52/a and 52/b auxiliary contacts during breaker operation. If transient disagreement still exists after this time has expired, the **BREAKER 1 BAD STATUS** FlexLogic operand is asserted for alarm or blocking purposes.

BREAKER 1 EXT ALARM — This setting selects an operand, usually an external contact input connected to a breaker alarm reporting contact. While the selected operand is active, the **BREAKER 1 TROUBLE** operand is activated.

BREAKER 1 ALARM DELAY — This setting specifies the delay interval during which a disagreement of status among the three-pole position tracking operands does not declare a pole disagreement. This allows for non-simultaneous operation of the poles.

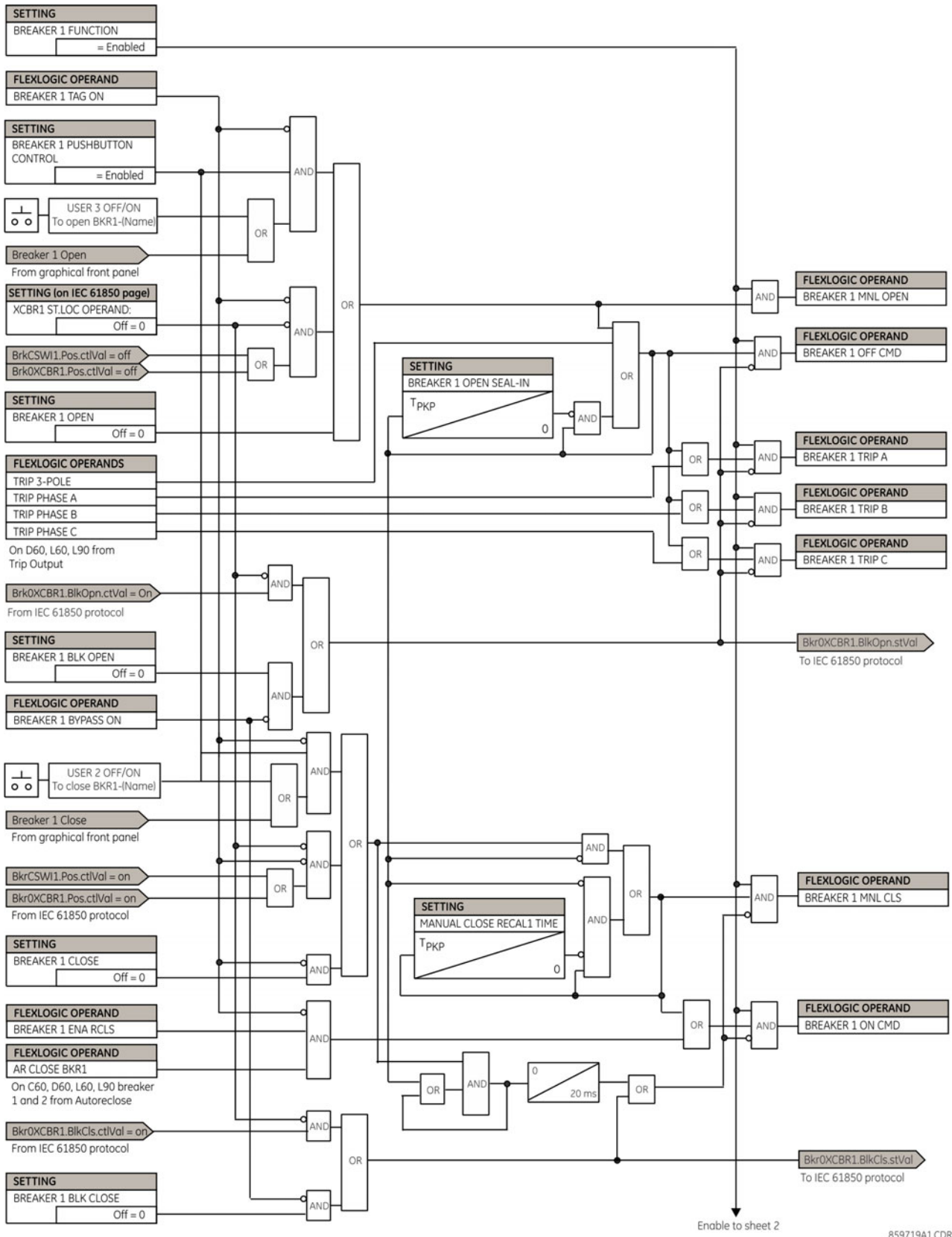
BREAKER 1 OPEN SEAL-IN — This setting specifies the seal-in time of the three-pole open command initiated by either the Trip Out element or a manual open command to the circuit breaker.

MANUAL CLOSE RECAL1 TIME — This setting specifies the seal-in time of the close commands due to an operator-initiated manual close command to the circuit breaker.

BREAKER 1 OUT OF SV — Selects an operand indicating that breaker 1 is out-of-service.

BREAKER 1 RACKED-IN — This setting selects a contact input to show whether the breaker is racked-in or racked-out. The racked-in or racked-out status is used to indicate dynamically the status of breaker symbol, only applied in the single-line diagram in the graphical front panel. If this setting is set to Off, the racked status is not considered.

Figure 5-65: Dual breaker control logic (Sheet 1 of 3)



5

Enable to sheet 2

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Figure 5-66: Dual breaker control logic (Sheet 2 of 3)

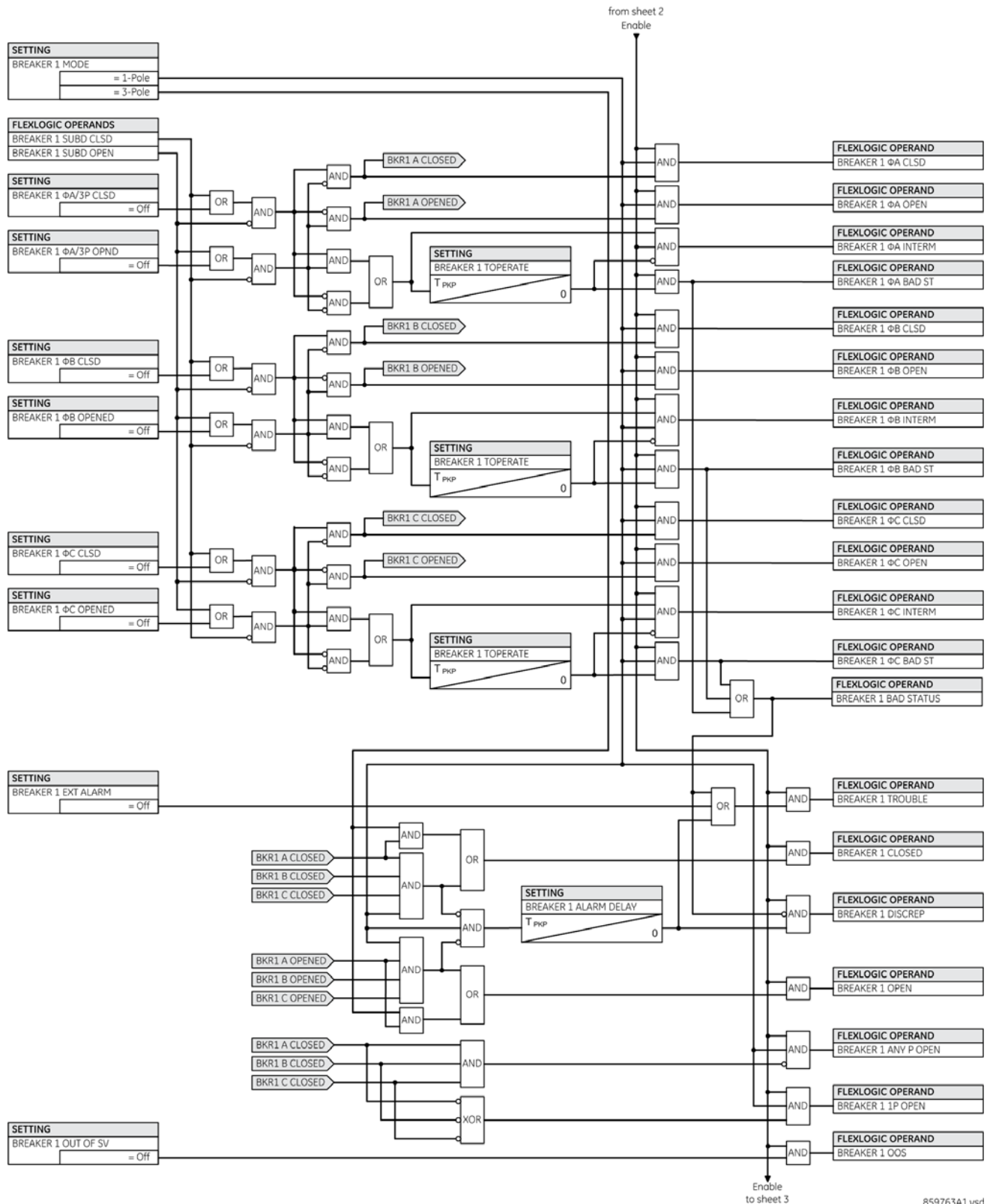
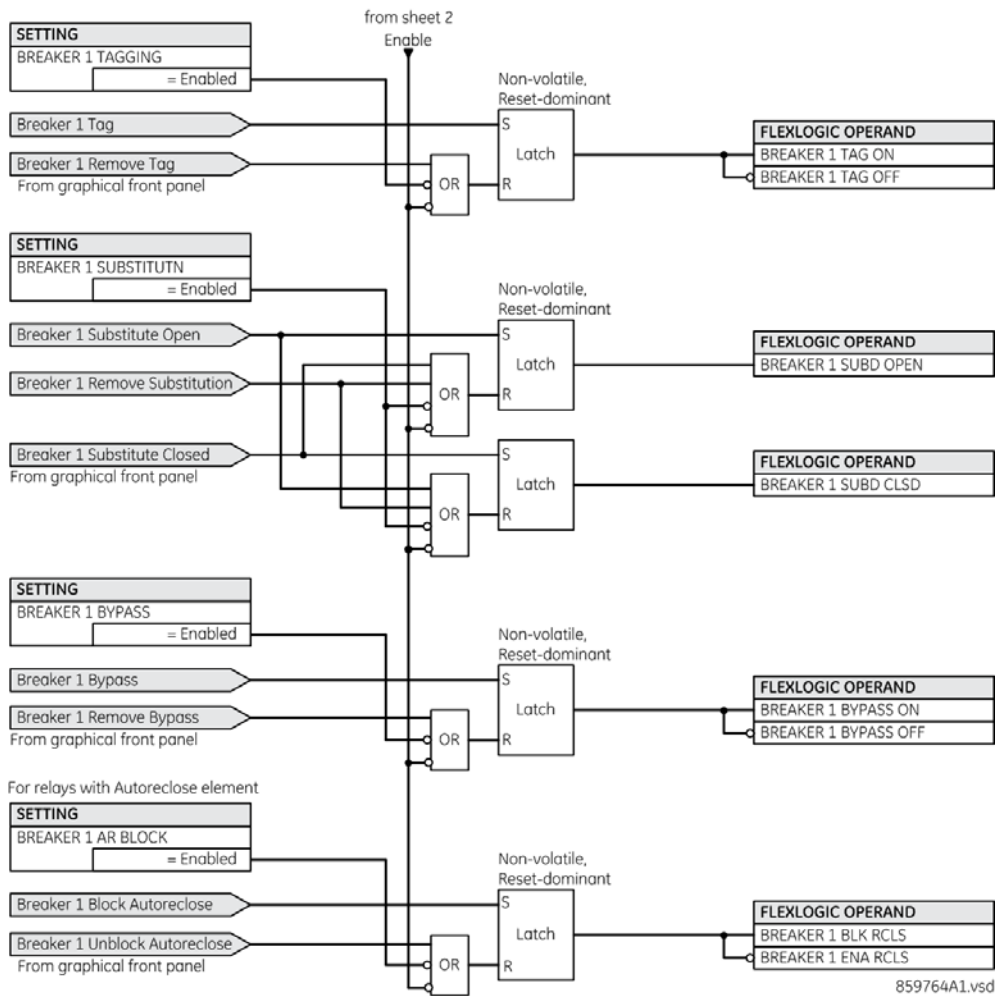


Figure 5-67: Dual breaker / graphical front panel control logic (Sheet 3 of 3)



5

The breaker element has direct hard-coded connections to the IEC 61850 model as shown in the logic diagram. This allows remote open/close operation of each breaker, using either CSWI or XCBR IEC 61850 logical nodes. IEC 61850 select-before-operate functionality, local/remote switch functionality, along with blocking of open/close commands are provided. Note that the dwell time for the IEC 61850 trip and close commands shown is one protection pass only. To maintain the close/open command for a certain time, do so by setting the seal-in timers **BREAKER 1 OPEN SEAL-IN** and **MANUAL CLOSE RECAL1 TIME**, on the contact outputs using the "Seal-in" setting, in the Trip Output element, and/or in FlexLogic.

5.5.6 Disconnect switch control

SETTINGS ⇄ SYSTEM SETUP ⇄ SWITCHES ⇄ SWITCH 1(8)

<div style="border: 1px solid black; padding: 2px;"> SWITCH 1 </div>	⇄	<div style="border: 1px solid black; padding: 2px;"> SWITCH 1 FUNCTION: Disabled </div>	Range: Disabled, Enabled
	⇄	<div style="border: 1px solid black; padding: 2px;"> SWITCH 1 NAME: SW 1 </div>	Range: up to six alphanumeric characters
	⇄	<div style="border: 1px solid black; padding: 2px;"> SWITCH 1 MODE: 3-Pole </div>	Range: 3-Pole, 1-Pole
	⇄	<div style="border: 1px solid black; padding: 2px;"> SWITCH 1 OPEN: Off </div>	Range: FlexLogic operand

↕	SWITCH 1 BLK OPEN: Off	Range: FlexLogic operand
↕	SWITCH 1 CLOSE: Off	Range: FlexLogic operand
↕	SWITCH 1 BLK CLOSE: Off	Range: FlexLogic operand
↕	SWITCH 1 Φ A/3P CLSD: Off	Range: FlexLogic operand
↕	SWITCH 1 Φ A/3P OPND: Off	Range: FlexLogic operand
↕	SWITCH 1 Φ B CLOSED: Off	Range: FlexLogic operand
↕	SWITCH 1 Φ B OPENED: Off	Range: FlexLogic operand
↕	SWITCH 1 Φ C CLOSED: Off	Range: FlexLogic operand
↕	SWITCH 1 Φ C OPENED: Off	Range: FlexLogic operand
↕	SWITCH1 PUSH BUTTON CONTROL: Disabled	Range: Disabled, Enabled
↕	SWITCH 1 TAGGING: Disabled	Range: Disabled, Enabled
↕	SWITCH 1 SUBSTITUTN: Disabled	Range: Disabled, Enabled
↕	SWITCH 1 BYPASS: Disabled	Range: Disabled, Enabled
↕	SWITCH 1 OPEN SEAL-IN: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	SWITCH 1 CLOSE SEAL-IN: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	SWITCH 1 TOPERATE: 70 ms	Range: 0 to 65535 ms in steps of 1
↕	SWITCH 1 ALARM DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↑	SWITCH 1 EVENTS: Disabled	Range: Disabled, Enabled

The disconnect switch control element contains the auxiliary logic for status and serves as the interface for opening and closing of disconnect switches from SCADA or through the front panel interface. The disconnect switch control element can be used to create interlocking functionality. For greater security in determination of the switch pole position, both the 89/a and 89/b auxiliary contacts are used with reporting of the discrepancy between them. There are eight disconnect switch control elements for each CT/VT module installed.

To use this element, configure the contact outputs that open and close the disconnect switch to use FlexLogic operands [SWITCH 1 OFF CMD](#) and [SWITCH 1 ON CMD](#), and configure the disconnect switch control element's inputs as outlined here.

SWITCH 1 FUNCTION — This setting enables and disables operation of the disconnect switch element.

SWITCH 1 NAME — Assign a user-defined name (up to six characters) to the disconnect switch. This name is used in flash messages related to disconnect switch 1.

SWITCH 1 MODE — This setting selects “3-Pole” mode, where disconnect switch poles have a single common auxiliary switch, or “1-Pole” mode where each disconnect switch pole has its own auxiliary switch.

SWITCH 1 OPEN — This setting selects an operand that when activated, and unless blocked, initiates the disconnect switch 1 open command.

SWITCH 1 BLK OPEN — This setting selects an operand that prevents initiation of the disconnect switch 1 command. This setting can be used to block the disconnect switch from opening, for instance when switchyard monitoring indicates that current exceeding the switch's interrupting rating can be flowing through the switch.

SWITCH 1 CLOSE — This setting selects an operand that when activated, and unless blocked, initiates the disconnect switch 1 close command.

SWITCH 1 BLK CLOSE — This setting selects an operand that prevents initiation of disconnect switch 1 close commands. This setting can be used to block the disconnect switch from closing, for instance to prevent closing into a closed ground switch.

SWITCH 1 Φ A/3P CLSD — This setting selects an operand, usually a contact input connected to a disconnect switch auxiliary position tracking mechanism. This input is for a normally-open 89/a status input that creates a logic 1 when the disconnect switch is closed. If the **SWITCH 1 MODE** setting is selected as "3-Pole," this setting selects a single 89/a input as the operand used to track the disconnect switch open or closed position. If the mode is selected as "1-Pole," the input mentioned is used to track phase A and the **SWITCH 1 Φ B** and **SWITCH 1 Φ C** settings select operands to track phases B and C, respectively.

SWITCH 1 Φ A/3P OPND — This setting selects an operand, usually a contact input, that is for a normally-closed 89/b status input that creates a logic 1 when the disconnect switch is open. If a separate 89/b contact input is not available, then an inverted 89/a status signal can be used.

SWITCH 1 Φ B CLOSED — If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the disconnect switch phase B closed position as outlined for phase A.

SWITCH 1 Φ B OPENED — If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the disconnect switch phase B opened position as outlined for phase A.

SWITCH 1 Φ C CLOSED — If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the disconnect switch phase C closed position as outlined for phase A.

SWITCH 1 Φ C OPENED — If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the disconnect switch phase C opened position as outlined for phase A.

SWITCH 1 PUSH BUTTON CONTROL — Set to "Enable" to allow front panel pushbutton open/close control operations.

SWITCH 1 TAGGING — Set to "Enable" to allow the graphical front panel to tag switch 1. When tagged, the following operations are disabled:

- Pushbutton Open/Close
- IEC 61850 Open/Close
- Open command initiated by **SWITCH 1 OPEN** setting
- Close command initiated by **SWITCH 1 CLOSE** setting

SWITCH 1 SUBSTITUTN — Set to "Enable" to allow the graphical front panel to substitute switch 1 status. When substituted, switch 1 control open/close status is forced to the substituted value.

SWITCH 1 BYPASS — Set to "Enable" to allow the graphical front panel to bypass switch 1 interlocking. When asserted, **SWITCH 1 BLK OPEN** and **SWITCH 1 BLK CLOSE** settings are bypassed.

SWITCH 1 OPEN SEAL-IN — This setting specifies the seal-in time of the open command due to an operator-initiated manual open command to the disconnect switch.

SWITCH 1 CLOSE SEAL-IN — This setting specifies the seal-in time of the close command due to an operator-initiated manual close command to the disconnect switch.

SWITCH 1 TOPERATE — This setting specifies the required interval to overcome transient disagreement between the 89/a and 89/b auxiliary contacts during disconnect switch operation. If transient disagreement still exists after this time has expired, the **SWITCH 1 BAD STATUS** FlexLogic operand is asserted for alarm or blocking purposes.

SWITCH 1 ALARM DELAY — This setting specifies the delay interval during which a disagreement of status among the pole position tracking operands do not declare a pole disagreement. This allows for non-simultaneous operation of the poles.



IEC 61850 functionality is permitted when the L30 is in "Programmed" mode and not in local control mode.

The switch element has direct hard-coded connections to the IEC 61850 model as shown in the logic diagrams. This allows remote open/close operation of each switch, using either CSWI or XSWI IEC 61850 logical nodes. IEC 61850 select-before-operate functionality, local/remote switch functionality, along with blocking open/close commands are provided. Note that the dwell time for the IEC 61850 trip and close commands shown is one protection pass only. To maintain close/open command for a certain time, do so using the seal-in timers **SWITCH 1 OPEN SEAL-IN** and **SWITCH 1 CLOSE SEAL-IN**, on the contact outputs using the "Seal-in" setting, or in FlexLogic.

Figure 5-68: Disconnect switch control logic (sheet 1 of 3)

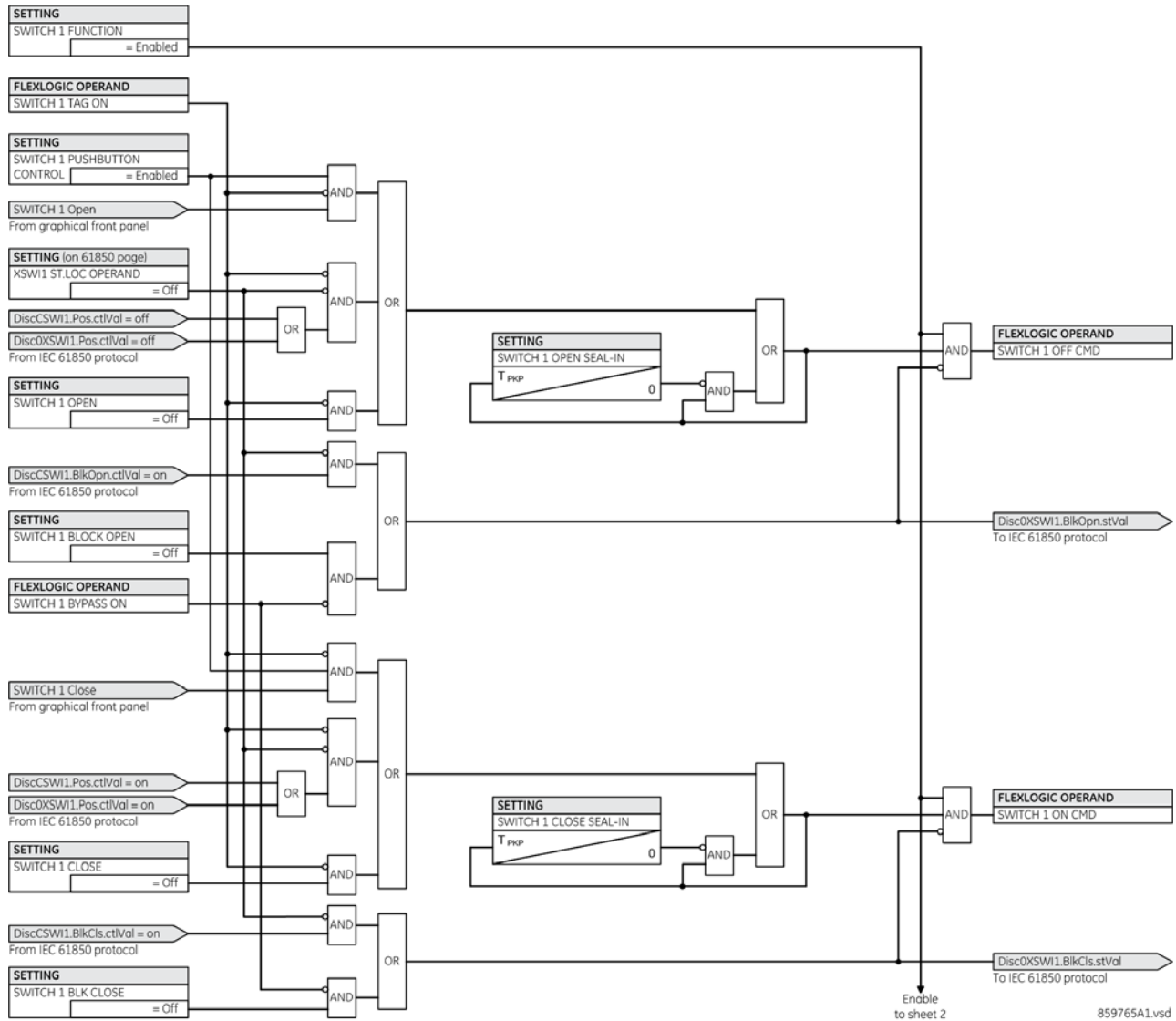


Figure 5-69: Disconnect switch control status logic (sheet 2 of 3)

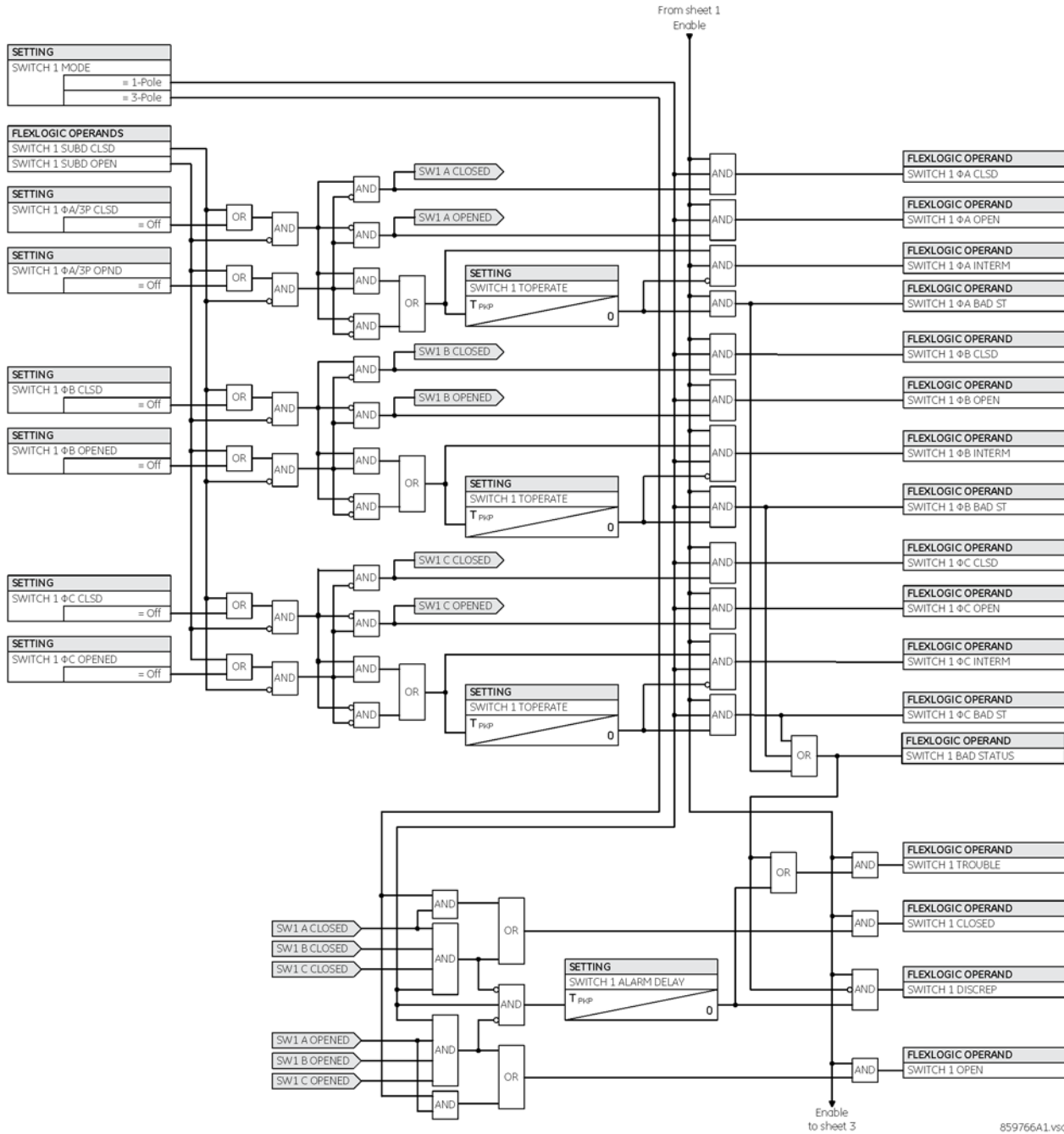
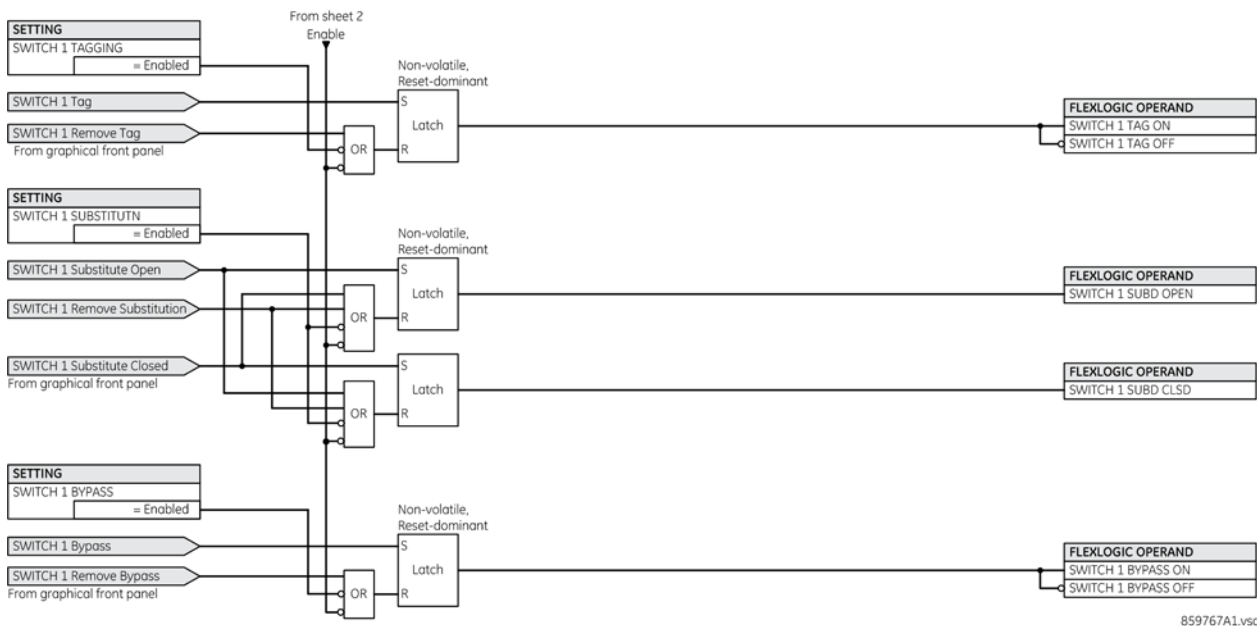


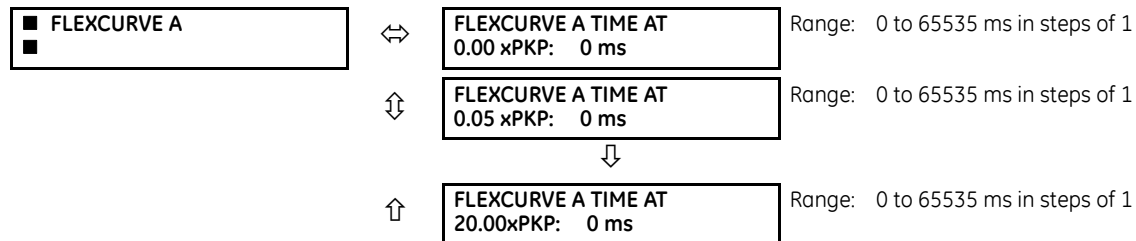
Figure 5-70: Disconnect switch control graphical front panel logic (sheet 3 of 3)



5.5.7 FlexCurves

5.5.7.1 Settings

SETTINGS ⇄ SYSTEM SETUP ⇄ FLEXCURVES ⇄ FLEXCURE A(D)



FlexCurves A through D have settings for entering times to reset and operate at the following pickup levels: 0.00 to 0.98 and 1.03 to 20.00. This data is converted into two continuous curves by linear interpolation between data points. To enter a custom FlexCurve, enter the reset and operate times (using the **VALUE** keys) for each selected pickup point (using the **MESSAGE** up/down keys) for the required protection curve (A, B, C, or D).

Table 5-17: FlexCurve table

Reset	Time ms	Reset	Time ms	Operate	Time ms	Operate	Time ms	Operate	Time ms	Operate	Time ms
0.00		0.68		1.03		2.9		4.9		10.5	
0.05		0.70		1.05		3.0		5.0		11.0	
0.10		0.72		1.1		3.1		5.1		11.5	
0.15		0.74		1.2		3.2		5.2		12.0	
0.20		0.76		1.3		3.3		5.3		12.5	
0.25		0.78		1.4		3.4		5.4		13.0	
0.30		0.80		1.5		3.5		5.5		13.5	
0.35		0.82		1.6		3.6		5.6		14.0	
0.40		0.84		1.7		3.7		5.7		14.5	
0.45		0.86		1.8		3.8		5.8		15.0	
0.48		0.88		1.9		3.9		5.9		15.5	
0.50		0.90		2.0		4.0		6.0		16.0	
0.52		0.91		2.1		4.1		6.5		16.5	
0.54		0.92		2.2		4.2		7.0		17.0	
0.56		0.93		2.3		4.3		7.5		17.5	
0.58		0.94		2.4		4.4		8.0		18.0	
0.60		0.95		2.5		4.5		8.5		18.5	
0.62		0.96		2.6		4.6		9.0		19.0	
0.64		0.97		2.7		4.7		9.5		19.5	
0.66		0.98		2.8		4.8		10.0		20.0	



The relay using a given FlexCurve applies linear approximation for times between the user-entered points. Take care when setting the two points that are close to the multiple of pickup of 1; that is, 0.98 pu and 1.03 pu. It is recommended to set the two times to a similar value, otherwise the linear approximation can result in undesired behavior for the operating quantity that is close to 1.00 pu.

5.5.7.2 FlexCurve configuration with EnerVista software

The EnerVista software allows for easy configuration and management of FlexCurves and their associated data points. Prospective FlexCurves can be configured from a selection of standard curves to provide the best approximate fit, then specific data points can be edited afterwards. Alternately, curve data can be imported from a specified file (.csv format) by selecting the EnerVista **Import Data From** setting (**Settings > System Setup > FlexCurves > FlexCurve**).

Curves and data can be exported, viewed, and cleared by clicking the appropriate buttons. FlexCurves are customized by editing the operating time (ms) values at pre-defined per-unit current multiples. Note that the pickup multiples start at zero (implying the "reset time"), operating time below pickup, and operating time above pickup.

5.5.7.3 Recloser curve editing

Recloser curve selection is special in that recloser curves can be shaped into a composite curve with a minimum response time and a fixed time above a specified pickup multiples. There are 41 recloser curve types supported. These definite operating times are useful to coordinate operating times, typically at higher currents and where upstream and downstream protective devices have different operating characteristics. The recloser curve configuration window shown here appears when the **Initialize From** setting in the EnerVista software is set to "Recloser Curve" and the **Initialize FlexCurve** button is clicked.

Figure 5-71: Recloser curve initialization

Multiplier: Scales (multiplies) the curve operating times

Adder: Adds the time specified in this field (in ms) to each curve operating time value.

Minimum Response Time (MRT): If enabled, the MRT setting defines the shortest operating time even if the curve suggests a shorter time at higher current multiples. A composite operating characteristic is effectively defined. For current multiples lower than the intersection point, the curve dictates the operating time; otherwise, the MRT does. An information message appears when attempting to apply an MRT shorter than the minimum curve time.

High Current Time: Allows the user to set a pickup multiple from which point onwards the operating time is fixed. This is normally only required at higher current levels. The **HCT Ratio** defines the high current pickup multiple; the **HCT** defines the operating time.

842721A1.CDR

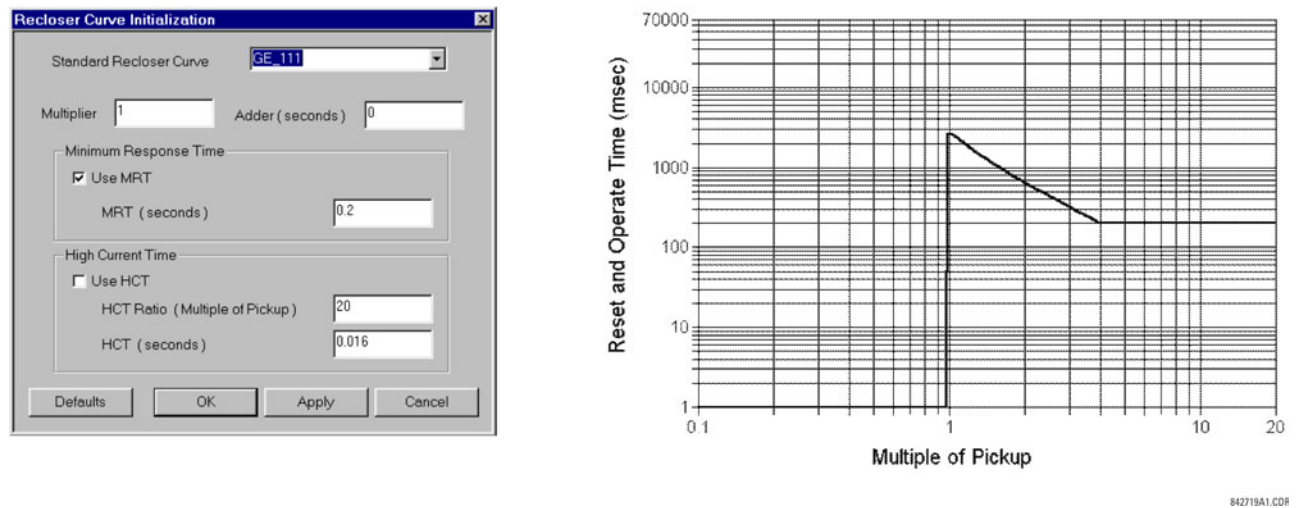


The **Multiplier** and **Adder** settings only affect the curve portion of the characteristic and not the MRT and HCT settings. The HCT settings override the MRT settings for multiples of pickup greater than the HCT ratio.

5.5.7.4 Example

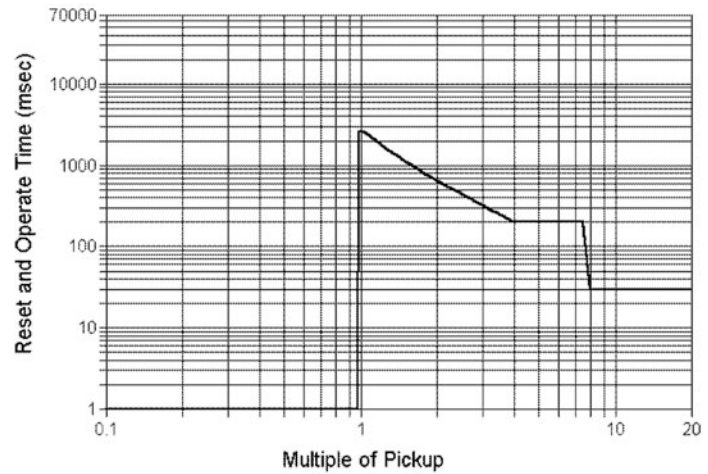
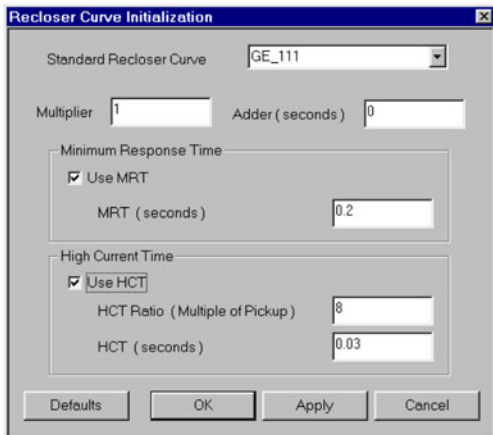
A composite curve can be created from the GE_111 standard with MRT = 200 ms and HCT initially disabled and then enabled at eight times pickup with an operating time of 30 ms. At approximately four times pickup, the curve operating time is equal to the MRT and from then onwards the operating time remains at 200 ms.

Figure 5-72: Composite recloser curve with HCT disabled



With the HCT feature enabled, the operating time reduces to 30 ms for pickup multiples exceeding eight times pickup.

Figure 5-73: Composite recloser curve with HCT enabled



842720A1.CDR



Configuring a composite curve with an increase in operating time at increased pickup multiples is not allowed. If this is attempted, the EnerVista software generates an error message and discards the proposed changes.

5

5.5.7.5 Standard recloser curves

The following graphs display standard recloser curves available for the L30.

Figure 5-74: Recloser curves GE101 to GE106

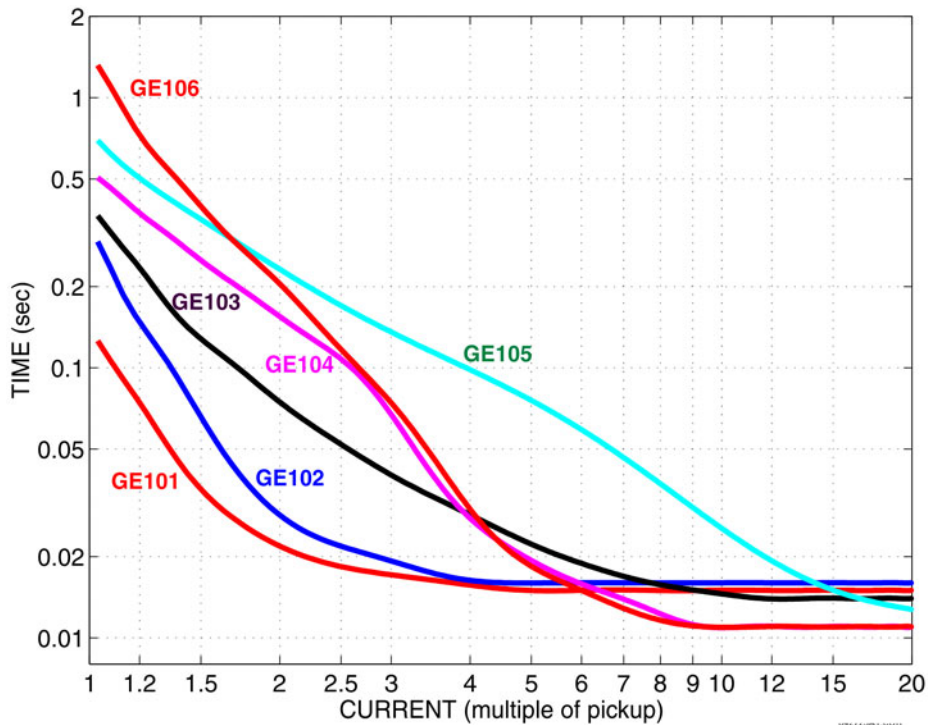


Figure 5-75: Recloser curves GE113, GE120, GE138, and GE142

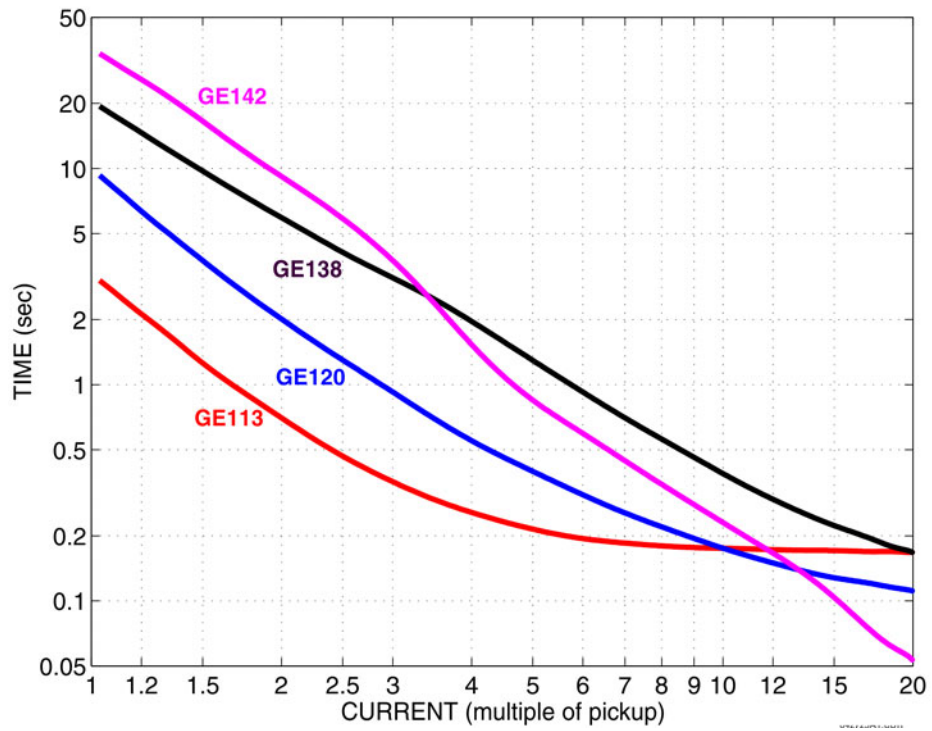


Figure 5-76: Recloser curves GE134, GE137, GE140, GE151, and GE201

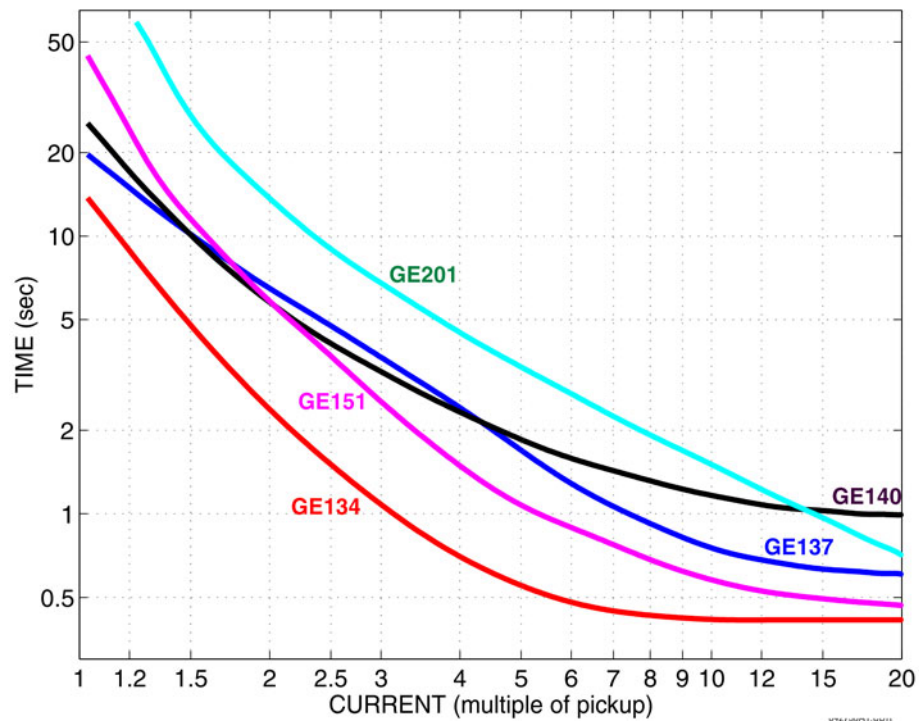


Figure 5-77: Recloser curves GE131, GE141, GE152, and GE200

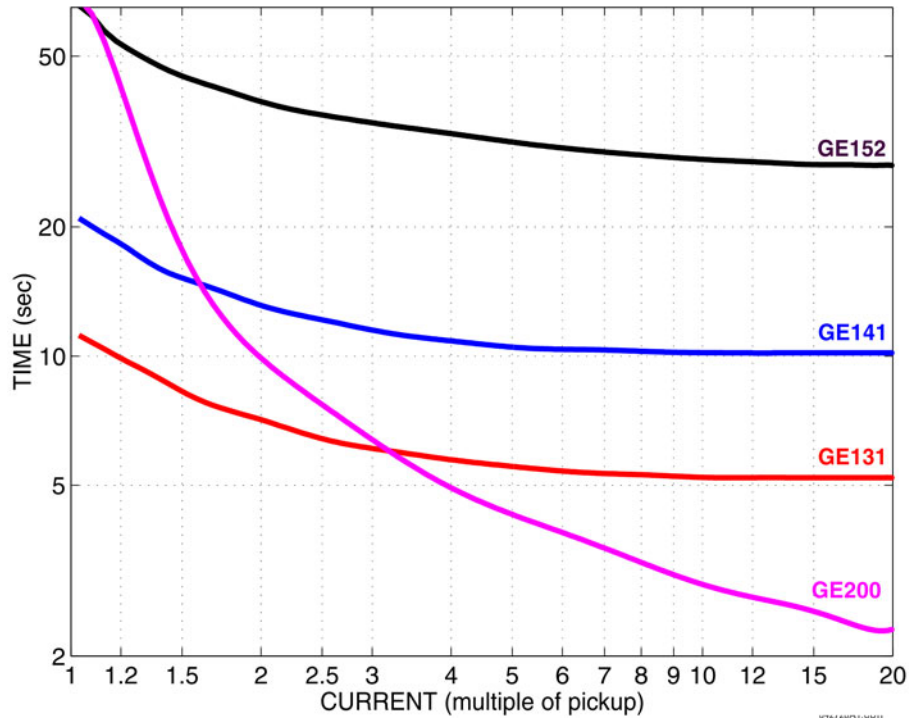


Figure 5-78: Recloser curves GE133, GE161, GE162, GE163, GE164, and GE165

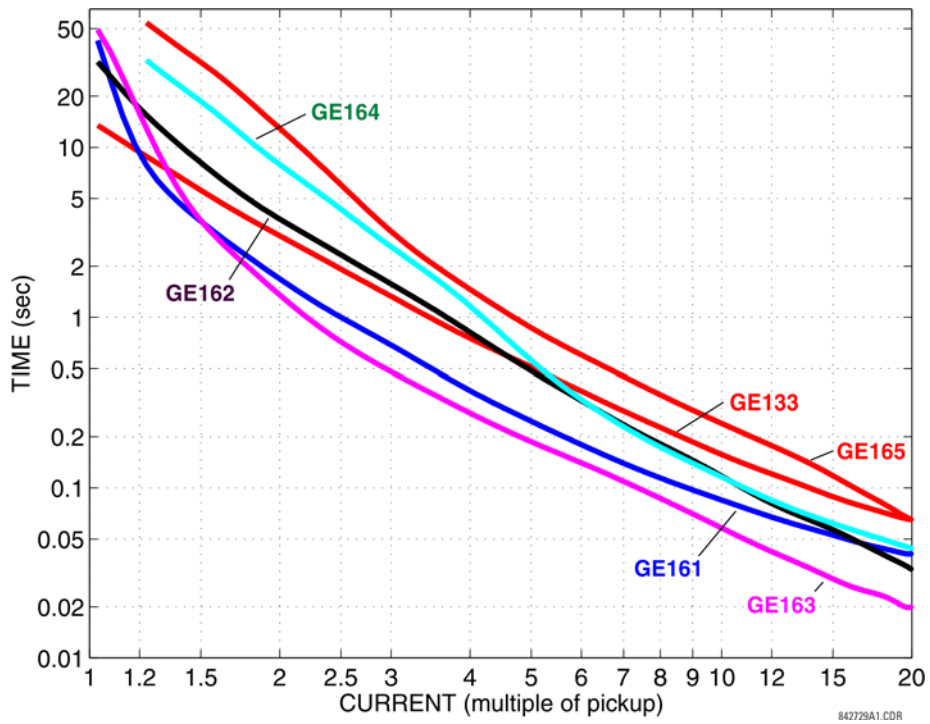


Figure 5-79: Recloser curves GE116, GE117, GE118, GE132, GE136, and GE139

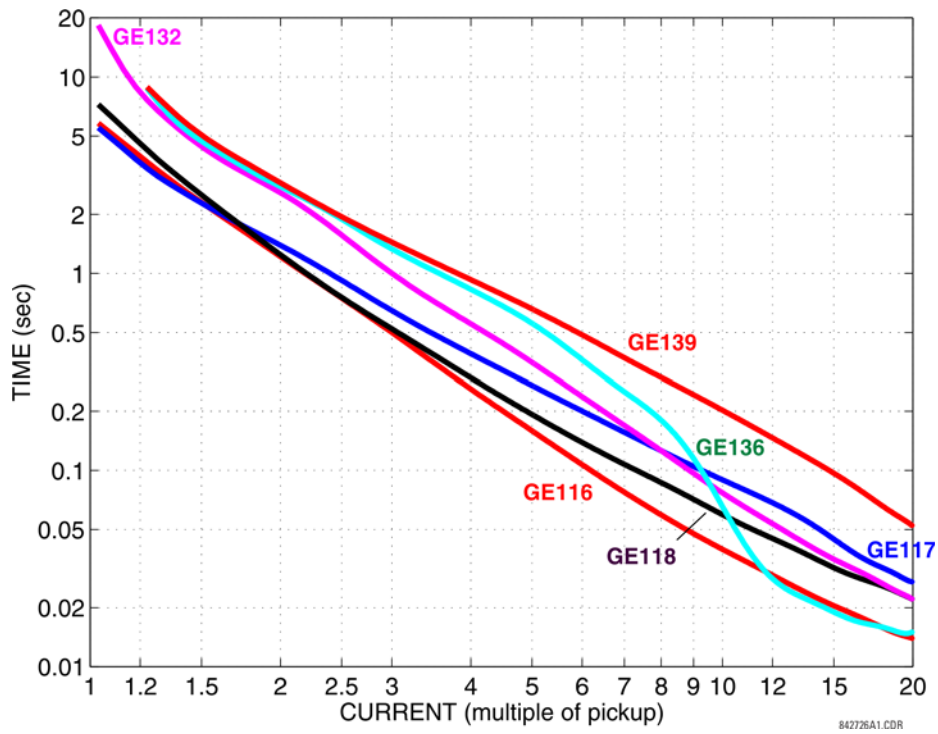


Figure 5-80: Recloser curves GE107, GE111, GE112, GE114, GE115, GE121, and GE122

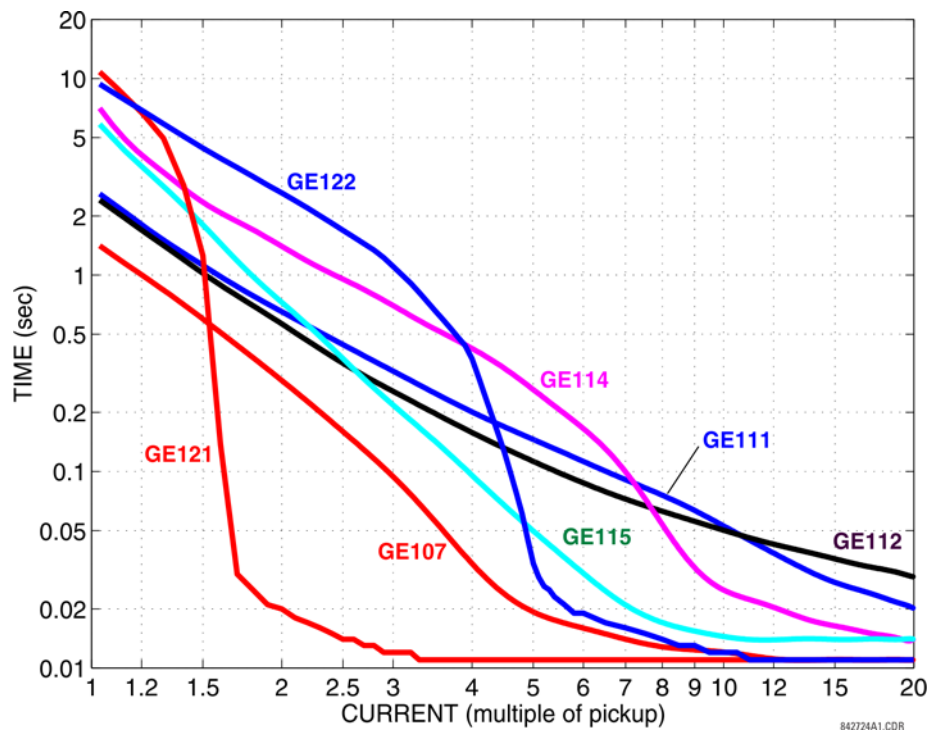
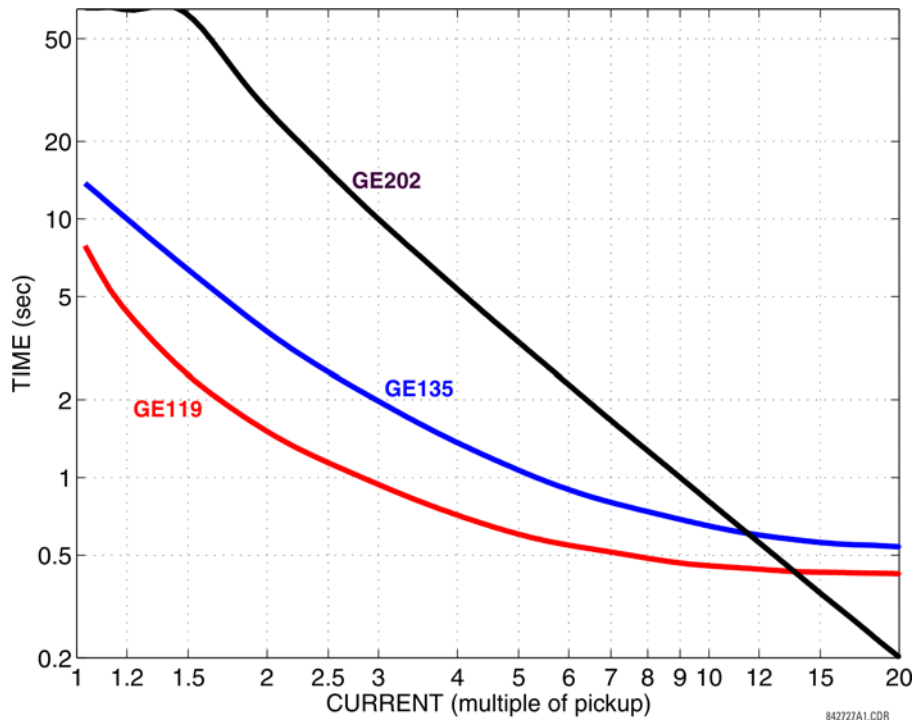


Figure 5-81: Recloser curves GE119, GE135, and GE202

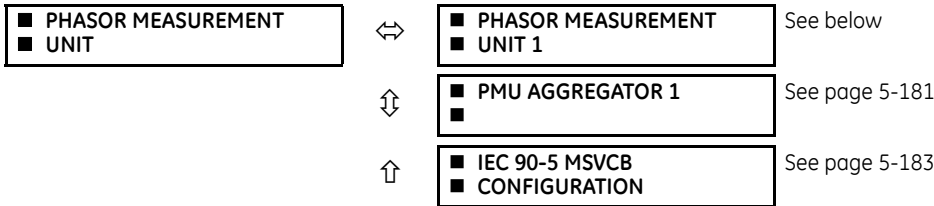


5

5.5.8 Phasor Measurement Unit

5.5.8.1 Menu

SETTINGS ⇄ SYSTEM SETUP ⇄ PHASOR MEASUREMENT UNIT



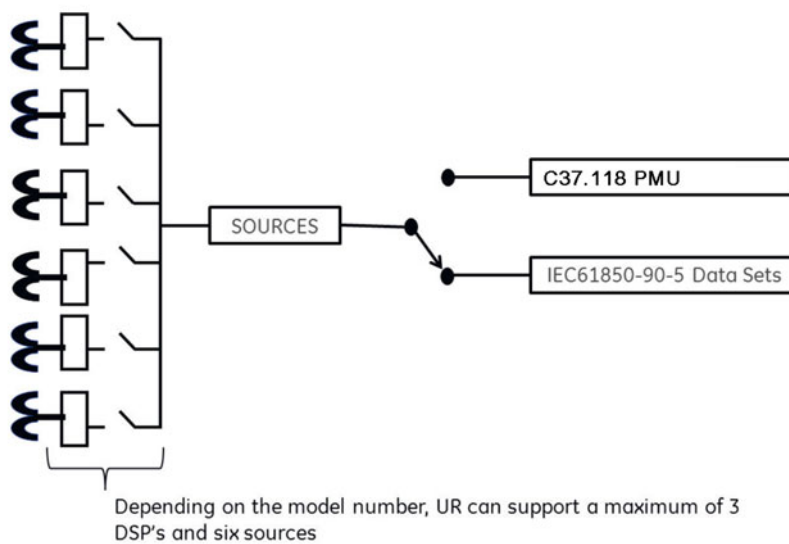
The L30 is provided with an optional Phasor Measurement Unit (PMU) feature. This feature is specified as a software option at the time of ordering. The number of PMUs available also depends on this option. Using the order code for your device, see the order codes in chapter 2 for details.

5.5.8.2 UR synchrophasor implementation

Phasors are used in protection relays. When these phasors are referenced to a common time base, they are referred to as synchrophasors. A vastly improved method for tracking power system dynamic phenomena for power system monitoring, protection, operation, and control can be realized when synchrophasors from different locations within the power system are networked to a central location.

The L30 offers PMU features over two communication standards, IEC 61850-90-5 and IEEE C37.118. The figure shows complete synchrophasor implementation.

Figure 5-82: Synchrophasor implementation



5.5.8.3 UR implementation of IEC 61850-90-5

Synchrophasor data as measured and calculated by PMUs is used to assess the condition of the electrical power network. The IEEE C37.118 standards define synchrophasors and related message formats to transmit synchrophasor data. Synchrophasor streaming via IEEE C37.118 has proven to work but the need to have a communication mechanism that is compliant with the concept of IEC 61850 has led to the development of IEC 61850-90-5. The IEC 61850-90-5 technical report defines the packet structure for multicast routing of streamed Sampled Value (SV) known as R-SV.

UR firmware versions 7.0 and above have a 90-5 based R-SV implementation equivalent in structure and configuration to that of the existing IEEE C37.118 implementation of firmware version 6.0, that is, synchrophasor data at rates up to 60 Hz for metering and 120 Hz for protection class synchrophasors. The following two figures depict the general data flow for the generation of synchrophasor data for IEC 61850-90-5. In the first figure, when IEC 61850-90-5 is selected all real and virtual sources are available for the IEC 61850-90-5 PMUs.

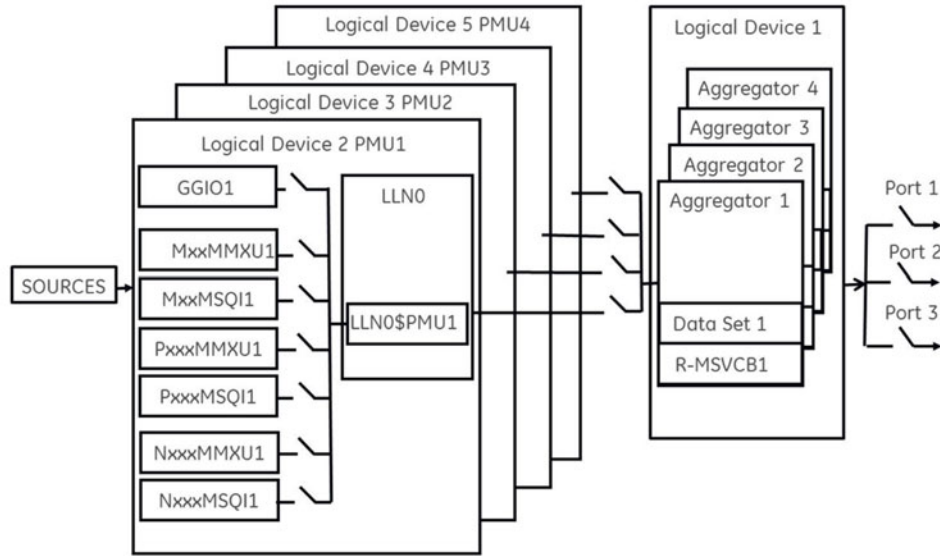
The number of PMUs and aggregators vary by product, as outlined in the table.

Table 5-18: PMU implementation by UR device

UR device	Number of PMUS	Number of aggregators	Number of analog inputs	Comment
N60	6	4	16	1, 2, 4, or 6 PMUs can be used
C60	2	2	16	
D60, F60, G60, L30, L90, T60	1	1	16	

The figure shows an example of an N60 using four Logical Device PMUs (Logical Device 2 through 5) and four aggregators. The control blocks for the aggregators are located in LD1. A 64 character LDName setting is provided.

Figure 5-83: N60 example for four logical device PMUs

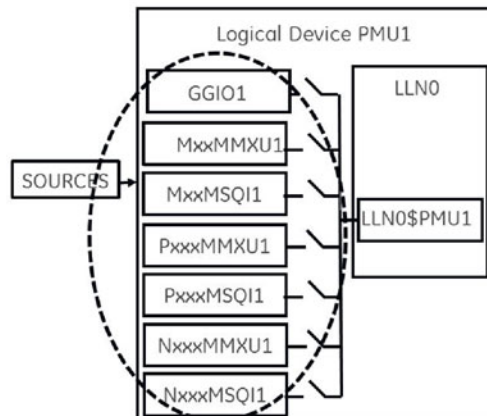


Precise time input to the relay from the international time standard, via either IRIG-B or PTP, is vital for correct synchrophasor measurement and reporting. For IRIG-B, a DC level shift IRIG-B receiver must be used for the PMU to output proper synchrophasor values.

5

Depending on the applied filter, the synchrophasors that are produced by PMUs are classified as either P (protection) or M (Measurement) class synchrophasors. Synchrophasors available within the UR that have no filtering applied are classified as NONE, which within the standard is classified as PRES OR UNKNOWN under the Calculation Method - ClcMth. Each Logical Device PMU supports one MxxMMXU, MxxMSQI, PxxxMMXU, PxxxMSQI, NxxxMMXU, and one NxxMSQI logical node.

Figure 5-84: Logical nodes supported in each logical device



The following is a summary of LNs that are in each Logical Device (LD2 through LD7):

- PxxxMMXU1 ClcMth = P-Class (Note Vaux is mapped to Vneut of MMXU)
- PxxxMSQI1 ClcMth = P-CLASS
- MxxMMXU1 ClcMth = M-Class (Note Vaux is mapped to Vneut of MMXU)
- MxxMSQI1 ClcMth = M-CLASS
- NxxMMXU1 ClcMth = M-Class (Note Vaux is mapped to Vneut of MMXU)
- NxxMSQI1 ClcMth = M-CLASS

- GGIO1, which contains 16 digital status indication points and 16 analog points. The Analog GGIO values are selectable from any FlexAnalog value in the UR.



The Synchro Logical Nodes in an LD report at the same rate as set in the PMUn Basic Configuration setting. This is reflected in the instantiation of the Data Object – SmpRate in the msvcb## of LLN0 in the LD1. SmpRate is a Read Only Integer Status (INS).

When the first PMU from any LD is mapped into an aggregator, the aggregator inherits the Sample Rate (SmpRate) and IEEE C37.118 Class (P or M) of that PMU. The value of the SmpRate DO in the Report Control Block is set based on the value of the Sample Rate in the PMU. The Class of the Dataset are mapped into the MSVID of the Dataset (see text that follows for the overall name of the MSVID). If other PMUs are mapped into the same aggregator with different Sample Rates or from different classes, then a Self-Test error (DatSetErr) is set and dataset transmission is blocked.

A setting value — MSVID — is created with a maximum input range of 56 characters (=64 less 6 for the IDCode less 2 for the Class).

The value of MSVID in the dataset is a concatenation of the aggregator IDCode and the MSVID setting value in the format: MSVID-AggregatorIDCode-CLASS where CLASS is P, M, or N (for None) – depending on the Class of the first PMU included in the Aggregator.



Synchrophasor Rectangular Format and Integer data types are NOT supported in IEC 61850-90-5 (only supported with IEEE C37.118) and not to set — GGIO1 that contains 16 digital status indication points — aggregated as a 16 bit bitstring and 16 analog points. The Analog GGIO values are selectable from any FlexAnalog value in the UR. For firmware versions 7.0 and later, the description fields for the phasors, analog, and digital channels are populated with the 16 character name field provided within the Basic Configuration menu. Additionally, the names of the 16 binary points are implemented as numbered descriptions — d1, d2, d3, and so on. The number of descriptions are equal to the number of bits configured in the 16 bit digital status word.

All bitstrings less than or equal to 32 bits in length map into a 32 bit bitstring in an IEC 61850-90-5 dataset.

The Value of the Nominal Frequency of the chassis is instantiated as a DO in LPHD of LD1. The value is named HzNom and is an Integer Status (INS).

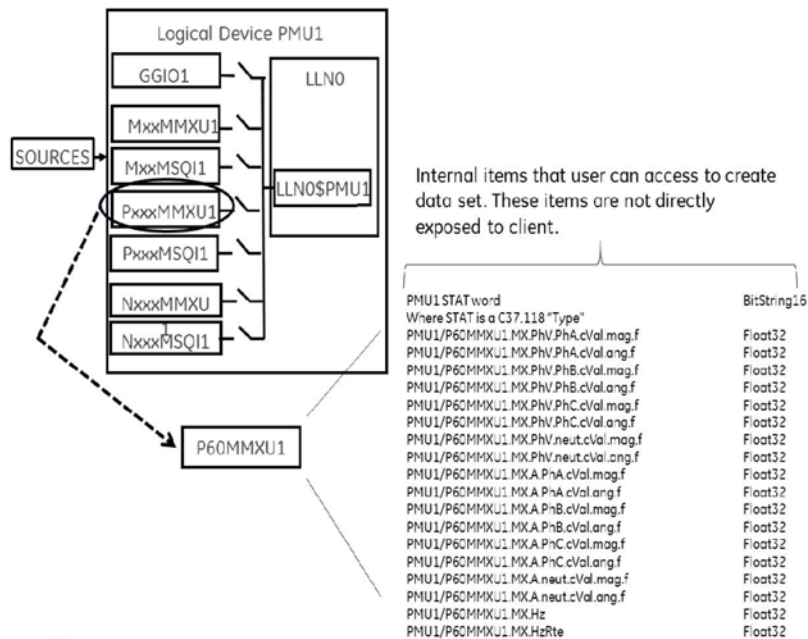
The UR also supports the option to apply no filtering to the synchrophasors. If no filtering is applied (PMU Class = None), according to the standard, the ClcMth attribute is PRES. The semantic of the ClcMth used is not carried in the individual DO and so it is recommended that one of letters of the prefix on the instantiated LNs be set to “P” or “M” accordingly in order to differentiate. For firmware versions 7.0 and later, only FCDA data is supported. The PMU Implementation by UR Device table earlier indicates the maximum size of each PMU data set for version 7.2 and later using FCDA data (non-structured data).

5.5.8.4 Example: Protection synchrophasors data set with reporting rate 60 frames/second

This example gives the protection synchrophasors data set with a reporting rate of 60 frames per second (P60MMXU1). See the figure earlier, Logical Nodes Supported in Each Logical Device. This data or list of items, as shown in the following figure, is not available to the UR setup program but is available to be mapped by the user into a selected aggregator or aggregators dataset. The logical device name (LDName) of each PMU LD is a 64 character user setting. The IEEE C37.118 STN and IDCode is to be mapped as a concatenated value in the (d)escription field of LPL CDC of the NamPlt DO in LLN0. The mapping is implemented as STN-IDCode (text string).

From each PMU, the user selects the phasor information of interest that is mapped into the selected aggregator dataset(s). For version 7.0 and later, only FCDA data is supported.

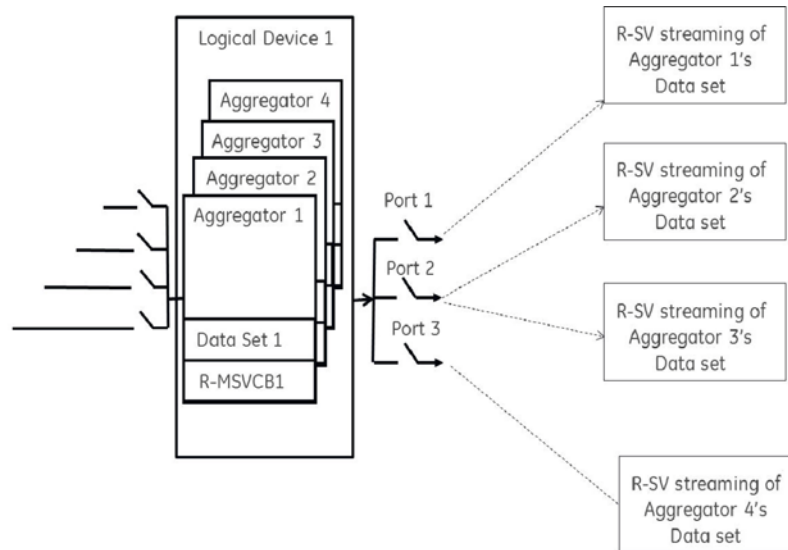
Figure 5-85: Data set created from user-selected internal items



5.5.8.5 Example: Creation of different data sets

The aggregators allow the aggregation of phasors from multiple PMUs (with the same reporting rate) into a single custom data set to optimize bandwidth when streaming.

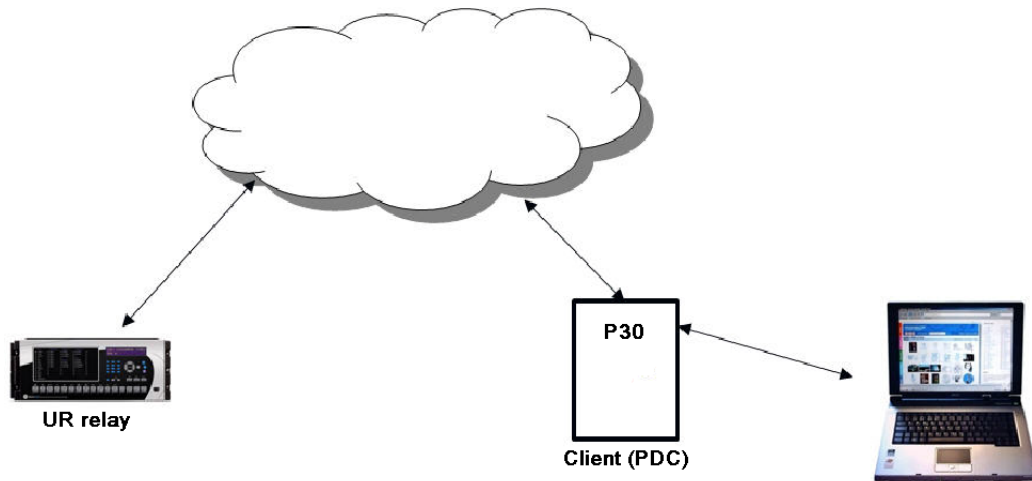
Figure 5-86: Example of aggregator data sets



5.5.8.6 Configuration example: CFG-2 based configuration (using IEC 61850-90-5)

The L30 is expected to send the CFG-2 file (IEEE C37.118 config. file) upon request from the upstream synchrophasor devices (for example, P30) without stopping R-SV multicasting, as shown in the following figure. The primary domain controller (PDC) does not need to use a stop/start data stream command if the UR protocol is set to IEC 61850-90-5 prior to requesting the configuration via CFG-2 (IEEE C37.118 config. file). The CFG-2 request from the P30 can be on TCP/IP or UDP/IP, however, R-SV data streaming is only UDP multicasts (not TCP).

Figure 5-87: CFG-2 based configuration solution



5.5.8.7 Modification of SYNC word in CFG-2 for TR 90-5 data sets

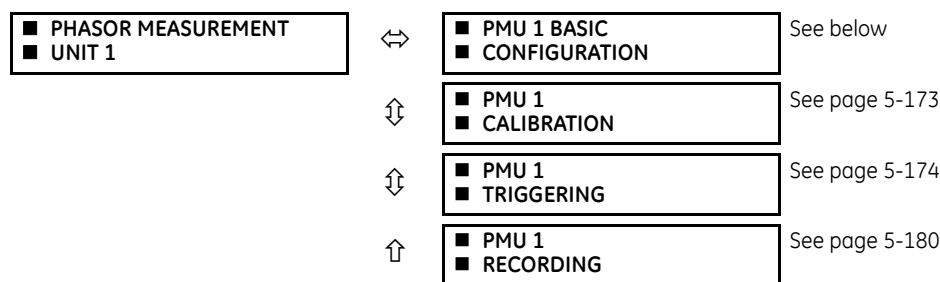
In the CFG-2 file, all relevant information about the data being streamed is included. However, this file does not include the fact that it describes a 90-5 dataset or the number of Application Service Data Units (datasets). In order to communicate this information via the CFG-2 file for a given aggregator, when the aggregator is set to 90-5, the version number of the CFG-2 file (found in bits 0-3 of the frame SYNC word, which is set presently to 2) is set as follows:

Value (decimal)	Number of ASDUs
11	1
12	2
13	3
14	4

5.5.8.8 Settings

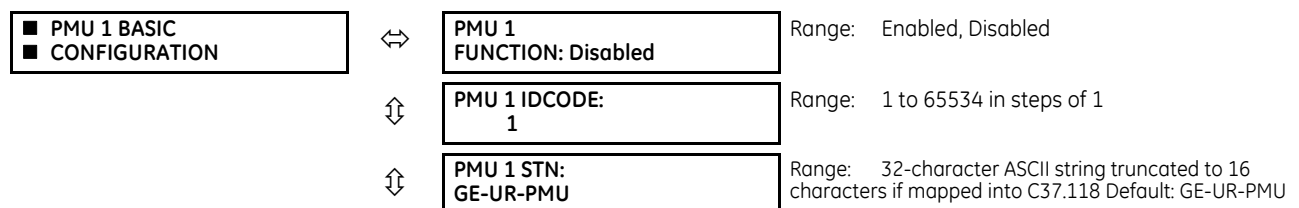
The PMU settings are organized as follows.

SETTINGS ⇨ SYSTEM SETUP ⇨ PHASOR MEASUREMENT UNIT ⇨ PHASOR MEASUREMENT UNIT 1

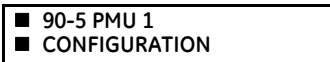


5.5.8.9 Basic configuration

SETTINGS ⇨ SYSTEM SETUP ⇨ PHASOR MEASUREMENT UNIT ⇨ BASIC CONFIGURATION ⇨ PMU 1



↕	PMU 1 SIGNAL SOURCE: SRC 1	Range: available signal sources
↕	PMU 1 CLASS: M-CLASS	Range: None, M-CLASS, P-CLASS
↕	PMU 1 FORMAT: Integer	Range: Integer, Floating-point
↕	PMU 1 STYLE: Polar	Range: Polar, Rectangular
↕	PMU 1 RATE: 10/sec	Range: 1, 2, 4, 5, 10, 12, 15,20, 25, 30,50, 60, 100, 120 /sec
↕	PMU 1 f & df/dt FILTER: None	Range: None, 10Hz/s <10Hz, 10Hz/s <20Hz, 20Hz/s <10Hz, 20Hz/s <20Hz
↕	■ C37.118 PMU 1 ■ CONFIGURATION	See below
↕	PMU 1 PHS- 1: Off	Range: available synchrophasor values
	↓	
↕	PMU 1 PHS-14: Off	Range: available synchrophasor values
↕	PMU 1 PHS- 1: NM: GE-UR-PMU-PHS 1	Range: 16-character ASCII string
	↓	
↕	PMU 1 PHS-14: NM: GE-UR-PMU-PHS 14	Range: 16-character ASCII string
↕	PMU 1 A-CH- 1: Off	Range: available FlexAnalog values
	↓	
↕	PMU 1 A-CH-8: Off	Range: available FlexAnalog values
↕	PMU 1 A-CH- 1: NM: AnalogChannel 1	Range: 16-character ASCII string
	↓	
↕	PMU 1 A-CH-8: NM: AnalogChannel 8	Range: 16-character ASCII string
↕	PMU 1 D-CH- 1: Off	Range: available FlexLogic operands
	↓	
↕	PMU 1 D-CH-16: Off	Range: available FlexLogic operands
↕	PMU 1 D-CH- 1 NM: Dig Channel 1	Range: 16-character ASCII string
	↓	
↕	PMU 1 D-CH-16 NM: Dig Channel 16	Range: 16-character ASCII string
↕	PMU 1 D-CH- 1 NORMAL STATE: Off	Range: Off, On
	↓	
↕	PMU 1 D-CH-16: NORMAL STATE: Off	Range: Off, On



See below

This section contains basic Phasor Measurement Unit (PMU) data, such as functions, source settings, and names.

PMU 1 FUNCTION — This setting enables the LOGICAL Device PMU 1 functionality. Use this setting to permanently enable or disable the feature.

PMU 1 IDCODE — This setting assigns a numerical ID to the PMU. It corresponds to the IDCODE field of the data, configuration, header, and command frames of the IEEE C37.118 protocol. The PMU uses this value when sending data, configuration, and header frames; and it responds to this value when receiving the command frame. This is used when only data from one PMU is present.

PMU 1 STN — This setting assigns an alphanumeric ID to the PMU station. It corresponds to the STN field of the configuration frame of the IEEE C37.118 protocol. This value is a 16-character ASCII string as per the IEEE C37.118 standard.

PMU 1 SIGNAL SOURCE — This setting specifies one of the available L30 signal sources for processing in the PMU. Any combination of voltages and currents can be configured as a source. The current channels can be configured as sums of physically connected currents. This facilitates PMU applications in breaker-and-a-half, ring-bus, and similar arrangements. The PMU feature calculates voltage phasors for actual voltage (A, B, C, and auxiliary) and current (A, B, C, and ground) channels of the source, as well as symmetrical components (0, 1, and 2) of both voltages and currents. When configuring communication and recording features of the PMU, the user can select, from the above superset, the content to be sent out or recorded. When one source is selected by one PMU, it cannot be selected by another PMU.

PMU 1 CLASS (Range P, M, None) — This setting selects the synchrophasor class. A reporting rate of 100 or 120 can only be selected for class P synchrophasors and if the system frequency is 50 or 60 Hz, respectively.

PMU 1 NETWORK REPORTING FORMAT — This setting selects between reporting synchrophasors as 16-bit integer or 32-bit IEEE floating point numbers. This setting complies with bit-1 of the FORMAT field of the C37.118 configuration frame. Note that this setting applies to synchrophasors only; the user-selectable FlexAnalog channels are always transmitted as 16-bit integer values.

PMU 1 NETWORK REPORTING STYLE — This setting selects between reporting synchrophasors in rectangular (real and imaginary) or in polar (magnitude and angle) coordinates. This setting complies with bit-0 of the FORMAT field of the C37.118 configuration frame.

PMU 1 RATE — This setting specifies the reporting rate for the network (Ethernet) port. This value applies to all PMU streams of the device that are assigned to transmit over this aggregator. For a system frequency of 60 Hz (50 Hz), the L30 generates a reporting mismatch message if the selected rate is not set as 10 Hz, 12 Hz, 15 Hz, 20 Hz, 30 Hz, 60 Hz, or 120 Hz (or 10 Hz, 25 Hz, 50 Hz, or 100 Hz when the system frequency is 50 Hz) when entered via the keypad or software; and the L30 stops the transmission of reports. Note that 4 Hz is not allowed for an M-class 50 Hz system.

PMU 1 f & df/dt FILTER — This setting allows applying post-filtering to the frequency and rate-of-change-of-frequency to avoid reporting erroneous values, which can possibly happen during fault, switching, and other system disturbances. For example, choosing 20Hz/s <10Hz setting ensures that if rate-of-change-of-frequency between current reporting instance and previous one exceeds 20Hz/s or frequency deviation from the nominal frequency exceeds 10Hz, then new frequency and rate-of-change-of-frequency value are invalidated. If this happens, the previous valid value of the frequency is maintained and rate-of-change-of-frequency value is forced to 0 at this reporting instance.

PMU 1 PHS-1 to PMU 1 PHS-14 — These settings specify synchrophasors to be transmitted from the superset of all synchronized measurements. The table outlines available synchrophasor values.

Table 5-19: Synchrophasor settings

Selection	Meaning
Va	First voltage channel, either Va or Vab
Vb	Second voltage channel, either Vb or Vbc
Vc	Third voltage channel, either Vc or Vca
Vx	Fourth voltage channel
Ia	Phase A current, physical channel or summation as per the source settings
Ib	Phase B current, physical channel or summation as per the source settings

Selection	Meaning
Ic	Phase C current, physical channel or summation as per the source settings
Ig	Fourth current channel, physical or summation as per the source settings
V1	Positive-sequence voltage, referenced to Va
V2	Negative-sequence voltage, referenced to Va
V0	Zero-sequence voltage
I1	Positive-sequence current, referenced to Ia
I2	Negative-sequence current, referenced to Ia
I0	Zero-sequence current

These settings allow for optimizing the frame size and maximizing transmission channel usage, depending on a given application. Select “Off” to suppress transmission of a given value.

PMU 1 PHS-1 NM to PMU 1 PHS-14 NM — These settings allow for custom naming of the synchrophasor channels. Sixteen-character ASCII strings are allowed as in the CHNAM field of the configuration frame. These names are typically based on station, bus, or breaker names.

PMU 1 A-CH-1 to PMU 1 A-CH-16 — These settings specify any analog data measured by the relay to be included as a user-selectable analog channel of the data frame. Up to eight analog channels can be configured to send any FlexAnalog value from the relay. Examples include frequency, rate of frequency change, active and reactive power, per phase or three-phase power, power factor, temperature via RTD inputs, and THD. The configured analog values are sampled concurrently with the synchrophasor instant and sent as 32-bit floating-point values scaled to Engineering units.

PMU 1 A-CH-1 NM to PMU 1 A-CH-16 NM — These settings allow for custom naming of the analog channels. Sixteen-character ASCII strings are allowed as in the CHNAM field of the configuration frame.

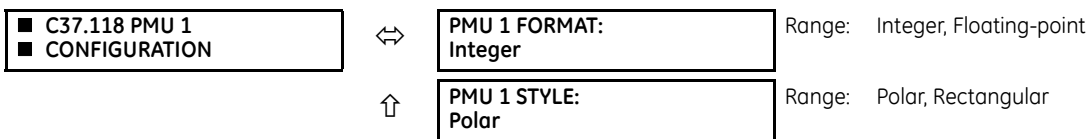
PMU 1 D-CH-1 to PMU 1 D-CH-16 — These settings specify any digital flag measured by the relay to be included as a user-selectable digital channel of the data frame. Up to 16 digital channels can be configured to send any FlexLogic operand from the relay. The configured digital flags are sampled concurrently with the synchrophasor instant. These values are mapped into a two-byte integer number, with byte 1 LSB corresponding to the digital channel 1 and byte 2 MSB corresponding to digital channel 16.

PMU 1 D-CH-1 NM to PMU 1 D-CH-16 NM — These settings allow for custom naming of the digital channels. Sixteen-character ASCII strings are allowed as in the CHNAM field of the configuration frame.

PMU 1 D-CH-1 NORMAL STATE to PMU 1 D-CH-16 NORMAL STATE — These settings allow for specifying a normal state for each digital channel. These states are transmitted in configuration frames to the data concentrator.


C37.118 PMU 1 configuration

SETTINGS ⇄ SYSTEM SETUP ⇄ PHASOR MEASUREMENT UNIT ⇄ BASIC CONFIGURATION ⇄ PMU 1 ⇄ PMU 1 BASIC CONFIGURATION ⇄ C37.118 PMU 1 CONFIGURATION



PMU 1 FORMAT — This setting selects whether synchrophasors are reported as 16-bit integers or 32-bit IEEE floating point numbers. This setting complies with bit-1 of the FORMAT field of the IEEE C37.118 configuration frame. This setting applies to synchrophasors only; user-selectable FlexAnalog channels are always transmitted as 16-bit integer values.

PMU 1 STYLE — This setting selects whether synchrophasors are reported in rectangular (real and imaginary) coordinates or in polar (magnitude and angle) coordinates. This setting complies with bit-0 of the FORMAT field of the IEEE C37.118 configuration frame.


 With 90-5 PMU, the FORMAT and STYLE are Floating-point and Polar respectively, as specified in the IEC 61850-90-5 technical report.

IEC 61850-90-5 PMU 1 configuration

SETTINGS ⇒ SYSTEM SETUP ⇒ PHASOR MEASUREMENT UNIT ⇒ BASIC CONFIGURATION ⇒ PMU 1 ⇒ PMU 1 BASIC CONFIGURATION ⇒ 90-5 PMU 1 CONFIGURATION

<input checked="" type="checkbox"/> 90-5 PMU 1 <input checked="" type="checkbox"/> CONFIGURATION	↔	PMU 1 LDINST: PMU1	Range: 64 char ASCII text
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PMU1 LDINST — A user-defined visible string (maximum 64 char ASCII test) to assign Logical Device (LD) Inst for a PMU logical device.

 As per IEC 61850-6 standard specification, the PMU LD Name is the concatenated combination (to total 64 characters) of IED Name (specified in IEC 61850 Server Settings) appended with PMU X LDINST string.

5.5.8.10 PMU calibration

SETTINGS ⇒ SYSTEM SETUP ⇒ PHASOR MEASUREMENT UNIT ⇒ PHASOR MEASUREMENT UNIT 1 ⇒ PMU 1 CALIBRATION

<input checked="" type="checkbox"/> PMU 1 <input checked="" type="checkbox"/> CALIBRATION	↔	PMU 1 VA CALIBRATION ANGLE: 0.00°	Range: -5.00 to 5.00° in steps of 0.05
	⇅	PMU 1 VA CALIBRATION MAG: 100.0%	Range: 95.0 to 105.0 in steps of 0.1%
	⇅	PMU 1 VB CALIBRATION ANGLE: 0.00°	Range: -5.00 to 5.00° in steps of 0.05
	⇅	PMU 1 VB CALIBRATION MAG: 100.0%	Range: 95.0 to 105.0 in steps of 0.1%
	⇅	PMU 1 VC CALIBRATION ANGLE: 0.00°	Range: -5.00 to 5.00° in steps of 0.05
	⇅	PMU 1 VC CALIBRATION MAG: 100.0%	Range: 95.0 to 105.0 in steps of 0.1%
	⇅	PMU 1 VX CALIBRATION ANGLE: 0.00°	Range: -5.00 to 5.00° in steps of 0.05
	⇅	PMU 1 VX CALIBRATION MAG: 100.0%	Range: 95.0 to 105.0 in steps of 0.1%
	⇅	PMU 1 IA CALIBRATION ANGLE: 0.00°	Range: -5.00 to 5.00° in steps of 0.05
	⇅	PMU 1 IA CALIBRATION MAG: 100.0%	Range: 95.0 to 105.0 in steps of 0.1%
	⇅	PMU 1 IB CALIBRATION ANGLE: 0.00°	Range: -5.00 to 5.00° in steps of 0.05
	⇅	PMU 1 IB CALIBRATION MAG: 100.0%	Range: 95.0 to 105.0 in steps of 0.1%
	⇅	PMU 1 IC CALIBRATION ANGLE: 0.00°	Range: -5.00 to 5.00° in steps of 0.05
	⇅	PMU 1 IC CALIBRATION MAG: 100.0%	Range: 95.0 to 105.0 in steps of 0.1%
	⇅	PMU 1 IG CALIBRATION ANGLE: 0.00°	Range: -5.00 to 5.00° in steps of 0.05
	⇅	PMU 1 IG CALIBRATION MAG: 100.0%	Range: 95.0 to 105.0 in steps of 0.1%



This menu contains user angle and magnitude calibration data for the Phasor Measurement Unit (PMU). This data is combined with the factory adjustments to shift the phasors for better accuracy.

PMU 1 VA... IG CALIBRATION ANGLE — These settings recognize applications with protection class voltage and current sources, and they allow the user to calibrate each channel (four voltages and four currents) individually to offset errors introduced by VTs, CTs, and cabling. The setting values are effectively added to the measured angles. Therefore, enter a positive correction when the secondary signal lags the true signal and a negative value when the secondary signal leads the true signal.

PMU 1 VA... IG CALIBRATION MAGNITUDE — These settings recognize applications with protection class voltage and current sources, and they allow the user to calibrate each channel (four voltages and four currents) individually to offset errors introduced by VTs, CTs. The setting values are effectively a multiplier of the measured magnitudes. Therefore, entering a multiplier greater than 100% of the secondary signal increases the true signal, and a multiplier less than 100% value of the secondary signal reduces the true signal.

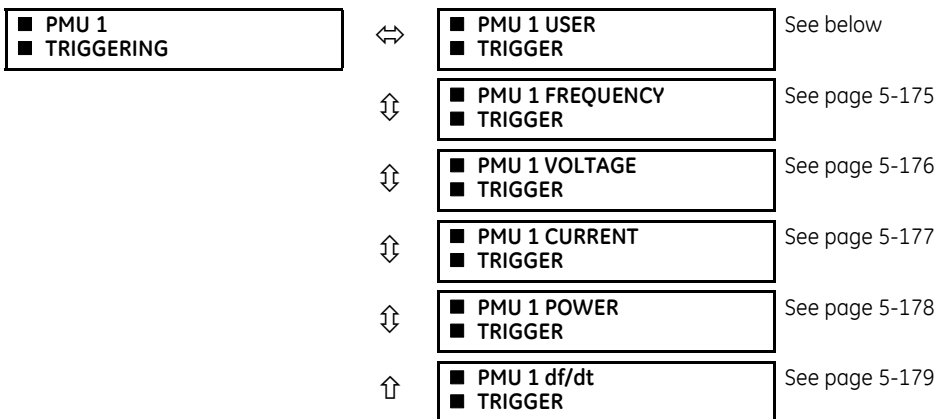
PMU 1 SEQ VOLT SHIFT ANGLE — This setting allows correcting positive- and negative-sequence voltages for vector groups of power transformers located between the PMU voltage point and the reference node. This angle is effectively added to the positive-sequence voltage angle and subtracted from the negative-sequence voltage angle. Note that:

- When this setting is not “0°”, the phase and sequence voltages do not agree. Unlike sequence voltages, the phase voltages cannot be corrected in a general case and therefore are reported as measured.
- When receiving synchrophasor data at multiple locations, with possibly different reference nodes, it can be more beneficial to allow the central locations to perform the compensation of sequence voltages.
- This setting applies to PMU data only. The L30 calculates symmetrical voltages independently for protection and control purposes without applying this correction.
- When connected to line-to-line voltages, the PMU calculates symmetrical voltages with the reference to the AG voltage and not to the physically connected AB voltage (see the Metering Conventions section in Chapter 6).

PMU 1 SEQ CURR SHIFT ANGLE — This setting allows correcting positive and negative-sequence currents for vector groups of power transformers located between the PMU current point and the reference node. The setting has the same meaning for currents as the **PMU 1 SEQ VOLT SHIFT ANGLE** setting has for voltages. Normally, the two correcting angles are set identically, except rare applications when the voltage and current measuring points are located at different windings of a power transformer.

5.5.8.11 PMU triggering overview

SETTINGS ⇄ SYSTEM SETUP ⇄ PHASOR MEASUREMENT UNIT ⇄ PHASOR MEASUREMENT UNIT 1 ⇄ PMU 1 TRIGGERING



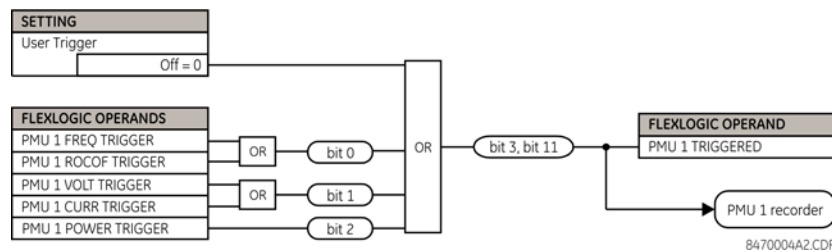
Each Phasor Measurement Unit (PMU) contains five triggering mechanisms to facilitate triggering of the associated PMU recorder, or cross-triggering of other PMUs in the system. They are

- Overfrequency and underfrequency
- Overvoltage and undervoltage
- Overcurrent
- Overpower
- High rate of change of frequency

The pre-configured triggers can be augmented with a user-specified condition built freely using programmable logic of the relay. The entire triggering logic is refreshed once every two power system cycles.

All five triggering functions and the user-definable condition are consolidated (ORed) and connected to the PMU recorder. Each trigger can be programmed to log its operation into the event recorder and to signal its operation via targets. The five triggers drive the STAT bits of the data frame to inform the destination of the synchrophasor data regarding the cause of trigger. The following convention is adopted to drive bits 11, 3, 2, 1, and 0 of the STAT word.

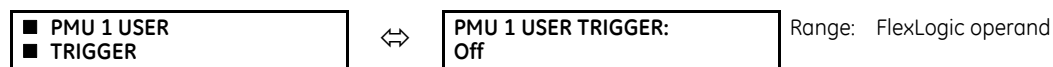
Figure 5-88: STAT bits logic



The trigger reset (drop-off) timer is available for all five triggering functions (FREQ, ROCOF, VOLT, CURR, POWER) in individual trigger settings under the **TRIGGER DPO TIME** setting. This asserts individual trigger operand and overall **PMU x TRIGGERED** operand with stat bits 3 and 11 for a fixed interval defined by this setting. If it is required that **PMU x TRIGGERED** operand with stat bits 3 and 11 stay longer than the individual reset timer, then use the **PMU x USER TRIGGER** setting assigned with appropriate elements and FlexLogic. In short, in case of **USER TRIGGER**, the drop-off time needs to be implemented using FlexLogic.

5.5.8.12 User triggering

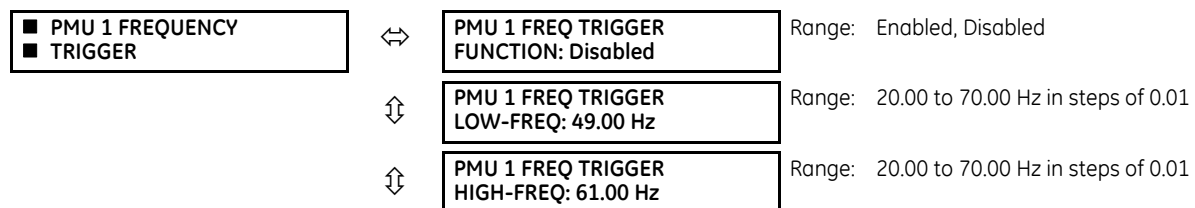
SETTINGS ⇒ SYSTEM SETUP ⇒ PHASOR MEASUREMENT UNIT ⇒ PHASOR MEASUREMENT UNIT 1 ⇒ PMU 1 TRIGGERING ⇒ PMU 1 USER TRIGGER



The user trigger allows customized triggering logic to be constructed from FlexLogic. The entire triggering logic is refreshed every two power system cycles.

5.5.8.13 Frequency triggering

SETTINGS ⇒ SYSTEM SETUP ⇒ PHASOR MEASUREMENT UNIT ⇒ PHASOR MEASUREMENT UNIT 1 ⇒ PMU 1 TRIGGERING ⇒ PMU 1 FREQUENCY TRIGGER



⇅	PMU 1 FREQ TRIGGER PKP TIME: 0.10 s	Range: 0.00 to 600.00 s in steps of 0.01
⇅	PMU 1 FREQ TRIGGER DPO TIME: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
⇅	PMU 1 FREQ TRIG BLK: Off	Range: FlexLogic operand
⇅	PMU 1 FREQ TRIGGER TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↑	PMU 1 FREQ TRIGGER EVENTS: Disabled	Range: Enabled, Disabled

The trigger responds to the frequency signal of the Phasor Measurement Unit (PMU) source. The frequency is calculated from among phase voltages, auxiliary voltage, phase currents, and ground current, in this hierarchy, depending on the source configuration as per L30 standards. This element requires that the frequency be above the minimum measurable value. If the frequency is below this value, such as when the circuit is de-energized, the trigger drops out.

PMU 1 FREQ TRIGGER LOW-FREQ — Specifies the low threshold for the abnormal frequency trigger. The comparator applies a 0.02 Hz hysteresis.

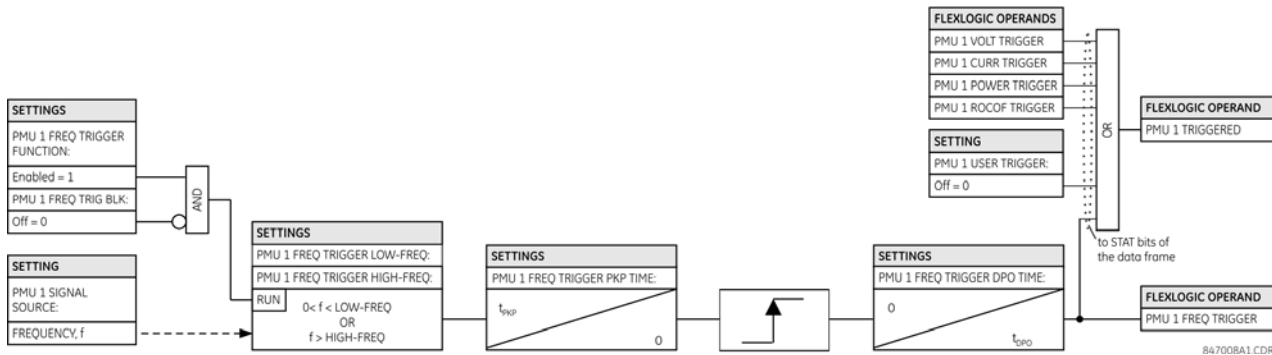
PMU 1 FREQ TRIGGER HIGH-FREQ — Specifies the high threshold for the abnormal frequency trigger. The comparator applies a 0.02 Hz hysteresis.

PMU 1 FREQ TRIGGER PKP TIME — Use to filter out spurious conditions and avoid unnecessary triggering of the recorder.

PMU 1 FREQ TRIGGER DPO TIME — Use to extend the trigger after the situation returns to normal. This setting is of importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

5

Figure 5-89: Frequency trigger logic



5.5.8.14 Voltage triggering

SETTINGS ⇅ SYSTEM SETUP ⇅ PHASOR MEASUREMENT UNIT ⇅ PHASOR MEASUREMENT UNIT 1 ⇅ PMU 1 TRIGGERING ⇅ PMU 1 VOLTAGE TRIGGER

<div style="display: flex; align-items: center;"> <div style="width: 15px; height: 15px; background-color: black; margin-right: 5px;"></div> PMU 1 VOLTAGE TRIGGER </div>	⇅	PMU 1 VOLT TRIGGER FUNCTION: Disabled	Range: Enabled, Disabled
	⇅	PMU 1 VOLT TRIGGER LOW-VOLT: 0.800 pu	Range: 0.250 to 1.250 pu in steps of 0.001
	⇅	PMU 1 VOLT TRIGGER HIGH-VOLT: 1.200 pu	Range: 0.750 to 1.750 pu in steps of 0.001
	⇅	PMU 1 VOLT TRIGGER PKP TIME: 0.10 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇅	PMU 1 VOLT TRIGGER DPO TIME: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01

⇅	PMU 1 VOLT TRIG BLK: Off	Range: FlexLogic operand
⇅	PMU 1 VOLT TRIGGER TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↑	PMU 1 VOLT TRIGGER EVENTS: Disabled	Range: Enabled, Disabled

This element responds to abnormal voltage. Separate thresholds are provided for low and high voltage. In terms of signaling its operation, the element does not differentiate between the undervoltage and overvoltage events. The trigger responds to the phase voltage signal of the Phasor Measurement Unit (PMU) source. All voltage channels (A, B, and C or AB, BC, and CA) are processed independently and can trigger the recorder. A minimum voltage supervision of 0.1 pu is implemented to prevent pickup on a de-energized circuit, similarly to the undervoltage protection element.

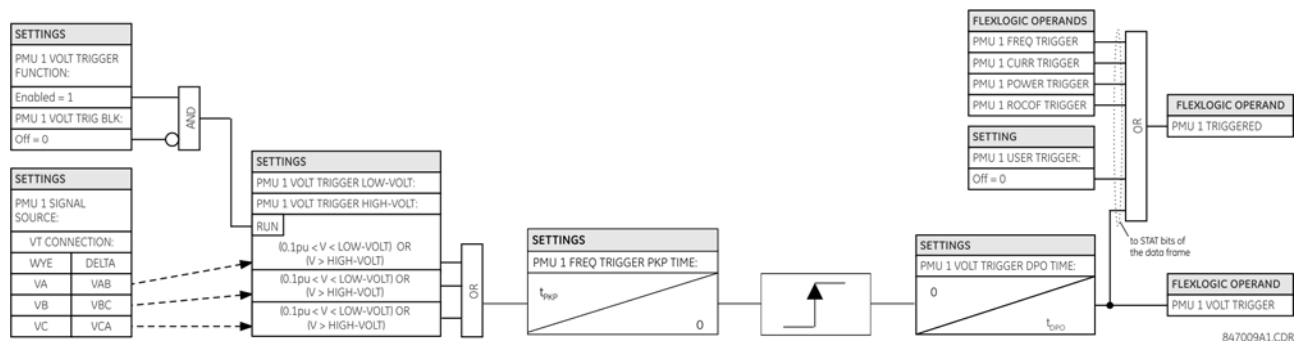
PMU 1 VOLT TRIGGER LOW-VOLT — Specifies the low threshold for the abnormal voltage trigger, in per-unit of the PMU source. 1 pu is a nominal voltage value defined as the nominal secondary voltage times VT ratio. The comparator applies a 1% hysteresis.

PMU 1 VOLT TRIGGER HIGH-VOLT — Specifies the high threshold for the abnormal voltage trigger, in per-unit of the PMU source. 1 pu is a nominal voltage value defined as the nominal secondary voltage times VT ratio. The comparator applies a 1% hysteresis.

PMU 1 VOLT TRIGGER PKP TIME — Use to filter out spurious conditions and avoid unnecessary triggering of the recorder.

PMU 1 VOLT TRIGGER DPO TIME — Use to extend the trigger after the situation returns to normal. This setting is of importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

Figure 5-90: Voltage trigger logic



5.5.8.15 Current triggering

SETTINGS ⇅ SYSTEM SETUP ⇅ PHASOR MEASUREMENT UNIT ⇅ PHASOR MEASUREMENT UNIT 1 ⇅ PMU 1 TRIGGERING ⇅ PMU 1 CURRENT TRIGGER

<div style="background-color: black; color: white; padding: 2px;">PMU 1 CURRENT TRIGGER</div>	⇅	PMU 1 CURR TRIGGER FUNCTION: Disabled	Range: Enabled, Disabled
	⇅	PMU 1 CURR TRIGGER PICKUP: 1.800 pu	Range: 0.100 to 30.000 pu in steps of 0.001
	⇅	PMU 1 CURR TRIGGER PKP TIME: 0.10 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇅	PMU 1 CURR TRIGGER DPO TIME: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇅	PMU 1 CURR TRIG BLK: Off	Range: FlexLogic operand
	⇅	PMU 1 CURR TRIGGER TARGET: Self-reset	Range: Self-reset, Latched, Disabled

↑ **PMU 1 CURR TRIGGER EVENTS: Disabled** Range: Enabled, Disabled

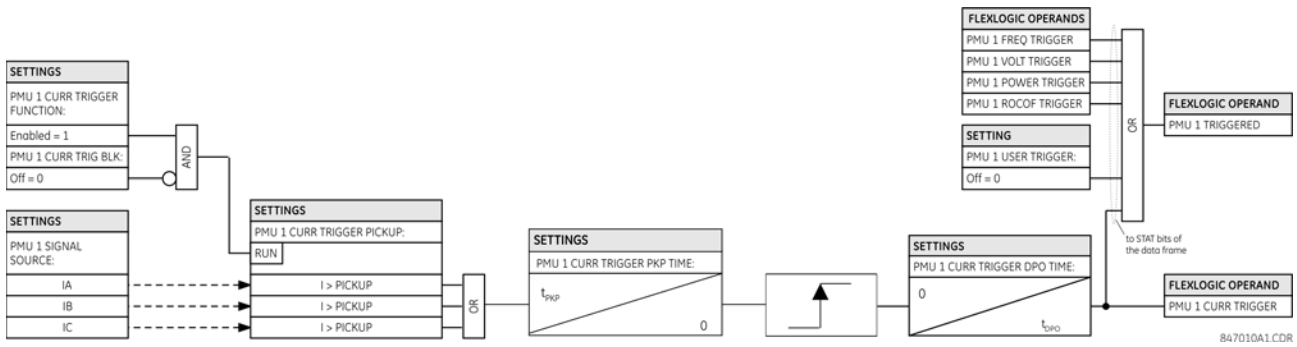
This element responds to elevated current. The trigger responds to the phase current signal of the Phasor Measurement Unit (PMU) source. All current channel (A, B, and C) are processed independently and can trigger the recorder.

PMU 1 CURR TRIGGER PICKUP — Specifies the pickup threshold for the overcurrent trigger, in per unit of the PMU source. A value of 1 pu is a nominal primary current. The comparator applies a 3% hysteresis.

PMU 1 CURR TRIGGER PKP TIME — Use to filter out spurious conditions and avoid unnecessary triggering of the recorder.

PMU 1 CURR TRIGGER DPO TIME — Use to extend the trigger after the situation returns to normal. This setting is of importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

Figure 5-91: Current trigger logic



5

5.5.8.16 Power triggering

SETTINGS ⇄ SYSTEM SETUP ⇄ PHASOR MEASUREMENT UNIT ⇄ PHASOR MEASUREMENT UNIT 1 ⇄ PMU 1 TRIGGERING ⇄ PMU 1 POWER TRIGGER

<p>■ PMU 1 POWER TRIGGER</p>	⇄	<p>PMU 1 POWER TRIGGER FUNCTION: Disabled</p>	Range: Enabled, Disabled
	⇄	<p>PMU 1 POWER TRIGGER ACTIVE: 1.250 pu</p>	Range: 0.250 to 3.000 pu in steps of 0.001
	⇄	<p>PMU 1 POWER TRIGGER REACTIVE: 1.250 pu</p>	Range: 0.250 to 3.000 pu in steps of 0.001
	⇄	<p>PMU 1 POWER TRIGGER APPARENT: 1.250 pu</p>	Range: 0.250 to 3.000 pu in steps of 0.001
	⇄	<p>PMU 1 POWER TRIGGER PKP TIME: 0.10 s</p>	Range: 0.00 to 600.00 s in steps of 0.01
	⇄	<p>PMU 1 POWER TRIGGER DPO TIME: 1.00 s</p>	Range: 0.00 to 600.00 s in steps of 0.01
	⇄	<p>PMU 1 PWR TRIG BLK: Off</p>	Range: FlexLogic operand
	⇄	<p>PMU 1 POWER TRIGGER TARGET: Self-reset</p>	Range: Self-reset, Latched, Disabled
	↑	<p>PMU 1 POWER TRIGGER EVENTS: Disabled</p>	Range: Enabled, Disabled

This element responds to abnormal power. Separate thresholds are provided for active, reactive, and apparent powers. In terms of signaling its operation, the element does not differentiate among the three types of power. The trigger responds to the single-phase and three-phase power signals of the Phasor Measurement Unit (PMU) source.

PMU 1 POWER TRIGGER ACTIVE — Specifies the pickup threshold for the active power of the source. For single-phase power, 1 pu is a product of 1 pu voltage and 1 pu current, or the product of nominal secondary voltage, the VT ratio and the nominal primary current. For the three-phase power, 1 pu is three times that for a single-phase power. The comparator applies a 3% hysteresis.

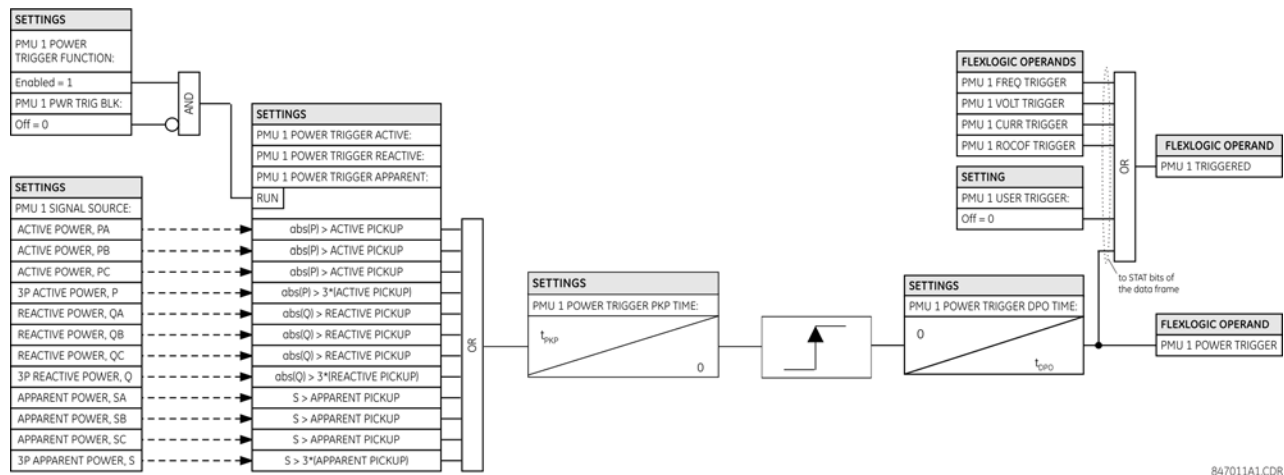
PMU 1 POWER TRIGGER REACTIVE — Specifies the pickup threshold for the reactive power of the source. For single-phase power, 1 pu is a product of 1 pu voltage and 1 pu current, or the product of nominal secondary voltage, the VT ratio and the nominal primary current. For the three-phase power, 1 pu is three times that for a single-phase power. The comparator applies a 3% hysteresis.

PMU 1 POWER TRIGGER APPARENT — Specifies the pickup threshold for the apparent power of the source. For single-phase power, 1 pu is a product of 1 pu voltage and 1 pu current, or the product of nominal secondary voltage, the VT ratio and the nominal primary current. For the three-phase power, 1 pu is three times that for a single-phase power. The comparator applies a 3% hysteresis.

PMU 1 POWER TRIGGER PKP TIME — Use to filter out spurious conditions and avoid unnecessary triggering of the recorder.

PMU 1 POWER TRIGGER DPO TIME — Use to extend the trigger after the situation returns to normal. This setting is of particular importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

Figure 5-92: Power trigger logic



5.5.8.17 df/dt triggering

SETTINGS ⇒ SYSTEM SETUP ⇒ PHASOR MEASUREMENT UNIT ⇒ PHASOR MEASUREMENT UNIT 1 ⇒ PMU 1 TRIGGERING ⇒ PMU 1 df/dt TRIGGER

■ PMU 1 df/dt TRIGGER	⇔	PMU 1 df/dt TRIGGER FUNCTION: Disabled	Range: Enabled, Disabled
	⇕	PMU 1 df/dt TRIGGER RAISE: 0.25 Hz/s	Range: 0.10 to 15.00 Hz/s in steps of 0.01
	⇕	PMU 1 df/dt TRIGGER FALL: 0.25 Hz/s	Range: 0.10 to 15.00 Hz/s in steps of 0.01
	⇕	PMU 1 df/dt TRIGGER PKP TIME: 0.10 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇕	PMU 1 df/dt TRIGGER DPO TIME: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇕	PMU 1 df/dt TRG BLK: Off	Range: FlexLogic operand
	⇕	PMU 1 df/dt TRIGGER TARGET: Self-reset	Range: Self-reset, Latched, Disabled

↑ **PMU 1 df/dt TRIGGER EVENTS: Disabled** Range: Enabled, Disabled

This element responds to frequency rate of change. Separate thresholds are provided for rising and dropping frequency. The trigger responds to the rate of change of frequency (df/dt) of the Phasor Measurement Unit (PMU) source.

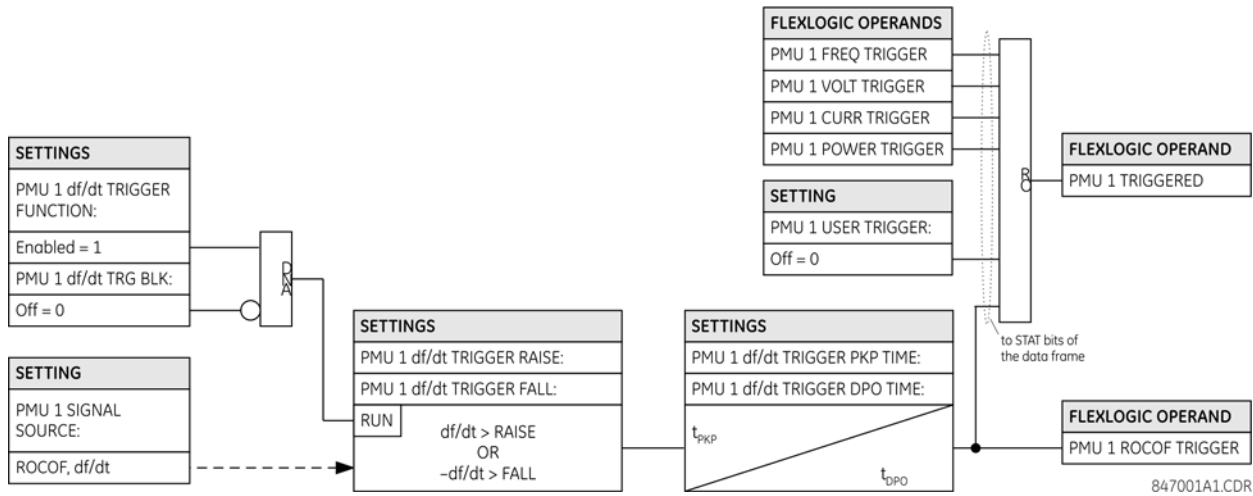
PMU 1 df/dt TRIGGER RAISE — Specifies the pickup threshold for the rate of change of frequency in the raising direction (positive df/dt). The comparator applies a 4% hysteresis.

PMU 1 df/dt TRIGGER FALL — Specifies the pickup threshold for the rate of change of frequency in the falling direction (negative df/dt). The comparator applies a 4% hysteresis.

PMU 1 df/dt TRIGGER PKP TIME — Use to filter out spurious conditions and avoid unnecessary triggering of the recorder.

PMU 1 df/dt TRIGGER DPO TIME — Use to extend the trigger after the situation returns to normal. This setting is of importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

Figure 5-93: Rate of change of frequency trigger logic



5

5.5.8.18 PMU recording

SETTINGS ⇒ SYSTEM SETUP ⇒ PHASOR MEASUREMENT UNIT ⇒ PHASOR MEASUREMENT UNIT 1 ⇒ RECORDING PMU 1

■ PMU 1 ■ RECORDING	↔	PMU 1 FUNCTION: Disabled	Range: Enabled, Disabled
	↕	PMU 1 NO OF TIMED RECORDS: 10	Range: 2 to 128 in steps of 1
	↕	PMU 1 TRIGGER MODE: Automatic Overwrite	Range: Automatic Overwrite, Protected
	↑	PMU 1 TIMED TRIGGER POSITION: 10%	Range: 1 to 50% in steps of 1

PMU 1 FUNCTION — This setting enables or disables the recorder for PMU 1. The rate is fixed at the reporting rate set within the aggregator (that is, Aggregator 1).

PMU 1 NO OF TIMED RECORDS — Specifies the number of timed records that are available for a given logical PMU 1. The length of each record is equal to the available memory divided by the content size and number of records. As the number of records is increased, the available storage for each record is reduced. The relay supports a maximum of 128 records in either timed or forced mode.

PMU 1 TRIGGER MODE — Specifies what happens when the recorder uses its entire available memory storage. With “Automatic Overwrite,” the last record is erased to facilitate new recording, when triggered. Under the “Protected” selection, the recorder stops creating new records when the entire memory is used up by the old uncleared records.

PMU 1 TIMED TRIGGER POSITION — Specifies the amount of pre-trigger data as a percent of the entire record. This setting applies only to the timed mode of recording.

5.5.8.19 Aggregators

SETTINGS ⇌ SYSTEM SETUP ⇌ PHASOR MEASUREMENT UNIT ⇌ PMU AGGREGATOR 1

<input checked="" type="checkbox"/> PMU AGGREGATOR 1 <input checked="" type="checkbox"/>	↔	PMU AGGREGATOR 1 PROTOCOL: NONE	Range: NONE, 37.118, 90-5
	↕	PMU AGGREGATOR 1 IDCODE: 1	Range: 1 to 65534 in steps of 1
	↕	PMU AGGREGATOR 1 INCLUDE PMU1: No	Range: No, Yes
	↕	<input checked="" type="checkbox"/> C37.118 AGGR 1 <input checked="" type="checkbox"/> CONFIGURATION	See below
	↑	<input checked="" type="checkbox"/> 90-5 AGGR 1 <input checked="" type="checkbox"/> CONFIGURATION	See below



When the protocol selection is set via the software or keypad, all aggregators whose protocol is not set to None are set to the last protocol saved (that is, IEEE C37.118 or IEC 61850-90-5) to any aggregators, as both IEEE C37.118 and IEC 61850-90-5 simultaneous streaming is not possible.

PMU AGGREGATOR1 PROTOCOL — Selects if the IEEE C37.118 or IEC 61850-90-5 technical report is used. Because one protocol is supported at a time in a device, this setting applies to all PMU aggregators.

PMU AGGREGATOR1 IDCODE — Numeric identifier of the Aggregator / PDC function. In an IEEE C37.118 output stream, this identifies the ID of the aggregator, which is only used if there is more than 1 PMU mapped into an aggregator.

PMU AGGREGATOR1 PMU1 — If set to “Yes,” aggregator 1 includes the PMU1 data set in the reporting data stream. AGGREGATOR1 does not include PMU1 data set in the report if set to “No.”



Only PMUs with same reporting rate can be assigned to the same PMU AGGREGATOR.

SETTINGS ⇌ SYSTEM SETUP ⇌ PHASOR MEASUREMENT UNIT ⇌ PMU AGGREGATOR 1 ⇌ C37.118 AGGR 1 CONFIGURATION

<input checked="" type="checkbox"/> C37.118 AGGR 1 <input checked="" type="checkbox"/> CONFIGURATION	↔	PMU AGGREGATOR 1 TCP PORT: 4712	Range: 0 to 65534
	↕	PMU AGGREGATOR 1: UDP PORT: 4713	Range: 0 to 65534
	↑	PMU AGGREGATOR 1: PDC CONTROL: Disabled	Range: Disabled, Enabled

PMU AGGREGATOR 1 TCP PORT — Selects the TCP port number to be used by this aggregator for network reporting. All ports, even those of unused aggregators, must be valid and unique to avoid port number collisions.

PMU AGGREGATOR 1 UDP PORT — Selects the UDP port number to be used by this aggregator for network reporting. All ports, even those of unused aggregators, must be valid and unique to avoid port number collisions.

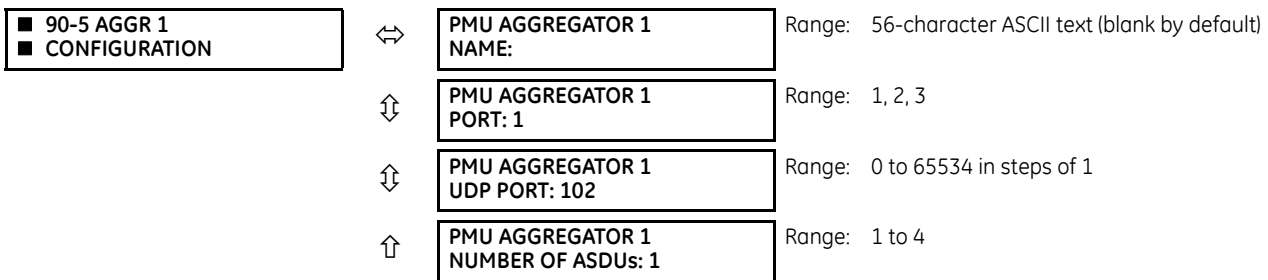
PMU AGGREGATOR 1 PDC CONTROL — The synchrophasor standard allows for user-defined controls originating at the PDC, to be executed on the PMU. The control is accomplished via an extended command frame. The relay decodes the first word of the extended field, EXTFRAME, to drive 16 dedicated FlexLogic operands. Each aggregator supports 16 FlexLogic operands, as shown in the table. The operands are asserted for five seconds following reception of the command frame. If the new command frame arrives within the five-second period, the FlexLogic operands are updated, and the five-second timer restarts. This setting enables or disables the control. When enabled, all 16 operands for each aggregator are active; when disabled, all 16 operands for each aggregator remain reset.

Table 5-20: FlexLogic operands supported by aggregator

Operand type	Operand syntax	Operand description
ELEMENT: Synchrophasor, phasor data, concentrator	AGTR1 PDC CNTRL 1	Phasor data concentrator asserts control bit 1, as received via the network
as above	AGTR1 PDC CNTRL 2	Phasor data concentrator asserts control bit 2 as received via the network
as above	AGTR1 PDC CNTRL 3	Phasor data concentrator asserts control bit 3 as received via the network
⇩		
as above	AGTR1 PDC CNTRL 16	Phasor data concentrator asserts control bit 16, as received via the network
as above	AGTR2 PDC CNTRL 1	Phasor data concentrator asserts control bit 1 as received via the network
as above	AGTR2 PDC CNTRL 2	Phasor data concentrator asserts control bit 2 as received via the network
as above	AGTR2 PDC CNTRL 3	Phasor data concentrator asserts control bit 3 as received via the network
⇩		
as above	AGTR1 PDC CNTRL 16	Phasor data concentrator asserts control bit 16, as received via the network

SETTINGS ⇒ ⇩ SYSTEM SETUP ⇒ ⇩ PHASOR MEASUREMENT UNIT ⇒ ⇩ PMU AGGREGATOR 1 ⇩ 90-5 AGGR 1 CONFIGURATION

5



PMU AGGREGATOR 1 NAME — A user-defined visible string of characters (maximum 56) to identify the source of the stream. This value, concatenated with the Aggregator IDCode and Aggregator Class of Service, is mapped into the IEC 61850 MSVID filed in the output stream. The field allows 65 characters, but uses the first 56 characters.

AGGREGATOR 1: PHYSICAL PORT — This setting determines the physical ports through which the synchrophasor traffic is transmitted. The range is 1, 2, 3.

PMU AGGREGATOR 1: UDP PORT — This setting selects the UDP port number that is used by this dataset for network reporting. A default setting value for IEC 6150-90-5 is provided.

PMU AGGREGATOR 1: NUMBER OF ASDUs — This setting sets the number of Application Service Data Units (ASDUs) from 1 through to 4.

Table 5-21: Number of ASDUs

Settings for ASDU	Transmission
1	ASDU at T0 (current values)
2	ASDU at T-1 (previous values) + ASDU at T0 (current values)
3	ASDU at T-2 (previous values) + ASDU at T-1 (previous values) + ASDU at T0 (current values)
4	ASDU at T-3 (previous values) + ASDU at T-2 (previous values) + ASDU at T-1 (previous values) + ASDU at T0 (current values)

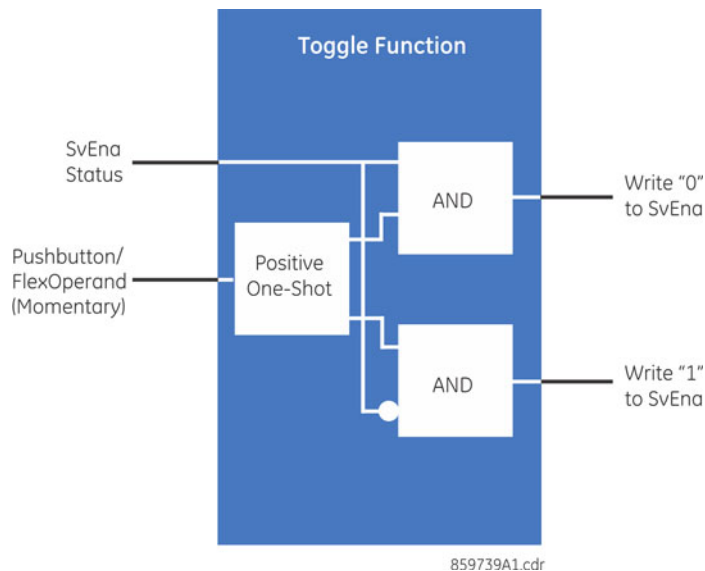
5.5.8.20 Control blocks

SETTINGS ⇒ SYSTEM SETUP ⇒ PHASOR MEASUREMENT UNIT ⇒ 90-5 R-SV CB 1 CONFIGURATION

<div style="border: 1px solid black; padding: 2px;"> <p>■ 90-5 R-SV CB 1 ■ CONFIGURATION</p> </div>	↔	R-SV CB1 SVENA: Off	Range: FlexLogic operand
	↕	R-SV CB1 CLIENT CTRL: Off	Range: FlexLogic operand
	↕	R-SV CB1 SVENA DFLT: Off	Range: FlexLogic operand
	↕	R-SV CB1 CONFREV: 1	Range: 1 to 4294967295
	↕	R-SV CB1 PRIORITY: 4	Range: 0 to 7
	↕	R-SV CB1 CSCP CLASS: Expedited Forwarding	Range: None, Expedited Forwarding
	↕	R-SV CB1 VLAN ID: 0	Range: 0 to 4095
	↕	R-SV CB1 APPID: 0	Range: 0 to 16383
	↕	R-SV CB1 DEST IP: 224.0.0.0	Range: 0 to 255.255.255.255
	↑	R-SV CB1 SECURITY: 0	Range: 0 to 2

R-SV CB1 SVENA — The SV Stream Control is set by either toggling an assigned FlexLogic operand or a remote client write, to start and stop the streaming of R-SV frames. If remote client control is disabled, a negative response is provided to the client in response to a write attempt. A FlexLogic operand (SvEna) is provided for each Aggregator that reflects the state of the SvEna control where “1”= Enabled and “0”=Disabled. The figure shows the logic for setting the SvEna control bit.

Figure 5-94: Logic for setting SvEna control bit



R-SV CB1 CLIENT CONTRL — This setting determines if a client can write to the reserve bit. When the assigned FlexLogic operand is a logic 1 state, remote clients can write to both the reserve bit and the SvEna bit. When the FlexLogic operand is a logic 0 state, the remote client writes to the reserve bit, the SvEna is rejected by the UR, and a negative response with the appropriate Service Error is returned to the client.

R-SV CB1 SVENA DFLT — This setting sets the default state of the stream (On or Off) on power-up or restart.

R-SV CB1 CONFREV — The relay increments the Configuration revision every time the configuration is changed. This setting allows the user to reset the configuration back to 1 or a value from 1 to 4294967295.

R-SV CB1 PRIORITY — A value from 0 through 7. The default value is 4.

R-SV CB1 DSCP CLASS — The value represents the IPv4 Differentiated Services (formerly called TypeOfService) value. The default value is set for Expedited Forwarding (101110B (46 or 2EH). This value provides priority routing, when supported in the routers.

R-SV CB1 VLAN ID — A range of values limited from 0 to 4095.

R-SV CB1 APPID — This setting allows the selection of a specific application ID for each sending device.

R-SV CB1 DEST IP — This is the destination multicast IP address that is entered in Standard IPV4 address format. The valid range for IPV4 is from 224.0.0.0 to 239.255.255.255. The UR does not test the address entered.

R-SV CB1 SECURITY — This setting selects the level of security and authentication used, as outlined in the following table, and is in the form of an enumeration as per standard. The range is 0 to 2.



Shaded settings in the table are not supported in firmware 7.0.

NOTE

Table 5-22: Security

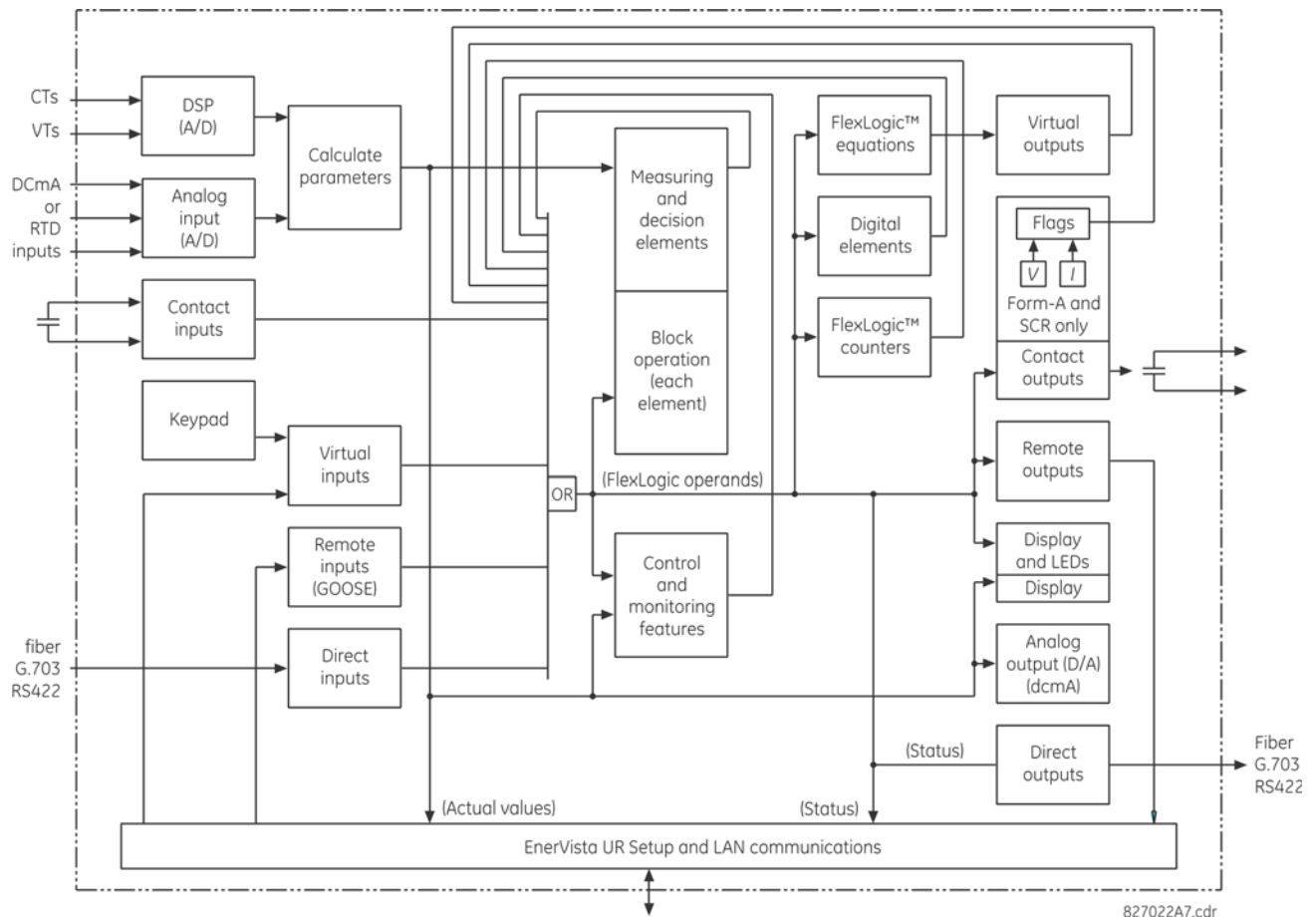
Enumeration	Authentication	Encryption
0	No	No
1	Yes	No
2	Yes	Yes

5.6 FlexLogic

5.6.1 FlexLogic operands

For flexibility, the arrangement of internal digital logic combines fixed and user-programmed parameters. Logic upon which individual features are designed is fixed, and all other logic, from contact input signals through elements or combinations of elements to contact outputs, is variable. The user has complete control of all variable logic through FlexLogic. In general, the system receives analog and digital inputs that it uses to produce analog and digital outputs. The figure shows major subsystems of a generic UR-series relay involved in this process.

Figure 5-95: UR architecture overview



The states of all digital signals used in the L30 are represented by flags (or FlexLogic operands, which are described later in this section). A digital “1” is represented by a set flag. Any external contact change-of-state can be used to block an element from operating, as an input to a control feature in a FlexLogic equation, or to operate a contact output. The state of the contact input can be displayed locally or viewed remotely via the communications facilities provided. If a simple scheme where a contact input is used to block an element is wanted, this selection is made when programming the element. This capability also applies to the other features that set flags: elements, virtual inputs, remote inputs, schemes, and human operators.

If more complex logic than shown in the figure is required, it is implemented via FlexLogic. For example, to have the closed state of contact input H7a and the operated state of the phase undervoltage element block the operation of the phase time overcurrent element, the two control input states are programmed in a FlexLogic equation. This equation ANDs the two control inputs to produce a virtual output that is then selected when programming the phase time overcurrent to be used as a blocking input. Virtual outputs can only be created by FlexLogic equations.

Traditionally, protective relay logic has been relatively limited. Any unusual applications involving interlocks, blocking, or supervisory functions had to be hard-wired using contact inputs and outputs. FlexLogic minimizes the requirement for auxiliary components and wiring while making more complex schemes possible.

The logic that determines the interaction of inputs, elements, schemes, and outputs is field-programmable through the use of logic equations that are sequentially processed. The use of virtual inputs and outputs in addition to hardware is available internally and on the communication ports for other relays to use (distributed FlexLogic).

FlexLogic allows users to customize the relay through a series of equations that consist of operators and operands. The operands are the states of inputs, elements, schemes, and outputs. The operators are logic gates, timers, and latches (with set and reset inputs). A system of sequential operations allows any combination of operands to be assigned as inputs to

specified operators to create an output. The final output of an equation is a numbered register called a virtual output. Virtual outputs can be used as an input operand in any equation, including the equation that generates the output, as a seal-in or other type of feedback.

A FlexLogic equation consists of parameters that are either operands or operators. Operands have a logic state of 1 or 0. Operators provide a defined function, such as an AND gate or a Timer. Each equation defines the combinations of parameters to be used to set a Virtual Output flag. Evaluation of an equation results in either a 1 (=ON, or flag set) or 0 (=OFF, or flag not set). Each equation is evaluated at least four times every power system cycle.

Some types of operands are present in the relay in multiple instances, for example contact and remote inputs. These types of operands are grouped together (for presentation purposes only) on the front panel display. The table lists characteristics of the different types of operands.

Table 5-23: L30 FlexLogic operand types

Operand type	State	Example of format	Characteristics [Input Is '1' (= ON) if...]
Contact Input	On	Cont Ip On	Voltage is applied presently to the input (external contact closed)
	Off	Cont Ip Off	Voltage is not applied presently to the input (external contact open)
Contact Output (type Form-A contact only)	Contact Closed	Cont Op 1 Closed	Contact output is closed
	Current On	Cont Op 1 Ion	Current is flowing through the contact
	Voltage On	Cont Op 1 VOn	Voltage exists across the contact
	Voltage Off	Cont Op 1 VOff	Voltage does not exist across the contact
Direct Input	On	DIRECT INPUT 1 On	The direct input is presently in the ON state
Element (Analog)	Pickup	PHASE TOC1 PKP	The tested parameter is presently above the pickup setting of an element that responds to rising values or below the pickup setting of an element that responds to falling values
	Dropout	PHASE TOC1 DPO	This operand is the logical inverse of the above PKP operand
	Operate	PHASE TOC1 OP	The tested parameter has been above/below the pickup setting of the element for the programmed delay time, or has been at logic 1 and is now at logic 0 but the reset timer has not finished timing
	Block	PHASE TOC1 BLK	The output of the comparator is set to the block function
Element (Digital)	Pickup	Dig Element 1 PKP	The input operand is at logic 1
	Dropout	Dig Element 1 DPO	This operand is the logical inverse of the above PKP operand
	Operate	Dig Element 1 OP	The input operand has been at logic 1 for the programmed pickup delay time, or has been at logic 1 for this period and is now at logic 0 but the reset timer has not finished timing
Element (Digital Counter)	Higher than	Counter 1 HI	The number of pulses counted is above the set number
	Equal to	Counter 1 EQL	The number of pulses counted is equal to the set number
	Lower than	Counter 1 LO	The number of pulses counted is below the set number
Fixed	On	On	Logic 1
	Off	Off	Logic 0
RxGOOSE Boolean	On	RxGOOSE Boolean 1 On	The RxGOOSE Boolean is presently in the ON state
Virtual Input	On	Virt Ip 1 On	The virtual input is presently in the ON state
Virtual Output	On	Virt Op 1 On	The virtual output is presently in the set state (that is, evaluation of the equation that produces this virtual output results in a "1")

The following table lists the operands available for the relay. The operands can be viewed online by entering the IP address of the relay in a web browser and accessing the Device Information Menu.

Table 5-24: L30 FlexLogic operands

Operand type	Operand syntax	Operand description
ANNUNCIATOR Graphical front panel	ANY ANCTR ABNORMAL ANY ANCTR ALARMED	On for one second when any annunciator window state changes from normal to abnormal On while any annunciator window state is abnormal
CONTROL PUSHBUTTONS Enhanced and standard front panels	CONTROL PUSHBTN 1 ON CONTROL PUSHBTN 2 ON CONTROL PUSHBTN 3 ON CONTROL PUSHBTN 4 ON CONTROL PUSHBTN 5 ON CONTROL PUSHBTN 6 ON CONTROL PUSHBTN 7 ON	Control pushbutton 1 is being pressed Control pushbutton 2 is being pressed Control pushbutton 3 is being pressed Control pushbutton 4 is being pressed Control pushbutton 5 is being pressed Control pushbutton 6 is being pressed Control pushbutton 7 is being pressed
CYBERSENTRY	ROLE ADMIN ACT ROLE SUPERVISOR ACT ROLE ENGINEER ACT ROLE OPERATOR ACT ROLE OBSERVER ACT AUTHENTICATION FAIL UNAUTH FW ATTEMPT UNAUTH SETTING WRITE	Administrator role is active and is set to true when that is the case Supervisor role is active and is set to true when that is the case Engineer role is active and is set to true when that is the case Operator role is active and is set to true when that is the case Observer role is active and is set to true when that is the case Operand set for Failed Authentication self-test and alarm Operand set for firmware lock self-test and alarm Operand set for settings lock self-test and alarm
ELEMENT: 50DD supervision	50DD SV 50DD SV 87LG	Disturbance detector has operated Disturbance detector for 87LG has operated
ELEMENT: 87L current differential	87L DIFF OP 87L DIFF RECVD DTT 87L DIFF KEY DTT 87L DIFF PFLL FAIL 87L DIFF CH ASYM DET 87L DIFF CH1 FAIL 87L DIFF CH2 FAIL 87L DIFF CH1 LOSTPKT 87L DIFF CH2 LOSTPKT 87L DIFF CH1 CRCFAIL 87L DIFF CH2 CRCFAIL 87L DIFF CH1 ID FAIL 87L DIFF CH2 ID FAIL 87L DIFF GPS FAIL 87L DIFF 1 MAX ASYM 87L DIFF 2 MAX ASYM 87L DIFF 1 TIME CHNG 87L DIFF 2 TIME CHNG 87L DIFF GPS 1 FAIL 87L DIFF GPS 2 FAIL 87L DIFF BLOCKED 87L DIFF PKP G 87L DIFF OP G	At least one phase of current differential has operated Direct transfer trip has been received Direct transfer trip is keyed Phase and frequency lock loop (PFLL) has failed Channel asymmetry greater than 1.5 ms detected Channel 1 has failed Channel 2 has failed Exceeded maximum lost packet threshold on channel 1 Exceeded maximum lost packet threshold on channel 2 Exceeded maximum CRC error threshold on channel 1 Exceeded maximum CRC error threshold on channel 2 The ID check for a peer L30 on channel 1 has failed The ID check for a peer L30 on channel 2 has failed The GPS signal failed or is not configured properly at any terminal Asymmetry on channel 1 exceeded preset value Asymmetry on channel 2 exceeded preset value Change in round trip delay on channel 1 exceeded preset value Change in round trip delay on channel 2 exceeded preset value GPS failed at remote terminal 1 (channel 1) GPS failed at remote terminal 1 (channel 2) The 87L function is blocked due to communication problems The ground differential element has picked up The ground differential element has operated
ELEMENT: 87L in-zone transformer compensation	87L HARM2 A OP 87L HARM2 B OP 87L HARM2 C OP	Asserted when phase A of second harmonic of the transformer magnetizing inrush current inhibits the current differential element from operating. Asserted when phase B of second harmonic of the transformer magnetizing inrush current inhibits the current differential element from operating. Asserted when phase C of second harmonic of the transformer magnetizing inrush current inhibits the current differential element from operating.
ELEMENT: Autoreclose (per CT bank)	AR1 ENABLED AR1 RIP AR1 LO AR1 BLK FROM MAN CLS AR1 CLOSE AR1 SHOT CNT=0 AR1 SHOT CNT=1 AR1 SHOT CNT=2 AR1 SHOT CNT=3 AR1 SHOT CNT=4 AR1 DISABLED AR2 to 3	Autoreclose 1 is enabled Autoreclose 1 is in progress Autoreclose 1 is locked out Autoreclose 1 is temporarily disabled Autoreclose 1 close command is issued Autoreclose 1 shot count is 0 Autoreclose 1 shot count is 1 Autoreclose 1 shot count is 2 Autoreclose 1 shot count is 3 Autoreclose 1 shot count is 4 Autoreclose 1 is disabled Same set of operands as shown for AR1
ELEMENT: Auxiliary overvoltage	AUX OV1 PKP AUX OV1 DPO AUX OV1 OP	Auxiliary overvoltage element has picked up Auxiliary overvoltage element has dropped out Auxiliary overvoltage element has operated

Operand type	Operand syntax	Operand description
ELEMENT: Auxiliary undervoltage	AUX UV1 PKP AUX UV1 DPO AUX UV1 OP	Auxiliary undervoltage element has picked up Auxiliary undervoltage element has dropped out Auxiliary undervoltage element has operated
	AUX UV2 to 3	Same set of operands as shown for AUX UV1
ELEMENT: Breaker arcing	BKR ARC 1 OP BKR ARC 1 DPO BKR ARC 1 MAX OP BKR ARC 1 MAX DPO BKR ARC 2 OP BKR ARC 2 DPO BKR ARC 2 MAX OP BKR ARC 2 MAX DPO	Breaker arcing current 1 has operated Breaker arcing current 1 has dropped out Breaker arcing current 1 max interrupting current has operated Breaker arcing current 1 max interrupting current has dropped out Breaker arcing current 2 has operated Breaker arcing current 2 has dropped out Breaker arcing current 2 max interrupting current has operated Breaker arcing current 2 max interrupting current has dropped out
	BKR FAIL 1 RETRIPA BKR FAIL 1 RETRIPB BKR FAIL 1 RETRIPC BKR FAIL 1 RETRIP BKR FAIL 1 T1 OP BKR FAIL 1 T2 OP BKR FAIL 1 T3 OP BKR FAIL 1 TRIP OP	Breaker failure 1 re-trip phase A (only for 1-pole schemes) Breaker failure 1 re-trip phase B (only for 1-pole schemes) Breaker failure 1 re-trip phase C (only for 1-pole schemes) Breaker failure 1 re-trip 3-phase Breaker failure 1 timer 1 is operated Breaker failure 1 timer 2 is operated Breaker failure 1 timer 3 is operated Breaker failure 1 trip is operated
ELEMENT: Breaker failure	BKR FAIL 2	Same set of operands as shown for BKR FAIL 1
	BREAKER 1 OFF CMD BREAKER 1 ON CMD BREAKER 1 Φ A BAD ST BREAKER 1 Φ A INTERM BREAKER 1 Φ A CLSD BREAKER 1 Φ A OPEN BREAKER 1 Φ B BAD ST BREAKER 1 Φ B INTERM BREAKER 1 Φ B CLSD BREAKER 1 Φ B OPEN BREAKER 1 Φ C BAD ST BREAKER 1 Φ C INTERM BREAKER 1 Φ C CLSD BREAKER 1 Φ C OPEN BREAKER 1 BAD STATUS BREAKER 1 CLOSED BREAKER 1 OPEN BREAKER 1 DISCREP BREAKER 1 TROUBLE BREAKER 1 MNL OPEN BREAKER 1 MNL CLS BREAKER 1 TRIP A BREAKER 1 TRIP B BREAKER 1 TRIP C BREAKER 1 ANY P OPEN BREAKER 1 ONE P OPEN BREAKER 1 OOS BREAKER 1 TAG ON BREAKER 1 TAG OFF BREAKER 1 SUBD CLSD BREAKER 1 SUBD OPEN BREAKER 1 BYPASS ON BREAKER 1 BYPASS OFF BREAKER 1 BLK RCLS BREAKER 1 ENA RCLS	Breaker 1 3-pole open command/trip initiated Breaker 1 close command initiated Breaker 1 phase A bad status is detected (discrepancy between the 52/a and 52/b contacts) Breaker 1 phase A intermediate status is detected (transition from one position to another) Breaker 1 phase A is closed Breaker 1 phase A is open Breaker 1 phase B bad status is detected (discrepancy between the 52/a and 52/b contacts) Breaker 1 phase B intermediate status is detected (transition from one position to another) Breaker 1 phase B is closed Breaker 1 phase B is open Breaker 1 phase C bad status is detected (discrepancy between the 52/a and 52/b contacts) Breaker 1 phase C intermediate status is detected (transition from one position to another) Breaker 1 phase C is closed Breaker 1 phase C is open Breaker 1 bad status is detected on any pole Breaker 1 is closed Breaker 1 is open Breaker 1 has discrepancy Breaker 1 trouble alarm Breaker 1 manual open Breaker 1 manual close Breaker 1 trip phase A command Breaker 1 trip phase B command Breaker 1 trip phase C command At least one pole of breaker 1 is open Only one pole of breaker 1 is open Breaker 1 is out of service Breaker 1 tagged so manual trip and close and autoreclose are blocked Breaker 1 not tagged Breaker 1 status manually substituted to closed Breaker 1 status manually substituted to open Breaker 1 control interlocking is manually bypassed Breaker 1 control interlocking is not manually bypassed Breaker 1 command to manually block autoreclose Breaker 1 command to manually enable autoreclose
ELEMENT: Breaker control	BREAKER 2	Same set of operands as shown for BREAKER 1
	BROKEN CONDUCT 1 OP BROKEN CONDUCT 1 PKP	Asserted when the broken conductor 1 element operates Asserted when the broken conductor 1 element picks up
ELEMENT: Broken conductor	BROKEN CONDUCT 2	Same set of operands as shown for BROKEN CONDUCTOR 1

Operand type	Operand syntax	Operand description
ELEMENT: CT fail	CT FAIL 1 PKP CT FAIL 1 OP	CT fail has picked up CT fail has dropped out
	CT FAIL 2	Same set of operands as per CT FAIL 1
ELEMENT: Digital counters	Counter 1 HI Counter 1 EQL Counter 1 LO	Digital counter 1 output is 'more than' comparison value Digital counter 1 output is 'equal to' comparison value Digital counter 1 output is 'less than' comparison value
	Counter 2 to 8	Same set of operands as shown for Counter 1
ELEMENT: Digital elements	Dig Element 1 PKP Dig Element 1 OP Dig Element 1 DPO	Digital Element 1 is picked up Digital Element 1 is operated Digital Element 1 is dropped out
	Dig Element 2 to 48	Same set of operands as shown for Dig Element 1
ELEMENT: Frequency rate of change	FREQ RATE 1 PKP FREQ RATE 1 DPO FREQ RATE 1 OP	The frequency rate of change 1 element has picked up The frequency rate of change 1 element has dropped out The frequency rate of change 1 element has operated
	FREQ RATE 2	Same set of operands as shown for FREQ RATE 1
ELEMENT: FlexElements	FxE 1 PKP FxE 1 OP FxE 1 DPO	FlexElement 1 has picked up FlexElement 1 has operated FlexElement 1 has dropped out
	FxE 2 to 8	Same set of operands as shown for FxE 1
ELEMENT: Ground instantaneous overcurrent	GROUND IOC1 PKP GROUND IOC1 OP GROUND IOC1 DPO	Ground instantaneous overcurrent 1 has picked up Ground instantaneous overcurrent 1 has operated Ground instantaneous overcurrent 1 has dropped out
	GROUND IOC2 to 4	Same set of operands as shown for GROUND IOC 1
ELEMENT: Ground time overcurrent	GROUND TOC1 PKP GROUND TOC1 OP GROUND TOC1 DPO	Ground time overcurrent 1 has picked up Ground time overcurrent 1 has operated Ground time overcurrent 1 has dropped out
	GROUND TOC2	Same set of operands as shown for GROUND TOC1
ELEMENT: Incipient cable fault detection	INCIPNT FLT 1 OP INCIPNT FLT 1 OP A INCIPNT FLT 1 OP B INCIPNT FLT 1 OP C INCIPNT FLT 1 PKP INCIPNT FLT 1 PKP A INCIPNT FLT 1 PKP B INCIPNT FLT 1 PKP C	Asserted when incipient cable fault detector 1 operates in any phase Asserted when incipient cable fault detector 1 operates in phase A Asserted when incipient cable fault detector 1 operates in phase B Asserted when incipient cable fault detector 1 operates in phase C Asserted when incipient cable fault detector 1 picks up in any phase Asserted when incipient cable fault detector 1 picks up in phase A Asserted when incipient cable fault detector 1 picks up in phase B Asserted when incipient cable fault detector 1 picks up in phase C
	LATCH 1 ON LATCH 1 OFF	Non-volatile latch 1 is ON (Logic = 1) Non-volatile latch 1 is OFF (Logic = 0)
ELEMENT: Non-volatile latches	LATCH 2 to 16	Same set of operands as shown for LATCH 1
	NEG SEQ IOC1 PKP NEG SEQ IOC1 OP NEG SEQ IOC1 DPO	Negative-sequence instantaneous overcurrent 1 has picked up Negative-sequence instantaneous overcurrent 1 has operated Negative-sequence instantaneous overcurrent 1 has dropped out
ELEMENT: Negative-sequence instantaneous overcurrent	NEG SEQ IOC2	Same set of operands as shown for NEG SEQ IOC1
	NEG SEQ OV1 PKP NEG SEQ OV1 DPO NEG SEQ OV1 OP	Negative-sequence overvoltage element has picked up Negative-sequence overvoltage element has dropped out Negative-sequence overvoltage element has operated
ELEMENT: Negative-sequence overvoltage	NEG SEQ OV2 to 3	Same set of operands as shown for NEG SEQ OV1
	NEG SEQ TOC1 PKP NEG SEQ TOC1 OP NEG SEQ TOC1 DPO	Negative-sequence time overcurrent 1 has picked up Negative-sequence time overcurrent 1 has operated Negative-sequence time overcurrent 1 has dropped out
ELEMENT: Negative-sequence time overcurrent	NEG SEQ TOC2	Same set of operands as shown for NEG SEQ TOC1
	NEUTRAL IOC1 PKP NEUTRAL IOC1 OP NEUTRAL IOC1 DPO	Neutral instantaneous overcurrent 1 has picked up Neutral instantaneous overcurrent 1 has operated Neutral instantaneous overcurrent 1 has dropped out
ELEMENT: Neutral instantaneous overcurrent	NEUTRAL IOC2 to 4	Same set of operands as shown for NEUTRAL IOC1

Operand type	Operand syntax	Operand description
ELEMENT: Neutral overvoltage	NEUTRAL OV1 PKP NEUTRAL OV1 DPO NEUTRAL OV1 OP	Neutral overvoltage element 1 has picked up Neutral overvoltage element 1 has dropped out Neutral overvoltage element 1 has operated
	NEUTRAL OV2 to 3	Same set of operands as shown for NEUTRAL OV1
ELEMENT: Neutral time overcurrent	NEUTRAL TOC1 PKP NEUTRAL TOC1 OP NEUTRAL TOC1 DPO	Neutral time overcurrent 1 has picked up Neutral time overcurrent 1 has operated Neutral time overcurrent 1 has dropped out
	NEUTRAL TOC2 to 4	Same set of operands as shown for NEUTRAL TOC1
ELEMENT: Neutral directional overcurrent	NTRL DIR OC1 FWD NTRL DIR OC1 REV	Neutral directional overcurrent 1 forward has operated Neutral directional overcurrent 1 reverse has operated
	NTRL DIR OC2	Same set of operands as shown for NTRL DIR OC1
ELEMENT: Synchrophasor phasor data concentrator	PDC NETWORK CNTRL 1 PDC NETWORK CNTRL 2 ↓ PDC NETWORK CNTRL 16	Phasor data concentrator asserts control bit 1 as received via the network Phasor data concentrator asserts control bit 2 as received via the network ↓ Phasor data concentrator asserts control bit 16 as received via the network
	PH DIR1 BLK A PH DIR1 BLK B PH DIR1 BLK C PH DIR1 BLK PH DIR2	Phase A directional 1 block Phase B directional 1 block Phase C directional 1 block Phase directional 1 block Same set of operands as shown for PH DIR1
ELEMENT: Phase instantaneous overcurrent	PHASE IOC1 PKP PHASE IOC1 OP PHASE IOC1 DPO PHASE IOC1 PKP A PHASE IOC1 PKP B PHASE IOC1 PKP C PHASE IOC1 OP A PHASE IOC1 OP B PHASE IOC1 OP C PHASE IOC1 DPO A PHASE IOC1 DPO B PHASE IOC1 DPO C	At least one phase of phase instantaneous overcurrent 1 has picked up At least one phase of phase instantaneous overcurrent 1 has operated All phases of phase instantaneous overcurrent 1 have dropped out Phase A of phase instantaneous overcurrent 1 has picked up Phase B of phase instantaneous overcurrent 1 has picked up Phase C of phase instantaneous overcurrent 1 has picked up Phase A of phase instantaneous overcurrent 1 has operated Phase B of phase instantaneous overcurrent 1 has operated Phase C of phase instantaneous overcurrent 1 has operated Phase A of phase instantaneous overcurrent 1 has dropped out Phase B of phase instantaneous overcurrent 1 has dropped out Phase C of phase instantaneous overcurrent 1 has dropped out
	PHASE IOC2 to 4	Same set of operands as shown for PHASE IOC1
ELEMENT: Phase overvoltage	PHASE OV1 PKP PHASE OV1 OP PHASE OV1 DPO PHASE OV1 PKP A PHASE OV1 PKP B PHASE OV1 PKP C PHASE OV1 OP A PHASE OV1 OP B PHASE OV1 OP C PHASE OV1 DPO A PHASE OV1 DPO B PHASE OV1 DPO C	At least one phase of overvoltage 1 has picked up At least one phase of overvoltage 1 has operated All phases of overvoltage 1 have dropped out Phase A of overvoltage 1 has picked up Phase B of overvoltage 1 has picked up Phase C of overvoltage 1 has picked up Phase A of overvoltage 1 has operated Phase B of overvoltage 1 has operated Phase C of overvoltage 1 has operated Phase A of overvoltage 1 has dropped out Phase B of overvoltage 1 has dropped out Phase C of overvoltage 1 has dropped out
	PHASE OV2 to 3	Same set of operands as shown for PHASE OV1
ELEMENT: Phase time overcurrent	PHASE TOC1 PKP PHASE TOC1 OP PHASE TOC1 DPO PHASE TOC1 PKP A PHASE TOC1 PKP B PHASE TOC1 PKP C PHASE TOC1 OP A PHASE TOC1 OP B PHASE TOC1 OP C PHASE TOC1 DPO A PHASE TOC1 DPO B PHASE TOC1 DPO C	At least one phase of phase time overcurrent 1 has picked up At least one phase of phase time overcurrent 1 has operated All phases of phase time overcurrent 1 have dropped out Phase A of phase time overcurrent 1 has picked up Phase B of phase time overcurrent 1 has picked up Phase C of phase time overcurrent 1 has picked up Phase A of phase time overcurrent 1 has operated Phase B of phase time overcurrent 1 has operated Phase C of phase time overcurrent 1 has operated Phase A of phase time overcurrent 1 has dropped out Phase B of phase time overcurrent 1 has dropped out Phase C of phase time overcurrent 1 has dropped out
	PHASE TOC2 to 4	Same set of operands as shown for PHASE TOC1

Operand type	Operand syntax	Operand description
ELEMENT: Phase undervoltage	PHASE UV1 PKP PHASE UV1 OP PHASE UV1 DPO PHASE UV1 PKP A PHASE UV1 PKP B PHASE UV1 PKP C PHASE UV1 OP A PHASE UV1 OP B PHASE UV1 OP C PHASE UV1 DPO A PHASE UV1 DPO B PHASE UV1 DPO C	At least one phase of phase undervoltage 1 has picked up At least one phase of phase undervoltage 1 has operated All phases of phase undervoltage 1 have dropped out Phase A of phase undervoltage 1 has picked up Phase B of phase undervoltage 1 has picked up Phase C of phase undervoltage 1 has picked up Phase A of phase undervoltage 1 has operated Phase B of phase undervoltage 1 has operated Phase C of phase undervoltage 1 has operated Phase A of phase undervoltage 1 has dropped out Phase B of phase undervoltage 1 has dropped out Phase C of phase undervoltage 1 has dropped out
	PHASE UV2 to 3	Same set of operands as shown for PHASE UV1
ELEMENT: Synchrophasor Phasor Measurement Unit (PMU)	PMU Agg 1 SvEng On PMU 1 CURR TRIGGER PMU 1 FREQ TRIGGER PMU 1 POWER TRIGGER PMU 1 ROCOF TRIGGER	SvEng data item in associated control block is on Overcurrent trigger of phasor measurement unit 1 has operated Abnormal frequency trigger of phasor measurement unit 1 has operated Overpower trigger of phasor measurement unit 1 has operated Rate of change of frequency trigger of phasor measurement unit 1 has operated
	PMU 1 VOLT TRIGGER PMU 1 TRIGGERED	Abnormal voltage trigger of phasor measurement unit 1 has operated Phasor measurement unit 1 triggered; no events or targets are generated by this operand
ELEMENT: Synchrophasor one- shot	PMU ONE-SHOT EXPIRED	Indicates the one-shot operation has been executed, and the present time is at least 30 seconds past the scheduled one-shot time
	PMU ONE-SHOT OP	Indicates the one-shot operation and remains asserted for 30 seconds afterwards
	PMU ONE-SHOT PENDING	Indicates the one-shot operation is pending; that is, the present time is before the scheduled one-shot time
ELEMENT: Selector switch	SELECTOR 1 POS Y SELECTOR 1 BIT 0 SELECTOR 1 BIT 1 SELECTOR 1 BIT 2 SELECTOR 1 STP ALARM	Selector switch 1 is in Position Y (mutually exclusive operands) First bit of the 3-bit word encoding position of selector 1 Second bit of the 3-bit word encoding position of selector 1 Third bit of the 3-bit word encoding position of selector 1 Position of selector 1 has been pre-selected with the stepping up control input but not acknowledged
	SELECTOR 1 BIT ALARM	Position of selector 1 has been pre-selected with the 3-bit control input but not acknowledged
	SELECTOR 1 ALARM SELECTOR 1 PWR ALARM	Position of selector 1 has been pre-selected but not acknowledged Position of selector switch 1 is undetermined or restored from memory when the relay powers up and synchronizes to the three-bit input
SELECTOR 2	Same set of operands as shown for SELECTOR 1	
ELEMENT: Setting group	SETTING GROUP ACT 1 SETTING GROUP ACT 2 SETTING GROUP ACT 3 SETTING GROUP ACT 4 SETTING GROUP ACT 5 SETTING GROUP ACT 6	Setting group 1 is active Setting group 2 is active Setting group 3 is active Setting group 4 is active Setting group 5 is active Setting group 6 is active
ELEMENT: Disturbance detector	SRC1 50DD OP SRC2 50DD OP	Source 1 disturbance detector has operated Source 2 disturbance detector has operated
ELEMENT: VTFF (Voltage transformer fuse failure)	SRC1 VT FF OP SRC1 VT FF DPO SRC1 VT FF VOL LOSS SRC1 VT FF ALARM	Source 1 VT fuse failure detector has operated Source 1 VT fuse failure detector has dropped out Source 1 has lost voltage signals (V2 below 10% and V1 below 5% of nominal) Source 1 has triggered a VT fuse failure alarm
	SRC1 VT NEU WIRE OPEN	Source 1 VT neutral wire open detected. When the VT is connected in Delta, do not enable this function because there is no neutral wire for Delta connected VT.
	SRC2 VT FUSE FAIL	Same set of operands as shown for SRC1 VT FF
ELEMENT: Stub bus	STUB BUS OP	Stub bus is operated

Operand type	Operand syntax	Operand description
ELEMENT: Disconnect switch	SWITCH 1 OFF CMD SWITCH 1 ON CMD SWITCH 1 CLOSED SWITCH 1 OPEN SWITCH 1 DISCREP SWITCH 1 TROUBLE SWITCH 1 Φ A CLSD SWITCH 1 Φ A OPEN SWITCH 1 Φ A BAD ST SWITCH 1 Φ A INTERM SWITCH 1 Φ B CLSD SWITCH 1 Φ B OPEN SWITCH 1 Φ B BAD ST SWITCH 1 Φ B INTERM SWITCH 1 Φ C CLSD SWITCH 1 Φ C OPEN SWITCH 1 Φ C BAD ST SWITCH 1 Φ C INTERM SWITCH 1 BAD STATUS SWITCH 1 TAG ON SWITCH 1 TAG OFF SWITCH 1 SUBD CLSD SWITCH 1 SUBD OPEN SWITCH 1 BYPASS ON SWITCH 1 BYPASS OFF	Disconnect switch 1 open command initiated Disconnect switch 1 close command initiated Disconnect switch 1 is closed Disconnect switch 1 is open Disconnect switch 1 has discrepancy Disconnect switch 1 trouble alarm Disconnect switch 1 phase A is closed Disconnect switch 1 phase A is open Disconnect switch 1 phase A bad status is detected (discrepancy between the 89/a and 89/b contacts) Disconnect switch 1 phase A intermediate status is detected (transition from one position to another) Disconnect switch 1 phase B is closed Disconnect switch 1 phase B is open Disconnect switch 1 phase B bad status is detected (discrepancy between the 89/a and 89/b contacts) Disconnect switch 1 phase B intermediate status is detected (transition from one position to another) Disconnect switch 1 phase C is closed Disconnect switch 1 phase C is open Disconnect switch 1 phase C bad status is detected (discrepancy between the 89/a and 89/b contacts) Disconnect switch 1 phase C intermediate status is detected (transition from one position to another) Disconnect switch 1 bad status is detected on any pole Switch 1 tagged so manual trip and close is blocked Switch 1 not tagged Switch 1 status manually substituted to closed Switch 1 status manually substituted to open Switch 1 control interlocking is bypassed manually Switch 1 control interlocking is not bypassed manually
	SWITCH 2 to 8	Same set of operands as shown for SWITCH 1
ELEMENT: Synchrocheck	SYNC1 DEAD S OP SYNC1 DEAD S DPO SYNC1 SYNC OP SYNC1 SYNC DPO SYNC1 CLS OP SYNC1 CLS DPO SYNC1 V1 ABOVE MIN SYNC1 V1 BELOW MAX SYNC1 V2 ABOVE MIN SYNC1 V2 BELOW MAX SYNC1 S-CLOSE OP SYNC1 S-CLOSE OP DPO SYNC1 S-CLOSE ARMD	Synchrocheck 1 dead source has operated Synchrocheck 1 dead source has dropped out Synchrocheck 1 in synchronization has operated Synchrocheck 1 in synchronization has dropped out Synchrocheck 1 close has operated Synchrocheck 1 close has dropped out Synchrocheck 1 V1 is above the minimum live voltage Synchrocheck 1 V1 is below the maximum dead voltage Synchrocheck 1 V2 is above the minimum live voltage Synchrocheck 1 V2 is below the maximum dead voltage Synchrocheck 1 S-CLOSE has operated Synchrocheck 1 S-CLOSE has dropped out Synchrocheck 1 S-CLOSE has been armed
	SYNC 2 to 4	Same set of operands as shown for SYNC 1
ELEMENT: Thermal overload protection	THERMAL PROT 1 PKP THERMAL PROT 1 OP	Thermal overload protection 1 picked up Thermal overload protection 1 operated
	THERMAL PROT 2	Same set of operands as shown for THERMAL PROT 1
ELEMENT: Trip bus	TRIP BUS 1 PKP TRIP BUS 1 OP	Asserted when the trip bus 1 element picks up Asserted when the trip bus 1 element operates
	TRIP BUS 2 to 6	Same set of operands as shown for TRIP BUS 1
ELEMENT: Underfrequency	UNDERFREQ 1 PKP UNDERFREQ 1 OP UNDERFREQ 1 DPO	Underfrequency 1 has picked up Underfrequency 1 has operated Underfrequency 1 has dropped out
	UNDERFREQ 2 to 6	Same set of operands as shown for UNDERFREQ 1
FIXED OPERANDS	Off	Logic = 0. Does nothing and can be used as a delimiter in an equation list; used as 'Disable' by other features.
	On	Logic = 1. Can be used as a test setting.

Operand type	Operand syntax	Operand description
INPUTS/OUTPUTS: Contact inputs	Cont Ip 1 On Cont Ip 2 On ↓ Cont Ip 1 Off Cont Ip 2 Off ↓ Cont Ip 120 On Cont Ip 120 Off	(does not appear unless ordered) (does not appear unless ordered) ↓ (does not appear unless ordered) (does not appear unless ordered) ↓ (does not appear unless ordered) (does not appear unless ordered)
	Cont Op 1 IOn Cont Op 2 IOn ↓ Cont Op 72 IOn	(does not appear unless ordered) (does not appear unless ordered) ↓ (does not appear unless ordered)
	Cont Op 1 VOn Cont Op 2 VOn ↓ Cont Op 72 VOn Cont Op 1 VOff Cont Op 2 VOff ↓ Cont Op 72 VOff	(does not appear unless ordered) (does not appear unless ordered) ↓ (does not appear unless ordered) (does not appear unless ordered) (does not appear unless ordered) ↓ (does not appear unless ordered)
INPUTS/OUTPUTS: Direct input	Direct I/P 1-1 On ↓ Direct I/P 1-8 On Direct I/P 2-1 On ↓ Direct I/P 2-8 On	(appears only when an inter-relay communications card is used) ↓ (appears only when inter-relay communications card is used) (appears only when inter-relay communications card is used) ↓ (appears only when inter-relay communications card is used)
	RxG DPS 1 BAD RxG DPS 1 INTERM RxG DPS 1 OFF RxG DPS 1 ON RxG DPS 2 to 5	Asserted while the RxGOOSE double-point status input is in the bad state Asserted while the RxGOOSE double-point status input is in the intermediate state Asserted while the RxGOOSE double-point status input is off Asserted while the RxGOOSE double-point status input is on Same set of operands as per RxG DPS 1
	RxG Bool 1 On RxG Bool 2 On RxG Bool 3 On ↓ RxG Bool 256 On	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
INPUTS/OUTPUTS: Virtual inputs	Virt Ip 1 On Virt Ip 2 On Virt Ip 3 On ↓ Virt Ip 64 On	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
INPUTS/OUTPUTS: Virtual outputs	Virt Op 1 On Virt Op 2 On Virt Op 3 On ↓ Virt Op 96 On	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
LED INDICATORS: Enhanced and standard front panels	LED IN SERVICE LED TROUBLE LED TEST MODE LED TRIP LED ALARM LED PICKUP LED VOLTAGE LED CURRENT LED FREQUENCY LED OTHER LED PHASE A LED PHASE B LED PHASE C LED NEUTRAL/GROUND	Asserted when the front panel IN SERVICE LED is on Asserted when the front panel TROUBLE LED is on Asserted when the front panel TEST MODE LED is on Asserted when the front panel TRIP LED is on Asserted when the front panel ALARM LED is on Asserted when an element picks up and to turn PICKUP LED on Asserted when a voltage element involved and to turn VOLTAGE LED on Asserted when a current element involved and to turn CURRENT LED on Asserted when a frequency element involved and to turn FREQUENCY LED on Asserted when a composite element involved and to turn OTHER LED on Asserted when phase A involved and to turn PHASE A LED on Asserted when phase B involved and to turn PHASE B LED on Asserted when phase C involved and to turn PHASE C LED on Asserted when a neutral or ground element involved and to turn NEUTRAL/ GROUND LED on

Operand type	Operand syntax	Operand description
LED INDICATORS: Graphical front panel	LED IN SERVICE LED TROUBLE LED TEST MODE LED TRIP LED ALARM LED PICKUP LED VOLTAGE LED CURRENT LED FREQUENCY LED OTHER LED PHASE A LED PHASE B LED PHASE C LED NEUTRAL/GROUND	Asserted when the front panel IN SERVICE LED is on Asserted when the front panel TROUBLE LED is on Asserted when the front panel TEST MODE LED is on Asserted when the front panel TRIP LED is on Asserted when the front panel ALARM LED is on Asserted when an element picks up and to turn Event Cause LED 1 on by default Asserted when a voltage element involved and to turn Event Cause LED 2 on by default Asserted when a current element involved and to turn Event Cause LED 3 on by default Asserted when a frequency element involved and to turn Event Cause LED 4 on by default Asserted when a composite element involved and to turn Event Cause LED 5 on by default Asserted when phase A involved and to turn Event Cause LED 6 on by default Asserted when phase B involved and to turn Event Cause LED 7 on by default Asserted when phase C involved and to turn Event Cause LED 8 on by default Asserted when a neutral or ground element involved and to turn Event Cause LED 9 on by default
LED INDICATORS: LED test	LED TEST IN PROGRESS	An LED test has been initiated and has not finished
LED INDICATORS: User-programmable LEDs Enhanced and standard front panels	LED USER 1	Asserted when user-programmable LED 1 is on
	LED USER 2 to 48	The operand above is available for user-programmable LEDs 2 through 48
LED INDICATORS: User-programmable LEDs Graphical front panel	EVENT CAUSE LED 1	Asserted when event cause LED 1 is on
	EVENT CAUSE LED 2 to 9	Same operand as EVENT CAUSE LED 1
PASSWORD SECURITY	ACCESS LOC SETG OFF ACCESS LOC SETG ON ACCESS LOC CMND OFF ACCESS LOC CMND ON ACCESS REM SETG OFF ACCESS REM SETG ON ACCESS REM CMND OFF ACCESS REM CMND ON UNAUTHORIZED ACCESS	Asserted when local setting access is disabled Asserted when local setting access is enabled Asserted when local command access is disabled Asserted when local command access is enabled Asserted when remote setting access is disabled Asserted when remote setting access is enabled Asserted when remote command access is disabled Asserted when remote command access is enabled Asserted when a password entry fails while accessing a password protected level of the L30
RxGOOSE	RxGOOSE 1 On ↓ RxGOOSE 64 On RxGOOSE 1 Off ↓ RxGOOSE 64 Off R-RxGOOSE1 IGMP On R-TxGOOSE1 ARP On <RxGOOSE Boolean1 ID> On <RxGOOSE DPS1 ID> Bad <RxGOOSE DPS1 ID> Interm <RxGOOSE DPS1 ID> Off <RxGOOSE DPS1 ID> On	Flag is set, logic=1 ↓ Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1 Indicates status of IGMP connection for R-GOOSE multicast reception Indicates status of ARP connection for R GOOSE unicast transmission Replace bracketed text with RxGOOSE Boolean1 status of "true" Replace bracketed text with RxGOOSE DPS1 status of "bad-state" Replace bracketed text with RxGOOSE DPS1 status is "intermediate-state" Replace bracketed text with RxGOOSE DPS1 status is "off" Replace bracketed text with RxGOOSE DPS1 status is "on"
RESETTING	RESET OP RESET OP (COMMS) RESET OP (OPERAND) RESET OP (PUSHBUTTON) RESET ANCTR OP RESET ANCTR OP(OPRD) RESET ANCTR OP(MNUL)	Reset command is operated (set by all three operands below) Communications source of the reset command Operand (assigned in the INPUTS/OUTPUTS ⇒ RESETTING menu) source of the reset command Reset key (pushbutton) source of the reset command Reset annunciator command is operated (set by any operands below) Reset operand (assigned in INPUTS/OUTPUTS ⇒ RESETTING ANNUNCIATOR menu) source of the reset annunciator command Reset manual (pushbutton or EnerVista software) source of the reset annunciator command

Operand type	Operand syntax	Operand description
SELF-DIAGNOSTICS (See Relay Self-tests descriptions in Chapter 7: Commands and Targets)	ANY MAJOR ERROR ANY MINOR ERROR ANY SELF-TESTS BATTERY FAIL CLOCK UNSYNCHRONIZED DIRECT DEVICE OFF DIRECT RING BREAK EQUIPMENT MISMATCH FLEXLOGIC ERR TOKEN IRIG-B FAILURE LATCHING OUT ERROR MAINTENANCE ALERT FIRST ETHERNET FAIL PROCESS BUS FAILURE PTP FAILURE RxGOOSE OFF RRTD COMM FAIL SECOND ETHERNET FAIL THIRD ETHERNET FAIL SNTP FAILURE SYSTEM EXCEPTION TEMP MONITOR UNIT NOT PROGRAMMED SETTING CHANGED	Any of the major self-test errors generated (major error) Any of the minor self-test errors generated (minor error) Any self-test errors generated (generic, any error) The battery is weak or not functioning. Replace as outlined in the Maintenance chapter. Relay is not synchronized to the international time standard A direct device is configured but not connected The Direct I/O settings is for a connection that is not in a ring The configuration of modules does not match the stored order code A FlexLogic equation is incorrect "Bad IRIG-B Signal" self-test. See Chapter 7: Commands and Targets. A difference is detected between the desired and actual latch contact state A subset of the minor self-test errors generated, see Chapter 7 Link failure detected. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets "Bad PTP Signal" self-test as described in Chapter 7 One or more GOOSE messages are not being received See description in Chapter 7: Commands and Targets See description in Chapter 7: Commands and Targets See description in Chapter 7: Commands and Targets See description in Chapter 7: Commands and Targets SNTP server is not responding See description in Chapter 7: Commands and Targets Monitors ambient temperature and maximum operating temperature The product SETUP > INSTALLATION > RELAYS SETTINGS setting is not programmed Any device settings changed over any available interface; operand is asserted for at least one second and then self-reset
TEMPERATURE MONITOR	TEMP MONITOR	Asserted while the ambient temperature is greater than the maximum operating temperature (80°C)
USER-PROGRAMMABLE PUSHBUTTONS	PUSHBUTTON 1 ON PUSHBUTTON 1 OFF ANY PB ON	Pushbutton number 1 is in the "On" position Pushbutton number 1 is in the "Off" position Any of 12 pushbuttons is in the "On" position
	PUSHBUTTON 2 to 6, 12, or 16 depending on front panel	Same set of operands as PUSHBUTTON 1

Some operands can be re-named. These are the names of the breakers in the breaker control feature, the ID (identification) of contact inputs and outputs, the ID of virtual inputs, and the ID of virtual outputs. If the user changes the default name or ID of any of these operands, the assigned name appears in the relay list of operands. The default names are shown in the FlexLogic operands table.

The characteristics of the logic gates are tabulated in the following table, and the operators available in FlexLogic are listed in the FlexLogic operators table.

Table 5-25: FlexLogic gate characteristics

Gates	Number of inputs	Output is '1' (= ON) if...
NOT	1	input is '0'
OR	2 to 16	any input is '1'
AND	2 to 16	all inputs are '1'
NOR	2 to 16	all inputs are '0'
NAND	2 to 16	any input is '0'
XOR	2	only one input is '1'

Table 5-26: FlexLogic operators

Type	Syntax	Description	Notes
Editor	INSERT	Insert a parameter in an equation list	
	DELETE	Delete a parameter from an equation list	
End	END	The first END encountered signifies the last entry in the list of processed FlexLogic parameters	
One-shot	POSITIVE ONE SHOT	One shot that responds to a positive going edge	A 'one shot' refers to a single input gate that generates a pulse in response to an edge on the input. The output from a 'one shot' is True (positive) for only one pass through the FlexLogic equation. There is a maximum of 64 'one shots.'
	NEGATIVE ONE SHOT	One shot that responds to a negative going edge	
	DUAL ONE SHOT	One shot that responds to both the positive and negative going edges	
Logic gate	NOT	Logical NOT	Operates on the previous parameter
	OR(2) ↓	2 input OR gate	Operates on the 2 previous parameters
	OR(16)	16 input OR gate	Operates on the 16 previous parameters
	AND(2) ↓	2 input AND gate	Operates on the 2 previous parameters
	AND(16)	16 input AND gate	Operates on the 16 previous parameters
	NOR(2) ↓	2 input NOR gate	Operates on the 2 previous parameters
	NOR(16)	16 input NOR gate	Operates on the 16 previous parameters
	NAND(2) ↓	2 input NAND gate	Operates on the 2 previous parameters
	NAND(16)	16 input NAND gate	Operates on the 16 previous parameters
XOR(2)	2 input Exclusive OR gate	Operates on the 2 previous parameters	
LATCH (S,R)	Latch (set, reset): reset-dominant	The parameter preceding LATCH(S,R) is the reset input. The parameter preceding the reset input is the set input.	
Timer	TIMER 1 ↓	Timer set with FlexLogic timer 1 settings	The timer is started by the preceding parameter. The output of the timer is TIMER #.
	TIMER 32	Timer set with FlexLogic timer 32 settings	
Assign virtual output	= Virt Op 1 ↓ = Virt Op 96	Assigns previous FlexLogic operand to virtual output 1 ↓ Assigns previous FlexLogic operand to virtual output 96	The virtual output is set by the preceding parameter

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5.6.2 FlexLogic rules

When forming a FlexLogic equation, the sequence in the linear array of parameters must follow these general rules:

1. Operands must precede the operator that uses the operands as inputs.
2. Operators have only one output. The output of an operator must be used to create a virtual output if it is to be used as an input to two or more operators.
3. Assigning the output of an operator to a virtual output terminates the equation.
4. A timer operator (for example, "TIMER 1") or virtual output assignment (for example, "= Virt Op 1") can be used once only. If this rule is broken, a syntax error is declared.

5.6.3 FlexLogic evaluation

Each equation is evaluated in the ascending order in which the parameters have been entered.



FlexLogic provides built-in latches that by definition have a memory action, remaining in the set state after the set input has been asserted. These built-in latches are reset dominant, meaning that if logical "1" is applied to both set and reset entries simultaneously, then the output of the latch is logical "0." However, they are volatile, meaning that they reset upon removal of control power.

When making changes to FlexLogic entries in the settings, all FlexLogic equations are re-compiled whenever any new FlexLogic entry value is entered, and as a result of the re-compile all latches are reset automatically.

To implement FlexLogic using a graphical user interface, see the FlexLogic Design and Monitoring using Engineer section in the previous chapter.

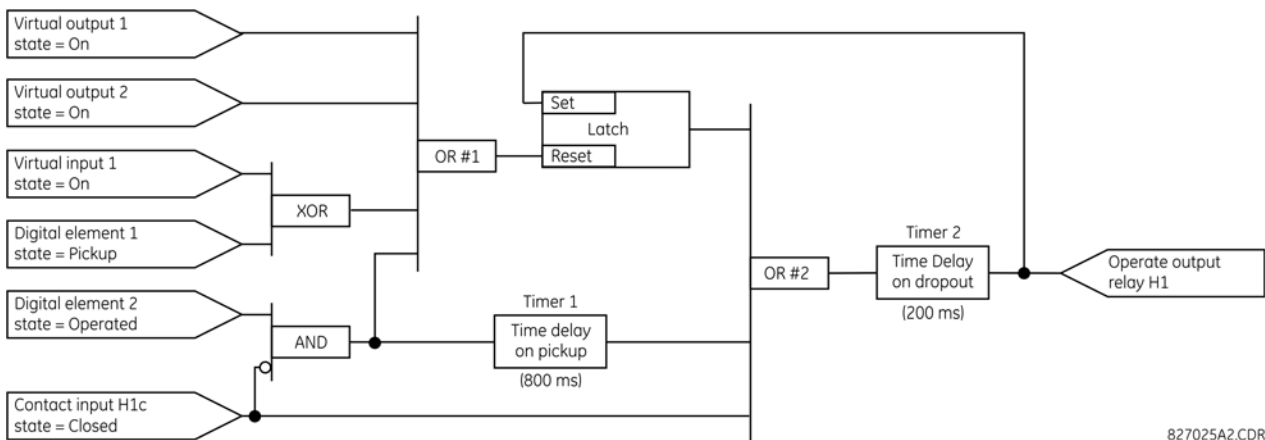
5.6.4 FlexLogic example

This section provides an example of logic implementation for a typical application. The sequence of steps is important to minimize the work to develop the relay settings. Note that the example in the following figure demonstrates the procedure, not to solve a specific application situation.

Note that there is also a graphical interface with which to draw logic and populate FlexLogic equation entries. See the Engineer content at the end of the previous chapter.

In the example, it is assumed that logic has already been programmed to produce virtual outputs 1 and 2, and is only a part of the full set of equations used. When using FlexLogic, it is important to make a note of each virtual output used; a virtual output designation (1 to 96) can be assigned only once.

Figure 5-96: Logic example



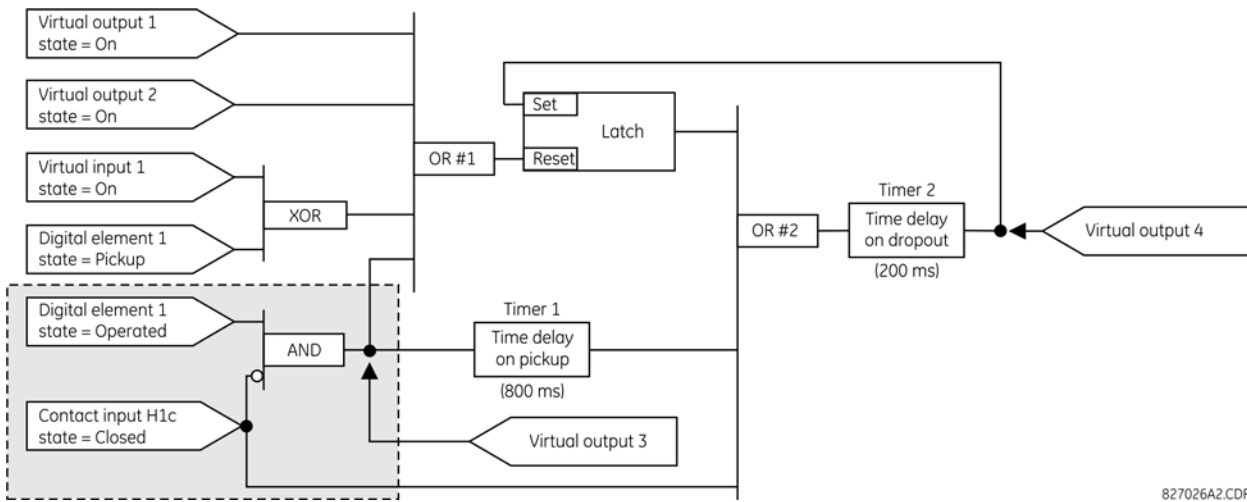
1. Inspect the example logic diagram to determine if the required logic can be implemented with the FlexLogic operators. If this is not possible, the logic must be altered until this condition is satisfied. Once done, count the inputs to each gate to verify that the number of inputs does not exceed the FlexLogic limits, which is unlikely but possible. If the number of inputs is too high, subdivide the inputs into multiple gates to produce an equivalent. For example, if 25 inputs to an AND gate are required, connect Inputs 1 through 16 to AND(16), 17 through 25 to AND(9), and the outputs from these two gates to AND(2).

Inspect each operator between the initial operands and final virtual outputs to determine if the output from the operator is used as an input to more than one following operator. If so, the operator output must be assigned as a virtual output.

For the example shown, the output of the AND gate is used as an input to both OR#1 and Timer 1, and must therefore be made a virtual output and assigned the next available number (that is, Virtual Output 3). The final output must also be assigned to a virtual output as virtual output 4, which is programmed in the contact output section to operate relay H1 (that is, contact output H1).

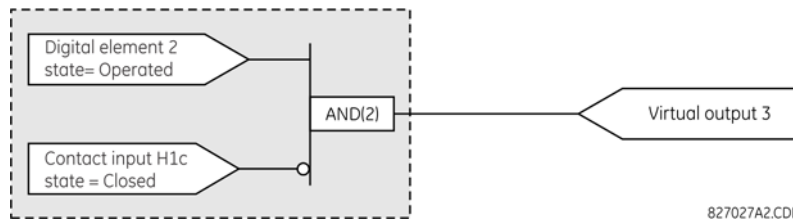
Therefore, the required logic can be implemented with two FlexLogic equations with outputs of virtual output 3 and virtual output 4, shown as follows.

Figure 5-97: Logic example with virtual outputs



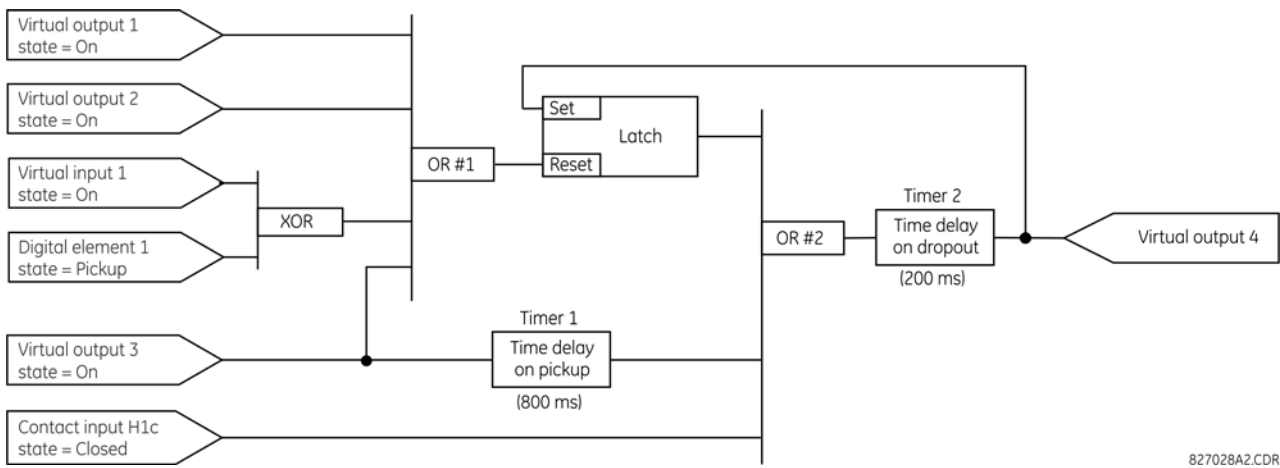
2. Prepare a logic diagram for the equation to produce virtual output 3, as this output is used as an operand in the virtual output 4 equation (create the equation for every output that is used as an operand first, so that when these operands are required they already have been evaluated and assigned to a specific virtual output). The logic for virtual output 3 is shown as follows with the final output assigned.

Figure 5-98: Logic for virtual output 3



3. Prepare a logic diagram for virtual output 4, replacing the logic ahead of virtual output 3 with a symbol identified as virtual output 3, shown as follows.

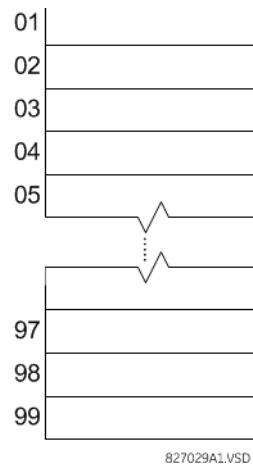
Figure 5-99: Logic for virtual output 4



4. Program the FlexLogic equation for virtual output 3 by translating the logic into available FlexLogic parameters. The equation is formed one parameter at a time until the required logic is complete. It is generally easier to start at the output end of the equation and work back towards the input, as shown in the following steps. It is also recommended

to list operator inputs from bottom to top. For demonstration, the final outputs are arbitrarily identified as parameter 99, and each preceding parameter decremented by one in turn. Until accustomed to using FlexLogic, it is suggested that a worksheet with a series of cells marked with the arbitrary parameter numbers be prepared shown as follows.

Figure 5-100: FlexLogic worksheet



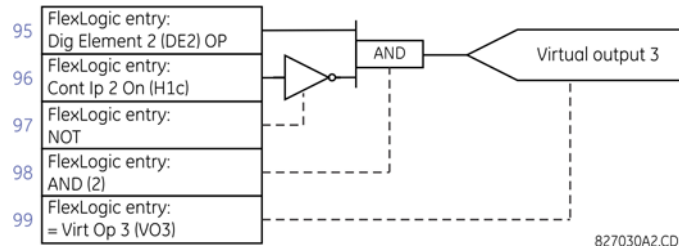
5. Following the procedure outlined, start with parameter 99, as follows:
 - 99: The final output of the equation is virtual output 3, which is created by the operator "= Virt Op n". This parameter is therefore "= Virt Op 3".
 - 98: The gate preceding the output is an AND, which in this case requires two inputs. The operator for this gate is a 2-input AND so the parameter is "AND(2)". Note that FlexLogic rules require that the number of inputs to most types of operators must be specified to identify the operands for the gate. As the 2-input AND operates on the two operands preceding it, these inputs must be specified, starting with the lower.
 - 97: This lower input to the AND gate must be passed through an inverter (the NOT operator) so the next parameter is "NOT". The NOT operator acts upon the operand immediately preceding it, so specify the inverter input next.
 - 96: The input to the NOT gate is to be contact input H1c. The ON state of a contact input can be programmed to be set when the contact is either open or closed. Assume for this example that the state is to be ON for a closed contact. The operand is therefore "Cont Ip H1c On".
 - 95: The last step in the procedure is to specify the upper input to the AND gate, the operated state of digital element 2. This operand is "DIG ELEM 2 OP".

Writing the parameters in numerical order forms the equation for virtual output 3:

```
[95] DIG ELEM 2 OP
[96] Cont Ip H1c on
[97] NOT
[98] AND(2)
[99] = virt op 3
```

It is now possible to check that this selection of parameters produces the required logic by converting the set of parameters into a logic diagram. The result of this process is shown in the figure, which is compared to the logic for virtual output 3 diagram as a check.

Figure 5-101: FlexLogic equation for virtual output 3



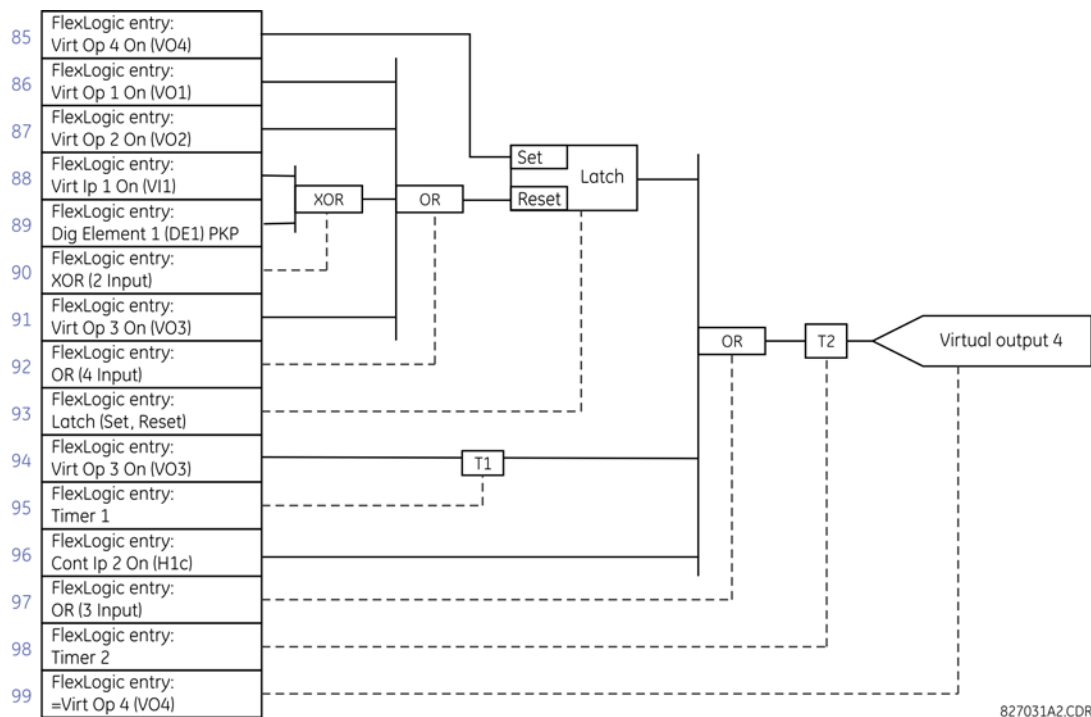
6. Repeating the process described for virtual output 3, select the FlexLogic parameters for Virtual Output 4.
 - 99: The final output of the equation is virtual output 4, which is parameter “= Virt Op 4”.
 - 98: The operator preceding the output is timer 2, which is operand “TIMER 2”. Note that the settings required for the timer are established in the timer programming section.
 - 97: The operator preceding timer 2 is OR #2, a 3-input OR, which is parameter “OR(3)”.
 - 96: The lowest input to OR #2 is operand “Cont Ip H1c On”.
 - 95: The center input to OR #2 is operand “TIMER 1”.
 - 94: The input to timer 1 is operand “Virt Op 3 On”.
 - 93: The upper input to OR #2 is operand “LATCH (S,R)”.
 - 92: There are two inputs to a latch, and the input immediately preceding the latch reset is OR #1, a 4-input OR, which is parameter “OR(4)”.
 - 91: The lowest input to OR #1 is operand “Virt Op 3 On”.
 - 90: The input just above the lowest input to OR #1 is operand “XOR(2)”.
 - 89: The lower input to the XOR is operand “DIG ELEM 1 PKP”.
 - 88: The upper input to the XOR is operand “Virt Ip 1 On”.
 - 87: The input just below the upper input to OR #1 is operand “Virt Op 2 On”.
 - 86: The upper input to OR #1 is operand “Virt Op 1 On”.
 - 85: The last parameter is used to set the latch, and is operand “Virt Op 4 On”.

The equation for virtual output 4 is:

```
[85] virt op 4 on
[86] virt op 1 on
[87] virt op 2 on
[88] virt ip 1 on
[89] DIG ELEM 1 PKP
[90] XOR(2)
[91] virt op 3 on
[92] OR(4)
[93] LATCH (S,R)
[94] virt op 3 on
[95] TIMER 1
[96] Cont Ip H1c on
[97] OR(3)
[98] TIMER 2
[99] = virt op 4
```

Now check that the selection of parameters produce the required logic by converting the set of parameters into a logic diagram. The result is shown in the figure, which is compared to the logic for virtual output 4 diagram as a check.

Figure 5-102: FlexLogic equation for virtual output 4



7. Now write the complete FlexLogic expression required to implement the logic, making an effort to assemble the equation in an order where Virtual Outputs that are used as inputs to operators are created before needed. In cases where a lot of processing is required to perform logic, this can be difficult to achieve, but in most cases does not cause problems as all logic is calculated at least four times per power frequency cycle. The possibility of a problem caused by sequential processing emphasizes the necessity to test the performance of FlexLogic before it is placed in service. In the following equation, virtual output 3 is used as an input to both latch 1 and timer 1 as arranged in the following order:

```

DIG ELEM 2 OP
Cont Ip H1c On
NOT
AND(2)
= Virt Op 3
Virt Op 4 On
Virt Op 1 On
Virt Op 2 On
Virt Ip 1 On
DIG ELEM 1 PKP
XOR(2)
Virt Op 3 On
OR(4)
LATCH (S,R)
Virt Op 3 On
TIMER 1
Cont Ip H1c On
OR(3)
TIMER 2
= Virt Op 4
END

```

In this expression, the virtual output 4 input to the four-input OR is listed before it is created. This is typical of a form of feedback, in this case, used to create a seal-in effect with the latch, and is correct.

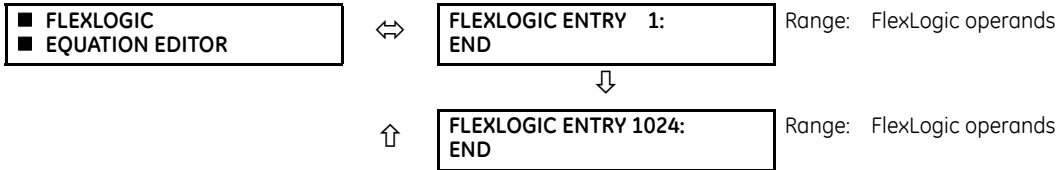
8. Always test the logic after it is loaded into the relay, in the same way as has been used in the past. Testing can be simplified by placing an "END" operator within the overall set of FlexLogic equations. The equations are evaluated up

to the first "END" operator.

The "On" and "Off" operands can be placed in an equation to establish a known set of conditions for test purposes, and the "INSERT" and "DELETE" commands can be used to modify equations.

5.6.5 FlexLogic equation editor

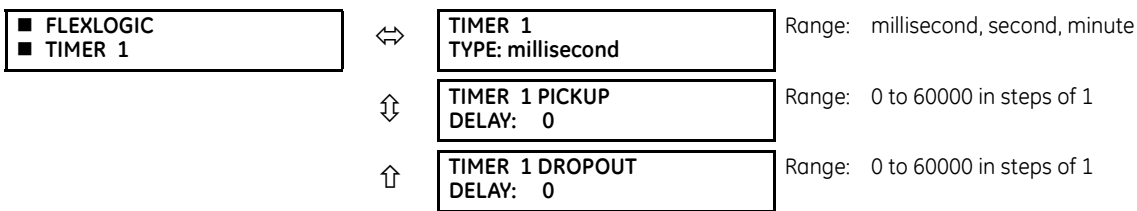
SETTINGS ⇨ FLEXLOGIC ⇨ FLEXLOGIC EQUATION EDITOR



There are 1,024 FlexLogic entries available, numbered from 1 to 1024, with default END entry settings. If a "Disabled" element is selected as a FlexLogic entry, the associated state flag is never set to '1'. Press the +/- key when editing FlexLogic equations to quickly scan through the major parameter types.

5.6.6 FlexLogic timers

SETTINGS ⇨ FLEXLOGIC ⇨ FLEXLOGIC TIMERS ⇨ FLEXLOGIC TIMER 1(32)



There are 32 identical FlexLogic timers available. These timers are used as operators for FlexLogic equations.

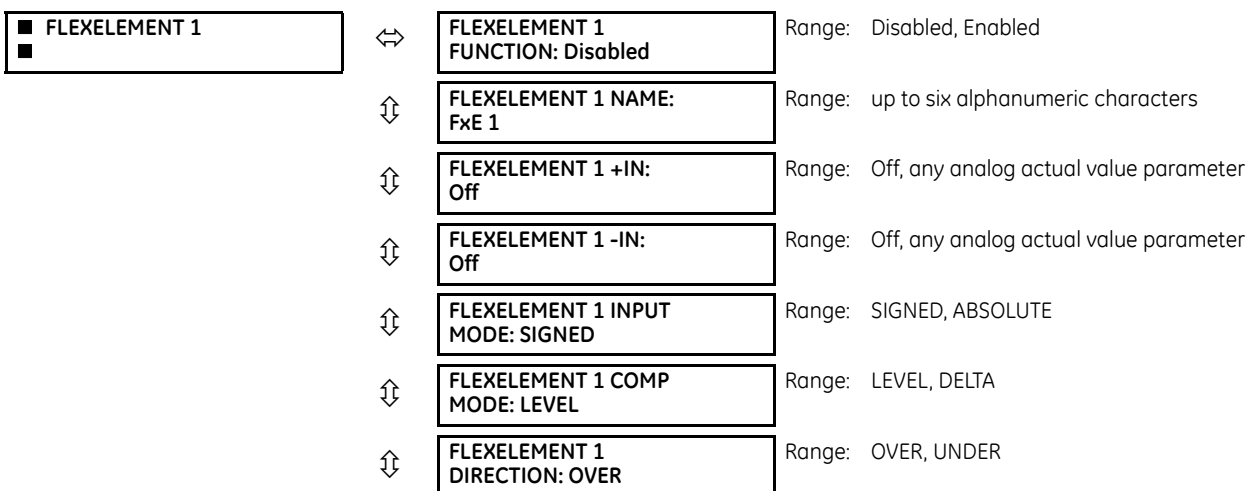
TIMER 1 TYPE — Selects the time measurement unit.

TIMER 1 PICKUP DELAY — Sets the time delay to pickup. If a pickup delay is not required, set this function to "0."

TIMER 1 DROPOUT DELAY — Sets the time delay to dropout. If a dropout delay is not required, set this function to "0."

5.6.7 FlexElements

SETTINGS ⇨ FLEXLOGIC ⇨ FLEXELEMENTS ⇨ FLEXELEMENT 1(8)



⇅	FLEXELEMENT 1 PICKUP: 1.000 pu	Range: -90.000 to 90.000 pu in steps of 0.001
⇅	FLEXELEMENT 1 HYSTERESIS: 3.0%	Range: 0.1 to 50.0% in steps of 0.1
⇅	FLEXELEMENT 1 dt UNIT: Milliseconds	Range: Milliseconds, Seconds, Minutes
⇅	FLEXELEMENT 1 dt: 20	Range: 20 to 86400 in steps of 1
⇅	FLEXELEMENT 1 PKP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
⇅	FLEXELEMENT 1 RST DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
⇅	FLEXELEMENT 1 BLK: Off	Range: FlexLogic operand
⇅	FLEXELEMENT 1 TARGET: Self-reset	Range: Self-reset, Disabled, Latched
⇅	FLEXELEMENT 1 EVENTS: Disabled	Range: Disabled, Enabled

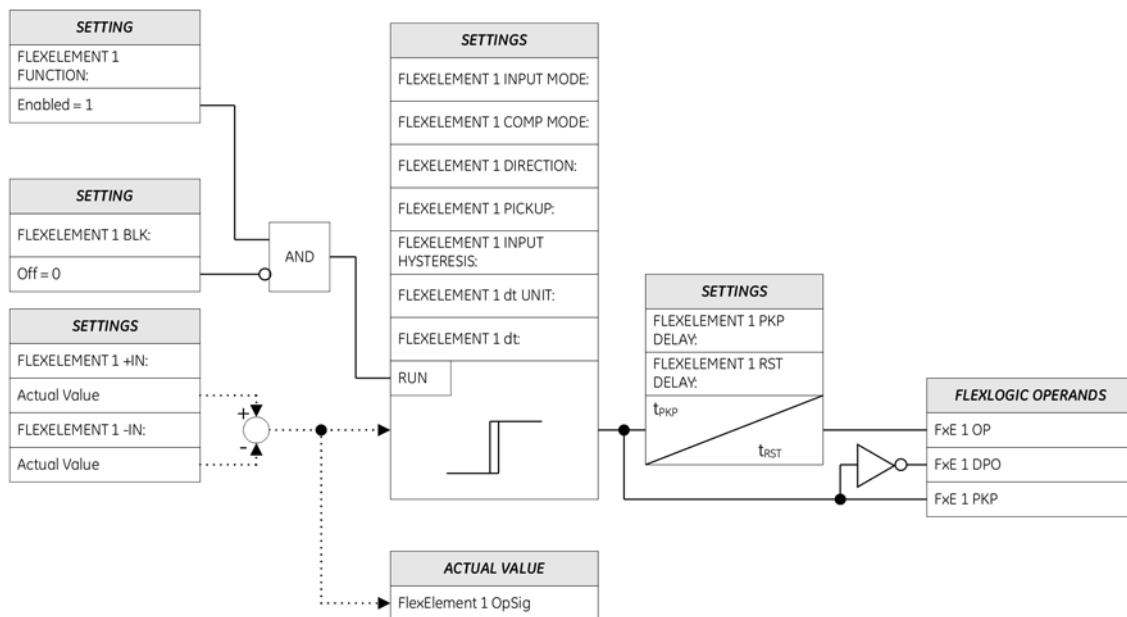
A FlexElement is a universal comparator used to monitor any analog actual value calculated by the relay or a net difference of any two analog actual values of the same type. The effective operating signal can be treated as a signed number or its absolute value can be used.

FlexElements run every half power cycle (every four protection passes).

The element can be programmed to respond either to a signal level or to a rate-of-change (delta) over a pre-defined period of time. The output operand is asserted when the operating signal is higher than a threshold or lower than a threshold, as per your choice.



Figure 5-103: FlexElement logic



842004A4.CDR

FLEXELEMENT 1 +IN — This setting specifies the first (non-inverted) input to the FlexElement. Zero is assumed as the input if this setting is set to “Off.” For proper operation of the element, at least one input must be selected. Otherwise, the element does not assert its output operands.

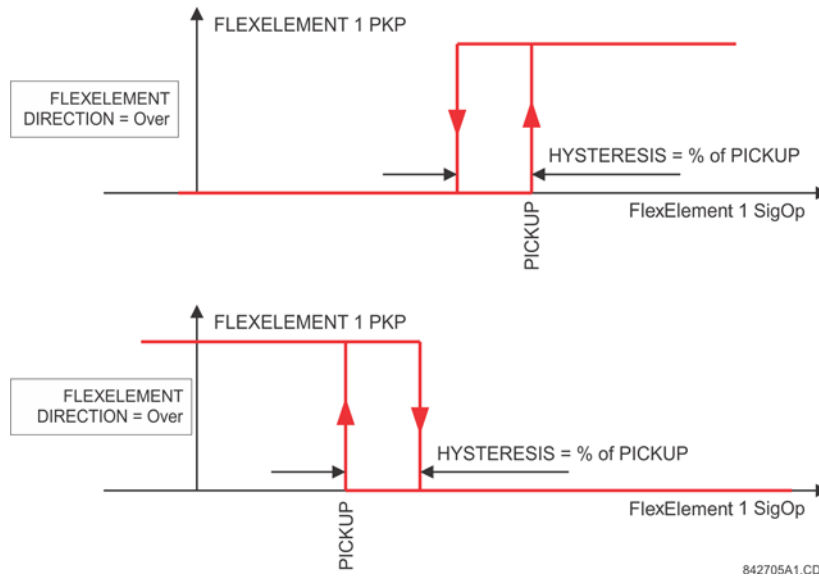
FLEXELEMENT 1 -IN — Specifies the second (inverted) input to the FlexElement. Zero is assumed as the input if this setting is set to “Off.” For proper operation of the element, at least one input must be selected. Otherwise, the element does not assert its output operands. This input is used to invert the signal if needed for convenience, or to make the element respond to a differential signal, such as for a top-bottom oil temperature differential alarm. The element does not operate if the two input signals are of different types, for example if one tries to use active power and phase angle to build the effective operating signal.

The element responds directly to the differential signal if the **FLEXELEMENT 1 INPUT MODE** setting is set to “Signed.” The element responds to the absolute value of the differential signal if this setting is set to “Absolute.” Sample applications for the “Absolute” setting include monitoring the angular difference between two phasors with a symmetrical limit angle in both directions, monitoring power regardless of its direction, or monitoring a trend.

The element responds directly to its operating signal—as defined by the **FLEXELEMENT 1 +IN**, **FLEXELEMENT 1 -IN** and **FLEXELEMENT 1 INPUT MODE** settings—if the **FLEXELEMENT 1 COMP MODE** setting is set to “Level.” The element responds to the rate of change of its operating signal if the **FLEXELEMENT 1 COMP MODE** setting is set to “Delta.” In this case, the **FLEXELEMENT 1 dt UNIT** and **FLEXELEMENT 1 dt** settings specify how the rate of change is derived.

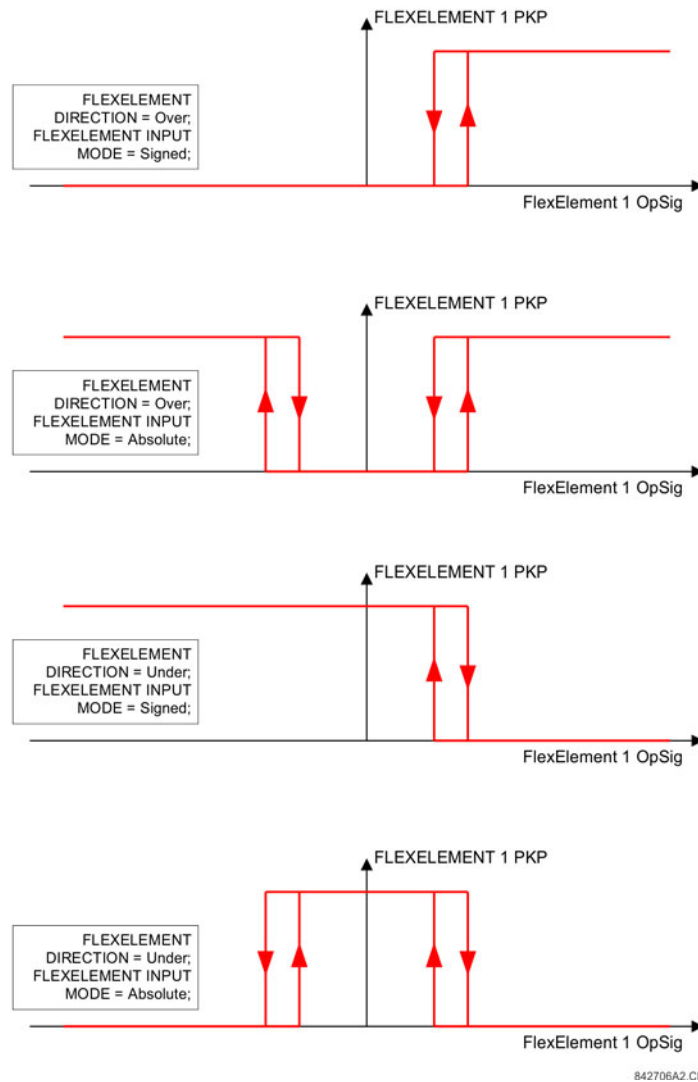
FLEXELEMENT 1 DIRECTION — Enables the relay to respond to either high or low values of the operating signal. The following figure explains the application of the **FLEXELEMENT 1 DIRECTION**, **FLEXELEMENT 1 PICKUP**, and **FLEXELEMENT 1 HYSTERESIS** settings.

Figure 5-104: FlexElement direction, pickup, and hysteresis



In conjunction with the **FLEXELEMENT 1 INPUT MODE** setting, the element can be programmed to provide two extra characteristics, as shown in the following figure.

Figure 5-105: FlexElement input mode setting



FLEXELEMENT 1 PICKUP — This setting specifies the operating threshold for the effective operating signal of the element. If set to “Over,” the element picks up when the operating signal exceeds the **FLEXELEMENT 1 PICKUP** value. If set to “Under,” the element picks up when the operating signal falls below the **FLEXELEMENT 1 PICKUP** value.

FLEXELEMENT 1 HYSTERESIS — This setting controls the element dropout. Notice that both the operating signal and the pickup threshold can be negative, facilitating applications such as reverse power alarm protection. The FlexElement can be programmed to work with all analog actual values measured by the relay. The **FLEXELEMENT 1 PICKUP** setting is entered in per-unit values using the following definitions of the base units.

Table 5-27: FlexElement base units

Unit	Description
87L SIGNALS (Local IA Mag, IB, and IC) (Diff Curr IA Mag, IB, and IC) (Terminal 1 IA Mag, IB, and IC) (Terminal 2 IA Mag, IB and IC)	I_{BASE} = maximum primary RMS value of the +IN and -IN inputs (CT primary for source currents, and 87L source primary current for line differential currents)
87L SIGNALS (Op Square Curr IA, IB, and IC) (Rest Square Curr IA, IB, and IC)	BASE = Squared CT secondary of the 87L source

Unit	Description
BREAKER ACC ARCING AMPS (Brk X Acc Arc Amp A, B, and C)	BASE = 2000 kA ² × cycle
BREAKER ARCING AMPS (Brk X Arc Amp A, B, and C)	BASE = 1 kA ² × cycle
DCmA	BASE = maximum value of the DCMA INPUT MAX setting for the two transducers configured under the +IN and -IN inputs
DELTA TIME	BASE = 1 μs
FAULT LOCATION	BASE = Line Length as specified in Fault Report
FREQUENCY	f _{BASE} = 1 Hz
FREQUENCY RATE OF CHANGE	df/dt _{BASE} = 1 Hz/s
PHASE ANGLE	φ _{BASE} = 360 degrees (see the UR angle referencing convention)
POWER FACTOR	PF _{BASE} = 1.00
RTDs	BASE = 100°C
SOURCE CURRENT	I _{BASE} = maximum nominal primary RMS value of the +IN and -IN inputs
SOURCE POWER	P _{BASE} = maximum value of V _{BASE} × I _{BASE} for the +IN and -IN inputs
SOURCE THD & HARMONICS	BASE = 1%
SOURCE VOLTAGE	V _{BASE} = maximum nominal primary RMS value of the +IN and -IN inputs
SYNCHROCHECK (Max Delta Volts)	V _{BASE} = maximum primary RMS value of all the sources related to the +IN and -IN inputs

FLEXELEMENT 1 HYSTERESIS — This setting defines the pickup-dropout relation of the element by specifying the width of the hysteresis loop as a percentage of the pickup value as shown in the FlexElement Direction, Pickup, and Hysteresis diagram.

FLEXELEMENT 1 dt UNIT — Specifies the time unit for the setting **FLEXELEMENT 1 dt**. This setting is applicable only if **FLEXELEMENT 1 COMP MODE** is set to “Delta.”

FLEXELEMENT 1 dt — Specifies duration of the time interval for the rate of change mode of operation. This setting is applicable only if **FLEXELEMENT 1 COMP MODE** is set to “Delta.”

FLEXELEMENT 1 PKP DELAY — Specifies the pickup delay of the element.

FLEXELEMENT 1 RST DELAY — Specifies the reset delay of the element.

5.6.8 Non-volatile latches

SETTINGS ⇨ FLEXLOGIC ⇨ NON-VOLATILE LATCHES ⇨ LATCH 1(16)

<input checked="" type="checkbox"/> LATCH 1 <input type="checkbox"/>	↔	LATCH 1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	LATCH 1 ID: NV Latch 1	Range: up to 20 alphanumeric characters
	⇅	LATCH 1 TYPE: Reset Dominant	Range: Reset Dominant, Set Dominant
	⇅	LATCH 1 SET: Off	Range: FlexLogic operand
	⇅	LATCH 1 RESET: Off	Range: FlexLogic operand
	⇅	LATCH 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	LATCH 1 EVENTS: Disabled	Range: Disabled, Enabled

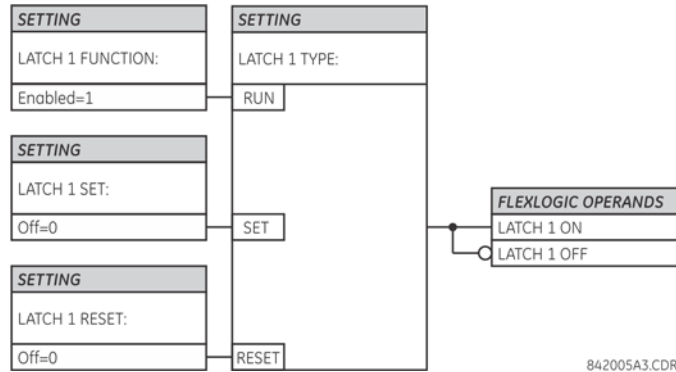
The non-volatile latches provide a permanent logical flag that is stored safely and do not reset upon restart after the relay is powered down. Typical applications include sustaining operator commands or permanently blocking relay functions, such as Autorecloser, until a deliberate interface action resets the latch.

LATCH 1 TYPE — This setting characterizes Latch 1 to be Set- or Reset-dominant.

LATCH 1 SET — If asserted, the specified FlexLogic operands 'sets' Latch 1.

LATCH 1 RESET — If asserted, the specified FlexLogic operand 'resets' Latch 1.

Figure 5-106: Non-volatile latch operation table (N = 1 to 16) and logic



Latch n type	Latch n set	Latch n reset	Latch n on	Latch n off
Reset Dominant	ON	OFF	ON	OFF
	OFF	OFF	Previous State	Previous State
	ON	ON	OFF	ON
	OFF	ON	OFF	ON
Set Dominant	ON	OFF	ON	OFF
	ON	ON	ON	OFF
	OFF	OFF	Previous State	Previous State
	OFF	ON	OFF	ON

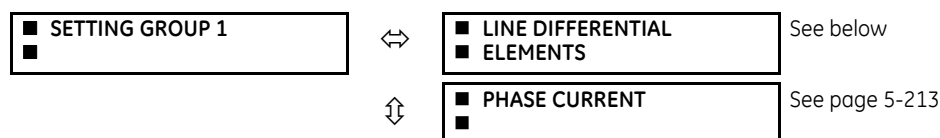
5.7 Grouped elements

5.7.1 Overview

Each protection element can be assigned up to six sets of settings with designations 1 to 6. The performance of these elements is defined by the active setting group at a given time. Multiple setting groups allow the user to conveniently change protection settings for different operating situations (for example, altered power system configuration or season of the year). The active setting group can be preset or selected in the **SETTING GROUPS** menu (see the Control Elements section later in this chapter). See also the Introduction to Elements section at the beginning of this chapter.

5.7.2 Setting group 1

SETTINGS ⇄ GROUPED ELEMENTS ⇄ SETTING GROUP 1(6)



↕	■ NEUTRAL CURRENT ■	See page 5-225
↕	■ GROUND CURRENT ■	See page 5-233
↕	■ NEGATIVE SEQUENCE ■ CURRENT	See page 5-236
↕	■ BREAKER FAILURE ■	See page 5-238
↕	■ VOLTAGE ELEMENTS ■	See page 5-248
↑	■ SUPERVISING ■ ELEMENTS	See page 5-255

Each of the six setting group menus is identical. Setting group 1 (the default active group) is active automatically when no other group is active.

If the device incorrectly switches to group 1 after power cycling, upgrade the firmware to version 7.31 or later to correct this issue.

5.7.3 Line differential elements

SETTINGS ⇒ ↓ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ LINE DIFFERENTIAL ELEMENTS

5	■ LINE DIFFERENTIAL ■ ELEMENTS	↔	■ CURRENT ■ DIFFERENTIAL	See below
		↑	■ STUB BUS ■	See page 5-212

5.7.3.1 Current differential

SETTINGS ⇒ ↓ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ LINE DIFFERENTIAL... ⇒ CURRENT DIFFERENTIAL

5	■ CURRENT ■ DIFFERENTIAL	↔	CURRENT DIFF FUNCTION: Disabled	Range: Disabled, Enabled
		↕	CURRENT DIFF SIGNAL SOURCE 1: SRC 1	Range: SRC 1, SRC 2
		↕	CURRENT DIFF BLOCK: Off	Range: FlexLogic operand
		↕	CURRENT DIFF PICKUP: 0.20 pu	Range: 0.10 to 4.00 pu in steps of 0.01
		↕	CURRENT DIFF CT TAP 1: 1.00	Range: 0.20 to 5.00 in steps of 0.01
		↕	CURRENT DIFF CT TAP 2: 1.00	Range: 0.20 to 5.00 in steps of 0.01
		↕	CURRENT DIFF RESTRAINT 1: 30%	Range: 1 to 50% in steps of 1
		↕	CURRENT DIFF RESTRAINT 2: 50%	Range: 1 to 70% in steps of 1
		↕	CURRENT DIFF BREAK PT: 1.0 pu	Range: 0.0 to 20.0 pu in steps of 0.1
	↕	INRUSH INHIBIT MODE: Disabled	Range: Disabled, Per phase, 2-out-of-3, Average	

⇅	INRUSH INHIBIT LEVEL: 20% f ₀	Range: 1.0 to 40.0% f ₀ in steps of 0.1
⇅	CURRENT DIFF GND FUNCTION: Disabled	Range: Disabled, Enabled
⇅	CURRENT DIFF GND PICKUP: 0.10 pu	Range: 0.05 to 1.00 pu in steps of 0.01
⇅	CURRENT DIFF GND RESTRAINT: 25%	Range: 1 to 50% in steps of 1
⇅	CURRENT DIFF GND DELAY: 0.10 s	Range: 0.00 to 5.00 s in steps of 0.01
⇅	CURRENT DIFF DTT: Enabled	Range: Disabled, Enabled
⇅	CURRENT DIFF KEY DTT: Off	Range: FlexLogic operand
⇅	CURRENT DIFF TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↑	CURRENT DIFF EVENTS: Disabled	Range: Disabled, Enabled

CURRENT DIFF SIGNAL SOURCE 1 — This setting selects the first source for the current differential element local operating current. If more than one source is configured, the other source currents are scaled to the CT with the maximum primary current assigned by the **CURRENT DIFF SIGNAL SOURCE 1** to **CURRENT DIFF SIGNAL SOURCE 4** settings. This source is mandatory and is assigned with the **SYSTEM SETUP** ⇌ **SIGNAL SOURCES** ⇌ **SOURCE 1** menu.

CURRENT DIFF BLOCK — This setting selects a FlexLogic operand to block the operation of the current differential element.

CURRENT DIFF PICKUP — This setting is used to select the current differential pickup value.

CURRENT DIFF CT TAP 1, 2 — These settings adapt the remote terminal 1 or 2 (communication channel 1 and 2 respectively) CT ratio to the local ratio if the CT ratios for the local and remote terminals differ. In two-terminal, two-channel applications use the same value for both TAP 1 and TAP 2 settings, and in three-terminals accordingly remote 1 and 2 CTs. The setting value is determined by $CT_{prim_rem} / CT_{prim_loc}$ for local and remote terminal CTs (where $CT_{prim_rem} / CT_{prim_loc}$ is referred to as the CT primary rated current). Ratio matching must always be performed against the remote CT with the maximum CT primary defined by the **CURRENT DIFF SIGNAL SOURCE 1** through **CURRENT DIFF SIGNAL SOURCE 4** settings. See the Current Differential Settings example in the Application of Settings chapter for details.

When an in-zone power transformer is present, calculate and use this setting by taking into account the in-zone power transformer as follows.

$$CT\ Tap = \frac{CT_{prim_rem} \times V_{prim_rem}}{CT_{prim_loc} \times V_{prim_loc}} \text{ for remote terminals 1 and 2, respectively} \quad \text{Eq. 5-13}$$

In this equation, V_{prim_rem} is primary nominal voltage of the transformer winding at the remote terminal and V_{prim_loc} is primary nominal voltage of the transformer winding at the local terminal.

CURRENT DIFF RESTRAINT 1, 2 — These settings select the bias characteristic for the first and second slope, respectively.

CURRENT DIFF BREAK PT — This setting is used to select an intersection point between the two slopes.

INRUSH INHIBIT MODE — This setting selects the mode for blocking differential protection during magnetizing inrush conditions. Modern transformers can produce small second harmonic ratios during inrush conditions. This can result in undesired tripping of the protected line. Reducing the second harmonic inhibit threshold can jeopardize dependability and speed of differential protection. When low, the second harmonic ratio causes problems in one phase only. This can be utilized to ensure security by applying cross-phase blocking rather than lowering the inrush inhibit threshold.

If set to “Disabled”, no inrush inhibit action is taken.

If set to “Per phase”, the L30 performs inrush inhibit individually in each phase.

If set to “2-out-of-3,” the L30 checks second harmonic level in all three phases individually. If any two phases establish an inhibiting condition, then the remaining phase is restrained automatically.

If set to “Average”, the L30 first calculates the average second harmonic ratio, then applies the inrush threshold to the calculated average.

INRUSH INHIBIT LEVEL — This setting specifies the level of second harmonic component in the transformer magnetizing inrush current, above which the current differential element is inhibited from operating. The value of the **INRUSH INHIBIT MODE** setting must be taken into account when programming this value. This setting is typically programmed as “20% f_0 .”

CURRENT DIFF GND FUNCTION — This setting enables and disabled the 87LG neutral differential element, which can be used to detect high-resistive faults. This element uses restrained characteristics to cope with spurious zero-sequence current during system unbalance and signal distortions. The differential neutral current is calculated as the vector sum of all in-zone CT input neutral currents. The restraint current is derived as the maximum of phase currents from all terminals flowing through any individual CT, including breaker-and-a-half configurations. The 87LG neutral differential element is blocked when the phase current at any terminal is greater than 3 pu, since the phase differential element should operate for internal faults. To correctly derive the restraint quantity from the maximum through current at any terminal, it is important that the 87L phase-segregated differential pickup and slope settings be equal at all terminals. See the Application of Settings chapter for details.

CURRENT DIFF GND PICKUP — This setting specifies the pickup threshold for neutral current differential element.

CURRENT DIFF GND RESTRAINT — This setting specifies the bias characteristic for the neutral current differential element.

CURRENT DIFF GND DELAY — This setting specifies the operation delay for the neutral current differential element. Since this element is used to detect high-resistive faults where fault currents are relatively low, high-speed operation is usually not critical. This delay provides security against spurious neutral current during switch-off transients and external fault clearing.

CURRENT DIFF DTT — This setting enables and disables the sending of a direct transfer trip (DTT) by the current differential element on per single-phase basis to remote devices. To allow the L30 to restart from master-master to master-slave mode (very important on three-terminal applications), **CURR DIFF DTT** must be “Enabled.”

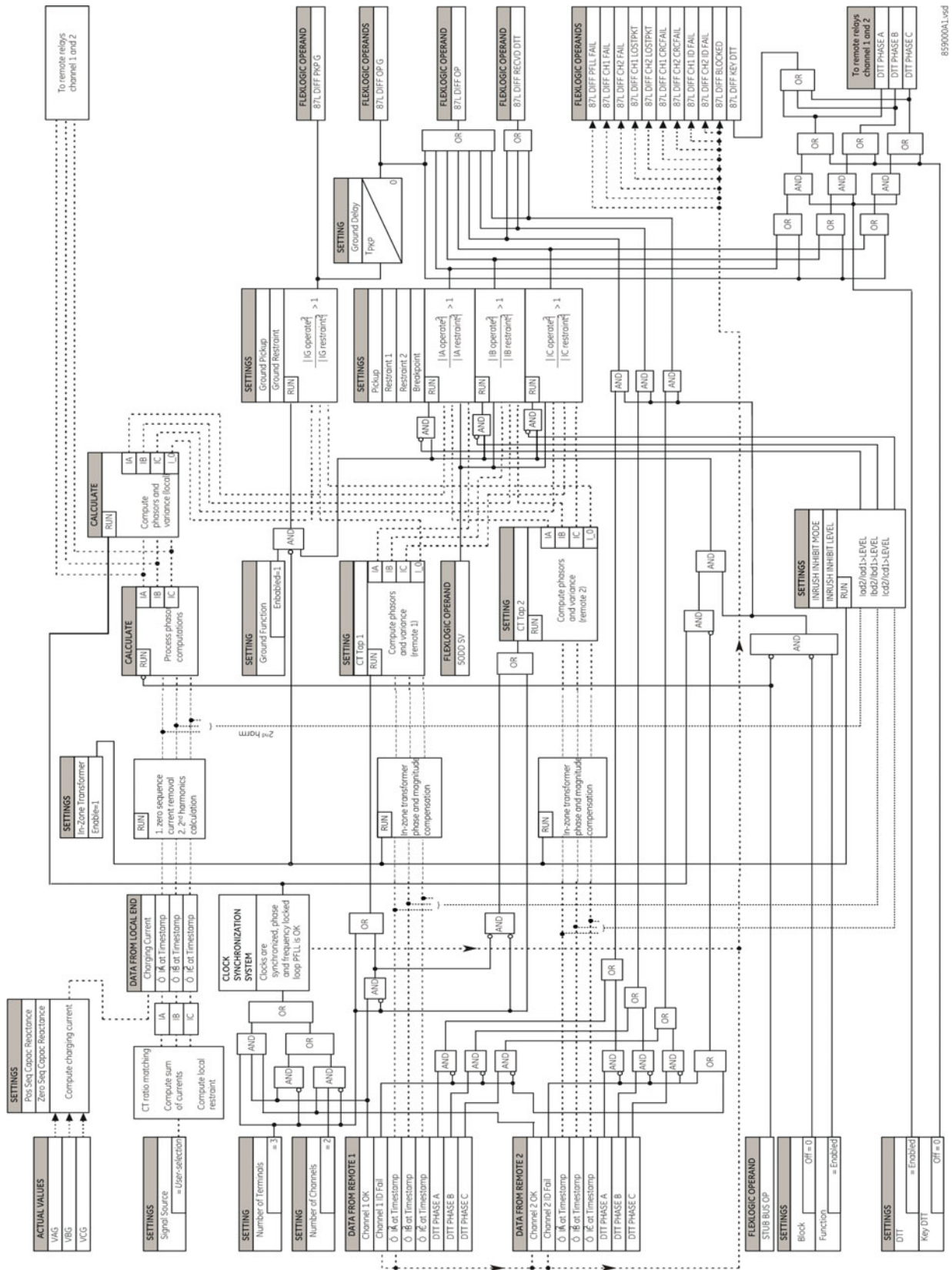
CURRENT DIFF KEY DTT — This setting selects an additional protection element (besides the current differential element; for example, distance element or breaker failure) that keys the DTT on a per three-phase basis.



NOTE

For the current differential element to function properly, it is imperative that all L30 devices on the protected line have identical firmware revisions. For example, revision 5.62 is only compatible with 5.62, not 5.61 or 5.63.

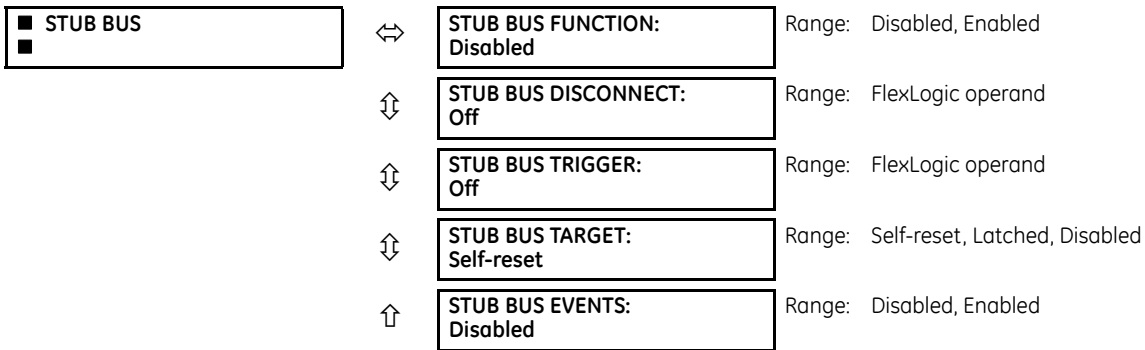
Figure 5-107: Current differential logic



859004L1.vsd

5.7.3.2 Stub bus

SETTINGS ⇨ ↓ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ LINE DIFFERENTIAL ELEMENT ⇨ ↓ STUB BUS



The stub bus element protects for faults between two breakers in a breaker-and-a-half or ring bus configuration when the line disconnect switch is open. At the same time, if the line is still energized through the remote terminal(s), differential protection is still required (the line can still need to be energized because there is a tapped load on a two-terminal line or because the line is a three-terminal line with two of the terminals still connected). Correct operation for this condition is achieved by the local relay sending zero current values to the remote end(s) so that a local bus fault does not result in tripping the line. At the local end, the differential element is disabled and stub bus protection is provided by a user-selected overcurrent element. If there is a line fault, the remote end(s) trips on differential but local differential function and the DTT signal (if enabled) to the local end are blocked by the stub bus logic, allowing the local breakers to remain closed.

STUB BUS FUNCTION — There are three requirements for stub bus operation: the element must be enabled, an indication that the line disconnect is open, and the **STUB BUS TRIGGER** setting is set. There are two methods to set the stub bus trigger and thus setting up stub bus operation, as follows:

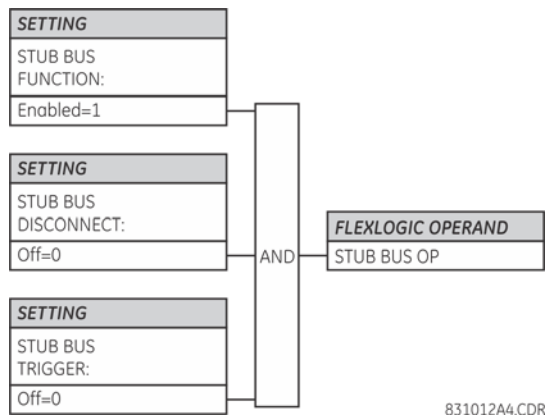
1. If **STUB BUS TRIGGER** is “On,” the **STUB BUS OPERATE** operand picks up as soon as the disconnect switch opens, causing zero currents to be transmitted to remote end(s) and DTT receipt from remote end(s) to be permanently blocked. An overcurrent element, blocked by disconnect switch closed, provides protection for the local bus.
2. An alternate method is to set **STUB BUS TRIGGER** to be the pickup of an assigned instantaneous overcurrent element. The instantaneous overcurrent element must operate quickly enough to pick up the **STUB BUS OPERATE** operand, disable the local differential, and send zero currents to the other terminal(s). If the bus minimum fault current is above five times the instantaneous overcurrent pickup, tests have confirmed that the **STUB BUS OPERATE** operand always picks up correctly for a stub bus fault and prevents tripping of the remote terminal. If minimum stub bus fault current is below this value, then use method 1. Note also that correct testing of stub bus operation, when this method is used, requires sudden injection of a fault currents above five times instantaneous overcurrent pickup. The assigned current element needs to be mapped to the appropriate output contact(s) to trip the stub bus breakers. It should be blocked unless disconnect is open. To prevent 87L tripping from remote L30 relays still protecting the line, assign the auxiliary contact of line disconnect switch (logic “1” when line switch is open) to block the local 87L function by using the **CURRENT DIFF BLOCK** setting.

STUB BUS DISCONNECT — Selects a FlexLogic operand to represent the open state of auxiliary contact of line disconnect switch (logic “1” when line disconnect switch is open). If necessary, simple logic representing not only the line disconnect switch but also the closed state of the breakers can be created with FlexLogic and assigned to this setting.

STUB BUS TRIGGER — Selects a FlexLogic operand that causes the **STUB BUS OPERATE** operand to pick up if the line disconnect is open. It can be set either to “On” or to an instantaneous overcurrent element (as outlined). If the instantaneous overcurrent used for the stub bus protection is set with a time delay, then **STUB BUS TRIGGER** should use the associated instantaneous overcurrent pickup operand. The source assigned for the current of this element must cover the stub between CTs of the associated breakers and disconnect switch.

5

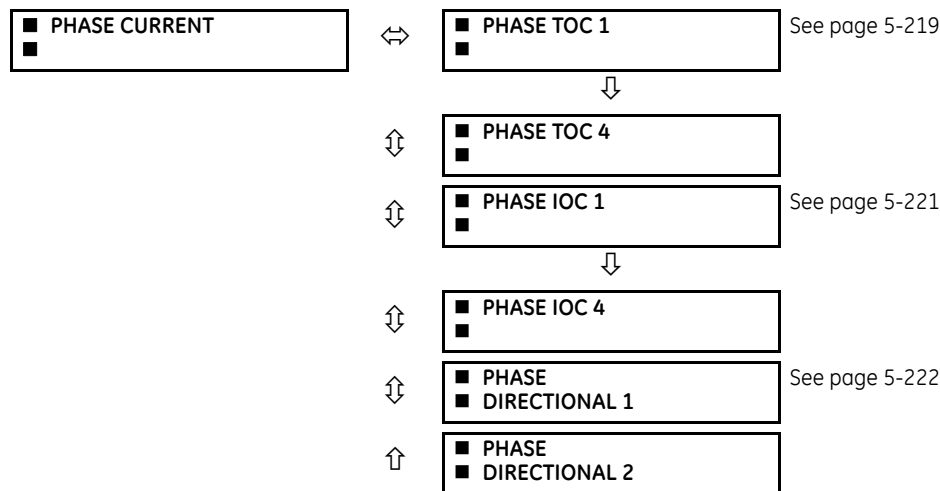
Figure 5-108: Stub bus logic



5.7.4 Phase current

5.7.4.1 Menu

SETTINGS ⇄ GROUPED ELEMENTS ⇄ SETTING GROUP 1(6) ⇄ PHASE CURRENT



5.7.4.2 Inverse TOC curve characteristics

The inverse time overcurrent curves used by the time overcurrent elements are the IEEE, IEC, GE Type IAC, and I^2t standard curve shapes. This allows for simplified coordination with downstream devices.

If none of these curve shapes is adequate, FlexCurves can be used to customize the inverse time curve characteristics. The definite time curve is also an option that can be appropriate if only simple protection is required.

Table 5-28: Overcurrent curve types

IEEE	IEC	GE type IAC	Other
IEEE Extremely Inverse	IEC Curve A (BS142)	IAC Extremely Inverse	I^2t
IEEE Very Inverse	IEC Curve B (BS142)	IAC Very Inverse	FlexCurves A, B, C, and D
IEEE Moderately Inverse	IEC Curve C (BS142)	IAC Inverse	Recloser Curves
	IEC Short Inverse	IAC Short Inverse	Definite Time

A time dial multiplier setting allows selection of a multiple of the base curve shape (where the time dial multiplier = 1) with the curve shape (**CURVE**) setting. Unlike the electromechanical time dial equivalent, operate times are directly proportional to the time multiplier (**TD MULTIPLIER**) setting value. For example, all times for a multiplier of 10 are 10 times the multiplier 1 or base curve values. Setting the multiplier to zero results in an instantaneous response to all current levels above pickup.

Time overcurrent time calculations are made with an internal *energy capacity* memory variable. When this variable indicates that the energy capacity has reached 100%, a time overcurrent element operates. If less than 100% energy capacity is accumulated in this variable and the current falls below the dropout threshold of 97 to 98% of the pickup value, the variable must be reduced. Two methods of this resetting operation are available: "Instantaneous" and "Timed." The "Instantaneous" selection is intended for applications with other relays, such as most static relays, which set the energy capacity directly to zero when the current falls below the reset threshold. The "Timed" selection can be used where the relay must coordinate with electromechanical relays.

IEEE curves

The IEEE time overcurrent curve shapes conform to industry standards and the IEEE C37.112-1996 curve classifications for extremely, very, and moderately inverse curves. The IEEE curves are derived from the operate and reset time equations.

$$T = TDM \times \left[\frac{A}{\left(\frac{I}{I_{pickup}}\right)^p - 1} + B \right], T_{RESET} = TDM \times \left[\frac{t_r}{1 - \left(\frac{I}{I_{pickup}}\right)^2} \right] \tag{Eq. 5-14}$$

where

T = operate time (in seconds)

TDM = Multiplier setting

I = input current

I_{pickup} = Pickup Current setting

A, B, p = constants defined in the table

T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

t_r = characteristic constant defined in the table

Table 5-29: IEEE inverse time curve constants

IEEE curve shape	A	B	p	t _r
IEEE Extremely Inverse	28.2	0.1217	2.0000	29.1
IEEE Very Inverse	19.61	0.491	2.0000	21.6
IEEE Moderately Inverse	0.0515	0.1140	0.02000	4.85

Table 5-30: IEEE curve trip times (in seconds)

Multiplier (TDM)	Current (I / I _{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEEE Extremely Inverse										
0.5	11.341	4.761	1.823	1.001	0.648	0.464	0.355	0.285	0.237	0.203
1.0	22.682	9.522	3.647	2.002	1.297	0.927	0.709	0.569	0.474	0.407
2.0	45.363	19.043	7.293	4.003	2.593	1.855	1.418	1.139	0.948	0.813
4.0	90.727	38.087	14.587	8.007	5.187	3.710	2.837	2.277	1.897	1.626
6.0	136.090	57.130	21.880	12.010	7.780	5.564	4.255	3.416	2.845	2.439
8.0	181.454	76.174	29.174	16.014	10.374	7.419	5.674	4.555	3.794	3.252
10.0	226.817	95.217	36.467	20.017	12.967	9.274	7.092	5.693	4.742	4.065
IEEE Very Inverse										
0.5	8.090	3.514	1.471	0.899	0.654	0.526	0.450	0.401	0.368	0.345
1.0	16.179	7.028	2.942	1.798	1.308	1.051	0.900	0.802	0.736	0.689
2.0	32.358	14.055	5.885	3.597	2.616	2.103	1.799	1.605	1.472	1.378

Multiplier (TDM)	Current (I / I _{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
4.0	64.716	28.111	11.769	7.193	5.232	4.205	3.598	3.209	2.945	2.756
6.0	97.074	42.166	17.654	10.790	7.849	6.308	5.397	4.814	4.417	4.134
8.0	129.432	56.221	23.538	14.387	10.465	8.410	7.196	6.418	5.889	5.513
10.0	161.790	70.277	29.423	17.983	13.081	10.513	8.995	8.023	7.361	6.891
IEEE Moderately Inverse										
0.5	3.220	1.902	1.216	0.973	0.844	0.763	0.706	0.663	0.630	0.603
1.0	6.439	3.803	2.432	1.946	1.688	1.526	1.412	1.327	1.260	1.207
2.0	12.878	7.606	4.864	3.892	3.377	3.051	2.823	2.653	2.521	2.414
4.0	25.756	15.213	9.729	7.783	6.753	6.102	5.647	5.307	5.041	4.827
6.0	38.634	22.819	14.593	11.675	10.130	9.153	8.470	7.960	7.562	7.241
8.0	51.512	30.426	19.458	15.567	13.507	12.204	11.294	10.614	10.083	9.654
10.0	64.390	38.032	24.322	19.458	16.883	15.255	14.117	13.267	12.604	12.068

IEC curves

For European applications, the relay offers three standard curves defined in IEC 255-4 and British standard BS142. These are defined as IEC Curve A, IEC Curve B, and IEC Curve C. The IEC curves are derived by the operate and reset time equations.

$$T = \text{TDM} \times \left[\frac{K}{(I/I_{\text{pickup}})^E - 1} \right], \quad T_{\text{RESET}} = \text{TDM} \times \left[\frac{t_r}{1 - (I/I_{\text{pickup}})^2} \right]$$

Eq. 5-15

where

T = operate time (in seconds)

TDM = Multiplier setting

I = input current

I_{pickup} = Pickup Current setting

K, E = constants defined in the table

t_r = characteristic constant defined in the table

T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Table 5-31: IEC (BS) inverse time curve constants

IEC (BS) curve shape	K	E	t _r
IEC Curve A (BS142)	0.140	0.020	9.7
IEC Curve B (BS142)	13.500	1.000	43.2
IEC Curve C (BS142)	80.000	2.000	58.2
IEC Short Inverse	0.050	0.040	0.500

Table 5-32: IEC curve trip times (in seconds)

Multiplier (TDM)	Current (I / I _{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEC Curve A										
0.05	0.860	0.501	0.315	0.249	0.214	0.192	0.176	0.165	0.156	0.149
0.10	1.719	1.003	0.630	0.498	0.428	0.384	0.353	0.330	0.312	0.297
0.20	3.439	2.006	1.260	0.996	0.856	0.767	0.706	0.659	0.623	0.594
0.40	6.878	4.012	2.521	1.992	1.712	1.535	1.411	1.319	1.247	1.188
0.60	10.317	6.017	3.781	2.988	2.568	2.302	2.117	1.978	1.870	1.782
0.80	13.755	8.023	5.042	3.984	3.424	3.070	2.822	2.637	2.493	2.376

Multiplier (TDM)	Current (I / I _{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
1.00	17.194	10.029	6.302	4.980	4.280	3.837	3.528	3.297	3.116	2.971
IEC Curve B										
0.05	1.350	0.675	0.338	0.225	0.169	0.135	0.113	0.096	0.084	0.075
0.10	2.700	1.350	0.675	0.450	0.338	0.270	0.225	0.193	0.169	0.150
0.20	5.400	2.700	1.350	0.900	0.675	0.540	0.450	0.386	0.338	0.300
0.40	10.800	5.400	2.700	1.800	1.350	1.080	0.900	0.771	0.675	0.600
0.60	16.200	8.100	4.050	2.700	2.025	1.620	1.350	1.157	1.013	0.900
0.80	21.600	10.800	5.400	3.600	2.700	2.160	1.800	1.543	1.350	1.200
1.00	27.000	13.500	6.750	4.500	3.375	2.700	2.250	1.929	1.688	1.500
IEC Curve C										
0.05	3.200	1.333	0.500	0.267	0.167	0.114	0.083	0.063	0.050	0.040
0.10	6.400	2.667	1.000	0.533	0.333	0.229	0.167	0.127	0.100	0.081
0.20	12.800	5.333	2.000	1.067	0.667	0.457	0.333	0.254	0.200	0.162
0.40	25.600	10.667	4.000	2.133	1.333	0.914	0.667	0.508	0.400	0.323
0.60	38.400	16.000	6.000	3.200	2.000	1.371	1.000	0.762	0.600	0.485
0.80	51.200	21.333	8.000	4.267	2.667	1.829	1.333	1.016	0.800	0.646
1.00	64.000	26.667	10.000	5.333	3.333	2.286	1.667	1.270	1.000	0.808
IEC Short Inverse										
0.05	0.153	0.089	0.056	0.044	0.038	0.034	0.031	0.029	0.027	0.026
0.10	0.306	0.178	0.111	0.088	0.075	0.067	0.062	0.058	0.054	0.052
0.20	0.612	0.356	0.223	0.175	0.150	0.135	0.124	0.115	0.109	0.104
0.40	1.223	0.711	0.445	0.351	0.301	0.269	0.247	0.231	0.218	0.207
0.60	1.835	1.067	0.668	0.526	0.451	0.404	0.371	0.346	0.327	0.311
0.80	2.446	1.423	0.890	0.702	0.602	0.538	0.494	0.461	0.435	0.415
1.00	3.058	1.778	1.113	0.877	0.752	0.673	0.618	0.576	0.544	0.518

IAC curves

The curves for the General Electric type IAC relay family are derived from the formulae:

$$T = TDM \times \left(A + \frac{B}{(I/I_{pkp}) - C} + \frac{D}{((I/I_{pkp}) - C)^2} + \frac{E}{((I/I_{pkp}) - C)^3} \right), \quad T_{RESET} = TDM \times \left[\frac{t_r}{1 - (I/I_{pkp})^2} \right] \quad \text{Eq. 5-16}$$

where

T = operate time (in seconds)

TDM = Multiplier setting

I = Input current

I_{pkp} = Pickup Current setting

A to E = constants defined in the table

t_r = characteristic constant defined in the table

T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Table 5-33: GE type IAC inverse time curve constants

IAC curve shape	A	B	C	D	E	t _r
IAC Extreme Inverse	0.0040	0.6379	0.6200	1.7872	0.2461	6.008
IAC Very Inverse	0.0900	0.7955	0.1000	-1.2885	7.9586	4.678
IAC Inverse	0.2078	0.8630	0.8000	-0.4180	0.1947	0.990

IAC curve shape	A	B	C	D	E	t_r
IAC Short Inverse	0.0428	0.0609	0.6200	-0.0010	0.0221	0.222

Table 5-34: GE type IAC curve trip times

Multiplier (TDM)	Current (I / I _{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IAC Extremely Inverse										
0.5	1.699	0.749	0.303	0.178	0.123	0.093	0.074	0.062	0.053	0.046
1.0	3.398	1.498	0.606	0.356	0.246	0.186	0.149	0.124	0.106	0.093
2.0	6.796	2.997	1.212	0.711	0.491	0.372	0.298	0.248	0.212	0.185
4.0	13.591	5.993	2.423	1.422	0.983	0.744	0.595	0.495	0.424	0.370
6.0	20.387	8.990	3.635	2.133	1.474	1.115	0.893	0.743	0.636	0.556
8.0	27.183	11.987	4.846	2.844	1.966	1.487	1.191	0.991	0.848	0.741
10.0	33.979	14.983	6.058	3.555	2.457	1.859	1.488	1.239	1.060	0.926
IAC Very Inverse										
0.5	1.451	0.656	0.269	0.172	0.133	0.113	0.101	0.093	0.087	0.083
1.0	2.901	1.312	0.537	0.343	0.266	0.227	0.202	0.186	0.174	0.165
2.0	5.802	2.624	1.075	0.687	0.533	0.453	0.405	0.372	0.349	0.331
4.0	11.605	5.248	2.150	1.374	1.065	0.906	0.810	0.745	0.698	0.662
6.0	17.407	7.872	3.225	2.061	1.598	1.359	1.215	1.117	1.046	0.992
8.0	23.209	10.497	4.299	2.747	2.131	1.813	1.620	1.490	1.395	1.323
10.0	29.012	13.121	5.374	3.434	2.663	2.266	2.025	1.862	1.744	1.654
IAC Inverse										
0.5	0.578	0.375	0.266	0.221	0.196	0.180	0.168	0.160	0.154	0.148
1.0	1.155	0.749	0.532	0.443	0.392	0.360	0.337	0.320	0.307	0.297
2.0	2.310	1.499	1.064	0.885	0.784	0.719	0.674	0.640	0.614	0.594
4.0	4.621	2.997	2.128	1.770	1.569	1.439	1.348	1.280	1.229	1.188
6.0	6.931	4.496	3.192	2.656	2.353	2.158	2.022	1.921	1.843	1.781
8.0	9.242	5.995	4.256	3.541	3.138	2.878	2.695	2.561	2.457	2.375
10.0	11.552	7.494	5.320	4.426	3.922	3.597	3.369	3.201	3.072	2.969
IAC Short Inverse										
0.5	0.072	0.047	0.035	0.031	0.028	0.027	0.026	0.026	0.025	0.025
1.0	0.143	0.095	0.070	0.061	0.057	0.054	0.052	0.051	0.050	0.049
2.0	0.286	0.190	0.140	0.123	0.114	0.108	0.105	0.102	0.100	0.099
4.0	0.573	0.379	0.279	0.245	0.228	0.217	0.210	0.204	0.200	0.197
6.0	0.859	0.569	0.419	0.368	0.341	0.325	0.314	0.307	0.301	0.296
8.0	1.145	0.759	0.559	0.490	0.455	0.434	0.419	0.409	0.401	0.394
10.0	1.431	0.948	0.699	0.613	0.569	0.542	0.524	0.511	0.501	0.493

I^2t curves

The I^2t curves are derived as follows:

$$T = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{\text{pickup}}}\right)^2} \right], \quad T_{\text{RESET}} = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{\text{pickup}}}\right)^{-2}} \right] \quad \text{Eq. 5-17}$$

where

T = Operate time (in seconds)
 TDM = Multiplier setting
 I = Input current
 I_{pickup} = Pickup Current setting
 T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Table 5-35: I^2t curve trip times

Multiplier (TDM)	Current (I / I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0.01	0.44	0.25	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01
0.10	4.44	2.50	1.11	0.63	0.40	0.28	0.20	0.16	0.12	0.10
1.00	44.44	25.00	11.11	6.25	4.00	2.78	2.04	1.56	1.23	1.00
10.00	444.44	250.00	111.11	62.50	40.00	27.78	20.41	15.63	12.35	10.00
100.00	4444.4	2500.0	1111.1	625.00	400.00	277.78	204.08	156.25	123.46	100.00
600.00	26666.7	15000.0	6666.7	3750.0	2400.0	1666.7	1224.5	937.50	740.74	600.00

FlexCurves

FlexCurves are described in the FlexCurves section later in this chapter. The curve shapes for the FlexCurves are derived from the formulae:

$$T = TDM \times \left[\text{FlexCurve Time at } \left(\frac{I}{I_{pickup}} \right) \right] \text{ when } \left(\frac{I}{I_{pickup}} \right) \geq 1.00 \tag{Eq. 5-18}$$

$$T_{RESET} = TDM \times \left[\text{FlexCurve Time at } \left(\frac{I}{I_{pickup}} \right) \right] \text{ when } \left(\frac{I}{I_{pickup}} \right) \leq 0.98 \tag{Eq. 5-19}$$

where

T = operate time (in seconds)
 TDM = Multiplier setting
 I = Input Current
 I_{pickup} = Pickup Current setting
 T_{RESET} = Reset Time in seconds (assuming energy capacity is 100% and RESET: Timed)

Definite time curve

The Definite Time curve shape operates as soon as the pickup level is exceeded for a specified period of time. The base definite time curve delay is in seconds. The curve multiplier of 0.00 to 600.00 makes this delay adjustable from instantaneous to 600.00 seconds in steps of 10 ms. The definite time curve shapes are defined as follows:

$$T = TDM \text{ in seconds, when } I > I_{pickup} \tag{Eq. 5-20}$$

$$T_{RESET} = TDM \text{ in seconds} \tag{Eq. 5-21}$$

where

T = Operate Time (in seconds)
 TDM = Multiplier setting
 I = Input Current
 I_{pickup} = Pickup Current setting
 T_{RESET} = Reset Time in seconds (assuming energy capacity is 100% and RESET: Timed)

Recloser curves

The L30 uses the FlexCurve feature to facilitate programming of 41 recloser curves. See the FlexCurves settings section earlier in this chapter for details.

5.7.4.3 Phase time overcurrent (ANSI 51P, IEC PTOC)

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ PHASE CURRENT ⇒ PHASE TOC1(4)

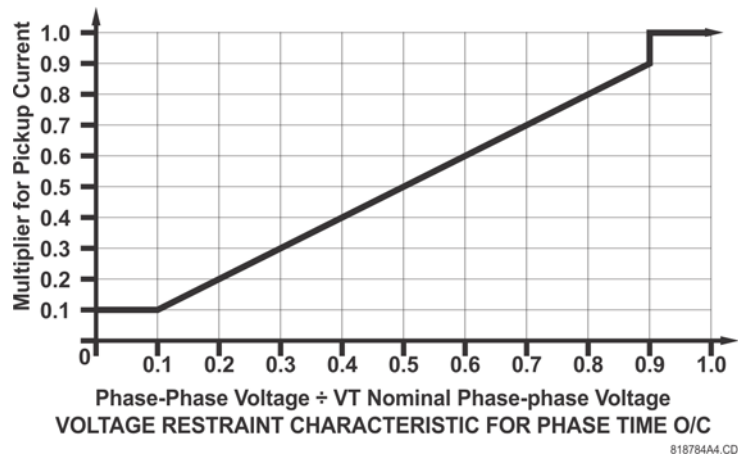
■ PHASE TOC 1	↔	PHASE TOC1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	PHASE TOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	⇅	PHASE TOC1 INPUT: Phasor	Range: Phasor, RMS
	⇅	PHASE TOC1 PICKUP: 1.000 pu	Range: 0.020 to 30.000 pu in steps of 0.001
	⇅	PHASE TOC1 CURVE: IEEE Mod Inv	Range: see Overcurrent Curve Types table
	⇅	PHASE TOC1 TD MULTIPLIER: 1.00	Range: 0.00 to 600.00 in steps of 0.01
	⇅	PHASE TOC1 RESET: Instantaneous	Range: Instantaneous, Timed
	⇅	PHASE TOC1 VOLTAGE RESTRAINT: Disabled	Range: Disabled, Enabled
	⇅	PHASE TOC1 BLOCK A: Off	Range: FlexLogic operand
	⇅	PHASE TOC1 BLOCK B: Off	Range: FlexLogic operand
	⇅	PHASE TOC1 BLOCK C: Off	Range: FlexLogic operand
	⇅	PHASE TOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	PHASE TOC1 EVENTS: Disabled	Range: Disabled, Enabled

The phase time overcurrent element can provide a specified time-delay operating characteristic versus the applied current or be used as a simple definite time element. The phase current input quantities can be programmed as fundamental phasor magnitude or total waveform RMS magnitude as required by the application.

Two methods of resetting operation are available: “Timed” and “Instantaneous” (see the Inverse TOC Curve Characteristics section earlier for details on curve setup, trip times, and reset operation). When the element is blocked, the time accumulator resets according to the reset characteristic. For example, if the element reset characteristic is set to “Instantaneous” and the element is blocked, the time accumulator clears immediately.

The **PHASE TOC1 PICKUP** setting can be reduced dynamically by a voltage restraint feature (when enabled). This is accomplished via the multipliers (Mvr) corresponding to the phase-phase voltages of the voltage restraint characteristic curve (see the figure); the pickup level is calculated as Mvr times the **PHASE TOC1 PICKUP** setting. If the voltage restraint feature is disabled, the pickup level always remains at the setting value.

Figure 5-109: Phase time overcurrent voltage restraint characteristic



FUNCTION — This setting enables and disables the phase time overcurrent protection element.

SIGNAL SOURCE — Selects the signal source for the phase time overcurrent protection element.

INPUT — Selects how phase current input quantities are interpreted by the L30. Inputs can be selected as fundamental phasor magnitudes or total waveform RMS magnitudes as required by the application.

PICKUP — Specifies the phase time overcurrent pickup level in per-unit values.

CURVE — Selects the time inverse overcurrent curve style.

TD MULTIPLIER — Specifies a multiple of the base curve shape specified by the **CURVE** setting. Programming this value to zero results in an instantaneous response to all current levels above pickup.

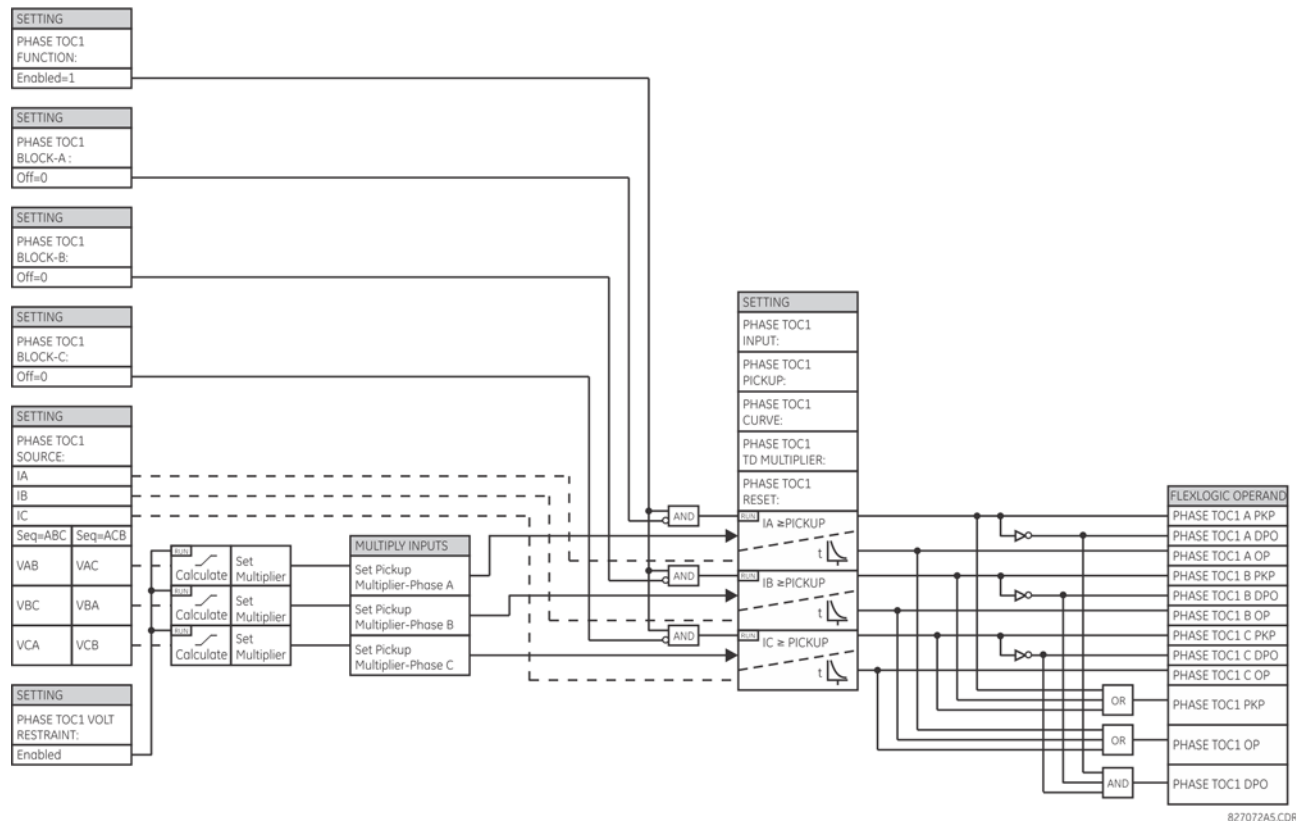
RESET — The “Instantaneous” reset method is intended for applications with other relays, such as most static relays, which set the energy capacity directly to zero when the current falls below the reset threshold. The “Timed” reset method can be used where the relay must coordinate with electromechanical relays.

VOLTAGE RESTRAINT — Enables and disables the phase time overcurrent voltage restraint feature.

BLOCK A — Assertion of the operand assigned to this setting blocks phase A of the phase time overcurrent element.

EVENTS — Enables and disables the logging of phase time overcurrent events in the sequence of events recorder.

Figure 5-110: Phase time overcurrent 1 logic



5.7.4.4 Phase instantaneous overcurrent (ANSI 50P, IEC PIOC)

SETTINGS ⇌ GROUPED ELEMENTS ⇌ SETTING GROUP 1(6) ⇌ PHASE CURRENT ⇌ PHASE IOC 1(4)

■ PHASE IOC 1	⇌	PHASE IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
■	⇌	PHASE IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	⇌	PHASE IOC1 PICKUP: 1.000 pu	Range: 0.005 to 30.000 pu in steps of 0.001
	⇌	PHASE IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇌	PHASE IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇌	PHASE IOC1 BLOCK A: Off	Range: FlexLogic operand
	⇌	PHASE IOC1 BLOCK C: Off	Range: FlexLogic operand
	⇌	PHASE IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	⇌	PHASE IOC1 EVENTS: Disabled	Range: Disabled, Enabled

The phase instantaneous overcurrent element can be used as an instantaneous element with no intentional delay or as a definite time element. The input current is the fundamental phasor magnitude. For timing curves, see the publication Instantaneous Overcurrent (IOC) Element Response to Saturated Waveforms in UR Series Relays ([GET-8400A](#)).

FUNCTION — This setting enables and disables the phase instantaneous overcurrent protection element.

SOURCE — Selects the signal source for the phase instantaneous overcurrent protection element.

PICKUP — Specifies the phase instantaneous overcurrent pickup level in per-unit values.

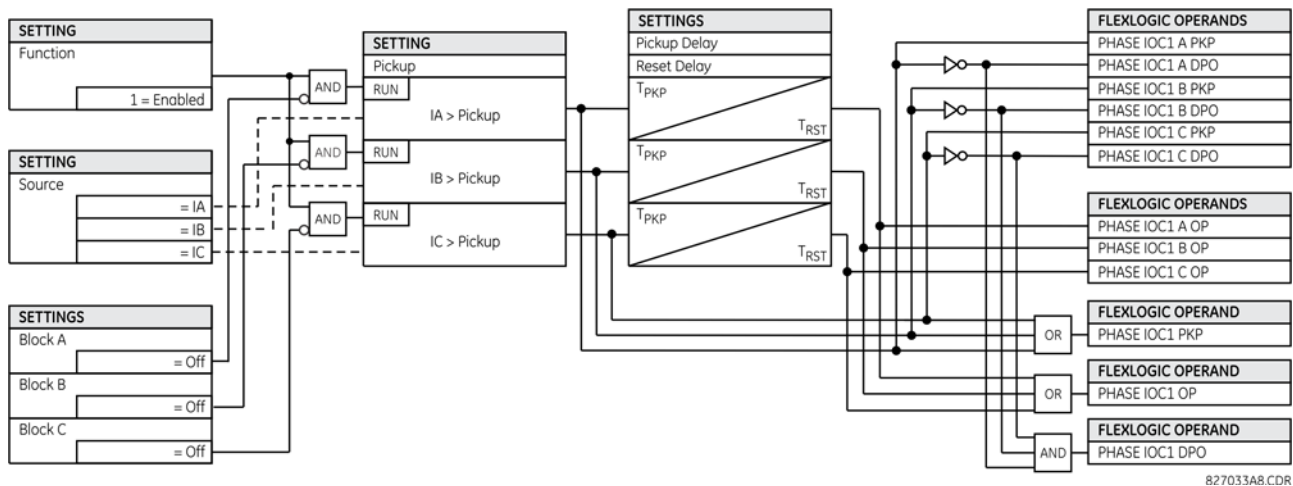
DELAY — Delays the assertion of the **PHASE IOC OP** operands. It is used to achieve timing coordination with other elements and relays.

RESET DELAY — Specifies a delay for the reset of the phase instantaneous overcurrent element between the operate output state and the return to logic 0 after the input passes outside the defined pickup range. This setting is used to ensure that the relay output contacts are closed long enough to ensure reception by downstream equipment.

BLOCK A — Assertion of the operand assigned to this setting block's phase A of the phase instantaneous overcurrent element.

EVENTS — Enables and disables the logging of phase instantaneous overcurrent events in the sequence of events recorder.

Figure 5-111: Phase instantaneous overcurrent 1 logic



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5.7.4.5 Phase directional overcurrent (ANSI 67P, IEC PDOC/PTOC)

SETTINGS ⇄ GROUPED ELEMENTS ⇄ SETTING GROUP 1(6) ⇄ PHASE CURRENT ⇄ PHASE DIRECTIONAL 1(2)

<ul style="list-style-type: none"> ■ PHASE ■ DIRECTIONAL 1 	⇄	PHASE DIR 1 FUNCTION: Disabled Range: Disabled, Enabled
	⇄	PHASE DIR 1 SIGNAL SOURCE: SRC 1 Range: SRC 1, SRC 2
	⇄	PHASE DIR 1 BLOCK: Off Range: FlexLogic operand
	⇄	PHASE DIR 1 ECA: 30° Range: 0 to 359° in steps of 1
	⇄	PHASE DIR POL V1 THRESHOLD: 0.700 pu Range: 0.004 to 3.000 pu in steps of 0.001
	⇄	PHASE DIR 1 BLOCK WHEN V MEM EXP: No Range: No, Yes
	⇄	PHASE DIR 1 TARGET: Self-reset Range: Self-reset, Latched, Disabled

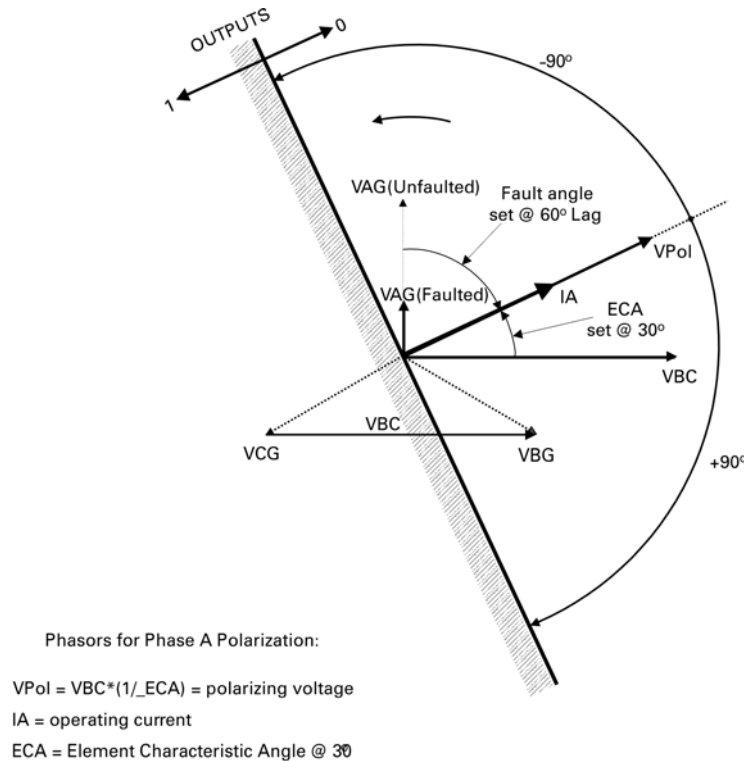
↑ **PHASE DIR 1** Range: Disabled, Enabled
EVENTS: Disabled



The TARGET setting is not user-selectable and forced to "Disabled". If Targets are required from directional elements, it can be achieved by assigning directional element output to a digital element, where targets selection can be used as required.

The phase directional elements (one for each of phases A, B, and C) determine the phase current flow direction for steady state and fault conditions and can be used to control the operation of the phase overcurrent elements via the **BLOCK** inputs of these elements.

Figure 5-112: Phase A directional polarization



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This element is intended to apply a block signal to an overcurrent element to prevent an operation when current is flowing in a particular direction. The direction of current flow is determined by measuring the phase angle between the current from the phase CTs and the line-line voltage from the VTs, based on the 90° or quadrature connection. If there is a requirement to supervise overcurrent elements for flows in opposite directions, such as can happen through a bus-tie breaker, two phase directional elements should be programmed with opposite element characteristic angle (ECA) settings.

To increase security for three phase faults very close to the VTs used to measure the polarizing voltage, a voltage memory feature is incorporated. This feature stores the polarizing voltage the moment before the voltage collapses, and uses it to determine direction. The voltage memory remains valid for one second after the voltage has collapsed.

The main component of the phase directional element is the phase angle comparator with two inputs: the operating signal (phase current) and the polarizing signal (the line voltage, shifted in the leading direction by the characteristic angle, ECA).

The table shows the operating and polarizing signals used for phase directional control.

Table 5-36: Operating and polarizing signals

Phase	Operating signal	Polarizing signal V_{pol}	
		ABC phase sequence	ACB phase sequence
A	angle of IA	angle of VBC $\times (1\angle ECA)$	angle of VCB $\times (1\angle ECA)$
B	angle of IB	angle of VCA $\times (1\angle ECA)$	angle of VAC $\times (1\angle ECA)$
C	angle of IC	angle of VAB $\times (1\angle ECA)$	angle of VBA $\times (1\angle ECA)$

Mode of operation

- When the function is “Disabled” or the operating current is below $5\% \times CT$ nominal, the element output is logic “0”
- When the function is “Enabled,” the operating current is above $5\% \times CT$ nominal, and the polarizing voltage is above the **PRODUCT SETUP** \Rightarrow **DISPLAY PROPERTIES** \Rightarrow **VOLTAGE CUT-OFF LEVEL** value, the element output is dependent on the phase angle between the operating and polarizing signals:
 - The element output is logic “0” when the operating current is within polarizing voltage $\pm 90^\circ$
 - For all other angles, the element output is logic “1”
- Once the voltage memory has expired, the phase overcurrent elements under directional control can be set to block or trip on overcurrent as follows:
 - When **BLOCK WHEN V MEM EXP** is set to “Yes,” the directional element blocks the operation of any phase overcurrent element under directional control when voltage memory expires
 - When **BLOCK WHEN V MEM EXP** is set to “No,” the directional element allows tripping of phase overcurrent elements under directional control when voltage memory expires

In all cases, directional blocking is permitted to resume when the polarizing voltage becomes greater than the polarizing voltage threshold.

Settings

PHASE DIR 1 FUNCTION — This setting enables and disables the phase directional overcurrent protection element.

PHASE DIR 1 SIGNAL SOURCE — This setting is used to select the source for the operating and polarizing signals. The operating current for the phase directional element is the phase current for the selected current source. The polarizing voltage is the line voltage from the phase VTs, based on the 90° or quadrature connection and shifted in the leading direction by the element characteristic angle (ECA).

PHASE DIR 1 BLOCK — Assertion of the operand assigned to this setting blocks operation of the phase directional overcurrent element.

PHASE DIR 1 ECA — This setting specifies the element characteristic angle, that is, the angle by which the polarizing voltage is shifted in the leading direction to achieve dependable operation. In the design of the UR-series elements, a block is applied to an element by asserting logic 1 at the blocking input. Program the phase directional overcurrent element using this setting so that the output is logic 1 for current in the non-tripping direction.

PHASE DIR 1 POL V THRESHOLD — This setting is used to establish the minimum level of voltage for which the phase angle measurement is reliable. The setting is based on VT accuracy.

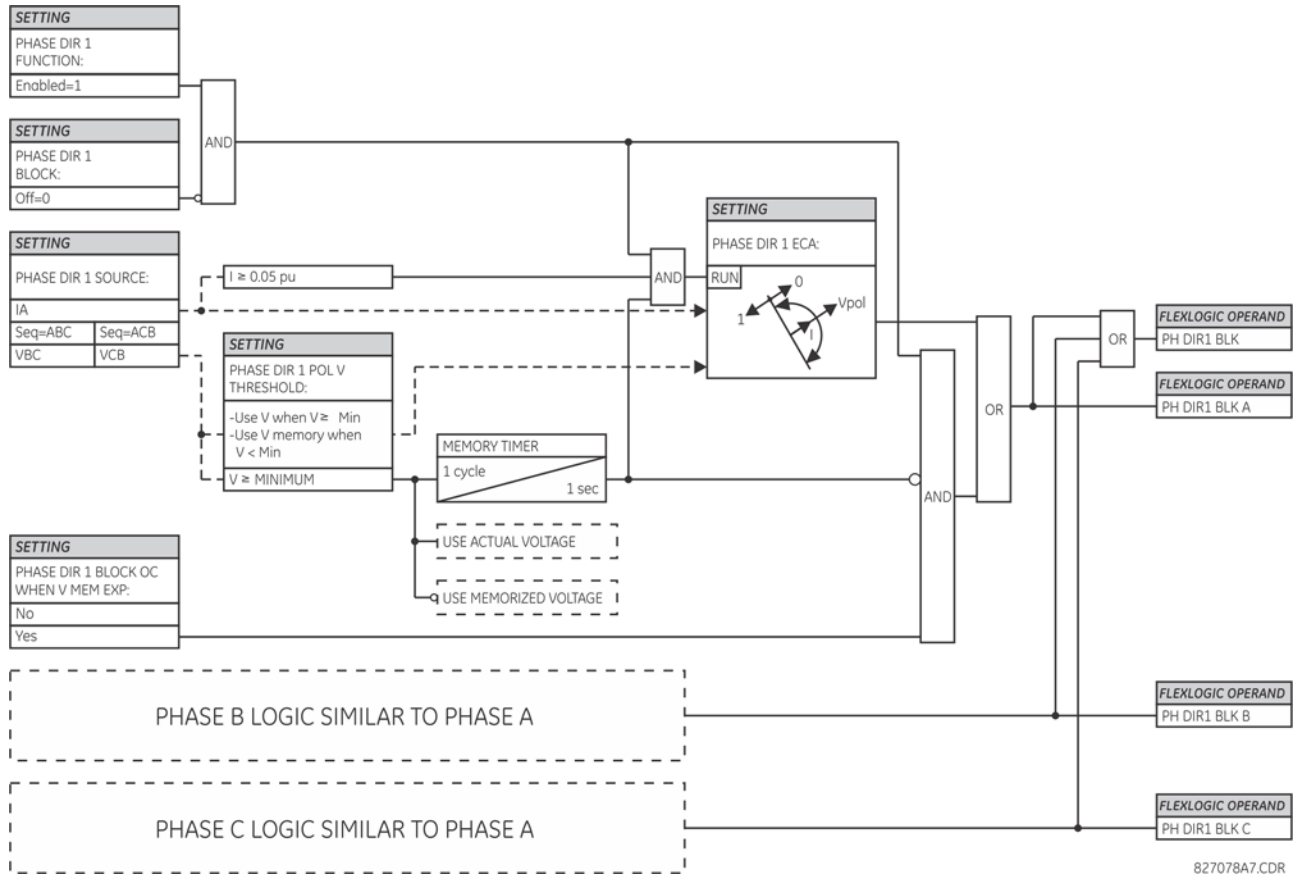
PHASE DIR 1 BLOCK WHEN V MEM EXP — This setting is used to select the required operation upon expiration of voltage memory. When set to “Yes,” the directional element blocks the operation of any phase overcurrent element under directional control, when voltage memory expires. When set to “No,” the directional element allows tripping of phase overcurrent elements under directional control.

PHASE DIR 1 EVENTS — This setting enables and disables the logging of phase directional overcurrent events in the sequence of events recorder.



The phase directional element responds to the forward load current. In the case of a following reverse fault, the element needs some time—in the order of 8 ms—to establish a blocking signal. Some protection elements, such as instantaneous overcurrent, respond to reverse faults before the blocking signal is established. Therefore, a coordination time of at least 10 ms must be added to all the instantaneous protection elements under the supervision of the phase directional element. If current reversal is of concern, a longer delay—in the order of 20 ms—is needed.

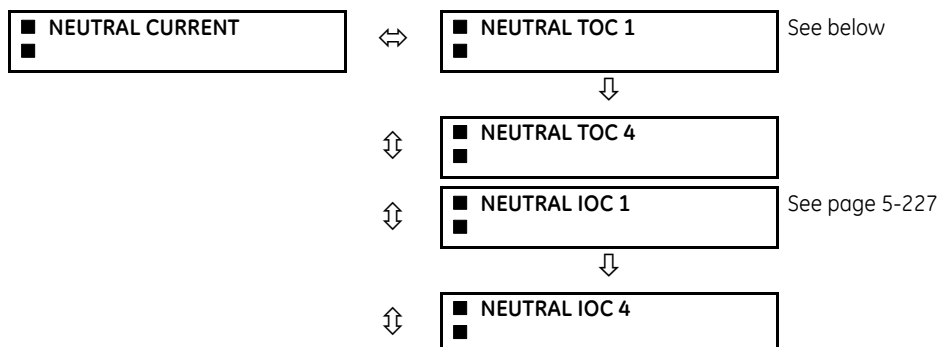
Figure 5-113: Phase directional logic



5.7.5 Neutral current

5.7.5.1 Menu

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ NEUTRAL CURRENT



⇅	<div style="border: 1px solid black; padding: 2px;"> ■ NEUTRAL ■ DIRECTIONAL OC1 </div>	See page 5-228
⇅	<div style="border: 1px solid black; padding: 2px;"> ■ NEUTRAL ■ DIRECTIONAL OC2 </div>	

5.7.5.2 Neutral time overcurrent (ANSI 51N, IEC PTOC)

SETTINGS ⇅ GROUPED ELEMENTS ⇅ SETTING GROUP 1(6) ⇅ NEUTRAL CURRENT ⇅ NEUTRAL TOC1(4)

⇅	<div style="border: 1px solid black; padding: 2px;"> ■ NEUTRAL TOC1 ■ </div>	<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 FUNCTION: Disabled </div>	Range: Disabled, Enabled
⇅		<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 SIGNAL SOURCE: SRC 1 </div>	Range: SRC 1, SRC 2
⇅		<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 INPUT: Phasor </div>	Range: Phasor, RMS
⇅		<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 PICKUP: 1.000 pu </div>	Range: 0.020 to 30.000 pu in steps of 0.001
⇅		<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 CURVE: IEEE Mod Inv </div>	Range: see Overcurrent Curve Types table
⇅		<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 TD MULTIPLIER: 1.00 </div>	Range: 0.00 to 600.00 in steps of 0.01
⇅		<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 RESET: Instantaneous </div>	Range: Instantaneous, Timed
⇅		<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 BLOCK: Off </div>	Range: FlexLogic operand
⇅		<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 TARGET: Self-reset </div>	Range: Self-reset, Latched, Disabled
⇅		<div style="border: 1px solid black; padding: 2px;"> NEUTRAL TOC1 EVENTS: Disabled </div>	Range: Disabled, Enabled

The neutral time overcurrent element can provide a desired time-delay operating characteristic versus the applied current or be used as a simple definite time element. The neutral current input value is a quantity calculated as $3I_0$ from the phase currents and can be programmed as fundamental phasor magnitude or total waveform RMS magnitude as required by the application.

Two methods of resetting operation are available: “Timed” and “Instantaneous” (see the Inverse TOC Curve Characteristics section for details on curve setup, trip times, and reset operation). When the element is blocked, the time accumulator resets according to the reset characteristic. For example, if the element reset characteristic is set to “Instantaneous” and the element is blocked, the time accumulator clears immediately.

NEUTRAL TOC1 FUNCTION — This setting enables and disables the neutral time overcurrent protection element.

NEUTRAL TOC1 SIGNAL SOURCE — This setting selects the signal source for the neutral time overcurrent protection element.

NEUTRAL TOC1 INPUT — This setting selects how neutral current input quantities are interpreted by the L30. Inputs can be selected as fundamental phasor magnitudes or total waveform RMS magnitudes as required by the application.

NEUTRAL TOC1 PICKUP — This setting specifies the neutral time overcurrent pickup level in per-unit values.

NEUTRAL TOC1 CURVE — This setting selects the inverse time overcurrent curve style.

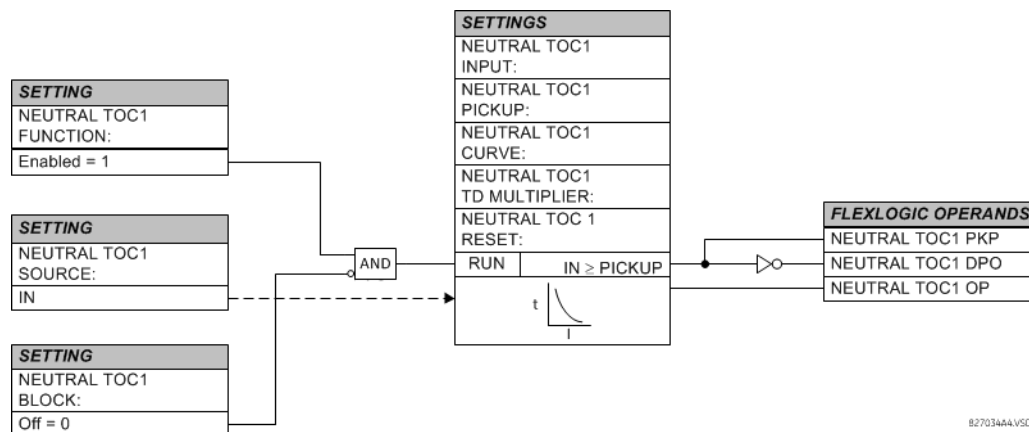
NEUTRAL TOC1 TD MULTIPLIER — This setting specifies a multiple of the base curve shape specified by the **CURVE** setting. Programming this value to zero results in an instantaneous response to all current levels above pickup.

NEUTRAL TOC1 RESET — The “Instantaneous” reset method is intended for applications with other relays, such as most static relays, which set the energy capacity directly to zero when the current falls below the reset threshold. The “Timed” reset method can be used where the relay must coordinate with electromechanical relays.

NEUTRAL TOC1 BLOCK — Assertion of the operand assigned to this setting blocks operation of the neutral time overcurrent element.

NEUTRAL TOC1 EVENTS — This setting enables and disables the logging of neutral time overcurrent events in the sequence of events recorder.

Figure 5-114: Neutral time overcurrent 1 logic



5.7.5.3 Neutral instantaneous overcurrent (ANSI 50N, IEC PIOC)

SETTINGS ⇄ GROUPED ELEMENTS ⇄ SETTING GROUP 1(6) ⇄ NEUTRAL CURRENT ⇄ NEUTRAL IOC1(4)

■ NEUTRAL IOC1	↔	NEUTRAL IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	NEUTRAL IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	↕	NEUTRAL IOC1 PICKUP: 1.000 pu	Range: 0.020 to 30.000 pu in steps of 0.001
	↕	NEUTRAL IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	↕	NEUTRAL IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	↕	NEUTRAL IOC1 BLOCK: Off	Range: FlexLogic operand
	↕	NEUTRAL IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	NEUTRAL IOC1 EVENTS: Disabled	Range: Disabled, Enabled

The neutral instantaneous overcurrent element can be used as an instantaneous function with no intentional delay or as a definite time function. The element essentially responds to the magnitude of a neutral current fundamental frequency phasor calculated from the phase currents. A positive-sequence restraint is applied for better performance. A small portion (6.25%) of the positive-sequence current magnitude is subtracted from the zero-sequence current magnitude when forming the operating quantity of the element as follows:

$$I_{op} = 3 \times (|I_0| - K \times |I_1|) \text{ where } K = 1/16 \tag{Eq. 5-22}$$

The positive-sequence restraint allows for more sensitive settings by counterbalancing spurious zero-sequence currents resulting from:

- System unbalances under heavy load conditions
- Transformation errors of current transformers (CTs) during double-line and three-phase faults
- Switch-off transients during double-line and three-phase faults

The positive-sequence restraint must be considered when testing for pickup accuracy and response time (multiple of pickup). The operating quantity depends on how test currents are injected into the relay (single-phase injection):

$$I_{op} = \frac{1}{3} \times (3 - K) \times I_{injected} \tag{Eq. 5-23}$$

NEUTRAL IOC1 FUNCTION — This setting enables and disables the neutral instantaneous overcurrent protection element.

NEUTRAL IOC1 SIGNAL SOURCE — This setting selects the signal source for the neutral instantaneous overcurrent protection element.

NEUTRAL IOC1 PICKUP — This setting specifies the neutral instantaneous overcurrent pickup level in per-unit values.

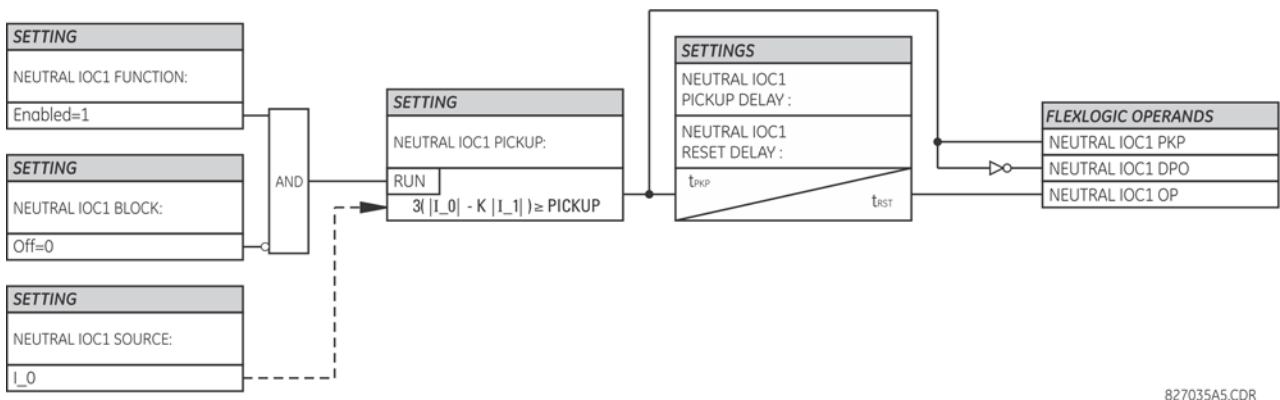
NEUTRAL IOC1 PICKUP DELAY — This setting delays the assertion of the **NEUTRAL IOC OP** operands. It is used to achieve timing coordination with other elements and relays.

NEUTRAL IOC1 RESET DELAY — This setting specifies a delay for the reset of the neutral instantaneous overcurrent element between the operate output state and the return to logic 0 after the input passes outside the defined pickup range. This setting is used to ensure that the relay output contacts are closed long enough to ensure reception by downstream equipment.

NEUTRAL IOC1 BLOCK — Assertion of the operand assigned to this setting blocks operation of the neutral instantaneous overcurrent element.

NEUTRAL IOC1 EVENTS — This setting enables and disables the logging of neutral instantaneous overcurrent events in the sequence of events recorder.

Figure 5-115: Neutral IOC1 logic



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5.7.5.4 Neutral directional overcurrent (ANSI 67N, IEC PDEF/PTOC)

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ NEUTRAL CURRENT ⇒ NEUTRAL DIRECTIONAL OC1(2)

<ul style="list-style-type: none"> ■ NEUTRAL ■ DIRECTIONAL OC1 	↔	<div style="border: 1px solid black; padding: 2px;">NEUTRAL DIR OC1 FUNCTION: Disabled</div>	Range: Disabled, Enabled
	⇕	<div style="border: 1px solid black; padding: 2px;">NEUTRAL DIR OC1 SOURCE: SRC 1</div>	Range: SRC 1, SRC 2
	⇕	<div style="border: 1px solid black; padding: 2px;">NEUTRAL DIR OC1 POLARIZING: Voltage</div>	Range: Voltage, Current, Dual, Dual-V, Dual-I
	⇕	<div style="border: 1px solid black; padding: 2px;">NEUTRAL DIR OC1 POL VOLT: Calculated V0</div>	Range: Calculated V0, Measured VX
	⇕	<div style="border: 1px solid black; padding: 2px;">NEUTRAL DIR OC1 OP CURR: Calculated 3I0</div>	Range: Calculated 3I0, Measured IG
	⇕	<div style="border: 1px solid black; padding: 2px;">NEUTRAL DIR OC1 POS-SEQ RESTRAINT: 0.063</div>	Range: 0.000 to 0.500 in steps of 0.001

↕	NEUTRAL DIR OC1 OFFSET: 0.00 Ω	Range: 0.00 to 250.00 Ω in steps of 0.01
↕	NEUTRAL DIR OC1 FWD ECA: 75° Lag	Range: -90 to 90° in steps of 1
↕	NEUTRAL DIR OC1 FWD LIMIT ANGLE: 90°	Range: 40 to 90° in steps of 1
↕	NEUTRAL DIR OC1 FWD PICKUP: 0.050 pu	Range: 0.006 to 30.000 pu in steps of 0.001
↕	NEUTRAL DIR OC1 REV LIMIT ANGLE: 90°	Range: 40 to 90° in steps of 1
↕	NEUTRAL DIR OC1 REV PICKUP: 0.050 pu	Range: 0.006 to 30.000 pu in steps of 0.001
↕	NEUTRAL DIR OC1 BLK: Off	Range: FlexLogic operand
↕	NEUTRAL DIR OC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↑	NEUTRAL DIR OC1 EVENTS: Disabled	Range: Disabled, Enabled

The neutral directional overcurrent element provides both forward and reverse fault direction indications for the **NEUTRAL DIR OC1 FWD** and **NEUTRAL DIR OC1 REV** operands, respectively. The output operand is asserted if the magnitude of the operating current is above a pickup level (overcurrent unit) and the fault direction is seen as forward or reverse, respectively (directional unit).

The **overcurrent unit** responds to the magnitude of a fundamental frequency phasor of either the neutral current calculated from the phase currents or the ground current. There are separate pickup settings for the forward-looking and reverse-looking functions. If set to use the calculated $3I_0$, the element applies a positive-sequence restraint for better performance: a small user-programmable portion of the positive-sequence current magnitude is subtracted from the zero-sequence current magnitude when forming the operating quantity.

$$I_{op} = 3 \times (|I_0| - K \times |I_1|) \quad \text{Eq. 5-24}$$

The positive-sequence restraint allows for more sensitive settings by counterbalancing spurious zero-sequence currents resulting from

- System unbalances under heavy load conditions
- Transformation errors of current transformers (CTs) during double-line and three-phase faults
- Switch-off transients during double-line and three-phase faults

The positive-sequence restraint must be considered when testing for pickup accuracy and response time (multiple of pickup). The operating quantity depends on the way the test currents are injected into the relay (single-phase injection: $I_{op} = (1 - K) \times I_{injected}$; three-phase pure zero-sequence injection: $I_{op} = 3 \times I_{injected}$).

The positive-sequence restraint is removed for low currents. If the positive-sequence current is below 0.8 pu, the restraint is removed by changing the constant K to zero. This facilitates better response to high-resistance faults when the unbalance is very small and there is no danger of excessive CT errors as the current is low.

The **directional unit** uses the zero-sequence current (I_0) or ground current (IG) for fault direction discrimination and can be programmed to use either zero-sequence voltage ("Calculated V0" or "Measured VX"), ground current (IG), or both for polarizing. The zero-sequence current (I_0) must be greater than the **PRODUCT SETUP** ⇒ **DISPLAY PROPERTIES** ⇒ **CURRENT CUT-OFF LEVEL** setting value and IG must be greater than 0.05 pu to be validated as the operating quantity for directional current. The following tables define the neutral directional overcurrent element. V₀ is the zero-sequence voltage, I₀ is the zero-sequence current, ECA is the element characteristic angle, and IG is the ground current.

Table 5-37: Quantities for "calculated 3I0" configuration

Directional unit				Overcurrent unit
Polarizing mode	Direction	Compared phasors		
Voltage	Forward	$-V_{0} + Z_{offset} \times I_{0}$	$I_{0} \times 1\angle ECA$	$I_{op} = 3 \times (I_{0} - K \times I_{1})$ if $ I_{1} > 0.8$ pu $I_{op} = 3 \times (I_{0})$ if $ I_{1} \leq 0.8$ pu
	Reverse	$-V_{0} + Z_{offset} \times I_{0}$	$-I_{0} \times 1\angle ECA$	
Current	Forward	IG	I_{0}	
	Reverse	IG	$-I_{0}$	
Dual, Dual-V, Dual-I	Forward	$-V_{0} + Z_{offset} \times I_{0}$	$I_{0} \times 1\angle ECA$	
		or		
		IG	I_{0}	
	Reverse	$-V_{0} + Z_{offset} \times I_{0}$	$-I_{0} \times 1\angle ECA$	
		or		
		IG	$-I_{0}$	

Table 5-38: Quantities for "measured IG" configuration

Directional unit				Overcurrent unit
Polarizing mode	Direction	Compared phasors		
Voltage	Forward	$-V_{0} + Z_{offset} \times IG/3$	$IG \times 1\angle ECA$	$I_{op} = IG $
	Reverse	$-V_{0} + Z_{offset} \times IG/3$	$-IG \times 1\angle ECA$	

where:

$$V_{0} = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG}) = \text{zero sequence voltage}$$

$$I_{0} = \frac{1}{3}I_{N} = \frac{1}{3}(I_{A} + I_{B} + I_{C}) = \text{zero sequence current}$$

ECA = element characteristic angle

IG = ground current

Z_offset is the offset impedance, for which magnitude is the OFFSET setting and angle is the FWD ECA

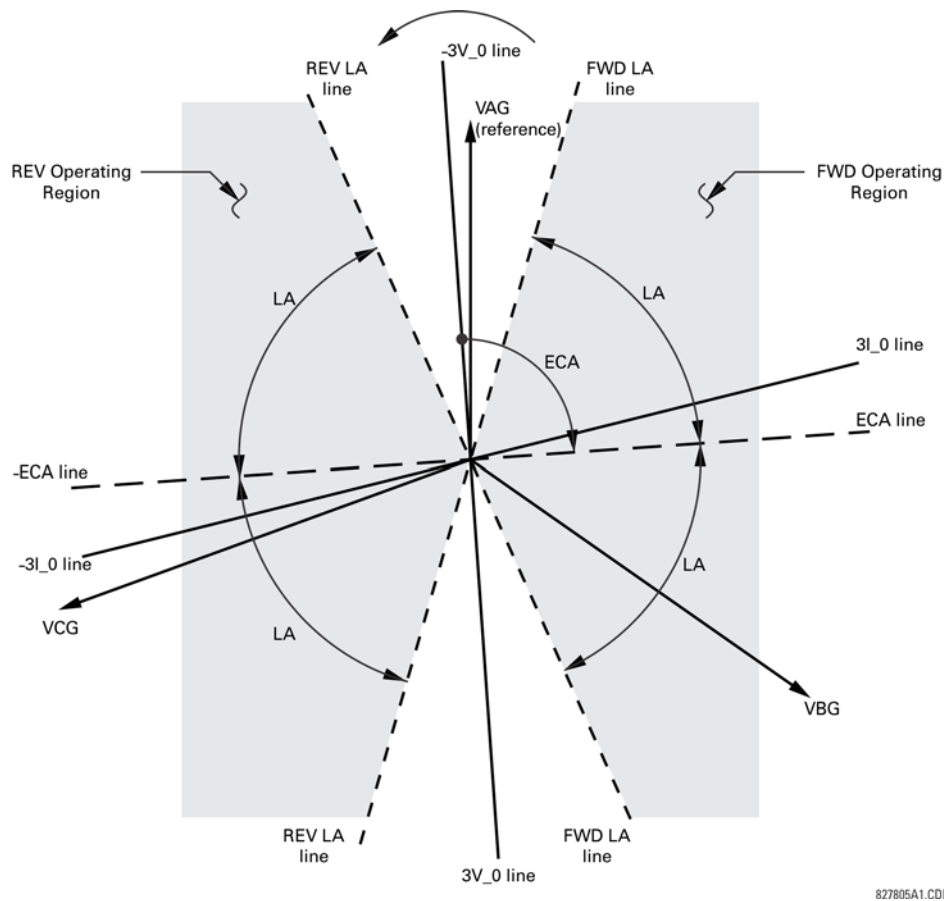
When **NEUTRAL DIR OC1 POL VOLT** is set to "Measured VX," one-third of this voltage is used in place of V_0. The following figure explains the usage of the voltage polarized directional unit of the element.

The figure shows the voltage-polarized phase angle comparator characteristics for a phase A to ground fault, with:

- ECA = 90° (element characteristic angle = centerline of operating characteristic)
- FWD LA = 80° (forward limit angle = the ± angular limit with the ECA for operation)
- REV LA = 80° (reverse limit angle = the ± angular limit with the ECA for operation)

Take the bias into account when using the neutral directional overcurrent element to directionalize other protection elements.

Figure 5-116: Neutral directional voltage-polarized characteristics



NEUTRAL DIR OC1 POLARIZING — This setting selects the polarizing mode for the directional unit.

- If “Voltage” polarizing is selected, the element uses the zero-sequence voltage angle for polarization. The user can use either the zero-sequence voltage V_0 calculated from the phase voltages, or the zero-sequence voltage supplied externally as the auxiliary voltage V_X , both from the **NEUTRAL DIR OC1 SOURCE**.

The calculated V_0 can be used as polarizing voltage only if the voltage transformers are connected in Wye. The auxiliary voltage can be used as the polarizing voltage provided **SYSTEM SETUP** ⇒ **AC INPUTS** ⇒ **VOLTAGE BANK** ⇒ **AUXILIARY VT CONNECTION** is set to “Vn” and the auxiliary voltage is connected to a zero-sequence voltage source (such as broken delta connected secondary of VTs).

The zero-sequence voltage V_0 must be greater than 0.02 pu to be validated for use as a polarizing signal. Additionally, when offset impedance is applied and zero-sequence current is above 0.2 pu, compensated zero-sequence voltage $-V_0 + Z_{\text{offset}} \times I_0$ has to be above 0.02 pu in order to discriminate fault direction; otherwise when zero-sequence current is less than 0.2 pu, $-V_0$ is then used as the polarizing signal. If the polarizing signal is invalid, neither forward nor reverse indication is given.

- If “Current” polarizing is selected, the element uses the ground current angle connected externally and configured under **NEUTRAL OC1 SOURCE** for polarization. The ground CT must be connected between the ground and neutral point of an adequate local source of ground current. The ground current must be greater than 0.05 pu to be validated as a polarizing signal. If the polarizing signal is not valid, neither forward nor reverse indication is given. In addition, the zero-sequence current (I_0) must be greater than the **PRODUCT SETUP** ⇒ **DISPLAY PROPERTIES** ⇒ **CURRENT CUT-OFF LEVEL** setting value.

For a choice of current polarizing, it is recommended that the polarizing signal be analyzed to ensure that a known direction is maintained irrespective of the fault location. For example, if using an autotransformer neutral current as a polarizing source, ensure that a reversal of the ground current does not occur for a high-side fault. Assume that the

low-side system impedance is minimal when checking for this condition. A similar situation arises for a wye/delta/wye transformer, where current in one transformer winding neutral can reverse when faults on both sides of the transformer are considered.

- If "Dual" polarizing is selected, the element performs both directional comparisons as described. A given direction is confirmed if either voltage or current comparators indicate so. If a conflicting (simultaneous forward and reverse) indication occurs, the forward direction overrides the reverse direction.
- If "Dual-V" polarizing is selected, "Voltage" polarizing is performed and "Current" polarizing is ignored if the voltage polarizing signal is valid; otherwise "Current" polarizing is performed if the current polarizing signal is valid. If neither of them is valid, neither forward nor reverse indication is given.
- If "Dual-I" polarizing is selected, "Current" polarizing is performed and "Voltage" polarizing is ignored if the current polarizing signal is valid; otherwise "Voltage" polarizing is performed if the voltage polarizing signal is valid. If neither of them is valid, neither forward nor reverse indication is given.

NEUTRAL DIR OC1 POL VOLT — Selects the polarizing voltage used by the directional unit when "Voltage," "Dual," "Dual-V," or "Dual-I" polarizing mode is set. The polarizing voltage can be programmed to be either the zero-sequence voltage calculated from the phase voltages ("Calculated V0") or supplied externally as an auxiliary voltage ("Measured VX").

NEUTRAL DIR OC1 OP CURR — This setting indicates whether the 3I₀ current calculated from the phase currents, or the ground current is used by this protection. This setting acts as a switch between the neutral and ground modes of operation (ANSI devices 67N and 67G). If set to "Calculated 3I₀," the element uses the phase currents and applies the positive-sequence restraint. If set to "Measured IG," the element uses ground current supplied to the ground CT of the CT bank configured as **NEUTRAL DIR OC1 SOURCE**. If this setting is "Measured IG," then the **NEUTRAL DIR OC1 POLARIZING** setting must be "Voltage", as it is not possible to use the ground current as an operating and polarizing signal simultaneously. IG current has to be above 0.05 ps to be used as operate quantity.

NEUTRAL DIR OC1 POS-SEQ RESTRAINT — This setting controls the amount of the positive-sequence restraint. Set it to 0.063 for backward compatibility with firmware revision 3.40 and older. Set it to zero to remove the restraint. Set it higher if large system unbalances or poor CT performance are expected.

NEUTRAL DIR OC1 OFFSET — This setting specifies the offset impedance used by this protection. The primary application for the offset impedance is to guarantee correct identification of fault direction on series compensated lines. In regular applications, the offset impedance ensures proper operation even if the zero-sequence voltage at the relaying point is very small. If this is the intent, the offset impedance is not to be larger than the zero-sequence impedance of the protected circuit. Practically, it shall be several times smaller. Enter the offset impedance in secondary ohms.

NEUTRAL DIR OC1 FWD ECA — This setting defines the characteristic angle (ECA) for the forward direction in the "Voltage" polarizing mode. The "Current" polarizing mode uses a fixed ECA of 0°. The ECA in the reverse direction is the angle set for the forward direction shifted by 180°.

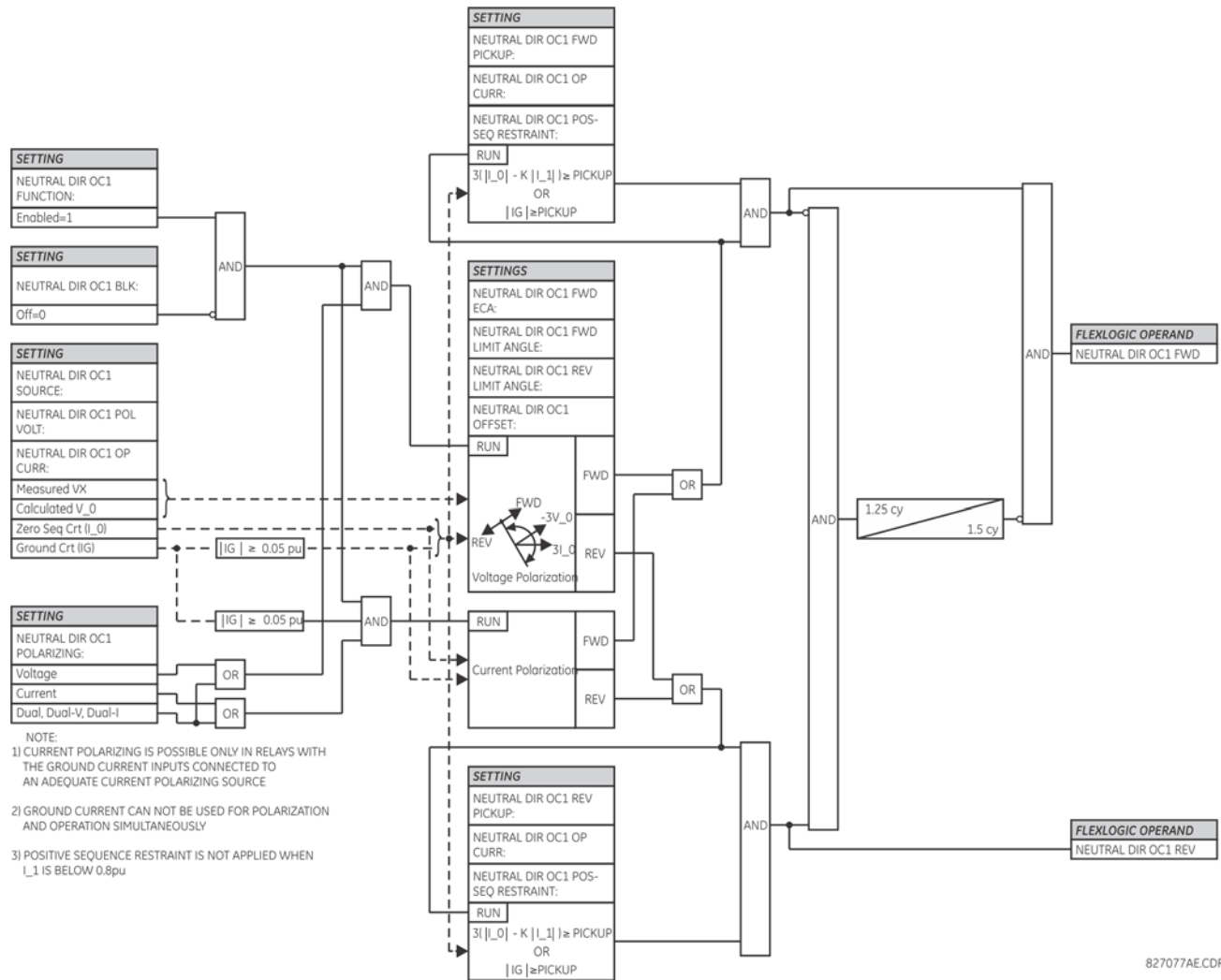
NEUTRAL DIR OC1 FWD LIMIT ANGLE — This setting defines a symmetrical (in both directions from the ECA) limit angle for the forward direction.

NEUTRAL DIR OC1 FWD PICKUP — This setting defines the pickup level for the overcurrent unit of the element in the forward direction. When selecting this setting, keep in mind that the design uses a positive-sequence restraint technique for the "Calculated 3I₀" mode of operation.

NEUTRAL DIR OC1 REV LIMIT ANGLE — This setting defines a symmetrical (in both directions from the ECA) limit angle for the reverse direction.

NEUTRAL DIR OC1 REV PICKUP — This setting defines the pickup level for the overcurrent unit of the element in the reverse direction. When selecting this setting, keep in mind that the design uses a positive-sequence restraint technique for the "Calculated 3I₀" mode of operation.

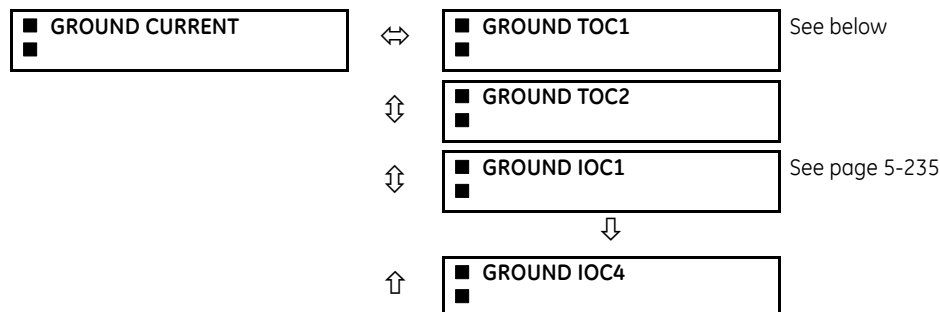
Figure 5-117: Neutral directional overcurrent logic



5.7.6 Ground current

5.7.6.1 Menu

SETTINGS ⇄ GROUPED ELEMENTS ⇄ SETTING GROUP 1(6) ⇄ GROUND CURRENT



The L30 contains protection elements for ground time overcurrent (ANSI device 51G) and ground instantaneous overcurrent (ANSI device 50G).

5.7.6.2 Ground time overcurrent (ANSI 51G, IEC PTOC)

SETTINGS ⇌ GROUPED ELEMENTS ⇌ SETTING GROUP 1(6) ⇌ GROUND CURRENT ⇌ GROUND TOC1(2)

<div style="border: 1px solid black; padding: 2px;"> <p>■ GROUND TOC1</p> <p>■</p> </div>	↔	GROUND TOC1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	GROUND TOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	↕	GROUND TOC1 INPUT: Phasor	Range: Phasor, RMS
	↕	GROUND TOC1 PICKUP: 1.000 pu	Range: 0.020 to 30.000 pu in steps of 0.001
	↕	GROUND TOC1 CURVE: IEEE Mod Inv	Range: see the Overcurrent Curve Types table
	↕	GROUND TOC1 TD MULTIPLIER: 1.00	Range: 0.00 to 600.00 in steps of 0.01
	↕	GROUND TOC1 RESET: Instantaneous	Range: Instantaneous, Timed
	↕	GROUND TOC1 BLOCK: Off	Range: FlexLogic operand
	↕	GROUND TOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↑	GROUND TOC1 EVENTS: Disabled	Range: Disabled, Enabled	

This element can provide a required time-delay operating characteristic versus the applied current or be used as a simple definite time element. The ground current input value is the quantity measured by the ground input CT and is the fundamental phasor or RMS magnitude. Two methods of resetting operation are available: “Timed” and “Instantaneous” (see the Inverse TOC Curve Characteristics section for details). When the element is blocked, the time accumulator resets according to the reset characteristic. For example, if the element reset characteristic is set to “Instantaneous” and the element is blocked, the time accumulator clears immediately.

GROUND TOC1 FUNCTION — This setting enables and disables the ground time overcurrent protection element.

GROUND TOC1 SIGNAL SOURCE — This setting selects the signal source for the ground time overcurrent protection element.

GROUND TOC1 INPUT — This setting selects how ground current input quantities are interpreted by the L30. Inputs can be selected as fundamental phasor magnitudes or total waveform RMS magnitudes as required by the application.

GROUND TOC1 PICKUP — This setting specifies the ground time overcurrent pickup level in per-unit values.

GROUND TOC1 CURVE — This setting selects the inverse time overcurrent curve style.

GROUND TOC1 TD MULTIPLIER — This setting specifies a multiple of the base curve shape specified by the **CURVE** setting. Programming this value to zero results in an instantaneous response to all current levels above pickup.

GROUND TOC1 RESET — The “Instantaneous” reset method is intended for applications with other relays, such as most static relays, which set the energy capacity directly to zero when the current falls below the reset threshold. The “Timed” reset method can be used where the relay must coordinate with electromechanical relays.

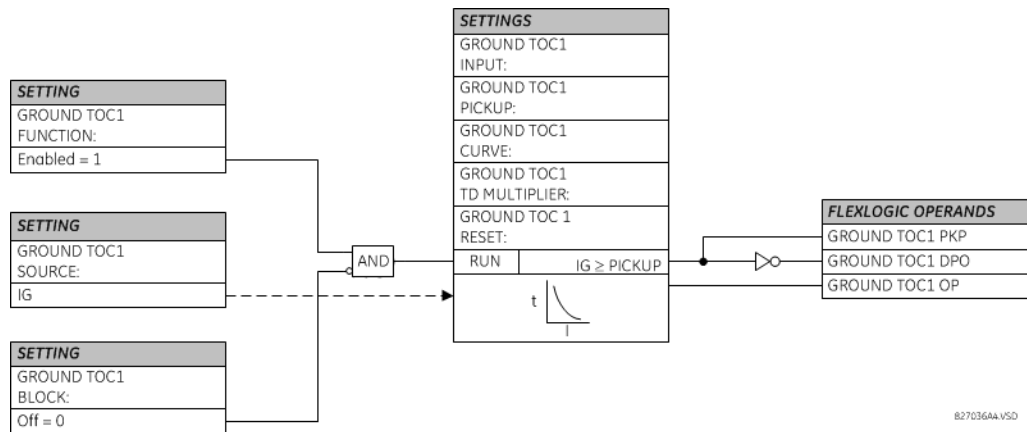
GROUND TOC1 BLOCK — Assertion of the operand assigned to this setting blocks operation of the ground time overcurrent element.

GROUND TOC1 EVENTS — This setting enables and disables the logging of ground time overcurrent events in the sequence of events recorder.



These elements measure the current that is connected to the ground channel of a CT/VT module. The conversion range of a standard channel is from 0.02 to 46 times the CT rating.

Figure 5-118: Ground TOC1 logic



5.7.6.3 Ground instantaneous overcurrent (ANSI 50G, IEC PIOC)

SETTINGS ⇄ GROUPED ELEMENTS ⇄ SETTING GROUP 1(6) ⇄ GROUND CURRENT ⇄ GROUND IOC1(4)

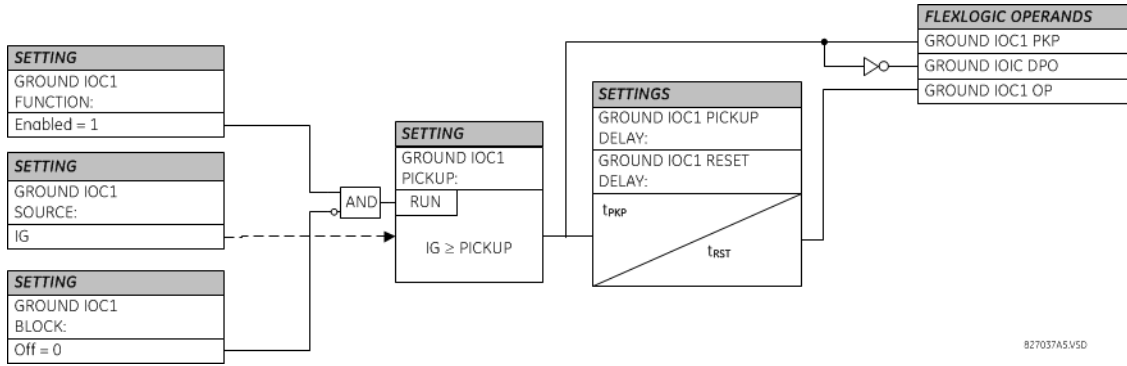
■ GROUND IOC1	↔	GROUND IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	GROUND IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	⇅	GROUND IOC1 PICKUP: 1.000 pu	Range: 0.020 to 30.000 pu in steps of 0.001
	⇅	GROUND IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇅	GROUND IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇅	GROUND IOC1 BLOCK: Off	Range: FlexLogic operand
	⇅	GROUND IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	GROUND IOC1 EVENTS: Disabled	Range: Disabled, Enabled

The ground instantaneous overcurrent element can be used as an instantaneous element with no intentional delay or as a definite time element. The ground current input is the quantity measured by the ground input CT and is the fundamental phasor magnitude.



These elements measure the current that is connected to the ground channel of a CT/VT module. The conversion range of a standard channel is from 0.02 to 46 times the CT rating.

Figure 5-119: Ground IOC1 logic

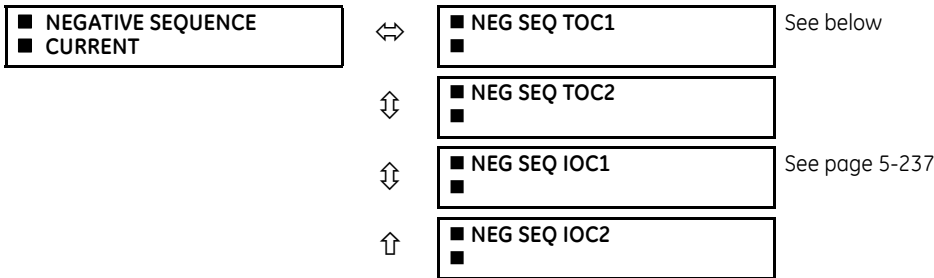


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5.7.7 Negative sequence current

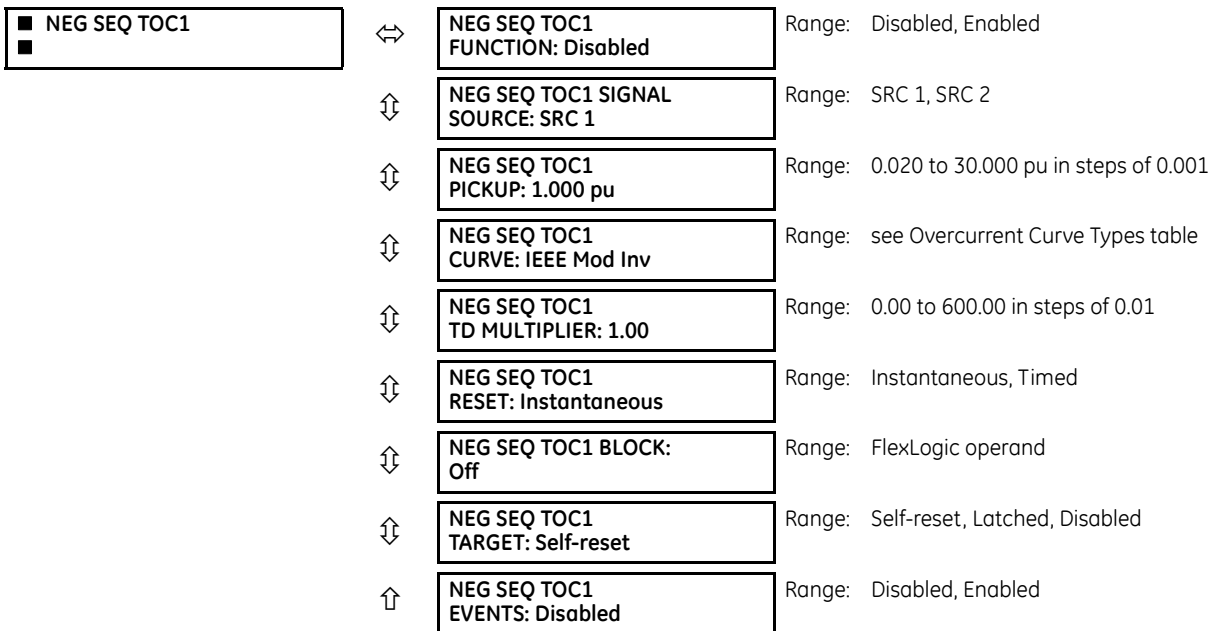
5.7.7.1 Menu

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ NEGATIVE SEQUENCE CURRENT



5.7.7.2 Negative sequence time overcurrent (ANSI 51Q, IEC PTOC)

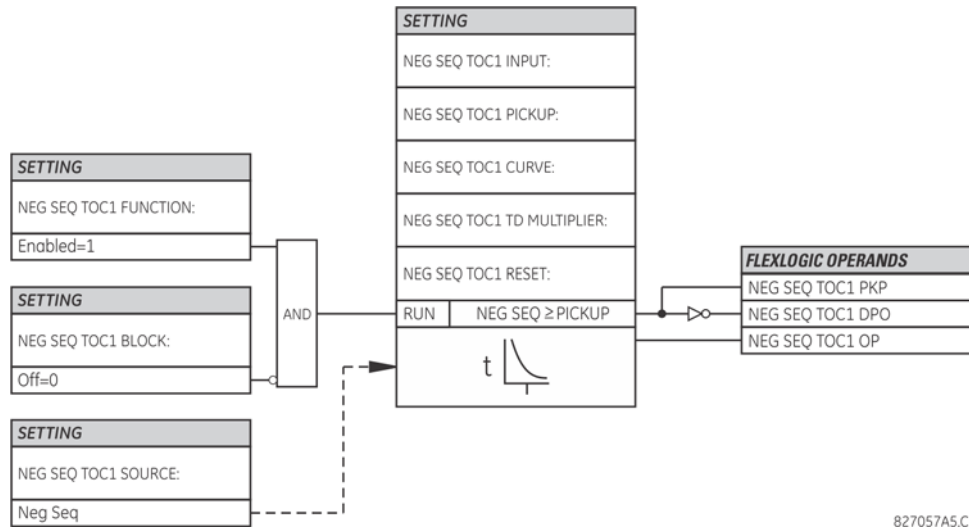
SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ NEGATIVE SEQUENCE CURRENT ⇒ NEG SEQ TOC1(2)



The negative-sequence time overcurrent element can be used to determine and clear unbalance in the system. The input for calculating negative-sequence current is the fundamental phasor value.

Two methods of resetting operation are available; “Timed” and “Instantaneous” (see the Inverse TOC Curve Characteristics section earlier for details on curve setup, trip times and reset operation). When the element is blocked, the time accumulator resets according to the reset characteristic. For example, if the element reset characteristic is set to “Instantaneous” and the element is blocked, the time accumulator clears immediately.

Figure 5-120: Negative sequence TOC1 logic



5.7.7.3 Negative sequence instantaneous overcurrent (ANSI 50Q, IEC PIOC)

SETTINGS ⇄ GROUPED ELEMENTS ⇄ SETTING GROUP 1(6) ⇄ NEGATIVE SEQUENCE CURRENT ⇄ NEG SEQ OC1(2)

■ NEG SEQ IOC1	↔	NEG SEQ IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	NEG SEQ IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	↕	NEG SEQ IOC1 PICKUP: 1.000 pu	Range: 0.020 to 30.000 pu in steps of 0.001
	↕	NEG SEQ IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	↕	NEG SEQ IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	↕	NEG SEQ IOC1 BLOCK: Off	Range: FlexLogic operand
	↕	NEG SEQ IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	NEG SEQ IOC1 EVENTS: Disabled	Range: Disabled, Enabled

The negative-sequence instantaneous overcurrent element can be used as an instantaneous function with no intentional delay or as a definite time function. The element responds to the negative-sequence current fundamental frequency phasor magnitude (calculated from the phase currents) and applies a positive-sequence restraint for better performance: a small portion (12.5%) of the positive-sequence current magnitude is subtracted from the negative-sequence current magnitude when forming the operating quantity.

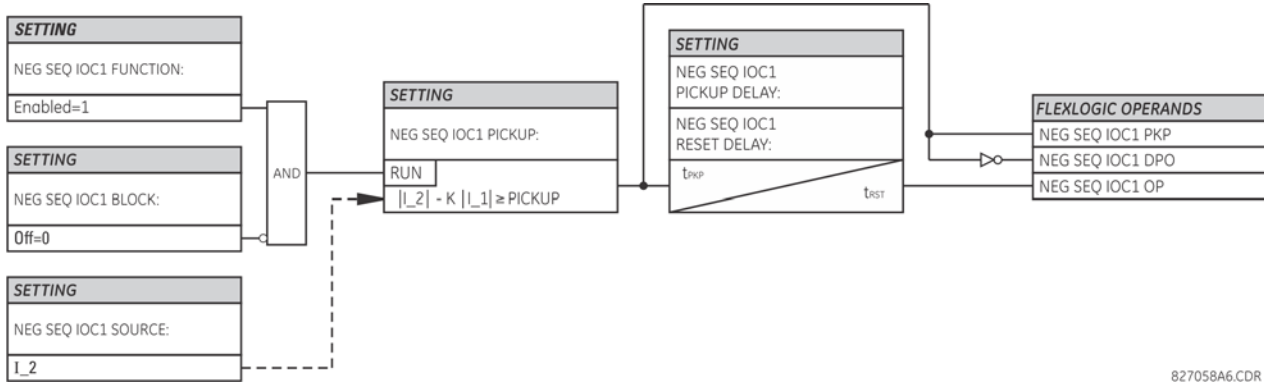
$$I_{op} = |I_2| - K \times |I_1| \text{ where } K = 1/8 \quad \text{Eq. 5-25}$$

The positive-sequence restraint allows for more sensitive settings by counterbalancing spurious negative-sequence currents resulting from

- System unbalances under heavy load conditions
- Transformation errors of current transformers (CTs) during three-phase faults
- Fault inception and switch-off transients during three-phase faults

The positive-sequence restraint must be considered when testing for pickup accuracy and response time (multiple of pickup). The operating quantity depends on how the test currents are injected into the relay (single-phase injection: $I_{op} = 0.2917 \times I_{injected}$; three-phase injection, opposite rotation: $I_{op} = I_{injected}$).

Figure 5-121: Negative sequence IOC1 logic



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5.7.8 Breaker failure (ANSI 50BF)

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ BREAKER FAILURE ⇒ BREAKER FAILURE 1(2)

■ BREAKER FAILURE 1	↔	BF1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	BF1 MODE: 3-Pole	Range: 3-Pole, 1-Pole
	↕	BF1 SOURCE: SRC 1	Range: SRC 1, SRC 2
	↕	BF1 USE AMP SUPV: Yes	Range: Yes, No
	↕	BF1 USE SEAL-IN: Yes	Range: Yes, No
	↕	BF1 3-POLE INITIATE: Off	Range: FlexLogic operand
	↕	BF1 BLOCK: Off	Range: FlexLogic operand
	↕	BF1 RETRIP PICKUP DELAY: 0.033 s	Range: 0.000 to 65.535 s in steps of 0.001
	↕	BF1 PH AMP SUPV PICKUP: 1.050 pu	Range: 0.020 to 30.000 pu in steps of 0.001
	↕	BF1 N AMP SUPV PICKUP: 1.050 pu	Range: 0.020 to 30.000 pu in steps of 0.001
	↕	BF1 USE TIMER 1: Yes	Range: Yes, No

↕	BF1 TIMER 1 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	BF1 USE TIMER 2: Yes	Range: Yes, No
↕	BF1 TIMER 2 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	BF1 USE TIMER 3: Yes	Range: Yes, No
↕	BF1 TIMER 3 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	BF1 BKR POS1 ϕA/3P: Off	Range: FlexLogic operand
↕	BF1 BKR POS2 ϕA/3P: Off	Range: FlexLogic operand
↕	BF1 BREAKER TEST ON: Off	Range: FlexLogic operand
↕	BF1 PH AMP HISET PICKUP: 1.050 pu	Range: 0.020 to 30.000 pu in steps of 0.001
↕	BF1 N AMP HISET PICKUP: 1.050 pu	Range: 0.020 to 30.000 pu in steps of 0.001
↕	BF1 PH AMP LOSET PICKUP: 1.050 pu	Range: 0.020 to 30.000 pu in steps of 0.001
↕	BF1 N AMP LOSET PICKUP: 1.050 pu	Range: 0.020 to 30.000 pu in steps of 0.001
↕	BF1 LOSET TIME DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	BF1 TRIP DROPOUT DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
↕	BF1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↕	BF1 EVENTS: Disabled	Range: Disabled, Enabled
↕	BF1 PH A INITIATE: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes
↕	BF1 PH B INITIATE: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes
↕	BF1 PH C INITIATE: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes
↕	BF1 BKR POS1 ϕB: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes
↕	BF1 BKR POS1 ϕC: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes
↕	BF1 BKR POS2 ϕB: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes
↕	BF1 BKR POS2 ϕC: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes

In general, a breaker failure scheme determines that a breaker signaled to trip has not cleared a fault within a definite time, so further tripping action must be performed. Tripping from the breaker failure scheme should trip all breakers, both local and remote, that can supply current to the faulted zone. Usually operation of a breaker failure element causes clearing of a larger section of the power system than the initial trip. Because breaker failure can result in tripping a large number of breakers and this affects system safety and stability, a very high level of security is required.

Two schemes are provided: one for three-pole tripping only (identified by the name “3BF”) and one for three pole plus single-pole operation (identified by the name “1BF”). The philosophy used in these schemes is identical. The operation of a breaker failure element includes three stages: initiation, determination of a breaker failure condition, and output.

Initiation stage

A FlexLogic operand representing the protection trip signal initially sent to the breaker must be selected to initiate the scheme. The initiating signal is sealed-in if primary fault detection can reset before the breaker failure timers have finished timing. The seal-in is supervised by current level, so it is reset when the fault is cleared. If desired, an incomplete sequence seal-in reset can be implemented by using the initiating operand to also initiate a FlexLogic timer, set longer than any breaker failure timer, whose output operand is selected to block the breaker failure scheme.

Schemes can be initiated either directly or with current level supervision. It is particularly important in any application to decide if a current-supervised initiate is to be used. The use of a current-supervised initiate results in the breaker failure element not being initiated for a breaker that has very little or no current flowing through it, which can be the case for transformer faults. For those situations where it is required to maintain breaker fail coverage for fault levels below the **BF1 PH AMP SUPV PICKUP** or the **BF1 N AMP SUPV PICKUP** setting, do not use a current supervised initiate. Utilize this feature for those situations where coordinating margins can be reduced when high speed reclosing is used. Thus, if this choice is made, fault levels must always be above the supervision pickup levels for dependable operation of the breaker fail scheme. This can also occur in breaker-and-a-half or ring bus configurations where the first breaker closes into a fault; the protection trips and attempts to initiate breaker failure for the second breaker, which is in the process of closing, but does not yet have current flowing through it.

When the scheme is initiated, it sends a trip signal after a pickup delay to the breaker initially signaled to trip (this feature is usually described as re-trip). This reduces the possibility of widespread tripping that results from a declaration of a failed breaker.

Determination of a breaker failure condition

The schemes determine a breaker failure condition via three paths. Each of these paths is equipped with a time delay, after which a failed breaker is declared and trip signals are sent to all breakers required to clear the zone. The delayed paths are associated with breaker failure timers 1, 2, and 3, which are intended to have delays increasing with increasing timer numbers. These delayed paths are individually enabled to allow for maximum flexibility.

Timer 1 logic (early path) is supervised by a fast-operating breaker auxiliary contact. If the breaker is still closed (as indicated by the auxiliary contact) and fault current is detected after the delay interval, an output is issued. Operation of the breaker auxiliary switch indicates that the breaker has mechanically operated. The continued presence of current indicates that the breaker has failed to interrupt the circuit.

Timer 2 logic (main path) is not supervised by a breaker auxiliary contact. If fault current is detected after the delay interval, an output is issued. This path is intended to detect a breaker that opens mechanically but fails to interrupt fault current; the logic therefore does not use a breaker auxiliary contact.

The timer 1 and 2 paths provide two levels of current supervision, high-set and low-set, that allow the supervision level to change from a current which flows before a breaker inserts an opening resistor into the faulted circuit to a lower level after resistor insertion. The high-set detector is enabled after timeout of timer 1 or 2, along with a timer that enables the low-set detector after its delay interval. The delay interval between high-set and low-set is the expected breaker opening time. Both current detectors provide a fast operating time for currents at small multiples of the pickup value. The overcurrent detectors are required to operate after the breaker failure delay interval to eliminate the need for very fast resetting overcurrent detectors.

Timer 3 logic (slow path) is supervised by a breaker auxiliary contact and a control switch contact used to indicate that the breaker is in or out-of-service, disabling this path when the breaker is out-of-service for maintenance. There is no current level check in this logic as it is intended to detect low magnitude faults and it is therefore the slowest to operate.

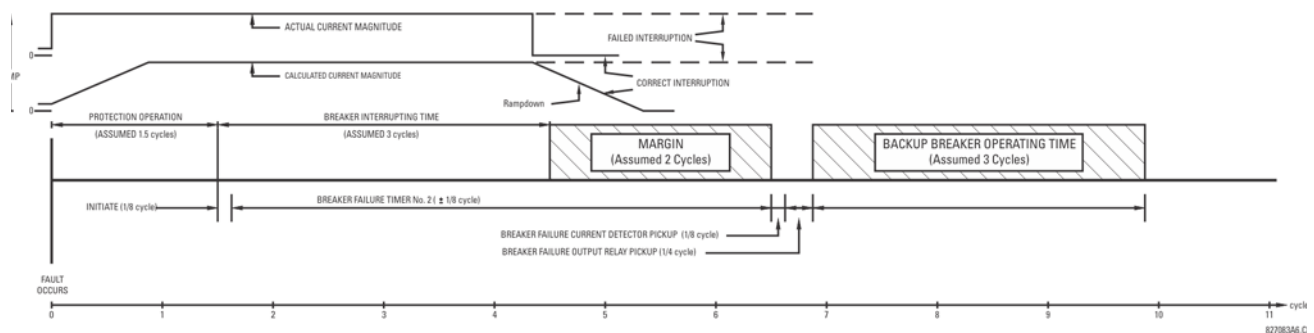
Output

The outputs from the schemes are:

- FlexLogic operands that report on the operation of portions of the scheme
- FlexLogic operand used to re-trip the protected breaker
- FlexLogic operands that initiate tripping required to clear the faulted zone. The trip output can be sealed-in for an adjustable period.
- Target message indicating a failed breaker has been declared
- Illumination of the front panel Trip LED (and the Phase A, B, or C LED, if applicable)

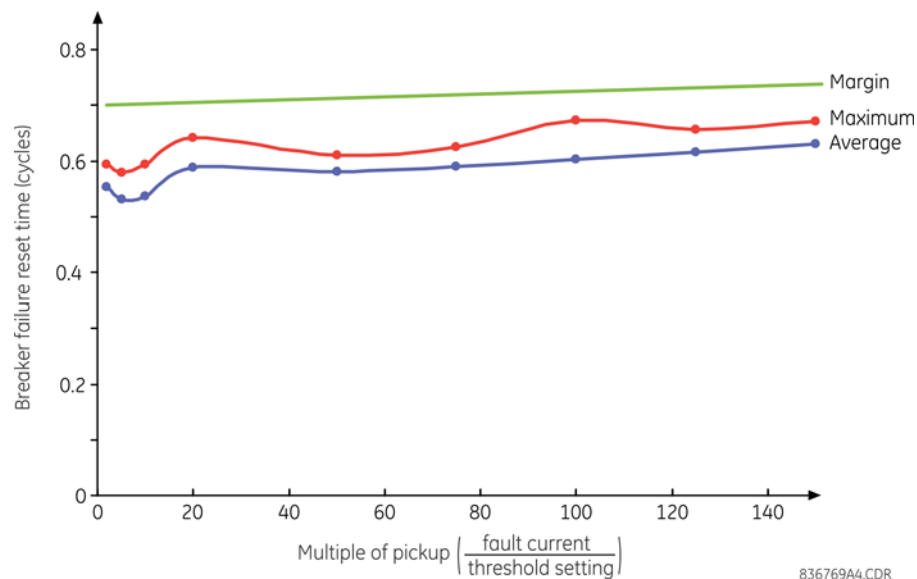
Main path sequence

Figure 5-122: Breaker failure main path sequence



The current supervision elements reset in less than 0.7 of a power cycle for any multiple of pickup current as shown in the following figure.

Figure 5-123: Breaker failure overcurrent supervision reset time



Settings

BF1 MODE — This setting is used to select the breaker failure operating mode: single or three pole.

BF1 USE AMP SUPV — If set to "Yes," the element is initiated if current flowing through the breaker is above the supervision pickup level.

BF1 USE SEAL-IN — If set to "Yes," the element is sealed-in if current flowing through the breaker is above the supervision pickup level.

BF1 3-POLE INITIATE — This setting selects the FlexLogic operand that initiates three-pole tripping of the breaker.

BF1 RETRIP PICKUP DELAY — This setting specifies a pickup delay for the re-trip command. Set this delay longer than the possible spurious contact input activation duration due to transients or temporary DC grounds, taking into account the contact input de-bounce time to avoid re-trip operation for such transients.

BF1 PH AMP SUPV PICKUP — This setting is used to set the phase current initiation and seal-in supervision level. Generally this setting detects the lowest expected fault current on the protected breaker. It can be set as low as necessary (lower than breaker resistor current or lower than load current)—high-set and low-set current supervision guarantee correct operation.

BF1 N AMP SUPV PICKUP — This setting is used to set the neutral current initiate and seal-in supervision level. Generally this setting detects the lowest expected fault current on the protected breaker. Neutral current supervision is used only in the three phase scheme to provide increased sensitivity. This setting is valid only for three-pole tripping schemes.

BF1 USE TIMER 1 — If set to "Yes," the early path is operational.

BF1 TIMER 1 PICKUP DELAY — Timer 1 is set to the shortest time required for breaker auxiliary contact Status-1 to open, from the time the initial trip signal is applied to the breaker trip circuit, plus a safety margin.

BF1 USE TIMER 2 — If set to "Yes," the main path is operational.

BF1 TIMER 2 PICKUP DELAY — Timer 2 is set to the expected opening time of the breaker, plus a safety margin. This safety margin was historically intended to allow for measuring and timing errors in the breaker failure scheme equipment. In microprocessor relays this time is not significant. In L30 relays, which use a Fourier transform, the calculated current magnitude ramps-down to zero one power frequency cycle after the current is interrupted, and this lag needs to be included in the overall margin duration, as it occurs after current interruption. The Breaker Failure Main Path Sequence figure that follows shows a margin of two cycles; this interval is considered the minimum appropriate for most applications.

Note that in bulk oil circuit breakers, the interrupting time for currents less than 25% of the interrupting rating can be significantly longer than the normal interrupting time.

BF1 USE TIMER 3 — If set to "Yes," the Slow Path is operational.

BF1 TIMER 3 PICKUP DELAY — Timer 3 is set to the same interval as timer 2, plus an increased safety margin. Because this path is intended to operate only for low level faults, the delay can be in the order of 300 to 500 ms.

BF1 BKR POS1 Φ A/3P — This setting selects the FlexLogic operand that represents the protected breaker early-type auxiliary switch contact (52/a). When using the single-pole breaker failure scheme, this operand represents the protected breaker early-type auxiliary switch contact on pole A. This is normally a non-multiplied form-A contact. The contact can even be adjusted to have the shortest possible operating time.

BF1 BKR POS2 Φ A/3P — This setting selects the FlexLogic operand that represents the breaker normal-type auxiliary switch contact (52/a). When using the single-pole breaker failure scheme, this operand represents the protected breaker auxiliary switch contact on pole A. This can be a multiplied contact.

BF1 BREAKER TEST ON — This setting is used to select the FlexLogic operand that represents the breaker in-service/out-of-service switch set to the out-of-service position.

BF1 PH AMP HISET PICKUP — This setting sets the phase current output supervision level. Generally this setting is to detect the lowest expected fault current on the protected breaker, before a breaker opening resistor is inserted.

BF1 N AMP HISET PICKUP — This setting sets the neutral current output supervision level. Generally this setting is to detect the lowest expected fault current on the protected breaker, before a breaker opening resistor is inserted. Neutral current supervision is used only in the three pole scheme to provide increased sensitivity. This setting is valid only for three-pole breaker failure schemes.

BF1 PH AMP LOSET PICKUP — This setting sets the phase current output supervision level. Generally this setting is to detect the lowest expected fault current on the protected breaker, after a breaker opening resistor is inserted (approximately 90% of the resistor current).

BF1 N AMP LOSET PICKUP — This setting sets the neutral current output supervision level. Generally this setting is to detect the lowest expected fault current on the protected breaker, after a breaker opening resistor is inserted (approximately 90% of the resistor current). This setting is valid only for three-pole breaker failure schemes.

BF1 LOSET TIME DELAY — Sets the pickup delay for current detection after opening resistor insertion.

BF1 TRIP DROPOUT DELAY — This setting is used to set the period of time for which the trip output is sealed-in. This timer must be coordinated with the automatic reclosing scheme of the failed breaker, to which the breaker failure element sends a cancel reclosure signal. Reclosure of a remote breaker can also be prevented by holding a transfer trip signal on longer than the reclaim time.

BF1 PH A INITIATE / BF1 PH B INITIATE / BF 1 PH C INITIATE — These settings select the FlexLogic operand to initiate phase A, B, or C single-pole tripping of the breaker and the phase A, B, or C portion of the scheme, accordingly. This setting is only valid for single-pole breaker failure schemes.

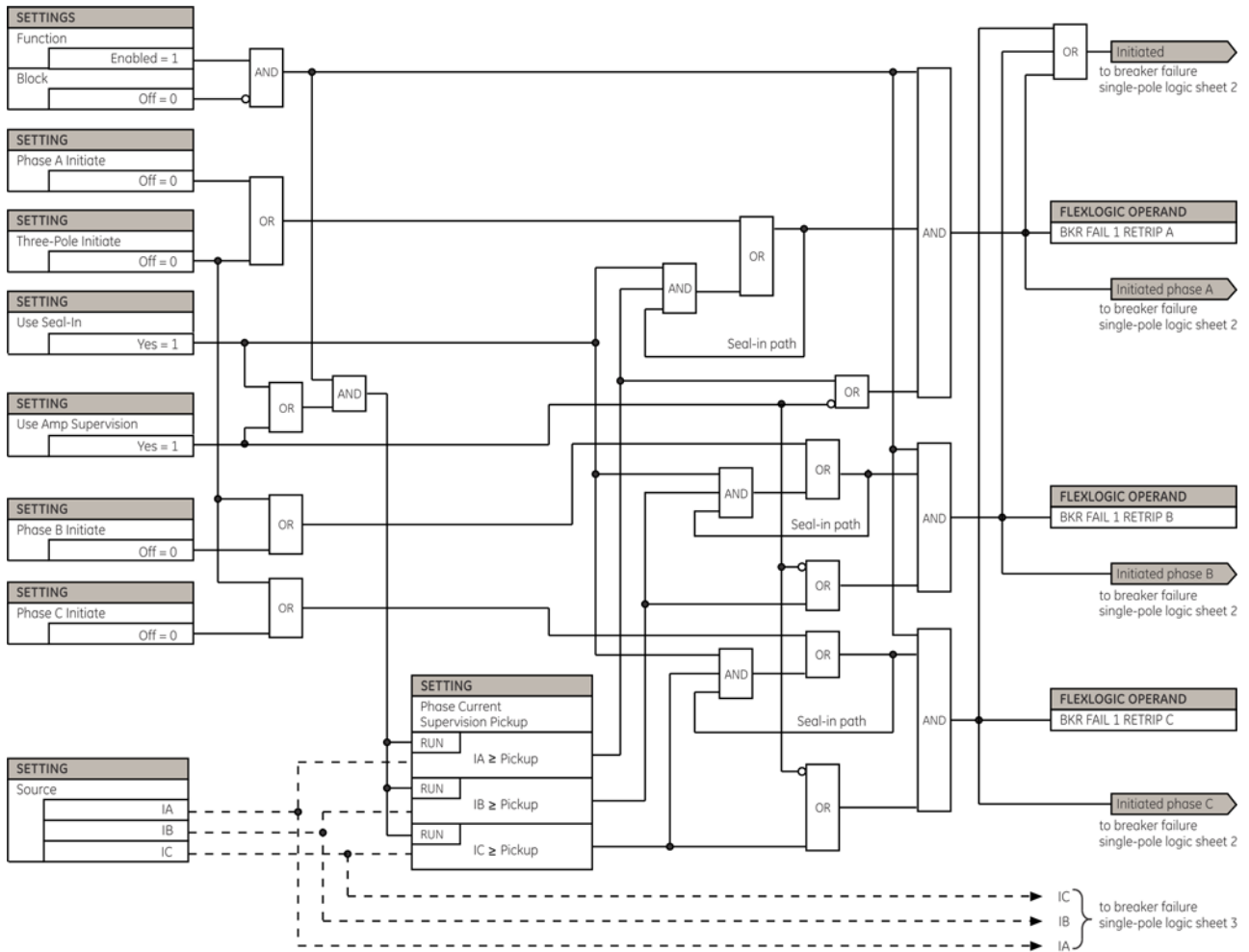
BF1 BKR POS1 ϕ B / BF1 BKR POS 1 ϕ C — These settings select the FlexLogic operand to represents the protected breaker early-type auxiliary switch contact on poles B or C, accordingly. This contact is normally a non-multiplied Form-A contact. The contact can even be adjusted to have the shortest possible operating time. This setting is valid only for single-pole breaker failure schemes.

BF1 BKR POS2 ϕ B — Selects the FlexLogic operand that represents the protected breaker normal-type auxiliary switch contact on pole B (52/a). This can be a multiplied contact. This setting is valid only for single-pole breaker failure schemes.

BF1 BKR POS2 ϕ C — This setting selects the FlexLogic operand that represents the protected breaker normal-type auxiliary switch contact on pole C (52/a). This can be a multiplied contact. For single-pole operation, the scheme has the same overall general concept except that it provides re-tripping of each single pole of the protected breaker. The approach shown in the following single pole tripping diagram uses the initiating information to determine which pole is supposed to trip. The logic is segregated on a per-pole basis. The overcurrent detectors have ganged settings. This setting is valid only for single-pole breaker failure schemes.

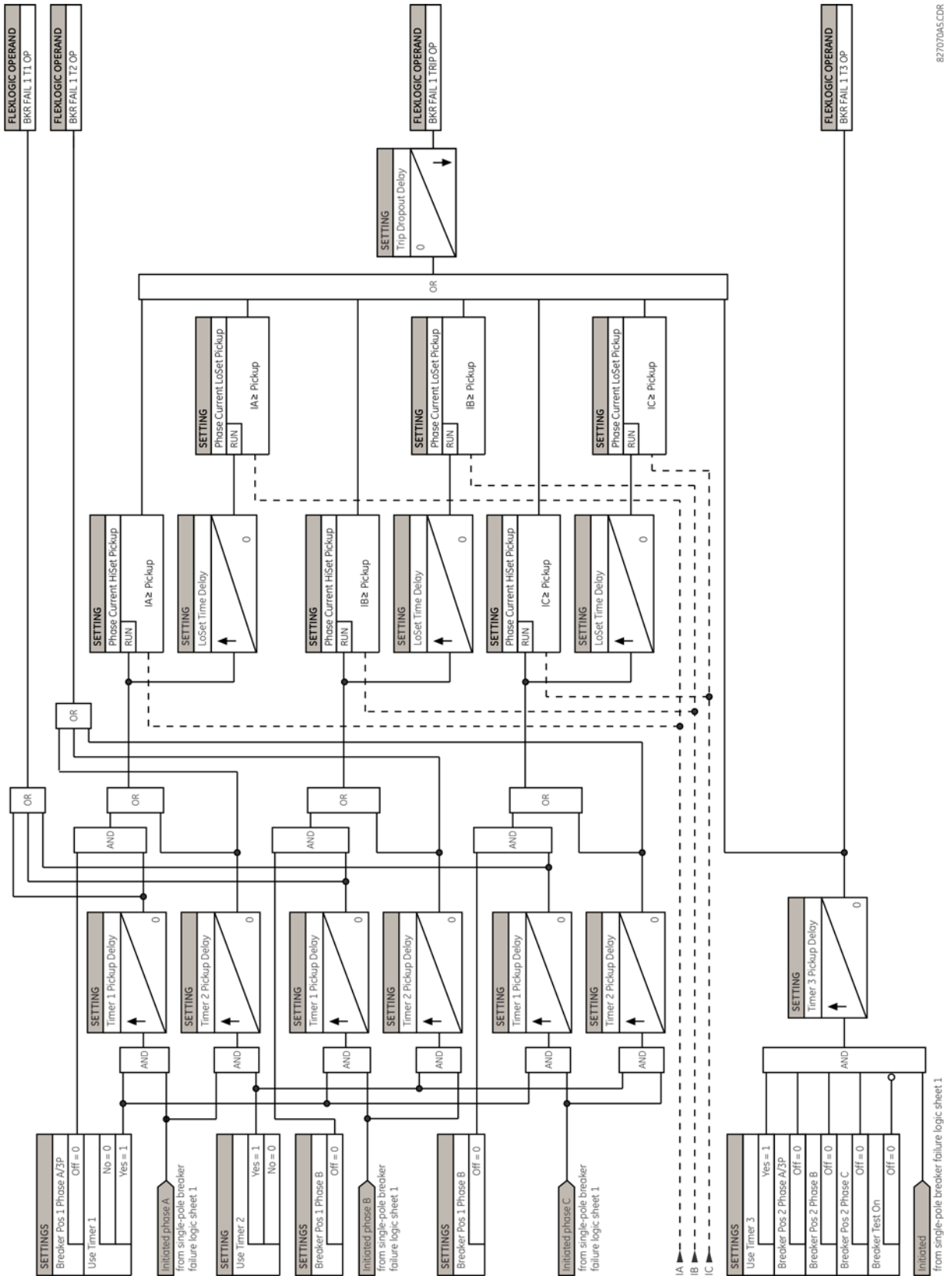
Upon operation of the breaker failure element for a single pole trip command, a three-pole trip command needs to be given via output operand **BKR FAIL 1 TRIP OP**.

Figure 5-124: Single-pole breaker failure initiate logic



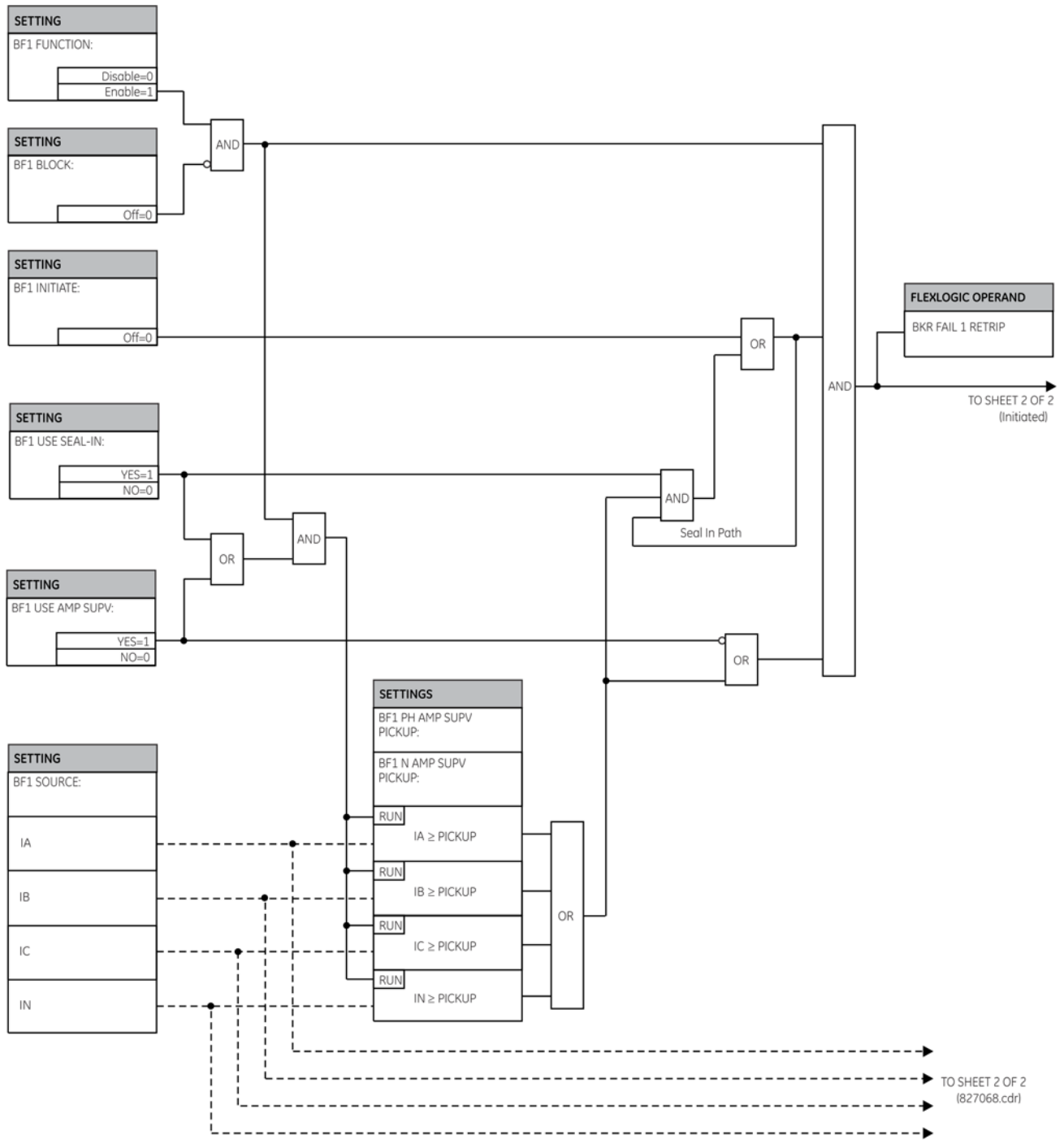
834013A3.CDR

Figure 5-125: Single-pole breaker failure, timers logic



827070M5.CDR

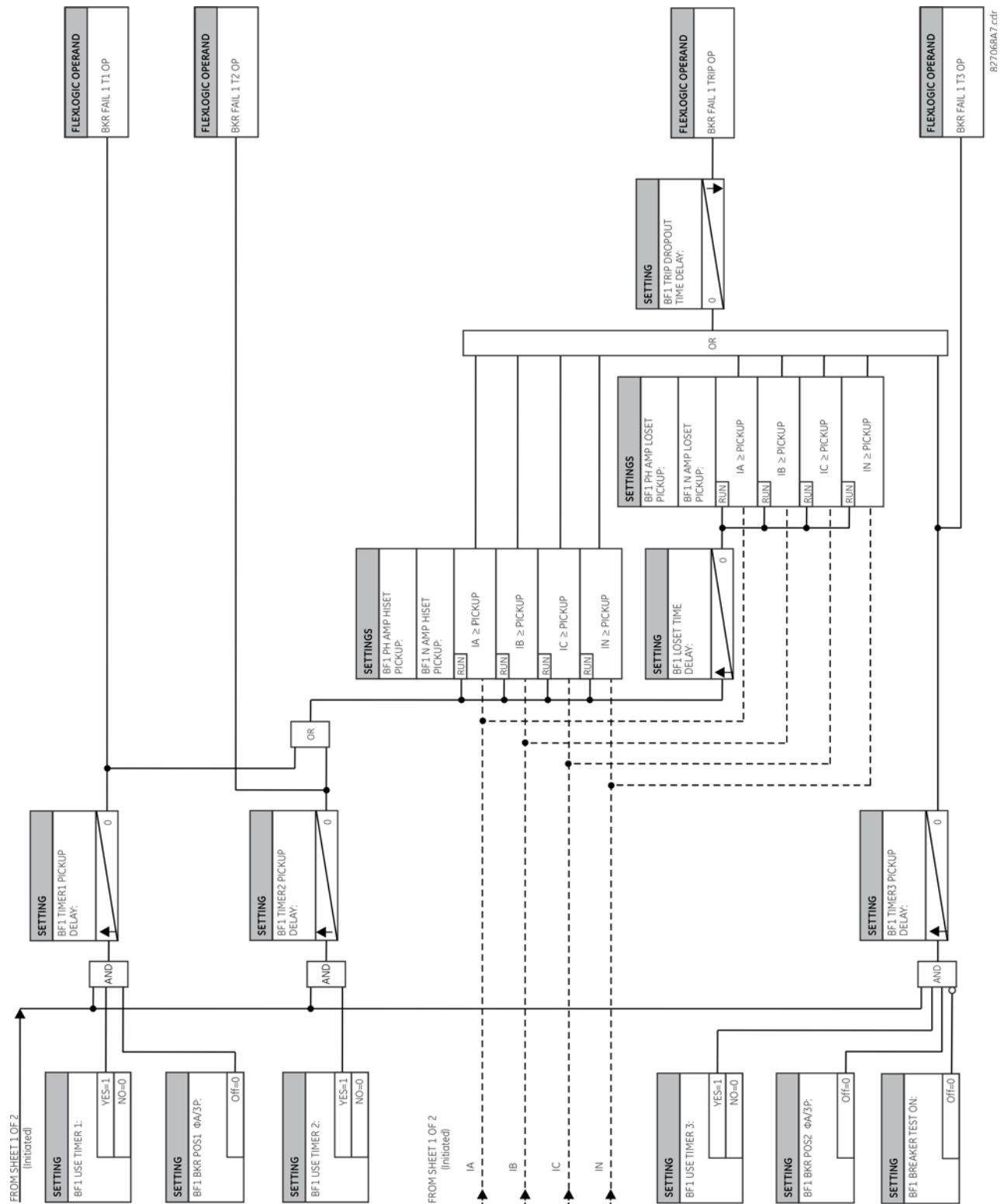
Figure 5-126: Three-pole breaker failure, initiate logic



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827067A5.cdr

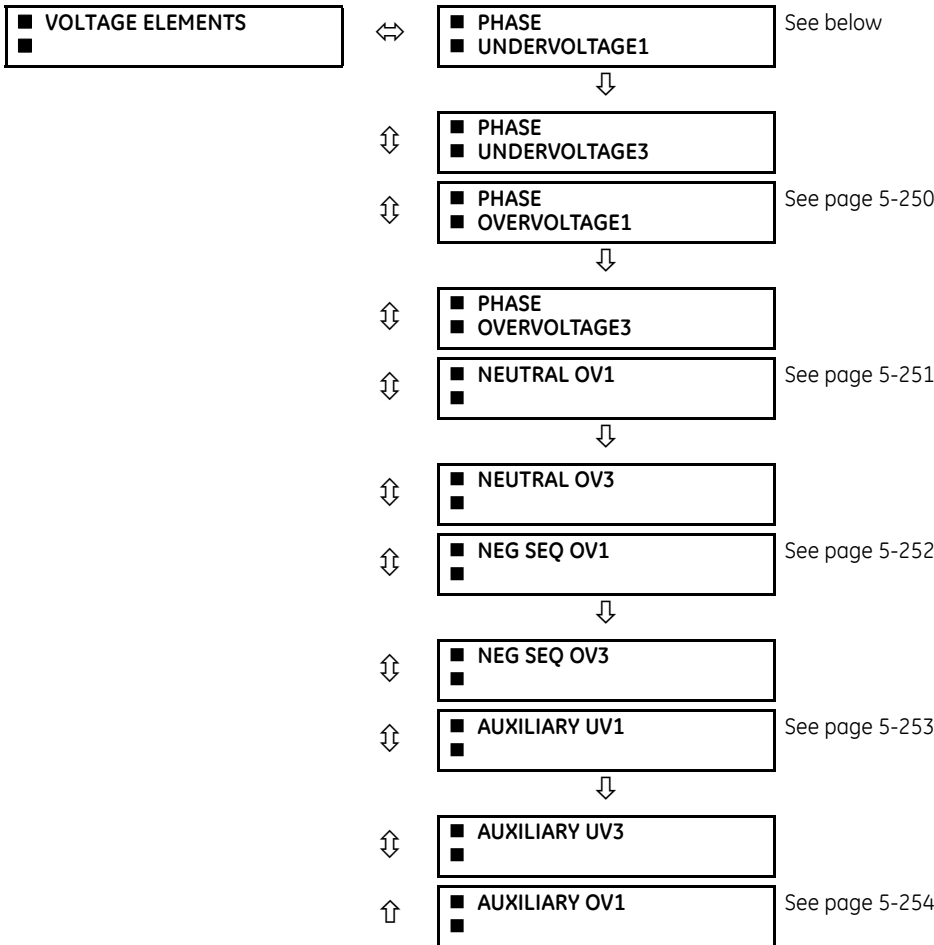
Figure 5-127: Three-pole breaker failure, timers logic



5.7.9 Voltage elements

5.7.9.1 Menu

SETTINGS ⇒ ↓ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ ↓ VOLTAGE ELEMENTS



These protection elements can be used for a variety of applications, such as

- **Undervoltage protection** — For voltage sensitive loads, such as induction motors, a drop in voltage increases the drawn current, which can cause dangerous overheating in the motor. The undervoltage protection feature can be used to either cause a trip or generate an alarm when the voltage drops below a specified voltage setting for a specified time delay.
- **Permissive functions** — The undervoltage feature can be used to block the functioning of external devices by operating an output relay when the voltage falls below the specified voltage setting. The undervoltage feature can also be used to block the functioning of other elements through the block feature of those elements.
- **Source transfer schemes** — In the event of an undervoltage, a transfer signal can be generated to transfer a load from its normal source to a standby or emergency power source.

The undervoltage elements can be programmed to have a definite time delay characteristic. The definite time curve operates when the voltage drops below the pickup level for a specified period of time. The time delay is adjustable from 0 to 600.00 seconds in steps of 0.01. The undervoltage elements can also be programmed to have an inverse time delay characteristic.

The undervoltage delay setting defines the family of curves shown as follows.

$$T = \frac{D}{\left(1 - \frac{V}{V_{pickup}}\right)}$$

Eq. 5-26

where

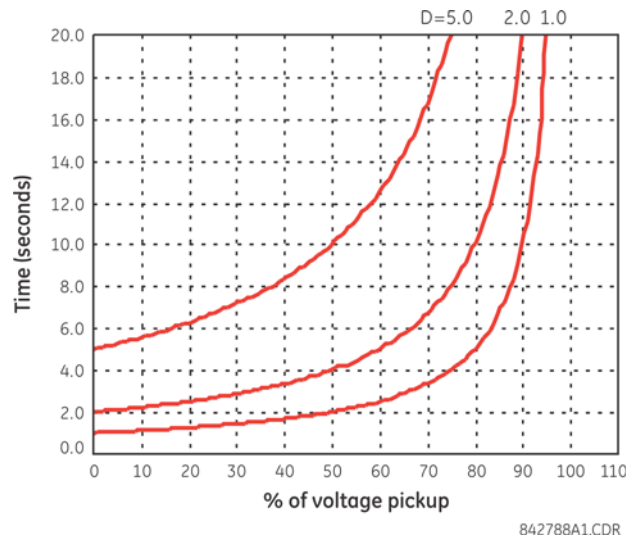
T = operating time

D = undervoltage delay setting (D = 0.00 operates instantaneously)

V = secondary voltage applied to the relay

V_{pickup} = pickup level

Figure 5-128: Inverse time undervoltage curves



At 0% of pickup, the operating time equals the PHASE UNDERVOLTAGE DELAY setting.

5.7.9.2 Phase undervoltage (ANSI 27P, IEC PTUV)

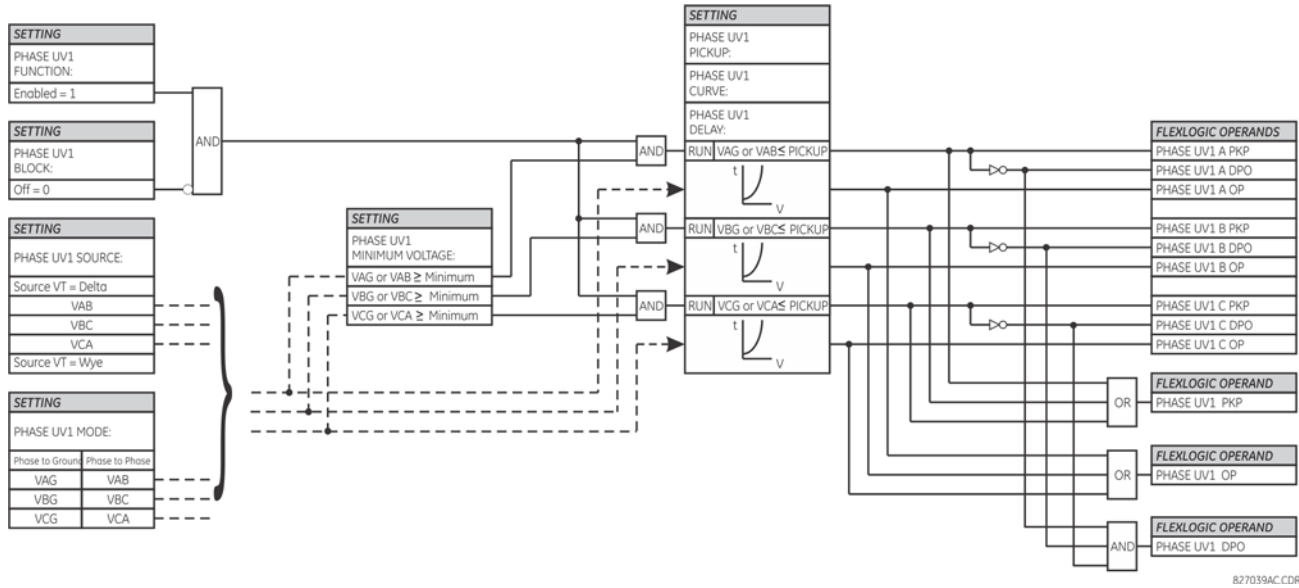
SETTINGS ⇄ GROUPED ELEMENTS ⇄ SETTING GROUP 1(6) ⇄ VOLTAGE ELEMENTS ⇄ PHASE UNDERVOLTAGE1(3)

<ul style="list-style-type: none"> ■ PHASE ■ UNDERVOLTAGE1 	↔	PHASE UV1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	PHASE UV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	↕	PHASE UV1 MODE: Phase to Ground	Range: Phase to Ground, Phase to Phase
	↕	PHASE UV1 PICKUP: 1.000 pu	Range: 0.004 to 3.000 pu in steps of 0.001
	↕	PHASE UV1 CURVE: Definite Time	Range: Definite Time, Inverse Time
	↕	PHASE UV1 DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	↕	PHASE UV1 MINIMUM VOLTAGE: 0.100 pu	Range: 0.000 to 3.000 pu in steps of 0.001
	↕	PHASE UV1 BLOCK: Off	Range: FlexLogic operand

- ⇕ **PHASE UV1**
TARGET: Self-reset Range: Self-reset, Latched, Disabled
- ↑ **PHASE UV1**
EVENTS: Disabled Range: Disabled, Enabled

This element is used to give a time-delay operating characteristic versus the applied fundamental voltage (phase-to-ground or phase-to-phase for wye VT connection, or phase-to-phase for delta VT connection) or as a definite time element. The element resets instantaneously if the applied voltage exceeds the dropout voltage. The delay setting selects the minimum operating time of the phase undervoltage. The minimum voltage setting selects the operating voltage below which the element is blocked (a setting of "0" allows a dead source to be considered a fault condition).

Figure 5-129: Phase undervoltage1 logic



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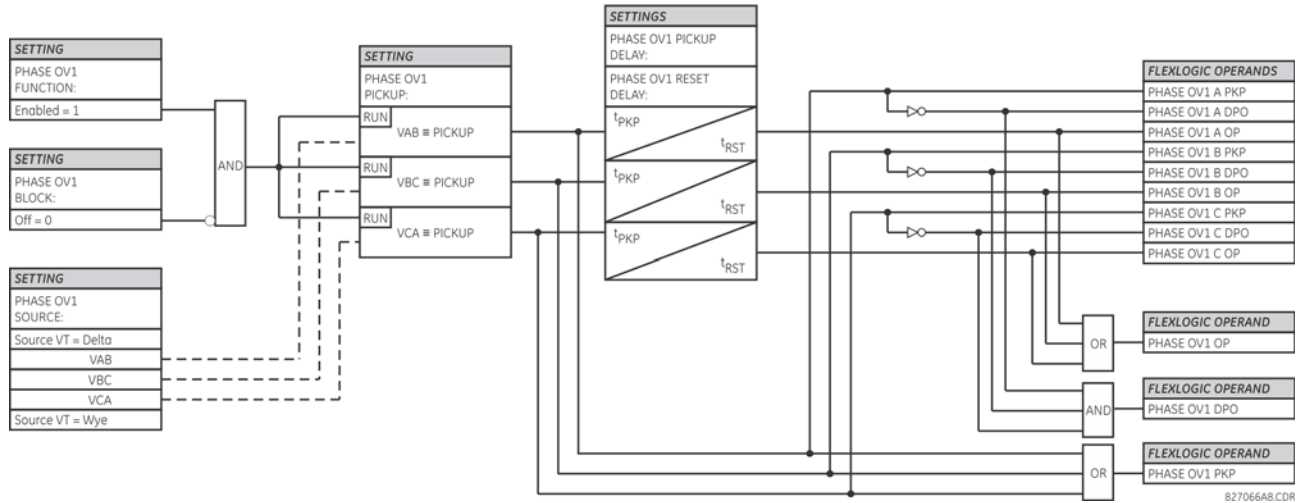
5.7.9.3 Phase overvoltage (ANSI 59P, IEC PTOV)

SETTINGS ⇕ GROUPED ELEMENTS ⇕ SETTING GROUP 1(6) ⇕ VOLTAGE ELEMENTS ⇕ PHASE OVERVOLTAGE1(3)

- **PHASE OVERVOLTAGE1** ⇕ **PHASE OV1**
FUNCTION: Disabled Range: Disabled, Enabled
- ⇕ **PHASE OV1 SIGNAL**
SOURCE: SRC 1 Range: SRC 1, SRC 2
- ⇕ **PHASE OV1**
PICKUP: 1.000 pu Range: 0.004 to 3.000 pu in steps of 0.001
- ⇕ **PHASE OV1 PICKUP**
DELAY: 1.00 s Range: 0.00 to 600.00 s in steps of 0.01
- ⇕ **PHASE OV1 RESET**
DELAY: 1.00 s Range: 0.00 to 600.00 s in steps of 0.01
- ⇕ **PHASE OV1 BLOCK:**
Off Range: FlexLogic Operand
- ⇕ **PHASE OV1**
TARGET: Self-reset Range: Self-reset, Latched, Disabled
- ↑ **PHASE OV1**
EVENTS: Disabled Range: Disabled, Enabled

There are three phase overvoltage elements available. A phase overvoltage element is used as an instantaneous element with no intentional time delay or as a definite time element. The input voltage is the phase-to-phase voltage, either measured directly from delta-connected VTs or as calculated from phase-to-ground (wye) connected VTs. The figure shows specific voltages to be used for each phase.

Figure 5-130: Phase overvoltage logic



If the source VT is wye-connected, then the phase overvoltage pickup condition is $V > \sqrt{3} \times \text{Pickup}$ for V_{AB} , V_{BC} , and V_{CA} .

5.7.9.4 Neutral overvoltage (ANSI 59N, IEC PTOV)

SETTINGS ⇨ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ VOLTAGE ELEMENTS ⇨ NEUTRAL OV1(3)

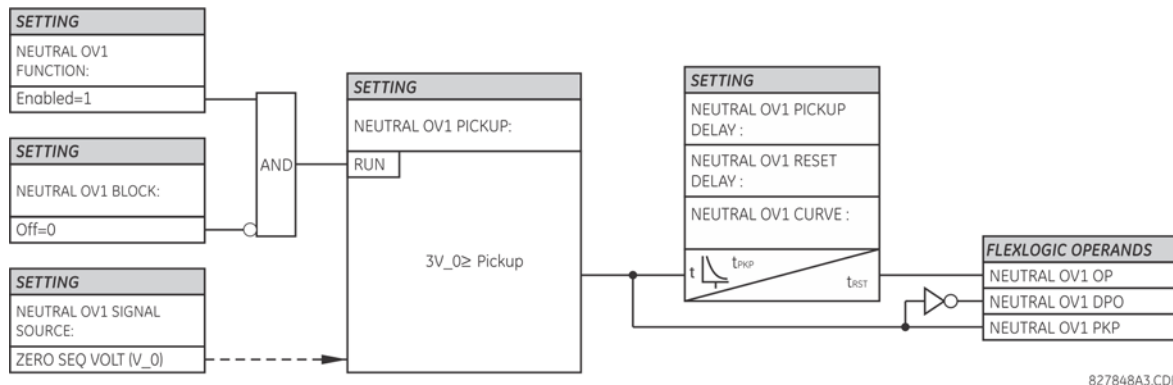
■ NEUTRAL OV1	↔	NEUTRAL OV1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	NEUTRAL OV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	⇅	NEUTRAL OV1 PICKUP: 0.300 pu	Range: 0.004 to 3.000 pu in steps of 0.001
	⇅	NEUTRAL OV1 CURVE: Definite Time	Range: Definite Time, FlexCurve A, FlexCurve B, FlexCurve C
	⇅	NEUTRAL OV1 PICKUP: DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇅	NEUTRAL OV1 RESET: DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇅	NEUTRAL OV1 BLOCK: Off	Range: FlexLogic operand
	⇅	NEUTRAL OV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	⇅	NEUTRAL OV1 EVENTS: Disabled	Range: Disabled, Enabled

There are three neutral overvoltage elements available. The neutral overvoltage element can be used to detect asymmetrical system voltage condition due to a ground fault or to the loss of one or two phases of the source. The element responds to the system neutral voltage ($3V_0$), calculated from the phase voltages. The nominal secondary voltage of the phase voltage channels entered under **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **AC INPUTS** ⇒ **VOLTAGE BANK** ⇒ **PHASE VT SECONDARY** is the p.u. base used when setting the pickup level.

The neutral overvoltage element can provide a time-delayed operating characteristic versus the applied voltage (initialized from FlexCurves A, B, or C) or be used as a definite time element. The **NEUTRAL OV1 PICKUP DELAY** setting applies only if the **NEUTRAL OV1 CURVE** setting is “Definite Time.” The source assigned to this element must be configured for a phase VT.

VT errors and normal voltage unbalance must be considered when setting this element. This function requires the VTs to be wye-connected.

Figure 5-131: Neutral overvoltage1 logic



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5.7.9.5 Negative sequence overvoltage (ANSI 59Q, IEC PTOV)

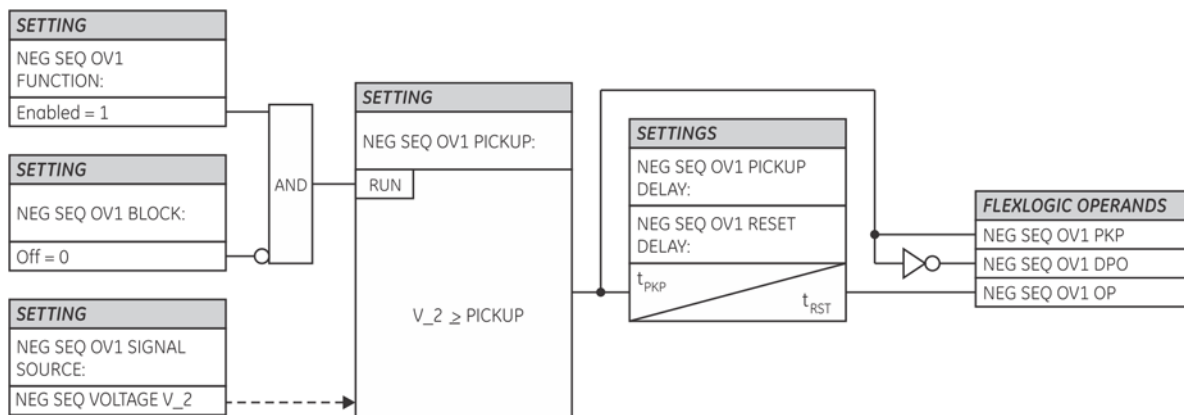
SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ VOLTAGE ELEMENTS ⇒ NEG SEQ OV1(3)

■ NEG SEQ OV1	↔	NEG SEQ OV1 FUNCTION: Disabled	Range: Disabled, Enabled
■	↕	NEG SEQ OV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	↕	NEG SEQ OV1 PICKUP: 0.300 pu	Range: 0.004 to 1.250 pu in steps of 0.001
	↕	NEG SEQ OV1 PICKUP DELAY: 0.50 s	Range: 0.00 to 600.00 s in steps of 0.01
	↕	NEG SEQ OV1 RESET DELAY: 0.50 s	Range: 0.00 to 600.00 s in steps of 0.01
	↕	NEG SEQ OV1 BLOCK: Off	Range: FlexLogic operand
	↕	NEG SEQ OV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	NEG SEQ OV1 EVENTS: Disabled	Range: Disabled, Enabled

There are three negative-sequence overvoltage elements available.

Use the negative-sequence overvoltage element to detect loss of one or two phases of the source, a reversed phase sequence of voltage, or a non-symmetrical system voltage condition.

Figure 5-132: Negative-sequence overvoltage logic



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5.7.9.6 Auxiliary undervoltage (ANSI 27X, IEC PTUV)

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ VOLTAGE ELEMENTS ⇒ AUXILIARY UV1(3)

■ AUXILIARY UV1	↔	AUX UV1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	AUX UV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	⇅	AUX UV1 PICKUP: 0.700 pu	Range: 0.004 to 3.000 pu in steps of 0.001
	⇅	AUX UV1 CURVE: Definite Time	Range: Definite Time, Inverse Time
	⇅	AUX UV1 DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇅	AUX UV1 MINIMUM: VOLTAGE: 0.100 pu	Range: 0.000 to 3.000 pu in steps of 0.001
	⇅	AUX UV1 BLOCK: Off	Range: FlexLogic operand
	⇅	AUX UV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	AUX UV1 EVENTS: Disabled	Range: Disabled, Enabled

The L30 contains one auxiliary undervoltage element for each VT bank. This element monitors undervoltage conditions of the auxiliary voltage.

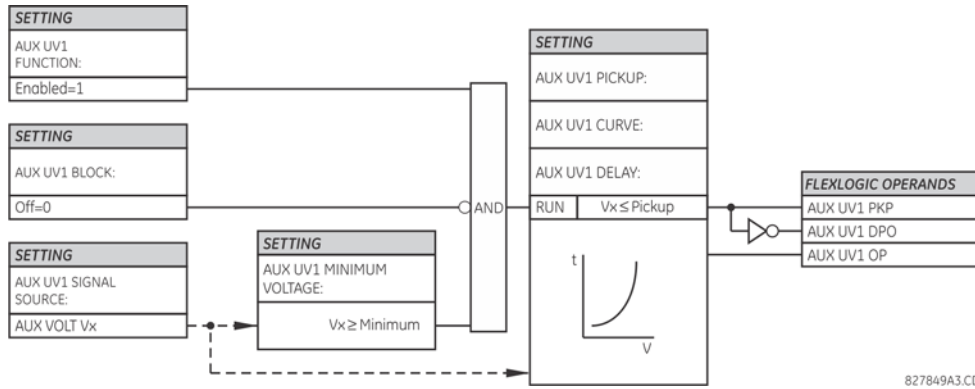
The **AUX UV1 PICKUP** selects the voltage level at which the time undervoltage element starts timing. The nominal secondary voltage of the auxiliary voltage channel entered under **SETTINGS ⇒ SYSTEM SETUP ⇒ AC INPUTS ⇒ VOLTAGE BANK X5 ⇒ AUXILIARY VT X5 SECONDARY** is the per-unit base used when setting the pickup level.

The **AUX UV1 DELAY** setting selects the minimum operating time of the auxiliary undervoltage element.

Both **AUX UV1 PICKUP** and **AUX UV1 DELAY** settings establish the operating curve of the undervoltage element. The auxiliary undervoltage element can be programmed to use either definite time delay or inverse time delay characteristics. The operating characteristics and equations for both definite and inverse time delay are as for the phase undervoltage element.

The element resets instantaneously. The minimum voltage setting selects the operating voltage below which the element is blocked.

Figure 5-133: Auxiliary undervoltage logic



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5.7.9.7 Auxiliary overvoltage (ANSI 59X, IEC PTOV)

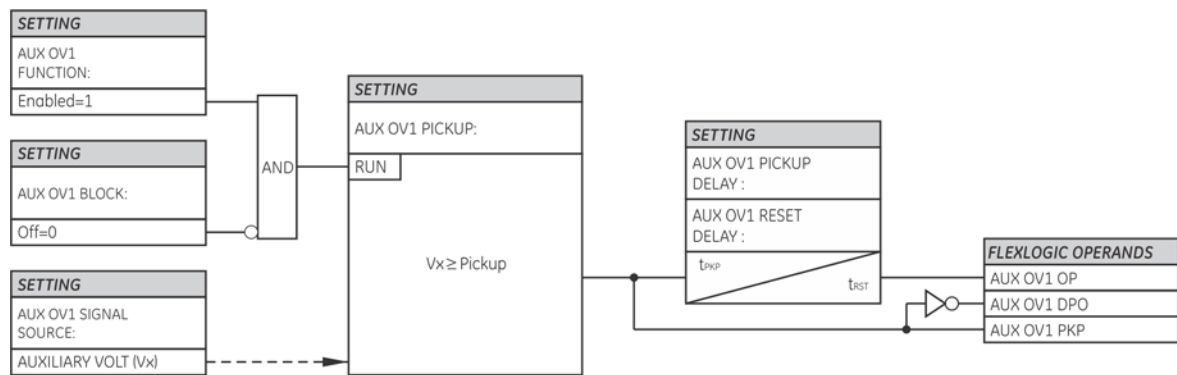
SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ VOLTAGE ELEMENTS ⇒ AUXILIARY OV1

<ul style="list-style-type: none"> ■ AUXILIARY OV1 ■ 	↔	AUX OV1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	AUX OV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	↕	AUX OV1 PICKUP: 0.300 pu	Range: 0.004 to 3.000 pu in steps of 0.001
	↕	AUX OV1 PICKUP DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	↕	AUX OV1 RESET DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	↕	AUX OV1 BLOCK: Off	Range: FlexLogic operand
	↕	AUX OV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	AUX OV1 EVENTS: Disabled	Range: Disabled, Enabled

The L30 contains one auxiliary overvoltage element for each VT bank. This element is intended for monitoring overvoltage conditions of the auxiliary voltage. The nominal secondary voltage of the auxiliary voltage channel entered under **SYSTEM SETUP ⇒ AC INPUTS ⇒ VOLTAGE BANK X5 ⇒ AUXILIARY VT X5 SECONDARY** is the per-unit (pu) base used when setting the pickup level.

A typical application for this element is monitoring the zero-sequence voltage (3V_0) supplied from an open-corner-delta VT connection.

Figure 5-134: Auxiliary overvoltage logic



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5.7.10 Supervising elements

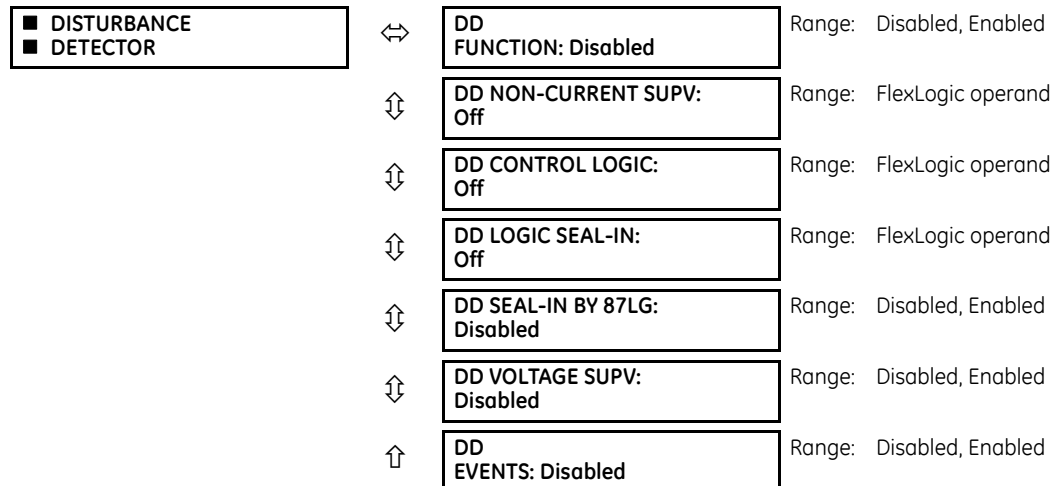
5.7.10.1 Menu

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ SUPERVISING ELEMENTS



5.7.10.2 Disturbance detector

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ SUPERVISING ELEMENTS ⇒ DISTURBANCE DETECTOR



The disturbance detector (50DD) element is an 87L-dedicated sensitive current disturbance detector that is used to detect any disturbance on the protected system. It is intended for such functions as trip output supervision and starting oscillography. The disturbance detector also signals the 87L function that a disturbance (possible fault) occurred and to resize the operating window to remove the pre-fault current. It is essential to have the disturbance detector enabled for applications where the 87L operating time is critical.

The disturbance detector function measures the magnitude of the negative-sequence current (I_{-2}), the magnitude of the zero-sequence current (I_{0}), the change in negative-sequence current (DI_{-2}), the change in zero-sequence current (DI_{0}), and the change in positive-sequence current (DI_{1}). The disturbance detector element uses net local current, computed as

a sum of all sources configured in the current differential element, to detect system disturbances. If the weak condition exists at one terminal, the voltage-based disturbance detector measures the changes in three-phase voltages (DVA, DVB, DVC).

The adaptive level detector operates as follows:

- When the absolute level increases above 0.12 pu for I_0 or I_2, the adaptive level detector output is active and the next highest threshold level is increased eight cycles later from 0.12 to 0.24 pu in steps of 0.02 pu. If the level exceeds 0.24 pu, the current adaptive level detector setting remains at 0.24 pu and the output remains active (as well as the disturbance detector output) when the measured value remains above the current setting.
- When the absolute level is decreasing from 0.24 to 0.12 pu, the lower level is set every eight cycles without the adaptive level detector active. Note that the 50DD output remains inactive during this change as long as the delta change is less than 0.04 pu.

The current delta level detectors (DI) detectors are designed to pick up for the 0.04 pu change in I_1, I_2, and I_0 currents. The DI value is measured by comparing the present value to the value calculated four cycles earlier.

The voltage delta level detectors (DV) are designed to pickup for the 0.1 pu change in any of three-phase voltages and the old voltage is greater than 0.8 pu. The DV value is measured by comparing the present value to the value calculated four cycles earlier.

The settings are explained as follows.

DD FUNCTION — This setting is used to enable/disable the operation of the disturbance detector.

DD NON-CURRENT SUPV — Selects a FlexLogic operand that activates the output of the disturbance detector upon events (such as frequency or voltage change) not accompanied by a current change.

DD CONTROL LOGIC — Used to prevent operation of I_0 and I_2 logic of disturbance detector during conditions such as single breaker pole being open that leads to unbalanced load current in single-pole tripping schemes. Breaker auxiliary contact can be used for such a scheme.

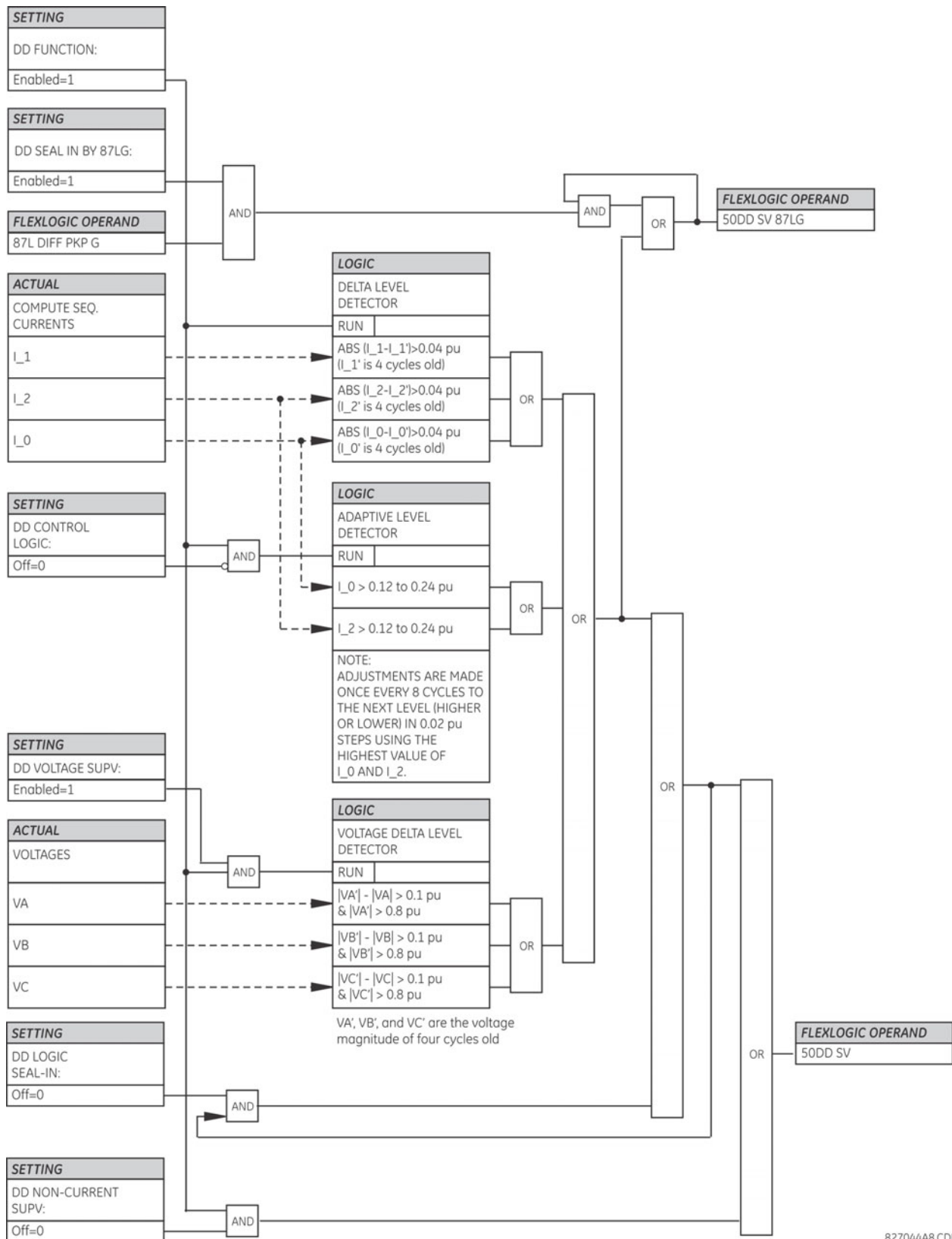
DD LOGIC SEAL-IN — Used to maintain disturbance detector output, 50DD SV, for such conditions as balanced three-phase fault and low level time overcurrent fault, whenever the disturbance detector might reset. 50DD SV is maintained until the chosen FlexLogic operand resets.

DD SEAL-IN BY 87LG — Used to seal-in the disturbance detector output, 50DD SV 87LG, especially for the 87LG element whenever the 50DD SV might reset before 87LG time delay elapses. 50DD SV 87LG is maintained until the 87L DIFF PKP G operand resets.

DD VOLTAGE SUPV — Used to enable the voltage-based disturbance detector for such applications as the weak condition exists at one terminal, where the weak-infeed current is not able to trigger the current-based disturbance detector. The voltage signals used for this detector are taken from the source assigned with the **CURRENT DIFF SIGNAL SOURCE 1** setting.

DD EVENTS — This setting can be disabled when the disturbance detector element responds to any current disturbance on the system that results in filling the events buffer and possible loss of valuable data.

Figure 5-135: Disturbance detector logic



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5.8 Control elements

5.8.1 Overview

Control elements are used for control rather than protection. See the Introduction to Elements section at the beginning of this chapter for information.

5.8.2 Trip bus

SETTINGS ⇒ CONTROL ELEMENTS ⇒ TRIP BUS ⇒ TRIP BUS 1(6)

<div style="border: 1px solid black; padding: 5px;"> <p>■ TRIP BUS 1</p> <p>■</p> </div>	↔	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1 FUNCTION: Disabled</p> </div>	Range: Enabled, Disabled	
	↕	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1 BLOCK: Off</p> </div>	Range: FlexLogic operand	
	↕	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1 PICKUP DELAY: 0.00 s</p> </div>	Range: 0.00 to 600.00 s in steps of 0.01	
	↕	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1 RESET DELAY: 0.00 s</p> </div>	Range: 0.00 to 600.00 s in steps of 0.01	
	↕	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1 INPUT 1: Off</p> </div>	Range: FlexLogic operand	
		↓		
	↕	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1 INPUT 16: Off</p> </div>	Range: FlexLogic operand	
	↕	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1 LATCHING: Disabled</p> </div>	Range: Enabled, Disabled	
	↕	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1 RESET: Off</p> </div>	Range: FlexLogic operand	
	↕	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1: TARGET: Self-reset</p> </div>	Range: Self-reset, Latched, Disabled	
↕	<div style="border: 1px solid black; padding: 5px;"> <p>TRIP BUS 1 EVENTS: Disabled</p> </div>	Range: Enabled, Disabled		

The trip bus element allows aggregating outputs of protection and control elements without using FlexLogic and assigning them a simple and effective manner. Each trip bus can be assigned for either trip or alarm actions. Simple trip conditioning such as latch, delay, and seal-in delay are available.

The easiest way to assign element outputs to a trip bus is through the EnerVista software under **Settings > Protection Summary**. Navigate to a specific protection or control protection element and check the bus box by hovering over the blank check box and selecting an option that displays. Once the required element is selected for a specific bus, a list of element operate-type operands are displayed and can be assigned to a trip bus. If more than one operate-type operand is required, it can be assigned directly from the trip bus menu.

Figure 5-136: Trip bus fields in the protection summary

GROUPED ELEMENTS	TB1	TB2	TB3	TB4	TB5	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6
Current Differential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Stub Bus	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Line Pickup	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase Distance Z 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase Distance Z 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase Distance Z 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Ground Distance Z 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Ground Distance Z 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Ground Distance Z 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Power Swing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Load Encroachment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled

The following settings are available.

TRIP BUS 1 BLOCK — The trip bus output is blocked when the operand assigned to this setting is asserted.

TRIP BUS 1 PICKUP DELAY — This setting specifies a time delay to produce an output depending on how output is used.

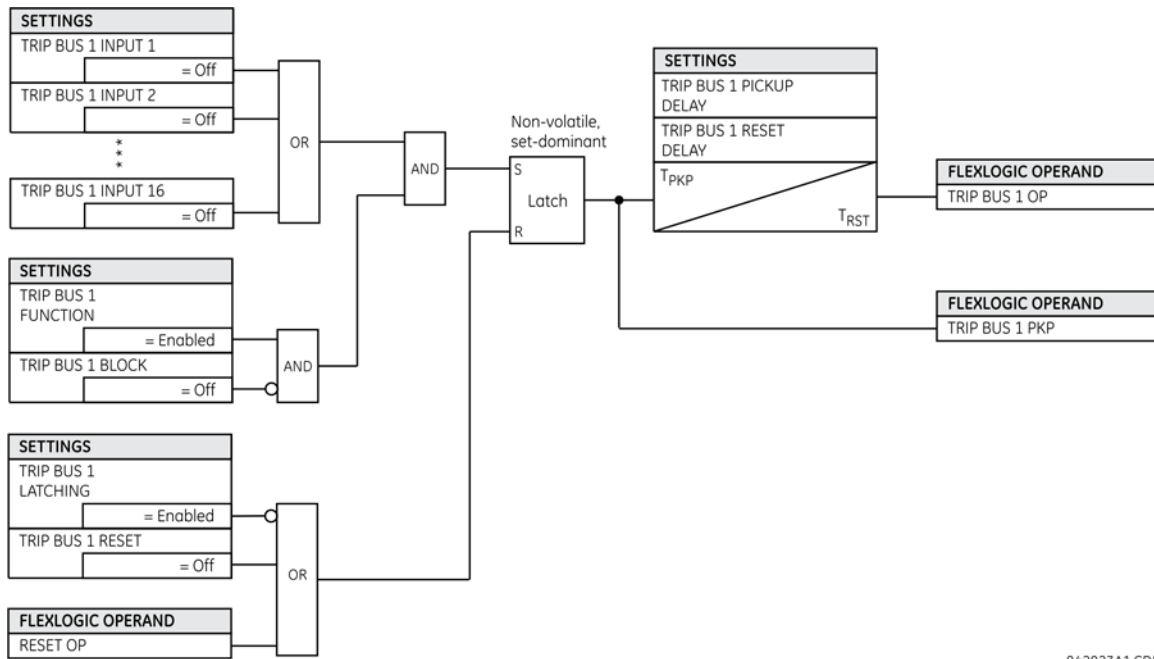
TRIP BUS 1 RESET DELAY — This setting specifies a time delay to reset an output command. Set the time delay long enough to allow the breaker or contactor to perform a required action.

TRIP BUS 1 INPUT 1 to TRIP BUS 1 INPUT 16 — These settings select a FlexLogic operand to be assigned as an input to the trip bus.

TRIP BUS 1 LATCHING — This setting enables or disables latching of the trip bus output. This is typically used when lockout is required or user acknowledgement of the relay response is required.

TRIP BUS 1 RESET — The trip bus output is reset when the operand assigned to this setting is asserted. Note that the [RESET OP](#) operand is pre-wired to the reset gate of the latch, As such, a reset command from the front panel interface or via communications resets the trip bus output.

Figure 5-137: Trip bus logic

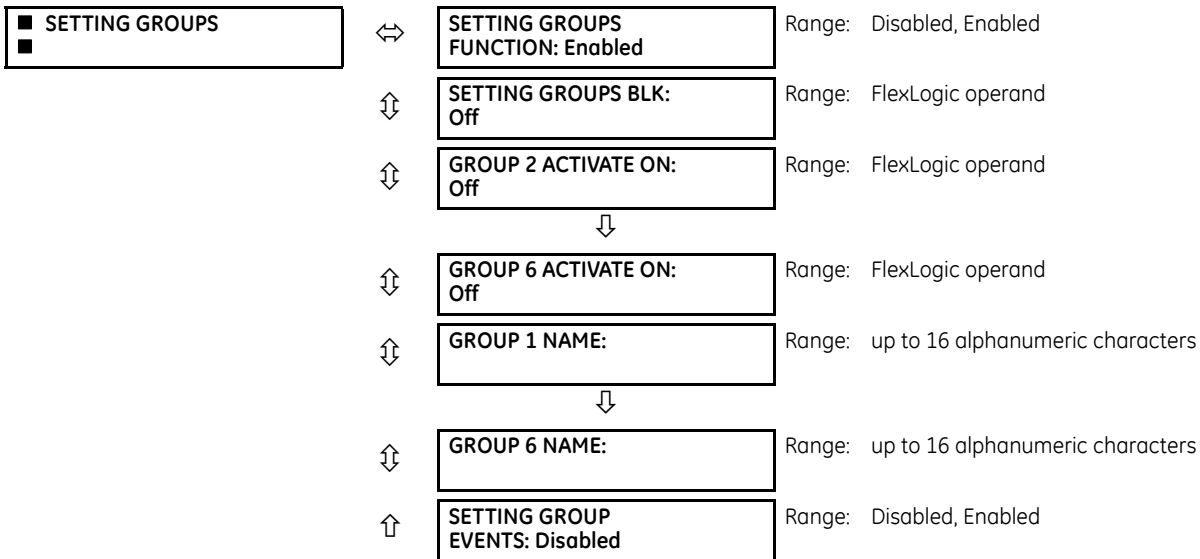


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5.8.3 Setting groups

SETTINGS ⇌ CONTROL ELEMENTS ⇌ SETTING GROUPS



The setting groups menu controls the activation and deactivation of up to six possible groups of settings in the **GROUPED ELEMENTS** settings menu. The active setting group can be indicated on the front display of the UR by configuring User-Programmable LEDs to display the state of the **SETTING GROUP ACT** FlexLogic operands.

SETTING GROUPS FUNCTION — When Enabled, allows setting groups other than group 1 (the default active group) to be activated. The default setting group is forced active while the **SETTING GROUPS FUNCTION** setting is Disabled.

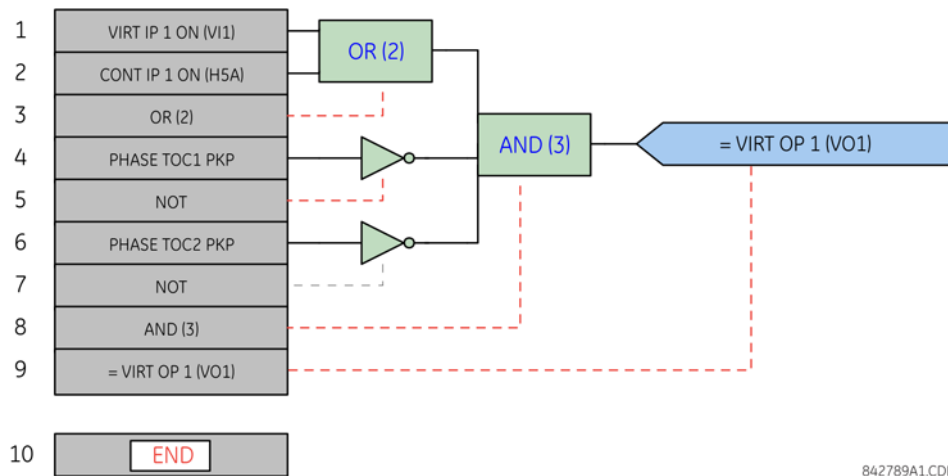
SETTING GROUPS BLK — Prevents the active setting group from changing when the selected FlexLogic operand is "On." This can be useful in applications where it is undesirable to change the settings under certain conditions, such as during a control sequence.

GROUP 2 ACTIVATE ON to GROUP 6 ACTIVATE ON — Selects a FlexLogic operand which, when set, makes the particular setting group active for use by any grouped element. A priority scheme ensures that only one group is active at a given time — the highest-numbered group that is activated by its **ACTIVATE ON** parameter takes priority over the lower-numbered groups. There is no activate on setting for group 1 (the default active group), because group 1 automatically becomes active if no other group is active.

SETTING GROUP 1 NAME to SETTING GROUP 6 NAME — Allows the user to assign a name to each of the six settings groups. Once programmed, this name appears on the second line of the **GROUPED ELEMENTS ⇒ SETTING GROUP 1(6)** menu display.

The relay can be set up via a FlexLogic equation to receive requests to activate or de-activate a particular non-default settings group. The following FlexLogic equation (see the following figure) illustrates requests via remote communications (for example, **VIRTUAL INPUT 1 ON**) or from a local contact input (for example, **CONTACT IP 1 ON**) to initiate the use of a particular settings group, and requests from several overcurrent pickup measuring elements to inhibit the use of the particular settings group. The assigned **VIRTUAL OUTPUT 1** operand is used to control the “On” state of a particular settings group.

Figure 5-138: Example of FlexLogic control of a setting group



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A setting group selection can also be made by the IEC 61850 MMS service SelectActiveSG to the control block @Master/LLN0.SGCB. The priority scheme mentioned makes active the highest numbered group selected by SelectActiveSG or the **GROUP ACTIVATE ON** settings. The SelectActiveSG selection has a default value of 1, so until a higher SelectActiveSG selection is received, the **GROUP ACTIVATE ON** settings control the active group.

The most recent SelectActiveSG selection is preserved while the UR is powered down or reset.

If it becomes necessary to cancel the SelectActiveSG selection without using a SelectActiveSG service request, change the **SETTING GROUPS FUNCTION** setting to Disabled. This resets the SelectActiveSG selection to 1.

5.8.4 Selector switch

SETTINGS ⇒ CONTROL ELEMENTS ⇒ SELECTOR SWITCH ⇒ SELECTOR SWITCH 1(2)

<div style="border: 1px solid black; padding: 2px;"> ■ SELECTOR SWITCH 1 ■ </div>	↔	<div style="border: 1px solid black; padding: 2px;"> SELECTOR 1 FUNCTION: Disabled </div>	Range: Disabled, Enabled
	⇕	<div style="border: 1px solid black; padding: 2px;"> SELECTOR 1 FULL RANGE: 7 </div>	Range: 1 to 7 in steps of 1
	⇕	<div style="border: 1px solid black; padding: 2px;"> SELECTOR 1 TIME-OUT: 5.0 s </div>	Range: 3.0 to 60.0 s in steps of 0.1
	⇕	<div style="border: 1px solid black; padding: 2px;"> SELECTOR 1 STEP-UP: Off </div>	Range: FlexLogic operand
	⇕	<div style="border: 1px solid black; padding: 2px;"> SELECTOR 1 STEP-UP MODE: Time-out </div>	Range: Time-out, Acknowledge

⇅	SELECTOR 1 ACK: Off	Range: FlexLogic operand
⇅	SELECTOR 1 3BIT A0: Off	Range: FlexLogic operand
⇅	SELECTOR 1 3BIT A1: Off	Range: FlexLogic operand
⇅	SELECTOR 1 3BIT A2: Off	Range: FlexLogic operand
⇅	SELECTOR 1 3BIT MODE: Time-out	Range: Time-out, Acknowledge
⇅	SELECTOR 1 3BIT ACK: Off	Range: FlexLogic operand
⇅	SELECTOR 1 POWER-UP MODE: Restore	Range: Restore, Synchronize, Sync/Restore
⇅	SELECTOR 1 TARGETS: Self-reset	Range: Self-reset, Latched, Disabled
↑	SELECTOR 1 EVENTS: Disabled	Range: Disabled, Enabled

The selector switch element is intended to replace a mechanical selector switch. Typical applications include setting group control or control of multiple logic sub-circuits in user-programmable logic.

The element provides for two control inputs. The step-up control allows stepping through selector position one step at a time with each pulse of the control input, such as a user-programmable pushbutton. The three-bit control input allows setting the selector to the position defined by a three-bit word.

The element allows pre-selecting a new position without applying it. The pre-selected position gets applied either after time-out or upon acknowledgement via separate inputs (user setting). The selector position is stored in non-volatile memory. Upon power-up, either the previous position is restored or the relay synchronizes to the current three-bit word (user setting). Basic alarm functionality alerts the user under abnormal conditions; for example, the three-bit control input being out of range.

A selector switch runs every two power cycles.

SELECTOR 1 FULL RANGE — This setting defines the upper position of the selector. When stepping up through available positions of the selector, the upper position wraps up to the lower position (position 1). When using a direct three-bit control word for programming the selector to a desired position, the change would take place only if the control word is within the range of 1 to the **SELECTOR FULL RANGE**. If the control word is outside the range, an alarm is established by setting the **SELECTOR ALARM** FlexLogic operand for three seconds.

SELECTOR 1 TIME-OUT — This setting defines the time-out period for the selector. This value is used by the relay in the following two ways. When the **SELECTOR STEP-UP MODE** is “Time-out,” the setting specifies the required period of inactivity of the control input after which the pre-selected position is automatically applied. When the **SELECTOR STEP-UP MODE** is “Acknowledge,” the setting specifies the period of time for the acknowledging input to appear. The timer is re-started by any activity of the control input. The acknowledging input must come before the **SELECTOR 1 TIME-OUT** timer expires; otherwise, the change does not take place and an alarm is set.

SELECTOR 1 STEP-UP — This setting specifies a control input for the selector switch. The switch is shifted to a new position at each rising edge of this signal. The position changes incrementally, wrapping up from the last (**SELECTOR 1 FULL RANGE**) to the first (position 1). Consecutive pulses of this control operand must not occur faster than every 50 ms. After each rising edge of the assigned operand, the time-out timer is restarted and the **SELECTOR SWITCH 1: POS Z CHNG INITIATED** target message is displayed, where Z the pre-selected position. The message is displayed for the time specified by the **FLASH MESSAGE TIME** setting. The pre-selected position is applied after the selector times out (“Time-out” mode), or when the acknowledging signal appears before the element times out (“Acknowledge” mode). When the new position is applied, the relay displays the **SELECTOR SWITCH 1: POSITION Z IN USE** message. Typically, a user-programmable pushbutton is configured as the stepping up control input.

SELECTOR 1 STEP-UP MODE — This setting defines the selector mode of operation. When set to “Time-out,” the selector changes its position after a pre-defined period of inactivity at the control input. The change is automatic and does not require any explicit confirmation of the intent to change the selector’s position. When set to “Acknowledge,” the selector changes its position only after the intent is confirmed through a separate acknowledging signal. If the acknowledging signal does not appear within a pre-defined period of time, the selector does not accept the change and an alarm is established by setting the **SELECTOR STP ALARM** output FlexLogic operand for three seconds.

SELECTOR 1 ACK — This setting specifies an acknowledging input for the stepping up control input. The pre-selected position is applied on the rising edge of the assigned operand. This setting is active only under “Acknowledge” mode of operation. The acknowledging signal must appear within the time defined by the **SELECTOR 1 TIME-OUT** setting after the last activity of the control input. A user-programmable pushbutton is typically configured as the acknowledging input.

SELECTOR 1 3BIT A0, A1, and A2 — These settings specify a three-bit control input of the selector. The three-bit control word pre-selects the position using the following encoding convention:

A2	A1	A0	Position
0	0	0	rest
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

The “rest” position (0, 0, 0) does not generate an action and is intended for situations when the device generating the three-bit control word is having a problem. When **SELECTOR 1 3BIT MODE** is “Time-out,” the pre-selected position is applied in **SELECTOR 1 TIME-OUT** seconds after the last activity of the three-bit input. When **SELECTOR 1 3BIT MODE** is “Acknowledge,” the pre-selected position is applied on the rising edge of the **SELECTOR 1 3BIT ACK** acknowledging input.

The stepping up control input (**SELECTOR 1 STEP-UP**) and the three-bit control inputs (**SELECTOR 1 3BIT A0** through **A2**) lock-out mutually: once the stepping up sequence is initiated, the three-bit control input is inactive; once the three-bit control sequence is initiated, the stepping up input is inactive.

SELECTOR 1 3BIT MODE — This setting defines the selector mode of operation. When set to “Time-out,” the selector changes its position after a pre-defined period of inactivity at the control input. The change is automatic and does not require explicit confirmation to change the selector position. When set to “Acknowledge,” the selector changes its position only after confirmation via a separate acknowledging signal. If the acknowledging signal does not appear within a pre-defined period of time, the selector rejects the change and an alarm established by invoking the **SELECTOR BIT ALARM** FlexLogic operand for three seconds.

SELECTOR 1 3BIT ACK — This setting specifies an acknowledging input for the three-bit control input. The pre-selected position is applied on the rising edge of the assigned FlexLogic operand. This setting is active only under the “Acknowledge” mode of operation. The acknowledging signal must appear within the time defined by the **SELECTOR TIME-OUT** setting after the last activity of the three-bit control inputs. Note that the stepping up control input and three-bit control input have independent acknowledging signals (**SELECTOR 1 ACK** and **SELECTOR 1 3BIT ACK**, accordingly).

SELECTOR 1 POWER-UP MODE — This setting specifies the element behavior on power up of the relay.

When set to “Restore,” the last position of the selector (stored in the non-volatile memory) is restored after powering up the relay. If the position restored from memory is out of range, position 0 (no output operand selected) is applied and an alarm is set (**SELECTOR 1 PWR ALARM**).

When set to “Synchronize,” the selector switch acts as follows. For two power cycles, the selector applies position 0 to the switch and activates **SELECTOR 1 PWR ALARM**. After two power cycles expire, the selector synchronizes to the position dictated by the three-bit control input. This operation does not wait for time-out or the acknowledging input. When the synchronization attempt is unsuccessful (that is, the three-bit input is not available (0,0,0) or out of range), then the selector switch output is set to position 0 (no output operand selected) and an alarm is established (**SELECTOR 1 PWR ALARM**).

The operation of “Synch/Restore” mode is similar to the “Synchronize” mode. The only difference is that after an unsuccessful synchronization attempt, the switch attempts to restore the position stored in the relay memory. The “Synch/Restore” mode is useful for applications where the selector switch is employed to change the setting group in redundant (two relay) protection schemes.

SELECTOR 1 EVENTS — If enabled, the following events are logged:

Event name	Description
SELECTOR 1 POS Z	Selector 1 changed its position to Z
SELECTOR 1 STP ALARM	The selector position pre-selected via the stepping up control input has not been confirmed before the time out
SELECTOR 1 BIT ALARM	The selector position pre-selected via the three-bit control input has not been confirmed before the time out

The following figures illustrate the operation of the selector switch. In these diagrams, “T” represents a time-out setting.

Figure 5-139: Time-out mode

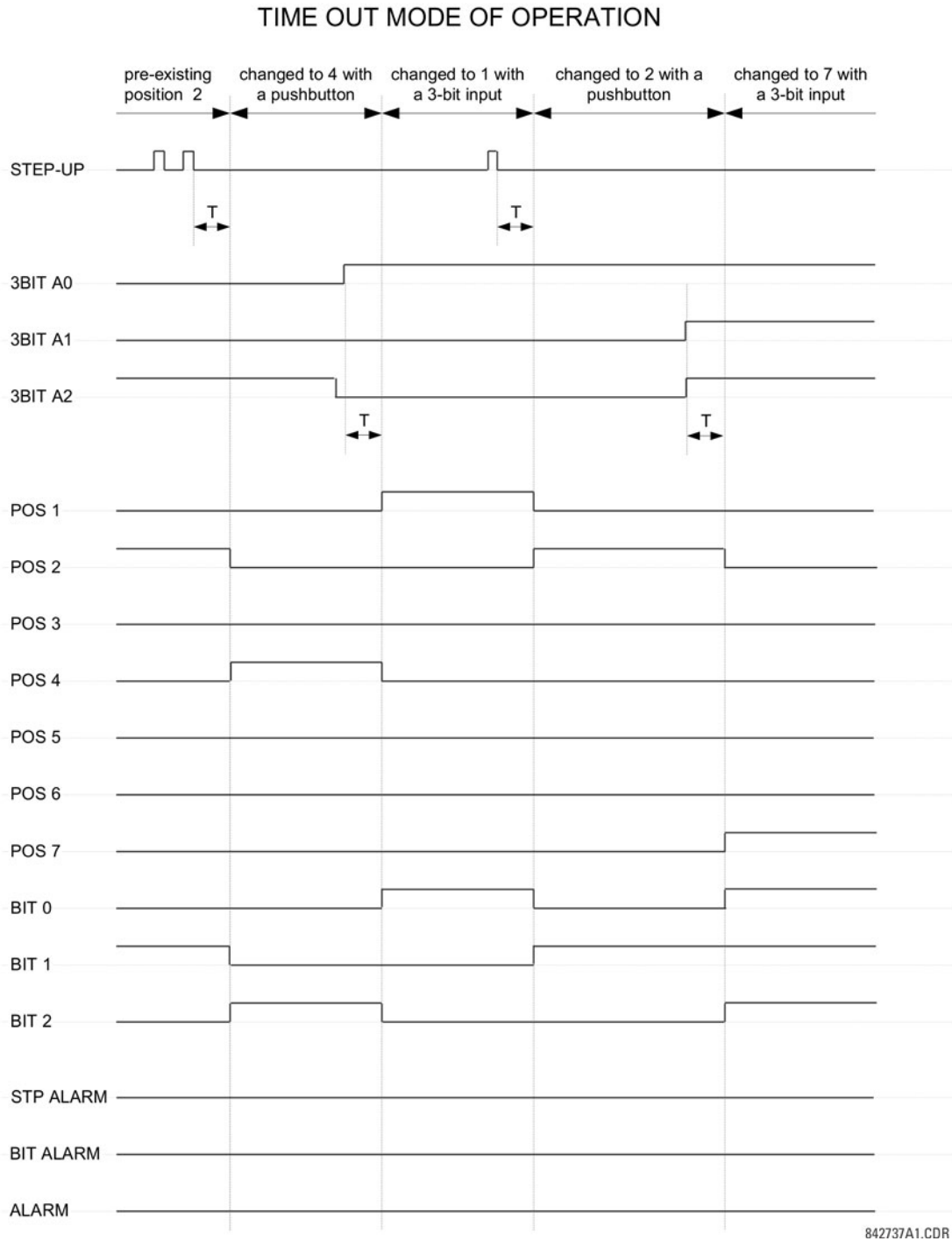
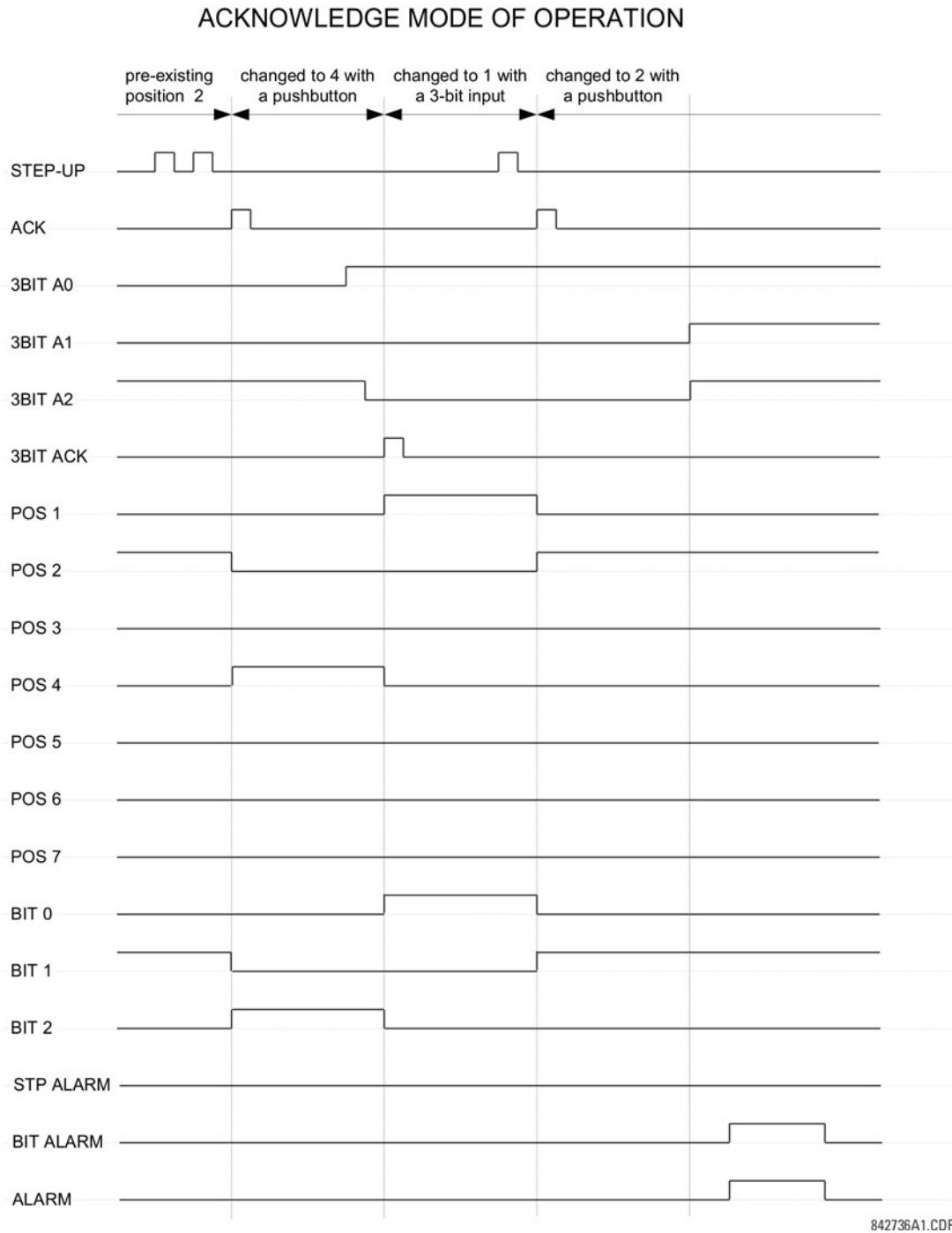


Figure 5-140: Acknowledge mode



5

Application example

Consider an application where the selector switch is used to control setting groups 1 through 4 in the relay. The setting groups are to be controlled from both user-programmable pushbutton 1 and from an external device via contact inputs 1 through 3. The active setting group is to be available as an encoded three-bit word to the external device and SCADA via output contacts 1 through 3. The pre-selected setting group is to be applied automatically after five seconds of inactivity of the control inputs. When the relay powers up, it is to synchronize the setting group to the three-bit control input.

Make the following changes to setting group control in the **SETTINGS** ⇒ **CONTROL ELEMENTS** ⇒ **SETTING GROUPS** menu:

SETTING GROUPS FUNCTION: "Enabled"
SETTING GROUPS BLK: "Off"
GROUP 2 ACTIVATE ON: "SELECTOR 1 POS 2"
GROUP 3 ACTIVATE ON: "SELECTOR 1 POS 3"
GROUP 4 ACTIVATE ON: "SELECTOR 1 POS 4"
GROUP 5 ACTIVATE ON: "Off"
GROUP 6 ACTIVATE ON: "Off"

Make the following changes to selector switch element in the **SETTINGS** ⇒ **CONTROL ELEMENTS** ⇒ **SELECTOR SWITCH** ⇒ **SELECTOR SWITCH 1** menu to assign control to user programmable pushbutton 1 and contact inputs 1 through 3:

SELECTOR 1 FUNCTION: "Enabled"
SELECTOR 1 FULL-RANGE: "4"
SELECTOR 1 STEP-UP MODE: "Time-out"
SELECTOR 1 TIME-OUT: "5.0 s"
SELECTOR 1 STEP-UP: "PUSHBUTTON 1 ON"
SELECTOR 1 ACK: "Off"
SELECTOR 1 3BIT A0: "CONT IP 1 ON"
SELECTOR 1 3BIT A1: "CONT IP 2 ON"
SELECTOR 1 3BIT A2: "CONT IP 3 ON"
SELECTOR 1 3BIT MODE: "Time-out"
SELECTOR 1 3BIT ACK: "Off"
SELECTOR 1 POWER-UP MODE: "Synchronize"

Now, assign the contact output operation (assume the H6E module) to the selector switch element by making the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **CONTACT OUTPUTS** menu:

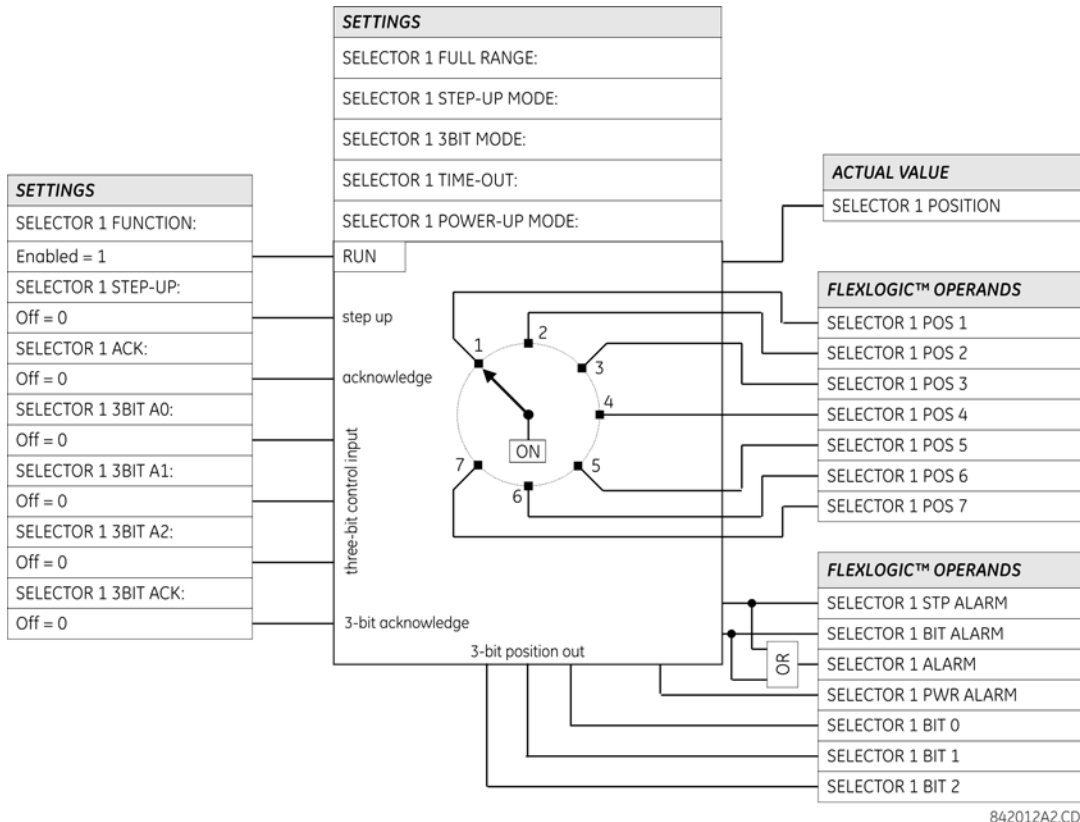
OUTPUT H1 OPERATE: "SELECTOR 1 BIT 0"
OUTPUT H2 OPERATE: "SELECTOR 1 BIT 1"
OUTPUT H3 OPERATE: "SELECTOR 1 BIT 2"

Finally, assign configure user-programmable pushbutton 1 by making the following changes in the **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **USER-PROGRAMMABLE PUSHBUTTONS** ⇒ **USER PUSHBUTTON 1** menu:

PUSHBUTTON 1 FUNCTION: "Self-reset"
PUSHBUTTON 1 DROP-OUT TIME: "0.10 s"

The figure shows the logic for the selector switch.

Figure 5-141: Selector switch logic



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5.8.5 Underfrequency (ANSI 81U)

SETTINGS ⇄ CONTROL ELEMENTS ⇄ UNDERFREQUENCY ⇄ UNDERFREQUENCY 1(6)

<div style="border: 1px solid black; padding: 2px;"> ■ UNDERFREQUENCY 1 </div>	⇄	<div style="border: 1px solid black; padding: 2px;"> UNDFREQ 1 FUNCTION: Disabled </div>	Range: Disabled, Enabled
	⇄	<div style="border: 1px solid black; padding: 2px;"> UNDFREQ 1 BLOCK: Off </div>	Range: FlexLogic operand
	⇄	<div style="border: 1px solid black; padding: 2px;"> UNDFREQ 1 SOURCE: SRC 1 </div>	Range: SRC 1, SRC 2
	⇄	<div style="border: 1px solid black; padding: 2px;"> UNDFREQ 1 MIN VOLT/AMP: 0.10 pu </div>	Range: 0.10 to 1.25 pu in steps of 0.01
	⇄	<div style="border: 1px solid black; padding: 2px;"> UNDFREQ 1 PICKUP: 59.50 Hz </div>	Range: 20.00 to 65.00 Hz in steps of 0.01
	⇄	<div style="border: 1px solid black; padding: 2px;"> UNDFREQ 1 PICKUP DELAY: 2.000 s </div>	Range: 0.000 to 65.535 s in steps of 0.001
	⇄	<div style="border: 1px solid black; padding: 2px;"> UNDFREQ 1 RESET DELAY : 2.000 s </div>	Range: 0.000 to 65.535 s in steps of 0.001
	⇄	<div style="border: 1px solid black; padding: 2px;"> UNDFREQ 1 TARGET: Self-reset </div>	Range: Self-reset, Latched, Disabled
	⇄	<div style="border: 1px solid black; padding: 2px;"> UNDFREQ 1 EVENTS: Disabled </div>	Range: Disabled, Enabled

There are six identical underfrequency elements, numbered 1 through 6.

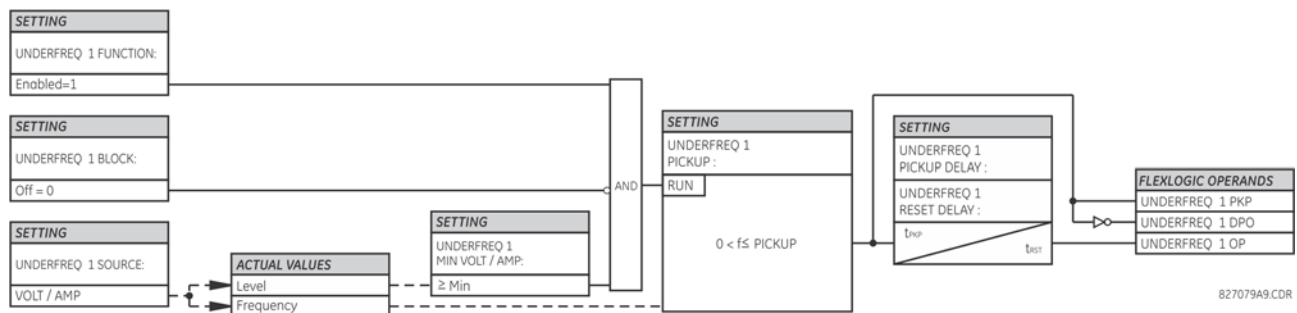
The steady-state frequency of a power system is a certain indicator of the existing balance between the generated power and the load. Whenever this balance is disrupted through the loss of an important generating unit or the isolation of part of the system from the rest of the system, the effect is a reduction in frequency. If the control systems of the system generators do not respond fast enough, the system can collapse. A reliable method to quickly restore the balance between load and generation is to automatically disconnect selected loads, based on the actual system frequency. This technique, called “load-shedding,” maintains system integrity and minimize widespread outages. After the frequency returns to normal, the load can be restored automatically or manually.

UNDERFREQ 1 SOURCE — This setting is used to select the source for the signal to be measured. The element first checks for a live phase voltage available from the selected source. If voltage is not available, the element attempts to use a phase current. If neither voltage nor current is available, the element does not operate, as it does not measure a parameter below the minimum voltage/current setting.

UNDERFREQ 1 MIN VOLT/AMP — Selects the minimum per unit voltage or current level required to allow the underfrequency element to operate. This threshold is used to prevent an incorrect operation because there is no signal to measure.

UNDERFREQ 1 PICKUP — Selects the level at which the underfrequency element is to pickup. For example, if the system frequency is 60 Hz and the load shedding is required at 59.5 Hz, the setting is 59.50 Hz.

Figure 5-142: Underfrequency logic



5.8.6 Frequency rate of change (ANSI 81R)

SETTINGS ⇌ CONTROL ELEMENTS ⇌ FREQUENCY RATE OF CHANGE ⇌ FREQUENCY RATE OF CHANGE 1(2)

■ FREQUENCY RATE OF CHANGE 1	⇌	FREQ RATE 1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇌	FREQ RATE 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
	⇌	FREQ RATE 1 TREND: Increasing	Range: Increasing, Decreasing, Bi-directional
	⇌	FREQ RATE 1 PICKUP: 0.50 Hz/sec	Range: 0.10 to 15.00 Hz/sec in steps of 0.01
	⇌	FREQ RATE 1 OV SUPV PICKUP: 0.700 pu	Range: 0.100 to 3.000 pu in steps of 0.001
	⇌	FREQ RATE 1 OC SUPV PICKUP: 0.200 pu	Range: 0.020 to 30.000 pu in steps of 0.001
	⇌	FREQ RATE 1 MIN FREQUENCY: 45.00 Hz	Range: 20.00 to 80.00 Hz in steps of 0.01
	⇌	FREQ RATE 1 MAX FREQUENCY: 65.00 Hz	Range: 20.00 to 80.00 Hz in steps of 0.01
	⇌	FREQ RATE 1 PICKUP DELAY: 0.000 s	Range: 0 to 65.535 s in steps of 0.001
	⇌	FREQ RATE 1 RESET DELAY: 0.000 s	Range: 0 to 65.535 s in steps of 0.001

↕	FREQ RATE 1 BLOCK: Off	Range: FlexLogic operand
↕	FREQ RATE 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↑	FREQ RATE 1 EVENTS: Disabled	Range: Disabled, Enabled

The element responds to rate of change of frequency with voltage, current and frequency supervision.

FREQ RATE 1 TREND — This setting configures the element to respond to increasing or decreasing frequency, or to frequency change in either direction.

FREQ RATE 1 PICKUP — This setting specifies an intended df/dt pickup threshold. For applications monitoring a decreasing trend, set **FREQ RATE 1 TREND** to “Decreasing” and specify the pickup threshold accordingly. The operating condition is: $-df/dt > \text{Pickup}$.

For applications monitoring an increasing trend, set **FREQ RATE 1 TREND** to “Increasing” and specify the pickup threshold accordingly. The operating condition is: $df/dt > \text{Pickup}$.

For applications monitoring rate of change of frequency in any direction set **FREQ RATE 1 TREND** to “Bi-Directional” and specify the pickup threshold accordingly. The operating condition is: $\text{abs}(df/dt) > \text{Pickup}$.

FREQ RATE 1 OV SUPV PICKUP — This setting defines the minimum voltage level required for operation of the element. The supervising function responds to the positive-sequence voltage. Use overvoltage supervision to prevent operation under specific system conditions, such as faults.

FREQ RATE 1 OC SUPV PICKUP — This setting defines minimum current level required for operation of the element. The supervising function responds to the positive-sequence current. Typical application includes load shedding. Set the pickup threshold to 0.020 if no overcurrent supervision is required.

FREQ RATE 1 MIN FREQUENCY — This setting defines the minimum frequency level required for operation of the element. The setting can be used to effectively block the feature based on frequency. For example, if the intent is to monitor an increasing trend but only if the frequency is already above certain level, set this setting to the required frequency level.

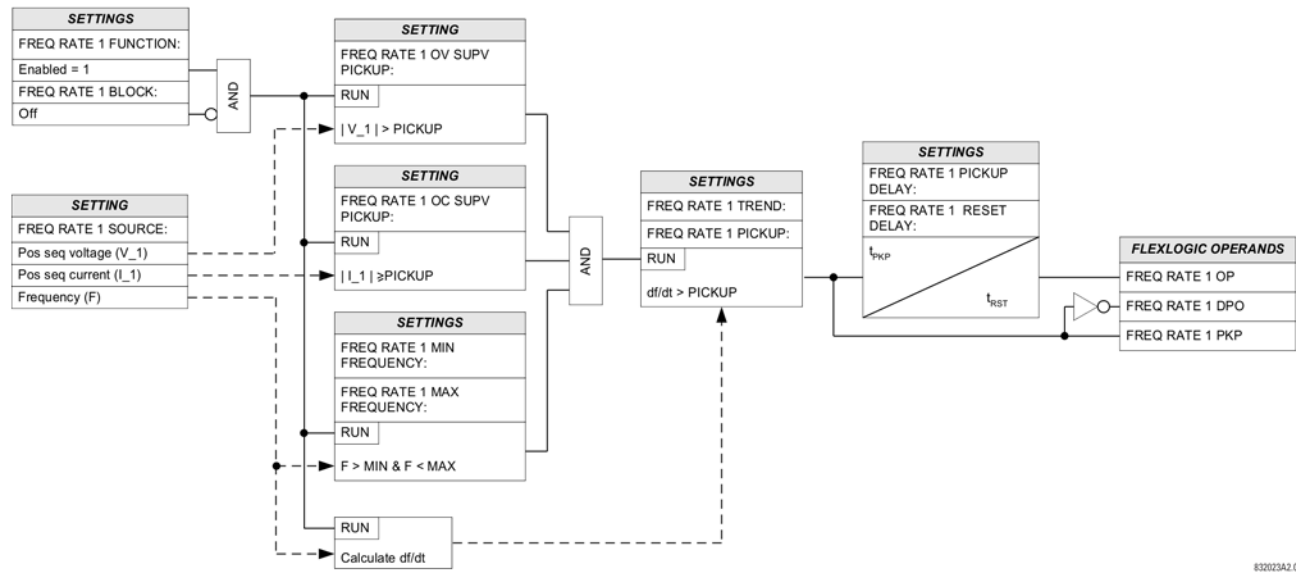
FREQ RATE 1 MAX FREQUENCY — This setting defines the maximum frequency level required for operation of the element. The setting can be used to effectively block the feature based on frequency. For example, if the intent is to monitor a decreasing trend but only if the frequency is already below a certain level (such as for load shedding), set this setting to the required frequency level.



If the signal source assigned to the frequency rate of change element is only set to auxiliary VT, then the minimum voltage supervision is 3 V.

NOTE

Figure 5-143: Frequency rate of change logic



5.8.7 Synchrocheck (ANSI 25)

SETTINGS ⇨ CONTROL ELEMENTS ⇨ SYNCHROCHECK ⇨ SYNCHROCHECK 1(4)

<div style="border: 1px solid black; padding: 2px;"> <input checked="" type="checkbox"/> SYNCHROCHECK 1 </div>	⇔	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 FUNCTION: Disabled </div>	Range: Disabled, Enabled
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 BLOCK: Off </div>	Range: FlexLogic operand
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 V1 SOURCE: SRC 1 </div>	Range: SRC 1, SRC 2
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 V2 SOURCE: SRC 2 </div>	Range: SRC 1, SRC 2
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 MAX VOLT DIFF: 10000 V </div>	Range: 0 to 400000 V in steps of 1
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 MAX ANGLE DIFF: 30° </div>	Range: 0 to 100° in steps of 1
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 MAX FREQ DIFF: 1.00 Hz </div>	Range: 0.00 to 2.00 Hz in steps of 0.01
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 MAX FREQ HYSTERESIS: 0.06 Hz </div>	Range: 0.00 to 0.10 Hz in steps of 0.01
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 SYNC CLOSE: Off </div>	Range: FlexLogic operand
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 S-CLS MAX dF: 0.50 Hz </div>	Range: 0.10 to 2.00 Hz in steps of 0.01
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 S-CLS MIN dF: 0.10 Hz </div>	Range: 0.01 to 1.00 Hz in steps of 0.01
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 S-CLS BRK TIME: 0.035 s </div>	Range: 0.010 to 0.500 s in steps of 0.001
	⇕	<div style="border: 1px solid black; padding: 2px;"> SYNCHK1 V2 MAG CORR FACTOR: 1.00 </div>	Range: 0.10 to 10.00 in steps of 0.01

⇅	SYNCHK1 V2 ANGLE SHIFT: 0	Range: -180 to +180 degrees in steps of 1
⇅	SYNCHK1 DEAD SOURCE SELECT: LV1 and DV2	Range: None, LV1 and DV2, DV1 and LV2, DV1 or DV2, DV1 Xor DV2, DV1 and DV2
⇅	SYNCHK1 DEAD V1 MAX VOLT: 0.30 pu	Range: 0.04 to 1.25 pu in steps of 0.01
⇅	SYNCHK1 DEAD V2 MAX VOLT: 0.30 pu	Range: 0.04 to 1.25 pu in steps of 0.01
⇅	SYNCHK1 LIVE V1 MIN VOLT: 0.70 pu	Range: 0.04 to 1.25 pu in steps of 0.01
⇅	SYNCHK1 LIVE V2 MIN VOLT: 0.70 pu	Range: 0.04 to 1.25 pu in steps of 0.01
⇅	SYNCHK1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↑	SYNCHK1 EVENTS: Disabled	Range: Disabled, Enabled

The synchronism check function supervises the paralleling of two parts of a system that are to be joined by the closure of a circuit breaker. The synchrocheck elements are typically used at locations where the two parts of the system are interconnected through at least one other point in the system.

Synchrocheck verifies that the voltages (V1 and V2) on the two sides of the supervised circuit breaker are within set limits of magnitude, angle, and frequency differences. The time that the two voltages remain within the admissible angle difference is determined by the setting of the phase angle difference $\Delta\Phi$ and the frequency difference ΔF (slip frequency). It can be defined as the time it takes the voltage phasor V1 or V2 to traverse an angle equal to $2 \times \Delta\Phi$ at a frequency equal to the frequency difference ΔF . This time is calculated by:

$$T = \frac{1}{\frac{360^\circ}{2 \times \Delta\Phi} \times \Delta F} \quad \text{Eq. 5-27}$$

where

$\Delta\Phi$ is phase angle difference in degrees

ΔF is frequency difference in Hz

If one or both sources are de-energized, the synchrocheck programming can allow for closing of the circuit breaker using undervoltage control to bypass the synchrocheck measurements (dead source function).

SYNCHK1 V1 SOURCE — This setting selects the source for voltage V1 (see the Notes section that follows).

SYNCHK1 V2 SOURCE — Selects the source for voltage V2, which must not be the same as used for the V1 (see Notes).

SYNCHK1 MAX VOLT DIFF — Selects the maximum primary voltage difference in volts between the two sources. A primary voltage magnitude difference between the two input voltages below this value is within the permissible limit for synchronism.

SYNCHK1 MAX ANGLE DIFF — Selects the maximum angular difference in degrees between the two sources. An angular difference between the two input voltage phasors below this value is within the permissible limit for synchronism.

SYNCHK1 MAX FREQ HYSTERESIS — Specifies the required hysteresis for the maximum frequency difference condition. The condition becomes satisfied when the frequency difference becomes lower than **SYNCHK1 MAX FREQ DIFF**. Once the Synchrocheck element has operated, the frequency difference must increase above the **SYNCHK1 MAX FREQ DIFF + SYNCHK1 MAX FREQ HYSTERESIS** sum to drop out (assuming the other two conditions, voltage and angle, remain satisfied).

SYNCHK1 SYNC CLOSE — Enables the dynamic mode of synchrocheck. When it is enabled, the location of where the present V2 vector will be arriving to synchronize (shown as V2' in the figures here) with breaker close time being taken into account will be predicted based on the measured slip frequency so that breaker close command can be issued in advance to ensure the synchronism at the time when the breaker is actually closed.

Figure 5-144: Synchrocheck plot for slip > 0 (slip = F2-F1)

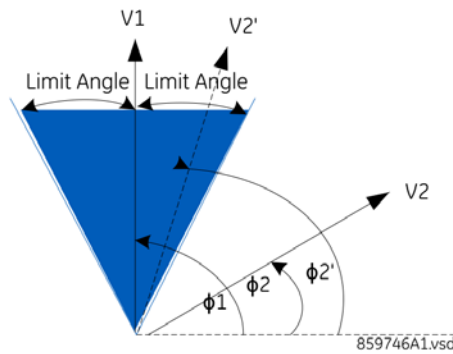
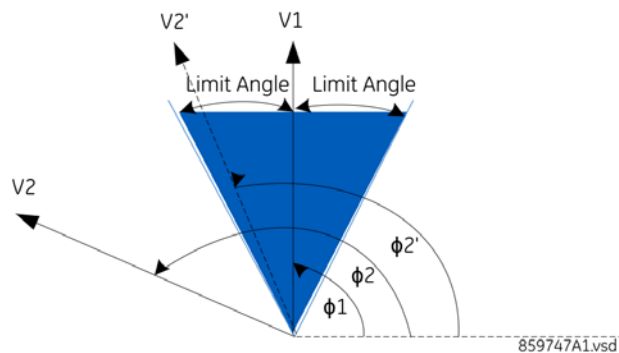


Figure 5-145: Synchrocheck plot for slip < 0 (slip = F2-F1)



SYNCHK1 S-CLS MAX dF — Specifies the maximum slip frequency allowed in Hz in the dynamic mode. The dynamic mode is disarmed when the slip frequency exceeds this setting.

SYNCHK1 S-CLS MIN dF — Specifies the minimum slip frequency allowed in Hz in the dynamic mode. The dynamic mode is disarmed when the slip frequency drops below this setting.

SYNCHK1 S-CLS BRK TIME — Specifies the breaker closing time in seconds.

SYNCHK1 V2 MAG CORR FACTOR — Specifies the magnitude correction factor of source V2. This setting is used for V2 magnitude compensation so that V2 magnitude can be directly compared with V1 magnitude. For example, when V1 and V2 are taken from 2 different windings of the transformer and at different voltage levels, the magnitude compensation must be performed before starting magnitude comparison in synchrocheck element.

SYNCHK1 V2 ANGLE SHIFT — Specifies the angle of source V2 that needs to be shifted so that V2 angle can be directly compared with V1 angle. For example, when V1 and V2 are taken from two different windings of the transformer and with different angle shift due to winding connections, the angle shift compensation must be performed before starting angle comparison in synchrocheck element.

SYNCHK1 DEAD SOURCE SELECT — Selects the combination of dead and live sources that bypass the synchronism check function and permit the breaker to be closed when one or both of the two voltages (V1 or/and V2) are below the maximum voltage threshold. A dead or live source is declared by monitoring the voltage level. Six options are available:

- None — Dead Source function is disabled
- LV1 and DV2 — Live V1 and Dead V2
- DV1 and LV2 — Dead V1 and Live V2
- DV1 or DV2 — Dead V1 or Dead V2
- DV1 Xor DV2 — Dead V1 exclusive-or Dead V2 (one source is Dead and the other is Live)
- DV1 and DV2 — Dead V1 and Dead V2

SYNCHK1 DEAD V1 MAX VOLT — Establishes a maximum voltage magnitude for V1 in 1 'pu'. Below this magnitude, the V1 voltage input used for synchrocheck is considered "Dead" or de-energized.

SYNCHK1 DEAD V2 MAX VOLT — Establishes a maximum voltage magnitude for V2 in ‘pu’. Below this magnitude, the V2 voltage input used for synchrocheck is considered “Dead” or de-energized.

SYNCHK1 LIVE V1 MIN VOLT — Establishes a minimum voltage magnitude for V1 in ‘pu’. Above this magnitude, the V1 voltage input used for synchrocheck is considered “Live” or energized.

SYNCHK1 LIVE V2 MIN VOLT — This setting establishes a minimum voltage magnitude for V2 in ‘pu’. Above this magnitude, the V2 voltage input used for synchrocheck is considered “Live” or energized.

Notes on the synchrocheck function

1. The selected sources for synchrocheck inputs V1 and V2 (which must not be the same source) can include both a three-phase and an auxiliary voltage. The relay automatically selects the specific voltages to be used by the synchrocheck element in accordance with the following table.

Number	V1 or V2 (source Y)	V2 or V1 (source Z)	Auto-selected combination		Auto-selected voltage
			Source Y	Source Z	
1	Phase VTs and Auxiliary VT	Phase VTs and Auxiliary VT	Phase	Phase	VAB
2	Phase VTs and Auxiliary VT	Phase VT	Phase	Phase	VAB
3	Phase VT	Phase VT	Phase	Phase	VAB
4	Phase VT and Auxiliary VT	Auxiliary VT	Phase	Auxiliary	V auxiliary (as set for source Z)
5	Auxiliary VT	Auxiliary VT	Auxiliary	Auxiliary	V auxiliary (as set for selected sources)

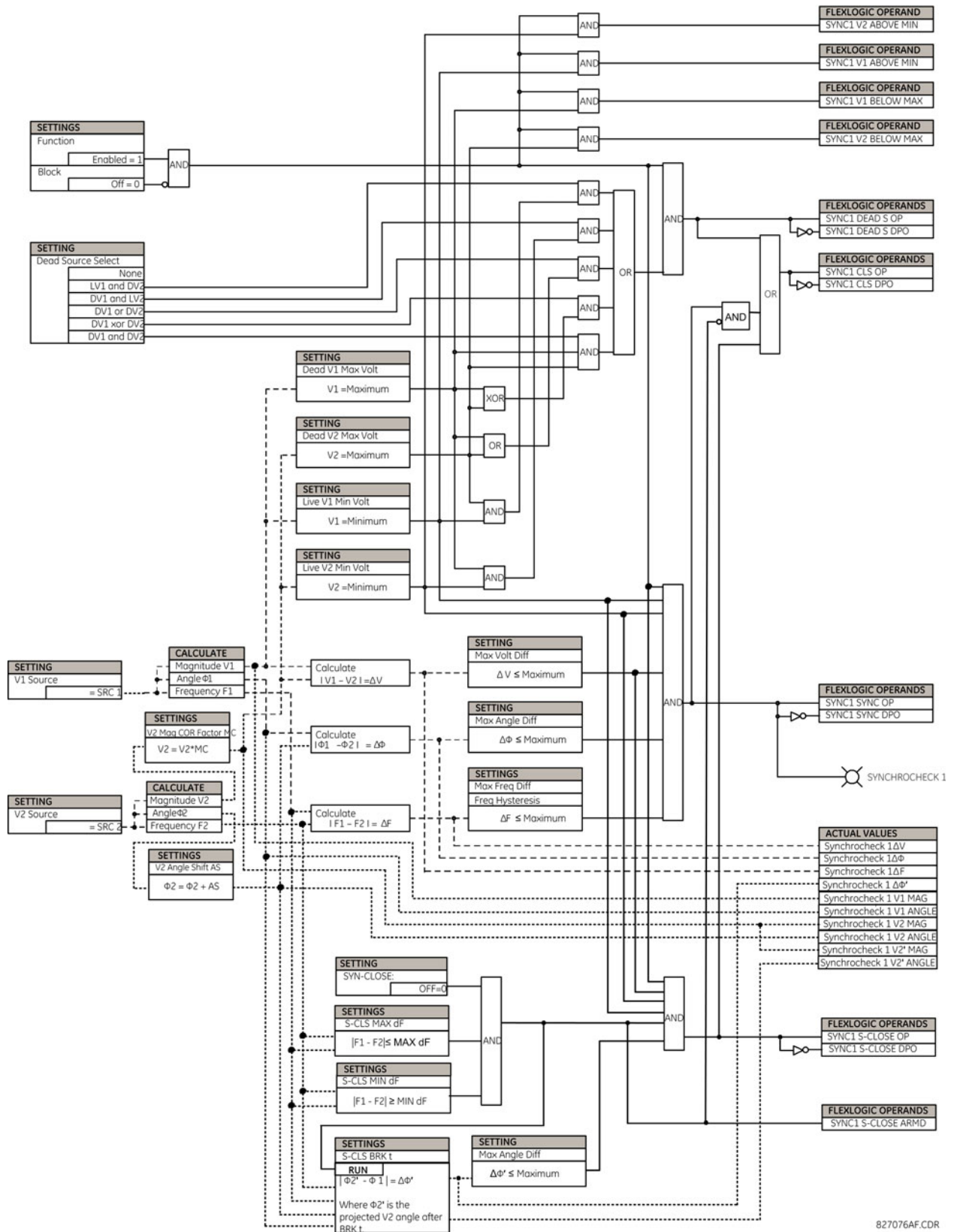
The voltages V1 and V2 are matched automatically so that the corresponding voltages from the two sources are used to measure conditions. A phase to phase voltage is used if available in both sources; if one or both of the Sources have only an auxiliary voltage, this voltage is used. For example, if an auxiliary voltage is programmed to VAG, the synchrocheck element automatically selects VAG from the other source. If the comparison is required on a specific voltage, the user can externally connect that specific voltage to auxiliary voltage terminals and then use this "Auxiliary Voltage" to check the synchronism conditions.

If using a single CT/VT module with both phase voltages and an auxiliary voltage, ensure that only the auxiliary voltage is programmed in one of the sources to be used for synchrocheck. An exception is that synchronism cannot be checked between Delta connected phase VTs and a Wye connected auxiliary voltage.

2. The relay measures frequency and Volts/Hz from an input on a given source with priorities as established by the configuration of input channels to the source. The relay uses the phase channel of a three-phase set of voltages if programmed as part of that source. The relay uses the auxiliary voltage channel only if that channel is programmed as part of the Source and a three-phase set is not.



Figure 5-146: Synchrocheck logic



5.8.8 Autoreclose (ANSI 79)

SETTINGS ⇒ CONTROL ELEMENTS ⇒ AUTORECLOSE ⇒ AUTORECLOSE 1(3)

<div style="border: 1px solid black; padding: 2px;"> <p>■ AUTORECLOSE 1</p> <p>■</p> </div>	↔	AR1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	AR1 INITIATE: Off	Range: FlexLogic operand
	↕	AR1 BLOCK: Off	Range: FlexLogic operand
	↕	AR1 MAX NUMBER OF SHOTS: 1	Range: 1, 2, 3, 4
	↕	AR1 REDUCE MAX TO 1: Off	Range: FlexLogic operand
	↕	AR1 REDUCE MAX TO 2: Off	Range: FlexLogic operand
	↕	AR1 REDUCE MAX TO 3: Off	Range: FlexLogic operand
	↕	AR1 MANUAL CLOSE: Off	Range: FlexLogic operand
	↕	AR1 MNL RST FRM LO: Off	Range: FlexLogic operand
	↕	AR1 RESET LOCKOUT IF BREAKER CLOSED: Off	Range: Off, On
	↕	AR1 RESET LOCKOUT ON MANUAL CLOSE: Off	Range: Off, On
	↕	AR1 BKR CLOSED: Off	Range: FlexLogic operand
	↕	AR1 BKR OPEN: Off	Range: FlexLogic operand
	↕	AR1 BLK TIME UPON MNL CLS: 10.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	↕	AR1 DEAD TIME 1: 1.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	↕	AR1 DEAD TIME 2: 2.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	↕	AR1 DEAD TIME 3: 3.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	↕	AR1 DEAD TIME 4: 4.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	↕	AR1 ADD DELAY 1: Off	Range: FlexLogic operand
	↕	AR1 DELAY 1: 0.000 s	Range: 0.00 to 655.35 s in steps of 0.01
↕	AR1 ADD DELAY 2: Off	Range: FlexLogic operand	
↕	AR1 DELAY 2: 0.000 s	Range: 0.00 to 655.35 s in steps of 0.01	
↕	AR1 RESET LOCKOUT DELAY: 60.000	Range: 0.00 to 655.35 s in steps of 0.01	

↕	AR1 RESET TIME: 60.000 s	Range: 0.00 to 655.35 s in steps of 0.01
↕	AR1 INCOMPLETE SEQ TIME: 5.000 s	Range: 0.00 to 655.35 s in steps of 0.01
↑	AR1 EVENTS: Disabled	Range: Disabled, Enabled



The L30 is provided with this optional feature, specified as an option at the time of ordering. Using the order code for your device, see the order codes in chapter 2 for details.

The maximum number of autoreclosure elements available is equal to the number of installed CT banks.

The autoreclosure feature is intended for use with transmission and distribution lines, in three-pole tripping schemes for single breaker applications. Up to four selectable reclosures "shots" are possible prior to locking out. Each shot has an independently settable dead time. The protection settings can be changed between shots if required, using FlexLogic. Logic inputs are available for disabling or blocking the scheme.

Faceplate panel LEDs indicate the state of the autoreclose scheme as follows:

- Reclose Enabled — The scheme is enabled and can reclose if initiated
- Reclose Disabled — The scheme is disabled
- Reclose In Progress — An autoreclosure has been initiated but the breaker has not yet been signaled to close
- Reclose Locked Out — The scheme has generated the maximum number of breaker closures allowed and, as the fault persists, does not close the breaker again; known as "Lockout." The scheme can also be sent in "Lockout" when the incomplete sequence timer times out or when a block signal occurs while in "reclose in progress." The scheme must be reset from Lockout in order to perform reclose for further faults.

The reclosure scheme is considered enabled when all of the following conditions are true:

- The **AR1 FUNCTION** is set to "Enabled"
- The scheme is not in the "Lockout" state
- The "Block" input is not asserted
- The **AR1 BLK TIME UPON MNL CLS** timer is not active

The autoreclose scheme is initiated by a trip signal from any selected protection feature operand. The scheme is initiated provided the circuit breaker is in the closed state before protection operation.

The reclose-in-progress (RIP) is set when a reclosing cycle begins following a reclose initiate signal. Once the cycle is successfully initiated, the RIP signal seals-in and the scheme continues through its sequence until one of the following conditions is satisfied:

- The close signal is issued when the dead timer times out, or
- The scheme goes to lockout

While RIP is active, the scheme checks that the breaker is open and the shot number is below the limit, and then begins measuring the dead time.

Each of the four possible shots has an independently settable dead time. Two additional timers can be used to increase the initial set dead times 1 to 4 by a delay equal to **AR1 DELAY 1** or **AR1 DELAY 2** or the sum of these two delays depending on the selected settings. This offers enhanced setting flexibility using FlexLogic operands to turn the two additional timers "on" and "off." These operands can possibly include **AR1 SHOT CNT =n**, **SETTING GROUP ACT 1**, and so on. The autoreclose provides up to maximum 4 selectable shots. Maximum number of shots can be dynamically modified through the settings **AR1 REDUCE MAX TO 1 (2, 3)**, using the appropriate FlexLogic operand.

Scheme lockout blocks all phases of the reclosing cycle, preventing automatic reclosure, if any of the following occurs:

- The maximum shot number was reached
- A "Block" input is in effect (for instance, Breaker Failure or bus differential protection operated)
- The "Incomplete Sequence" timer times out

The recloser is latched in the Lockout state until a "reset from lockout" signal is asserted, either from a manual close of the breaker or from a manual reset command (local or remote). The reset from lockout can be accomplished by operator command, by manually closing the breaker, or whenever the breaker has been closed and stays closed for a preset time. After the dead time elapses, the scheme issues the close signal. The close signal is latched until the breaker closes or the scheme goes to Lockout.

A reset timer output resets the recloser following a successful reclosure sequence. The reset time is based on the breaker "reclaim time," which is the minimum time required between successive reclose sequences.

5.8.8.1 Settings

AR1 INITIATE — Selects the FlexLogic operand that initiates the scheme, typically the trip signal from protection.

AR1 BLOCK — Selects the FlexLogic operand that blocks the autoreclosure initiate (it can be from the breaker failure, bus differential protection, and so on).

AR1 MAX NUMBER OF SHOTS — Specifies the number of reclosures that can be attempted before reclosure goes to "Lockout" because the fault is permanent.

AR1 REDUCE MAX TO 1(3) — Selects the FlexLogic operand that changes the maximum number of shots from the initial setting to 1, 2, or 3, respectively.

AR1 MANUAL CLOSE — Selects the logic input set when the breaker is manually closed.

AR1 MNL RST FRM LO — Selects the FlexLogic operand that resets the autoreclosure from Lockout condition. Typically this is a manual reset from lockout, local or remote.

AR1 RESET LOCKOUT IF BREAKER CLOSED — This setting allows the autoreclosure scheme to reset from Lockout if the breaker has been manually closed and stays closed for a preset time. In order for this setting to be effective, disable the next setting (**AR1 RESET LOCKOUT ON MANUAL CLOSE**).

AR1 RESET LOCKOUT ON MANUAL CLOSE — This setting allows the autoreclosure scheme to reset from Lockout when the breaker is manually closed regardless if the breaker remains closed or not. This setting overrides the previous setting (**AR1 RESET LOCKOUT IF BREAKER CLOSED**).

AR1 BLK TIME UPON MNL CLS — The autoreclosure scheme can be disabled for a programmable time delay after the associated circuit breaker is manually closed. This prevents reclosing onto a fault after a manual close. This delay must be longer than the slowest expected trip from any protection not blocked after manual closing. If no overcurrent trips occur after a manual close and this time expires, the autoreclosure scheme is enabled.

AR1 DEAD TIME 1 to AR1 DEAD TIME 4 — These are the intentional delays before first, second, third, and fourth breaker automatic reclosures (1st, 2nd, and 3rd shots), respectively. Set them longer than the estimated deionizing time following a three pole trip.

AR1 ADD DELAY 1 — This setting selects the FlexLogic operand that introduces an additional delay (Delay 1) to the initial set Dead Time (1 to 4). When this setting is "Off," Delay 1 is by-passed.

AR1 DELAY 1 — This setting establishes the extent of the additional dead time Delay 1.

AR1 ADD DELAY 2 — This setting selects the FlexLogic operand that introduces an additional delay (Delay 2) to the initial set Dead Time (1 to 4). When this setting is "Off," Delay 2 is by-passed.

AR1 DELAY 2 — This setting establishes the extent of the additional dead time Delay 2.

AR1 RESET LOCKOUT DELAY — This setting establishes how long the breaker stays closed after a manual close command, in order for the autorecloser to reset from Lockout.

AR1 RESET TIME — A reset timer output resets the recloser following a successful reclosure sequence. The setting is based on the breaker "reclaim time," which is the minimum time required between successive reclose sequences.

AR1 INCOMPLETE SEQ TIME — This timer defines the maximum time interval allowed for a single reclose shot. It is started whenever a reclosure is initiated and is active when the scheme is in the "reclose-in-progress" state. If all conditions allowing a breaker closure are not satisfied when this time expires, the scheme goes to Lockout.



This timer must be set to a delay less than the reset timer.

Figure 5-147: Autoreclosure logic (Sheet 1 of 2)

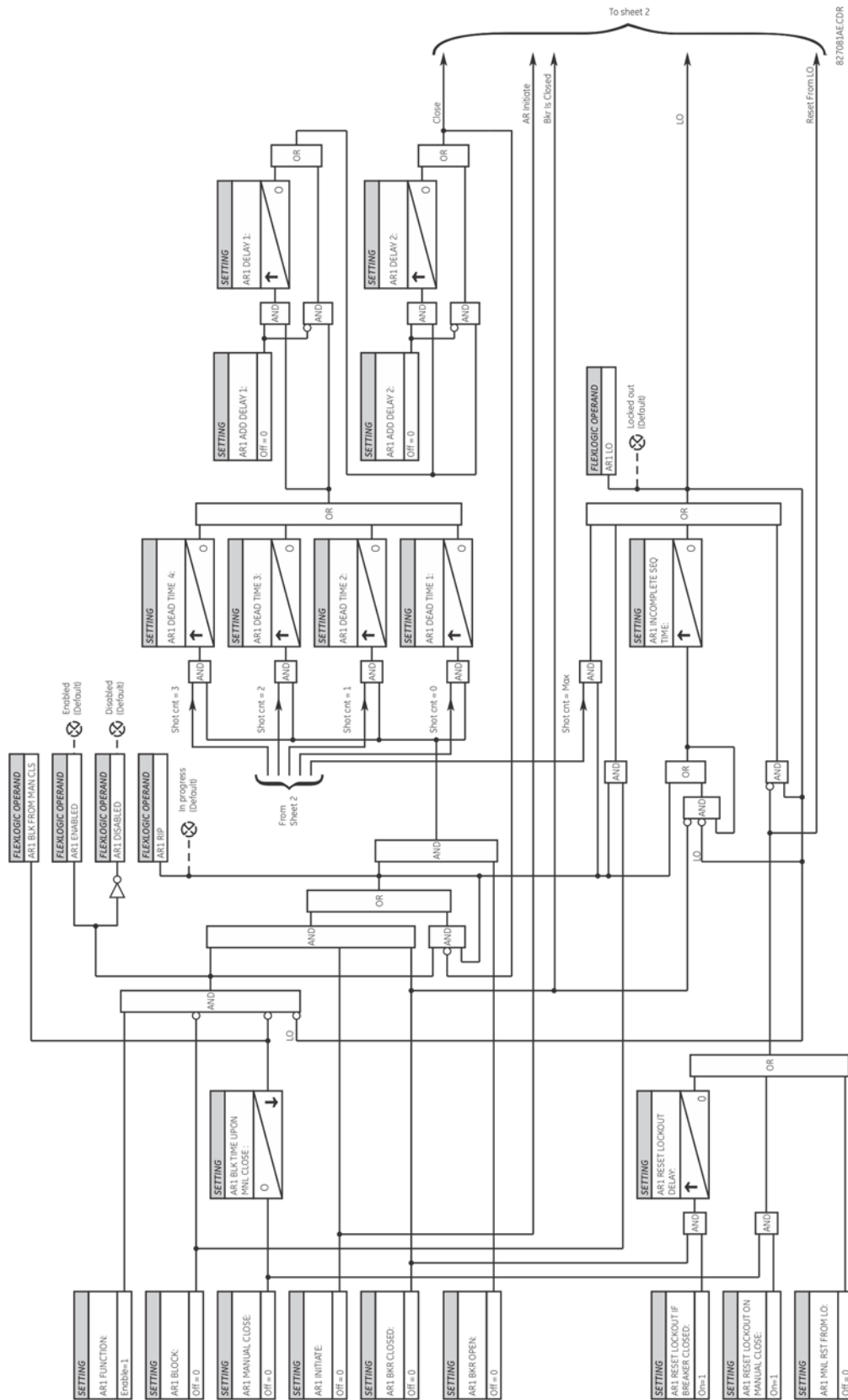
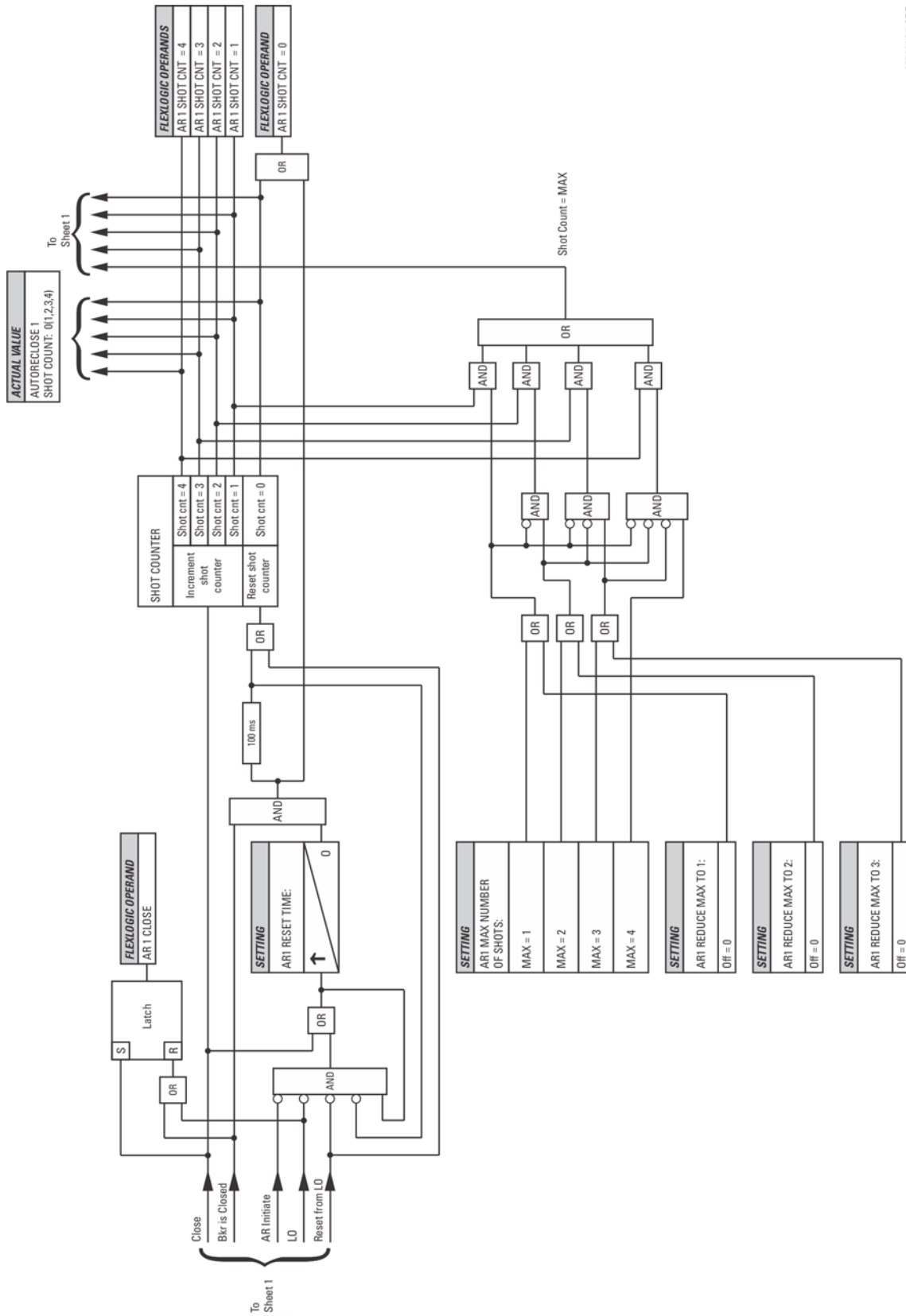
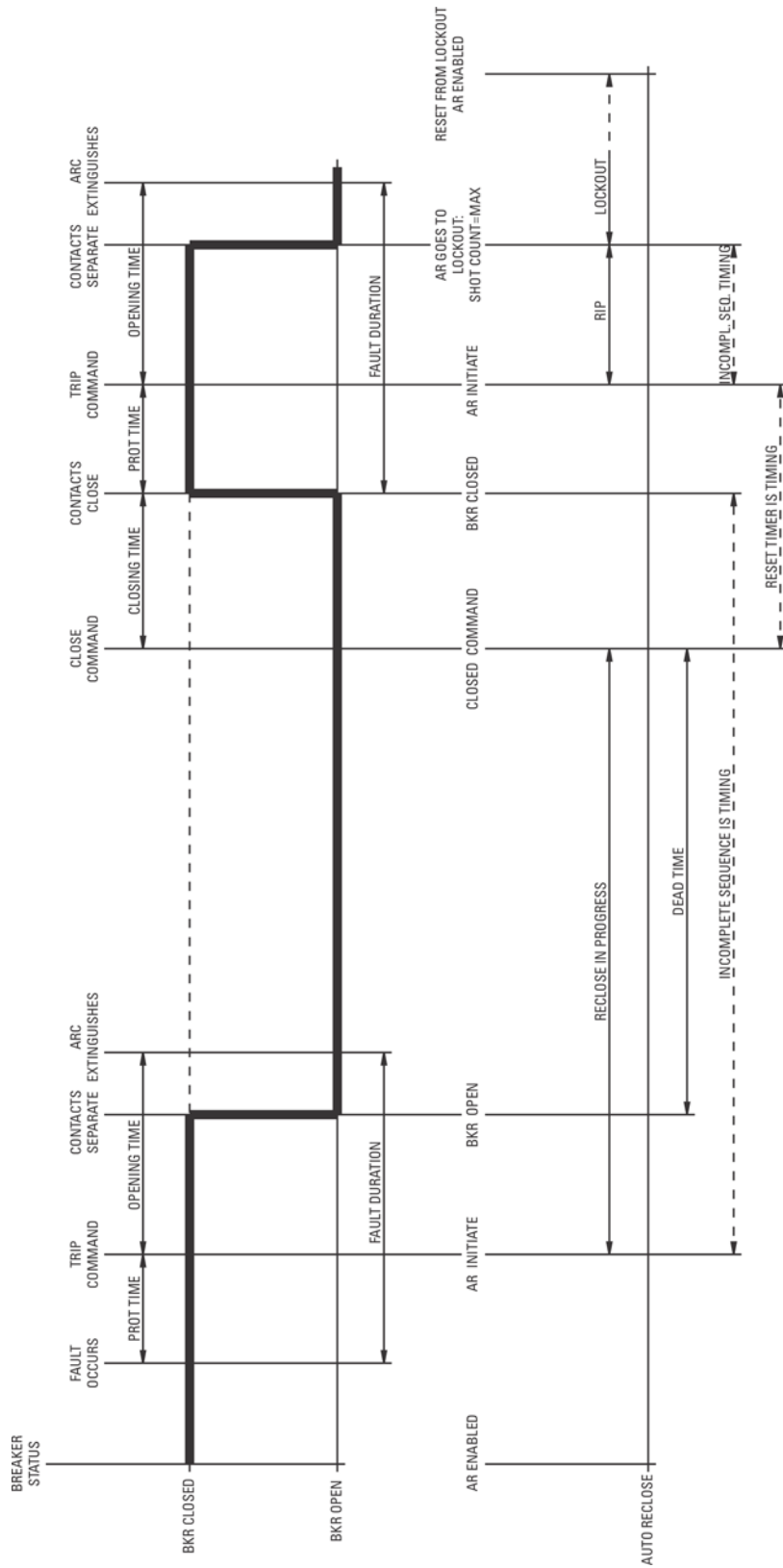


Figure 5-148: Autorecloser logic (Sheet 2 of 2)



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Figure 5-149: Single shot autoreclosing sequence - permanent fault



5.8.9 Digital elements

SETTINGS ⇒ CONTROL ELEMENTS ⇒ DIGITAL ELEMENTS ⇒ DIGITAL ELEMENT 1(48)

■ DIGITAL ELEMENT 1	↔	DIGITAL ELEMENT 1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	DIG ELEM 1 NAME: Dig Element 1	Range: up to 16 alphanumeric characters
	↕	DIG ELEM 1 INPUT: Off	Range: FlexLogic operand
	↕	DIG ELEM 1 PICKUP DELAY: 0.000 s	Range: 0.000 to 999999.999 s in steps of 0.001
	↕	DIG ELEM 1 RESET DELAY: 0.000 s	Range: 0.000 to 999999.999 s in steps of 0.001
	↕	DIGITAL ELEMENT 1 PICKUP LED: Enabled	Range: Disabled, Enabled
	↕	DIG ELEM 1 BLOCK: Off	Range: FlexLogic operand
	↕	DIGITAL ELEMENT 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	DIGITAL ELEMENT 1 EVENTS: Disabled	Range: Disabled, Enabled

Digital elements run once per power system cycle.



As such they can easily fail to react to an input signal or a block signal with a duration less than one power system cycle. This also means that digital element output can react up to one power system cycle later than the pickup and reset delay settings indicate.

Do not use digital elements with transient signals, such as communications commands. Do not use digital elements where random delays of up to one cycle cannot be tolerated, such as in high speed protection.

There are 48 identical digital elements available, numbered 1 to 48. A digital element can monitor any FlexLogic operand and present a target message and/or enable events recording depending on the output operand state. The digital element settings include a name to be referenced in any target message, a blocking input from any selected FlexLogic operand, and a timer for pickup and reset delays for the output operand.

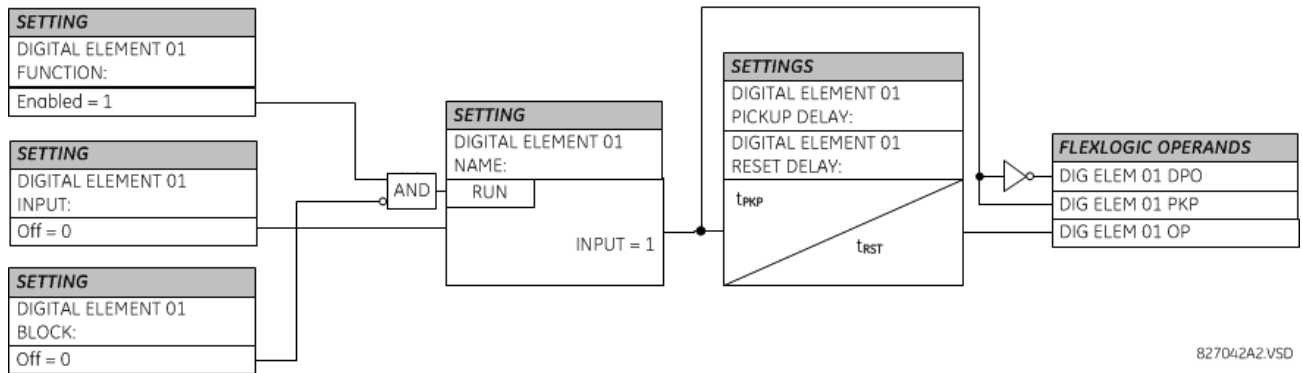
DIGITAL ELEMENT 1 INPUT — Selects a FlexLogic operand to be monitored by the digital element.

DIGITAL ELEMENT 1 PICKUP DELAY — Sets the required time delay from element pickup to element operation. If a pickup delay is not required, set to "0." To avoid nuisance alarms, set the delay greater than the operating time of the breaker.

DIGITAL ELEMENT 1 RESET DELAY — Sets the time delay to reset. If a reset delay is not required, set to "0."

DIGITAL ELEMENT 1 PICKUP LED — This setting enables or disabled the digital element pickup LED. When set to "Disabled," the operation of the pickup LED is blocked.

Figure 5-150: Digital element logic



Circuit monitoring applications

Some versions of the digital input modules include an active voltage monitor circuit connected across form-A contacts. The voltage monitor circuit limits the trickle current through the output circuit (see technical specifications for form-A).

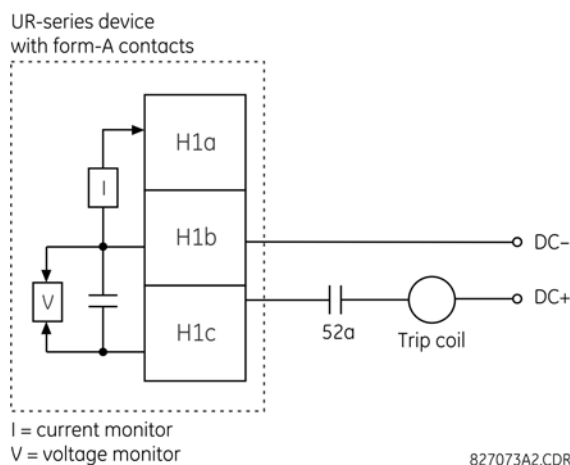
As long as the current through the voltage monitor is above a threshold (see technical specifications for form-A), the **Cont Op 1 VOn** FlexLogic operand is set (for contact input 1—corresponding operands exist for each contact output). If the output circuit has a high resistance or the DC current is interrupted, the trickle current drops below the threshold and the **Cont Op 1 VOff** FlexLogic operand is set. Consequently, the state of these operands can be used as indicators of the integrity of the circuits in which form-A contacts are inserted.

Example 1: Breaker trip circuit integrity monitoring

In many applications it is desired to monitor the breaker trip circuit integrity so that problems can be detected before a trip operation is required. The circuit is considered to be healthy when the voltage monitor connected across the trip output contact detects a low level of current, well below the operating current of the breaker trip coil. If the circuit presents a high resistance, the trickle current falls below the monitor threshold, and an alarm is declared.

In most breaker control circuits, the trip coil is connected in series with a breaker auxiliary contact that is open when the breaker is open (see figure). To prevent unwanted alarms in this situation, the trip circuit monitoring logic must include the breaker position.

Figure 5-151: Trip circuit example 1



Assume the output contact H1 is a trip contact. Using the contact output settings, this output is given an ID name; for example, "Cont Op 1." Assume a 52a breaker auxiliary contact is connected to contact input H7a to monitor breaker status. Using the contact input settings, this input is given an ID name, for example, "Cont Ip 1," and is set "On" when the breaker is closed. The settings to use digital element 1 to monitor the breaker trip circuit are indicated (EnerVista example shown).

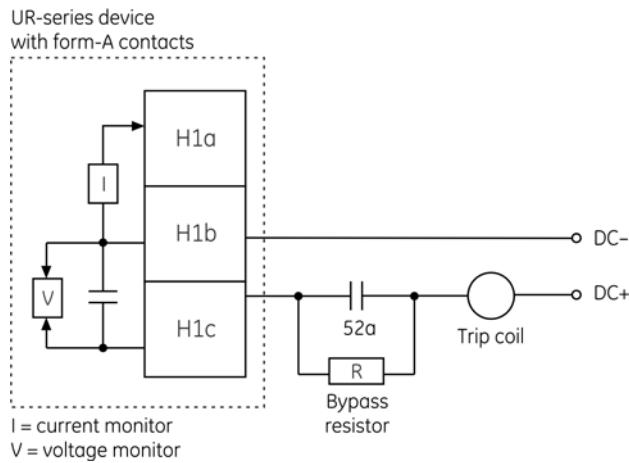
PARAMETER	DIGITAL ELEMENT 1
Function	Enabled
Digital Element 1 Name	Bkr Trip Cct Out
Input	Cont Op 1 VOff (H1)
Pickup Delay	0.200 s
Reset Delay	0.100 s
Pickup Led	Enabled
Block	Cont Ip 1 Off(H5a)
Target	Self-reset
Events	Enabled

Example 2: Breaker trip circuit integrity monitoring

If it is required to monitor the trip circuit continuously, independent of the breaker position (open or closed), a method to maintain the monitoring current flow through the trip circuit when the breaker is open must be provided (as shown in the following figure). This can be achieved by connecting a suitable resistor (see figure) across the auxiliary contact in the trip circuit. In this case, it is not required to supervise the monitoring circuit with the breaker position – the **BLOCK** setting is selected to "Off." In this case, the settings are as follows (EnerVista example shown).

PARAMETER	DIGITAL ELEMENT 1
Function	Enabled
Digital Element 1 Name	Bkr Trip Cct Out
Input	Cont Op 1 VOff (H1)
Pickup Delay	0.200 s
Reset Delay	0.100 s
Pickup Led	Enabled
Block	OFF
Target	Self-reset
Events	Enabled

Figure 5-152: Trip circuit example 2



Values for resistor "R"

Power supply	Resistance	Power
24 V DC	1000 O	2 W
30 V DC	5000 O	2 W
48 V DC	10000 O	2 W
110 V DC	25000 O	5 W
125 V DC	25000 O	5 W
250 V DC	50000 O	5 W

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The wiring connection for two examples above is applicable to both form-A contacts with voltage monitoring and solid-state contact with voltage monitoring.

5.8.10 Digital counters

SETTINGS ⇒ CONTROL ELEMENTS ⇒ DIGITAL COUNTERS ⇒ COUNTER 1(8)

■ COUNTER 1	⇔	COUNTER 1 FUNCTION: Disabled	Range: Disabled, Enabled
■	⇕	COUNTER 1 NAME: Counter 1	Range: up to 12 alphanumeric characters
	⇕	COUNTER 1 UNITS:	Range: up to six alphanumeric characters
	⇕	COUNTER 1 PRESET: 0	Range: -2,147,483,648 to +2,147,483,647
	⇕	COUNTER 1 COMPARE: 0	Range: -2,147,483,648 to +2,147,483,647
	⇕	COUNTER 1 UP: Off	Range: FlexLogic operand
	⇕	COUNTER 1 DOWN: Off	Range: FlexLogic operand
	⇕	COUNTER 1 BLOCK: Off	Range: FlexLogic operand
	⇕	CNT1 SET TO PRESET: Off	Range: FlexLogic operand
	⇕	COUNTER 1 RESET: Off	Range: FlexLogic operand
	⇕	COUNT1 FREEZE/RESET: Off	Range: FlexLogic operand
	⇕	COUNT1 FREEZE/COUNT: Off	Range: FlexLogic operand

There are eight identical digital counters, numbered from 1 to 8. A digital counter counts the number of state transitions from Logic 0 to Logic 1. The counter is used to count operations such as the pickups of an element, the changes of state of an external contact (for example, breaker auxiliary switch), or pulses from a watt-hour meter.

COUNTER 1 UNITS — Assigns a label to identify the unit of measure pertaining to the digital transitions to be counted. The units label appears in the corresponding actual values status.

COUNTER 1 PRESET — Sets the count to a required preset value before counting operations begin, as in the case where a substitute relay is to be installed in place of an in-service relay, or while the counter is running.

COUNTER 1 COMPARE — Sets the value to which the accumulated count value is compared. Three FlexLogic output operands are provided to indicate if the present value is 'more than (HI)', 'equal to (EQL)', or 'less than (LO)' the set value.

COUNTER 1 UP — Selects the FlexLogic operand for incrementing the counter. If an enabled UP input is received when the accumulated value is at the limit of +2,147,483,647 counts, the counter rolls over to -2,147,483,648.

COUNTER 1 DOWN — Selects the FlexLogic operand for decrementing the counter. If an enabled DOWN input is received when the accumulated value is at the limit of -2,147,483,648 counts, the counter rolls over to +2,147,483,647.

COUNTER 1 BLOCK — Selects the FlexLogic operand for blocking the counting operation. All counter operands are blocked.

CNT1 SET TO PRESET — Selects the FlexLogic operand used to set the count to the preset value. The counter sets to the preset value in the following situations:

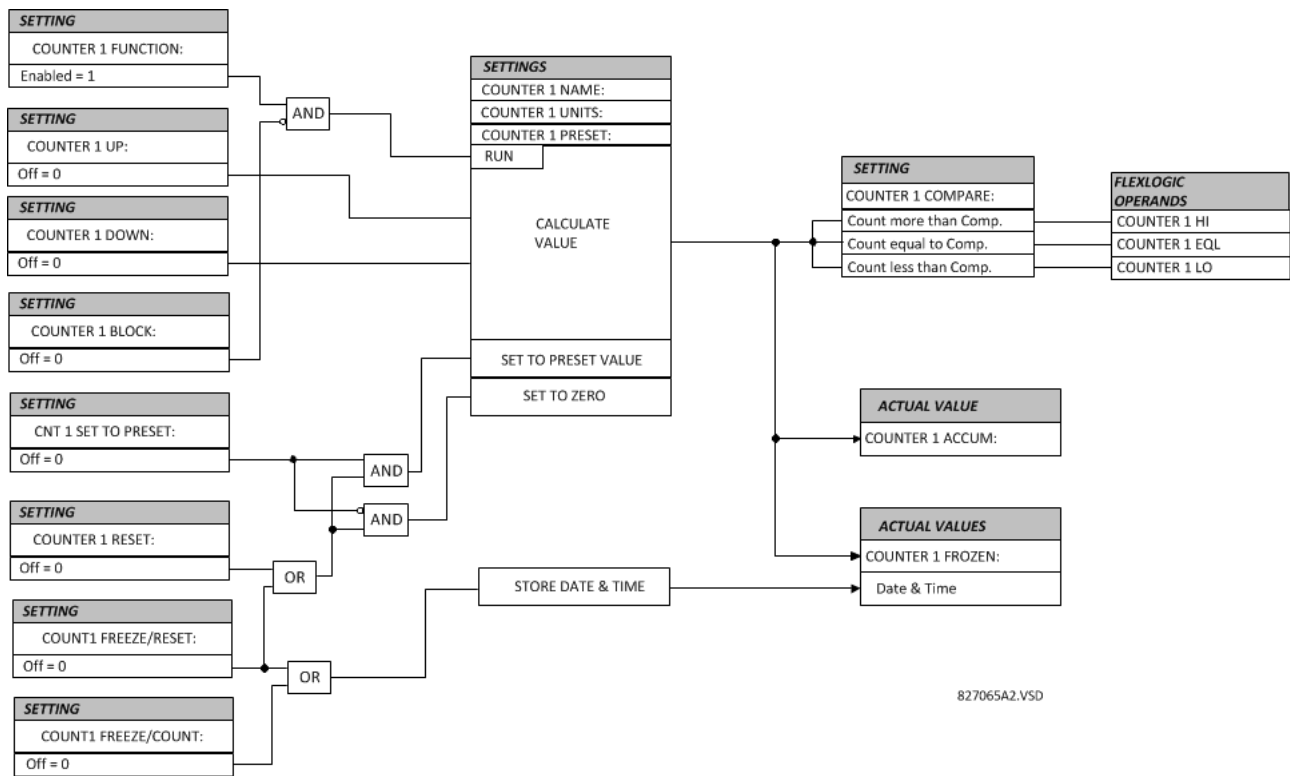
- When the counter is enabled and the **CNT1 SET TO PRESET** operand has the value 1 (when the counter is enabled and **CNT1 SET TO PRESET** operand is 0, the counter sets to 0)
- When the counter is running and the **CNT1 SET TO PRESET** operand changes the state from 0 to 1 (**CNT1 SET TO PRESET** changing from 1 to 0 while the counter is running has no effect on the count)
- When a reset or reset/freeze command is sent to the counter and the **CNT1 SET TO PRESET** operand has the value 1 (when a reset or reset/freeze command is sent to the counter and the **CNT1 SET TO PRESET** operand has the value 0, the counter sets to 0)

COUNTER 1 RESET — Selects the FlexLogic operand for setting the count to either "0" or the preset value depending on the state of the **CNT1 SET TO PRESET** operand.

COUNTER 1 FREEZE/RESET — Selects the FlexLogic operand for capturing (freezing) the accumulated count value into a separate register with the date and time of the operation, and resetting the count to "0."

COUNTER 1 FREEZE/COUNT — Selects the FlexLogic operand for capturing (freezing) the accumulated count value into a separate register with the date and time of the operation, and continuing counting. The present accumulated value and captured frozen value with the associated date/time stamp are available as actual values. If control power is interrupted, the accumulated and frozen values are saved into non-volatile memory during the power-down operation.

Figure 5-153: Digital counter logic

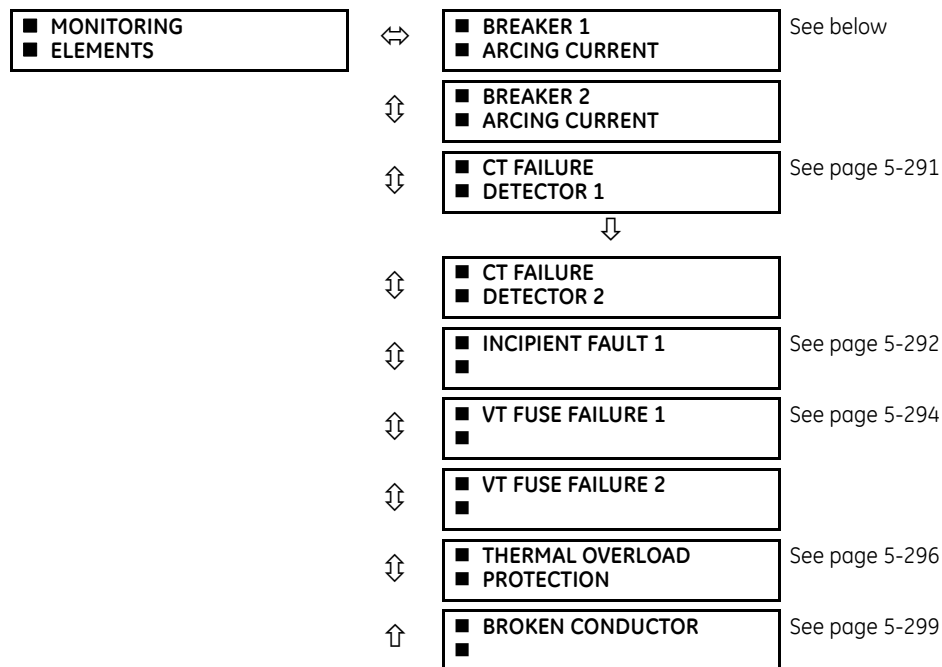


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5.8.11 Monitoring elements

5.8.11.1 Menu

SETTINGS ⇌ CONTROL ELEMENTS ⇌ MONITORING ELEMENTS



5.8.11.2 Breaker arcing current

SETTINGS ⇌ CONTROL ELEMENTS ⇌ MONITORING ELEMENTS ⇌ BREAKER 1(2) ARCING CURRENT

■ BREAKER 1 ■ ARCING CURRENT	⇌	BKR 1 ARC AMP FUNCTION: Disabled	Range: Disabled, Enabled
	⇕	BKR 1 ARC AMP SOURCE: SRC 1	Range: SRC 1, SRC 2
	⇕	BKR 1 ARC AMP INT-A: Off	Range: FlexLogic operand
		↓	
	⇕	BKR 1 ARC AMP INT-C: Off	Range: FlexLogic operand
	⇕	BKR 1 ARC AMP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	⇕	BKR 1 ARC AMP LIMIT: 1000 kA ² -cyc	Range: 0 to 50000 kA ² -cycle in steps of 1
	⇕	BKR 1 INTERRUPTION RATING: 31.5 kA	Range: 0.0 to 100.0 kA in steps of 0.1
	⇕	BKR 1 CLR ARC AMPS: Off	Range: FlexLogic operand
	⇕	BKR 1 ARC AMP BLOCK: Off	Range: FlexLogic operand
⇕	BKR 1 ARC AMP TARGET: Self-reset	Range: Self-reset, Latched, Disabled	
⇕	BKR 1 ARC AMP EVENTS: Disabled	Range: Disabled, Enabled	

There is one breaker arcing current element available per CT bank, with a minimum of two elements. This element calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the current squared passing through the breaker contacts as an arc. These per-phase values are added to accumulated totals for each phase and compared to a programmed threshold value. When the threshold is exceeded in any phase, the relay can set an output operand to "1." The accumulated value for each phase can be displayed as an actual value.

The operation of the scheme is shown in the following logic diagram. The same output operand that is selected to operate the output relay used to trip the breaker, indicating a tripping sequence has begun, is used to initiate this feature. A time delay is introduced between initiation and the starting of integration to prevent integration of current flow through the breaker before the contacts have parted. This interval includes the operating time of the output relay, any other auxiliary relays, and the breaker mechanism. For maximum measurement accuracy, measure the interval between change-of-state of the operand (from 0 to 1) and contact separation for the specific installation. Integration of the measured current continues for 100 ms, which is expected to include the total arcing period.

The feature is programmed to perform fault duration calculations. Fault duration is defined as a time between operation of the disturbance detector occurring before initiation of this feature, and reset of an internal low-set overcurrent function. Correction is implemented to account for a non-zero reset time of the overcurrent function.

Breaker arcing currents and fault duration values are available under the **ACTUAL VALUES ⇌ RECORDS ⇌ MAINTENANCE ⇌ BREAKER 1(2)** menus.

BKR 1 ARC AMP INT-A(C) — Select the same output operands that are configured to operate the output relays used to trip the breaker. In three-pole tripping applications, configure the same operand to initiate arcing current calculations for poles A, B, and C of the breaker. In single-pole tripping applications, configure per-pole tripping operands to initiate the calculations for the poles that are actually tripped.

BKR 1 ARC AMP DELAY — This setting is used to program the delay interval between the time the tripping sequence is initiated and the time the breaker contacts are expected to part, starting the integration of the measured current.

BKR 1 ARC AMP LIMIT — Selects the threshold value above which the output operand is set.

BKR 1 CLR ARC AMPS — Selects a FLeXLogic Operand to clear the accumulated I^2t values (kA²-cycle), reset fault duration items (breaker operating time), clear ARCING AMPS (kA²-cycle) and AMP MAX (kA) values of the last event.

BKR 1 INTERRUPTION RATING — This setting specifies the maximum symmetrical interruption rating of the circuit breaker.

Figure 5-154: Arcing current measurement

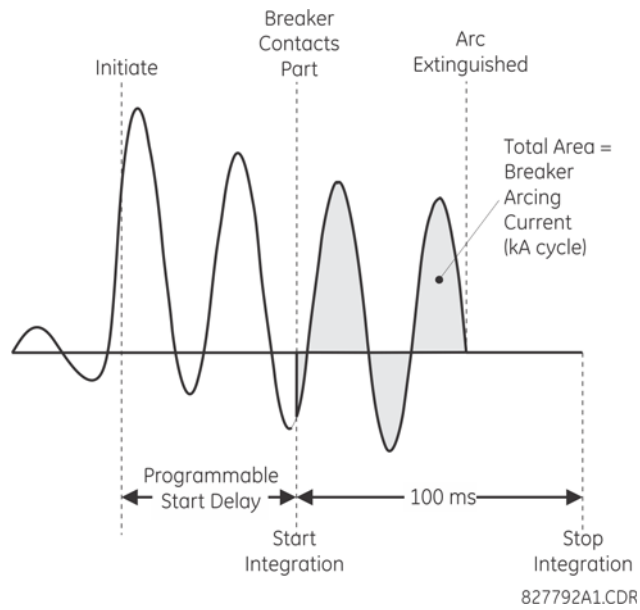
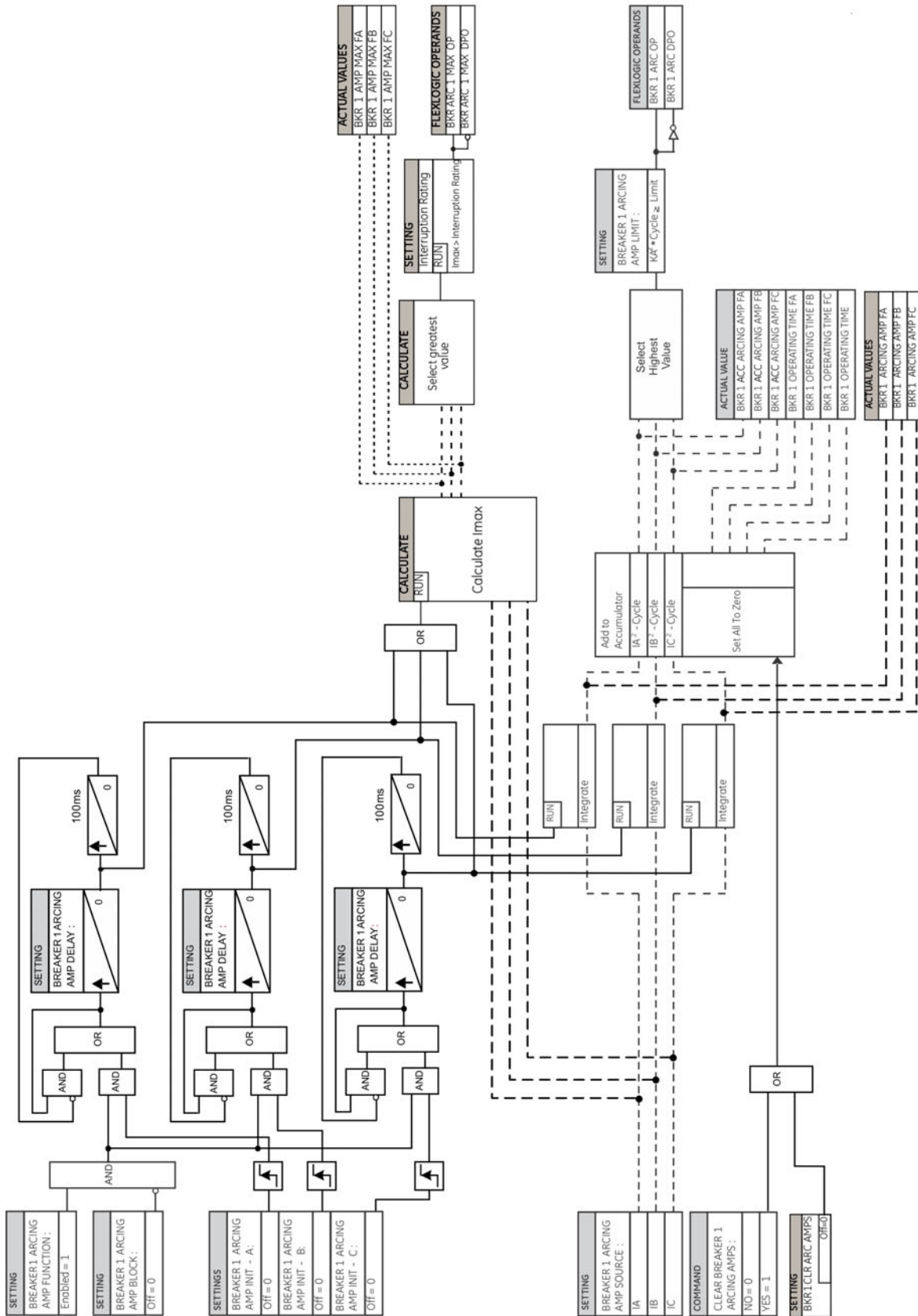


Figure 5-155: Breaker arcing current logic



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5.8.11.3 CT failure detector

SETTINGS ⇌ CONTROL ELEMENTS ⇌ MONITORING ELEMENTS ⇌ CT FAILURE DETECTOR 1(2)

<ul style="list-style-type: none"> ■ CT FAILURE ■ DETECTOR 1 	↔	CT FAIL 1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	CT FAIL 1 BLOCK: Off	Range: FlexLogic operand
	↕	CT FAIL 1 3I0 INP 1: SRC 1	Range: SRC 1, SRC 2
	↕	CT FAIL 1 3I0 INP 1 PKP: 0.2 pu	Range: 0.1 to 2.0 pu in steps of 0.1
	↕	CT FAIL 1 3I0 INP 2: SRC 2	Range: SRC 1, SRC 2
	↕	CT FAIL 1 3I0 INP 2 PKP: 0.2 pu	Range: 0.1 to 2.0 pu in steps of 0.1
	↕	CT FAIL 1 3V0 INPUT: SRC 1	Range: SRC 1, SRC 2
	↕	CT FAIL 1 3V0 INPUT PKP: 0.20 pu	Range: 0.04 to 2.00 pu in steps of 0.01
	↕	CT FAIL 1 PICKUP DELAY: 1.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	↕	CT FAIL 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	CT FAIL 1 EVENTS: Disabled	Range: Disabled, Enabled

The CT failure function detects problems with system current transformers used to supply current to the relay. This logic detects the presence of a zero-sequence current at the supervised source of current without a simultaneous zero-sequence current at another source, zero-sequence voltage, or some protection element condition.

The CT failure logic (see later) is based on the presence of the zero-sequence current in the supervised CT source and the absence of one of three or all of the three following conditions:

- Zero-sequence current at different source current (can be different set of CTs or different CT core of the same CT)
- Zero-sequence voltage at the assigned source
- Appropriate protection element or remote signal

Settings are described as follows.

CT FAIL 1 FUNCTION — Enables or disables operation of the CT failure element.

CT FAIL 1 BLOCK — Selects a FlexLogic operand to block operation of the element during some condition (for example, an open pole in process of the single pole tripping-reclosing). Local signals or remote signals representing operation of some remote current protection elements via communication channels can also be chosen.

CT FAIL 1 3I0 INPUT 1 — Selects the current source for input 1. The most critical protection element should also be assigned to the same source.

CT FAIL 1 3I0 INPUT 1 PICKUP — Selects the 3I_0 pickup value for input 1 (the main supervised CT source).

CT FAIL 1 3I0 INPUT 2 — Selects the current source for input 2. Input 2 should use a different set of CTs or a different CT core of the same CT. If 3I_0 does not exist at source 2, then a CT failure is declared.

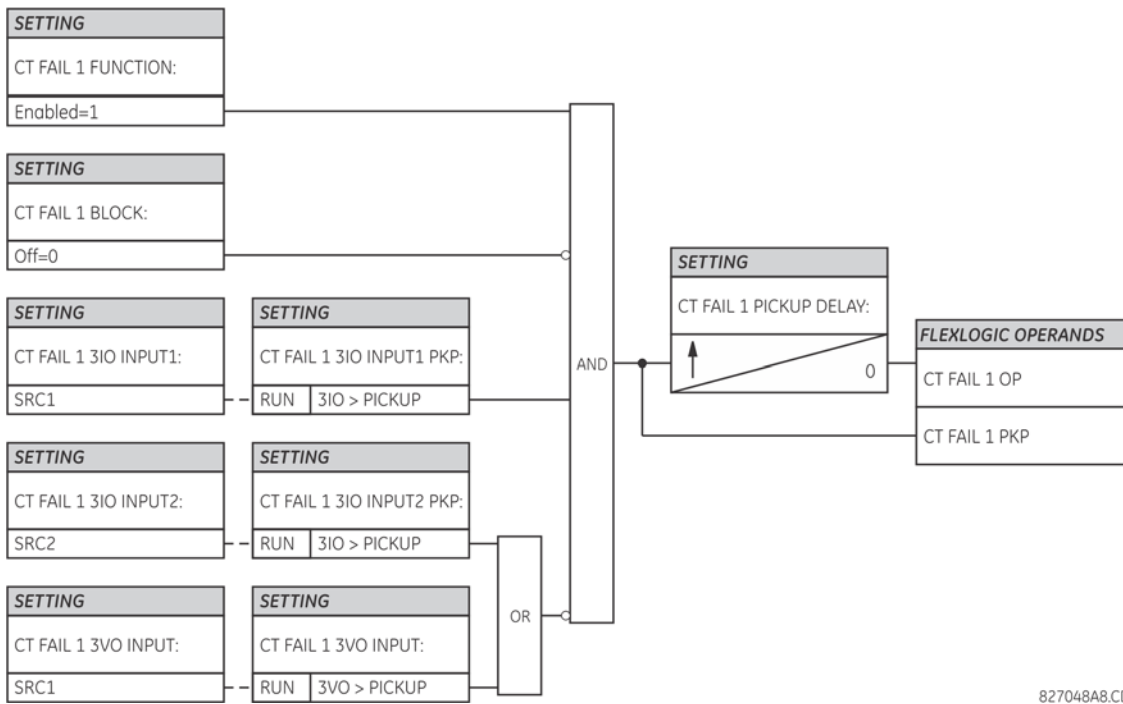
CT FAIL 1 3I0 INPUT 2 PICKUP — Selects the 3I_0 pickup value for input 2 (different CT input) of the relay.

CT FAIL 1 3V0 INPUT — Selects the voltage source.

CT FAIL 1 3V0 INPUT PICKUP — Specifies the pickup value for the 3V_0 source.

CT FAIL 1 PICKUP DELAY — Specifies the pickup delay of the CT failure element.

Figure 5-156: CT failure detector logic



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5.8.11.4 Incipient fault detector

SETTINGS ⇌ CONTROL ELEMENTS ⇌ MONITORING ELEMENTS ⇌ INCIPIENT FAULT 1

■ INCIPIENT FAULT 1	↔	INCIPIENT FAULT 1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	INCIPNT FLT 1 BLOCK: Off	Range: FlexLogic operand
	↕	INCIPIENT FAULT 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
	↕	INCIPIENT FAULT 1 PICKUP: 0.50 pu	Range: 0.10 to 10.00 pu in steps of 0.01
	↕	INCIPNT FLT 1 MODE: Number of counts	Range: Number of counts, Counts per window
	↕	INCIPIENT FLT 1 TRIP COUNTS NUMBER: 2	Range: 1 to 10 in steps of 1
	↕	INCIPNT FLT 1 DETECT WINDOW: 10.00 s	Range: 0.00 to 1000.00 s in steps of 0.01
	↕	INCIPIENT FAULT 1 RESET DELAY: 0.100 s	Range: 0.000 to 65.535 s in steps of 0.001
	↕	INCIPIENT FAULT 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	INCIPIENT FAULT 1 EVENTS: Disabled	Range: Disabled, Enabled

There is one incipient cable fault detection element.

Before a permanent cable fault occurs, there are usually signs of degrading insulation manifesting itself as a short, mostly half-cycle spikes asserting at the phase voltage peak. Due to shortness of such spikes, they are not usually detected by the instantaneous protection of the feeder, which operates on the RMS or fundamental component of the phase current with a relatively high pickup.

The number of detected incipient faults in each phase is counted and available in the **ACTUAL VALUES** ⇒ **STATUS** ⇒ **INCIPIENT FAULT** menus. The counters can be reset with the **COMMANDS** ⇒ **CLEAR RECORDS** ⇒ **CLEAR INCIPIENT FAULT COUNTERS** command.



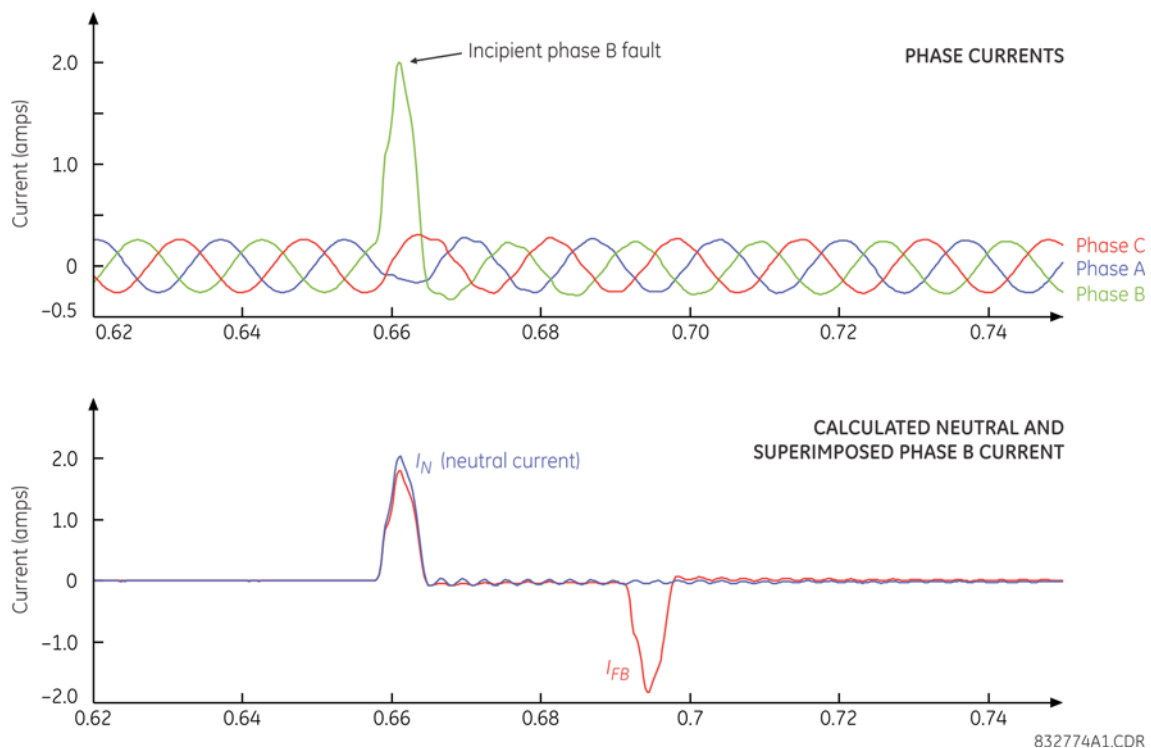
Changes to any of the incipient cable fault detector settings resets the number of the incipient faults detected to zero.

NOTE

To provide a clear timing indication when the incipient fault occurred, the incipient fault event is time-stamped with the time the fault actually occurred. However, the FlexLogic operand is asserted four cycles later, when the incipient fault pattern is confirmed and therefore detected.

The figure illustrates a recorded field case of an incipient phase B fault. The top portion of the figure shows the raw A, B, and C currents. The bottom portion shows the neutral current (blue) and reveals the fault period from under the load and the superimposed phase B current (red). The superimposed current shows two fault current blips as the data slides through the two-cycle memory window. During the actual fault, the neutral current and the superimposed phase B currents closely correspond, confirming the incipient fault hypothesis and identifying the affected phase.

Figure 5-157: Illustration of the incipient fault detector algorithm



The following settings are available for each incipient cable fault detector.

INCIPIENT FAULT 1 FUNCTION — This setting enables and disables operation of the incipient fault detection element.

INCIPIENT FLT 1 BLOCK — Blocks operation of the incipient cable fault detector element. Assertion of the FlexLogic operand assigned to this setting blocks operation.

INCIPIENT FAULT 1 SOURCE — Selects a current source for the incipient cable fault detector element. This source must be assigned a valid CT bank.

INCIPIENT FAULT 1 PICKUP — Specifies the pickup level of the overcurrent detector in per-unit values of the CT nominal current.

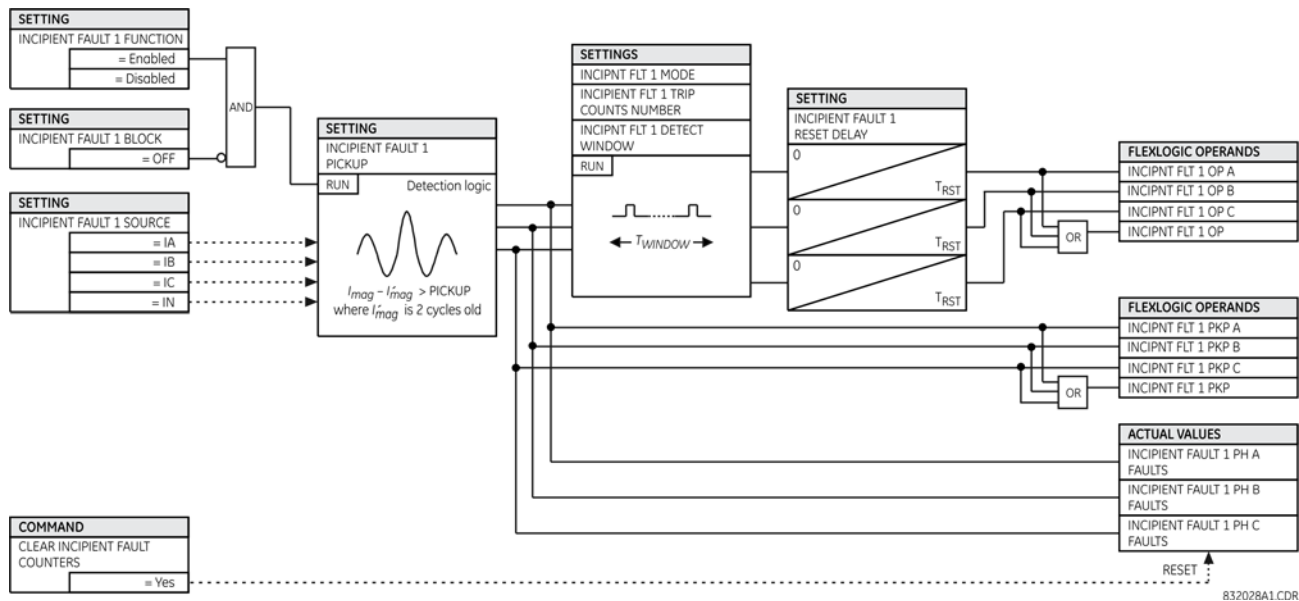
INCIPNT FLT 1 MODE — There are two modes of operation available for the incipient cable fault detector element. In the “Number of counts” mode, a trip is initiated only after the selected number of faults is detected. In the “Counts per window” mode, a trip is initiated only after the selected number of faults is detected within the time specified by the **INCIPNT FLT 1 DETECT WINDOW** setting.

INCIPNT FLT 1 TRIP COUNTS NUMBER — Selects the number of faults required to initiate a trip.

INCIPNT FLT 1 DETECT WINDOW — Specifies a time window for “Counts per window” mode of operation.

INCIPNT FAULT 1 RESET DELAY — Specifies a reset time for the output after the trip is initiated.

Figure 5-158: Incipient cable fault detector logic



5.8.11.5 VT fuse failure

SETTINGS ⇄ CONTROL ELEMENTS ⇄ MONITORING ELEMENTS ⇄ VT FUSE FAILURE 1(2)

■ VT FUSE FAILURE 1	⇄	VT FUSE FAILURE 1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇄	VT FUSE FAILURE 1 ALARM DELAY: 1.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	⇄	NEUTRAL WIRE OPEN 1 DETECTION: Disabled	Range: Disabled, Enabled
	⇄	NEUTRAL WIRE OPEN 1 3 HARM PKP: 0.100 pu	Range: 0.004 to 3.000 pu in steps of 0.001

Every signal source includes a fuse failure scheme.

The VT fuse failure detector is used to raise an alarm and/or block elements that operate incorrectly for a full or partial loss of AC potential caused by one or more blown fuses. Some elements that can be blocked (via the BLOCK input) are distance, voltage restrained overcurrent, and directional current.

There are two classes of fuse failure that occur:

- Class A — Loss of one or two phases
- Class B — Loss of all three phases

Different means of detection are required for each class. An indication of class A failures is a significant level of negative-sequence voltage, whereas an indication of class B failures is when positive sequence current is present and there is an insignificant amount of positive sequence voltage. Also, a rapid decrease in the phase voltages magnitude from a healthy

voltage level without disturbance in current can indicate VT fuse fail conditions. These noted indications of fuse failure can also be present when faults are present on the system, so a means of detecting faults and inhibiting fuse failure declarations during these events is provided.

Once the fuse failure condition is declared, it is sealed-in until the cause that generated it disappears.

An additional condition is introduced to inhibit a fuse failure declaration when the monitored circuit is de-energized; positive-sequence voltage and current are both below threshold levels.

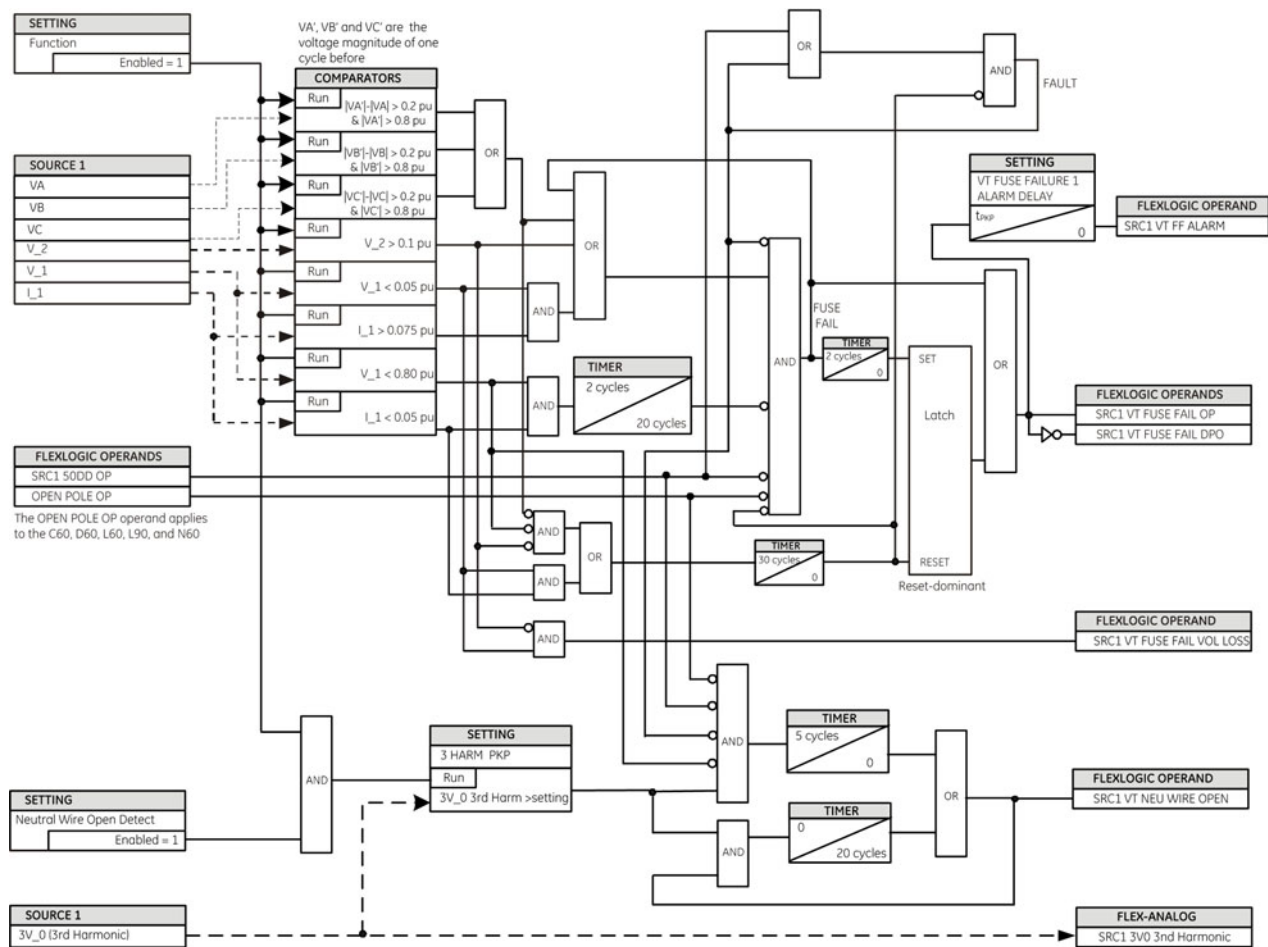
VT FUSE FAILURE 1 FUNCTION — Enables and disables the fuse failure feature for Source 1 VT Fuse Fail.

NEUTRAL WIRE OPEN 1 DETECTION — Enables and disables the VT neutral wire open detection function. When the VT is connected in Delta, do not enable this function because there is no neutral wire for Delta connected VT.

NEUTRAL WIRE OPEN 1 3 HARM PKP — Specifies the pickup level of 3rd harmonic of 3V0 signal for the **NEUTRAL WIRE OPEN DETECTION** logic to pick up.

Base voltage for this element is **PHASE VT SECONDARY** setting in the case of WYE VTs and $(\text{PHASE VT SECONDARY}) / \sqrt{3}$ in case of DELTA VTs. The setting is found under **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **AC INPUTS** ⇒ **VOLTAGE BANK** ⇒ **PHASE VT SECONDARY**.

Figure 5-159: VT fuse fail logic



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5.8.11.6 Thermal overload protection (ANSI 49)

SETTINGS ⇒ CONTROL ELEMENTS ⇒ MONITORING ELEMENTS ⇒ THERMAL OVERLOAD PROTECTION ⇒ THERMAL PROTECTION 1(2)

<div style="border: 1px solid black; padding: 2px;"> <p>■ THERMAL ■ PROTECTION 1</p> </div>	↔	THERMAL PROTECTION 1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	THERMAL PROTECTION 1 SOURCE: SRC1	Range: SRC 1, SRC 2
	⇅	THERMAL PROTECTION 1 BASE CURR: 0.80 pu	Range: 0.20 to 3.00 pu in steps of 0.01
	⇅	THERMAL PROTECTION 1 k FACTOR: 1.10	Range: 1.00 to 1.20 in steps of 0.05
	⇅	THERM PROT 1 TRIP TIME CONST: 45 min	Range: 0 to 1000 min. in steps of 1
	⇅	THERM PROT 1 RESET TIME CONST: 45 min	Range: 0 to 1000 min. in steps of 1
	⇅	THERM PROT 1 MINIM RESET TIME: 20 min	Range: 0 to 1000 min. in steps of 1
	⇅	THERM PROT 1 RESET: Off	Range: FlexLogic operand
	⇅	THERM PROT 1 BLOCK: Off	Range: FlexLogic operand
	⇅	THERMAL PROTECTION 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↑	THERMAL PROTECTION 1 EVENTS: Disabled	Range: Disabled, Enabled	

The thermal overload protection element corresponds to the IEC 255-8 standard and is used to detect thermal overload conditions in protected power system elements. Choosing an appropriate time constant element can be used to protect different elements of the power system. The cold curve characteristic is applied when the estimated I_p current is less than 10% of the base current. If I_p current is greater or equal than 10% than the base current, then the hot curve characteristic is applied. I_p current is estimated with a fixed time constant for both cooling and heating that reaches to the final value in two seconds on a step change (either step up or step down) signal.

The IEC255-8 cold curve is defined as follows:

$$t_{op} = \tau_{op} \times \ln\left(\frac{I^2}{I^2 - (k \times I_B)^2}\right) \quad \text{Eq. 5-28}$$

The IEC255-8 hot curve is defined as follows:

$$t_{op} = \tau_{op} \times \ln\left(\frac{I^2 - I_p^2}{I^2 - (k \times I_B)^2}\right) \quad \text{Eq. 5-29}$$

where

t_{op} = time to operate

τ_{op} = thermal protection trip time constant

I = measured overload RMS current

I_p = measured load RMS current before overload occurs

k = IEC 255-8 k-factor applied to I_B , defining maximum permissible current above nominal current

I_B = protected element base (nominal) current

To ensure element accuracy for high overcurrent conditions, the maximum value of $I/(k \times I_B)$ is limited to 8, even when realistically it is exceeding this value.

The reset time of the thermal overload protection element is also time delayed using following formula:

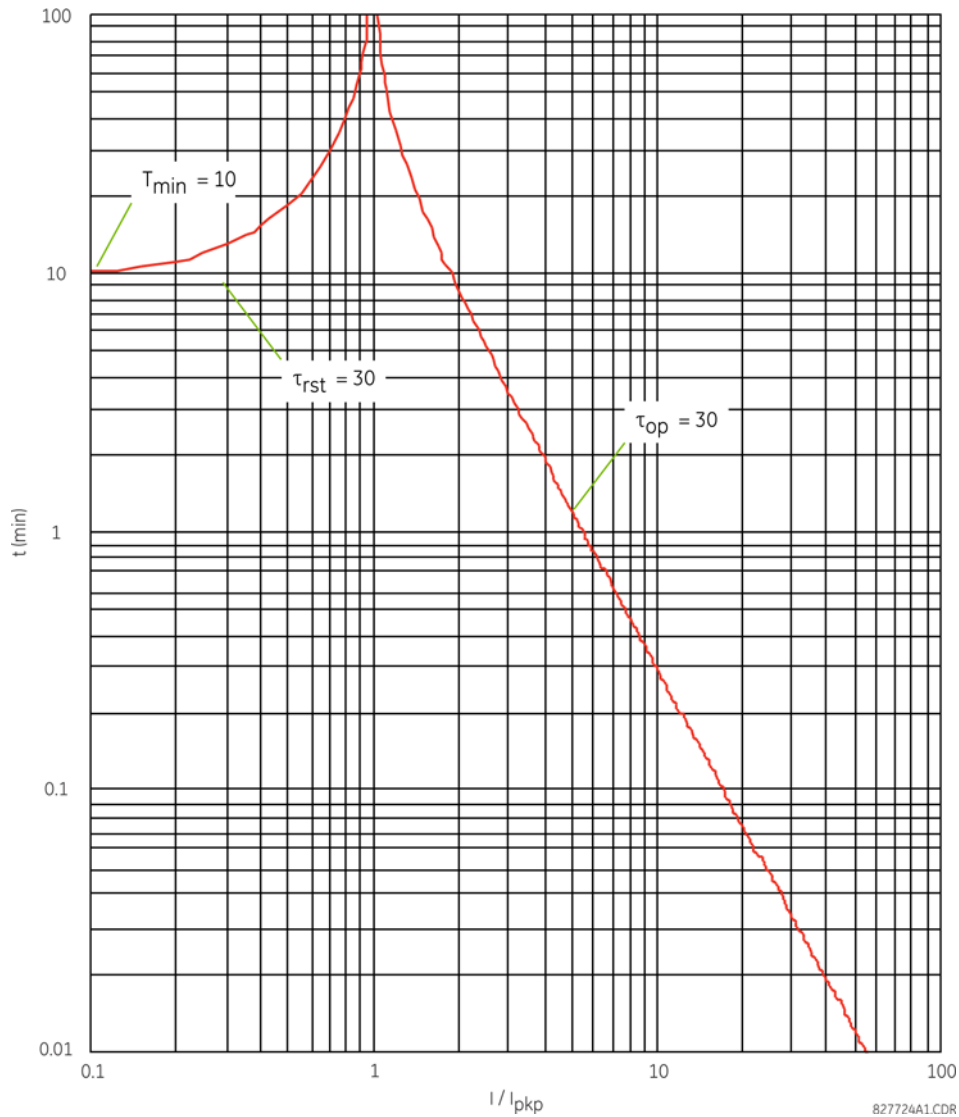
$$t_{rst} = \tau_{rst} \times \ln \left(\frac{(k \times I_B)^2}{|I|^2 - (k \times I_B)^2} \right) + T_{min} \tag{Eq. 5-30}$$

where

τ_{rst} = thermal protection trip time constant

T_{min} = a minimum reset time setting

Figure 5-160: IEC 255-8 sample operate and reset curves



The thermal overload protection element estimates accumulated thermal energy E using the following equations calculated each power cycle. When current is greater than the pickup level, $I_n > k \times I_B$, element starts increasing the thermal energy:

$$E_n = E_{n-1} + \frac{\Delta t}{t_{op}(I_n)} \tag{Eq. 5-31}$$

When current is less than the dropout level, $I_n > 0.97 \times k \times I_B$, the element starts decreasing the thermal energy:

$$E_n = E_{n-1} - \frac{\Delta t}{t_{rst(I_n)}} \tag{Eq. 5-32}$$

where

Δt is the power cycle duration

n is the power cycle index

$t_{op(I_n)}$ is the trip time calculated at index n as per the IEC255-8 cold curve or hot curve equations

$t_{rst(I_n)}$ is the reset time calculated at index n as per the reset time equation

I_n is the measured overload RMS current at index n

E_n is the accumulated energy at index n

E_{n-1} is the accumulated energy at index $n - 1$

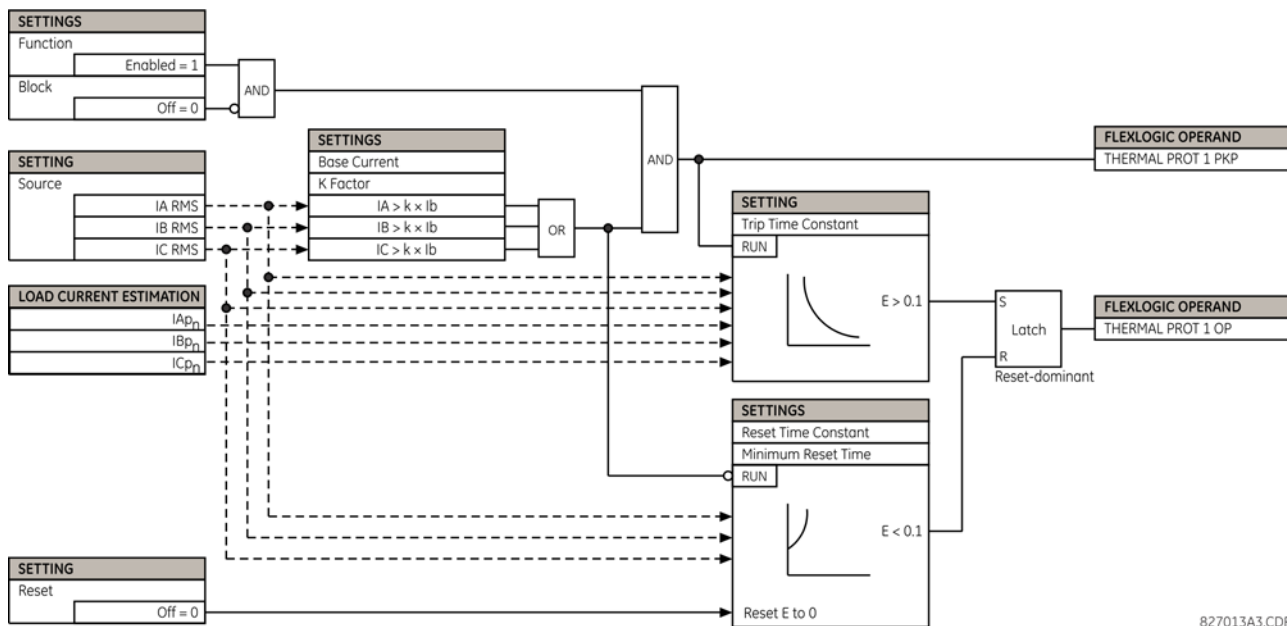
The thermal overload protection element removes the **THERMAL PROT 1 OP** output operand when $E < 0.05$. In case of emergency, the thermal memory and **THERMAL PROT 1 OP** output operand can be reset using **THERM PROT 1 RESET** setting. All calculations are performed per phase. If the accumulated energy reaches value 1 in any phase, the thermal overload protection element operates and only resets when energy is less than 0.05 in all three phases.

Table 5-39: Typical time constants

Protected equipment	Time constant	Minimum reset time
Capacitor bank	10 minutes	30 minutes
Overhead line	10 minutes	20 minutes
Air-core reactor	40 minutes	30 minutes
Busbar	60 minutes	20 minutes
Underground cable	20 to 60 minutes	60 minutes

The figure shows the logic for the thermal overload protection element.

Figure 5-161: Thermal overload protection logic



5.8.11.7 Broken conductor detection

SETTINGS ⇒ CONTROL ELEMENTS ⇒ MONITORING ELEMENTS ⇒ BROKEN CONDUCTOR 1(2)

■ BROKEN CONDUCTOR 1	↔	BROKEN CONDUCTOR 1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	BROKEN CONDUCTOR 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
	↕	BROKEN CONDUCTOR 1 I2/I1 RATIO: 20%	Range: 20.0% to 100.0% in steps of 0.1%
	↕	BROKEN CONDUCTOR 1 I1 MIN: 0.10 pu	Range: 0.05 to 1.00 pu in steps of 0.01
	↕	BROKEN CONDUCTOR 1 I1 MAX: 1.50 pu	Range: 0.05 to 5.00 pu in steps of 0.01
	↕	BROKEN CONDUCTOR 1 PKP DELAY: 20.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	↕	BROKEN CONDCT 1 BLK: Off	Range: FlexLogic operand
	↕	BROKEN CONDUCTOR 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	BROKEN CONDUCTOR 1 EVENTS: Disabled	Range: Disabled, Enabled

The broken conductor function detects a transmission line broken conductor condition or a single-pole breaker malfunction condition by checking the phase current input signals and the I_2 / I_1 ratio. The intent is to detect a single-phase broken conductor only. As such, two-phase or three-phase broken conductors cannot be detected.

To distinguish between single-phase disappearance and system disturbance in all three phases (such as load change and switching), the broken conductor element monitors the change in all three phase currents at the present instance and at four cycles previous. It also monitors changes in the I_2 / I_1 ratio, I_1 minimum, and I_1 maximum.

Do not use the broken conductor function to respond to fault transients and single-pole tripping/reclosing conditions. Therefore, program the time delay to a sufficient length to ensure coordination with the breaker dead time of the recloser function.

BROKEN CONDUCTOR 1 FUNCTION — This setting enables and disables the broken conductor function.

BROKEN CONDUCTOR 1 SOURCE — Selects a signal source used to provide three-phase current inputs to this function.

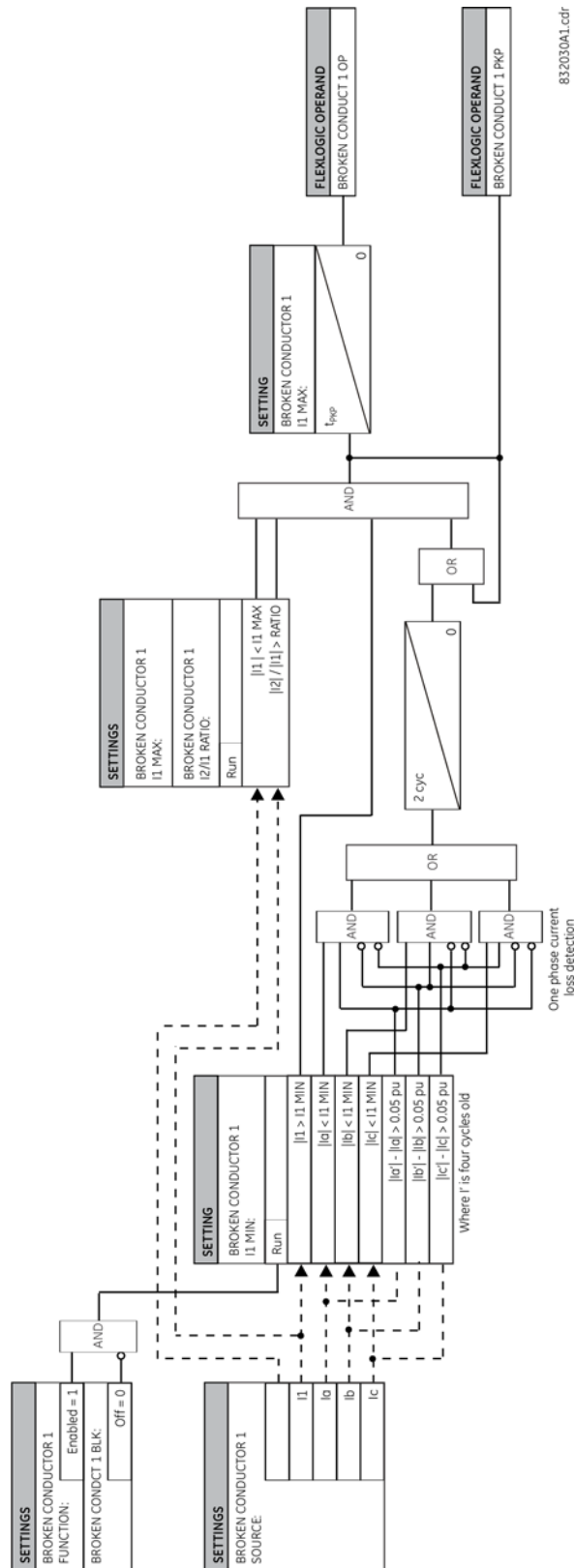
BROKEN CONDUCTOR 1 I2/I1 RATIO — This setting specifies the ratio of negative-sequence current to positive-sequence current. When one phase conductor is broken, the I_2 / I_1 ratio with a balanced remaining two phases is 50%. So normally you this setting below 50% (for example, to 30%).

BROKEN CONDUCTOR 1 I1 MIN — This setting specifies the minimum positive-sequence current supervision level. Ensure this setting is programmed to a sufficient level to prevent I_2 / I_1 from erratic pickup due to a low I_1 signal. However, do not set this setting too high, since the broken conductor condition cannot be detected under light load conditions when I_1 is less than the value specified by this setting.

BROKEN CONDUCTOR 1 I1 MAX — This setting specifies the maximum I_1 level allowed for the broken conductor function to operate. When I_1 exceeds this setting, this it is considered a fault. In order for this function to not respond to any fault conditions, set this setting to less than the maximum load current.

BROKEN CONDUCTOR 1 PKP DELAY — This setting specifies the pickup time delay for this function to operate after assertion of the broken conductor pickup FlexLogic operand.

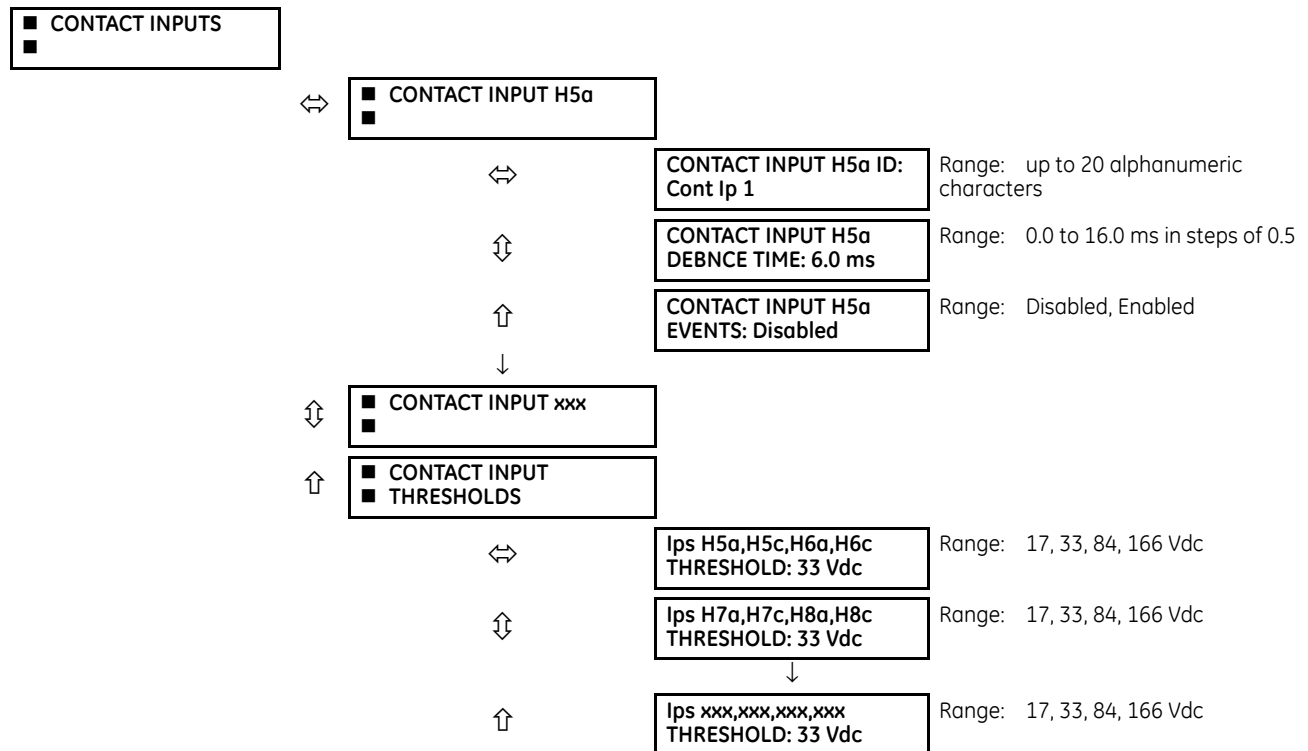
Figure 5-162: Broken conductor detection logic



5.9 Inputs/outputs

5.9.1 Contact inputs

SETTINGS ⇒ INPUTS/OUTPUTS ⇒ CONTACT INPUTS



A contact inputs and outputs are digital signals associated with connections to hard-wired contacts. Wet and dry contacts are supported.

The contact inputs menu contains configuration settings for each contact input as well as voltage thresholds for each group of four contact inputs. Upon startup, the relay processor determines (from an assessment of the installed modules) which contact inputs are available and then display settings for only those inputs.

An alphanumeric ID can be assigned to a contact input for diagnostic, setting, and event recording purposes. The **CONTACT IP X On** (Logic 1) FlexLogic operand corresponds to contact input “X” being closed, while **CONTACT IP X Off** corresponds to contact input “X” being open. The **CONTACT INPUT DEBNCE TIME** defines the time required for the contact to overcome ‘contact bouncing’ conditions. As this time differs for different contact types and manufacturers, set it as a maximum contact debounce time (per manufacturer specifications) plus some margin to ensure proper operation. If **CONTACT INPUT EVENTS** is set to “Enabled,” every change in the contact input state triggers an event.

A raw status is scanned for all Contact Inputs synchronously at the constant rate of 0.5 ms as shown in the following figure. The DC input voltage is compared to a user-settable threshold. A new contact input state must be maintained for a user-settable debounce time in order for the L30 to validate the new contact state. In the following figure, the debounce time is set at 2.5 ms; thus the 6th sample in a row validates the change of state (mark no. 1 in the diagram). Once validated (de-bounced), the contact input asserts a corresponding FlexLogic operand and logs an event as per user setting.

A time stamp of the first sample in the sequence that validates the new state is used when logging the change of the contact input into the Event Recorder (mark no. 2 in the figure).

Protection and control elements, as well as FlexLogic equations and timers, are executed eight times in a power system cycle. The protection pass duration is controlled by the frequency tracking mechanism. The FlexLogic operand reflecting the debounced state of the contact is updated at the protection pass following the validation (marks no. 3 and 4 on the figure that follows). The update is performed at the beginning of the protection pass so all protection and control functions, as well as FlexLogic equations, are fed with the updated states of the contact inputs.

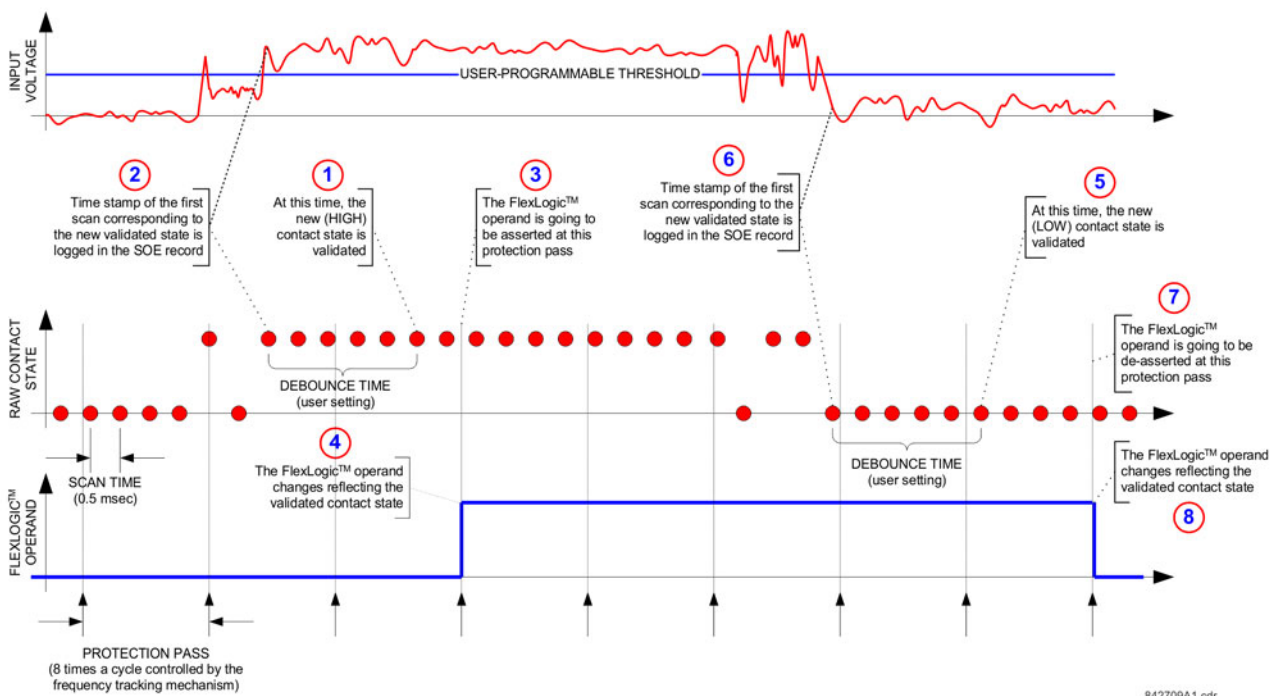
The FlexLogic operand response time to the contact input change is equal to the debounce time setting plus up to one protection pass (variable and depending on system frequency if frequency tracking enabled). If the change of state occurs just after a protection pass, the recognition is delayed until the subsequent protection pass; that is, by the entire duration of the protection pass. If the change occurs just prior to a protection pass, the state is recognized immediately. Statistically a delay of half the protection pass is expected. Owing to the 0.5 ms scan rate, the time resolution for the input contact is below 1 ms.

For example, eight protection passes per cycle on a 60 Hz system correspond to a protection pass every 2.1 ms. With a contact debounce time setting of 3.0 ms, the FlexLogic operand-assert time limits are: $3.0 + 0.0 = 3.0$ ms and $3.0 + 2.1 = 5.1$ ms. These time limits depend on how soon the protection pass runs after the debouncing time.

Regardless of the contact debounce time setting, the contact input event is time-stamped with a 1 μs accuracy using the time of the first scan corresponding to the new state (mark no. 2 shown). Therefore, the time stamp reflects a change in the DC voltage across the contact input terminals that was not accidental as it was subsequently validated using the debounce timer. Keep in mind that the associated FlexLogic operand is asserted/de-asserted later, after validating the change.

The debounce algorithm is symmetrical: the same procedure and debounce time are used to filter the LOW-HIGH (marks no. 1, 2, 3, and 4 in the figure) and HIGH-LOW (marks no. 5, 6, 7, and 8) transitions.

Figure 5-163: Input contact debouncing mechanism and time stamp sample timing



Contact inputs are isolated in groups of four to allow connection of wet contacts from different voltage sources for each group. The **CONTACT INPUT THRESHOLDS** determine the minimum voltage required to detect a closed contact input. This value is selected according to the following criteria: 17 for 24 V sources, 33 for 48 V sources, 84 for 110 to 125 V sources and 166 for 250 V sources.

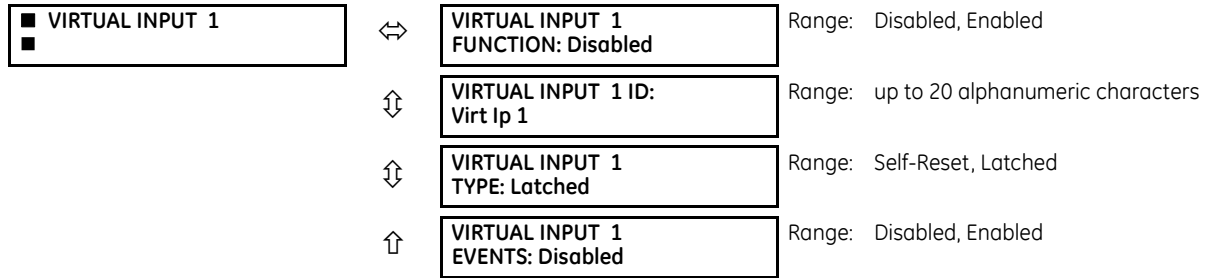
For example, to use contact input H5a as a status input from the breaker 52b contact to seal-in the trip relay and record it in the Event Records menu, make the following settings changes:

CONTACT INPUT H5a ID: "Breaker Closed (52b)"
 CONTACT INPUT H5a EVENTS: "Enabled"

Note that the 52b contact is closed when the breaker is open and open when the breaker is closed.

5.9.2 Virtual inputs

SETTINGS ⇒ INPUTS/OUTPUTS ⇒ VIRTUAL INPUTS ⇒ VIRTUAL INPUT 1(64)



The virtual inputs and outputs are digital signals associated with UR-series internal logic signals. Virtual inputs include signals generated by the local user interface. The virtual outputs are outputs of FlexLogic equations used to customize the device. Virtual outputs can also serve as virtual inputs to FlexLogic equations.

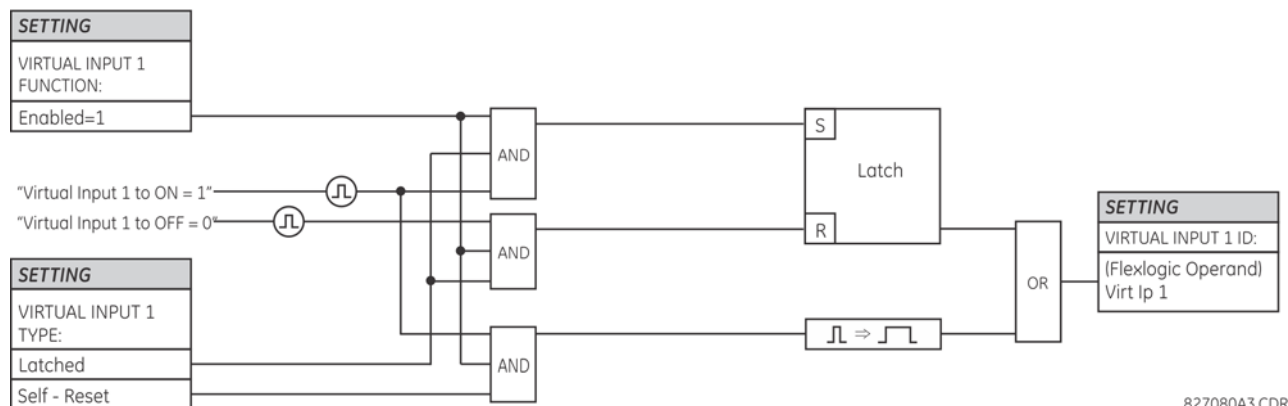
There are 64 virtual inputs that can be individually programmed to respond to input signals from the keypad (via the **COMMANDS** menu) and communications protocols. All virtual input operands are defaulted to "Off" (logic 0) unless the appropriate input signal is received.

If the **VIRTUAL INPUT x FUNCTION** is to "Disabled," the input is forced to off (logic 0) regardless of any attempt to alter the input. If set to "Enabled," the input operates as shown on the logic diagram and generates output FlexLogic operands in response to received input signals and the applied settings.

There are two types of operation: self-reset and latched. If **VIRTUAL INPUT x type** is "Self-Reset," when the input signal transits from off to on, the output operand is set to on for only one evaluation of the FlexLogic equations and then return to off. If set to "Latched," the virtual input sets the state of the output operand to the same state as the most recent received input.

The self-reset operating mode generates the output operand for a single evaluation of the FlexLogic equations. If the operand is to be used anywhere other than internally in a FlexLogic equation, it likely needs to be lengthened in time. A FlexLogic timer with a delayed reset can perform this function.

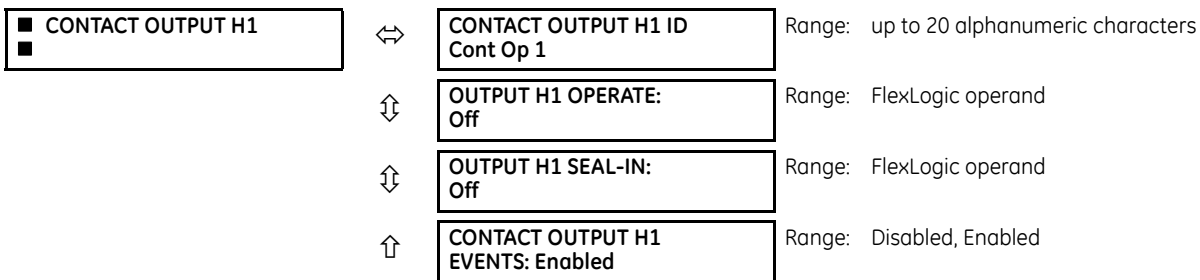
Figure 5-164: Virtual inputs logic



5.9.3 Contact outputs

5.9.3.1 Digital outputs

SETTINGS ⇒ INPUTS/OUTPUTS ⇒ CONTACT OUTPUTS ⇒ CONTACT OUTPUT H1



A contact inputs and outputs are digital signals associated with connections to hard-wired contacts. Wet and dry contacts are supported.

Upon startup of the relay, the main processor determines from an assessment of the modules installed in the chassis which contact outputs are available and then presents the settings for only these outputs. Where the contact input is non-latching, the settings are as shown.

An ID can be assigned to each contact output. The signal that can OPERATE a contact output can be any FlexLogic operand (virtual output, element state, contact input, or virtual input). An additional FlexLogic operand can be used to SEAL-IN the relay. Any change of state of a contact output can be logged as an Event if programmed to do so.

For example, the trip circuit current is monitored by providing a current threshold detector in series with some Form-A contacts (see the trip circuit example in the Digital Elements section). The monitor sets a flag (see the specifications for Form-A). The name of the FlexLogic operand set by the monitor, consists of the output relay designation, followed by the name of the flag; for example, *Cont OP 1 IO_n*.

In most breaker control circuits, the trip coil is connected in series with a breaker auxiliary contact used to interrupt current flow after the breaker has tripped, to prevent damage to the less robust initiating contact. This can be done by monitoring an auxiliary contact on the breaker which opens when the breaker has tripped, but this scheme is subject to incorrect operation caused by differences in timing between breaker auxiliary contact change-of-state and interruption of current in the trip circuit. The most dependable protection of the initiating contact is provided by directly measuring current in the tripping circuit, and using this parameter to control resetting of the initiating relay. This scheme is often called trip seal-in.

This can be realized using the *Cont OP 1 IO_n* FlexLogic operand to seal-in the contact output as follows:

- CONTACT OUTPUT H1 ID: "Cont Op 1"
- OUTPUT H1 OPERATE: any suitable FlexLogic operand
- OUTPUT H1 SEAL-IN: "Cont Op 1 IO_n"
- CONTACT OUTPUT H1 EVENTS: "Enabled"

Figure 5-165: Contact input/output module type 6A contact 1 logic



5.9.3.2 Latching outputs

SETTINGS ⇒ INPUTS/OUTPUTS ⇒ CONTACT OUTPUTS ⇒ CONTACT OUTPUT H1a

<div style="border: 1px solid black; padding: 2px;"> <p>■ CONTACT OUTPUT H1a</p> <p>■</p> </div>	↔	<div style="border: 1px solid black; padding: 2px;"> <p>OUTPUT H1a ID</p> <p>L-Cont Op 1</p> </div>	Range: up to 20 alphanumeric characters
	↕	<div style="border: 1px solid black; padding: 2px;"> <p>OUTPUT H1a OPERATE:</p> <p>Off</p> </div>	Range: FlexLogic operand
	↕	<div style="border: 1px solid black; padding: 2px;"> <p>OUTPUT H1a RESET:</p> <p>Off</p> </div>	Range: FlexLogic operand
	↕	<div style="border: 1px solid black; padding: 2px;"> <p>OUTPUT H1a TYPE:</p> <p>Operate-dominant</p> </div>	Range: Operate-dominant, Reset-dominant
	↑	<div style="border: 1px solid black; padding: 2px;"> <p>OUTPUT H1a EVENTS:</p> <p>Disabled</p> </div>	Range: Disabled, Enabled

The latching output contacts are mechanically bi-stable and controlled by two separate (open and close) coils. As such they retain their position even if the relay is not powered up. The relay recognizes all latching output contact cards and populates the setting menu accordingly. On power up, the relay reads positions of the latching contacts from the hardware before executing any other functions of the relay (such as protection and control features or FlexLogic).

The latching output modules, either as part of the relay or as individual modules, are shipped from the factory with all latching contacts open. It is highly recommended to double-check the programming and positions of the latching contacts when replacing a module.

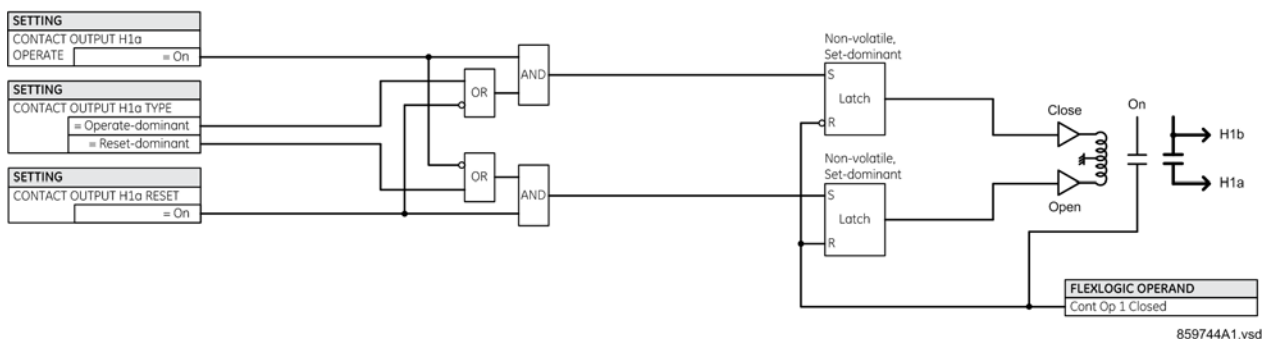
Since the relay asserts the output contact and reads back its position, it is possible to incorporate self-monitoring capabilities for the latching outputs. If any latching outputs exhibits a discrepancy, the LATCHING OUTPUT ERROR self-test error is declared. The error is signaled by the LATCHING OUT ERROR FlexLogic operand, event, and target message.

OUTPUT H1a OPERATE — This setting specifies a FlexLogic operand to operate the ‘close coil’ of the contact. The relay seals-in this input to safely close the contact. Once the contact is closed and the **RESET** input is logic 0 (off), any activity of the **OPERATE** input, such as subsequent chattering, does not have any effect. With both the **OPERATE** and **RESET** inputs active (logic 1), the response of the latching contact is specified by the **OUTPUT H1a TYPE** setting.

OUTPUT H1a RESET — This setting specifies a FlexLogic operand to operate the ‘trip coil’ of the contact. The relay seals-in this input to safely open the contact. Once the contact is opened and the **OPERATE** input is logic 0 (off), any activity of the **RESET** input, such as subsequent chattering, does not have any effect. With both the **OPERATE** and **RESET** inputs active (logic 1), the response of the latching contact is specified by the **OUTPUT H1a TYPE** setting.

OUTPUT H1a TYPE — This setting specifies the contact response under conflicting control inputs; that is, when both the **OPERATE** and **RESET** signals are applied. With both control inputs applied simultaneously, the contact closes if set to “Operate-dominant” and opens if set to “Reset-dominant.”

Figure 5-166: Contact input/output module type 4L contact 1 logic



Application example 1

A latching output contact H1a is to be controlled from two user-programmable pushbuttons (buttons number 1 and 2). The following settings are applied.

Program the Latching Outputs by making the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **CONTACT OUTPUTS** ⇒ **CONTACT OUTPUT H1a** menu (assuming an H4L module):

- OUTPUT H1a OPERATE:** "PUSHBUTTON 1 ON"
- OUTPUT H1a RESET:** "PUSHBUTTON 2 ON"

Program the pushbuttons by making the following changes in the **PRODUCT SETUP** ⇒ **USER-PROGRAMMABLE PUSHBUTTONS** ⇒ **USER PUSHBUTTON 1** and **USER PUSHBUTTON 2** menus:

- PUSHBUTTON 1 FUNCTION:** "Self-reset"
- PUSHBTN 1 DROP-OUT TIME:** "0.00 s"
- PUSHBUTTON 2 FUNCTION:** "Self-reset"
- PUSHBTN 2 DROP-OUT TIME:** "0.00 s"

Application example 2

A relay, having two latching contacts H1a and H1c, is to be programmed. The H1a contact is to be a Type-a contact, while the H1c contact is to be a Type-b contact (Type-a means closed after exercising the operate input; Type-b means closed after exercising the reset input). The relay is to be controlled from virtual outputs: VO1 to operate and VO2 to reset.

Program the Latching Outputs by making the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **CONTACT OUTPUTS** ⇒ **CONTACT OUTPUT H1a** and **CONTACT OUTPUT H1c** menus (assuming an H4L module):

- OUTPUT H1a OPERATE:** "VO1"
- OUTPUT H1a RESET:** "VO2"
- OUTPUT H1c OPERATE:** "VO2"
- OUTPUT H1c RESET:** "VO1"

Since the two physical contacts in this example are mechanically separated and have individual control inputs, they do not operate at exactly the same time. A discrepancy in the range of a fraction of a maximum operating time can occur. Therefore, a pair of contacts programmed to be a multi-contact relay do not guarantee any specific sequence of operation (such as make before break). If required, the sequence of operation must be programmed explicitly by delaying some of the control inputs as shown in the next application example.

Application example 3

A make before break functionality must be added to the preceding example. An overlap of 20 ms is required to implement this functionality.

Write the following FlexLogic equation (EnerVista example shown).

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Outputs On	Virt Op 1 On (VO1)
FlexLogic Entry 2	TIMER	Timer 1
FlexLogic Entry 3	Assign Virtual Output	= Virt Op 3 (VO3)
FlexLogic Entry 4	Virtual Outputs On	Virt Op 2 On (VO2)
FlexLogic Entry 5	TIMER	Timer 2
FlexLogic Entry 6	Assign Virtual Output	= Virt Op 4 (VO4)
FlexLogic Entry 7	End of List	

Set both timers (Timer 1 and Timer 2) to 20 ms pickup and 0 ms dropout.

Program the Latching Outputs by making the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **CONTACT OUTPUTS** ⇒ **CONTACT OUTPUT H1a** and **CONTACT OUTPUT H1c** menus (assuming an H4L module):

- OUTPUT H1a OPERATE:** "VO1"
- OUTPUT H1a RESET:** "VO4"
- OUTPUT H1c OPERATE:** "VO2"
- OUTPUT H1c RESET:** "VO3"

Application example 4

A latching contact H1a is to be controlled from a single virtual output VO1. The contact is to remain closed as long as VO1 is high, and is to remain opened when VO1 is low. Program the relay as follows.

Write the following FlexLogic equation (EnerVista example shown).

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Outputs On	Virt Op 1 On (VO1)
FlexLogic Entry 2	NOT	1 Input
FlexLogic Entry 3	Assign Virtual Output	= Virt Op 2 (VO2)
FlexLogic Entry 4	End of List	

Program the Latching Outputs by making the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **CONTACT OUTPUTS** ⇒ **CONTACT OUTPUT H1a** menu (assuming an H4L module):

OUTPUT H1a OPERATE: "VO1"
OUTPUT H1a RESET: "VO2"

5.9.4 Virtual outputs

SETTINGS ⇒ **INPUTS/OUTPUTS** ⇒ **VIRTUAL OUTPUTS** ⇒ **VIRTUAL OUTPUT 1(96)**

<input checked="" type="checkbox"/> VIRTUAL OUTPUT 1 <input checked="" type="checkbox"/>	↔	VIRTUAL OUTPUT 1 ID Virt Op 1	Range: up to 20 alphanumeric characters
	↑	VIRTUAL OUTPUT 1 EVENTS: Disabled	Range: Disabled, Enabled

The virtual inputs and outputs are digital signals associated with UR-series internal logic signals. Virtual inputs include signals generated by the local user interface. The virtual outputs are outputs of FlexLogic equations used to customize the device. Virtual outputs can also serve as virtual inputs to FlexLogic equations.

There are 96 virtual outputs that can be assigned using FlexLogic. If not assigned, the output is forced to 'OFF' (Logic 0). An ID also can be assigned to each virtual output. Virtual outputs are resolved in each pass through the evaluation of the FlexLogic equations. Any change of state of a virtual output can be logged as an event if programmed to do so.

For example, if Virtual Output 1 is the trip signal from FlexLogic and the trip relay is used to signal events, the settings is programmed as follows:

VIRTUAL OUTPUT 1 ID: "Trip"
VIRTUAL OUTPUT 1 EVENTS: "Disabled"

5.9.5 Resetting

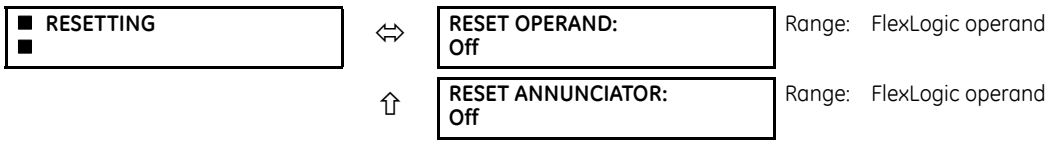
5.9.5.1 Enhanced and standard front panels

SETTINGS ⇒ **INPUTS/OUTPUTS** ⇒ **RESETTING**

<input checked="" type="checkbox"/> RESETTING <input checked="" type="checkbox"/>	↔	RESET OPERAND: Off	Range: FlexLogic operand
---	---	------------------------------	--------------------------

5.9.5.2 Graphical front panel

SETTINGS ⇄ INPUTS/OUTPUTS ⇄ RESETTING



Some events can be programmed to latch the front panel LED event indicators, target messages, and/or graphical front panel annunciator windows. Once set, the latching mechanism holds the latched indicators, messages, or windows in the set state after the initiating condition has cleared until a **RESET** command is received to return these latches (not including FlexLogic latches) to the reset state where the initiating condition has cleared. The **RESET** command can be sent from the front panel **RESET** button, a remote device via a communications channel, or any selected operand. The Modbus execute function 05h with operation code 1 command is also available to perform the same function as the front panel **RESET** key.

RESET OPERAND — The three sources of **RESET** commands each activates the **RESET OP** FlexLogic operand. Each individual source of a **RESET** command also activates its individual operand **RESET OP (PUSHBUTTON)**, **RESET OP (COMMS)**, or **RESET OP (OPERAND)** to identify the source of the command. Each of these three operands generates an event in the event record when activated. The **RESET OPERAND** setting here selects the operand that activates the **RESET OP (OPERAND)** operand.

RESET ANNUNCIATOR — Used to select a FlexLogic operand that when activated acknowledges/resets all annunciator windows on the graphical front panel. The other methods to acknowledge/reset annunciator windows include:

- On the displayed page, press the **RESET** pushbutton with none of the annunciator windows selected to acknowledge/reset all annunciator windows on that page
- To acknowledge/reset a specific annunciator window, use the Up, Down, Left and Right pushbuttons to select the window, and press the **RESET** or **ENTER** pushbutton
- All annunciator windows can be reset remotely by programming a Virtual Input (for example Virtual Input 1) as the input to the **RESET ANNUNCIATOR** setting. Then the Modbus execute function 05h with operation code 1000h command (or function 10h with address 400h) is used to set the state of Virtual Input 1.

For the **RESET ANNUNCIATOR** setting, the **RESET ANCTR OP** FlexLogic operand is activated by the two sources of **RESET** command, operand source and manual source. Each individual source of a **RESET ANNUNCIATOR** command also activates its individual operand **RESET OP (OPRD)** or **RESET ANCTR OP (MNUL)** to identify the source of the command. Each of these two operands generates an event in the event record when activated. The setting here selects the operand that activates the **RESET ANCTR OP (OPRD)** operand. The **RESET** pushbutton on the front panel or the reset command from the software activates the **RESET ANCTR OP (MNUL)** operand.

5.9.6 Direct inputs and outputs

5.9.6.1 Overview

The relay provides eight direct inputs conveyed on communications channel 1 (numbered 1-1 through 1-8) and eight direct inputs conveyed on communications channel 2 (on three-terminal systems only, numbered 2-1 through 2-8). The user must program the remote relay connected to channels 1 and 2 of the local relay by assigning the desired FlexLogic operand to be sent via the selected communications channel.

This relay allows the user to create distributed protection and control schemes via dedicated communications channels. Some examples are directional comparison pilot schemes and transfer tripping. Note that failures of communications channel affect direct input/output functionality. The 87L function must be enabled to utilize the direct inputs.

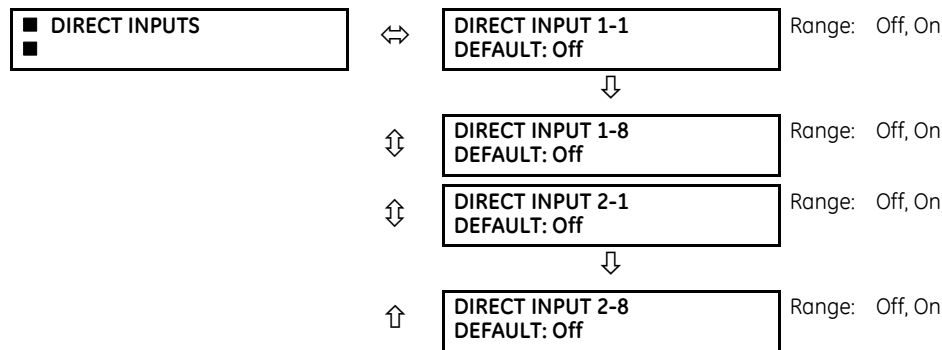
Direct input and output FlexLogic operands to be used at the local relay are assigned as follows:

- Direct input/output 1-1 through direct input/output 1-8 for communications channel 1
- Direct input/output 2-1 through direct input/output 2-8 for communications channel 2 (three-terminal systems only)

On the two-terminal, two channel system (redundant channel), direct outputs 1-1 to 1-8 are sent over both channels simultaneously and are received separately as direct inputs 1-1 to 1-8 at channel 1 and direct inputs 2-1 to 2-8 at channel 2. Therefore, to take advantage of redundancy, the respective operands from channel 1 and 2 can be ORed with FlexLogic or mapped separately.

5.9.6.2 Direct inputs

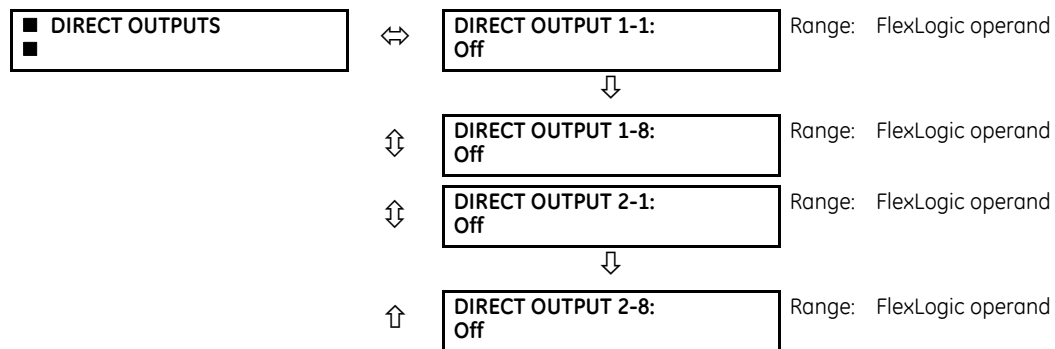
SETTINGS ⇌ INPUTS/OUTPUTS ⇌ DIRECT ⇌ DIRECT INPUTS



DIRECT INPUT 1-1(8) DEFAULT — Selects the logic state of this particular bit used for this point if the local relay has just completed startup or the local communications channel is declared to have failed. Setting **DIRECT INPUT 1-1(8) DEFAULT** to “On” means that the corresponding local FlexLogic operand (**DIRECT I/P 1-1(8)**) has logic state “1” on relay startup or during communications channel failure. When the channel is restored, the operand logic state reflects the actual state of the corresponding remote direct output.

5.9.6.3 Direct outputs

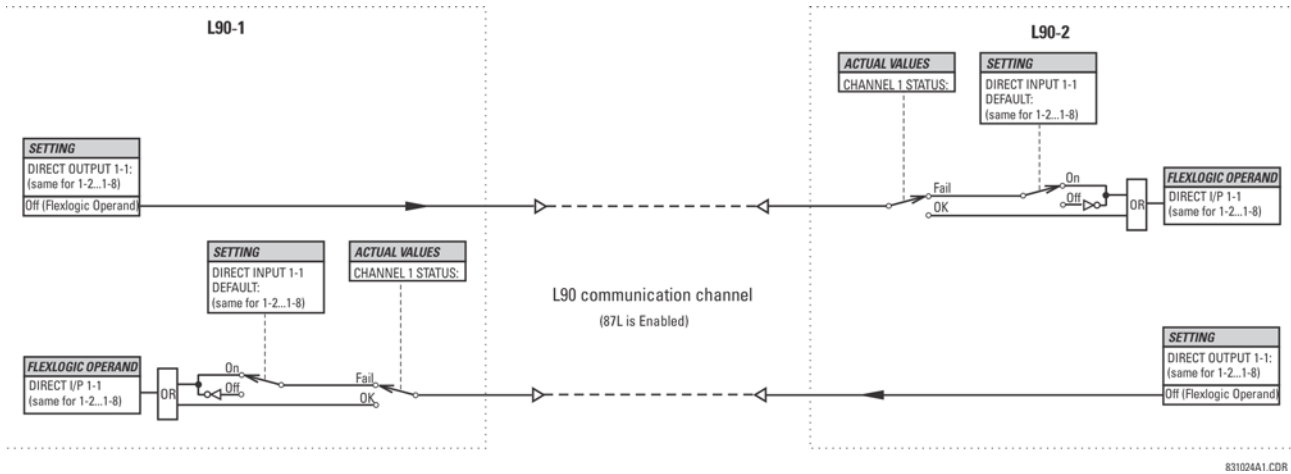
SETTINGS ⇌ INPUTS/OUTPUTS ⇌ DIRECT ⇌ DIRECT OUTPUTS



The relay provides eight direct outputs that are conveyed on communications channel 1 (numbered 1-1 through 1-8) and eight direct outputs that are conveyed on communications channel 2 (numbered 2-1 through 2-8). Each digital point in the message must be programmed to carry the state of a specific FlexLogic operand. The settings are used to select the operand that represents a specific function (as selected by the user) to be transmitted.

Direct outputs 2-1 to 2-8 are functional in three-terminal systems.

Figure 5-167: Direct inputs/outputs logic (example for L90 shown)



5.10 Transducer inputs/outputs

5.10.1 DCmA inputs

SETTINGS ⇄ TRANSDUCER I/O ⇄ DCMA INPUTS ⇄ DCMA INPUT H1(U8)

<ul style="list-style-type: none"> DCMA INPUT H1 	↔	DCMA INPUT H1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	DCMA INPUT H1 ID: DCMA Ip 1	Range: up to 20 alphanumeric characters
	↕	DCMA INPUT H1 UNITS: μ A	Range: six alphanumeric characters
	↕	DCMA INPUT H1 RANGE: 0 to -1 mA	Range: 0 to -1 mA, 0 to +1 mA, -1 to +1 mA, 0 to 5 mA, 0 to 10mA, 0 to 20 mA, 4 to 20 m
	↕	DCMA INPUT H1 MIN VALUE: 0.000	Range: -9999.999 to +9999.999 in steps of 0.001
	↑	DCMA INPUT H1 MAX VALUE: 0.000	Range: -9999.999 to +9999.999 in steps of 0.001



The L30 is provided with optional DCmA capability. This feature is specified as an option at the time of ordering. See the Order Codes section in chapter 2 for details.

Hardware and software are provided to receive signals from external transducers and to convert these signals into a digital format for use as required. The relay accepts inputs in the range of -1 to +20 mA DC, suitable for use with most common transducer output ranges; all inputs are assumed to be linear over the complete range. Hardware details are contained in chapter 3.

Before the DCmA input signal can be used, the value of the signal measured by the relay must be converted to the range and quantity of the external transducer primary input parameter, such as DC voltage or temperature. The relay simplifies this process by internally scaling the output from the external transducer and displaying the actual primary parameter.

DCmA input channels are arranged in a manner similar to CT and VT channels. Configure the individual channels with the settings shown here.

The channels are arranged in sub-modules of two channels, numbered from 1 through 8 from top to bottom. On power-up, the relay automatically generates configuration settings for every channel, based on the order code, in the same general manner that is used for CTs and VTs. Each channel is assigned a slot letter followed by the row number, 1 through 8 inclusive, which is used as the channel number. The relay generates an actual value for each available input channel.

Settings are generated automatically for every channel available in the specific relay as shown above for the first channel of a type 5F transducer module installed in slot H.

The function of the channel can be “Enabled” or “Disabled.” If “Disabled,” no actual values are created for the channel. An alphanumeric “ID” is assigned to each channel; this ID is included in the channel actual value, along with the programmed units associated with the parameter measured by the transducer, such as volts, °C, megawatts, and so on. This ID is also used to reference the channel as the input parameter to features designed to measure this type of parameter. The **DCMA INPUT H1 RANGE** setting specifies the mA DC range of the transducer connected to the input channel.

The **DCMA INPUT H1 MIN VALUE** and **DCMA INPUT H1 MAX VALUE** settings are used to program the span of the transducer in primary units. For example, a temperature transducer might have a span from 0 to 250 °C; in this case the **DCMA INPUT H1 MIN VALUE** value is “0” and the **DCMA INPUT H1 MAX VALUE** value is “250.” Another example is a watts transducer with a span from –20 to +180 MW; in this case the **DCMA INPUT H1 MIN VALUE** value is “–20” and the **DCMA INPUT H1 MAX VALUE** value is “180.” Intermediate values between the minimum and maximum values are scaled linearly.

5.10.2 RTD inputs

SETTINGS ⇅ TRANSDUCER I/O ⇅ RTD INPUTS ⇅ RTD INPUT H1(U8)

■ RTD INPUT H1 ■	↔	RTD INPUT H1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	RTD INPUT H1 ID: RTD Ip 1	Range: up to 20 alphanumeric characters
	↑	RTD INPUT H1 TYPE: 100Ω Platinum	Range: 100Ω Nickel, 10Ω Copper, 100Ω Platinum, 120Ω Nickel

Hardware and software is provided to receive signals from external resistance temperature detectors and convert these signals into a digital format for use as required. These channels are intended to be connected to any of the RTD types in common use. Specific hardware details are contained in chapter 3.

RTD input channels are arranged in a manner similar to CT and VT channels. The user configures individual channels with the settings shown here.

The channels are arranged in sub-modules of two channels, numbered from 1 through 8 from top to bottom. On power-up, the relay automatically generates configuration settings for every channel, based on the order code, in the same general manner that is used for CTs and VTs. Each channel is assigned a slot letter followed by the row number, 1 through 8 inclusive, which is used as the channel number. The relay generates an actual value for each available input channel.

Settings are automatically generated for every channel available in the specific relay as shown above for the first channel of a type 5C transducer module installed in the first available slot.

The function of the channel can be either “Enabled” or “Disabled.” If “Disabled,” there is not an actual value created for the channel. An alphanumeric ID is assigned to the channel; this ID is included in the channel actual values. It is also used to reference the channel as the input parameter to features designed to measure this type of parameter. Selecting the type of RTD connected to the channel configures the channel.

Actions based on RTD overtemperature, such as trips or alarms, are done in conjunction with the FlexElements feature. In FlexElements, the operate level is scaled to a base of 100°C. For example, a trip level of 150°C is achieved by setting the operate level at 1.5 pu. FlexElement operands are available to FlexLogic for further interlocking or to operate an output contact directly.

See the following table for reference temperature values for each RTD type.

Table 5-40: RTD temperature vs. resistance

Temperature		Resistance (in ohms)			
°C	°F	100 Ω Pt (DIN 43760)	120 Ω Ni	100 Ω Ni	10 Ω Cu
-50	-58	80.31	86.17	71.81	7.10
-40	-40	84.27	92.76	77.30	7.49
-30	-22	88.22	99.41	82.84	7.88
-20	-4	92.16	106.15	88.45	8.26
-10	14	96.09	113.00	94.17	8.65
0	32	100.00	120.00	100.00	9.04
10	50	103.90	127.17	105.97	9.42
20	68	107.79	134.52	112.10	9.81
30	86	111.67	142.06	118.38	10.19
40	104	115.54	149.79	124.82	10.58
50	122	119.39	157.74	131.45	10.97
60	140	123.24	165.90	138.25	11.35
70	158	127.07	174.25	145.20	11.74
80	176	130.89	182.84	152.37	12.12
90	194	134.70	191.64	159.70	12.51
100	212	138.50	200.64	167.20	12.90
110	230	142.29	209.85	174.87	13.28
120	248	146.06	219.29	182.75	13.67
130	266	149.82	228.96	190.80	14.06
140	284	153.58	238.85	199.04	14.44
150	302	157.32	248.95	207.45	14.83
160	320	161.04	259.30	216.08	15.22
170	338	164.76	269.91	224.92	15.61
180	356	168.47	280.77	233.97	16.00
190	374	172.46	291.96	243.30	16.39
200	392	175.84	303.46	252.88	16.78
210	410	179.51	315.31	262.76	17.17
220	428	183.17	327.54	272.94	17.56
230	446	186.82	340.14	283.45	17.95
240	464	190.45	353.14	294.28	18.34
250	482	194.08	366.53	305.44	18.73

5

5.10.3 DCmA outputs

SETTINGS ⇒ ⚡ TRANSDUCER I/O ⇒ ⚡ DCMA OUTPUTS ⇒ DCMA OUTPUT H1(U8)

<input checked="" type="checkbox"/> DCMA OUTPUT H1 <input checked="" type="checkbox"/>	↔	DCMA OUTPUT H1 SOURCE: Off	Range: Off, any analog actual value parameter
	⇅	DCMA OUTPUT H1 RANGE: -1 to 1 mA	Range: -1 to 1 mA, 0 to 1 mA, 4 to 20 mA
	⇅	DCMA OUTPUT H1 MIN VAL: 0.000 pu	Range: -90.000 to 90.000 pu in steps of 0.001
	↑	DCMA OUTPUT H1 MAX VAL: 1.000 pu	Range: -90.000 to 90.000 pu in steps of 0.001

Hardware and software is provided to generate DCmA signals that allow interfacing with external equipment. Hardware details are contained in chapter 3. The DCmA output channels are arranged in a manner similar to transducer input or CT and VT channels. The user configures individual channels with the settings as follows.

The channels are arranged in sub-modules of two channels, numbered 1 through 8 from top to bottom. On power-up, the relay automatically generates configuration settings for every channel, based on the order code, in the same manner used for CTs and VTs. Each channel is assigned a slot letter followed by the row number, 1 through 8 inclusive, which is used as the channel number.

Both the output range and a signal driving a given output are user-programmable via the following settings menu (an example for channel M5 is shown).

The relay checks the driving signal (x in equations below) for the minimum and maximum limits, and subsequently re-scales so the limits defined as **MIN VAL** and **MAX VAL** match the output range of the hardware defined as **RANGE**. The following equation is applied:

$$I_{out} = \begin{cases} I_{min} & \text{if } x < \text{MIN VAL} \\ I_{max} & \text{if } x > \text{MAX VAL} \\ k(x - \text{MIN VAL}) + I_{min} & \text{otherwise} \end{cases} \quad \text{Eq. 5-33}$$

where

x is a driving signal specified by the **SOURCE** setting

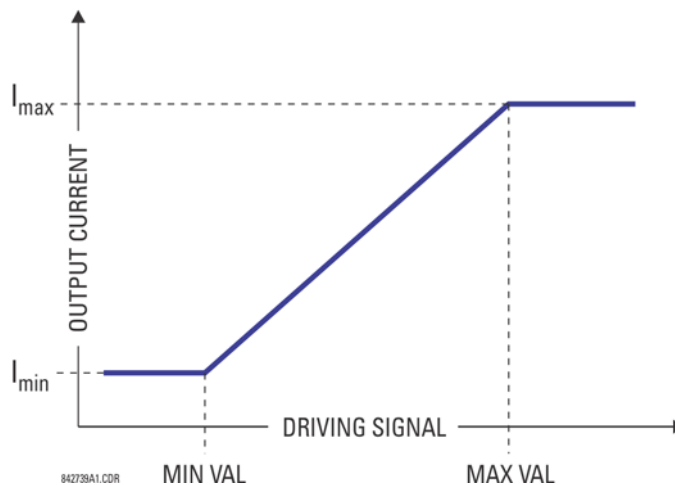
I_{min} and I_{max} are defined by the **RANGE** setting

k is a scaling constant calculated as:

$$k = \frac{I_{max} - I_{min}}{\text{MAX VAL} - \text{MIN VAL}} \quad \text{Eq. 5-34}$$

The feature is intentionally inhibited if the **MAX VAL** and **MIN VAL** settings are entered incorrectly, for example when **MAX VAL** - **MIN VAL** < 0.1 pu. The resulting characteristic is illustrated in the following figure.

Figure 5-168: DCmA output characteristic



Settings

DCMA OUTPUT H1 SOURCE — This setting specifies an internal analog value to drive the analog output. Actual values (FlexAnalog parameters) such as power, current amplitude, voltage amplitude, power factor, etc. can be configured as sources driving DCmA outputs. See Appendix A for a list of FlexAnalog parameters.

DCMA OUTPUT H1 RANGE — This setting allows selection of the output range. Each DCmA channel can be set independently to work with different ranges. The three most commonly used output ranges are available.

DCMA OUTPUT H1 MIN VAL — This setting allows setting the minimum limit for the signal that drives the output. This setting is used to control the mapping between an internal analog value and the output current. The setting is entered in per-unit values. The base units are defined in the same manner as the FlexElement base units.

DCMA OUTPUT H1 MAX VAL — This setting allows setting the maximum limit for the signal that drives the output. This setting is used to control the mapping between an internal analog value and the output current. The setting is entered in per-unit values. The base units are defined in the same manner as the FlexElement base units.



The **DCMA OUTPUT H1 MIN VAL** and **DCMA OUTPUT H1 MAX VAL** settings are ignored for power factor base units (i.e. if the **DCMA OUTPUT H1 SOURCE** is set to FlexAnalog value based on power factor measurement).

Three application examples follow.

Example: Power monitoring

A three phase active power on a 13.8 kV system measured via UR-series relay source 1 is to be monitored by the DCmA H1 output of the range of -1 to 1 mA. The following settings are applied on the relay: CT ratio = 1200:5, VT secondary 115, VT connection is delta, and VT ratio = 120. The nominal current is 800 A primary and the nominal power factor is 0.90. The power is to be monitored in both importing and exporting directions and allow for 20% overload compared to the nominal. The nominal three-phase power is:

$$P = \sqrt{3} \times 13.8 \text{ kV} \times 0.8 \text{ kA} \times 0.9 = 17.21 \text{ MW} \tag{Eq. 5-35}$$

The three-phase power with 20% overload margin is:

$$P_{\text{max}} = 1.2 \times 17.21 \text{ MW} = 20.65 \text{ MW} \tag{Eq. 5-36}$$

The base unit for power (refer to the FlexElements section in this chapter for additional details) is:

$$P_{\text{BASE}} = 115 \text{ V} \times 120 \times 1.2 \text{ kA} = 16.56 \text{ MW} \tag{Eq. 5-37}$$

The minimum and maximum power values to be monitored (in pu) are:

$$\text{minimum power} = \frac{-20.65 \text{ MW}}{16.56 \text{ MW}} = -1.247 \text{ pu}, \quad \text{maximum power} = \frac{20.65 \text{ MW}}{16.56 \text{ MW}} = 1.247 \text{ pu} \tag{Eq. 5-38}$$

The following settings are entered:

- DCMA OUTPUT H1 SOURCE:** "SRC 1 P"
- DCMA OUTPUT H1 RANGE:** "-1 to 1 mA"
- DCMA OUTPUT H1 MIN VAL:** "-1.247 pu"
- DCMA OUTPUT H1 MAX VAL:** "1.247 pu"

With the above settings, the output will represent the power with the scale of 1 mA per 20.65 MW. The worst-case error for this application can be calculated by superimposing the following two sources of error:

- ±0.5% of the full scale for the analog output module, or ±0.005 × (1-(-1)) × 20.65 MW = ±0.207 MW
- ±1% of reading error for the active power at power factor of 0.9

For example at the reading of 20 MW, the worst-case error is 0.01 × 20 MW + 0.207 MW = 0.407 MW.

Example: Current monitoring

The phase A current (true RMS value) is to be monitored via the H2 current output working with the range from 4 to 20 mA. The CT ratio is 5000:5 and the maximum load current is 4200 A. The current is to be monitored from 0 A upwards, allowing for 50% overload.

The phase current with the 50% overload margin is:

$$I_{\text{max}} = 1.5 \times 4.2 \text{ kA} = 6.3 \text{ kA} \tag{Eq. 5-39}$$

The base unit for current (see the FlexElements section in this chapter for additional details) is:

$$I_{\text{BASE}} = 5 \text{ kA} \quad \text{Eq. 5-40}$$

The minimum and maximum power values to be monitored (in pu) are:

$$\text{minimum current} = \frac{0 \text{ kA}}{5 \text{ kA}} = 0 \text{ pu}, \quad \text{maximum current} = \frac{6.3 \text{ kA}}{5 \text{ kA}} = 1.26 \text{ pu} \quad \text{Eq. 5-41}$$

The following settings are entered:

DCMA OUTPUT H2 SOURCE: "SRC 1 Ia RMS"
DCMA OUTPUT H2 RANGE: "4 to 20 mA"
DCMA OUTPUT H2 MIN VAL: "0.000 pu"
DCMA OUTPUT H2 MAX VAL: "1.260 pu"

The worst-case error for this application can be calculated by superimposing the following two sources of error:

- $\pm 0.5\%$ of the full scale for the analog output module, or $\pm 0.005 \times (20 - 4) \times 6.3 \text{ kA} = \pm 0.504 \text{ kA}$
- $\pm 0.25\%$ of reading or $\pm 0.1\%$ of rated (whichever is greater) for currents between 0.1 and 2.0 of nominal

For example, at the reading of 4.2 kA, the worst-case error is $\max(0.0025 \times 4.2 \text{ kA}, 0.001 \times 5 \text{ kA}) + 0.504 \text{ kA} = 0.515 \text{ kA}$.

Example: Voltage monitoring

A positive-sequence voltage on a 400 kV system measured via source 2 is to be monitored by the DCmA H3 output with a range of 0 to 1 mA. The VT secondary setting is 66.4 V, the VT ratio setting is 6024, and the VT connection setting is "Delta." The voltage is to be monitored in the range from 70% to 110% of nominal.

The minimum and maximum positive-sequence voltages to be monitored are:

$$V_{\text{min}} = 0.7 \times \frac{400 \text{ kV}}{\sqrt{3}} = 161.66 \text{ kV}, \quad V_{\text{max}} = 1.1 \times \frac{400 \text{ kV}}{\sqrt{3}} = 254.03 \text{ kV} \quad \text{Eq. 5-42}$$

The base unit for voltage (see the FlexElements section in this chapter for additional details) is:

$$V_{\text{BASE}} = 0.0664 \text{ kV} \times 6024 = 400 \text{ kV} \quad \text{Eq. 5-43}$$

The minimum and maximum voltage values to be monitored (in pu) are:

$$\text{minimum voltage} = \frac{161.66 \text{ kV}}{400 \text{ kV}} = 0.404 \text{ pu}, \quad \text{maximum voltage} = \frac{254.03 \text{ kV}}{400 \text{ kV}} = 0.635 \text{ pu} \quad \text{Eq. 5-44}$$

The following settings are entered:

DCMA OUTPUT H3 SOURCE: "SRC 2 V_1 mag"
DCMA OUTPUT H3 RANGE: "0 to 1 mA"
DCMA OUTPUT H3 MIN VAL: "0.404 pu"
DCMA OUTPUT H3 MAX VAL: "0.635 pu"

The limit settings differ from the expected 0.7 pu and 1.1 pu because the relay calculates the positive-sequence quantities scaled to the phase-to-ground voltages, even if the VTs are connected in "Delta" (see the Metering Conventions section in chapter 6), while at the same time the VT nominal voltage is 1 pu for the settings. Consequently the settings required in this example differ from naturally expected by the factor of $\sqrt{3}$.

The worst-case error for this application could be calculated by superimposing the following two sources of error:

- $\pm 0.5\%$ of the full scale for the analog output module, or $\pm 0.005 \times (1-0) \times 254.03 \text{ kV} = \pm 1.27 \text{ kV}$
- $\pm 0.5\%$ of reading

For example, under nominal conditions, the positive-sequence reads 230.94 kV and the worst-case error is $0.005 \times 230.94 \text{ kV} + 1.27 \text{ kV} = 2.42 \text{ kV}$.

5.11 Testing

5.11.1 Test mode function

SETTINGS ⇨ ⇩ TESTING ⇨ TEST MODE FUNCTION



The L30 provides a test facility to verify the functionality of contact inputs and outputs, some communication functions and the phasor measurement unit (where applicable), using simulated conditions.

The test mode can be in any of three states: Disabled, Isolated, or Forcible.

The Disabled mode is intended for normal in service operation; relay protection, control and communication function is normal. Test features are disabled, except channel tests and phasor measurement unit tests remain usable when provided.

The Isolated mode is intended to allow the relay to be quickly placed in a state where the relay cannot negatively impact the power system or other parts of the substation automation system. This is to allow changing settings, loading new firmware, changing hardware modules, and changing communication connections. As far as practical all relay output signals are blocked. Contact outputs are de-energized, latching outputs are frozen. Commands to bricks are blocked. GOOSE transmissions have their "simulation" flag (also known as "test" flag) set, which results in the messages not being accepted by compliant receiving devices that do not have a "Sim" data attribute set. The quality attribute of values that can be output via 61850 MMS services are set to "invalid," which results in the values not being used for operational purposes by compliant receiving devices. Direct I/O channel tests and PMU tests are usable on applicable models.

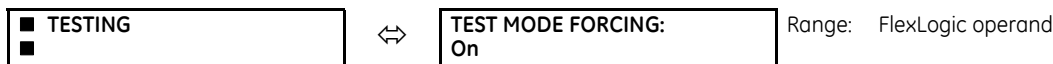
The Forcible mode is intended for testing involving forcing relay operation by test signal injection and verifying correct relay output. This mode is also for tests to verify the relay outputs (both contact and communications) have the intended impact on specific power system devices or on specific other substation automation devices. Contact outputs can be selectively enabled or forced as described in the following two sections. Shared outputs to bricks have their test mode flag raised, which results in their value only being accepted by relays also in forcible mode. GOOSE transmissions have the "simulation" flag set, which results in these only being accepted by other devices that have their "Sim" data attribute set. The "Sim" data attribute in the relay is set, so that if GOOSE messages are received with the "simulation" flag set, these are used in place of the normal messages. The quality attribute of values that are output via 61850 MMS services are set to "valid" + "test," which signals that the values should not be used for operational purposes.

Otherwise, the UR remains fully operational while in the Forcible test mode, allowing for various testing procedures. In particular, the protection and control elements, and FlexLogic function normally. Other than the IEC 61850 protocol, communications based inputs and outputs remain fully operational. The test procedure must take this into account. Direct I/O channel tests and PMU tests are usable on applicable models.

The test mode can be selected either through the front panel, through EnerVista UR Setup, or through IEC 61850 control to LLN0.Mod. LLN0.Mod.ctlVal "on" selects Disabled, "test/blocked" selects Isolated, and "test" selects Forcible. The **TEST MODE FUNCTION** setting can only be changed by a direct user command. Following a restart, power up, settings upload, or firmware upgrade, the test mode remains at the last programmed value. This allows a UR that has been placed in isolated mode to remain isolated during testing and maintenance activities.

5.11.2 Test mode forcing

SETTINGS ⇨ ⇩ TESTING ⇨ TEST MODE FORCING



When in Forcible mode, the operand selected by the **TEST MODE FORCING** setting dictates further response of the L30 to testing conditions, as described in the following two sections.

The test mode state is indicated on the relay front panel by a combination of the Test Mode LED indicator, the In-Service LED indicator, and by the critical fail relay, as shown in the following table.

Table 5-41: Test mode operation

TEST MODE FUNCTION	In-service LED	Test mode LED	Critical fail relay	TEST MODE FORCING	Contact input and output behavior
Disabled	Unaffected	Off	Normal	No effect	Normal
Isolated	Off	On	De-energized	No effect	Contact outputs disabled
Forcible	Off	Flashing	De-energized	Off	Normal
				On	Controlled by forcing features

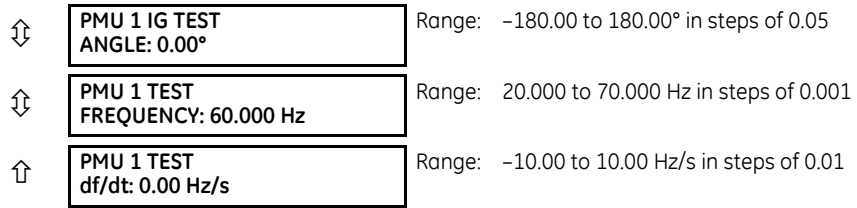


On restart, the **TEST MODE FORCING** setting and the force contact input and force contact output settings revert to their default states.

5.11.3 Phasor Measurement Unit test values

SETTINGS ⇌ TESTING ⇌ PMU TEST VALUES ⇌ PMU 1 TEST VALUES

<ul style="list-style-type: none"> ■ PMU 1 ■ TEST VALUES 	↔	PMU 1 TEST FUNCTION: Disabled	Range: Enabled, Disabled
	⇅	PMU 1 VA TEST MAGNITUDE: 500.00 kV	Range: 0.00 to 700.00 kV in steps of 0.01
	⇅	PMU 1 VA TEST ANGLE: 0.00°	Range: -180.00 to 180.00° in steps of 0.05
	⇅	PMU 1 VB TEST MAGNITUDE: 500.00 kV	Range: 0.00 to 700.00 kV in steps of 0.01
	⇅	PMU 1 VB TEST ANGLE: -120.00°	Range: -180.00 to 180.00° in steps of 0.05
	⇅	PMU 1 VC TEST MAGNITUDE: 500.00 kV	Range: 0.00 to 700.00 kV in steps of 0.01
	⇅	PMU 1 VC TEST ANGLE: 120.00°	Range: -180.00 to 180.00° in steps of 0.05
	⇅	PMU 1 VX TEST MAGNITUDE: 500.00 kV	Range: 0.00 to 700.00 kV in steps of 0.01
	⇅	PMU 1 VX TEST ANGLE: 0.00°	Range: -180.00 to 180.00° in steps of 0.05
	⇅	PMU 1 IA TEST MAGNITUDE: 1.000 kA	Range: 0.000 to 9.999 kA in steps of 0.001
	⇅	PMU 1 IA TEST ANGLE: -10.00°	Range: -180.00 to 180.00° in steps of 0.05
	⇅	PMU 1 IB TEST MAGNITUDE: 1.000 kA	Range: 0.000 to 9.999 kA in steps of 0.001
	⇅	PMU 1 IB TEST ANGLE: -130.00°	Range: -180.00 to 180.00° in steps of 0.05
	⇅	PMU 1 IC TEST MAGNITUDE: 1.000 kA	Range: 0.000 to 9.999 kA in steps of 0.001
	⇅	PMU 1 IC TEST ANGLE: 110.00°	Range: -180.00 to 180.00° in steps of 0.05
	⇅	PMU 1 IG TEST MAGNITUDE: 0.000 kA	Range: 0.000 to 9.999 kA in steps of 0.001



The relay must be in test mode to use the PMU test mode. That is, the **TESTING ⇒ TEST MODE FUNCTION** setting must be “Enabled,” and the **TESTING ⇒ TEST MODE INITIATE** initiating signal must be “On.”

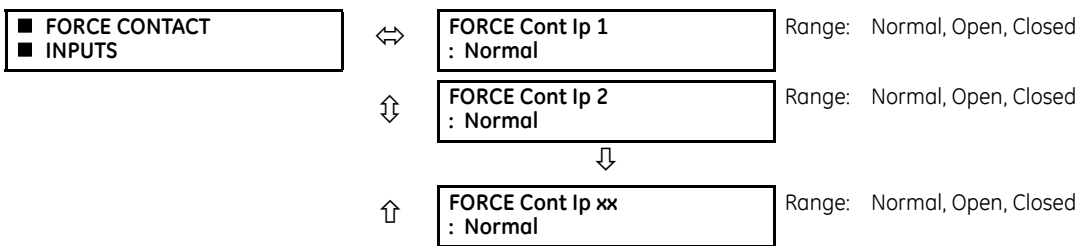
During the PMU test mode, the physical channels (VA, VB, VC, VX, IA, IB, IC, and IG), frequency, and rate of change of frequency are substituted with user values, while the symmetrical components are calculated from the physical channels. The test values are not explicitly marked in the outgoing data frames. When required, it is recommended to use the user-programmable digital channels to signal the IEEE C37.118 client that test values are being sent in place of the real measurements.

The UR Synchrophasor Implementation defines a test mode that sends a pre-defined set of synchrophasors out over the communication channel when the test mode function setting is enabled. In test mode, the following actions take place:

- The Data Invalid / Test Mode bit (bit 15 in the STAT word) is set
- The Sim bit in all output datasets is set

5.11.4 Force contact inputs

SETTINGS ⇒ TESTING ⇒ FORCE CONTACT INPUTS



The force contact inputs feature provides a method of performing checks on the function of all contact inputs.

While in Forcible test mode, the relay contact inputs can be pre-programmed to respond in the following ways:

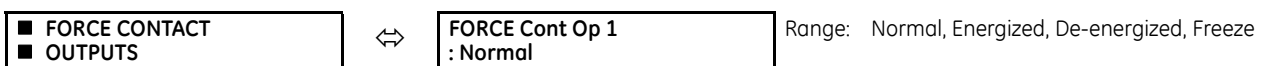
- If set to “Normal,” the input remains fully operational. It is controlled by the voltage across its input terminals and can be turned on and off by external circuitry. Select this value if a given input must be operational during the test. This includes, for example, an input initiating the test, or being a part of a user pre-programmed test sequence.
- If set to “Open,” the input is forced to report as opened (Logic 0) while the operand selected by **TEST MODE FORCING** setting is On, regardless of the voltage across the input terminals. While the selected operand is Off, the input behaves as it does when in service.
- If set to “Closed,” the input is forced to report as closed (Logic 1) while the operand selected by **TEST MODE FORCING** setting is On regardless of the voltage across the input terminals. While the selected operand is Off, the input behaves as it does when in service.

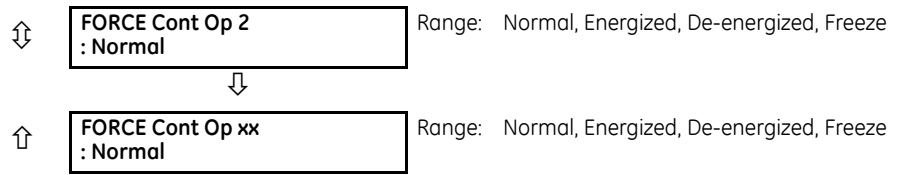


On restart, the **TEST MODE FORCING** setting and the force contact input and force contact output settings revert to their default states.

5.11.5 Force contact outputs

SETTINGS ⇒ TESTING ⇒ FORCE CONTACT OUTPUTS





The force contact outputs feature provides a method of performing checks on the function of all contact outputs.

While in Forcible test mode, the relay contact outputs can be pre-programmed to respond in the following ways:

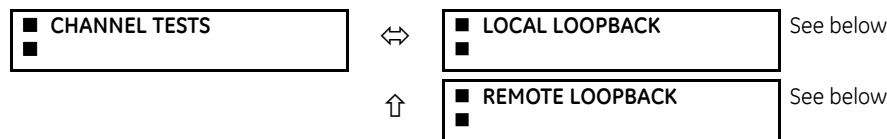
- If set to “Normal,” the contact output remains fully operational. It operates when its control operand is logic 1 and resets when its control operand is logic 0.
- If set to “Energized,” the output closes and remains closed while the operand selected by the **TEST MODE FORCING** setting is On, regardless of the status of the operand configured to control the output contact. While the selected operand is Off, the output behaves as it does when in service.
- If set to “De-energized,” the output opens and remains opened while the operand selected by the **TEST MODE FORCING** setting is On, regardless of the status of the operand configured to control the output contact. While the selected operand is Off, the output behaves as it does when in service.
- If set to “Freeze,” the output retains its position at the instant before the **TEST MODE FUNCTION** was Forcible and the operand selected by the **TEST MODE FORCING** setting was On, regardless of later changes in the status of the operand configured to control the output contact. While the selected operand is Off, the output behaves as it does when in service.



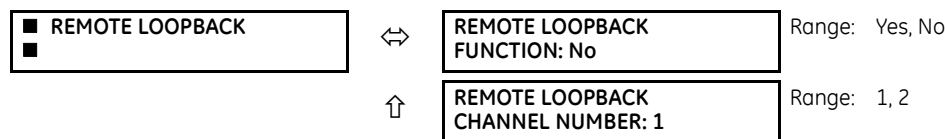
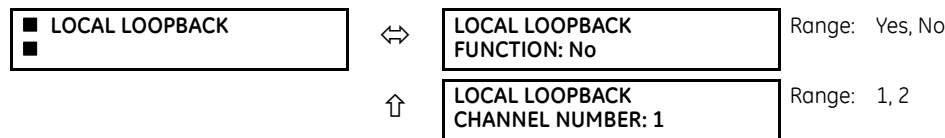
On restart, the **TEST MODE FORCING** setting and the force contact input and force contact output settings revert to their default states.

5.11.6 Channel tests

SETTINGS ⇄ TESTING ⇄ CHANNEL TESTS



This function checks the communications established by both relays.



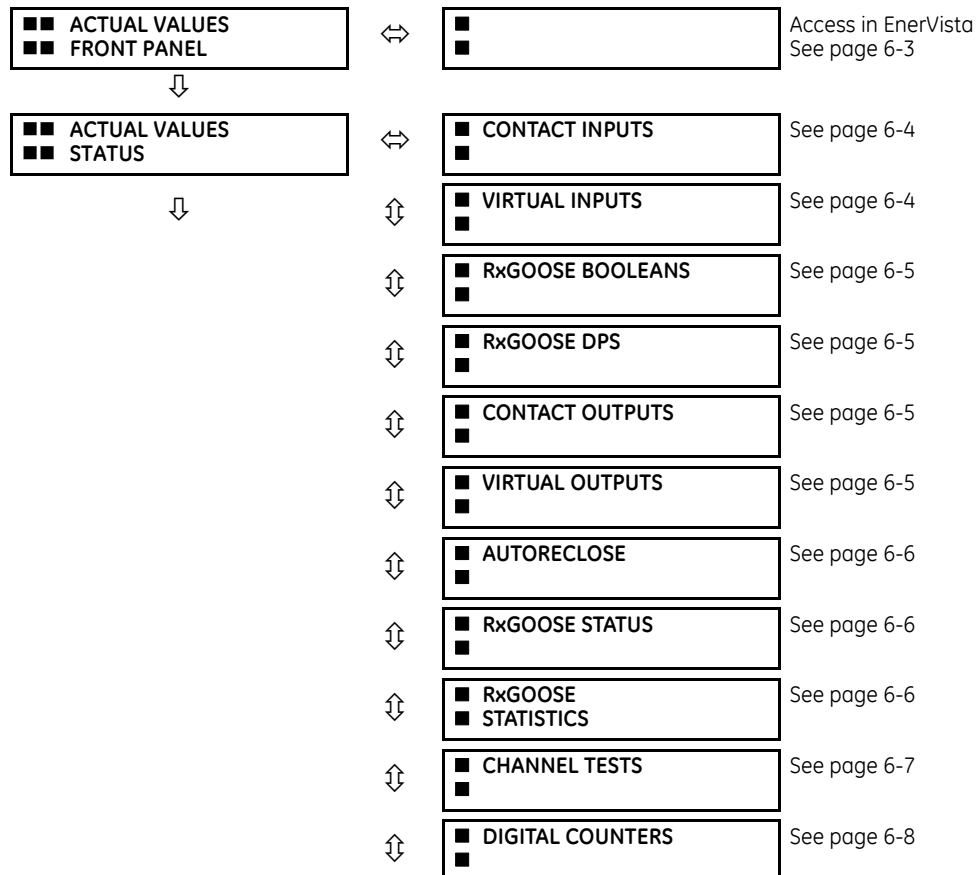
See the Commissioning chapter for information on using the channel tests.

L30 Line Current Differential System

Chapter 6: Actual values

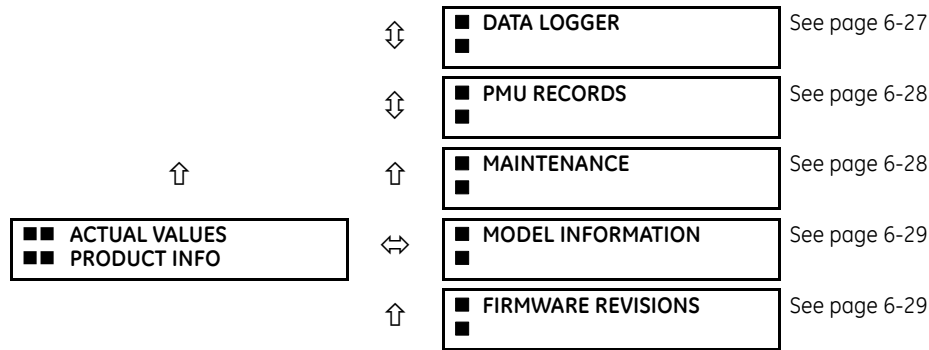
This chapter outlines viewing of data on the front panel and in the software.

6.1 Actual Values menu



6

↑	■ ■ ACTUAL VALUES ■ ■ METERING	↕	■ SELECTOR SWITCHES ■	See page 6-8
		↕	■ FLEX STATES ■	See page 6-8
		↕	■ ETHERNET ■	See page 6-9
		↕	■ REAL TIME CLOCK ■ SYNCHRONIZING	See page 6-9
		↕	■ DIRECT INPUTS ■	See page 6-10
		↕	■ INCIPIENT FAULT ■	See page 6-10
		↕	■ COMM STATUS ■ REMAINING CONNECT	See page 6-10
		↕	■ PRP ■	See page 6-11
		↑	■ TxGOOSE STATUS ■	See page 6-11
		↔	■ 87L DIFFERENTIAL ■ CURRENT	See page 6-16
↓		↕	■ SOURCE SRC 1 ■	See page 6-17
		↕	■ SOURCE SRC 2 ■	
		↕	■ SYNCHROCHECK ■	See page 6-21
		↕	■ TRACKING FREQUENCY ■	See page 6-22
		↕	■ FREQUENCY RATE ■ OF CHANGE	See page 6-22
		↕	■ FLEXELEMENTS ■	See page 6-22
		↕	■ RxGOOSE Analogs ■	See page 6-23
		↕	■ PHASOR MEASUREMENT ■ UNIT	See page 6-23
		↕	■ PMU AGGREGATOR ■	See page 6-24
		↕	■ TRANSDUCER I/O ■ DCMA INPUTS	See page 6-24
↑		↑	■ TRANSDUCER I/O ■ RTD INPUTS	See page 6-24
	■ ■ ACTUAL VALUES ■ ■ RECORDS	↔	■ FAULT REPORT ■	See page 6-25
		↕	■ EVENT RECORDS ■	See page 6-25
↓		↕	■ OSCILLOGRAPHY ■	See page 6-27



For status reporting, 'On' represents Logic 1 and 'Off' represents Logic 0.

6.2 Front panel

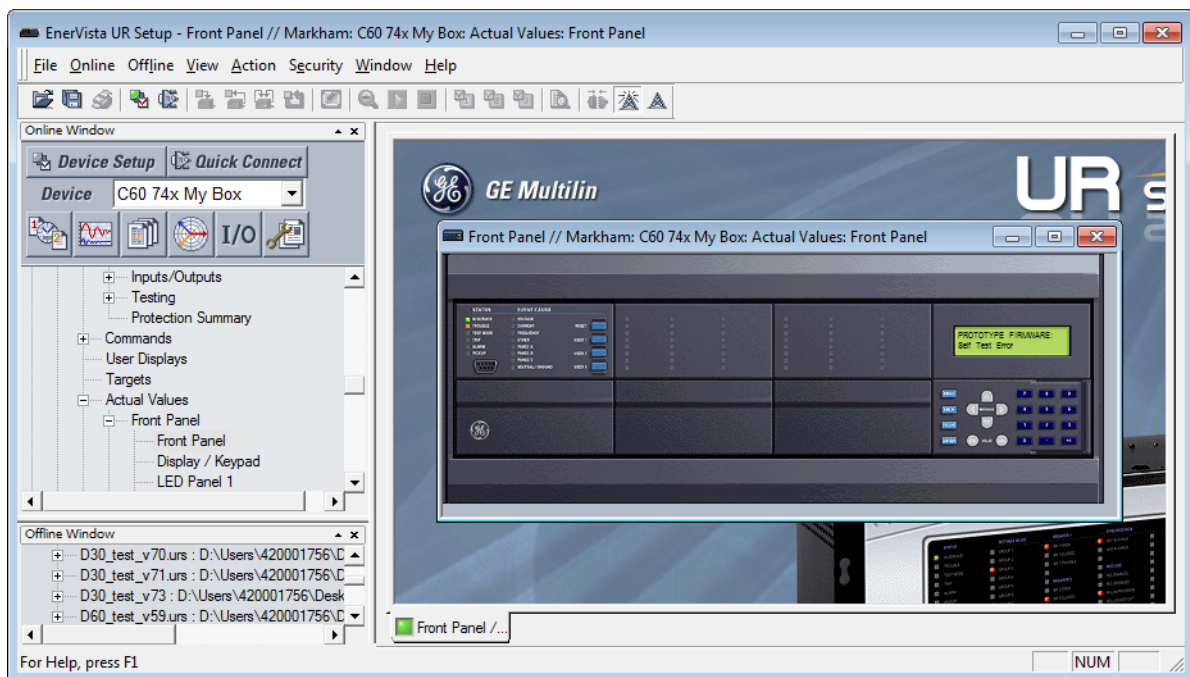
6.2.1 Enhanced and standard front panels

The front panel can be viewed and used in the EnerVista software, for example to view an error message displayed on the front panel.

To view the front panel in EnerVista software:

1. Click **Actual Values > Front Panel**.

Figure 6-1: Front panel use in the software (C60 shown)



6.2.2 Graphical front panel



The graphical front panel is a hardware option.

Annunciator alarms can be acknowledged and reset in this section.

To view alarms for the graphical front panel in EnerVista:

1. Access **Actual Values > Graphical Panel > Annunciator Panel**. Alarms are listed, allowing remote acknowledgement/reset.
2. Click the **Acknowledge** or **Reset** button for an alarm.

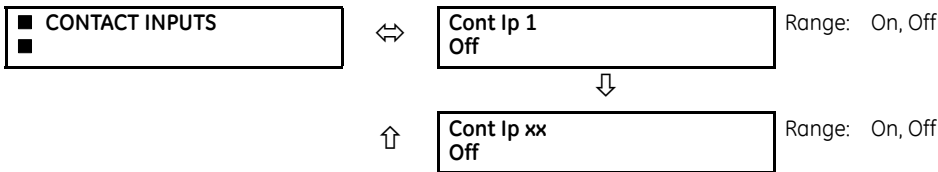
Figure 6-2: Annunciator alarms displayed in the software

PARAMETER	ALARM	ACTION
Indicator 1	NewTransientRecord	Acknowledge
Indicator 2	0.000	Acknowledge
Indicator 3	0.000	Acknowledge
Indicator 6	hiTest	Reset

6.3 Status

6.3.1 Contact inputs

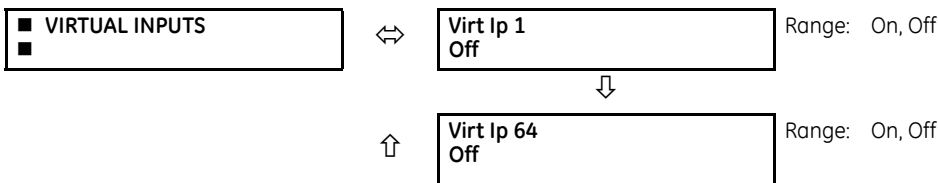
ACTUAL VALUES ⇒ STATUS ⇒ CONTACT INPUTS



The present status of the contact inputs is shown here. The first line of a message display indicates the ID of the contact input. For example, 'Cont Ip 1' refers to the contact input in terms of the default name-array index. The second line of the display indicates the logic state of the contact input.

6.3.2 Virtual inputs

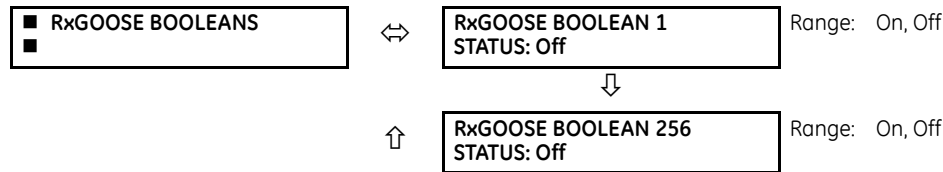
ACTUAL VALUES ⇒ STATUS ⇒ VIRTUAL INPUTS



The present status of the 64 virtual inputs is shown here. The first line of a message display indicates the ID of the virtual input. For example, 'Virt Ip 1' refers to the virtual input in terms of the default name. The second line of the display indicates the logic state of the virtual input.

6.3.3 RxGOOSE boolean inputs

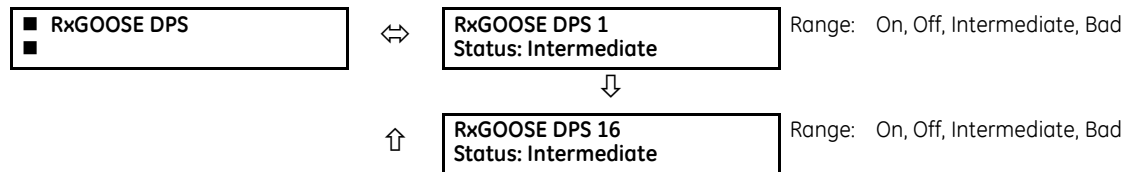
ACTUAL VALUES ⇒ STATUS ⇒ ↓ RxGOOSE BOOLEANS



The L30 is provided with optional IEC 61850 capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

6.3.4 RxGOOSE DPS inputs

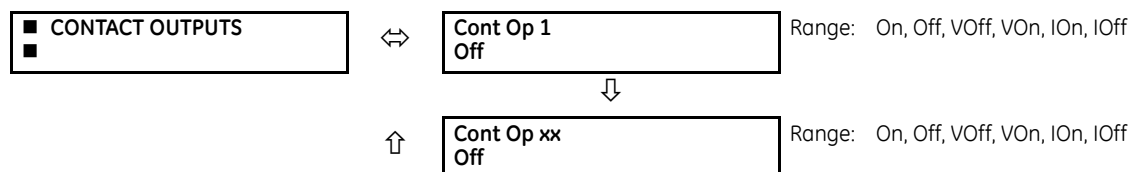
ACTUAL VALUES ⇒ STATUS ⇒ ↓ RxGOOSE DPS



The L30 is provided with optional IEC 61850 capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

6.3.5 Contact outputs

ACTUAL VALUES ⇒ STATUS ⇒ ↓ CONTACT OUTPUTS

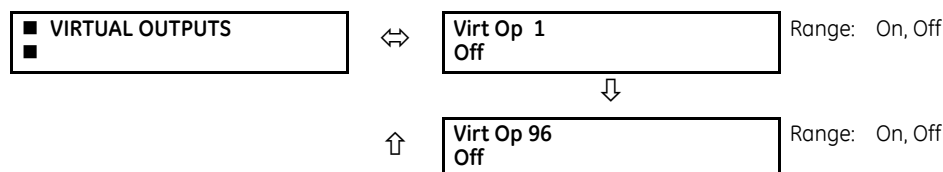


The present state of the contact outputs is shown here. The first line of a message display indicates the ID of the contact output. For example, 'Cont Op 1' refers to the contact output in terms of the default name-array index. The second line of the display indicates the logic state of the contact output.

For form-A contact outputs, the state of the voltage and current detectors is displayed as Off, VOff, IOff, On, IOOn, and VOn. For form-C contact outputs, the state is displayed as Off or On.

6.3.6 Virtual outputs

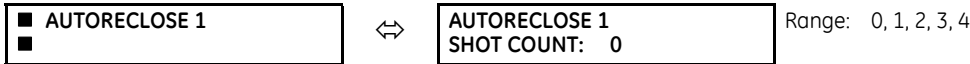
ACTUAL VALUES ⇒ STATUS ⇒ ↓ VIRTUAL OUTPUTS



The present state of up to 96 virtual outputs is shown here. The first line of a message display indicates the ID of the virtual output. For example, 'Virt Op 1' refers to the virtual output in terms of the default name-array index. The second line of the display indicates the logic state of the virtual output, as calculated by the FlexLogic equation for that output.

6.3.7 Autoreclose

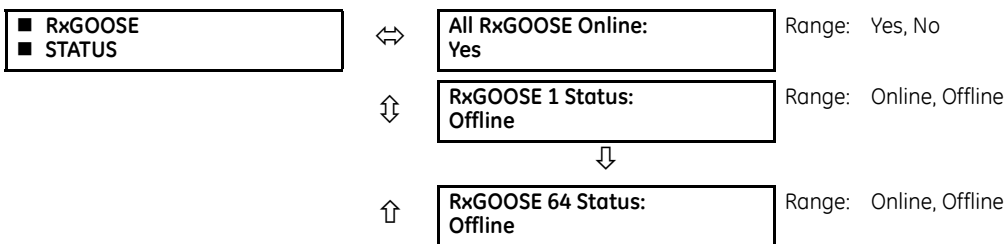
ACTUAL VALUES ⇒ STATUS ⇒ ⤴ AUTORECLOSE ⇒ AUTORECLOSE 1(3)



This menu displays the reclosure shot count.

6.3.8 RxGOOSE status

ACTUAL VALUES ⇒ STATUS ⇒ ⤴ RxGOOSE STATUS

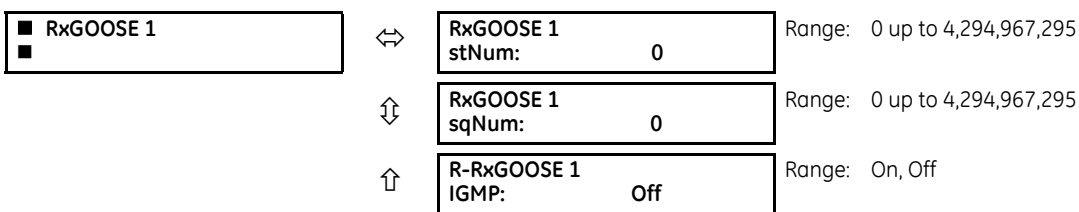


The L30 is provided with optional IEC 61850 capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

The **All RxGOOSE Online** actual value does not consider RxGOOSE that are not configured or are not used by any RxGOOSE Input.

6.3.9 RxGOOSE statistics

ACTUAL VALUES ⇒ STATUS ⇒ ⤴ RxGOOSE STATISTICS ⇒ ⤴ RxGOOSE 1(64)



The L30 is provided with optional IEC 61850 capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

stNum — State number. The most recently received value in GOOSE message field stNum. The publisher increments stNum each time that the state of one or more of the GOOSE message members is sent with a revised value.

sqNum — Sequence number. The most recently received value in GOOSE message field sqNum. The publisher sets sqNum to zero each time the state of one or more of the GOOSE message members is sent with a new value, and it increments it whenever a GOOSE message is resent without any member value change.

IGMP — Multicast (SSM and ASM) modes of R-GOOSE reception require that the L30 device subscribe to a multicast group over the Internet Group Management Protocol (IGMP) enabled network. R-RxGOOSE## IGMP status On indicates that IGMP negotiation with a network device (for example a router) was successful. In the case where setting R-RxGOOSE1 DST IP is configured to a multicast address and this status indicates Off, R-GOOSE reception cannot be successful, and therefore communication network diagnosis needs to be carried out. This status is relevant to R-GOOSE reception when configured for SSM or ASM reception modes. It is not relevant for GOOSE or for R-GOOSE in unicast reception mode.

6.3.10 Channel tests

ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS

■ CHANNEL TESTS	↔	CHANNEL 1 STATUS: n/a	Range: n/a, Fail, OK
	⇅	CHANNEL 1 LOST PACKETS: 0	Range: 0 to 65535 in steps of 1. Reset count to 0 through the COMMANDS ⇒ CHANNEL TESTS ⇒ CLEAR RECORDS menu.
	⇅	CHANNEL 1 LOCAL LOOPBCK STATUS: n/a	Range: n/a, Fail, OK
	⇅	CHANNEL 1 REMOTE LOOPBCK STATUS: n/a	Range: n/a, Fail, OK
	⇅	CHANNEL 1 LOOP DELAY: 0.0 ms	
	⇅	CHNL 1 ASYMMETRY: 0.000 ms	Range: -10 to 10 ms in steps of 0.1
	⇅	CHANNEL 2 STATUS: n/a	Range: n/a, Fail, OK
	⇅	CHANNEL 2 LOST PACKETS: 0	Range: 0 to 65535 in steps of 1. Reset count to 0 through the COMMANDS ⇒ CHANNEL TESTS ⇒ CLEAR RECORDS menu.
	⇅	CHANNEL 2 LOCAL LOOPBCK STATUS: n/a	Range: n/a, Fail, OK
	⇅	CHANNEL 2 REMOTE LOOPBCK STATUS: n/a	Range: n/a, Fail, OK
	⇅	CHANNEL 2 LOOP DELAY: 0.0 ms	
	⇅	CHNL 2 ASYMMETRY: 0.000 ms	Range: -10 to 10 ms in steps of 0.1
	⇅	VALIDITY OF CHANNEL CONFIGURATION: n/a	Range: n/a, Fail, OK
	↑	PFL STATUS: n/a	Range: n/a, Fail, OK

The status information for two channels displays in this menu.

CHANNEL 1(2) STATUS — This represents the receiver status of each channel. If the value is “OK,” the 87L current differential element is enabled and data is being received from the remote terminal; If the value is “Fail,” the 87L element is enabled and data is not being received from the remote terminal. If “n/a,” the 87L element is disabled.

CHANNEL 1(2) LOST PACKETS — Current, timing, and control data is transmitted to the remote terminals in data packets at a rate of two packets per cycle. The number of lost packets represents data packets lost in transmission; this count can be reset through the **COMMANDS ⇒ CHANNEL TESTS ⇒ CLEAR RECORDS** menu.

CHANNEL 1(2) LOCAL LOOPBACK STATUS — The result of the local loopback test displays here.

CHANNEL 1(2) REMOTE LOOPBACK STATUS — The result of the remote loopback test displays here.

CHANNEL 1(2) LOOP DELAY — Displays the round trip channel delay (including loopback processing time of the remote relay) computed during a remote loopback test under normal relay operation, in milliseconds (ms).

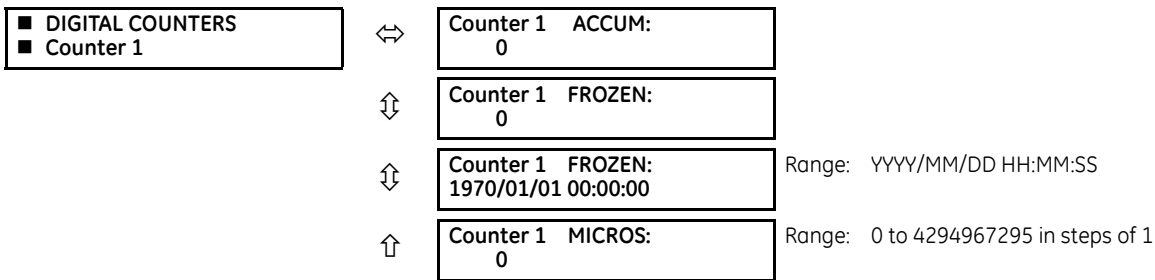
CHNL 1(2) ASYMMETRY — The result of channel asymmetry calculations derived from GPS signal displays here for both channels if **CHANNEL ASYMMETRY** is “Enabled”. A positive “+” sign indicates that the transit delay in the transmitting direction is less than the delay in the receiving direction; a negative “-” sign indicates that the transit delay in the transmitting direction is more than the delay in the receiving direction. A displayed value of “0.0” indicates that either asymmetry is not present or cannot be estimated due to failure with local/remote GPS clock source.

VALIDITY OF CHANNEL CONFIGURATION — The current state of the communications channel identification check, and hence validity, displays here. If a remote relay ID number does not match the programmed number at the local relay, the “Fail” value displays. The “n/a” value appears if the local relay ID is set to a default value of “0” or if the 87L element is disabled. See the **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **POWER SYSTEM** section for more information

PFLL STATUS — This value represents the status of the phase and frequency locked loop (PFLL) filter that uses timing information from local and remote terminals to synchronize the clocks of all terminals. If **PFLL STATUS** is “OK,” the clocks of all terminals are synchronized and 87L protection is enabled. If it is “Fail,” the clocks of all terminals are not synchronized and 87L protection is disabled. At startup, the clocks of all terminals are not synchronized and the PFLL status displays as “Fail.” It takes up to eight seconds after startup for the value to change from “Fail” to “OK.” When the status is “n/a,” then PFLL is disabled.

6.3.11 Digital counters

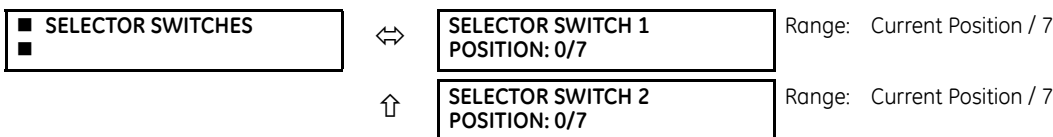
ACTUAL VALUES ⇒ STATUS ⇒ **DIGITAL COUNTERS** ⇒ **DIGITAL COUNTERS Counter 1(8)**



The present status of the eight digital counters displays here. The status of each counter, with the user-defined counter name, includes the accumulated and frozen counts (the count units label also appears). Also included, is the date and time stamp for the frozen count. The **COUNTER 1 MICROS** value refers to the microsecond portion of the time stamp.

6.3.12 Selector switches

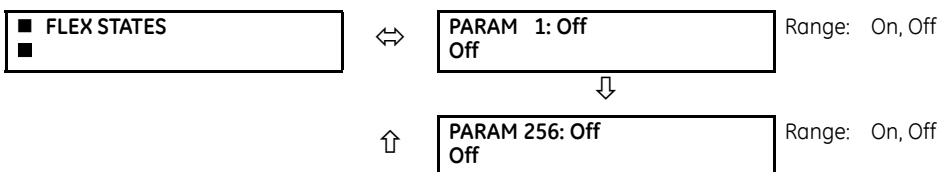
ACTUAL VALUES ⇒ STATUS ⇒ **SELECTOR SWITCHES**



The display shows both the current position and the full range. The current position only (an integer from 0 through 7) is the actual value.

6.3.13 Flex States

ACTUAL VALUES ⇒ STATUS ⇒ **FLEX STATES**



There are 256 FlexState™ bits available. The second line value indicates the state of the given FlexState bit.

6.3.14 Ethernet

ACTUAL VALUES ⇒ STATUS ⇒⇅ ETHERNET

■ ETHERNET ■	↔	ETHERNET PRI LINK STATUS: Fail	Range: Fail, OK
	⇅	ETHERNET SEC LINK STATUS: Fail	Range: Fail, OK
	↑	ETHERNET TER LINK STATUS: Fail	Range: Fail, OK

These values indicate the status of the first, second, and third Ethernet links.

6.3.15 Real time clock synchronizing

ACTUAL VALUES ⇒ STATUS ⇒⇅ REAL TIME CLOCK SYNCHRONIZING

■ REAL TIME CLOCK ■ SYNCHRONIZING	↔	RTC SYNC SOURCE: None	Range: see below
	⇅	GRANDMASTER ID: 0X0000000000000000	Range: any 8 octet value
	⇅	ACCURACY: 999999999 ns	Range: 0 to 999,999,999 ns
	⇅	PORT 1 PTP STATE: No Signal	Range: Disabled, No Signal, Calibrating, Synch'd (No Pdelay), Synchronized
	⇅	PORT 2 PTP STATE: No Signal	Range: Disabled, No Signal, Calibrating, Synch'd (No Pdelay), Synchronized
	⇅	PORT 3 PTP STATE: No Signal	Range: Disabled, No Signal, Calibrating, Synch'd (No Pdelay), Synchronized
	↑	PTP - IRIG-B DELTA: 500000000 ns	Range: -500,000,000 to +500,000,000 ns

RTC SYNC SOURCE actual value is the time synchronizing source the relay is using at present. Possible sources are: Port 1 PTP Clock, Port 2 PTP Clock, Port 3 PTP Clock, IRIG-B, Other, and None, where "Other" means any less precise source (SNTP, IEC 103, IEC 104, or DNP). An actual value displays when the relay includes the IEEE 1588 software option.

The **GRANDMASTER ID** is the grandmasterIdentity code being received from the present PTP grandmaster, if any. When the relay is not using any PTP grandmaster, this actual value is zero. The grandmasterIdentity code is specified by PTP to be globally unique, so one can always know which clock is grandmaster in a system with multiple grandmaster-capable clocks.

ACCURACY is the estimated maximum time error at present in the RTC, considering the quality information imbedded in the received time signal. The value 999,999,999 indicates that the magnitude of the estimated error is one second or more, or that the error cannot be estimated.

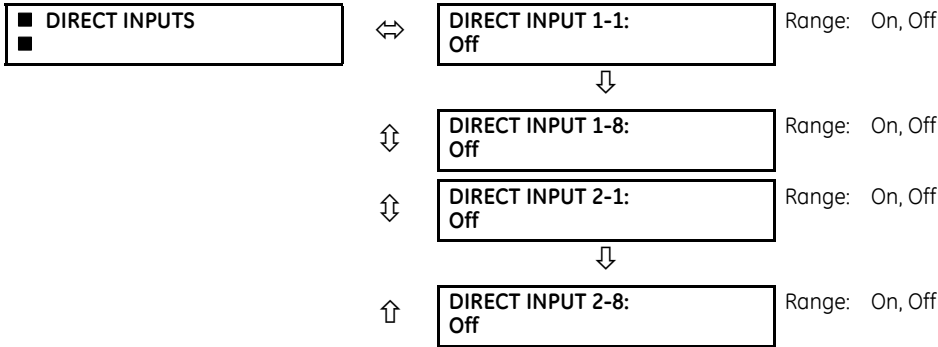
PORT 1...3 PTP STATE is the present state of the port's PTP clock. The PTP clock state is:

- **Disabled** is the port's function setting is Disabled
- **No Signal** if enabled but no signal from an active master has been found and selected
- **Calibrating** if an active master has been selected but lock is not at present established
- **Synch'd (No Pdelay)** if the port is synchronized, but the peer delay mechanism is non-operational
- **Synchronized** if synchronized

PTP - IRIG-B DELTA is the time difference, measured in nanoseconds, between the fractional seconds portion of the time being received via PTP and that being received via IRIG-B. A positive value indicates that PTP time is fast compared to IRIG-B time.

6.3.16 Direct inputs

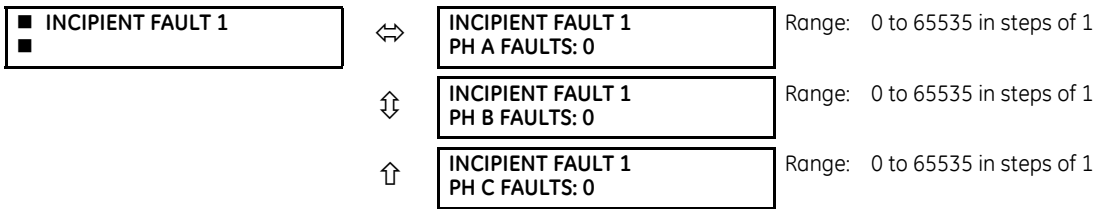
ACTUAL VALUES ⇌ STATUS ⇌ DIRECT INPUTS



The present state of the direct inputs from communications channels 1 and 2 display here. The state displayed is that of the remote point unless channel 1 or 2 has been declared to have “failed”, in which case the value shown is the programmed default state defined in the **SETTINGS** ⇌ **INPUTS/OUTPUTS** ⇌ **DIRECT** ⇌ **DIRECT INPUTS** menu.

6.3.17 Incipient fault detector

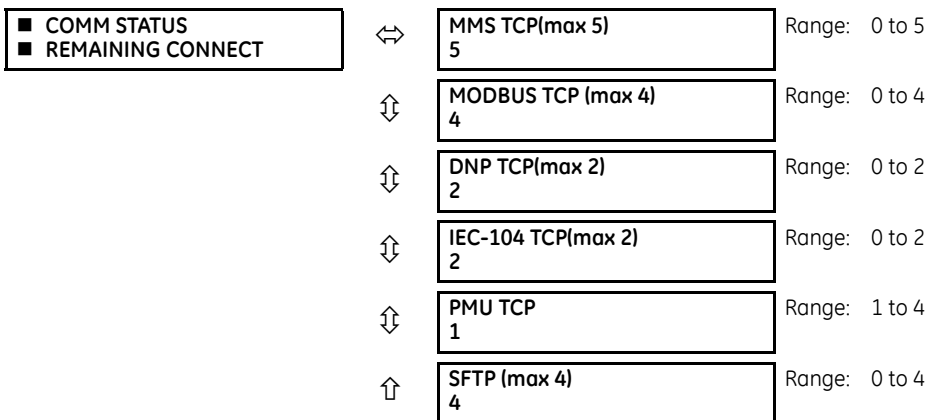
ACTUAL VALUES ⇌ STATUS ⇌ INCIPIENT FAULT ⇌ INCIPIENT FAULT 1



The number of detected incipient faults for each incipient fault element are displayed here for each phase. These values can be reset to zero with the **COMMANDS** ⇌ **CLEAR RECORDS** ⇌ **CLEAR INCIPIENT FAULT COUNTERS** command.

6.3.18 Remaining connection status

ACTUAL VALUES ⇌ STATUS ⇌ COMM STATUS REMAINING CONNECT



These values specify the remaining number of TCP connections still available for each protocol. The display depends on the options applicable to your device. Each time a connection is used, the remaining number of connections decrements. When released, the remaining number of connections increments. If no connection is made over the specific protocol, the number equals the maximum number available for the specific protocol.

For example, the maximum number of Modbus TCP connections is 4. Once an EnerVista session is opened on a computer connected to the UR over Ethernet, the Modbus TCP status shows 3. If the EnerVista application is closed, the Modbus TCP status shows 4.

For the graphical front panel, the remaining connections refer to TCP connections only.

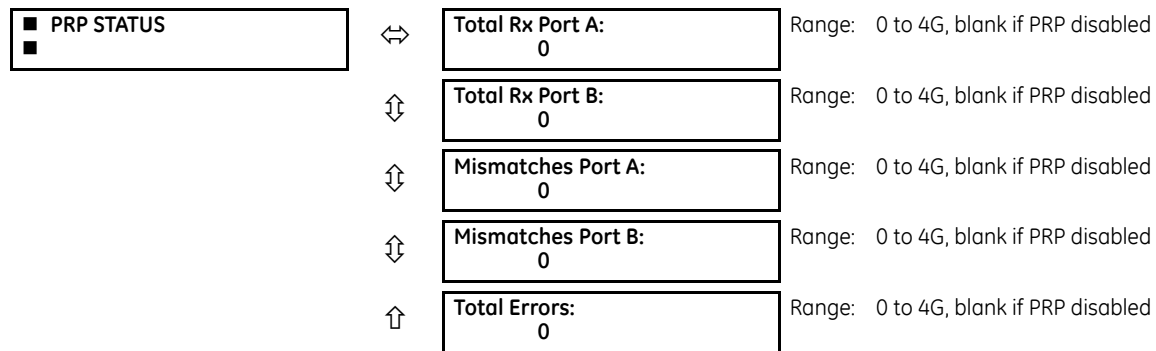
MMS TCP — The number of IEC 61850 connections remaining.

PMU TCP — The maximum number of PMU TCP connections matches the number of aggregators. The maximum number of aggregators for the N60 is 4. The maximum number for the C60 is 2. The maximum number is 1 for other products with a PMU. The remaining number of aggregators displays here.

6.3.19 Parallel Redundancy Protocol (PRP)

The Parallel Redundancy Protocol (PRP) defines a redundancy protocol for high availability in substation automation networks.

ACTUAL VALUES ⇒ STATUS ⇒ ⇅ PRP STATUS



The L30 is provided with optional PRP capability. This feature is specified as a software option at the time of ordering. See the Order Codes section in chapter 2 for details.

Total Received Port A is a counter for total messages received (either from DANPs or from SANs) on Port A.

Total Received Port B is a counter for total messages received (either from DANPs or from SANs) on Port B.

Total Errors is a counter for total messages received with an error (bad port code, frame length too short).

Mismatches Port A is a counter for total messages received with an error on Port A (PRP frame, but port received through and LAN ID in the frame do not match).

Mismatches Port B is a counter for total messages received with an error on Port B (PRP frame, but port received through and LAN ID in the frame do not match).

6.3.20 TxGOOSE status

ACTUAL VALUES ⇒ STATUS ⇒ ⇅ TxGOOSE STATUS





The L30 is provided with optional IEC 61850 capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

This status is relevant to R-GOOSE reception when configured for SSM or ASM reception modes. It is not relevant for GOOSE or for R-GOOSE in unicast reception mode.

ARP — The unicast mode of R-GOOSE transmission requires Address Resolution Protocol (ARP) for the resolution of the network layer address into the MAC layer address. R-TxGOOSE## ARP status On indicates that ARP responses are being received and the destination MAC address for R-GOOSE transmissions has been obtained. This status remains Off if TxGOOSE## is not configured for R-GOOSE. It also remains Off if setting R-TxGOOSE1 DST IP is set to a multicast address. In the case where setting R-TxGOOSE1 DST IP is configured with a unicast address and this status indicates Off, TxGOOSE## transmission will be off, and therefore communication network diagnosis needs to be carried out.

This status is only applicable for R-GOOSE transmission with setting R-TxGOOSE1 DST IP set to a unicast IP address. It is not applicable for GOOSE or for R-GOOSE when setting R-TxGOOSE1 DST IP is multicast.

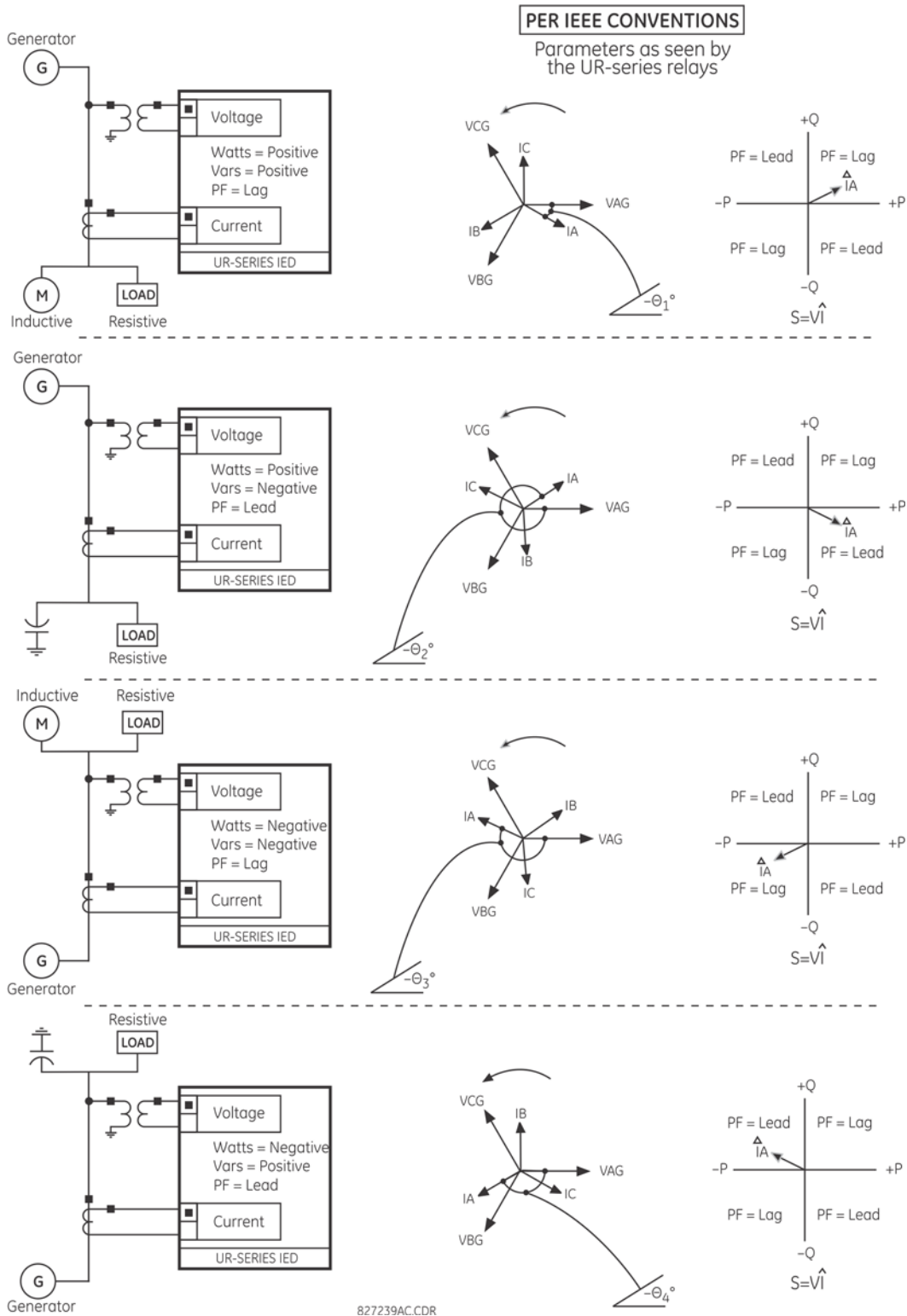
6.4 Metering

6.4.1 Metering conventions

6.4.1.1 UR conventions for measuring power and energy

The figure illustrates the conventions established for use in UR devices.

Figure 6-3: Flow direction of signed values for watts and VARs



6.4.1.2 UR convention for measuring phase angles

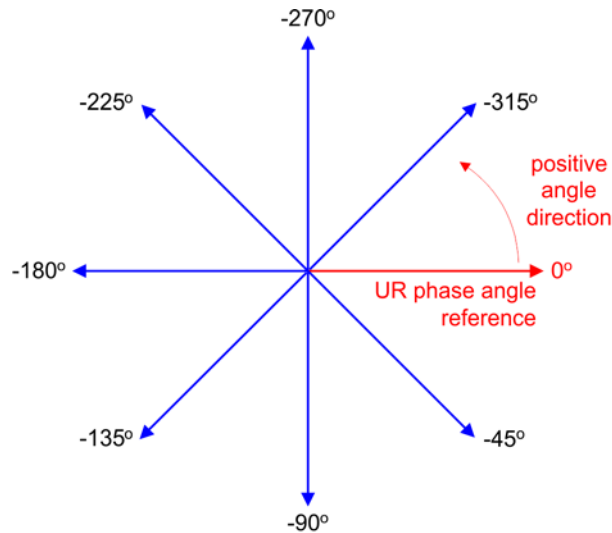
All phasors calculated by URs and used for protection, control and metering functions are rotating phasors that maintain the correct phase angle relationships with each other at all times.

For display and oscillography purposes, all phasor angles in a given relay are referred to an AC input channel pre-selected by the **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **POWER SYSTEM** ⇒ **FREQUENCY AND PHASE REFERENCE** setting. This setting defines a particular AC signal source to be used as the reference.

The relay first determines if any “Phase VT” bank is indicated in the source. If it is, voltage channel VA of that bank is used as the angle reference. Otherwise, the relay determines if any “Aux VT” bank is indicated; if it is, the auxiliary voltage channel of that bank is used as the angle reference. If neither of the two conditions is satisfied, then two more steps of this hierarchical procedure to determine the reference signal include “Phase CT” bank and “Ground CT” bank.

If the AC signal pre-selected by the relay upon configuration is not measurable, the phase angles are not referenced. The phase angles are assigned as positive in the leading direction, and are presented as negative in the lagging direction, to more closely align with power system metering conventions. The figure illustrates this.

Figure 6-4: UR phase angle measurement convention



827845A1.CDR

6.4.1.3 UR convention for measuring symmetrical components

The URs calculate voltage symmetrical components for the power system phase A line-to-neutral voltage, and symmetrical components of the currents for the power system phase A current. Owing to the above definition, phase angle relations between the symmetrical currents and voltages stay the same irrespective of the connection of instrument transformers. This is important for setting directional protection elements that use symmetrical voltages.

For display and oscillography purposes the phase angles of symmetrical components are referenced to a common reference as described in the previous sub-section.

WYE-connected instrument transformers

- ABC phase rotation:

$$V_{-0} = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG})$$

$$V_{-1} = \frac{1}{3}(V_{AG} + aV_{BG} + a^2V_{CG})$$

$$V_{-2} = \frac{1}{3}(V_{AG} + a^2V_{BG} + aV_{CG})$$

- ACB phase rotation:

$$V_{-0} = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG})$$

$$V_{-1} = \frac{1}{3}(V_{AG} + a^2V_{BG} + aV_{CG})$$

$$V_{-2} = \frac{1}{3}(V_{AG} + aV_{BG} + a^2V_{CG})$$

The above equations apply to currents as well.

DELTA-connected instrument transformers

- ABC phase rotation:

$$V_0 = N/A$$

$$V_1 = \frac{1\angle-30^\circ}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$

$$V_2 = \frac{1\angle30^\circ}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$

- ACB phase rotation:

$$V_0 = N/A$$

$$V_1 = \frac{1\angle30^\circ}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$

$$V_2 = \frac{1\angle-30^\circ}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$

The zero-sequence voltage is not measurable under the Delta connection of instrument transformers and is defaulted to zero. The table below shows an example of symmetrical components calculations for the ABC phase rotation.

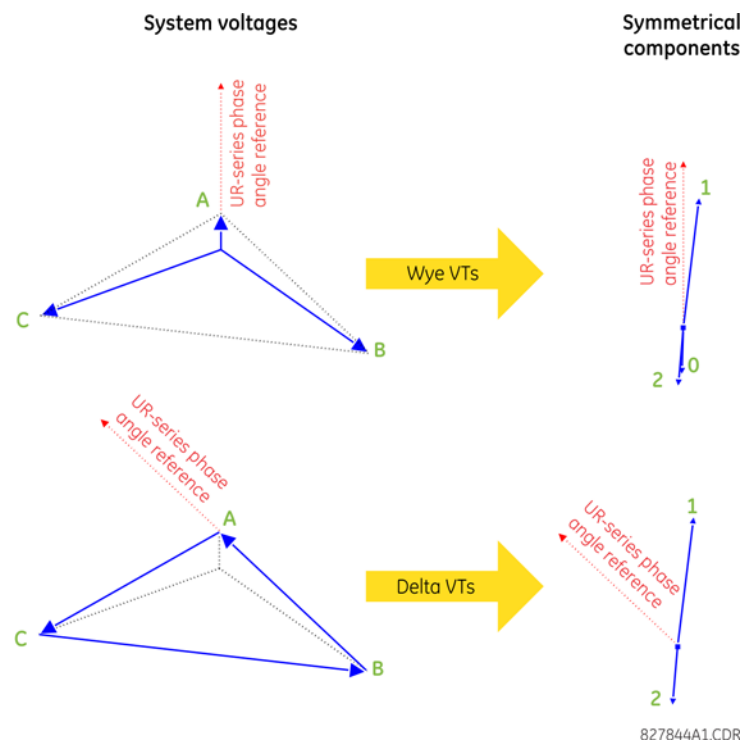
Table 6-1: Symmetrical components calculation example

SYSTEM VOLTAGES, sec. V *						VT conn.	relay INPUTS, sec. V			SYMM. COMP, sec. V		
V _{AG}	V _{BG}	V _{CG}	V _{AB}	V _{BC}	V _{CA}		F5ac	F6ac	F7ac	V ₀	V ₁	V ₂
13.9 ∠0°	76.2 ∠-125°	79.7 ∠-250°	84.9 ∠-313°	138.3 ∠-97°	85.4 ∠-241°	WYE	13.9 ∠0°	76.2 ∠-125°	79.7 ∠-250°	19.5 ∠-192°	56.5 ∠-7°	23.3 ∠-187°
UNKNOWN (only V ₁ and V ₂ can be determined)			84.9 ∠0°	138.3 ∠-144°	85.4 ∠-288°	DELTA	84.9 ∠0°	138.3 ∠-144°	85.4 ∠-288°	N/A	56.5 ∠-54°	23.3 ∠-234°

* The power system voltages are phase-referenced – for simplicity – to V_{AG} and V_{AB}, respectively. This, however, is a relative matter. It is important to remember that the L30 displays are always referenced as specified under **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **POWER SYSTEM** ⇒ **FREQUENCY AND PHASE REFERENCE**.

The example above is illustrated in the following figure.

Figure 6-5: Measurement convention for symmetrical components



6.4.2 Differential current

ACTUAL VALUES ⇌ METERING ⇌ 87L DIFFERENTIAL CURRENT

<div style="border: 1px solid black; padding: 2px;"> ■ 87L DIFFERENTIAL ■ CURRENT </div>	↔	LOCAL IA: 0.000 A 0.0°
	↕	LOCAL IB: 0.000 A 0.0°
	↕	LOCAL IC: 0.000 A 0.0°
	↕	TERMINAL 1 IA: 0.000 A 0.0°
	↕	TERMINAL 1 IB: 0.000 A 0.0°
	↕	TERMINAL 1 IC: 0.000 A 0.0°
	↕	TERMINAL 2 IA: 0.000 A 0.0°
	↕	TERMINAL 2 IB: 0.000 A 0.0°
	↕	TERMINAL 2 IC: 0.000 A 0.0°
	↕	IA DIFF. CURRENT: 0.000 A 0.0°
	↕	IA RESTR. CURRENT: 0.000 A
	↕	IB DIFF. CURRENT: 0.000 A 0.0°
	↕	IB RESTR. CURRENT: 0.000 A
	↕	IC DIFF. CURRENT: 0.000 A 0.0°
	↕	IC RESTR. CURRENT: 0.000 A
↕	IG DIFF. CURRENT: 0.000 A 0.0°	
↕	IG RESTR. CURRENT: 0.000 A	

The metered current values display for all line terminals in fundamental phasor form. All angles are shown with respect to the reference common for all L30 devices; that is, frequency, source currents, and voltages. The metered primary differential and restraint currents display for the local relay.

Terminal 1 refers to the communication channel 1 interface to a remote L30 at terminal 1. Terminal 2 refers to the communication channel 2 interface to a remote L30 at terminal 2.

6.4.3 Sources

6.4.3.1 Menu

ACTUAL VALUES ⇌ METERING ⇌ SOURCE SRC 1

<ul style="list-style-type: none"> ■ SOURCE SRC 1 ■ 	⇌	<ul style="list-style-type: none"> ■ PHASE CURRENT ■ SRC 1 	See below
	⇌	<ul style="list-style-type: none"> ■ GROUND CURRENT ■ SRC 1 	See page 6-18
	⇌	<ul style="list-style-type: none"> ■ PHASE VOLTAGE ■ SRC 1 	See page 6-18
	⇌	<ul style="list-style-type: none"> ■ AUXILIARY VOLTAGE ■ SRC 1 	See page 6-19
	⇌	<ul style="list-style-type: none"> ■ POWER ■ SRC 1 	See page 6-19
	⇌	<ul style="list-style-type: none"> ■ FREQUENCY ■ SRC 1 	See page 6-20
	⇌	<ul style="list-style-type: none"> ■ CURRENT HARMONICS ■ SRC 1 	See page 6-20
	⇌	<ul style="list-style-type: none"> ■ VOLTAGE HARMONICS ■ SRC 1 	See page 6-21

This menu displays the metered values available for each source.

Metered values presented for each source depend on the phase and auxiliary VTs and phase and ground CTs assignments for this particular source. For example, if no phase VT is assigned to this source, then any voltage, energy, and power values are unavailable.

6.4.3.2 Phase current metering

ACTUAL VALUES ⇌ METERING ⇌ SOURCE SRC 1 ⇌ PHASE CURRENT

<ul style="list-style-type: none"> ■ PHASE CURRENT ■ SRC 1 	⇌	SRC 1 RMS Ia: 0.000 b: 0.000 c: 0.000 A
	⇌	SRC 1 RMS Ia: 0.000 A
	⇌	SRC 1 RMS Ib: 0.000 A
	⇌	SRC 1 RMS Ic: 0.000 A
	⇌	SRC 1 RMS In: 0.000 A
	⇌	SRC 1 PHASOR Ia: 0.000 A 0.0°
	⇌	SRC 1 PHASOR Ib: 0.000 A 0.0°
	⇌	SRC 1 PHASOR Ic: 0.000 A 0.0°
	⇌	SRC 1 PHASOR In: 0.000 A 0.0°
	⇌	SRC 1 ZERO SEQ IO: 0.000 A 0.0°

⇅	SRC 1 POS SEQ I1: 0.000 A 0.0°
↑	SRC 1 NEG SEQ I2: 0.000 A 0.0°

The metered phase current values are displayed in this menu. The "SRC 1" text gets replaced by whatever name was programmed by the user for the associated source (see **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **SIGNAL SOURCES**).

6.4.3.3 Ground current metering

ACTUAL VALUES ⇒ **METERING** ⇒ **SOURCE SRC 1** ⇒ **GROUND CURRENT**

⇅	■ GROUND CURRENT ■ SRC 1	⇅	SRC 1 RMS Ig: 0.000 A
⇅		⇅	SRC 1 PHASOR Ig: 0.000 A 0.0°
↑		↑	SRC 1 PHASOR Igd: 0.000 A 0.0°

The metered ground current values are displayed in this menu. The "SRC 1" text is replaced by the name programmed by the user for the associated source (see **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **SIGNAL SOURCES**).

6.4.3.4 Phase voltage metering

ACTUAL VALUES ⇒ **METERING** ⇒ **SOURCE SRC 1** ⇒ **PHASE VOLTAGE**

⇅	■ PHASE VOLTAGE ■ SRC 1	⇅	SRC 1 RMS Vag: 0.00 V
⇅		⇅	SRC 1 RMS Vbg: 0.00 V
⇅		⇅	SRC 1 RMS Vcg: 0.00 V
⇅		⇅	SRC 1 PHASOR Vag: 0.000 V 0.0°
⇅		⇅	SRC 1 PHASOR Vbg: 0.000 V 0.0°
⇅		⇅	SRC 1 PHASOR Vcg: 0.000 V 0.0°
⇅		⇅	SRC 1 RMS Vab: 0.00 V
⇅		⇅	SRC 1 RMS Vbc: 0.00 V
⇅		⇅	SRC 1 RMS Vca: 0.00 V
⇅		⇅	SRC 1 PHASOR Vab: 0.000 V 0.0°
⇅		⇅	SRC 1 PHASOR Vbc: 0.000 V 0.0°
⇅		⇅	SRC 1 PHASOR Vca: 0.000 V 0.0°
⇅		⇅	SRC 1 ZERO SEQ V0: 0.000 V 0.0°

⇅	SRC 1 POS SEQ V1: 0.000 V 0.0°
↑	SRC 1 NEG SEQ V2: 0.000 V 0.0°

The metered phase voltage values are displayed in this menu. The "SRC 1" text is replaced by the name programmed by the user for the associated source (see **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **SIGNAL SOURCES**).

6.4.3.5 Auxiliary voltage metering

ACTUAL VALUES ⇒ **METERING** ⇒ **SOURCE SRC 1** ⇒ **AUXILIARY VOLTAGE**

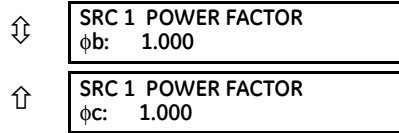
⇅	<input checked="" type="checkbox"/> AUXILIARY VOLTAGE <input checked="" type="checkbox"/> SRC 1	⇅	SRC 1 RMS Vx: 0.00 V
↑		↑	SRC 1 PHASOR Vx: 0.000 V 0.0°

The metered auxiliary voltage values are displayed in this menu. The "SRC 1" text is replaced by the name programmed by the user for the associated source (see **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **SIGNAL SOURCES**).

6.4.3.6 Power metering

ACTUAL VALUES ⇒ **METERING** ⇒ **SOURCE SRC 1** ⇒ **POWER**

⇅	<input checked="" type="checkbox"/> POWER <input checked="" type="checkbox"/> SRC 1	⇅	SRC 1 REAL POWER 3 ϕ : 0.000 W
⇅		⇅	SRC 1 REAL POWER ϕ a: 0.000 W
⇅		⇅	SRC 1 REAL POWER ϕ b: 0.000 W
⇅		⇅	SRC 1 REAL POWER ϕ c: 0.000 W
⇅		⇅	SRC 1 REACTIVE PWR 3 ϕ : 0.000 var
⇅		⇅	SRC 1 REACTIVE PWR ϕ a: 0.000 var
⇅		⇅	SRC 1 REACTIVE PWR ϕ b: 0.000 var
⇅		⇅	SRC 1 REACTIVE PWR ϕ c: 0.000 var
⇅		⇅	SRC 1 APPARENT PWR 3 ϕ : 0.000 VA
⇅		⇅	SRC 1 APPARENT PWR ϕ a: 0.000 VA
⇅		⇅	SRC 1 APPARENT PWR ϕ b: 0.000 VA
⇅		⇅	SRC 1 APPARENT PWR ϕ c: 0.000 VA
⇅		⇅	SRC 1 POWER FACTOR 3 ϕ : 1.000
⇅		⇅	SRC 1 POWER FACTOR ϕ a: 1.000



This menu displays metered values for real, reactive, and apparent power, as well as power factor. The "SRC 1" text is replaced by the name programmed by the user for the associated source (see **SETTINGS ⇒ ↓ SYSTEM SETUP ⇒ ↓ SIGNAL SOURCES**).

When VTs are configured in wye, the L30 calculates power in each phase and three-phase power is measured as

$$S = V_A \times \hat{I}_A + V_B \times \hat{I}_B + V_C \times \hat{I}_C \tag{Eq. 6-1}$$

When VTs are configured in delta, the L30 does not calculate power in each phase and three-phase power is measured as

$$S = V_{AB} \times \hat{I}_A + V_{CB} \times \hat{I}_C \tag{Eq. 6-2}$$

where

S is the apparent power

$V_A, V_B, V_C, I_A, I_B, I_C$ are phase voltage and phase current phasors

V_{AB} and V_{CB} are phase-to-phase voltage phasors

\hat{I} is the conjugate of I

6.4.3.7 Frequency metering

ACTUAL VALUES ⇒ ↓ METERING ⇒ SOURCE SRC 1 ⇒ ↓ FREQUENCY



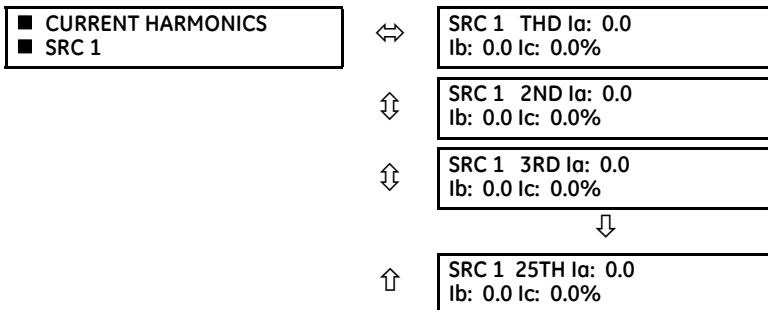
The metered frequency values are displayed in this menu. The "SRC 1" text is replaced by the name programmed by the user for the associated source (see **SETTINGS ⇒ ↓ SYSTEM SETUP ⇒ ↓ SIGNAL SOURCES**).

SOURCE FREQUENCY is measured via software-implemented zero-crossing detection of an AC signal. The signal is either a Clarke transformation of three-phase voltages or currents, auxiliary voltage, or ground current as per source configuration (see the **SYSTEM SETUP ⇒ ↓ POWER SYSTEM** settings). The signal used for frequency estimation is low-pass filtered. The final frequency measurement is passed through a validation filter that eliminates false readings due to signal distortions and transients.

If the 87L function is enabled, then dedicated 87L frequency tracking is engaged. In this case, the relay uses the **METERING ⇒ ↓ TRACKING FREQUENCY ⇒ TRACKING FREQUENCY** value for all computations, overriding the **SOURCE FREQUENCY** value.

6.4.3.8 Current harmonics and THD metering

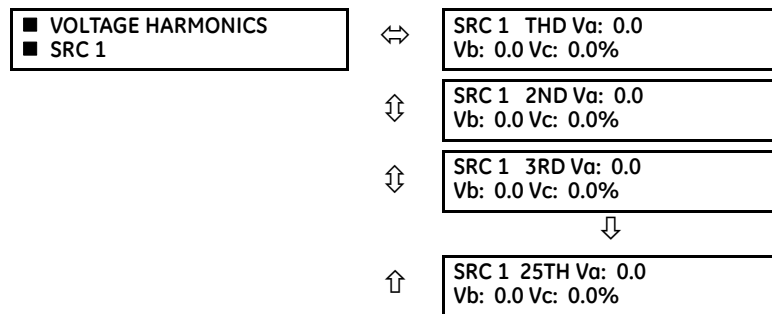
ACTUAL VALUES ⇒ ↓ METERING ⇒ SOURCE SRC 1 ⇒ ↓ CURRENT HARMONICS



This menu displays metered current harmonics values. The "SRC 1" text is replaced by the name was programmed for the associated source (see **SETTINGS ⇒ ↓ SYSTEM SETUP ⇒ ↓ SIGNAL SOURCES**). Current harmonics are measured for each source for the total harmonic distortion (THD) and 2nd to 25th harmonics per phase.

6.4.3.9 Voltage harmonics and THD metering

ACTUAL VALUES ⇒⇩ METERING ⇒ SOURCE SRC 1 ⇒⇩ VOLTAGE HARMONICS



This menu displays metered voltage harmonics values. The “SRC 1” text is replaced by the programmed name for the associated source (see the **SETTINGS ⇒⇩ SYSTEM SETUP ⇒⇩ SIGNAL SOURCES** menu).

To extract the 2nd to 25th voltage harmonics, each harmonic is computed on a per-phase basis, where:

$N = 64$ is the number of samples per cycle

$\omega_0 = 2\pi f$ is the angular frequency based on the system frequency (50 or 60 Hz)

$k = 1, 2, \dots, N - 1$ is the index over one cycle for the Fast Fourier Transform (FFT)

m is the last sample number for the sliding window

$h = 1, 2, \dots, 25$ is the harmonic number

The short-time Fourier transform is applied to the unfiltered signal:

$$F_{\text{real}}(m, h) = \frac{2}{N} \sum_k (f(m-k) \cdot \cos(h \cdot \omega_0 \cdot t(k)))$$

$$F_{\text{imag}}(m, h) = \frac{2}{N} \sum_k (f(m-k) \cdot \sin(h \cdot \omega_0 \cdot t(k)))$$

$$F_{\text{ampl}}(m, h) = \sqrt{F_{\text{real}}(m, h)^2 + F_{\text{imag}}(m, h)^2}$$

Eq. 6-3

The harmonics are a percentage of the fundamental signal obtained as a ratio of harmonic amplitude to fundamental amplitude multiplied by 100%. The total harmonic distortion (THD) is the ratio of the total harmonic content to the fundamental:

$$\text{THD} = \sqrt{F_2^2 + F_3^2 + \dots + F_{25}^2}$$

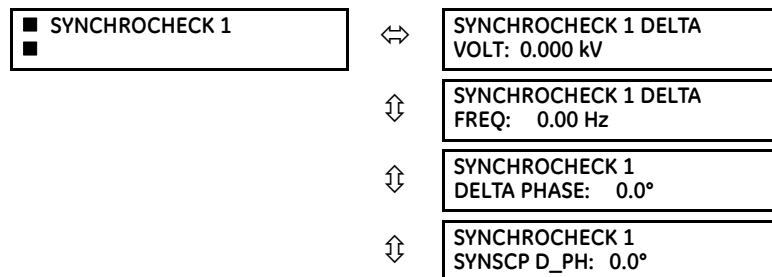
Eq. 6-4

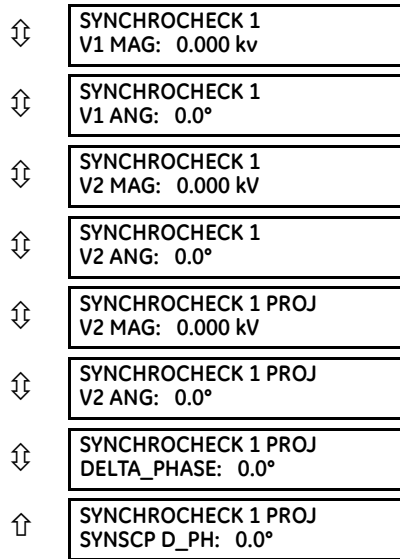


Voltage harmonics are calculated only for Wye connected phase VTs. Ensure that the **SYSTEM SETUP ⇒ AC INPUTS ⇒⇩ VOLTAGE BANK F5 ⇒⇩ PHASE VT XX CONNECTION** setting is “Wye” to enable voltage harmonics metering.

6.4.4 Synchrocheck

ACTUAL VALUES ⇒⇩ METERING ⇒ SYNCHROCHECK ⇒⇩ SYNCHROCHECK 1(4)





If synchrocheck or a setting is "Disabled," the corresponding actual values menu item does not display.

6.4.5 Tracking frequency

ACTUAL VALUES ⇌ METERING ⇌ TRACKING FREQUENCY



The tracking frequency displays here. The frequency is tracked based on configuration of the reference source. The **TRACKING FREQUENCY** is based on positive sequence current phasors from all line terminals and is synchronously adjusted at all terminals. If currents are below 0.125 pu, then the **NOMINAL FREQUENCY** is used.

6.4.6 Frequency rate of change

ACTUAL VALUES ⇌ METERING ⇌ FREQUENCY RATE OF CHANGE 1(2)



The metered frequency rate of change for the frequency rate of change elements is shown here.

6.4.7 FlexElements

ACTUAL VALUES ⇌ METERING ⇌ FLEXELEMENTS ⇌ FLEXELEMENT 1(8)



The operating signals for the FlexElements are displayed in pu values using the following definitions of the base units.

Table 6-2: FlexElement base units

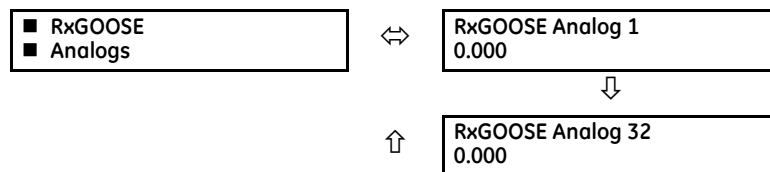
Base unit	Description
87L SIGNALS (Local IA Mag, IB, and IC) (Diff Curr IA Mag, IB, and IC) (Terminal 1 IA Mag, IB, and IC) (Terminal 2 IA Mag, IB and IC)	I_{BASE} = maximum primary RMS value of the +IN and -IN inputs (CT primary for source currents, and 87L source primary current for line differential currents)



Base unit	Description
87L SIGNALS (Op Square Curr IA, IB, and IC) (Rest Square Curr IA, IB, and IC)	BASE = Squared CT secondary of the 87L source
BREAKER ACC ARCING AMPS (Brk X Acc Arc Amp A, B, and C)	BASE = 2000 kA ² × cycle
BREAKER ARCING AMPS (Brk X Arc Amp A, B, and C)	BASE = 1 kA ² × cycle
DCmA	BASE = maximum value of the DCMA INPUT MAX setting for the two transducers configured under the +IN and -IN inputs.
FAULT LOCATION	BASE = Line Length as specified in Fault Report
FREQUENCY	f _{BASE} = 1 Hz
FREQUENCY RATE OF CHANGE	df/dt _{BASE} = 1 Hz/s
PHASE ANGLE	Φ _{BASE} = 360 degrees (see the UR angle referencing convention)
POWER FACTOR	PF _{BASE} = 1.00
RTDs	BASE = 100°C
SOURCE CURRENT	I _{BASE} = maximum nominal primary RMS value of the +IN and -IN inputs
SOURCE POWER	P _{BASE} = maximum value of V _{BASE} × I _{BASE} for the +IN and -IN inputs
SOURCE THD & HARMONICS	BASE = 1%
SOURCE VOLTAGE	V _{BASE} = maximum nominal primary RMS value of the +IN and -IN inputs
SYNCHROCHECK (Max Delta Volts)	V _{BASE} = maximum primary RMS value of all the sources related to the +IN and -IN inputs

6.4.8 RxGOOSE analogs

ACTUAL VALUES ⇌ METERING ⇌ RxGOOSE Analogs

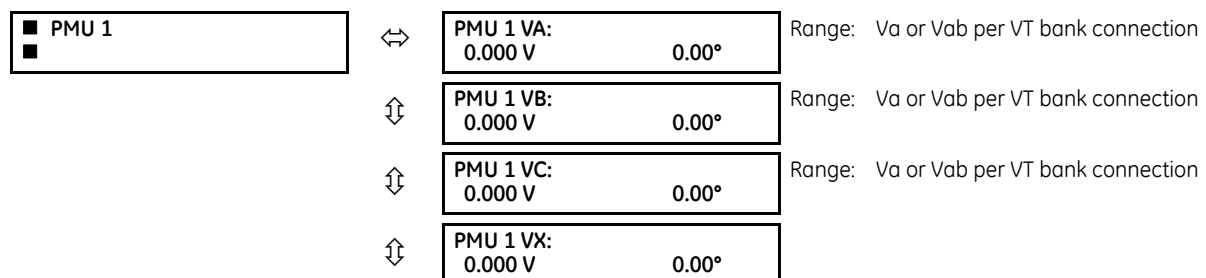


The L30 is provided with optional GOOSE communications capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

The RxGOOSE Analog values display in this menu. The RxGOOSE Analog values are received via IEC 61850 GOOSE messages sent from other devices.

6.4.9 Phasor Measurement Unit

ACTUAL VALUES ⇌ METERING ⇌ PHASOR MEASUREMENT UNIT ⇌ PMU 1



⇅	PMU 1 V1: 0.000 V	0.00°	
⇅	PMU 1 V2: 0.000 V	0.00°	
⇅	PMU 1 V0: 0.000 V	0.00°	Range: Substituted with zero if delta-connected VTs
⇅	PMU 1 IA: 0.000 A	0.00°	
⇅	PMU 1 IB: 0.000 A	0.00°	
⇅	PMU 1 IC: 0.000 A	0.00°	
⇅	PMU 1 IG: 0.000 A	0.00°	
⇅	PMU 1 I1: 0.000 A	0.00°	
⇅	PMU 1 I2: 0.000 A	0.00°	
⇅	PMU 1 I0: 0.000 A	0.00°	
⇅	PMU 1 FREQUENCY: 0.000 Hz		
⇅	PMU 1 df/dt: 0.00 Hz/s		
⇅	PMU 1 CONFIG CHANGE COUNTER:	0	Range: 0 to 65535

6

These actual values display without the corresponding time stamp as they become available per the recording rate setting. Also, the recording post-filtering setting is applied to these values.

6.4.10 PMU aggregator

ACTUAL VALUES ⇅ METERING ⇅ PHASOR MEASUREMENT UNIT ⇅ PMU AGGREGATOR 1



Actual values for the IEC 61850-90-5 PDU size are provided. These values allow you to know the approximate Ethernet frame size for the data streams from each aggregator. This can help to estimate network loading. The PDU size shown in the displays does not include the Ethernet, UDP, or IP layers. PDU sizes approaching approximately 1500 bytes result in fragmented data frames, causing increased network traffic.

6.4.11 Transducer inputs and outputs

ACTUAL VALUES ⇅ METERING ⇅ TRANSDUCER I/O DCMA INPUTS ⇅ DCMA INPUT xx



Actual values for each DCmA input channel that is enabled are displayed with the top line as the programmed channel ID and the bottom line as the value followed by the programmed units.

ACTUAL VALUES ⇄ METERING ⇄ TRANSDUCER I/O RTD INPUTS ⇄ RTD INPUT xx

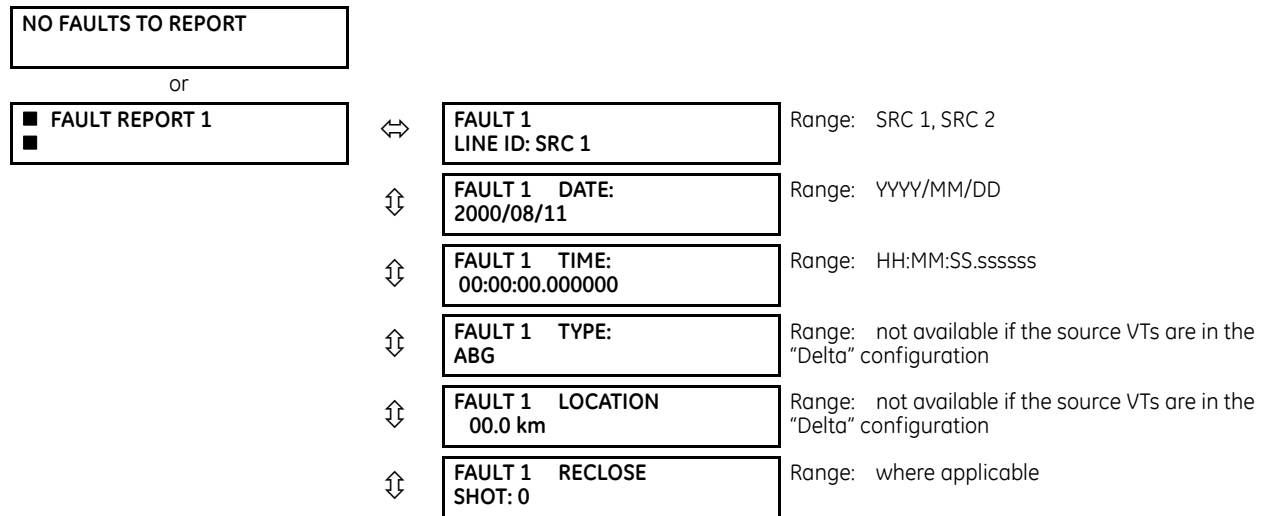


Actual values for each RTD input channel that is enabled are displayed with the top line as the programmed channel ID and the bottom line as the value.

6.5 Records

6.5.1 Fault reports

ACTUAL VALUES ⇄ RECORDS ⇄ FAULT REPORTS ⇄ FAULT REPORT 1(15)



The latest 15 fault reports can be stored. The most recent fault location calculation (when applicable) is displayed in this menu, along with the date and time stamp of the event which triggered the calculation. See the **SETTINGS ⇄ PRODUCT SETUP ⇄ FAULT REPORTS** menu for assigning the source and trigger for fault calculations. See the **COMMANDS ⇄ CLEAR RECORDS** menu for manual clearing of the fault reports and to the **SETTINGS ⇄ PRODUCT SETUP ⇄ CLEAR RELAY RECORDS** menu for automated clearing of the fault reports.

Where VA, VB, VC are phase voltage phasors in secondary volts; IA, IB, IC are current phasors in secondary amps, I0 is the zero sequence current phasors in secondary amps; and IG is the ground current from the parallel line scaled to the source phase CT in secondary amps. Z0/Z1 is the zero sequence impedance to positive sequence impedance ratio, and Z0M/Z1 is mutual zero sequence impedance to positive sequence impedance ratio.

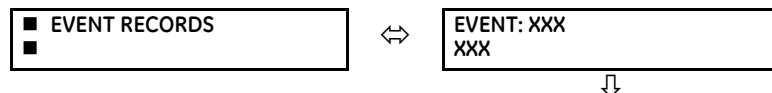


VTs of the **FAULT REPORT 1 SOURCE** must be connected in Wye or **VT SUBSTITUTION** must be set correctly for the Delta connected VT to display the loop impedance and fault resistance for single phase-to-ground faults.

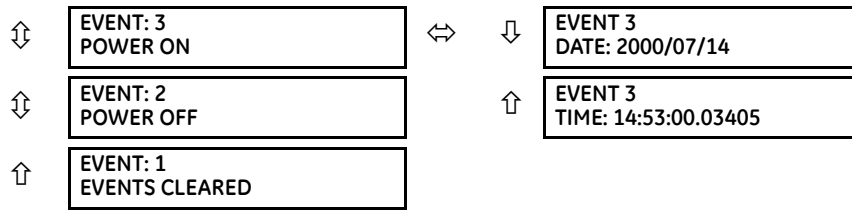
6.5.2 Event records

6.5.2.1 Enhanced and standard front panels

ACTUAL VALUES ⇄ RECORDS ⇄ EVENT RECORDS



Date and time stamps



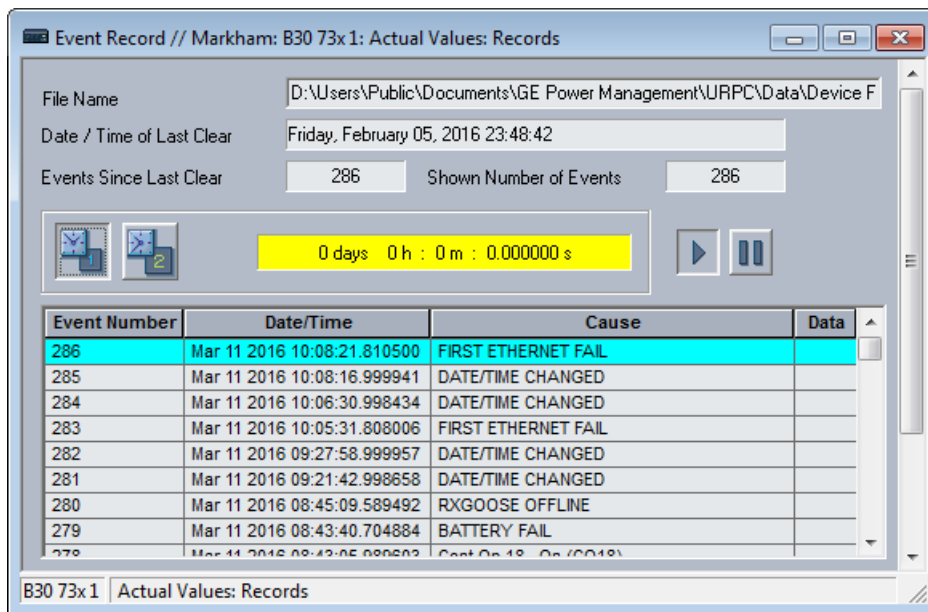
The event records menu shows the contextual data associated with up to the last 1024 events, listed in chronological order from most recent to oldest. When all 1024 event records have been filled, the oldest record is removed as a new record is added. Each event record shows the event identifier/sequence number, cause, and date/time stamp associated with the event trigger. See the **COMMANDS** ⇒ **↓ CLEAR RECORDS** menu for clearing event records.

Only major output operands generate events, not every operand. Elements that assert output per phase, for example, log operating phase output only without asserting the common three-phase operand event.

See also the system log (syslog) information in the previous chapter.

The event records are also viewable in the software and in a web browser. The figure shows the event records in the software. To view them in a web browser, enter the IP address of the device. When an oscillography icon displays, click it to open it.

Figure 6-6: Event records viewed in EnerVista software



6.5.2.2 Graphical front panel

To display the event records page, press the **Home** pushbutton then the **Event Record** Tab pushbutton.

The newest event is always at the top.

Up and Down pushbuttons move the event selector up and down. When the selector is at the bottom of the display, the Down pushbutton also scrolls the page, and similarly when the active selector is at the top of the display the Up pushbutton scroll the page.

A selected event is highlighted in yellow and becomes active by pressing the Up or Down pushbutton.

There are two event markers, one green, the other cyan. To mark some an event, use the Up and Down pushbuttons to select it (highlight in yellow), then press the green or cyan Mark Event Tab pushbutton. The mark color hides the selector until the selector is moved. A field at the top of the page shows the interval between the two marks.

Figure 6-7: Event record

\\Event Record 29-Jun-17 11:56:33 AM			
Most recent event number	38	Time between marks	0d 0h : 0m : 35.012364s
Event ID	Date/Time	Cause	
38	29-Jun-17 10:17:56.117582	WRONG TRANSCEIVER	
37	29-Jun-17 10:17:56.117582	POWER ON	
36	29-Jun-17 10:17:21.105218	POWER OFF	
35	29-Jun-17 10:17:21.105218	REBOOT COMMAND	
34	29-Jun-17 10:01:41.074062	FLASH PROGRAMMING	
33	29-Jun-17 09:49:33.711569	RESET ANCTR OP(MNUL)	
32	29-Jun-17 09:49:12.946980	RESET ANCTR OP(MNUL)	
31	29-Jun-17 09:47:51.344902	RESET ANCTR OP(MNUL)	
30	29-Jun-17 09:41:34.117044	WRONG TRANSCEIVER	
29	29-Jun-17 09:41:34.117044	POWER ON	
Mark Event		Page Up	Page Down

6.5.3 Oscillography

6.5.3.1 Enhanced and standard front panels

ACTUAL VALUES ⇄ RECORDS ⇄ OSCILLOGRAPHY

OSCILLOGRAPHY

↔

FORCE TRIGGER?
No

Range: No, Yes

↕

NUMBER OF TRIGGERS:
0

↕

AVAILABLE RECORDS:
0

↕

CYCLES PER RECORD:
0

↑

LAST CLEARED DATE:
2000/07/14 15:40:16

This menu allows the user to view the number of triggers involved and number of oscillography traces available. The cycles per record value is calculated to account for the fixed amount of data storage for oscillography. See the Oscillography section of chapter 5 for details.

A trigger can be forced here at any time by setting “Yes” to the FORCE TRIGGER? command. See the **COMMANDS ⇄ CLEAR RECORDS** menu for information on clearing the oscillography records.

6.5.4 Data logger

ACTUAL VALUES ⇄ RECORDS ⇄ DATA LOGGER

DATA LOGGER

↔

OLDEST SAMPLE TIME:
2000/01/14 13:45:51

↑

NEWEST SAMPLE TIME:
2000/01/14 15:21:19

The **OLDEST SAMPLE TIME** represents the time at which the oldest available samples were taken. It is static until the log gets full, at which time it starts counting at the defined sampling rate.

The **NEWEST SAMPLE TIME** represents the time the most recent samples were taken. It counts up at the defined sampling rate. If the data logger channels are defined, then both values are static.

See the **COMMANDS ⇄ CLEAR RECORDS** menu for clearing data logger records.

6.5.5 Phasor Measurement Unit records

ACTUAL VALUES ⇒ RECORDS ⇒ PMU RECORDS

<input checked="" type="checkbox"/> PMU <input checked="" type="checkbox"/> RECORDS	↔	NUMBER OF TRIGGERS: 0	Range: 0 to 65535 in steps of 1
	↑	<input checked="" type="checkbox"/> PMU 1 <input checked="" type="checkbox"/> RECORDING	See below

The number of triggers applicable to the Phasor Measurement Unit recorder is indicated by the **NUMBER OF TRIGGERS** value. The status of the phasor measurement unit recorder is indicated as follows.

ACTUAL VALUES ⇒ RECORDS ⇒ PMU RECORDS ⇒ PMU 1 RECORDING

<input checked="" type="checkbox"/> PMU 1 <input checked="" type="checkbox"/> RECORDING	↔	PMU 1 FORCE TRIGGER: No	Range: No, Yes
	↕	PMU 1 AVAILABLE RECORDS: 0	Range: 0 to 65535 in steps of 1
	↕	PMU 1 SECONDS PER RECORD: 0.0	Range: 0 to 6553.5 in steps of 0.1
	↑	PMU 1 LAST CLEARED: 2013/07/14 15:40:16	Range: YYYY/MM/DD HH:MM:SS

6.5.6 Breaker maintenance

ACTUAL VALUES ⇒ RECORDS ⇒ MAINTENANCE ⇒ BREAKER 1(2)

<input checked="" type="checkbox"/> BREAKER 1 <input checked="" type="checkbox"/>	↔	BKR 1 ACC ARCING AMP φA: 0.00 kA2-cyc
	↕	BKR 1 ACC ARCING AMP φB: 0.00 kA2-cyc
	↕	BKR 1 ACC ARCING AMP φC: 0.00 kA2-cyc
	↕	BKR 1 OPERATING TIME φA: 0 ms
	↕	BKR 1 OPERATING TIME φB: 0 ms
	↕	BKR 1 OPERATING TIME φC: 0 ms
	↕	BKR 1 OPERATING TIME 0 ms
	↕	BKR 1 ARCING AMP φA: 0.00 kA2-cyc
	↕	BKR 1 ARCING AMP φB: 0.00 kA2-cyc
	↑	BKR 1 ARCING AMP φC: 0.00 kA2-cyc
	↑	BKR 1 AMP MAX φA: 0.00 kA
	↑	BKR 1 AMP MAX φB: 0.00 kA
	↑	BKR 1 AMP MAX φC: 0.00 kA

There is an identical menu for each of the breakers.

The **BKR 1 ACC ARCING AMP** values are in units of kA^2 -cycles. See the **COMMANDS** ⇒⇩ **CLEAR RECORDS** menu for clearing breaker arcing current records.

The **BREAKER OPERATING TIME** is defined as the slowest operating time of breaker poles that were initiated to open.

All of the values are stored in non-volatile memory and retained with power cycling.

6.6 Product information

6.6.1 Model information

ACTUAL VALUES ⇒⇩ PRODUCT INFO ⇒ MODEL INFORMATION

■ MODEL INFORMATION	⇔	ORDER CODE LINE 1: L30-A00-AAA-A0A-A0A-	Range: standard GE order code format
	⇕	ORDER CODE LINE 2: A0A-A0A-A0A	Range: up to 20 alphanumeric characters
	⇕	ORDER CODE LINE 3:	Range: up to 20 alphanumeric characters
	⇕	ORDER CODE LINE 4:	Range: up to 20 alphanumeric characters
	⇕	SERIAL NUMBER:	Range: standard GE serial number format
	⇕	ETHERNET MAC ADDRESS 000000000000	Range: standard Ethernet MAC address format
	⇕	MANUFACTURING DATE:	Range: YYYY/MM/DD HH:MM:SS
	⇕	OPERATING TIME: 0:00:00	Range: operating time in HH:MM:SS
	⇕	PMU FEATURE ACTIVE: No	Range: Yes, No
	⇕	CT/ VT ADVANCED DIAG ACTIVE: No	Range: Yes, No
	↑	LAST SETTING CHANGE: 1970/01/01 23:11:19	Range: YYYY/MM/DD HH:MM:SS

The order code, serial number, Ethernet MAC address, date and time of manufacture, and operating time are shown here. The rear panel on the device contains similar information. The information is read-only in the software and modifiable on the front panel. For example, the order code can be corrected using the front panel.

ETHERNET MAC ADDRESS — UR devices with firmware 7.0x and above have three Ethernet ports that can be used on three networks. The MAC address displays for port 1. The MAC address for port 2 is one higher. The MAC address for port 3 is one higher than port 2. In redundant mode, the MAC addresses for ports 2 and 3 are the same as port 2.

6.6.2 Firmware revisions

6.6.2.1 Enhanced and standard front panels

ACTUAL VALUES ⇒⇩ PRODUCT INFO ⇒ FIRMWARE REVISIONS

■ FIRMWARE REVISIONS	⇔	L30 Relay REVISION: 7.6x	Range: 0.00 to 655.35 Revision number of the application firmware.
----------------------	---	-----------------------------	---

⇅	MODIFICATION FILE NUMBER: 0	Range: 0 to 65535 (ID of the MOD FILE) Value is 0 for each standard firmware release.
⇅	BOOT PROGRAM REVISION: 7.01	Range: 0.00 to 655.35 Revision number of the boot program firmware.
⇅	FRONT PANEL PROGRAM REVISION: 2.01	Range: 0.00 to 655.35 Revision number of front panel program firmware.
⇅	COMPILE DATE: 2016/09/15 04:55:16	Range: YYYY/MM/DD HH:MM:SS Date and time when product firmware was built.
⇅	BOOT DATE: 2013/09/15 16:41:32	Range: YYYY/MM/DD HH:MM:SS Date and time when the boot program was built.
⇅	FPGA PROGRAM REVISION: 02.02	Range: 0.00 to 655.35 Revision number for FPGA.
↑	FPGA DATE: 2016/09/15 16:41:32	Range: YYYY/MM/DD HH:MM:SS Date and time when the FPGA was built.

The shown data is illustrative only. A modification file number of 0 indicates that, currently, no modifications have been installed.

6.6.2.2 Graphical front panel

ACTUAL VALUES ⇅ PRODUCT INFO ⇅ FIRMWARE REVISIONS

<ul style="list-style-type: none"> ■ FIRMWARE REVISIONS ■ 	⇅	L30 Relay REVISION: 7.6x	Range: 0.00 to 655.35 Revision number of the application firmware.
	⇅	MODIFICATION FILE NUMBER: 0	Range: 0 to 65535 (ID of the MOD FILE) Value is 0 for each standard firmware release.
	⇅	BOOT PROGRAM REVISION: 7.01	Range: 0.00 to 655.35 Revision number of the boot program firmware.
	⇅	COMPILE DATE: 2017/06/15 04:55:16	Range: YYYY/MM/DD HH:MM:SS Date and time when product firmware was built.
	⇅	BOOT DATE: 2016/09/15 16:41:32	Range: YYYY/MM/DD HH:MM:SS Date and time when the boot program was built.
	⇅	GFP PROGRAM REVISION: 7.60	Range: 0.00 to 655.35 Revision number of front panel program firmware.
	⇅	GFP COMPILE DATE: 2017/03/03 12:58:00	Range: YYYY/MM/DD HH:MM:SS Date/time when graphical front panel firmware built.
	⇅	GFP BOOT PROGRAM REVISION: 1.00	Range: 0.00 to 655.35 Revision number of panel boot program firmware.
	⇅	GFP BOOT COMP. DATE: 2017/03/03 12:58:00	Range: YYYY/MM/DD HH:MM:SS Date/time when panel boot program was built.
	⇅	FPGA PROGRAM REVISION: 02.02	Range: 0.00 to 655.35 Revision number for FPGA.
	↑	FPGA DATE: 2016/09/15 16:41:32	Range: YYYY/MM/DD HH:MM:SS Date and time when the FPGA was built.

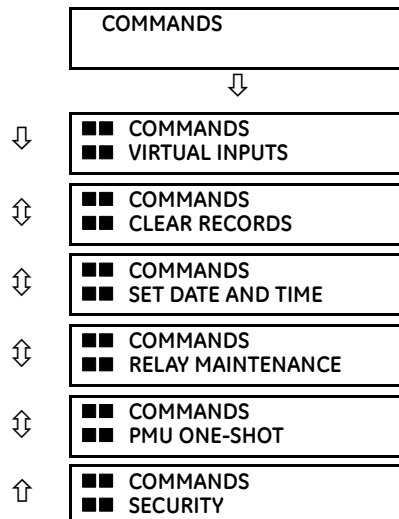
The shown data is illustrative only. A modification file number of 0 indicates that, currently, no modifications have been installed. The date format reflects the format specified for the clock and can vary from that shown here.

L30 Line Current Differential System

Chapter 7: Commands and targets

This chapter outlines the Commands and Targets menus and self-tests/error messages. Commands related to the IEC 61850 protocol are outlined in the IEC 61850 section of the Settings chapter. Log/error messages for IEC 61850 are outlined in the UR Family Communications Guide.

7.1 Commands menu

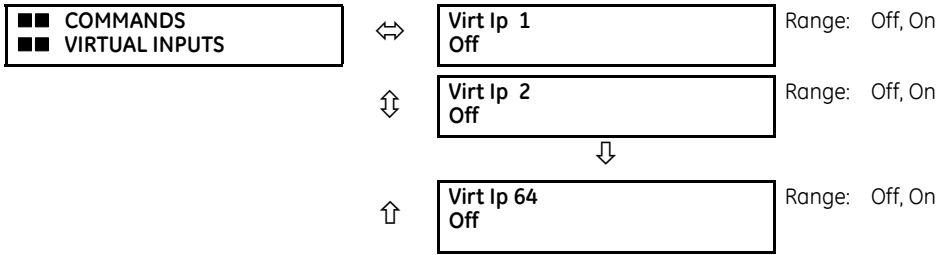


The commands menu contains relay directives intended for operations personnel. All commands can be protected from unauthorized access via the command password; see the Security section of chapter 5 for details. The following flash message appears after successfully command entry.

COMMAND
EXECUTED

7.1.1 Virtual inputs

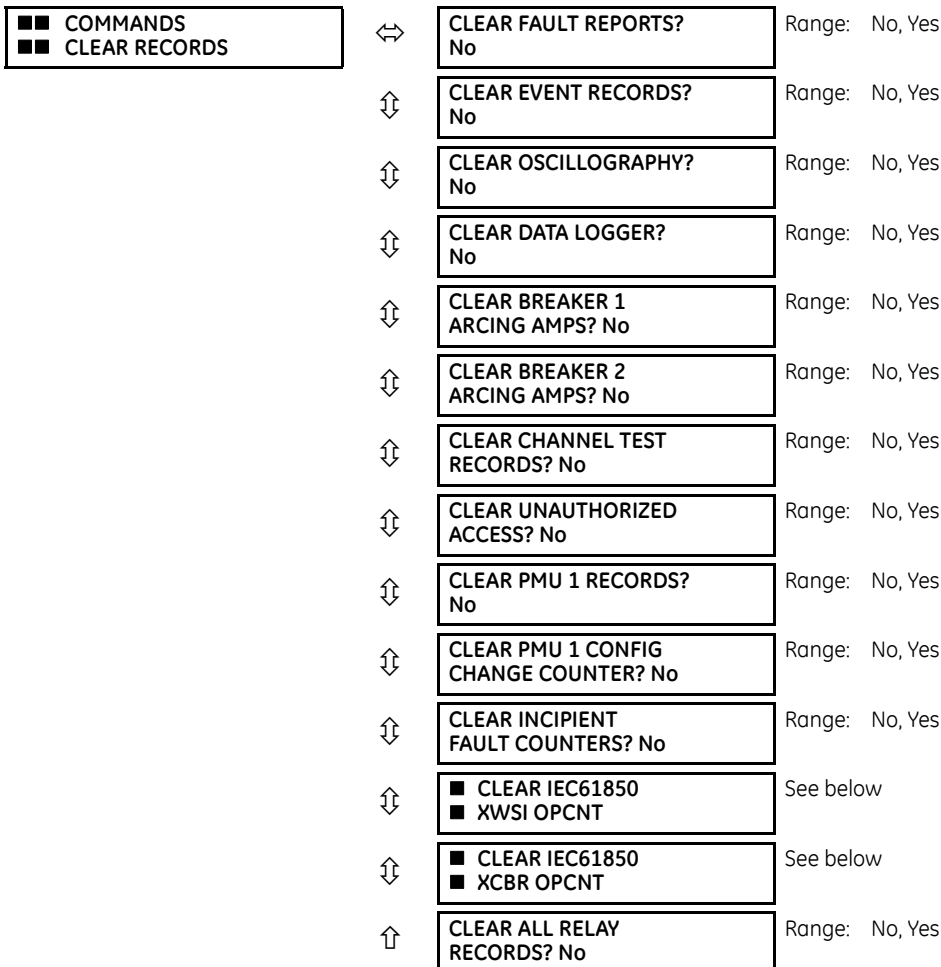
COMMANDS ⇌ VIRTUAL INPUTS



The states of up to 64 virtual inputs are changed here. The first line of the display indicates the ID of the virtual input. The second line indicates the current or selected status of the virtual input. This status is a state off (logic 0) or on (logic 1).

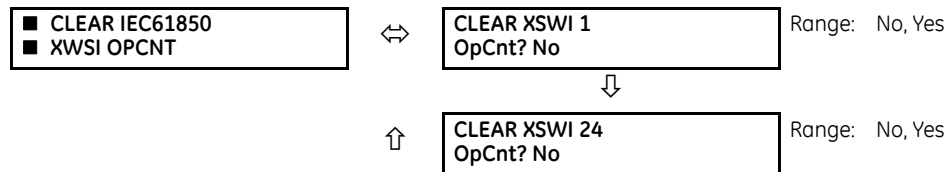
7.1.2 Clear records

COMMANDS ⇌ CLEAR RECORDS

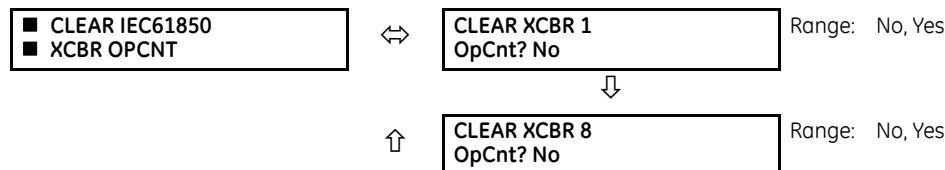


This menu contains commands for clearing historical data such as the event records. Data is cleared by changing a command setting to “Yes” and pressing the **ENTER** key. After clearing data, the command setting automatically reverts to “No.”

COMMANDS ⇒ CLEAR RECORDS ⇒⇅ CLEAR IEC61850 XWSI OPCNT



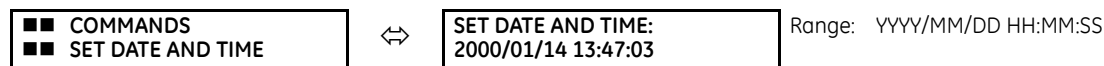
COMMANDS ⇒ CLEAR RECORDS ⇒⇅ CLEAR IEC61850 XCBR OPCNT



The Clear XSWI commands clear the disconnect operation counters for each phase and the three-phase counter. Similarly, the Clear XCBR commands clear the circuit breaker operation counters for each phase and the three-phase counter.

7.1.3 Set date and time

COMMANDS ⇒⇅ SET DATE AND TIME



The date and time can be entered on the front panel keypad. The time setting is based on the 24-hour clock. The complete date, as a minimum, must be entered to allow execution of this command. The new time and date take effect when the **ENTER** key is pressed.

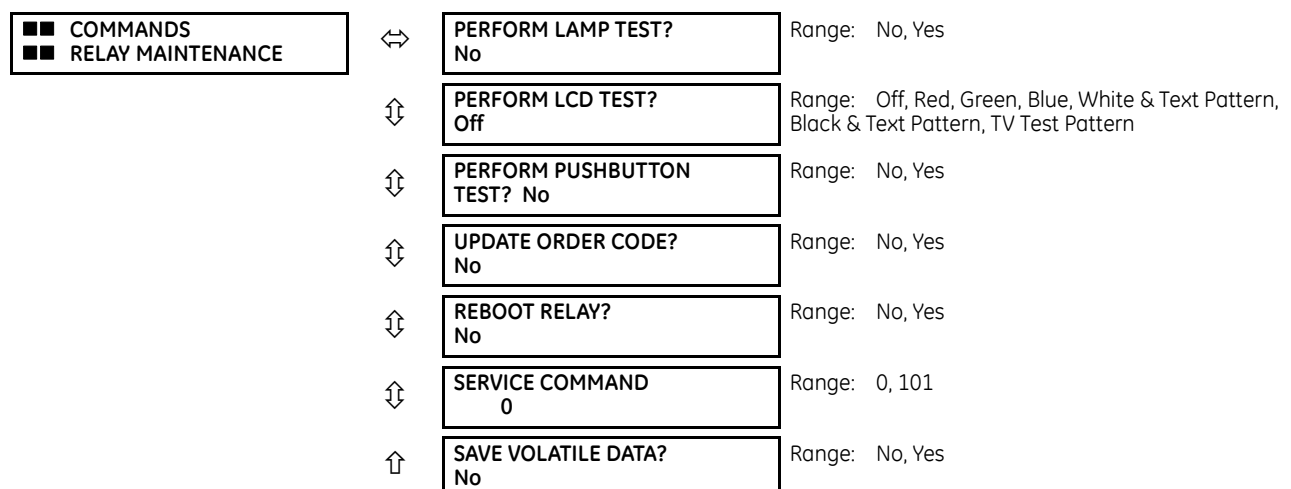
The clock also can be synchronized to the local computer time among several UR devices. Use the **Synchronize Devices** entry in the Online Window area of the EnerVista software. (Click the button at the top of the window that opens.)

When the relay is synchronizing to an external time source such as PTP, IRIG-B, or SNTP, the manually entered time or the manually synchronized time is over-written.

The timescale of the entered time is local time, including daylight savings time where and when applicable.

7.1.4 Relay maintenance

COMMANDS ⇒⇅ RELAY MAINTENANCE



This menu contains commands for relay maintenance purposes. Commands for the lamp test and order code are activated by changing a command setting to “Yes” and pressing the **ENTER** key. The command setting then automatically reverts to “No.” The service command is activated by entering a numerical code and pressing the **ENTER** key.

Not all commands display in the software; use the front panel when required.

PERFORM LAMP TEST — Turns on all front panel LEDs and display pixels for a short duration.

PERFORM LCD TEST — This command detects either stuck-ON or stuck-OFF pixels (dead pixels) in the display screen on the graphical front panel. RED/GREEN/BLUE is to display the solid background color in the whole screen. WHITE & TEXT PATTERN shows the white background and black texts. BLACK & TEXT PATTERN shows the black background and white texts. TV TEST PATTERN displays a standard television test pattern (SMPTE color bars). The test screen can be cancelled by pressing any pushbutton or after 30 seconds of inactivity.


PERFORM PUSHBUTTON TEST — This command tests the pushbuttons on the graphical front panel. During testing, press the corresponding pushbutton according to the prompt text. A failure message is given if the expected action is not detected in one minute. Holding the **ESCAPE** button for five seconds to interrupt the test sequence. The designated function of a specific pushbutton is bypassed in the test.

UPDATE ORDER CODE — This command causes the relay to scan the backplane for the hardware modules and update the order code to match. If an update occurs, the following message displays.

UPDATING...
PLEASE WAIT

There is no impact if there have been no changes to the hardware modules. When an update does not occur, the ORDER CODE NOT UPDATED message displays.

REBOOT RELAY — Restarts the relay so that changes to configuration settings can take effect. In most cases, if changes are made to the configuration settings these changes do not take effect unless the relay is rebooted.

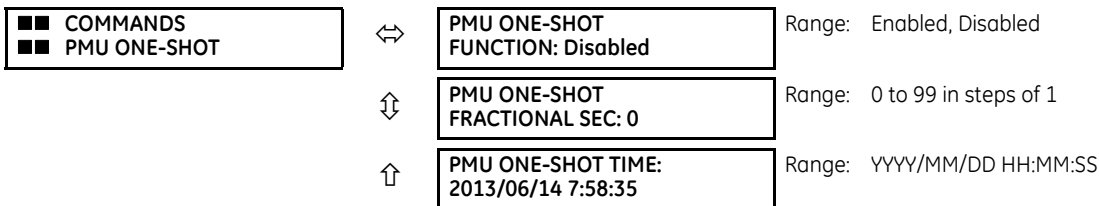
 With the CyberSentry option, the Administrator and Operator roles can initiate the Reboot Relay command.

SERVICE COMMAND — Performs specific L30 service actions. Presently, there are two service actions available. Code “20511” returns all settings to their factory default value. Code “101” is used to clear factory diagnostic information stored in the non-volatile memory. If a code other than these two is entered, the command is ignored and no action is taken. Various self-checking diagnostics are performed in the background while the L30 is running, and diagnostic information is stored on the non-volatile memory from time to time based on the self-checking result. Although the diagnostic information is cleared before the L30 is shipped from the factory, the user can want to clear the diagnostic information for themselves under certain circumstances. For example, you clear diagnostic information after replacement of hardware. Once the diagnostic information is cleared, all self-checking variables are reset to their initial state and diagnostics restart from scratch.

SAVE VOLATILE DATA — Saves this data to compact flash memory prior to shutdown. This allows the saved data to be as recent as possible instead of relying on the periodic timer to save the data.

7.1.5 Phasor Measurement Unit one-shot

COMMANDS ⇌ PMU ONE-SHOT



This feature allows pre-scheduling of a PMU measurement at a specific point in time. It can be used to test for accuracy of the PMU and for manual collection of synchronized measurements through the system, as explained here.



When enabled, the function continuously compares the present time with the pre-set **PMU ONE-SHOT TIME**. When the two times match, the function compares the present sequence number of the measured synchrophasors with the pre-set **PMU ONE-SHOT FRACTIONAL SEC**. When the two numbers match, the function freezes the synchrophasor actual values and the corresponding protocol data items for 30 seconds. This allows manual read-out of the synchrophasor values for the pre-set time and pre-set sequence number (via the faceplate display, supported communication protocols such as Modbus or DNP, and the EnerVista UR Setup software).

When freezing the actual values, the function also asserts a **PMU ONE-SHOT OP** FlexLogic operand. This operand can be configured to drive an output contact and trigger an external measuring device such as a digital scope with the intent to verify the accuracy of the PMU under test.

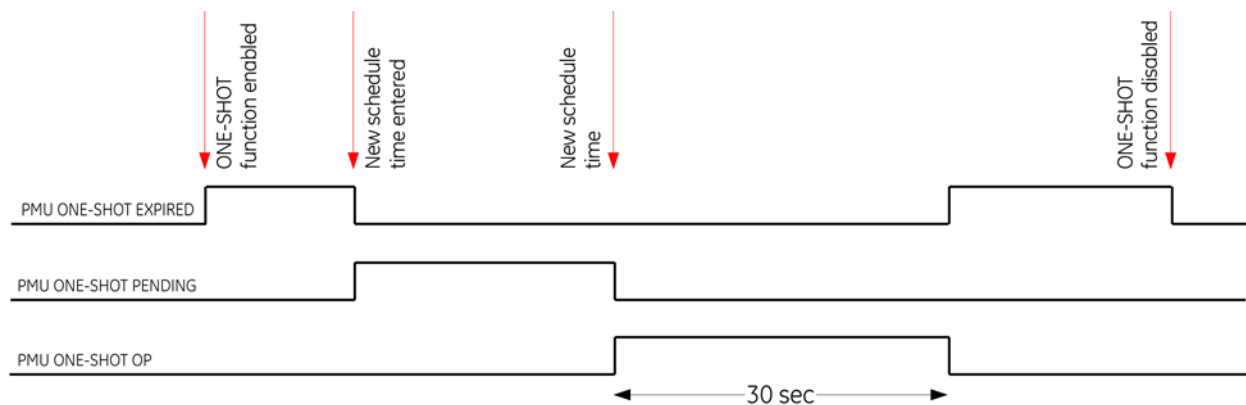
With reference to the following figure, the PMU one-shot function (when enabled) controls three FlexLogic operands:

- The **PMU ONE-SHOT EXPIRED** operand indicates that the one-shot operation has been executed, and the present time is at least 30 seconds past the scheduled one-shot time
- The **PMU ONE-SHOT PENDING** operand indicates that the one-shot operation is pending; that is, the present time is before the scheduled one-shot time
- The **PMU ONE-SHOT OP** operand indicates the one-shot operation and remains asserted for 30 seconds afterwards

When the function is disabled, all three operands are de-asserted.

The one-shot function applies to all logical PMUs of a given L30 relay.

Figure 7-1: PMU one-shot FlexLogic operands



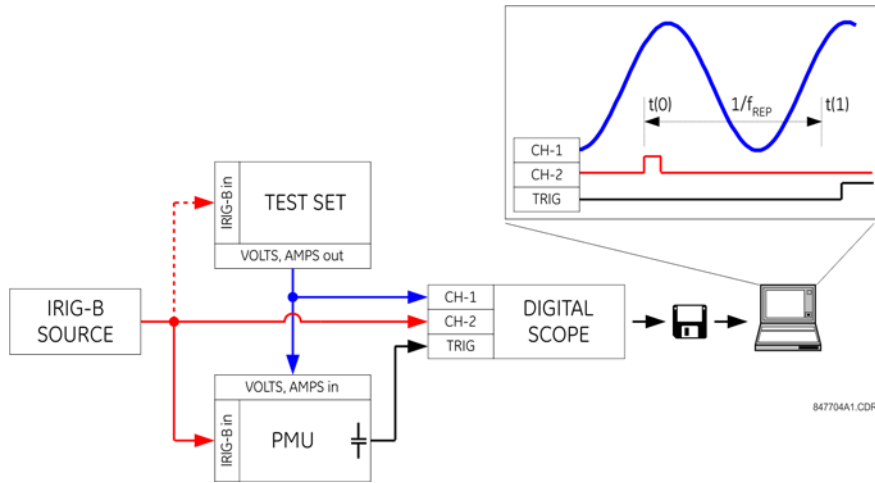
847703A1.CDR

7.1.5.1 Testing accuracy of the PMU

The one-shot feature is used to test accuracy of the synchrophasor measurement. GPS-synchronized test sets perform a similar function to PMUs; instead of measuring the phasor from physical signals with respect to the externally provided time reference, they produce the physical signals with respect to the externally provided time reference, given the desired phasor values. Therefore the GPS-synchronized test sets cannot be automatically assumed more accurate than the PMUs under test. This calls for a method to verify both the measuring device (PMU) and the source of signal (test set).

With reference to the following figure, the one-shot feature can be configured to trigger a high-accuracy scope to capture both the time reference signal (rising edge of the 1 pps signal of the IRIG-B time reference) and the measured waveform. The high-accuracy high-sampling rate record of the two signals captured by the scope can be processed using digital tools to verify the magnitude and phase angle with respect to the time reference signal. As both the time reference and the measured signals are raw inputs to the PMU under test, their independently captured record, processed using third-party software, is a good reference point for accuracy calculations. Such a record proves useful when discussing the test results, and can be retained as a part of the testing documentation.

Figure 7-2: Using the PMU one-shot feature to test synchrophasor measurement accuracy



7.1.5.2 Collecting synchronized measurements ad hoc

The one-shot feature can be used for ad hoc collection of synchronized measurements in the network. Two or more PMUs can be pre-scheduled to freeze their measurements at the same time. When frozen, the measurements can be collected using the EnerVista software or a protocol client.

7.1.6 Security

COMMANDS ⇌ SECURITY

<input checked="" type="checkbox"/> SECURITY <input checked="" type="checkbox"/>	↔	ADMINISTRATOR LOGOFF: No	Range: Yes, No
	↕	ENGINEER LOGOFF: No	Range: Yes, No
	↕	OPERATOR LOGOFF: No	Range: Yes, No
	↑	CLEAR SECURITY DATA: No	Range: Yes, No

With the CyberSentry option, this setting is available to enable or disable the following commands.

ADMINISTRATOR LOGOFF — Selecting 'Yes' allows the Supervisor to forcefully logoff an administrator session.

ENGINEER LOGOFF — Selecting 'Yes' allows the Supervisor to forcefully logoff an engineer session.

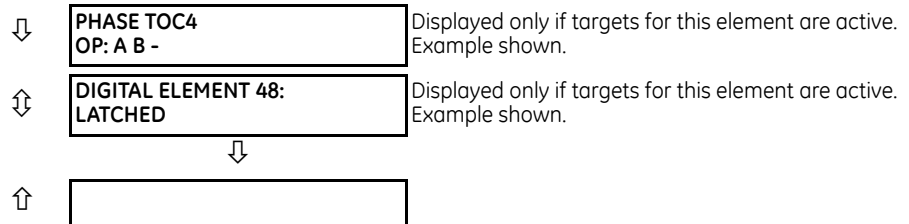
OPERATOR LOGOFF — Selecting 'Yes' allows the Supervisor to forcefully logoff an operator session.

CLEAR SECURITY DATA — Selecting 'Yes' allows the Supervisor to forcefully clear all the security logs and clears all the operands associated with the self-tests.

7.2 Targets menu

TARGETS





A target enables the EnerVista UR Setup software to monitor automatically and display the status of any active target messages of all the devices inserted into that site.

Each L30 element with a TARGET setting has a target message that when activated by its element is displayed in sequence with any other currently active target messages in the **TARGETS** menu. In the example shown, the Phase TOC4 and Digital Element 48 target settings are active and so have their targets displayed. The down arrow below the two elements indicates that there can be other active elements beyond these two.

For more information, see the description of target messages in the next section, and the Introduction to Elements section in the Settings chapter for instructions on TARGET setting.

When no targets are active, the display reads **NO ACTIVE TARGETS**.

7.2.1 Target messages

When there are no active targets, the first target to become active causes the display to immediately default to that message. If there are active targets and the user is navigating through other messages, and when the default message timer times out (i.e. the keypad has not been used for a determined period of time), the display again defaults back to the target message.

The range of variables for the target messages is described below. Phase information is included if applicable. If a target message status changes, the status with the highest priority displays.

Table 7-1: Target message priority status

Priority	Active status	Description
1	OP	element operated and still picked up
2	PKP	element picked up and timed out
3	LATCHED	element had operated but has dropped out

If a self test error is detected, a message appears indicating the cause of the error. For example UNIT NOT PROGRAMMED indicates that the minimal relay settings have not been programmed.

7.2.2 Relay self-tests

7.2.2.1 Description

The relay performs a number of self-test diagnostic checks to ensure device integrity. The two types of self-tests (major and minor) are listed in the following tables. When either type of error occurs, the Trouble LED Indicator turns on and a target message displays. All errors record an event in the event recorder. Latched errors can be cleared by pressing the **RESET** key, providing the condition is no longer present.

Major self-test errors also result in the following:

- The critical fail relay on the power supply module de-energizes
- All other output relays de-energize and are prevented from further operation
- The front panel In Service LED indicator turns off
- A RELAY OUT OF SERVICE event is recorded

To view error messages in EnerVista software:

1. Access **Actual Values > Records > Event Records**.

7.2.2.2 Major self-test error messages

The major self-test errors are outlined in this section.

INCOMPATIBLE H/W: Contact Factory (xxx)

- *Latched target message:* Yes.
- *Description of problem:* One or more installed hardware modules is not compatible with the L30 order code.
- *How often the test is performed:* Module dependent.
- *What to do:* Contact the factory and supply the failure code noted in the display. The “xxx” text identifies the failed module (for example, F8L).

EQUIPMENT MISMATCH: with 2nd line detail

- *Latched target message:* No.
- *Description of problem:* The number or type of installed hardware modules does not match the order code stored in the L30.
- *How often the test is performed:* On power up. Afterwards, the backplane is checked for missing cards every five seconds.
- *What to do:* Check all modules against the order code, ensure they are inserted properly, and cycle control power. If a module has intentionally been added or removed, refresh the order code under **Device Setup**. If the problem persists, contact the factory.

FLEXLOGIC ERROR: with 2nd line detail

- *Latched target message:* No.
- *Description of problem:* A FlexLogic equation is incorrect.
- *How often the test is performed:* The test is event driven, performed whenever FlexLogic equations are modified.
- *What to do:* Finish all equation editing and use self tests to debug any errors.

UNIT NOT PROGRAMMED: Check Settings

- *Latched target message:* No.
- *Description of problem:* The **PRODUCT SETUP** ⇒ **INSTALLATION** ⇒ **RELAY SETTINGS** setting indicates the L30 is not programmed.
- *How often the test is performed:* On power up and whenever the **PRODUCT SETUP** ⇒ **INSTALLATION** ⇒ **RELAY SETTINGS** setting is altered.
- *What to do:* Program all settings and then set **PRODUCT SETUP** ⇒ **INSTALLATION** ⇒ **RELAY SETTINGS** to “Programmed.”

DIAGNOSTIC FAILURE___: Self Test Error

- *Latched target message:* No.
- *Description of problem:* Internal recovery failure detected.
- *How often the test is performed:* Upon recovery.
- *What to do:* Extract a Service Report through UR Setup software. Contact technical support and supply details of the failure code on the display.

SYSTEM FAILURE___: with 2nd line detail

- *Latched target message:* Yes.
- *Description of problem:* Relay system failure detected.
- *How often the test is performed:* Continuous.
- *What to do:* Extract a Service Report through UR Setup software. Contact technical support and supply details of the failure code on the display.

7.2.2.3 Minor self-test error messages

Most of the minor self-test errors can be disabled. See the settings in the User-programmable Self-tests section in chapter 5.

DIAGNOSTIC ALARM: with 2nd line detail

- *Latched target message:* Yes.
- *Description of problem:* Transient communication failure detected.
- *How often the test is performed:* Module dependent.
- *What to do:* Extract a Service Report through UR Setup software. Contact technical support and supply details of the failure code on the display.

MAINTENANCE ALERT: Replace Battery

- *Latched target message:* Yes.
- *Description of problem:* The battery is weak or not functioning. It powers the real time clock. This message displays as Battery Fail in the event records. When the battery weakness reaches a critical level, the message displays persistently on the front panel and no front panel key navigation is possible.
- *How often the test is performed:* The battery is monitored every five seconds. The error message displays after 60 seconds if the problem persists.
- *What to do:* Replace the battery as outlined in the Maintenance chapter.

MAINTENANCE ALERT: Direct I/O Ring Break

- *Latched target message:* No.
- *Description of problem:* Direct input and output settings are configured for a ring, but the connection is not in a ring.
- *How often the test is performed:* Every second.
- *What to do:* Check direct input and output configuration and wiring.

MAINTENANCE ALERT: Bad IRIG-B Signal

- *Latched target message:* No.
- *Description of problem:* A bad IRIG-B input signal has been detected.
- *How often the test is performed:* Monitored whenever an IRIG-B signal is received.
- *What to do:* Ensure the following:
 - The IRIG-B cable is properly connected.
 - Proper cable functionality (that is, check for physical damage or perform a continuity test).
 - The IRIG-B receiver is functioning.
 - Check the input signal level (it can be less than specification).

If none of these apply, then contact the factory.

**MAINTENANCE ALERT:
Bad PTP Signal**

- *Latched target message:* No.
- *Description of problem:* No PTP enabled port has good PTP signal input.
- *How often the test is performed:* Activated when no acceptable signal is being received.
- *What to do:* Ensure the following:
 - The Ethernet cable(s) are properly connected.
 - At least one PTP grandmaster-capable clock is functioning.
 - If strict PP is enabled, that entire network is PP compliant.
 - The network is delivering PTP messages to the relay.

**MAINTENANCE ALERT:
SNTP Failure**

- *Latched target message:* No.
- *Description of problem:* The SNTP server is not responding.
- *How often the test is performed:* Every 10 to 60 seconds.
- *What to do:* Check that Ethernet cable(s) are properly connected. Check that configuration for the SNTP server corresponds to the actual server settings. Check connectivity to the server (ping the server IP address).

**MAINTENANCE ALERT:
4L Discrepancy**

- *Latched target message:* No.
- *Description of problem:* A discrepancy has been detected between the actual and desired state of a latching contact output of an installed type "4L" module.
- *How often the test is performed:* Upon initiation of a contact output state change.
- *What to do:* Verify the state of the output contact and contact the factory if the problem persists.

**MAINTENANCE ALERT:
GGIO Ind xxx oscill**

- *Latched target message:* No.
- *Description of problem:* A data item in a configurable GOOSE data set is oscillating.
- *How often the test is performed:* Upon scanning of each configurable GOOSE data set.
- *What to do:* The "xxx" text denotes the data item that has been detected as oscillating. Evaluate all logic pertaining to this item.

**MAINTENANCE ALERT:
Setting Changed**

- *Latched target message:* No.
- *Description of problem:* Any device settings were changed over any available interface.
- *How often the test is performed:* On any setting changes, when new settings were written to device.
- *What to do:* Verify that the setting change was legitimate and essential for proper functioning of the protection and control system.

**MAINTENANCE ALERT:
Front Panel Trouble**

- *Latched target message:* No.
- *Description of problem:* The graphical front panel is not communicating with the CPU module.

- *How often the test is performed:* Every five seconds.

What to do: Open the graphical front panel and check the connection between the CPU module and the front panel, then restart the relay in EnerVista under **Commands > Relay Maintenance > Reboot Relay** or by powering the relay off and on. If trouble persists, contact the factory.

**MAINTENANCE ALERT:
GFP Version Mismatch**

- *Latched target message:* No.
- *Description of problem:* The graphical front panel firmware revision is not synchronized with that of the CPU module in the relay.
- *How often the test is performed:* Whenever connection is established between the graphical front panel and the CPU module in the relay.
- *What to do:* Perform UR firmware upgrade with the graphical front panel connected to the CPU module in the relay. It can be done using any communication interface (Ethernet or USB). This synchronizes the graphical firmware revision with that of the relay. If trouble persists, contact the factory.

**DIRECT I/O FAILURE:
COMM Path Incomplete**

- *Latched target message:* No.
- *Description of problem:* A direct device is configured but not connected.
- *How often the test is performed:* Every second.
- *What to do:* Check direct input and output configuration and wiring.

**RxGOOSE FAIL:
Missing messages**

- *Latched target message:* No.
- *Description of problem:* One or more RxGOOSE messages are not being received.
- *How often the test is performed:* The self-test is activated when no message is received within the expected time interval, which is the time-to-live time in the previous message. This time can be from milliseconds to minutes.
- *What to do:* Check GOOSE setup.

AGGREGATOR ERROR:

- *Latched target message:* No.
- *Description of problem:* The second line of this self-test error indicates the problem with the PMU Aggregator.
- *How often the test is performed:* Each time a PMU's related settings is changed.
- *What to do:* Correct the problem indicated in the second line or contact the factory.

**TEMP MONITOR:
OVER TEMPERATURE**

- *Latched target message:* Yes.
- *Description of problem:* The ambient temperature is greater than the maximum operating temperature (+80°C).
- *How often the test is performed:* Every hour.
- *What to do:* Remove the L30 from service and install in a location that meets operating temperature standards.

**UNEXPECTED RESTART:
Press "RESET" key**

- *Latched target message:* Yes.

- *Description of problem:* Abnormal restart from modules being removed or inserted while the L30 is powered-up, when there is an abnormal DC supply, or as a result of internal relay failure.
- *How often the test is performed:* Event driven.
- *What to do:* Contact the factory.

FIRST ETHERNET FAIL

SECOND ETHERNET FAIL

THIRD ETHERNET FAIL

- *Latched target message:* Yes.
- *Description of problem:* A link loss detection on an Ethernet port. The link loss is due to unplugging the cable or the switch port being down.
- *How often the test is performed:*
- *What to do:* Check the connection.

WRONG TRANSCEIVER

- *Latched target message:* Yes.
- *Description of problem:* The type of SFP does not match the CPU type. The SFP is a silver device that plugs into the rear of the CPU module.
 T-type CPU = All ports support fiber SFPs only
 U-type CPU = Maintenance port needs RJ45 SFP and the other two ports fiber SFPs
 V-type CPU = All ports support RJ45 SFPs only
 The consequence of an incorrect SFP can range from damage to the L30 to no power information for the L30 on its web page (enter IP address in a web browser, then click the **SFP Transceiver Information** — only the type of SFP displays and not power data).
- *What to do:* A web page "SFP Transceiver Information" is provided. This page displays the type of the SFP in it. This data is to be used with the CPU type to know the cause of the problem.

SFP MODULE x FAIL

- *Latched target message:* No.
- *Description of problem:* A faulty small form-factor pluggable port (SFP) or unplugging of the SFP generates this self test message.
- *What to do:* The web page "SFP Transceiver Information" described in the previous section applies for this self test as well. The "SFP Module Fail" has higher priority and it suppresses the "Ethernet Fail" target message. The "SFP MODULE FAIL FUNCTION" setting enables/disables this self test. The target for this self test is priority-based, with the third one being the highest priority. For example, if all three SFP modules fail, then the third SFP target is activated. If the third SFP module failure resolves, then the second SFP target is activated.

AUTHENTICATION FAIL

- *Latched target message:* No.
- *Description of problem:* The number of failures threshold was exceeded.
- *What to do:* Wait for the lockout interval and try to authenticate again.

FIRMWARE LOCK

- *Message:* "Unauthorized firmware attempt"
- *Latched target message:* No.
- *Description of problem:* A firmware upgrade operation was attempted while the lock relay setting was enabled.
- *What to do:* Ask the Supervisor to unlock the relay and try again.

SETTING LOCK

- *Message:* "Unauthorized setting write"
- *Latched target message:* No.
- *Description of problem:* A setting write was attempted while the lock relay setting was enabled.
- *What to do:* Ask the Supervisor to unlock the settings and try again.

SERVER UNAVAILABLE

- *Message:* "An attempt to contact the Radius server has failed"
- *Latched target message:* No.
- *Description of problem:* The RADIUS authentication server is unavailable.
- *What to do:* Verify network connectivity and try again.

**DOS PARTITION ALARM:
SELF-TEST ERROR**

- *Description of problem:* There is a problem with the Compact Flash memory in the CPU module.
- *How often the test is performed:* On relay power-up and afterwards once every 24 hours.
- *What to do:* Contact the factory.

**PROTOTYPE FIRMWARE:
Self Test Error**

- *Description of problem:* Seen until the builds is tagged as being 'release candidate' or 'gold' builds.
- *What to do:* Update firmware to either of these builds.
-

7.2.2.4 HardFiber major self-test error messages

In addition to those provided by the standard UR-series devices, the UR devices implement HardFiber self-tests. These are listed here. Any abnormal diagnostic condition indicated by the LEDs or the critical failure relay also results in a self-test message, so troubleshooting is described here. For other relays, such as the B95^{Plus}, see that product's instruction manual.

EQUIPMENT MISMATCH

- *Description of problem:* The number or type of installed hardware modules does not match the order code stored in the CPU. The standard UR-series Equipment Mismatch self-test is extended to cover the possible presence of a Process Card.
- *Severity:* Protection is not available and all contact outputs and shared outputs are de-asserted.
- *What to do:* Check all modules against the order code. Ensure they are inserted properly, and cycle the control power. If a module has intentionally been added or removed use the Update Order Code command to notify the relay that the current module configuration is correct.

MODULE FAILURE

- *Description of problem:* UR-series device module hardware failure detected.
- *Severity:* Protection is not available and all contact outputs and shared outputs are de-asserted.
- *What to do:* Contact the factory and supply the failure code noted in the display. Text in the message identifies the failed module (for example, H81). If operated on a Process Card failure, the Module Fail self-test seals-in (latches) till the UR-series device is restarted.

PROCESS BUS FAILURE

- *Description of problem:* Mission critical data is not available via the process bus. An AC quantity is considered critical if both AC bank origins and the crosschecking settings are other than None. This self-test is also initiated by an AC input discrepancy being detected. See the description in the **Crosschecking** setting in the HardFiber manual for further information. In addition, this self-test can be initiated by user logic responding to loss of critical contact input/output or other data using the **Process Bus Failure Operand** user-programmable self-test setting. This setting is located in the **Settings > Product Setup > User-Programmable Self Test** menu.
- *Severity:* Protection is not available and all contact outputs and shared outputs are de-asserted.
- *What to do:* First rectify any Process Bus Trouble and Brick Trouble self-test errors. Check the actual value of the operand referenced by the Process Bus Failure Operand setting, and if "On," determine the cause and rectify.
If the problem persists with the foregoing all clear, the cause must be an AC input discrepancy, which is typically the result of problems in the input signals to the Bricks, or faults in the Brick input conditioning hardware. If the error was announced the first time significant signal was encountered, suspect the former cause and check the copper connections external to the Brick. Where multiple UR-series devices have self-test errors, look for common causes.
To further isolate AC input discrepancy errors, put the relay in test-isolated mode, then one by one, temporally change an AC bank Crosschecking setting to None, until the Process Bus Failure clears. Once the problem AC bank has been identified, the values from each of the two Bricks can be examined individually by temporarily mapping each to an AC bank with a single origin.

7.2.2.5 HardFiber minor self-test error messages**PROCESS BUS TROUBLE**

- *Description of problem:* Communications problems with one or more Bricks. The text of the message identifies the affected field units. This self-test is initiated by low received signal levels at either the Brick or Process Card end, and by the sustained failure to receive poll responses from the proper Brick.
- *Severity:* This self-test error does not directly inhibit protection. However, the affected Brick inputs/outputs may not be available to the UR device.
- *What to do:* Check the field unit actual values. An indication of equipment mismatch means that messages are being received from a Brick, but there is a discrepancy between the settings and the actual Brick serial number, order code, and/or core number. Check that the correct core on the correct Brick is patched through to the correct Process Card port, and that the field unit settings are correct. An indication of communications loss means that no messages are being received. Check that the patching is correct, and that the Brick has power. If that is not the problem, use a professional optical fiber connector cleaning kit to clean both sides of all optical fiber connections from the Process Card through to the affected Brick. If the problem continues after cleaning, consult the factory.

BRICK TROUBLE

- *Description of problem:* Brick internal self-testing has detected trouble internal to the Brick.
- *Severity:* This self-test error does not directly inhibit protection. However, some or all of the affected Brick inputs/outputs may not be available to the UR device.

- *What to do:* Check the Brick environment for over/under temperatures and the voltage of its power source. If the ambient temperature and supply voltage are within Brick specifications, consult the factory. Troubles resulting from a Brick output failing to respond to an output command can only be detected while the command is active, and so in this case the target is latched. A latched target can be unlatched by pressing the front panel reset key if the command has ended, however the output can still be non-functional.

L30 Line Current Differential System

Chapter 8: Application of settings

This chapter provides example(s) of use.

8.1 CT requirements

8.1.1 Introduction

In general, proper CT selection is required to provide both adequate fault sensitivity and prevention of operation on high-current external faults that can result from CT saturation. The use of high-quality CTs (such as class X) improves relay stability during transients and CT saturation and can increase relay sensitivity. A current differential scheme is highly dependent on adequate signals from the source CTs. Ideally, CTs selected for line current differential protection are based on the criteria described as follows, which presents the high-level CT requirements to avoid saturation and to provide undistorted CT secondary current.

Check the capability of the CTs, and the connected burden, as follows:

1. The CTs should be class TPX or TPY, or IEC class 5P20 or better. Use class TPZ only after discussion with both the manufacturer of the CT and GE Multilin.
2. The CT primary current rating should be somewhat higher than the maximum continuous load current, but not too high relative to the minimum fault current because the differential element minimum pickup setting is $0.2 \times$ CT rating for the phase differential and $0.1 \times$ CT rating for ground differential. Too high CT primary current rating limits sensitivity of the differential element for high-resistive faults.
3. As per the IEEE C37.110-2007 "Guide for the Application of Current Transformers Used for Protective Relaying Purposes," the CT must be capable of a secondary saturation voltage V_K to avoid AC saturation:

$$V_K > I_S \times Z_S \quad \text{Eq. 8-1}$$

where

I_S is maximum CT secondary fault current

Z_S is total secondary burden $Z_S = R_{CT} + 2 \times R_L + R_R$

4. As per the IEEE C37.110-2007 "Guide for the Application of Current Transformers Used for Protective Relaying Purposes," the CT must be capable of a secondary saturation voltage V_K to avoid DC saturation:

$$V_K > I_S \times \left(\frac{X}{R} + 1 \right) \times Z_S \quad \text{Eq. 8-2}$$

where

X/R is primary system reactance / resistance ratio

R_{CT} is CT secondary winding resistance

R_L is AC secondary wiring resistance (one-way)

R_R is relay burden at rated secondary current

- Practically, it is difficult to meet this criteria and avoid saturation completely. The L30 provides several means to ensure security during an external fault, including dual-slope restraint characteristics, adaptive restraint, and CT saturation mechanism, allowing the relay to be secure during severe external faults, while maintaining excellent performance for internal faults. Therefore, knee point voltage requirements with a default 87L settings can be approximately estimated by the following equation:

$$V_K > K_{tf} \times I_S \times Z_S \tag{Eq. 8-3}$$

where

K_{tf} is 2 for system $X/R > 20$ and K_{tf} is 1.5 for system $X/R \leq 20$

This is however applicable, where CT ratios are the same, CT burdens at both sides of the line are very close, and when just one CT at each side is used. When CTs are different at both sides (different CT characteristics, CT ratio and burden) or when more than one CT at each side is used, these equation may not provide correct estimation of the required knee point voltage.

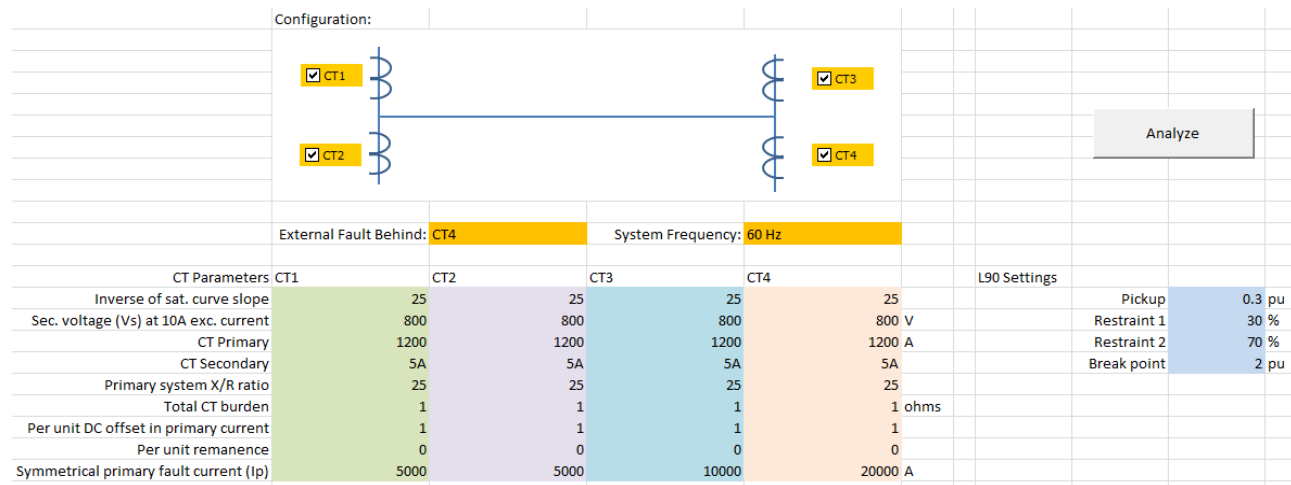
For this situation GE provides a CT saturation analysis tool, described in the following section.

8.1.2 CT saturation analysis tool

The CT saturation analysis tool is an Excel spreadsheet provided for users to analyze the L30 reliability during CT saturation caused by an external fault, to investigate the effect of adjusting 87L settings, and to examine the possibility of reducing the CT requirement.

The tool utilizes the CT model and CT saturation calculation algorithm proposed by the IEEE Power System Relaying Committee (PSRC), and it simulates the analog/digital signal processing and data calculations in the L30. The figure shows the interface.

Figure 8-1: CT saturation analysis tool main page



For a system where the CTs are already installed, the CT and system parameters are known. Use the procedure described in the tool to analyze the L30 security during CT saturation and investigate the effect of adjusting 87L settings.

The CT saturation analysis tool allows you to check the application, knowing CT parameters, fault current levels, and distribution through all breakers from short circuit studies, and to analyze L30 performance, having an ability to adjust settings as needed. The tool has all instructions to perform analysis.

Once all data is entered, by clicking the **Analyze** button, you can observe differential and restraint currents through the simulated fault in the **Results** tab, shown as follows. The application is considered secure when the worst through the plot $I_{restr}/I_{diff} > 1.25$ with selected settings and all fault scenarios considered.

Figure 8-2: Tool results for currents

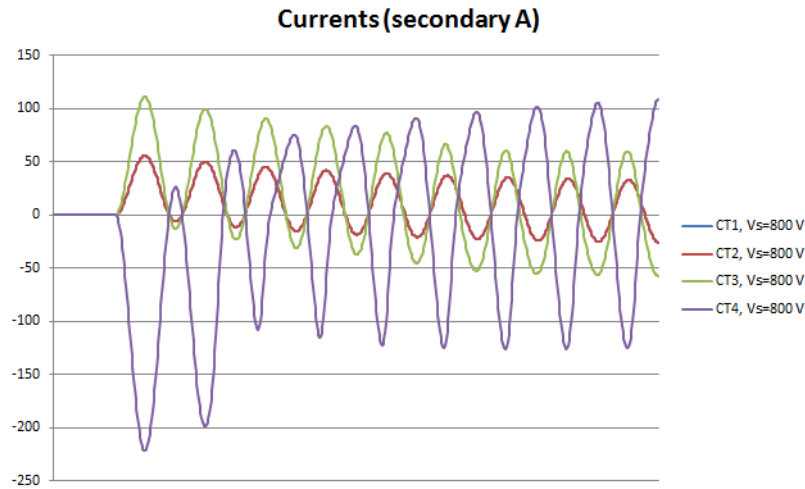
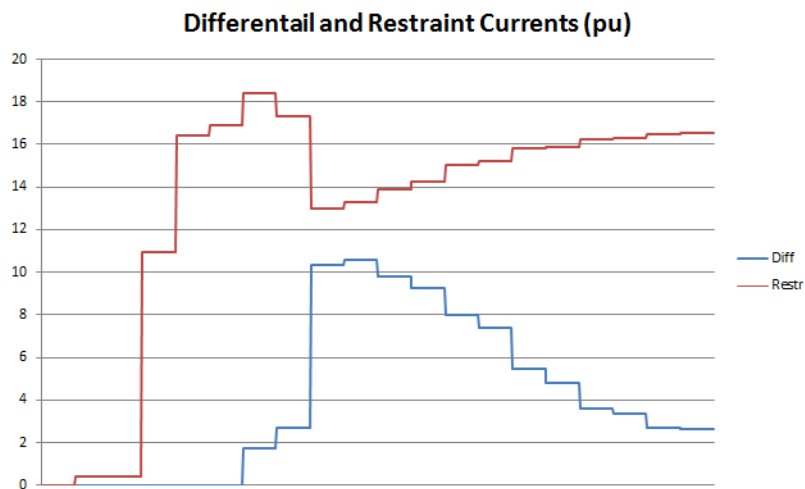


Figure 8-3: Tool results for differential and restraint currents



You are encouraged to test different fault locations and different fault levels and distributions per short circuit studies. Alternatively, the tool can help to estimate required CT parameters (ratio and knee point voltage), based on some pre-determined criteria.

8.2 Current differential (87L) settings

8.2.1 Introduction

Software is available from the GE Digital Energy website that is helpful in selecting settings for the specific application. Checking the performance of selected element settings with respect to known power system fault parameters makes it relatively simple to choose the optimum settings for the application.

This software program is also useful for establishing test parameters. It is strongly recommended this program be downloaded. Look for the "L90 Test Tool" on the GE Grid Solutions website, for example in the L90 support documents at <http://www.gegridsolutions.com/support/l90.htm>

The differential characteristic is defined by four settings: **CURRENT DIFF PICKUP**, **CURRENT DIFF RESTRAINT 1**, **CURRENT DIFF RESTRAINT 2**, and **CURRENT DIFF BREAK PT** (breakpoint). As is typical for current-based differential elements, the settings are a trade-off between operation on internal faults against restraint during external faults.

8.2.2 Current differential pickup

This setting establishes the sensitivity of the element to high impedance faults, and it is therefore good to choose a low level, but this can cause maloperation for an external fault causing CT saturation. The selection of this setting is influenced by the decision to use charging current compensation. If charging current compensation is Enabled, set pickup to a minimum of 150% of the steady-state line charging current, to a lower limit of 10% of CT rating. If charging current compensation is Disabled, set pickup to a minimum of 250% of the steady-state line charging current to a lower limit of 10% of CT rating.

If the CT at one terminal can saturate while the CTs at other terminals do not, increase this setting by approximately 20 to 50% (depending on how heavily saturated the one CT is while the other CTs are not saturated) of CT rating to prevent operation on a close-in external fault.

8.2.3 Current differential restraint 1

The **CURRENT DIFF RESTRAINT 1** setting controls the element characteristic when current is below the breakpoint, where CT errors and saturation effects are not expected to be significant. The setting is used to provide sensitivity to high impedance internal faults, or when system configuration limits the fault current to low values. A setting of 10 to 20% is appropriate in most cases, but increase this to 30% if the CTs can perform quite differently during faults.

8.2.4 Current differential restraint 2

The **CURRENT DIFF RESTRAINT 2** setting controls the element characteristic when current is above the breakpoint, where CT errors and saturation effects are expected to be significant. The setting is used to provide security against high current external faults. A setting of 30 to 40% is appropriate in most cases, but increase this to 70% if the CTs can perform quite differently during faults.



Assigning the same value to the **CURRENT DIFF RESTRAINT 1(2)** settings reverts dual slope bias characteristics into single slope bias characteristics.

NOTE

8.2.5 Current differential break point

The **CURRENT DIFF BREAK PT** setting controls the threshold where the relay changes from using the restraint 1 to the restraint 2 characteristics. Two approaches can be considered, as follows:

- Program the setting to 150 to 200% of the maximum emergency load current on the line, on the assumption that a maintained current above this level is a fault
- Program the setting below the current level where CT saturation and spurious transient differential currents can be expected

The first approach gives comparatively more security and less sensitivity; the second approach provides less security for more sensitivity.

8.2.6 CT tap

If the CT ratios at the line terminals are different, the **CURRENT DIFF CT TAP 1(2)** setting must be used to correct the ratios to a common base. In this case, modify the **CURRENT DIFF BREAK PT** and **CURRENT DIFF PICKUP** settings because the local current phasor is used as a reference to determine which differential equation is used, based on the value of local and

remote currents. If the setting is not modified, the responses of individual relays, especially during an external fault, can be asymmetrical, as one relay can be below the breakpoint and the other above the breakpoint. There are two methods to overcome this potential problem, as follows:

1. Set **CURRENT DIFF RESTRAINT 1** and **CURRENT DIFF RESTRAINT 2** to the same value (for example, 40% or 50%). This converts the relay characteristics from dual slope into single slope and the breakpoint becomes immaterial. Next, adjust differential pickup at all terminals according to CT ratios, referencing the required pickup to the line primary current (see below).
2. Set the breakpoints in each relay individually in accordance with the local CT ratio and the CT TAP setting. Next, adjust the differential pickup setting according to the terminal CT ratios. The slope value must be identical at all terminals.

Consider a two-terminal configuration with the following CT ratios for relays 1 and 2.

$$\begin{aligned}CT_{\text{ratio}}(\text{relay 1}) &= 1000/5 \\CT_{\text{ratio}}(\text{relay 2}) &= 2000/5\end{aligned}\quad \text{Eq. 8-4}$$

Consequently, we have the following CT tap value for relays 1 and 2.

$$\begin{aligned}CT_{\text{tap}}(\text{relay 1}) &= 2.0 \\CT_{\text{tap}}(\text{relay 2}) &= 0.5\end{aligned}\quad \text{Eq. 8-5}$$

To achieve maximum differential sensitivity, the minimum pickup is set as 0.2 pu at the terminal with the higher CT primary current; in this case 2000:5 for relay 2. The other terminal pickup is adjusted accordingly. The pickup values are set as follows:

$$\begin{aligned}\text{Pickup}(\text{relay 1}) &= 0.4 \\ \text{Pickup}(\text{relay 2}) &= 0.2\end{aligned}\quad \text{Eq. 8-6}$$

Choosing relay 1 as a reference with a breakpoint of 5.0, the breakpoint at relay 2 is chosen as follows:

$$\begin{aligned}\text{Breakpoint}(\text{relay 2}) &= \text{Breakpoint}(\text{relay 1}) \times \frac{CT_{\text{ratio}}(\text{relay 1})}{CT_{\text{ratio}}(\text{relay 2})} \\ &= 5.0 \times \frac{1000/5}{2000/5} = 2.5\end{aligned}\quad \text{Eq. 8-7}$$

Use the following equality to verify the calculated breakpoint:

$$\text{Breakpoint}(\text{relay 1}) \times CT_{\text{ratio}}(\text{relay 1}) = \text{Breakpoint}(\text{relay 2}) \times CT_{\text{ratio}}(\text{relay 2})\quad \text{Eq. 8-8}$$

Therefore, we have a breakpoint of 5.0 for relay 1 and 2.5 for relay 2.

Now, consider a three-terminal configuration with the following CT ratios for relays 1, 2, and 3.

$$\begin{aligned}CT_{\text{ratio}}(\text{relay 1}) &= 1000/5 \\CT_{\text{ratio}}(\text{relay 2}) &= 2000/5 \\CT_{\text{ratio}}(\text{relay 3}) &= 500/5\end{aligned}\quad \text{Eq. 8-9}$$

Consequently, we have the following CT tap value for relays 1, 2, and 3.

$$\begin{aligned}CT_{\text{tap1}}(\text{relay 1}) &= 2.00 & CT_{\text{tap2}}(\text{relay 1}) &= 0.50 \\CT_{\text{tap1}}(\text{relay 2}) &= 0.50 & CT_{\text{tap2}}(\text{relay 2}) &= 0.25 \\CT_{\text{tap1}}(\text{relay 3}) &= 2.00 & CT_{\text{tap2}}(\text{relay 3}) &= 4.00\end{aligned}\quad \text{Eq. 8-10}$$

In this case, the relay channels communicate as follows:

- For relay 1, channel 1 communicates to relay 2 and channel 2 communicates to relay 3
- For relay 2, channel 1 communicates to relay 1 and channel 2 communicates to relay 3

- For relay 3, channel 1 communicates to relay 1 and channel 2 communicates to relay 2

Consequently, to achieve the maximum sensitivity of 0.2 pu at the terminal with a CT ratio of 2000/5 (400 amps line primary differential current), the following pickup values are chosen:

$$\begin{aligned}\text{Pickup}(\text{relay 1}) &= 0.4 \\ \text{Pickup}(\text{relay 2}) &= 0.2 \\ \text{Pickup}(\text{relay 3}) &= 0.8\end{aligned}\quad \text{Eq. 8-11}$$

Choosing relay 1 as a reference with a breakpoint value of 5.0 pu, breakpoints for relays 2 and 3 are calculated as follows:

$$\begin{aligned}\text{Breakpoint}(\text{relay 2}) &= \text{Breakpoint}(\text{relay 1}) \times \frac{\text{CT}_{\text{ratio}}(\text{relay 1})}{\text{CT}_{\text{ratio}}(\text{relay 2})} \\ &= 5.0 \times \frac{1000/5}{2000/5} = 2.5\end{aligned}\quad \text{Eq. 8-12}$$

$$\begin{aligned}\text{Breakpoint}(\text{relay 3}) &= \text{Breakpoint}(\text{relay 1}) \times \frac{\text{CT}_{\text{ratio}}(\text{relay 1})}{\text{CT}_{\text{ratio}}(\text{relay 3})} \\ &= 5.0 \times \frac{1000/5}{500/5} = 10.0\end{aligned}\quad \text{Eq. 8-13}$$

To verify the calculated values, we have:

$$\begin{aligned}\text{Breakpoint}(\text{relay 1}) \times \text{CT}_{\text{ratio}}(\text{relay 1}) &= 5.0 \times 1000/5 = 1000 \\ \text{Breakpoint}(\text{relay 2}) \times \text{CT}_{\text{ratio}}(\text{relay 2}) &= 2.5 \times 2000/5 = 1000 \\ \text{Breakpoint}(\text{relay 3}) \times \text{CT}_{\text{ratio}}(\text{relay 3}) &= 10.0 \times 5000/5 = 1000\end{aligned}\quad \text{Eq. 8-14}$$

This satisfies the equality condition indicated earlier.

During on-load tests, the differential current at all terminals should be the same and generally equal to the charging current if the tap and CT ratio settings are chosen correctly.

8.3 Channel asymmetry compensation using GPS

8.3.1 Introduction

As indicated in the Settings chapter, the L30 provides three basic methods of applying channel asymmetry compensation using GPS. Channel asymmetry can also be monitored with actual values and an indication signalled (FlexLogic operands **87L DIFF 1(2) MAX ASYM** asserted) if channel asymmetry exceeds preset values. Depending on the implemented relaying philosophy, the relay can be programmed to perform the following on the loss of the GPS signal:

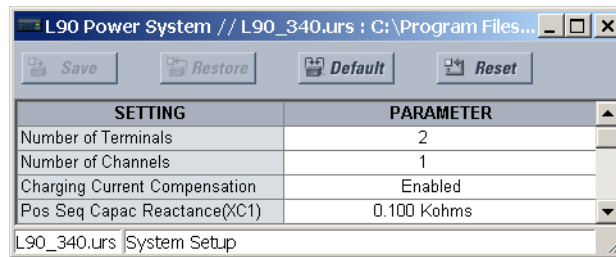
- Enable GPS compensation on the loss of the GPS signal at any terminal and continue to operate the 87L element (using the memorized value of the last asymmetry) until a change in the channel round-trip delay is detected.
- Enable GPS compensation on the loss of the GPS signal at any terminal and block the 87L element after a specified time.
- Continuously operate the 87L element but only enable GPS compensation when valid GPS signals are available. This provides less sensitive protection on the loss of the GPS signal at any terminal and runs with higher pickup and restraint settings.

8.3.2 Compensation method 1

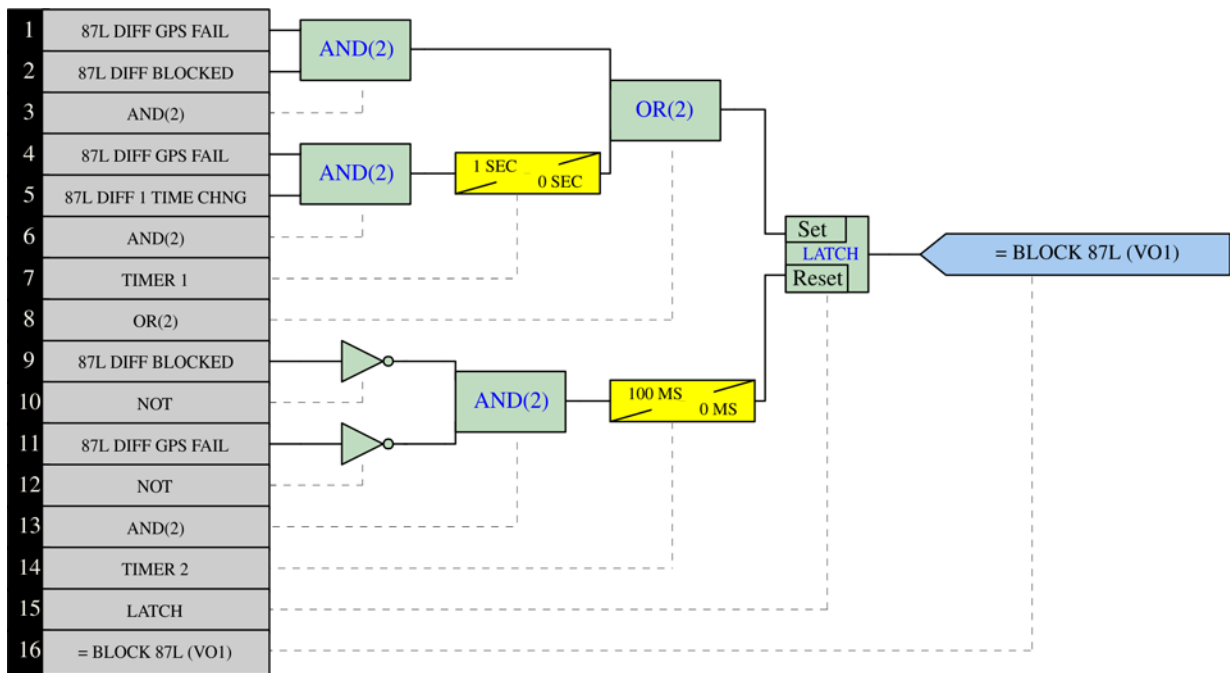
Enable GPS compensation on the loss of the GPS signal at any terminal and continue to operate the 87L element until a change in the channel round-trip delay is detected.

If GPS is enabled at all terminals and the GPS signal is present, the L30 compensates for the channel asymmetry. On the loss of the GPS signal, the L30 stores the last measured value of the channel asymmetry per channel and compensates for the asymmetry until the GPS clock is available. However, if the channel was switched to another physical path during GPS loss conditions, the 87L element must be blocked, since the channel asymmetry cannot be measured and system is no longer accurately synchronized. The value of the step change in the channel is preset in the L30 **POWER SYSTEM** settings menu and signaled by the **87L DIFF 1(2) TIME CHNG** FlexLogic operand. To implement this method, use the following steps:

1. Enable channel asymmetry compensation (**CHNL ASYM COMP**) by setting it to ON. Assign the GPS receiver failsafe alarm contact with the **BLOCK GPS TIME REF** setting.



2. Create FlexLogic similar to that shown as follows to block the 87L element on GPS loss if step change in the channel delay occurs during GPS loss conditions or on a startup before the GPS signal is valid. For three-terminal systems, the **87L DIFF 1 TIME CHNG** operand must be ORed with the **87L DIFF 2 TIME CHNG** FlexLogic operand. The Block 87L (VO1) output is reset if the GPS signal is restored and the 87L element is ready to operate.



831777A1.CDR

3. Assign virtual output BLOCK 87L (VO1) to the 87L Current Differential Block setting (**SETTINGS** ⇒ **GROUPED ELEMENTS** ⇒ **SETTING GROUP** ⇒ **LINE DIFFERENTIAL...** ⇒ **CURRENT DIFFERENTIAL** ⇒ **CURRENT DIFF BLOCK**). It can be used to enable backup protection, raise an alarm, and perform other functions as per the given protection philosophy.

8.3.3 Compensation method 2

Enable GPS compensation on the loss of the GPS signal at any terminal and block the 87L element after a specified time.

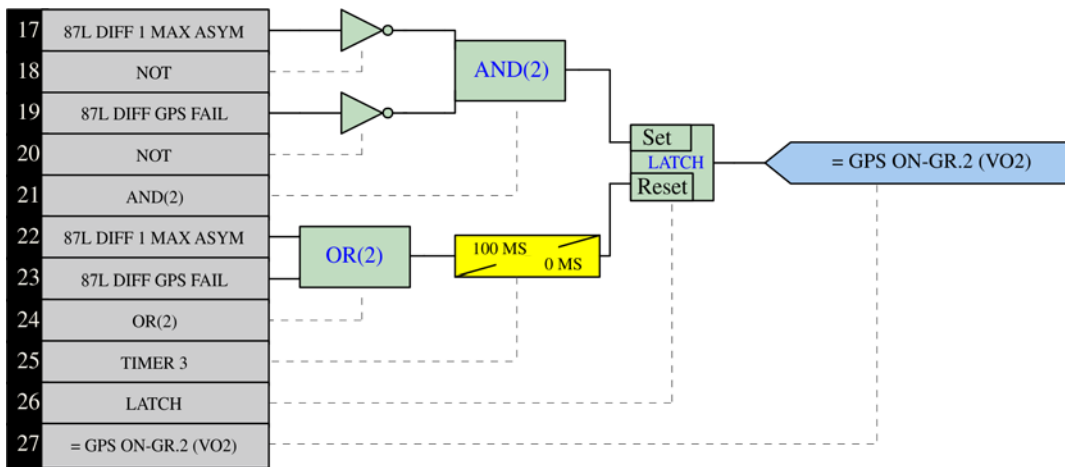
This is a simple and conservative way of using the GPS feature. Follow steps 1 and 3 in compensation method 1. The FlexLogic is simple: 87L DIFF GPS FAIL-Timer-Virtual Output Block 87L (VO1). It is recommended that the timer be set no higher than 10 seconds.

8.3.4 Compensation method 3

Continuously operate the 87L element but enable GPS compensation only when valid GPS signals are available. This provides less sensitive protection on GPS signal loss at any terminal and runs with higher pickup and restraint settings.

This approach can be used carefully if maximum channel asymmetry is known and does not exceed certain values (2.0 to 2.5 ms). The **87L DIFF MAX ASYM** operand can be used to monitor and signal maximum channel asymmetry. Essentially, the L30 switches to another setting group with higher pickup and restraint settings, sacrificing sensitivity to keep the 87L function operational.

1. Create FlexLogic similar to that shown as follows to switch the 87L element to Settings Group 2 (with most sensitive settings) if the L30 has a valid GPS time reference. If a GPS or 87L communications failure occurs, the L30 switches back to Settings Group 1 with less sensitive settings.



831778A1.CDR

2. Set the 87L element with different differential settings for Settings Groups 1 and 2 shown as follows.

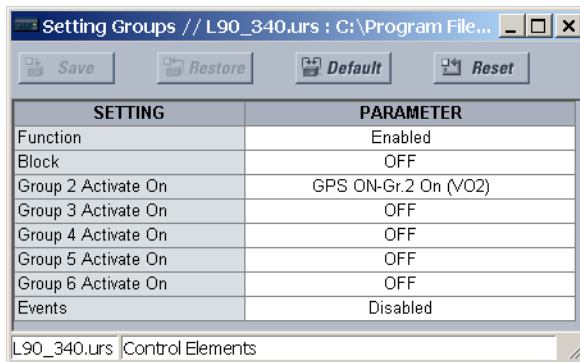
SETTING	PARAMETER
Function	Enabled
Signal Source	SRC 1 (SRC 1)
Block	OFF
Pickup	0.50 pu
CT Tap 1	1.00
Restraint 1	40 %
Restraint 2	70 %
Breakpoint	1.0 pu
DTT	Enabled
Key DTT	OFF
Target	Latched
Events	Disabled

L90_340.urs | Grouped Elements: Group 1: Line Differential Elements

SETTING	PARAMETER
Function	Enabled
Signal Source	SRC 1 (SRC 1)
Block	OFF
Pickup	0.20 pu
CT Tap 1	1.00
Restraint 1	20 %
Restraint 2	40 %
Breakpoint	1.0 pu
DTT	Enabled
Key DTT	OFF
Target	Latched
Events	Disabled

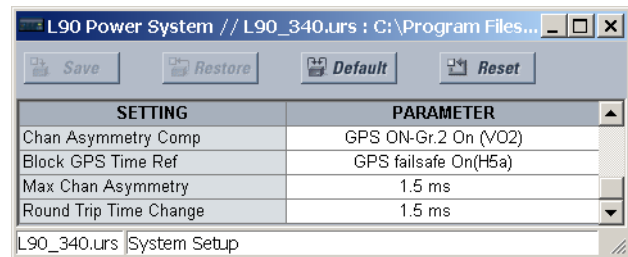
L90_340.urs | Grouped Elements: Group 2: Line Differential Elements

3. Enable GPS compensation when the GPS signal is valid and switch to Settings Group 2 (with more sensitive settings), shown as follows.



SETTING	PARAMETER
Function	Enabled
Block	OFF
Group 2 Activate On	GPS ON-Gr.2 On (VO2)
Group 3 Activate On	OFF
Group 4 Activate On	OFF
Group 5 Activate On	OFF
Group 6 Activate On	OFF
Events	Disabled

L90_340.urs | Control Elements



SETTING	PARAMETER
Chan Asymmetry Comp	GPS ON-Gr.2 On (VO2)
Block GPS Time Ref	GPS failsafe On(H5a)
Max Chan Asymmetry	1.5 ms
Round Trip Time Change	1.5 ms

L90_340.urs | System Setup

8.4 Instantaneous elements

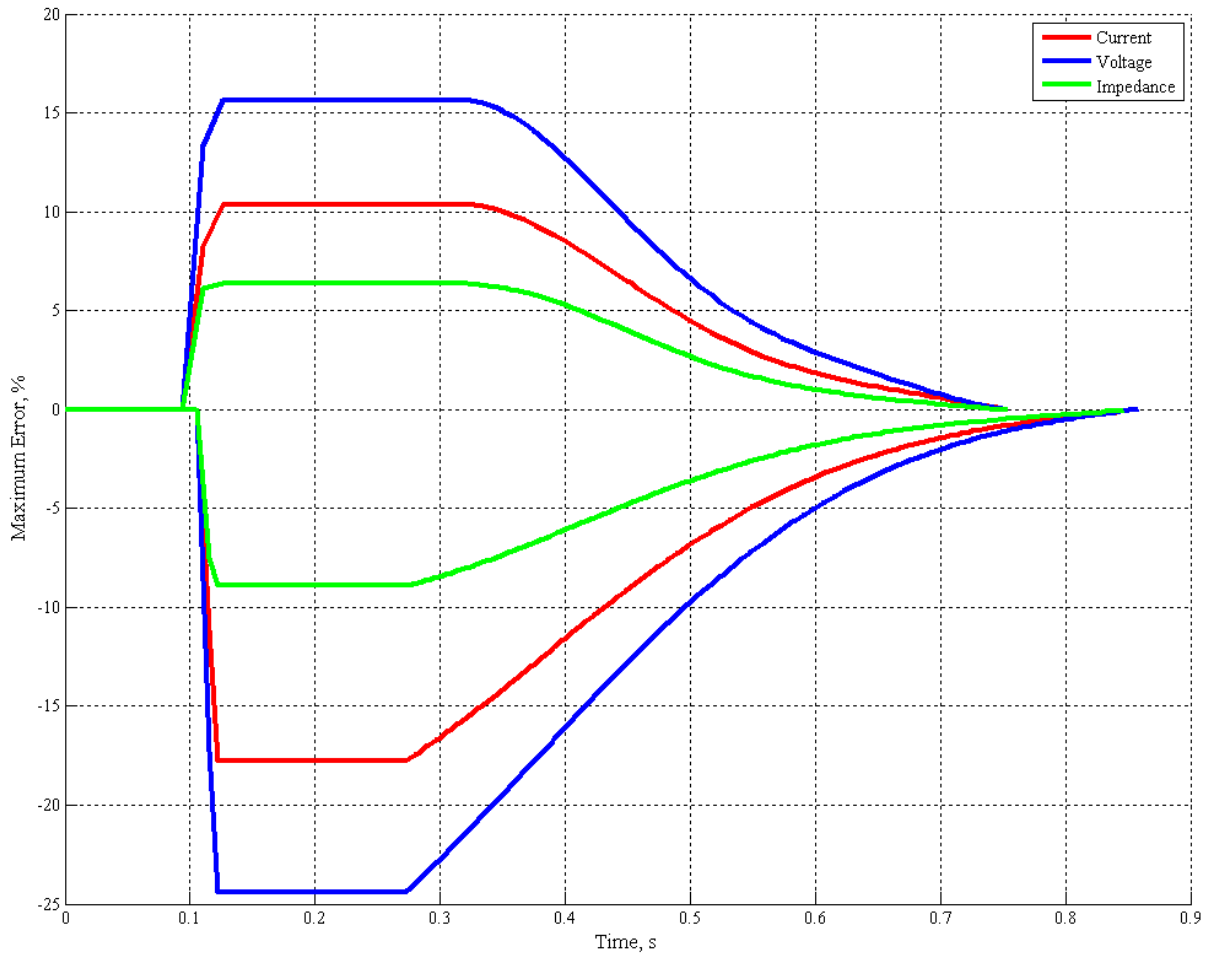
8.4.1 Instantaneous element error during L30 synchronization

Two or three L30 relays are synchronized to each other and to system frequency to provide line current differential protection and accurate measurements for other protection and control elements. When an L30 system starts up, the relays adjust their tracking frequency aggressively to bring all relays into synchronization within the system quickly. The tracking frequency can differ from the nominal (or system frequency) by a few hertz, especially during the first second of synchronization, with one relay having tracking frequency above system frequency and another below system frequency. The same re-synchronization process happens if a channel fails for a long time, leading to phase and frequency lock loop (PFLL) failure and then the channel is restored and relays are re-synchronized to each other again.

The 87L element is blocked during synchronization; therefore, the difference between system frequency and relay sampling frequency does not affect 87L element itself. However, instantaneous protection elements can experience additional error caused by the difference between signal frequency and tracking frequency.

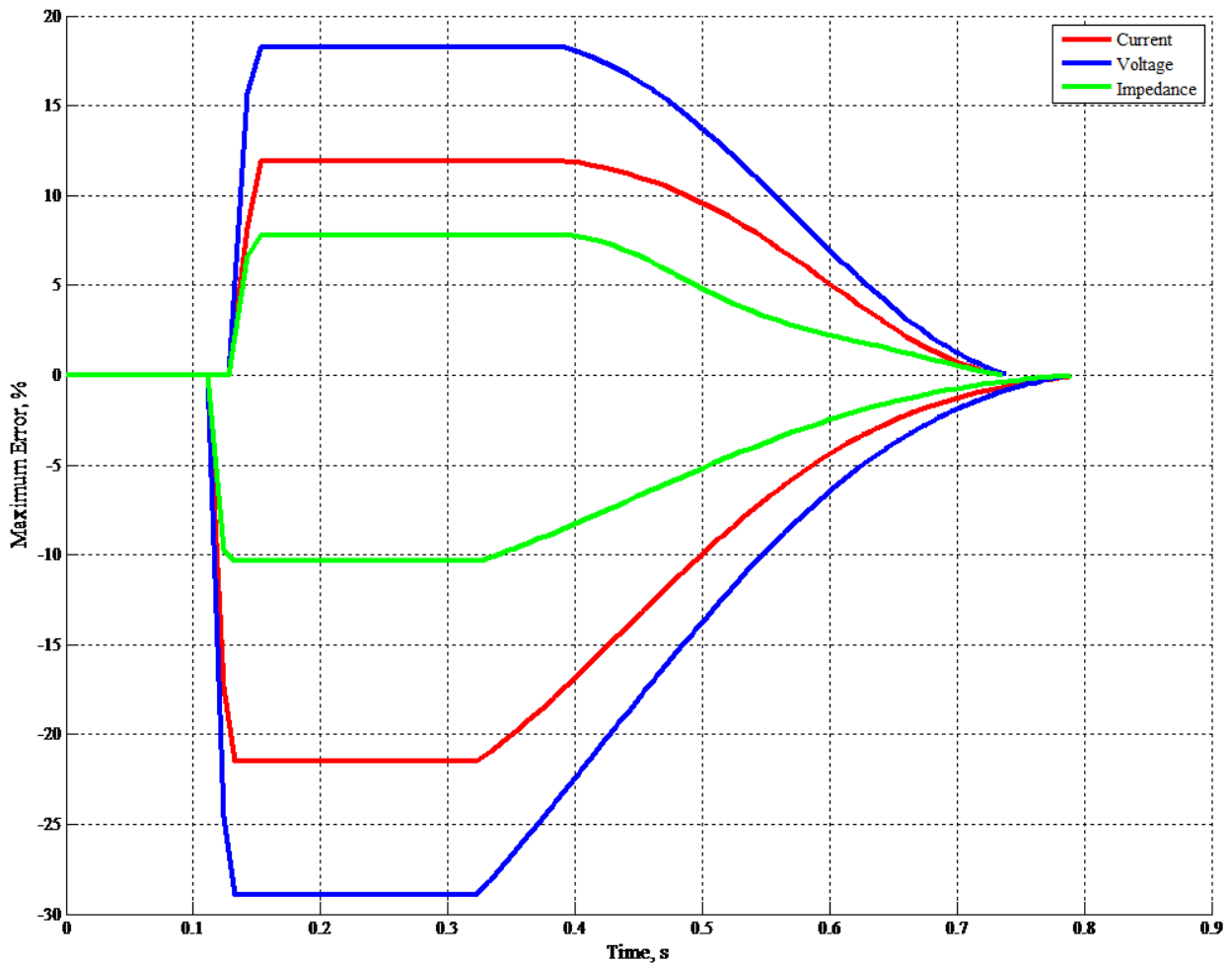
The following curves demonstrate the maximum error with tracking frequency both above and below system frequency. At time $t=0$ s, the channel is restored and in approximately 100 ms required to check channel reliability and to receive valid timestamps, while the re-synchronization process starts. As can be observed, instantaneous current, voltage, and impedance elements experience accuracy error, especially during first 100 to 330 ms during the re-synchronization process after either system start up or recovering from the communications failure. Because relay tracking frequency can be above or below system frequency randomly, consider the worst error depending on the element type. For example, for overvoltage or overcurrent, the worst case happens when error causes the measured quantity to appear above system value (positive error), which occurs when relay tracking frequency is below system frequency. For undervoltage or impedance, the worst case happens when error causes the measured quantity to appear below system value (negative error), which occurs when relay tracking frequency is above system frequency.

Figure 8-4: Maximum error for 60 Hz system



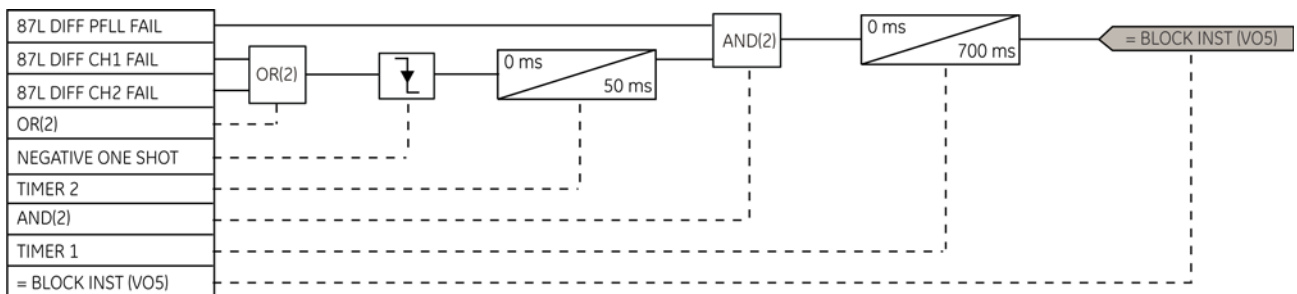
Not all instantaneous elements have to be blocked during the re-synchronization process. For example, the impedance element maximum error is 8.86% at 60 Hz. With a typical margin of 15 percent, this is still well below impedance reach point. Another example is Phase IOC; typically, these elements have very sufficient margin for the overload conditions and are set high enough above these conditions. But voltage-based elements can be set quite close to the system nominal voltage or operating voltage and can require attention.

Figure 8-5: Maximum error for 50 Hz system



To secure instantaneous element operation, it is recommended to use either FlexLogic as shown next to block the instantaneous elements during synchronization, or to use a different setting group with more conservative pickup for this brief interval. A 700 ms drop-off timer in the logic is shown as an example to guarantee error below 3 percent, but delay can be realistically even shorter, if the setting security margin allows this.

Figure 8-6: FlexLogic to block instantaneous element during 87L startup



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The elements must be treated selectively. If, for example, the phase over or under voltage setting includes margin or time delay sufficient to accommodate the maximum additional error on re-synchronization, blocking or delay are not needed for these elements. Similarly, if the phase instantaneous overcurrent setting has sufficient margin, blocking is not needed. Note that significant zero-sequence and negative-sequence current or voltage error do not appear during L30 startup, therefore all sequence-based elements using these quantities are safe.

For the three-terminal line, the synchronization process is longer and block times need to be three times longer than two-terminal line block times.

L30 Line Current Differential System

Chapter 9: Commissioning

9.1 Testing

9.1.1 Channel testing

The communications system transmits and receives data between two or three terminals for the 87L function. The system is designed to work with multiple channel options, including direct and multiplexed optical fiber, G.703, and RS422. The speed is 64 Kbaud in a transparent synchronous mode with automatic synchronous character detection and CRC insertion.

The Local Loopback Channel Test verifies the L30 communication modules are working properly. The Remote Loopback Channel Test verifies the communication link between the relays meets requirements (BER less than 10^{-4}). All tests are verified by using the internal channel monitoring and the monitoring in the Channel Tests. All of the tests presented in this section must be either OK or PASSED.

1. Verify that a type "W" module is placed in slot "W" in both relays (for example W7J).
2. Interconnect the two relays using the proper media (for example, single-mode fiber cable) observing correct connection of receiving (Rx) and transmitting (Tx) communications paths and turn power on to both relays.
3. Verify that the Order Code in both relays is correct.
4. Cycle power off/on in both relays.
5. Verify and record that both relays indicate In Service on the front display.
6. Make the following setting change in both relays: **GROUPED ELEMENTS** ⇒ **GROUP 1** ⇒ **CURRENT DIFFERENTIAL ELEMENTS** ⇒ **CURRENT DIFFERENTIAL** ⇒ **CURRENT DIFF FUNCTION**: "Enabled."
7. Verify and record that both relays have established communications with the following status checks:
ACTUAL VALUES ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **CHANNEL 1 STATUS**: "OK"
ACTUAL VALUES ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **CHANNEL 2 STATUS**: "OK" (If used)
8. Make the following setting change in both relays: **TESTING** ⇒ **TEST MODE**: "Enabled."
9. Make the following setting change in both relays:
TESTING ⇒ **CHANNEL TESTS** ⇒ **LOCAL LOOPBACK TEST** ⇒ **LOCAL LOOPBACK CHANNEL NUMBER**: "1"
10. Initiate the Local Loopback Channel Tests by making the following setting change:
TESTING ⇒ **CHANNEL TESTS** ⇒ **LOCAL LOOPBACK TEST** ⇒ **LOCAL LOOPBACK FUNCTION**: "Yes"

Expected result — In a few seconds “Yes” changes to “Local Loopback Test PASSED” and then to “No”, signifying the test was successfully completed and the communication modules operated properly.

- If Channel 2 is used, make the following setting change and repeat Step 10 for Channel 2 as performed for channel 1:

TESTING ⇒ **CHANNEL TESTS** ⇒ **LOCAL LOOPBACK TEST** ⇒ **LOCAL LOOPBACK CHANNEL NUMBER: "2"**

- Verify and record that the Local Loopback Test was performed properly with the following status check:

ACTUAL VALUES ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **CHANNEL 1(2) LOCAL LOOPBACK STATUS: "OK"**

- Make the following setting change in one of the relays:

TESTING ⇒ **CHANNEL TESTS** ⇒ **REMOTE LOOPBACK TEST** ⇒ **REMOTE LOOPBACK CHANNEL NUMBER: "1"**

- Initiate the Remote Loopback Channel Tests by making the following setting change:

TESTING ⇒ **CHANNEL TESTS** ⇒ **REMOTE LOOPBACK** ⇒ **REMOTE LOOPBACK FUNCTION: "Yes"**

Expected result — The “Running Remote Loopback Test” message appears; within 60 to 100 seconds, the “Remote Loopback Test PASSED” message appears for a few seconds and then changes to “No”, signifying that the test successfully completed and communications with the relay were successfully established. The “Remote Loopback Test FAILED” message indicates that either the communication link quality does not meet requirements (BER less than 10⁻⁴) or the channel is not established – check the communications link connections.

- If Channel 2 is used, make the following setting change and repeat Step 14 for Channel 2 as performed for Channel 1:

TESTING ⇒ **CHANNEL TESTS** ⇒ **REMOTE LOOPBACK TEST** ⇒ **REMOTE LOOPBACK CHANNEL NUMBER: "2"**

- Verify and record the Remote Loopback Test was performed properly with the following status check:

ACTUAL VALUES ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **CHANNEL 1(2) REMOTE LOOPBACK STATUS: "OK"**

- Verify and record that Remote Loopback Test fails during communications failures as follows: start test as per Steps 13 to 14 and in two to five seconds disconnect the fiber Rx cable on the corresponding channel.

Expected result — The “Running Remote Loopback Test” message appears. When the channel is momentarily cut off, the “Remote Loopback Test FAILED” message displays. The status check reads as follows: **ACTUAL VALUES** ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **CHANNEL 1(2) LOCAL LOOPBACK STATUS: "Fail"**

- Re-connect the fiber Rx cable. Repeat Steps 13 to 14 and verify that Remote Loopback Test performs properly again.
- Verify and record that Remote Loopback Test fails if communications are not connected properly by disconnecting the fiber Rx cable and repeating Steps 13 to 14.

Expected result — The **ACTUAL VALUES** ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **CHANNEL 1(2) REMOTE LOOPBACK TEST: "Fail"** message is constantly on the display.

- Repeat Steps 13 to 14 and verify that Remote Loopback Test is correct.

- Make the following setting change in both relays: **TESTING** ⇒ **TEST MODE: "Disabled"**



During channel tests, verify in the **ACTUAL VALUES** ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **CHANNEL 1(2) LOST PACKETS** display that the values are very low or even 0. If values are comparatively high, check the settings of communications equipment (if applicable).

9.1.2 Clock synchronization tests

The 87L clock synchronization is based upon a peer-to-peer architecture in which all relays are Masters. The relays are synchronized in a distributed fashion. The clocks are phase-synchronized to each other and frequency-synchronized to the power-system frequency. The performance requirement for the clock synchronization is a maximum error of ±130 μs.

All tests are verified by using PPLL status displays. All PPLL status displays must be either OK or Fail.

- Ensure that Steps 1 through 7 inclusive of the previous section are completed.
- Verify and record that both relays have established communications with the following checks after 60 to 120 seconds:

ACTUAL VALUES ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **CHANNEL 1(2) STATUS: "OK"**

ACTUAL VALUES ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **REMOTE LOOPBACK STATUS: "n/a"**

ACTUAL VALUES ⇒ **STATUS** ⇒ **CHANNEL TESTS** ⇒ **PPLL STATUS: "OK"**

3. Disconnect the fiber Channel 1(2) Tx cable for less than 66 ms (not possible with direct fiber module).
Expected result
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ CHANNEL 1(2) STATUS: "OK"
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ REMOTE LOOPBACK STATUS: "n/a"
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ PFL STATUS: "OK"
If fault conditions are applied to the relay during these tests, it trips with a specified 87L operation time.
4. Disconnect the fiber Channel 1(2) Tx cable for more than 66 ms but less than 5 seconds.
Expected result
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ CHANNEL 1(2) STATUS: "OK"
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ REMOTE LOOPBACK STATUS: "n/a"
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ PFL STATUS: "OK"
If fault conditions are applied to the relay (after the channel is brought back) during these tests, it trips with a specified 87L operation time plus 50 to 80 ms required for establishing PFL after such interruption.
5. Disconnect the fiber Channel 1(2) Tx cable for more than five seconds.
Expected result
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ CHANNEL 1(2) STATUS: "OK"
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ REMOTE LOOPBACK STATUS: "n/a"
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ PFL STATUS: "Fail"
6. Reconnect the fiber Channel 1(2) Tx cable and in six to eight seconds confirm that the relays have re-established communications again with the following status checks:
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ CHANNEL 1(2) STATUS: "OK"
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ REMOTE LOOPBACK STATUS: "n/a"
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ PFL STATUS: "OK"
7. Apply a current of 0.5 pu at a frequency 1 to 3% higher or lower than nominal only to local relay phase A to verify that frequency tracking does not affect PFL when only one relay has a current input and both relays track frequency. Wait 200 seconds and verify the following:
ACTUAL VALUES ⇒ STATUS ⇒ CHANNEL TESTS ⇒ PFL STATUS: "OK"
ACTUAL VALUES ⇒ METERING ⇒ TRACKING FREQUENCY ⇒ TRACKING FREQUENCY: actual frequency at both relays



For three-terminal configuration, carry out the test accordingly.

9.1.3 Current differential

The 87L element has adaptive restraint and dual slope characteristics. The pickup slope settings and the breakpoint settings determine the element characteristics. The relay displays both local and remote current magnitudes and angles and the differential current that helps with start-up activities. When a differential condition is detected, the output operands from the element are asserted along with energization of faceplate event indicators.

1. Ensure that relay will not issue any undesired signals to other equipment.
2. Ensure that relays are connected to the proper communication media, communications tests have been performed and the CHANNEL and PFL STATUS displays indicate OK.
3. Minimum pickup test with local current only:
 - 3.1. Ensure that all 87L setting are properly entered into the relay and connect a test set to the relay to inject current into Phase A.

- 3.2. Slowly increase the current until the relay operates and note the pickup value. The theoretical value of operating current below the breakpoint is given by the following formula, where P is the pickup setting and S_1 is the Slope 1 setting (in decimal format):

$$I_{op} = \sqrt{2 \times \frac{P^2}{1 - 2S_1^2}} \quad \text{Eq. 9-1}$$

- 3.3. Repeat the above test for different slope and pickup settings, if desired.
- 3.4. Repeat the above tests for Phases B and C.
4. Minimum pickup test with local current and simulated remote current (pure internal fault simulation):
- 4.1. Disconnect the local relay from the communications channel.
- 4.2. Loop back the transmit signal to the receive input on the back of the relay.
- 4.3. Wait until the CHANNEL and PFL status displays indicate OK.
- 4.4. Slowly increase the current until the relay operates and note the pickup value. The theoretical value of operating current below breakpoint is given by the following formula:

$$I_{op} = \sqrt{\frac{2P^2}{(1 + TAP)^2 - 2S_1^2(1 + TAP^2)}} \quad \text{Eq. 9-2}$$

where

TAP represents the CT Tap setting for the corresponding channel

- 4.5. Repeat the above test for different slope and pickup settings, if desired.
- 4.6. During the tests, observe the current phasor at **ACTUAL VALUES** ⇒ **METERING** ⇒ **87L DIFF CURRENT** ⇒ **LOCAL IA**. This phasor should also be seen at **ACTUAL VALUES** ⇒ **METERING** ⇒ **87L DIFF CURRENT** ⇒ **TERMINAL 1(2) IA** along with a phasor of twice the magnitude at **ACTUAL VALUES** ⇒ **METERING** ⇒ **87L DIFF CURRENT** ⇒ **IA DIFF**.
- 4.7. Repeat the above tests for Phases B and C.
- 4.8. Restore the communication circuits to normal.



Download the UR test software from the GE Grid Solutions website (<http://www.gegridsolutions.com/products/support/ur/l90test.zip>) or contact GE Grid Solutions for information about the UR current differential test program that allows the user to simulate different operating conditions for verifying correct responses of the relays during commissioning activities.

9.1.4 Local-remote relay tests

9.1.4.1 Direct transfer trip (DTT) tests

The direct transfer trip is a function by which one relay sends a signal to a remote relay to cause a trip of remote equipment. The local relay trip outputs closes upon receiving a direct transfer trip from the remote relay. The test procedure is as follows:

1. Ensure that relay will not issue any undesired signals to other equipment and all previous tests have been completed successfully.
2. Cycle power off/on in both relays.
3. Verify and record that both relays indicate In Service on the faceplate display.
4. Make the following setting change in the **SETTINGS** ⇒ **GROUPED ELEMENTS** ⇒ **LINE DIFFERENTIAL ELEMENT** ⇒ **CURRENT DIFFERENTIAL** menu of both relays:
CURRENT DIFF FUNCTION: "Enabled"
5. Verify and record that both relays have established communications by performing the following status check through the **ACTUAL VALUES** ⇒ **STATUS** ⇒ **CHANNEL TESTS** menu:
CHANNEL 1(2) STATUS: "OK"

6. At the remote relay, make the following changes in the **SETTINGS** ⇒ **GROUPED ELEMENTS** ⇒ **LINE DIFFERENTIAL ELEMENT** ⇒ **CURRENT DIFFERENTIAL** menu:
CURRENT DIFF DTT: "Enabled"
7. At the Local relay, make the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **CONTACT OUTPUT N1** menu:
CONTACT OUTPUT N1 OPERATE: "87L DIFF RECVD DTT"
8. At the Local relay, verify that **ACTUAL VALUES** ⇒ **STATUS** ⇒ **CONTACT OUTPUTS** ⇒ **Cont Op N1** is in the "Off" state.
9. Apply current to phase A of the remote relay and increase until 87L operates.
10. At the Local relay, observe **ACTUAL VALUES** ⇒ **STATUS** ⇒ **CONTACT OUTPUTS** ⇒ **Cont Op N1** is now in the "On" state.
11. Repeat steps 8 through 10 for phases A and B and observe Contact Outputs N2 and N3, respectively.
12. Repeat steps 8 through 11 with the Remote and Local relays inter-changed.
13. Make the following setting change in the **SETTINGS** ⇒ **GROUPED ELEMENTS** ⇒ **LINE DIFFERENTIAL ELEMENT** ⇒ **CURRENT DIFFERENTIAL** menu of both relays:
CURRENT DIFF FUNCTION: "Disabled"
14. At the Remote relay, set **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **CONTACT OUTPUT N1** ⇒ **CONTACT OUTPUT N1 OPERATE** to the **CURRENT DIFF KEY DTT** operand.
15. At the Local relay, observe under the **ACTUAL VALUES** ⇒ **STATUS** ⇒ **CONTACT OUTPUTS** menu that **CONTACT OUTPUT N1, N2, and N3** are "Off".
16. At the Remote relay, set **SETTINGS** ⇒ **TESTING** ⇒ **FORCE CONTACT INPUTS** ⇒ **FORCE Cont Ip N1** to "Closed".
17. At the Local relay, observe under **ACTUAL VALUES** ⇒ **STATUS** ⇒ **CONTACT OUTPUTS** that **CONTACT OUTPUT N1, N2, and N3** are now "On".
18. At both the Local and Remote relays, return all settings to normal.

9.1.4.2 Final tests

As proper operation of the relay is fundamentally dependent on the correct installation and wiring of the CTs, it must be confirmed that correct data is brought into the relays by an on-load test in which simultaneous measurements of current and voltage phasors are made at all line terminals. These phasors and differential currents can be monitored at the **ACTUAL VALUES** ⇒ **METERING** ⇒ **87L DIFFERENTIAL CURRENT** menu where all current magnitudes and angles can be observed and conclusions of proper relay interconnections can be made.

L30 Line Current Differential System

Chapter 10: Theory of operation

This chapter outlines advanced information on operation.

10.1 Overview

10.1.1 L30 design

All differential techniques rely on the fact that under normal conditions, the sum of the currents entering each phase of a transmission line from all connected terminals is equal to the charging current for that phase. Beyond the fundamental differential principle, the three most important technical considerations are data consolidation, restraint characteristic, and sampling synchronization. The L30 uses new and unique concepts in these areas.

Data consolidation refers to the extraction of appropriate parameters to be transmitted from raw samples of transmission line phase currents. By employing data consolidation, a balance is achieved between transient response and bandwidth requirements. Consolidation is possible along two dimensions: time and phases. Time consolidation consists of combining a time sequence of samples to reduce the required bandwidth. Phase consolidation consists of combining information from three phases and neutral. Although phase consolidation is possible, it is generally not employed in digital schemes, because you want to detect which phase is faulted. The L30 relay transmits data for all three phases.

Time consolidation reduces communications bandwidth requirements. It also improves security by eliminating the possibility of falsely interpreting a single corrupted data sample as a fault.

The L30 relay system uses a new consolidation technique called “phaselets.” Phaselets are partial sums of the terms involved in a complete phasor computation. The use of phaselets in the L30 design improves the transient response performance without increasing the bandwidth requirements.

Phaselets themselves are not the same as phasors, but they can be combined into phasors over any time window that is aligned with an integral number of phaselets (see the Phaselet Computation section in this chapter). The number of phaselets that must be transmitted per cycle per phase is the number of samples per cycle divided by the number of samples per phaselet. The L30 design uses 64 samples per cycle and 32 samples per phaselet, leading to a phaselet communication bandwidth requirement of two phaselets per cycle. Two phaselets per cycle fits comfortably within a communications bandwidth of 64 Kbaud, and can be used to detect faults within a half cycle plus channel delay.

The second major technical consideration is the restraint characteristic, which is the decision boundary between situations that are declared to be a fault and those that are not. The L30 uses an innovative adaptive decision process based on an online computation of the sources of measurement error. In this adaptive approach, the restraint region is an ellipse with variable major axis, minor axis, and orientation. Parameters of the ellipse vary with time to make best use of the accuracy of current measurements.

The third major element of L30 design is sampling synchronization. In order for a differential scheme to work, the data being compared must be taken at the same time. This creates a challenge when data is taken at remote locations.

The GE approach to clock synchronization relies upon distributed synchronization. Distributed synchronization is accomplished by synchronizing the clocks to each other rather than to a master clock. Clocks are phase-synchronized to each other and frequency-synchronized to the power-system frequency. Each relay compares the phase of its clock to the phase of the other clocks and compares the frequency of its clock to the power-system frequency and makes appropriate adjustments. As long as there are enough channels operating to provide protection, the clocks are synchronized.

10.1.2 L30 architecture

The L30 system uses a peer-to-peer architecture in which the relays at every terminal are identical. Each relay computes differential current and clocks are synchronized to each other. The peer-to-peer architecture is based on two concepts that reduce the dependence of the system on the communication channels: replication of protection and distributed synchronization.

Replication of protection means that each relay is designed to be able to provide protection for the entire system and does so whenever it has enough information. Thus a relay provides protection whenever it is able to communicate directly with all other relays. For a multi-terminal system, the degree of replication is determined by the extent of communication interconnection. If there is a channel between every pair of relays, every relay provides protection. If channels are not provided between every pair of relays, only those relays that are connected to all other relays provide protection.

Each L30 relay measures three phase currents 64 times per cycle. Synchronization in sampling is maintained throughout the system via the distributed synchronization technique.

The next step is the removal of any decaying offset from each phase current measurement. This is done using a digital simulation of the so-called “mimic circuit” (based on the differential equation of the inductive circuit that generates the offset). Next, phaselets are computed by each L30 for each phase from the outputs of the mimic calculation and transmitted to the other relay terminals. Also, the sum of the squares of the raw data samples is computed for each phase, and transmitted with the phaselets.

At the receiving relay, the received phaselets are combined into phasors. Also, ground current is reconstructed from phase information. An elliptical restraint region is computed by combining sources of measurement error. In addition to the restraint region, a separate disturbance detector is used to enhance security.

The possibility of a fault is indicated by the detection of a disturbance as well as the sum of the current phasors falling outside of the elliptical restraint region. The statistical distance from the phasor to the restraint region is an indication of the severity of the fault. To provide speed of response that is commensurate with fault severity, the distance is filtered. For mild faults, filtering improves measurement precision at the expense of a slight delay, on the order of one cycle. Severe faults are detected within a single phaselet. Whenever the sum of phasors falls within the elliptical restraint region, the system assumes there is no fault and uses whatever information is available for fine adjustment of the clocks.

10.1.3 Removal of decaying offset

The inductive behavior of power system transmission lines gives rise to decaying exponential offsets during transient conditions, which can lead to errors and interfere with the determination of how well measured current fits a sinewave.

The current signals are pre-filtered using an improved digital MIMIC filter. The filter removes the DC component(s), guaranteeing transient overshoot below 2% regardless of the initial magnitude and time constant of the DC component(s). The filter has significantly better filtering properties for higher frequencies as compared with a classical MIMIC filter. This is possible without introducing any significant phase delay due to the high sampling rate used by the relay. The output of the MIMIC calculation is the input for the phaselet computation. The MIMIC computation is applied to the data samples for each phase at each terminal. The equation shown is for one phase at one terminal.

10.1.4 Phaselet computation

Phaselets are partial sums in the computation for fitting a sine function to measured samples. Each slave computes phaselets for each phase current and transmits phaselet information to the master for conversion into phasors. Phaselets enable the efficient computation of phasors over sample windows that are not restricted to an integer multiple of a half cycle at the power system frequency. Determining the fundamental power system frequency component of current data

samples by minimizing the sum of the squares of the errors gives rise to the first frequency component of the Discrete Fourier Transform (DFT). In the case of a data window that is a multiple of a half cycle, the computation is simply sine and cosine weighted sums of the data samples. In the case of a window that is not a multiple of a half-cycle, there is an additional correction that results from the sine and cosine functions not being orthogonal over such a window. However, the computation can be expressed as a two-by-two matrix multiplication of the sine and cosine weighted sums.

Phaselets and sum of squares are computed for each phase at each terminal as follows. For the real part, we have:

$$I_{1_Re_A(k)} = \frac{4}{N} \sum_{p=0}^{N/2-1} i_{1_f_A(k-p)} \cdot \cos\left(\frac{2\pi(p+1/2)}{N}\right) \quad \text{Eq. 10-1}$$

For the imaginary part, we have:

$$I_{1_Im_A(k)} = -\frac{4}{N} \sum_{p=0}^{N/2-1} i_{1_f_A(k-p)} \cdot \sin\left(\frac{2\pi(p+1/2)}{N}\right) \quad \text{Eq. 10-2}$$

where

k is the present phaselet index

N is the number of samples per cycle

p is the present sample index

The computation of phaselets and sum of squares is basically a consolidation process. The phaselet sums are converted into stationary phasors by multiplying by a precomputed matrix. Phaselets and partial sums of squares are computed and time-stamped at each relay and communicated to the remote relay terminals, where they are added and the matrix multiplication is performed. Since the sampling clocks are synchronized, the time stamp is simply a sequence number.

10.1.5 Disturbance detection

A disturbance detection algorithm is used to enhance security and to improve transient response. Conditions to detect a disturbance include the magnitude of zero-sequence current, the magnitude of negative-sequence current, and changes in positive, negative, or zero-sequence current. Normally, differential protection is performed using a full-cycle Fourier transform. Continuous use of a full-cycle Fourier means that some pre-fault data is also used for computation. This can lead to a slowdown in the operation of the differential function. To improve operating time, the window is resized to the half-cycle Fourier once a disturbance is detected, thus removing pre-fault data.

10.1.6 Fault detection

Normally, the sum of the current phasors from all terminals is zero for each phase at every terminal. A fault is detected for a phase when the sum of the current phasors from each terminal for that phase falls outside of a dynamic elliptical restraint boundary for that phase. The severity of the fault is computed as follows for each phase.

The differential current is calculated as a sum of local and remote currents. The real part is expressed as:

$$I_{DIFF_RE_A} = I_{LOC_PHASOR_RE_A} + I_{REM1_PHASOR_RE_A} + I_{REM2_PHASOR_RE_A} \quad \text{Eq. 10-3}$$

The imaginary part is expressed as:

$$I_{DIFF_IM_A} = I_{LOC_PHASOR_IM_A} + I_{REM1_PHASOR_IM_A} + I_{REM2_PHASOR_IM_A} \quad \text{Eq. 10-4}$$

The differential current is squared for the severity equation:

$$(I_{DIFF_A})^2 = (I_{DIFF_RE_A})^2 + (I_{DIFF_IM_A})^2 \quad \text{Eq. 10-5}$$

The restraint current is composed from two distinctive terms: traditional and adaptive. Each relay calculates local portion of the traditional and restraint current to be used locally and sent to remote peers for use with differential calculations. If more than one CT is connected to the relay (breaker-and-the-half applications), then a maximum of all (up to four) currents is chosen to be processed for traditional restraint.

The current chosen is expressed as:

$$(I_{\text{LOC_TRAD_A}})^2 = \max((I_{1_MAG_A})^2, (I_{2_MAG_A})^2, (I_{3_MAG_A})^2, (I_{4_MAG_A})^2, (I_{q_MAG_A})^2) \quad \text{Eq. 10-6}$$

This current is then processed with the slope (S_1 and S_2) and breakpoint (BP) settings to form a traditional part of the restraint term for the local current as follows. For two-terminal systems, we have:

$$\begin{aligned} &\text{If } (I_{\text{LOC_TRAD_A}})^2 < \text{BP}^2 \\ &\text{then } (I_{\text{LOC_REST_TRAD_A}})^2 = 2(S_1 \cdot I_{\text{LOC_TRAD_A}})^2 \\ &\text{else } (I_{\text{LOC_REST_TRAD_A}})^2 = 2((S_2 \cdot I_{\text{LOC_TRAD_A}})^2 - (S_2 \cdot \text{BP})^2) + 2(S_1 \cdot \text{BP})^2 \end{aligned} \quad \text{Eq. 10-7}$$

For three-terminal systems we have:

$$\begin{aligned} &\text{If } (I_{\text{LOC_TRAD_A}})^2 < \text{BP}^2 \\ &\text{then } (I_{\text{LOC_REST_TRAD_A}})^2 = \frac{4}{3}(S_1 \cdot I_{\text{LOC_TRAD_A}})^2 \\ &\text{else } (I_{\text{LOC_REST_TRAD_A}})^2 = \frac{4}{3}((S_2 \cdot I_{\text{LOC_TRAD_A}})^2 - (S_2 \cdot \text{BP})^2) + \frac{4}{3}(S_1 \cdot \text{BP})^2 \end{aligned} \quad \text{Eq. 10-8}$$

The final restraint current sent to peers and used locally in differential calculations is as follows:

$$I_{\text{LOC_RESTRAINT_A}} = \sqrt{(I_{\text{LOC_REST_TRAD_A}})^2 + \text{MULT}_A \cdot (I_{\text{LOC_ADA_A}})^2} \quad \text{Eq. 10-9}$$

where

MULT_A is a multiplier that increases restraint if CT saturation is detected (see CT Saturation Detection for details)

$I_{\text{LOC_ADA_A}}$ is an adaptive restraint term (see Online Estimate Of Measurement Error for details)

The squared restraining current is calculated as a sum of squared local and all remote restraints:

$$(I_{\text{REST_A}})^2 = (I_{\text{LOC_PHASOR_RESTRAINT_A}})^2 + (I_{\text{REM1_PHASOR_RESTRAINT_A}})^2 + (I_{\text{REM2_PHASOR_RESTRAINT_A}})^2 \quad \text{Eq. 10-10}$$

The fault severity for each phase is determined by following equation:

$$S_A = (I_{\text{DIFF_A}})^2 - (2P^2 + (I_{\text{REST_A}})^2) \quad \text{Eq. 10-11}$$

where P is the pickup setting.

This equation is based on the adaptive strategy and yields an elliptical restraint characteristic. The elliptical area is the restraint region. When the adaptive portion of the restraint current is small, the restraint region shrinks. When the adaptive portion of the restraint current increases, the restraint region grows to reflect the uncertainty of the measurement. The computed severity increases with the probability that the sum of the measured currents indicates a fault. With the exception of "Restraint," all quantities are defined in previous sections. "Adaptive Restraint" is a restraint multiplier, analogous to the slope setting of traditional differential approaches, for adjusting the sensitivity of the relay.

Raising the restraint multiplier corresponds to demanding a greater confidence interval and has the effect of decreasing sensitivity while lowering it, equivalent to relaxing the confidence interval and increases sensitivity. Thus, the restraint multiplier is an application adjustment that is used to achieve balance between sensitivity and security. The computed severity is zero when the operate phasor is on the elliptical boundary, is negative inside the boundary, and positive outside the boundary. Outside of the restraint boundary, the computed severity grows as the square of the fault current. The restraint area grows as the square of the error in the measurements.

10.1.7 Ground differential element

The line ground differential function allows sensitive ground protection for single-line-to-ground faults, allowing the phase differential element to be set higher (above load) to provide protection for multi-phase faults. The L30 ground differential function calculates ground differential current from all terminal phase currents. The maximum phase current is used for the restraint. The L30 is applied in dual-breaker applications to cope with significant through current at remote terminals that can cause CT errors or saturation.

The line ground differential function uses the same CT matched and time-aligned phasors as the phase-segregated current differential function. The operate signal is calculated for both real and imaginary parts as follows:

$$I_{OP_87G_RE} = I_{LOC_PHASOR_RE_A} + I_{LOC_PHASOR_RE_B} + I_{LOC_PHASOR_RE_C} + I_{REM1_PHASOR_RE_A} + I_{REM1_PHASOR_RE_B} + I_{REM1_PHASOR_RE_C} + I_{REM2_PHASOR_RE_A} + I_{REM2_PHASOR_RE_B} + I_{REM2_PHASOR_RE_C} \quad \text{Eq. 10-12}$$

$$I_{OP_87G_JM} = I_{LOC_PHASOR_JM_A} + I_{LOC_PHASOR_JM_B} + I_{LOC_PHASOR_JM_C} + I_{REM1_PHASOR_JM_A} + I_{REM1_PHASOR_JM_B} + I_{REM1_PHASOR_JM_C} + I_{REM2_PHASOR_JM_A} + I_{REM2_PHASOR_JM_B} + I_{REM2_PHASOR_JM_C} \quad \text{Eq. 10-13}$$

The terms for the second remote terminal are omitted in two-terminal applications.

The maximum through current is available locally and re-constructed from the received remote restraint based on the maximum remote restraint current shown in the previous section and as indicated as follows.

For two-terminal applications:

$$\begin{aligned} \text{If } (I_{REM_REST_A})^2 < BP^2, \text{ then } (I_{REM_REST_A})^2 &= \frac{(I_{REM_RESTRAINT_A})^2}{2S_1^2} \\ \text{else } (I_{REM_REST_A})^2 &= \frac{(I_{REM_RESTRAINT_A})^2 - 2(S_1 \times BP)^2}{2S_2^2} + BP^2 \end{aligned} \quad \text{Eq. 10-14}$$

For three-terminal applications:

$$\begin{aligned} \text{If } (I_{REM_REST_A})^2 < BP^2, \text{ then } (I_{REM_REST_A})^2 &= \frac{(I_{REM_RESTRAINT_A})^2}{\frac{4}{3} \times S_1^2} \\ \text{else } (I_{REM_REST_A})^2 &= \frac{(I_{REM_RESTRAINT_A})^2 - \frac{4}{3}(S_1 \times BP)^2}{\frac{4}{3} \times S_2^2} + BP^2 \end{aligned} \quad \text{Eq. 10-15}$$

The 87G restraining signal is calculated as follows:

$$(I_{RES_87G})^2 = \max((I_{LOC_REST_A})^2, (I_{LOC_REST_B})^2, (I_{LOC_REST_C})^2, (I_{REM1_REST_A})^2, (I_{REM1_REST_B})^2, (I_{REM1_REST_C})^2, (I_{REM2_REST_A})^2, (I_{REM2_REST_B})^2, (I_{REM2_REST_C})^2) \quad \text{Eq. 10-16}$$

The terms for the second remote terminal are omitted in two-terminal applications.

The operate signal for the ground differential function $(I_{OP_87G})^2$ is then calculated as:

$$(I_{OP_87G})^2 = (I_{OP_87G_RE})^2 + (I_{OP_87G_JM})^2 \quad \text{Eq. 10-17}$$

The restraint signal $(I_{87G})^2$ is calculated as follows for two-terminal applications:

$$(I_{87G})^2 = 2S_{87G}^2 \times (I_{RES_87G})^2 \quad \text{Eq. 10-18}$$

The restraint signal $(I_{87G})^2$ is calculated as follows for three-terminal applications:

$$(I_{87G})^2 = \frac{4}{3} \times S_{87G}^2 \times (I_{RES_87G})^2 \quad \text{Eq. 10-19}$$

where S_{87G} is the slope setting for the ground differential function.

The ground differential element picks up if the following condition holds.

$$((I_{OP_87G})^2 - (2P_{87G}^2 + (I_{87G})^2) > 0) \text{ and } ((I_{RES_87G})^2 < (3 \text{ pu})^2) \quad \text{Eq. 10-20}$$

where P_{87G} is the pickup setting for the ground differential function.

In other words, when the squared magnitude of the operating signal is greater than the total restraining squared signal, the element operates. For additional security, the function is blocked if the restraining signal is high, indicating that the 87LG function is not required to clear high-current faults, allowing for more sensitive settings to be used for the 87LG function.

10.1.8 Clock synchronization

Synchronization of data sampling clocks is needed in a digital differential protection scheme, because measurements must be made at the same time. Synchronization errors show up as phase angle and transient errors in phasor measurements at the terminals. By phase angle errors, we mean that identical currents produce phasors with different phase angles. By transient errors, we mean that when currents change at the same time, the effect is seen at different times at different measurement points. For best results, take samples simultaneously at all terminals.

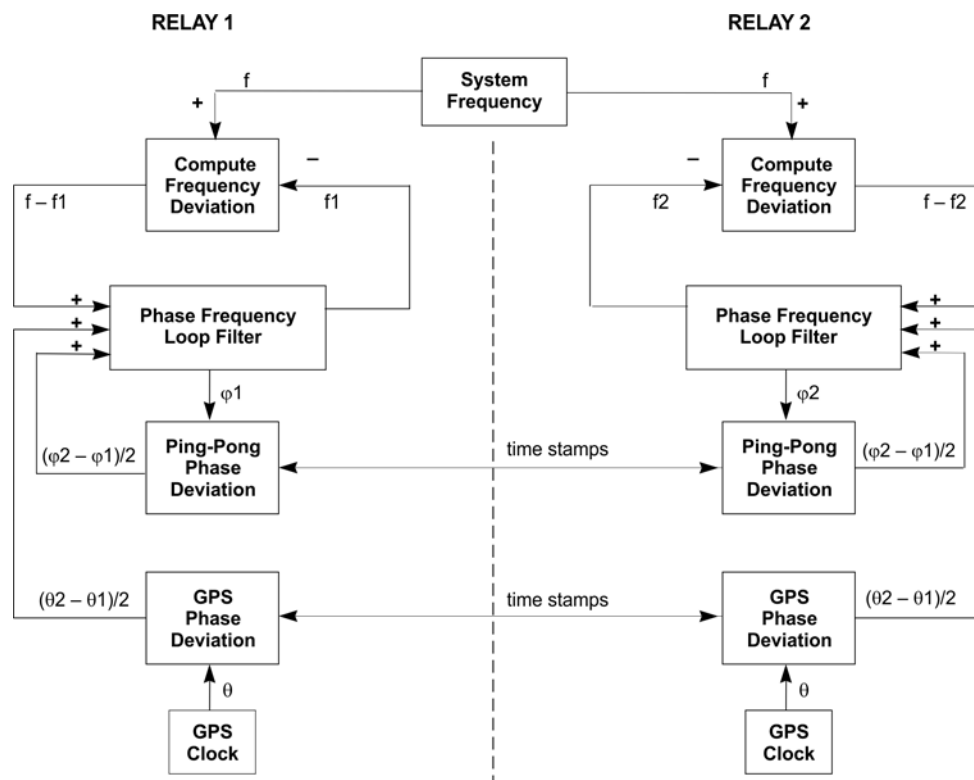
In the case of peer-to-peer architecture, synchronization is accomplished by synchronizing the clocks to each other rather than to a master clock. Each relay compares the phase of its clock to the phase of the other clocks and compares the frequency of its clock to the power-system frequency and makes appropriate adjustments. The frequency and phase tracking algorithm keeps the measurements at all relays within a plus or minus 25 microsecond error during normal conditions for a two or three-terminal system. For four or more terminals, the error can be somewhat higher, depending on the quality of the communications channels. The algorithm is unconditionally stable. In the case of two and three-terminal systems, asymmetric communications channel delay is automatically compensated for. In all cases, an estimate of phase error is computed and used to automatically adapt the restraint region to compensate. Frequency tracking is provided that accommodates any frequency shift normally encountered in power systems.

10.1.9 Frequency tracking and phase locking

Each relay has a digital clock that determines when to take data samples and which is phase synchronized to all other clocks in the system and frequency synchronized to the power-system frequency. Phase synchronization drives the relative timing error between clocks to zero. It is needed to control the uncertainty in the phase angle of phasor measurements, which are held to under 26 microseconds (0.6 degrees). Frequency synchronization to the power system eliminates a source of error in phasor measurements that arises when data samples do not exactly span one cycle.

The figure is a block diagram for clock control for a two-terminal system. Each relay makes a local estimate of the difference between the power-system frequency and the clock frequency based on the rotation of phasors. Each relay also makes a local estimate of the time difference between its clock and the other clocks either by exchanging timing information over communications channels or from information that is in the current phasors, depending on whichever one is more accurate at any given time. A loop filter then uses the frequency and phase angle deviation information to make fine adjustments to the clock frequency. Frequency tracking starts if the current at one or more terminals is above 0.125 pu of nominal; otherwise, the nominal frequency is used.

Figure 10-1: Block diagram for clock synchronization in a two-terminal system



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The L30 provides sensitive digital current differential protection by computing differential current from current phasors. To improve sensitivity, the clocks that control current sampling are closely synchronized via the ping-pong algorithm. However, this algorithm assumes that the communication channel delay is identical in each direction. If the delays are not the same, the error between current phasors is equal to half of the transmit-receive time difference. If the error is high enough, the relay perceives the “apparent” differential current and misoperates.

For applications where the communication channel is not symmetric (for example, SONET ring), the L30 allows the use of a global positioning system (GPS) to compensate for the channel delay asymmetry. This feature requires a GPS receiver to provide a GPS clock signal to the L30. With this option there are two clocks at each terminal: a local sampling clock and a local GPS clock. The sampling clock controls data sampling while the GPS clock provides an accurate, absolute time reference used to measure channel asymmetry. The local sampling clocks are synchronized to each other in phase and to the power system in frequency. The local GPS clocks are synchronized to GPS time using the externally provided GPS time signal.

GPS time stamp is included in the transmitted packet along with the sampling clock time stamp. Both sampling clock deviation and channel asymmetry are computed from the four time stamps. One half of the channel asymmetry is then subtracted from the computed sampling clock deviation. The compensated deviation drives the phase and frequency lock loop (PPLL) as shown in the previous figure. If GPS time reference is lost, the channel asymmetry compensation is not enabled, and the relay clock can start to drift and accumulate differential error. In this case, the 87L function has to be blocked. See the Application of Settings for examples of how to program the relay.

10.1.10 Frequency detection

Estimation of frequency deviation is done locally at each relay based on rotation of positive sequence current, or on rotation of positive sequence voltage, if it is available. The counter clockwise rotation rate is proportional to the difference between the desired clock frequency and the actual clock frequency. With the peer-to-peer architecture, there is redundant frequency tracking, so it is not necessary that all terminals perform frequency detection.

Normally each relay detects frequency deviation, but if there is no current flowing nor voltage measurement available at a particular relay, it is not be able to detect frequency deviation. In that case, the frequency deviation input to the loop filter is set to zero and frequency tracking is still achieved because of phase locking to the other clocks. If frequency detection is lost at all terminals because there is no current flowing, then the clocks continue to operate at the frequency present at the time of the loss of frequency detection. Tracking resumes as soon as there is current.

The rotational rate of phasors is equal to the difference between the power system frequency and the ratio of the sampling frequency divided by the number of samples per cycle. The correction is computed once per power system cycle at each relay. For conciseness, we use a phasor notation:

$$\begin{aligned}\overline{l(n)} &= \text{Re}(\text{Phasor}_n) + j \cdot \text{Im}(\text{Phasor}_n) \\ \overline{l_{a,k}(n)} &= \overline{l(n)} \quad \text{for phase a from the kth terminal at time step n} \\ \overline{l_{b,k}(n)} &= \overline{l(n)} \quad \text{for phase b from the kth terminal at time step n} \\ \overline{l_{c,k}(n)} &= \overline{l(n)} \quad \text{for phase c from the kth terminal at time step n}\end{aligned}\tag{Eq. 10-21}$$

Each terminal computes positive sequence current:

$$\overline{l_{\text{pos},k}(n)} = \frac{1}{3}(\overline{l_{a,k}(n)} + \overline{l_{b,k}(n)} \cdot e^{j2\pi/3} + \overline{l_{c,k}(n)} \cdot e^{j2\pi/3})\tag{Eq. 10-22}$$

Each relay computes a quantity derived from the positive sequence current that is indicative of the amount of rotation from one cycle to the next, by computing the product of the positive sequence current times the complex conjugate of the positive sequence current from the previous cycle:

$$\overline{\text{Deviation}_k(n)} = \overline{l_{\text{pos},k}(n)} \times \overline{l_{\text{pos},k}(n-N)}^*\tag{Eq. 10-23}$$

The angle of the deviation phasor for each relay is proportional to the frequency deviation at that terminal. Since the clock synchronization method maintains frequency synchronism, the frequency deviation is approximately the same for each relay. The clock deviation frequency is computed from the deviation phasor:

$$\text{FrequencyDeviation} = \frac{\Delta f}{f} = \frac{\tan^{-1}(\text{Im}(\overline{\text{Deviation}})/\text{Re}(\overline{\text{Deviation}}))}{2\pi}\tag{Eq. 10-24}$$

Note that a four-quadrant arctangent can be computed by taking the imaginary and the real part of the deviation separately for the two arguments of the four-quadrant arctangent. Also note that the input to the loop filter is in radian frequency which is two pi times the frequency in cycles per second; that is, $\Delta\omega = 2\pi \cdot \Delta f$.

So the radian frequency deviation can be calculated simply as:

$$\Delta\omega = \Delta f \cdot \tan^{-1}(\text{Im}(\overline{\text{Deviation}})/\text{Re}(\overline{\text{Deviation}}))\tag{Eq. 10-25}$$

10.1.11 Phase detection

There are two separate sources of clock phase information: exchange of time stamps over the communications channels and the current measurements themselves (although voltage measurements can be used to provide frequency information, they cannot be used for phase detection). Current measurements can generally provide the most accurate information, but they are not always available and can contain large errors during faults or switching transients. Time-stamped messages are the most reliable source of phase information but suffer from a phase offset due to a difference in the channel delays in each direction between a pair of relays. In some cases, one or both directions can be switched to a different physical path, leading to gross phase error.

The primary source of phase information is CPU time-tagged messages. If GPS compensation is enabled, GPS time stamps are used to compensate for asymmetry. In all cases, frequency deviation information also is used when available. The phase difference between a pair of clocks is computed by an exchange of time stamps. Each relay exchanges time stamps with all other relays that can be reached.

It is not necessary to exchange stamps with every relay, and the method works even with some of the channels failed. For each relay that a given relay can exchange time stamps with, the clock deviation is computed each time a complete set of time stamps arrives. The net deviation is the total deviation divided by the total number of relays involved in the exchange.

For example, in the case of two terminals, each relay computes a single time deviation from time stamps, and divides the result by two. In the case of three terminals, each relay computes two time deviations and divides the result by three. If a channel is lost, the single deviation that remains is divided by two.

Four time stamps are needed to compute round-trip delay time and phase deviation. Three stamps are included in the message in each direction. The fourth time stamp is the time when the message is received. Each time a message is received, the oldest two stamps of the four time stamps are saved to become the first two time stamps of the next outgoing message. The third time stamp of an outgoing message is the time when the message is transmitted. A fixed time shift is allowed between the stamp values and the actual events, provided the shift for outgoing message time stamps is the same for all relays, and the shift incoming message time stamps is also identical.

To reduce bandwidth requirements, time stamps are spread over three messages. In the case of systems with four messages per cycle, time stamps are sent out on three of the four messages, so a complete set is sent once per cycle. In the case of systems with one message per cycle, three time stamps are sent out each cycle in a single message. The transmit and receive time stamps are based on the first message in the sequence.

One of the strengths of this approach is that it is not necessary to explicitly identify or match time stamp messages. Usually, two of the time stamps in an outgoing message are simply taken from the last incoming message. The third time stamp is the transmittal time. However, there are two circumstances when these time stamps are not available. One situation is when the first message is transmitted by a given relay. The second is when the exchange is broken long enough to invalidate the last received set of time stamps (if the exchange is broken for longer than 66 ms, the time stamps from a given clock can roll over twice, invalidating time difference computations). In either of these situations, the next outgoing set of time stamps is a special start-up set containing transmittal time only. When such a message is received, nothing is computed from it, except the message time stamp and the received time stamp are saved for the next outgoing message (it is neither necessary nor desirable to “reset” the local clock when such a message is received).

Error analysis shows that time-stamp requirements are not very stringent because of the smoothing behavior of the phase locked loop. The time stamp can be basically a sample count with enough bits to cover the worst round trip, including channel delay and processing delay. An eight-bit time stamp with one bit corresponding to 1/64 of a cycle accommodates a round trip delay of up to four cycles, which is likely to be more than adequate.

The computation of round trip delay and phase offset from four time stamps is as follows:

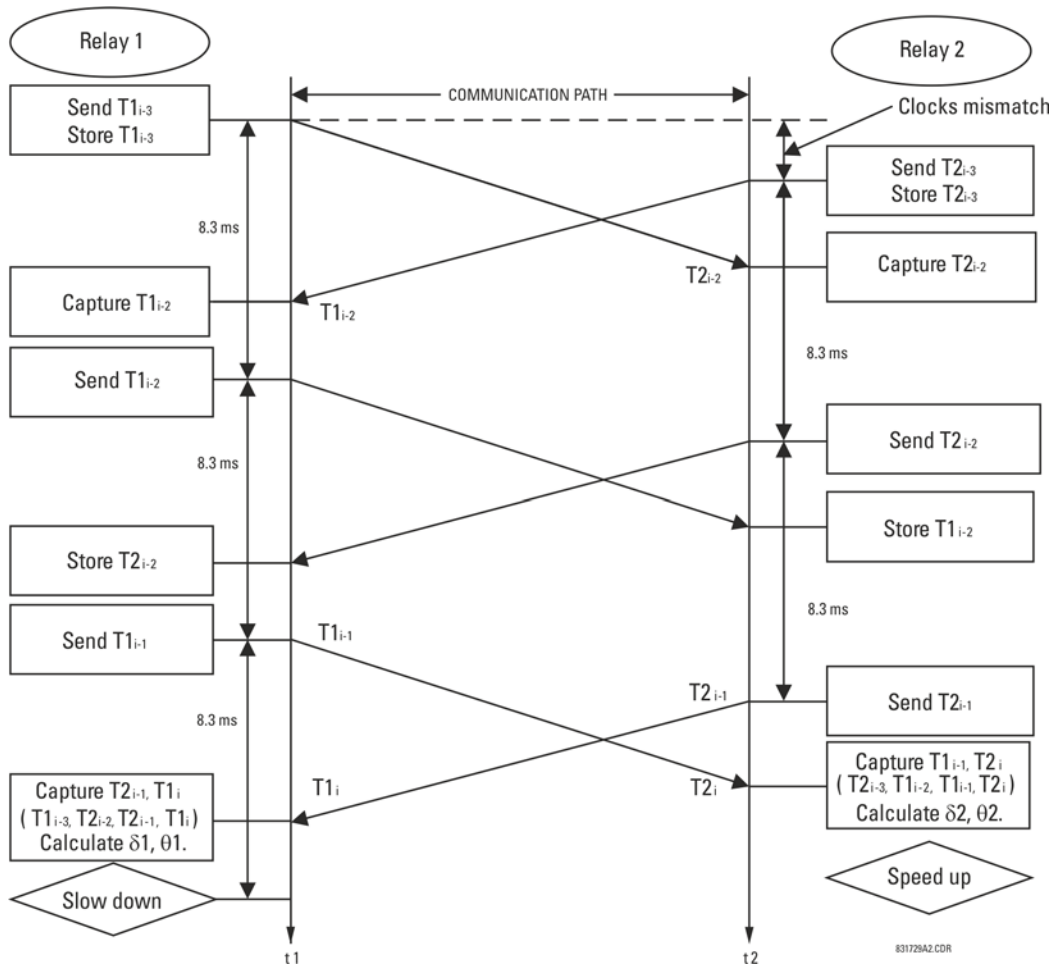
$$\begin{aligned} a &= T_{i-2} - T_{i-3} \\ b &= T_i - T_{i-1} \\ \delta_i &= a + b \\ \theta_i &= \frac{a - b}{2} \end{aligned} \qquad \text{Eq. 10-26}$$

The T s are the time stamps, with T_i the newest. Delta is the round trip delay. Theta is the clock offset, and is the correct sign for the feedback loop. Note that the time stamps are unsigned numbers that wrap around, while a and b can be positive or negative; δ_i must be positive and θ_i can be positive or negative. Some care must be taken in the arithmetic to take into account possible roll over of any of the time stamps. If T_{i-2} is greater than T_{i-1} , there was a roll over in the clock responsible for those two time stamps.

To correct for the roll over, subtract 256 from the round trip and subtract 128 from the phase angle. If T_{i-3} is greater than T_i , add 256 to the round trip and add 128 to the phase angle. Also, if the above equations are computed using integer values of time stamps, a conversion to phase angle in radians is required by multiplying by $\pi / 32$.

Time stamp values are snapshots of the local 256 bit sample counter taken at the time of the transmission or receipt of the first message in a time-stamp sequence. This can be done either in software or hardware, provided the jitter is limited to less than plus or minus 130 μ s. A fixed bias in the time stamp is acceptable, provided it is the same for all terminals.

Figure 10-2: Round-trip delay and clock-offset computation for time stamps



10.1.12 Phase-locking filter

Filters are used in the phase locked loop to assure stability, to reduce phase and frequency noise. This is well-known technology. The primary feedback mechanism shown in the Loop Filter Block Diagram is phase angle information through the well-known proportional plus integral (PI) filter (the Z in the diagram refers to a unit delay, and $1 / (Z - 1)$ represents a simple digital first order integrator). This loop is used to provide stability and zero steady state error.

A PI filter has two time parameters that determine dynamic behavior: the gain for the proportional term and the gain for the integral. Depending on the gains, the transient behavior of the loop can be underdamped, critically damped, or over damped. For this application, critically damped is a good choice.

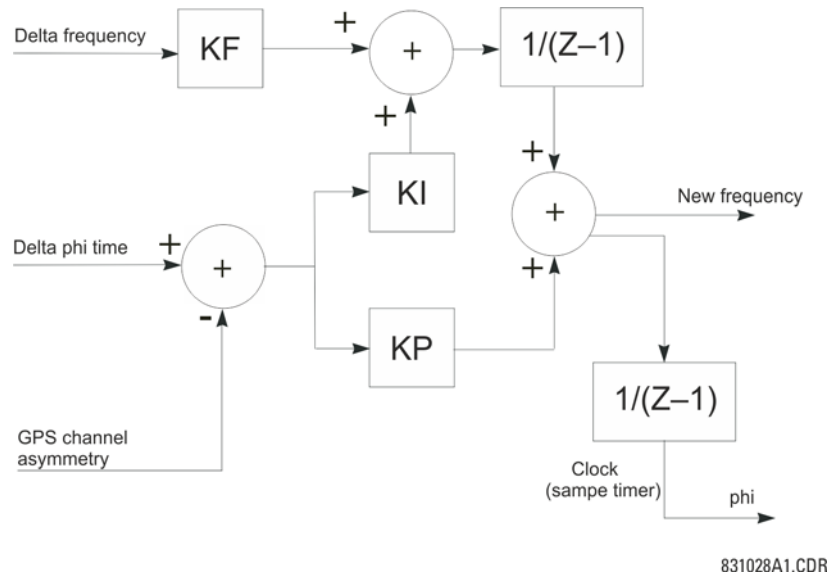
This sets a constraint relating the two parameters. A second constraint is derived from the desired time constants of the loop. By considering the effects of both phase and frequency noise in this application, it can be shown that optimum behavior results with a certain proportion between phase and frequency constraints.

A secondary input is formed through the frequency deviation input of the filter. Whenever frequency deviation information is available, it is used for this input; otherwise, the input is zero. Because frequency is the derivative of phase information, the appropriate filter for frequency deviation is an integrator, which is combined with the integrator of the PI filter for the phase. It is very important to combine these two integrators into a single function because it can be shown if two separate integrators are used, they can drift in opposite directions into saturation, because the loop would only drive their sum to zero.

In normal operation, frequency tracking at each terminal matches the tracking at all other terminals, because all terminals measure approximately the same frequency deviation. However, if there is not enough current at a terminal to compute frequency deviation, then frequency tracking at that terminal is accomplished indirectly via phase locking to other terminals. A small phase deviation must be present for the tracking to occur.

Also shown in the loop is the clock itself, because it behaves like an integrator. The clock is implemented in hardware and software with a crystal oscillator and a counter.

Figure 10-3: Loop filter block diagram



There are four gains in the filter that must be selected once and for all as part of the design of the system. The gains are determined by the time step of the integrators, and the required time constants of the system as follows:

$$K_I = \frac{T_{\text{repeat}}}{T_{\text{phase}}^2}, \quad K_P = \frac{2}{T_{\text{phase}}}, \quad K_F = \frac{T_{\text{repeat}}}{T_{\text{frequency}}} \quad \text{Eq. 10-27}$$

where

T_{repeat} = the time between execution of the filter algorithm

T_{phase} = time constant for the primary phase locked loop

$T_{\text{frequency}}$ = time constant for the frequency locked loop

10.1.13 Matching phaselets

An algorithm is needed to match phaselets, detect lost messages, and detect communications channel failure. Channel failure is defined by a sequence of lost messages, where the length of the sequence is a design parameter. In any case, the sequence is no longer than the maximum sequence number (four cycles) in order to be able to match up messages when the channel is assumed to be operating normally.

A channel failure can be detected by a watchdog software timer that times the interval between consecutive incoming messages. If the interval exceeds a maximum limit, channel failure is declared and the channel recovery process is initiated.

While the channel is assumed to be operating normally, it is still possible for an occasional message to be lost, in which case fault protection is suspended for the time period that depends on that message, and is resumed on the next occasional message. A lost message is detected simply by looking at the sequence numbers of incoming messages. A lost message shows up as a gap in the sequence.

Sequence numbers are also used to match messages for the protection computation. Whenever a complete set of current measurements from all terminals with matching sequence numbers are available, the differential protection function is computed using that set of measurements.

10.1.14 Start-up

Initialization in our peer-to-peer architecture is done independently at each terminal. Relays can be turned on in any order with the power system either energized or de-energized. Synchronization and protection functions are accomplished automatically whenever enough information is available.

After a relay completes other initialization tasks, such as resetting of buffer pointers and determining relay settings, initial values are computed for any state variables in the loop filters or the protection functions. The relay starts its clock at the nominal power-system frequency. Phaselet information is computed and transmitted.

- Outgoing messages over a given channel are treated in the same way as during the channel recovery process. The special start-up message is sent each time containing only a single time step value.
- When incoming messages begin arriving over a channel, that channel is placed in service and the loop filters are started up for that channel.
- Whenever the total clock uncertainty is less than a fixed threshold, the phase locking filter is declared locked and differential protection is enabled.

10.1.15 Hardware and communication requirements

The average total channel delay in each direction is not critical, provided that the total round trip delay is less than four power-system cycles. The jitter is important and needs to be less than $\pm 130 \mu\text{s}$ in each direction. The effect of a difference in the average delay between one direction and the other depends on the number of terminals. In the case of a two or three-terminal system, the difference is not critical, and can even vary with time. In the case of four or more terminals, variation in the difference limits the sensitivity of the system.

- The allowable margin of $130 \mu\text{s}$ jitter includes jitter in servicing the interrupt generated by an incoming message. For both incoming and outgoing messages, the important parameter is the jitter between when the time stamp is read and when the message begins to go out or to come in.
- The quality of the crystal driving the clock and software sampling is not critical, because of the compensation provided by the phase and frequency tracking algorithm, unless it is desired to perform under or over frequency protection. From the point of view of current differential protection only, the important parameter is the rate of drift of crystal frequency, which needs to be less than 100 parts per million per minute.
- A 6 MHz clock with a 16-bit hardware counter is adequate, provided that the method described in this document is used for achieving the 32-bit resolution
- An eight-bit time stamp is adequate provided that time-stamp messages are exchanged once per cycle
- A four-bit message sequence number is adequate

Depending on the 87L settings, channel asymmetry (the difference in the transmitting and receiving paths channel delay) cannot be higher than 1 to 1.5 ms if channel asymmetry compensation is not used. However, if the relay detects asymmetry higher than 1.5 ms, the **87L DIFF CH ASYM DET** FlexLogic operand is set high and the event and target are raised (if they are enabled in the **CURRENT DIFFERENTIAL** menu) to provide an indication about potential danger.

10.1.16 Online estimate of measurement errors

GE's adaptive elliptical restraint characteristic is a good approximation to the cumulative effects of various sources of error in determining phasors. Sources of error include power system noise, transients, inaccuracy in line charging current computation, current sensor gain, phase and saturation error, clock error, and asynchronous sampling. Errors that can be controlled are driven to zero by the system. For errors that cannot be controlled, all relays compute and sum the error for each source of error for each phase. The relay computes the error caused by power system noise, CT saturation, harmonics, and transients. These errors arise because power system currents are not always exactly sinusoidal. The intensity of these errors varies with time, for example growing during fault conditions, switching operations, or load variations. The system treats these errors as a Gaussian distribution in the real and in the imaginary part of each phasor,

with a standard deviation that is estimated from the sum of the squares of the differences between the data samples and the sine function that is used to fit them. This error has a spectrum of frequencies. Current transformer saturation is included with noise and transient error. The error for noise, harmonics, transients, and current transformer saturation is computed as follows. First, the sum of the squares of the errors in the data samples is computed from the sum of squares information for the present phaselet:

$$\text{SumSquares}_{1_A(k)} = \frac{4}{N} \sum_{p=0}^{N/2-1} (i_{1_f_A(k-p)})^2 \quad \text{Eq. 10-28}$$

Then fundamental magnitude is computed as follows for the same phaselet:

$$I_{1_MAG_A} = \sqrt{(I_{1_RE_A})^2 + (I_{1_JM_A})^2} \quad \text{Eq. 10-29}$$

Finally, the local adaptive restraint term is computed as follows, for each local current:

$$(I_{1_ADA_A})^2 = \frac{4}{N} (\text{SumSquares}_{1_A(k)} - (I_{1_MAG_A})^2) \quad \text{Eq. 10-30}$$

Another source of the measurement errors is clock synchronization error, resulting in a clock uncertainty term. The L30 algorithm accounts for two terms of synchronization error corresponding to:

- **Raw clock deviation computed from time stamps** — There are several effects that cause it to not track exactly. First, the ping-pong algorithm inherently produces slightly different estimates of clock deviation at each terminal. Second, because the transmission of time stamps is spread out over several packets, the clock deviation estimate is not up to date with other information it is combined with. Channel asymmetry also contributes to this term. The clock deviation computation is indicated in equation 10.15 as θ_i . If two channels are used, clock deviation is computed for both channels and then the average of absolute values is computed. If GPS compensation is used, then GPS clock compensation is subtracted from the clock deviation.
- **Startup error** — This term is used to estimate the initial startup transient of PFLs. During startup conditions, a decaying exponential is computed to simulate envelope of the error during startup.

The clock uncertainty is expressed as:

$$\text{clock_unc} = \text{clock_dev} + \text{start_up_error} \quad \text{Eq. 10-31}$$

Eventually, the local clock error is computed as:

$$\text{CLOCK}_A = \frac{(\text{clock_unc})^2}{9} \cdot ((I_{\text{LOC_RE_A}})^2 + (I_{\text{LOC_JM_A}})^2) \quad \text{Eq. 10-32}$$

The local squared adaptive restraint is computed from all local current sources (1 to 4) and is obtained as follows:

$$(I_{\text{LOC_ADA_A}})^2 = 18 \cdot ((I_{1_ADA_A})^2 + (I_{2_ADA_A})^2 + (I_{3_ADA_A})^2 + (I_{4_ADA_A})^2 + (I_{q_ADA_A})^2 + \text{CLOCK}_A) \quad \text{Eq. 10-33}$$

10.1.17 CT saturation detection

Current differential protection is inherently dependent on adequate CT performance at all terminals of the protected line, especially during external faults. CT saturation, particularly when it happens at only one terminal of the line, introduces a spurious differential current that can cause the differential protection to misoperate.

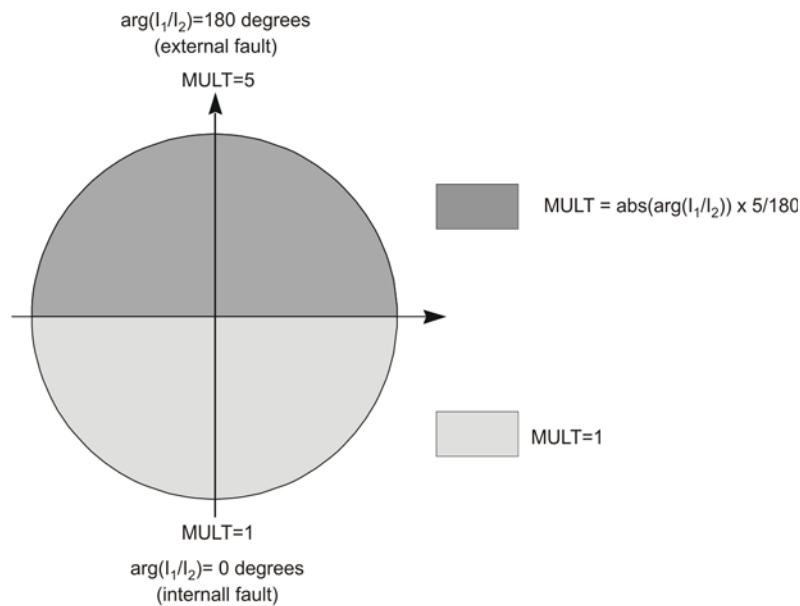
The L30 applies a dedicated mechanism to cope with CT saturation and ensure security of protection for external faults. The relay dynamically increases the weight of the square of errors (the so-called 'sigma') portion in the total restraint quantity, but for external faults only. The following logic is applied:

- First, the terminal currents are compared against a threshold of 3 pu to detect overcurrent conditions that can be caused by a fault and can lead to CT saturation

- For all the terminal currents that are above the 3 pu level, the relative angle difference is calculated. If all three terminals see significant current, then all three pairs (1, 2), (2, 3), and (1, 3) are considered and the maximum angle difference is used in further calculations.
- Depending on the angle difference between the terminal currents, the value of sigma used for the adaptive restraint current is increased by the multiple factor of 1, 5, or 2.5 to 5 as shown in the figure. As shown, a factor of 1 is used for internal faults, and a factor of 2.5 to 5 is used for external faults. This allows the relay to be sensitive simultaneously for internal faults and robust for external faults with a possible CT saturation.

If more than one CT is connected to the relay (breaker-and-the-half applications), the CT saturation mechanism is executed between the maximum local current against the sum of all others, then between the maximum local and remote currents to select the secure multiplier MULT. A maximum of two (local and remote) is selected and then applied to adaptive restraint.

Figure 10-4: CT saturation adaptive restraint multiplier



10.1.18 Charging current compensation

The basic premise for the operation of differential protection schemes in general, and of the L30 line differential element in particular, is that the sum of the currents entering the protected zone is zero. In the case of a power system transmission line, this is not entirely true because of the capacitive charging current of the line. For short transmission lines the charging current is a small factor and can therefore be treated as an unknown error. In this application, the L30 can be deployed without voltage sensors and the line charging current is included as a constant term in the total variance, increasing the differential restraint current. For long transmission lines, the charging current is a significant factor and needs to be computed to provide increased sensitivity to fault current.

Compensation for charging current requires the voltage at the terminals be supplied to the relays. The algorithm calculates $I_q = C \times dv/dt$ for each phase, which is then subtracted from the measured currents at both ends of the line. This is a simple approach that provides adequate compensation of the capacitive current at the fundamental power system frequency. Travelling waves on the transmission line are not compensated for, and contribute to restraint by increasing the measurement of errors in the data set.

The figures show underlying single phase models for compensation for two and three-terminal systems.

Figure 10-5: Terminal transmission line single phase model for compensation

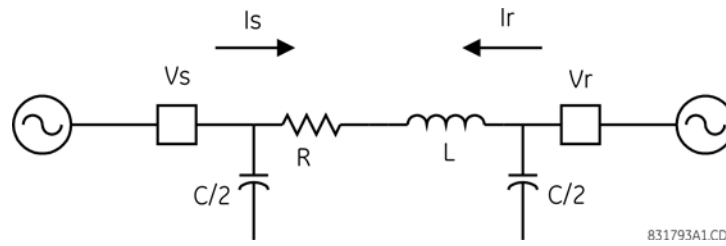
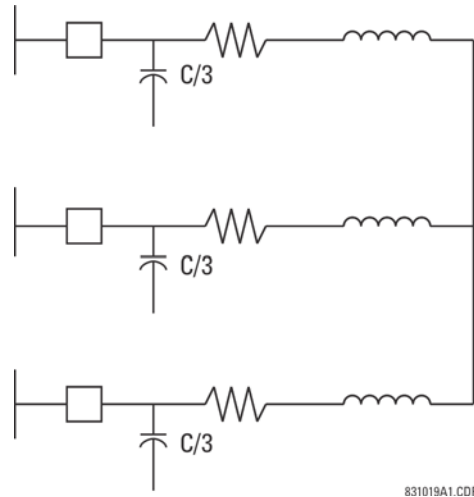


Figure 10-6: Terminal transmission line single phase model for compensation



Apportioning the total capacitance among the terminals is not critical for compensating the fundamental power system frequency charging current as long as the total capacitance is correct. Compensation at other frequencies is approximate.

If the VTs are connected in wye, the compensation is accurate for both balanced conditions (that is, all positive, negative and zero sequence components of the charging current are compensated). If the VTs are connected in delta, the compensation is accurate for positive and negative sequence components of the charging current. Since the zero sequence voltage is not available, the L30 cannot compensate for the zero sequence current.

The compensation scheme continues to work with the breakers open, provided that the voltages are measured on the line side of the breakers.

For very long lines, the distributed nature of the line leads to the classical transmission line equations that can be solved for voltage and current profiles along the line. What is needed for the compensation model is the effective positive and zero sequence capacitance seen at the line terminals.

Finally, in some applications the effect of shunt reactors needs to be taken into account. With very long lines shunt reactors can be installed to provide some of the charging current required by the line. This reduces the amount of charging current flowing into the line. In this application, the setting for the line capacitance is the residual capacitance remaining after subtracting the shunt inductive reactance from the total capacitive reactance at the power system frequency.

10.1.19 Differential element characteristics

The differential element is dependent completely on receiving data from the relay at the remote end of the line, therefore, upon startup, the differential element is disabled until the time synchronization system has aligned both relays to a common time base. After synchronization is achieved, the differential is enabled. If the communications channel delay time increases, such as caused by path switching in a SONET system or failure of the communications power supply, the relay acts as outlined in the next section.

The L30 incorporates an adaptive differential algorithm based on the traditional percent differential principle. In the traditional percent differential scheme, the operating parameter is based on the phasor sum of currents in the zone and the restraint parameter is based on the scalar (or average scalar) sum of the currents in the protected zone; when the operating parameter divided by the restraint parameter is above the slope setting, the relay operates. During an external fault, the operating parameter is relatively small compared to the restraint parameter, whereas for an internal fault, the operating parameter is relatively large compared to the restraint parameter. Because the traditional scheme is not adaptive, the element settings must allow for the maximum amount of error anticipated during an out-of-zone fault, when CT errors can be high and/or CT saturation can be experienced.

The major difference between the L30 differential scheme and a percent differential scheme is the use of an estimate of errors in the input currents to increase the restraint parameter during faults, permitting the use of more sensitive settings than those used in the traditional scheme. The inclusion of the adaptive feature in the scheme produces element characteristic equations that appear to be different from the traditional scheme, but the differences are minimal during system steady-state conditions. The element equations are shown in the Operating Condition Calculations section.

10.1.20 Relay synchronization

On startup of the relays, the channel status is checked first. If channel status is OK, all relays send a special “startup” message and the synchronization process is initiated. It takes about five to seven seconds to declare phase and frequency lock loop (PFLL) status as OK and to start performing current differential calculations. If one of the relays was powered off during the operation, the synchronization process restarts from the beginning. Relays tolerate channel delay (resulting sometimes in step change in communication paths) or interruptions up to four power cycles round trip time (about 66 ms at 60 Hz) without any deterioration in performance. If communications are interrupted for more than four cycles, the following applies:

In two-terminal mode

With a second, redundant channel, relays do not lose functionality at all if the second channel is live.

With one channel only, relays have a five-second time window. If the channel is restored within this time, it takes about two to three power cycles of valid PFLL calculations (and if estimated error is still within margin) to declare that PFLL is OK. If the channel is restored later than five seconds, PFLL at both relays is declared as failed and the re-synchronization process is initiated (about five to seven seconds) after channel status becomes OK.

In three-terminal mode

If one of the channels fails, the configuration reverts from master-master to master-slave where the master relay has both channels live. The master relay PFLL keeps the two slave relays in synchronization, and therefore there is no time limit for functionality. The PFLL of the slave relays is suspended (that is, the 87L function is not performed at these relays but they can still trip via DTT from the master relay) until the channel is restored. If the estimated error is within margin upon channel restoration and after two to three power cycles of valid PFLL calculations, the PFLL is declared as OK and the configuration reverts back to master-master.

If two channels fail, PFLL at all relays is declared as failed, and when the channels are back in service the re-synchronization process is initiated (about five to seven seconds) after channel status becomes OK.

Depending on the system configuration (number of terminals and channels), the 87L function operability depends on the status of channel(s), status of synchronization, and status of channel(s) ID validation. All these states are available as FlexLogic operands, for viewing in actual values, logged in the event recorder (if events are enabled in 87L menu), and also trigger targets (if targets are enabled in the 87L function). These FlexLogic operands can be used to trigger alarms, illuminate LEDs, and be captured in oscillography.

However, the **87L BLOCKED** FlexLogic operand reflects whether the local current differential function is blocked due to communications or settings problems. The state of this operand is based on the combination of conditions previously outlined. As such, it is recommended that it be used to enable backup protection if 87L is not available.

The **87L BLOCKED** operand is set when the 87L function is enabled and any of the following three conditions apply:

- At least one channel failed on a two or three-terminal single-channel system, or both channels failed on a two-terminal two-channel system
- PFLL has failed or is suspended

- A channel ID failure has been detected on at least one channel in a two-terminal single-channel system or in a three-terminal system, or a channel ID failure has been detected on both channels in a two-terminal dual-channel system
- All L30 communications alarms can be divided by major and minor alarms.

The major alarms are **CHANNEL FAIL**, **PFL FAIL**, and **CHANNEL ID FAIL**. The relay is blocked automatically if any of these conditions occur. Therefore, there is no need to assign these operands to a current differential block setting.

The minor alarms are **CRC FAIL** and **LOST PACKET**, which are indicators of a poor or noisy communications channel. If the relay recognizes that a packet is lost or corrupted, the 87L feature is not processed at that protection pass. Instead, it waits for the next valid packet.

10.2 Operating condition characteristics

10.2.1 Description

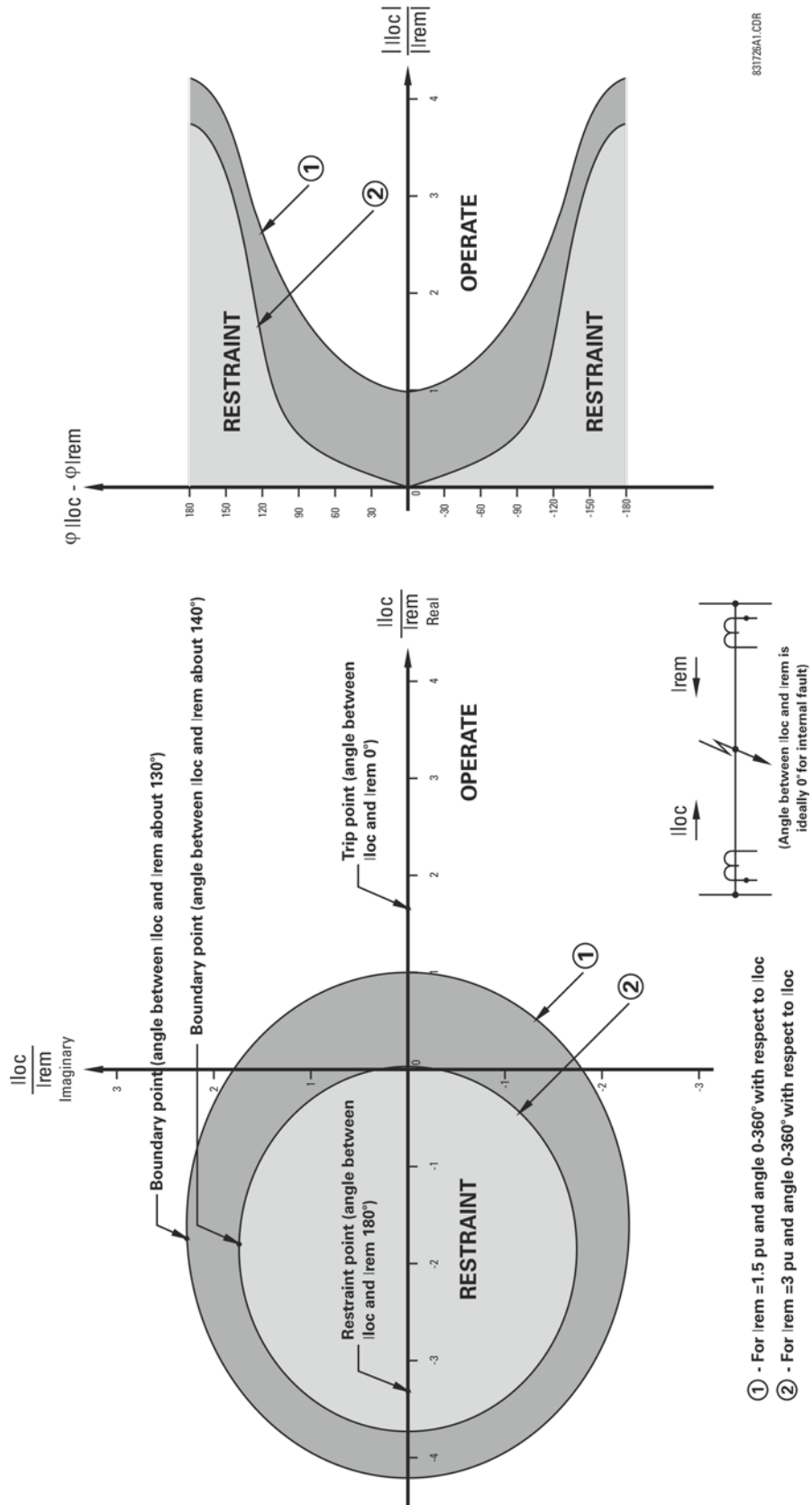
Characteristics of differential elements can be shown in the complex plane. The operating characteristics of the L30 are fundamentally dependant on the relative ratios of the local and remote current phasor magnitudes and the angles of I_{loc} / I_{rem} as shown in the Restraint Characteristics figure.

The main factors affecting the trip-restraint decisions are

- Difference in angles (+ real represents pure internal fault when currents are essentially in phase, - real represents external fault when currents are 180° apart)
- The magnitude of remote current
- The magnitude of the local current
- Dynamically estimated errors in calculations
- Settings

The following figure also shows the capability of the relay to handle weak infeed conditions by increasing the restraint ellipse when the remote current is relatively small (1.5 pu). Therefore, uncertainty is greater when compared with higher remote currents (3 pu). The characteristic shown also depend on settings. The second graph shows how the relay's trip-restraint calculation is made with respect to the variation in angle difference between local and remote currents. The characteristic for three-terminal mode is similar where both remote currents are combined together.

Figure 10-7: Restraint characteristics



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10.2.2 Trip decision example

Assume the following settings:

- Slope 1: $S_1 = 10\%$
- Slope 2: $S_2 = 10\%$
- Breakpoint: BP = 5 pu secondary
- Pickup: $P = 0.5$ pu

Assume the following local and remote currents:

- Local current: $I_{local} = 4.0$ pu $\angle 0^\circ$
- Remote current: $I_{remote} = 0.8$ pu $\angle 180^\circ$

The assumed condition is a radial line with a high resistance fault, with the source at the local end only, and through a resistive load current. The operating current is:

$$I_{op}^2 = |I_L + I_R|^2 = |4.0\angle 0^\circ + 0.8\angle 180^\circ|^2 = 10.24 \quad \text{Eq. 10-34}$$

Since the current at both ends is less than the breakpoint value of 5.0, the equation for two-terminal mode is used to calculate restraint as follows:

$$\begin{aligned} I_{Rest}^2 &= (2 \cdot S_1^2 \cdot |I_L|^2) + (2 \cdot S_1^2 \cdot |I_R|^2) + 2P^2 + \sigma \\ &= (2 \cdot (0.1)^2 \cdot |4|^2) + (2 \cdot (0.1)^2 \cdot |0.8|^2) + 2 \cdot (0.5)^2 + 0 \\ &= 0.8328 \end{aligned} \quad \text{Eq. 10-35}$$

where $\sigma = 0$, assuming a pure sine wave.

10.2.3 Trip decision test

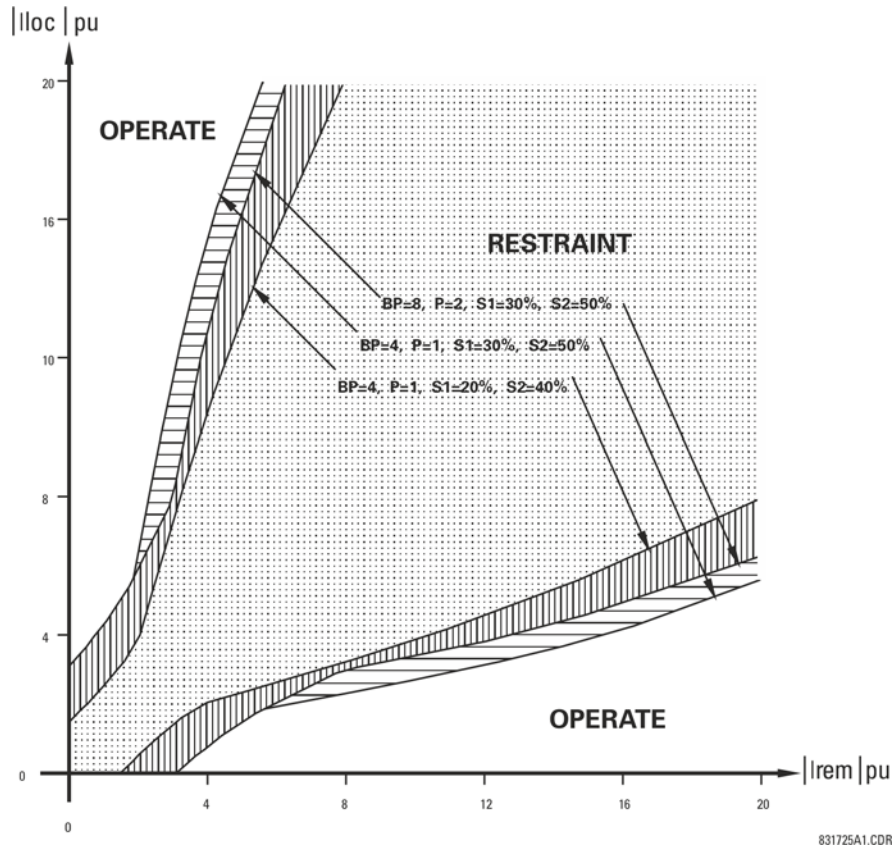
The trip condition is shown.

$$\frac{I_{Op}^2}{I_{Rest}^2} > 1 \Rightarrow \frac{10.24}{0.8328} = 12.3 > 1 \Rightarrow \text{Trip} \quad \text{Eq. 10-36}$$

The use of the **CURRENT DIFF PICKUP**, **CURRENT DIFF RESTRAINT 1**, **CURRENT DIFF RESTRAINT 2**, and **CURRENT DIFF BREAK PT** settings are discussed in the Current Differential section of the Settings chapter.

The following figure shows how the L30 settings affect the restraint characteristics. The local and remote currents are 180° apart, which represents an external fault. The breakpoint between the two slopes indicates the point where the restraint area is becoming wider to override uncertainties from CT saturation, fault noise, harmonics, and so on. Increasing the slope percentage increases the width of the restraint area.

Figure 10-8: Settings impact on restraint characteristic



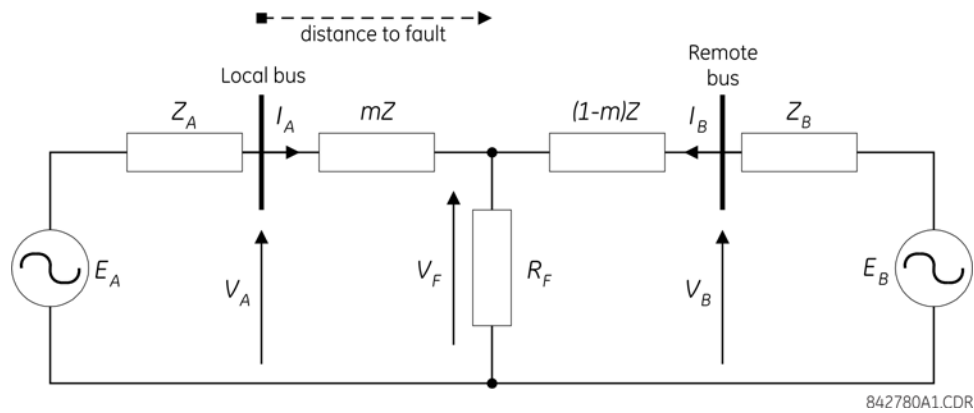
10.3 Fault locator

10.3.1 Description

Fault type determination is required for calculation of fault location. The algorithm uses the angle between the negative and positive sequence components of the relay currents. To improve accuracy and speed of operation, the fault components of the currents are used; that is, the pre-fault phasors are subtracted from the measured current phasors. In addition to the angle relationships, certain extra checks are performed on magnitudes of the negative and zero-sequence currents.

The single-ended fault location method assumes that the fault components of the currents supplied from the local (A) and remote (B) systems are in phase. The figure shows an equivalent system for fault location.

Figure 10-9: Equivalent system for fault location



The following equations hold true for this equivalent system.

$$V_A = m \cdot Z \cdot I_A + R_F \cdot I_F \tag{Eq. 10-37}$$

where

m = sought pu distance to fault

Z = positive sequence impedance of the line

I_F = fault current flowing through the fault point

The fault network during a fault can be decomposed into a pre-fault and a pure-fault network. Therefore, the fault current I_F is calculated as follows by using the current division rule in the pure-fault network.

$$I_F = \frac{Z_A + Z + Z_B}{(1 - m)Z + Z_B} \cdot I_{AF} = \frac{1}{d} \cdot I_{AF} \tag{Eq. 10-38}$$

where

d is the current distribution factor, which is a complex value

Substituting the second equation into the first equation and multiplying both sides by the complex conjugate of I_{AF} ,

$$V_A \cdot I_{AF}^* = m \cdot Z \cdot I_A \cdot I_{AF}^* + R_F \cdot \frac{1}{d} \cdot |I_{AF}|^2 \tag{Eq. 10-39}$$

where

* denotes complex conjugate

Assuming the system is homogeneous, d is then a real number. The fault resistance does not have any imaginary part. The preceding equation solved for the unknown m yields the following fault location algorithm:

$$m = \frac{\text{Im}(V_A \cdot I_{AF}^*)}{\text{Im}(Z \cdot I_A \cdot I_{AF}^*)} \tag{Eq. 10-40}$$

where

$\text{Im}()$ stands for the imaginary part of a complex number

Depending on the fault type, appropriate voltage and current signals are selected from the phase quantities before applying the preceding equation (the superscripts denote phases, the subscripts denote stations).

For AG faults:

$$V_A = V_A^A, \quad I_A = I_A^A + K_0 \cdot I_{0A} + Z_{0M}/Z \cdot I_{0M}, \quad I_{AF} = I_A^A - I_{Apre}^A \tag{Eq. 10-41}$$

For BG faults:

$$V_A = V_A^B, \quad I_A = I_A^B + K_0 \cdot I_{0A} + Z_{0M} / Z \cdot I_{0M}, \quad I_{AF} = I_A^B - I_{Apre}^B \tag{Eq. 10-42}$$

For CG faults:

$$V_A = V_A^C, \quad I_A = I_A^C + K_0 \cdot I_{0A} + Z_{0M} / Z \cdot I_{0M}, \quad I_{AF} = I_A^C - I_{Apre}^C \tag{Eq. 10-43}$$

For AB and ABG faults:

$$V_A = V_A^A - V_A^B, \quad I_A = I_A^A - I_A^B, \quad I_{AF} = (I_A^A - I_A^B) - (I_{Apre}^A - I_{Apre}^B) \tag{Eq. 10-44}$$

For BC and BCG faults:

$$V_A = V_A^B - V_A^C, \quad I_A = I_A^B - I_A^C, \quad I_{AF} = (I_A^B - I_A^C) - (I_{Apre}^B - I_{Apre}^C) \tag{Eq. 10-45}$$

For CA and CAG faults:

$$V_A = V_A^C - V_A^A, \quad I_A = I_A^C - I_A^A, \quad I_{AF} = (I_A^C - I_A^A) - (I_{Apre}^C - I_{Apre}^A) \tag{Eq. 10-46}$$

where K_0 is the zero sequence compensation factor (for the first six equations)

Z_{0M} is the mutual zero sequence impedance

$I_{0M} = I_G / 3$ and I_G is the ground current of the adjacent line. The I_{0M} compensation term is applied for the entirely parallel line.

For ABC faults, all three AB, BC, and CA loops are analyzed and the final result is selected based upon consistency of the results.

The element calculates the distance to the fault (with m in miles or kilometers) and the phases involved in the fault.

The relay allows locating faults from delta-connected VTs. If the **FAULT REPORT 1 VT SUBSTITUTION** setting is set to "None," and the VTs are connected in wye, the fault location is performed based on the actual phase to ground voltages. If the VTs are connected in delta, fault location is suspended.

If the **FAULT REPORT 1 VT SUBSTITUTION** setting value is "V0" and the VTs are connected in a wye configuration, the fault location is performed based on the actual phase to ground voltages. If the VTs are connected in a delta configuration, fault location is performed based on the delta voltages and externally supplied neutral voltage:

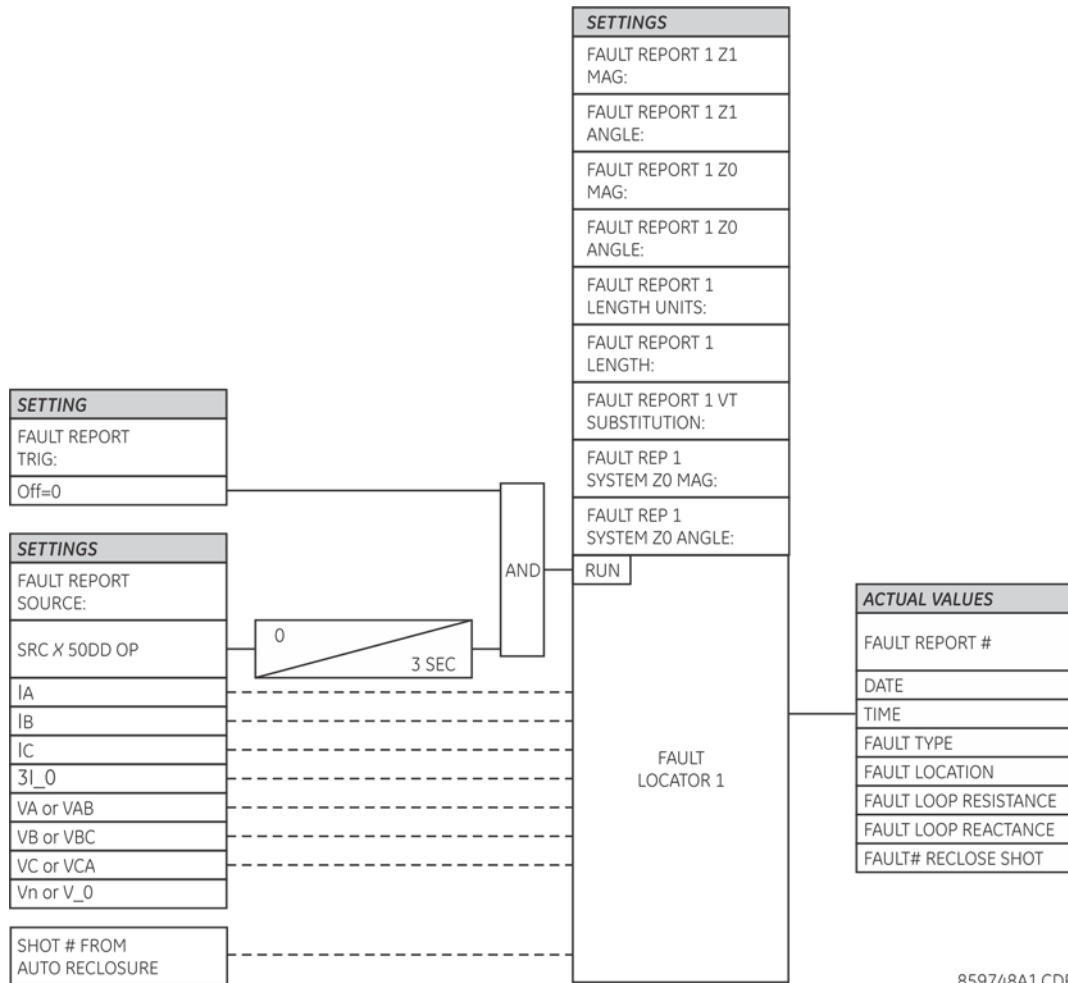
$$\begin{aligned} V_A &= \frac{1}{3}(V_N + V_{AB} - V_{CA}) \\ V_B &= \frac{1}{3}(V_N + V_{BC} - V_{AB}) \\ V_C &= \frac{1}{3}(V_N + V_{CA} - V_{BC}) \end{aligned} \tag{Eq. 10-47}$$

If the **FAULT REPORT 1 VT SUBSTITUTION** setting value is "I0" and the VTs are connected in a wye configuration, the fault location is performed based on the actual phase to ground voltages. If the VTs are connected in a delta configuration, fault location is performed based on the delta voltages and zero-sequence voltage approximated based on the zero-sequence current:

$$\begin{aligned} V_A &= \frac{1}{3}(V_{AB} - V_{CA}) - Z_{S\text{VSO}} I_0 \\ V_B &= \frac{1}{3}(V_{BC} - V_{AB}) - Z_{S\text{VSO}} I_0 \\ V_C &= \frac{1}{3}(V_{CA} - V_{BC}) - Z_{S\text{VSO}} I_0 \end{aligned} \tag{Eq. 10-48}$$

where Z_{SY0} is the equivalent zero-sequence impedance behind the relay as entered under the fault report setting menu.

Figure 10-10: Fault locator scheme



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L30 Line Current Differential System

Chapter 11: Maintenance

This chapter outlines monitoring, maintenance, repair, storage, and disposal of the hardware and software.

11.1 Monitoring

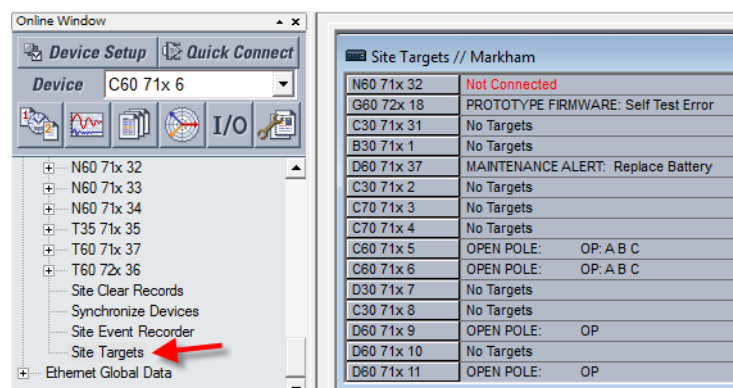
Devices and data can be monitored.

11.1.1 Devices with Site Targets

To view an overview of devices:

1. Access the **Site Targets** item in the Online Window area, below the list of devices. It can take a few minutes for all devices to be read.
2. Acknowledge any messages for unaccessible devices. The Site Targets window opens when done.

Figure 11-1: Site Targets window



11.1.2 Data with Modbus Analyzer

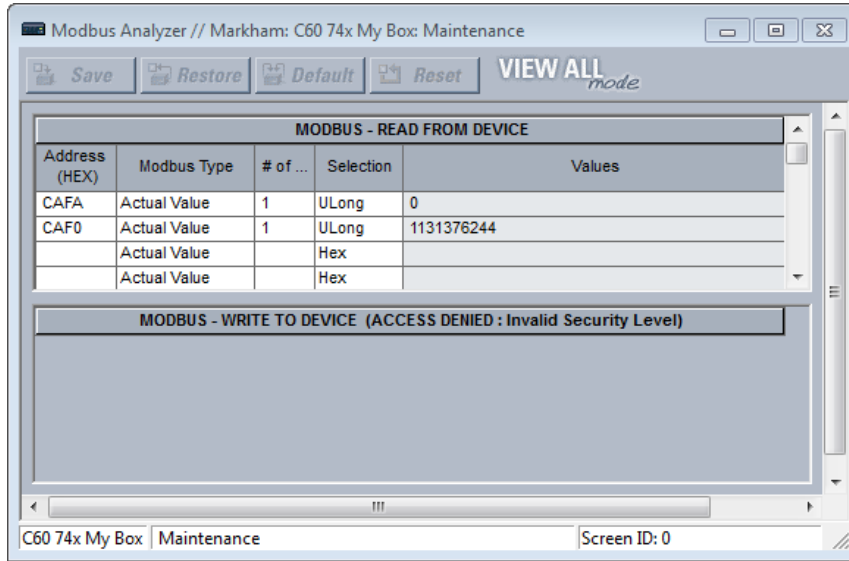
Use the Modbus Analyzer under **Maintenance > Modbus Analyzer** to monitor the values of the UR device. Use the Modbus memory map addresses outlined in the UR Family Communications Guide for the entries.

The upper part of the window displays values. The lower part of the window is for factory service use.

The first row in the figure shows that Contact Output 1 operation is being monitored. Its Modbus address is CAFA. The actual value read from the device is 0, which means that it is off.

The second row in the figure shows the Contact Output 1 Name. It has a Modbus address of CAF0 and a default value of "Cont Op 1." None of **Selection** column settings render this value because they present the information based on numbering systems.

Figure 11-2: Modbus Analyzer used to monitor actual values on a UR



Address (HEX) — Modbus address in hexadecimal. See the Modbus memory map in the UR Family Communications Guide or in the web interface (enter IP address of UR device in a web browser).

Modbus Type

- Actual Value — To read the data in the UR device
- Setting — To read a setting in the UR device
- Coil — To read a command in the UR device

of — Element, input, or output to read. An example is 1 for Contact Output 1.

Selection (examples demonstrate various ways to represent 0)

Hex — A decimal numbering system based on 16 possible values, from 0 to 9 and A to F. An example is 0x0000.

Char — A single unicode character, such as C. An example is 0.

Int — A 32-bit number, either positive or negative. An example is 0.

UInt — Unsigned 32-bit integer, which means that it cannot be negative but can be twice as large as a signed integer. An example is 0.

Long — A 64-bit number, either positive or negative. An example is 0.

ULong — Unsigned 64-bit number, which means that it cannot be negative but can be twice as large as a signed 64-bit number. An example is 0.

Float — A numbering system with no fixed number of digits before or after the decimal point. An example is 0.000000.

Binary — A numbering system using 0 and 1. An example is 0000-0000-0000-0000.

Entries are not saved when closing the window.

11.2 General maintenance

The L30 requires minimal maintenance. As a microprocessor-based relay, its characteristics do not change over time. Expected service life is 20 years for UR devices manufactured June 2014 or later when applied in a controlled indoor environment and electrical conditions within specification.

While the L30 performs continual self-tests, it is recommended that maintenance be scheduled with other system maintenance. This maintenance can involve in-service, out-of-service, or unscheduled maintenance.

11.2.1 In-service maintenance

1. Visual verification of the analog values integrity, such as voltage and current (in comparison to other devices on the corresponding system).
2. Visual verification of active alarms, relay display messages, and LED indications.
3. LED test.
4. Visual inspection for any damage, corrosion, dust, or loose wires.
5. Event recorder file download with further events analysis.

11.2.2 Out-of-service maintenance

1. Check wiring connections for firmness.
2. Analog values (currents, voltages, RTDs, analog inputs) injection test and metering accuracy verification. Calibrated test equipment is required.
3. Protection elements setting verification (analog values injection or visual verification of setting file entries against relay settings schedule).
4. Contact inputs and outputs verification. This test can be conducted by direct change of state forcing or as part of the system functional testing.
5. Visual inspection for any damage, corrosion, or dust.
6. Event recorder file download with further events analysis.
7. LED Test and pushbutton continuity check.

NOTICE

To avoid deterioration of electrolytic capacitors, power up units that are stored in a de-energized state once per year, for one hour continuously.

11.2.3 Unscheduled maintenance (system interruption)

View the event recorder and oscillography or fault report for correct operation of inputs, outputs, and elements.

11.3 Retrieve files

Data, oscillography, log, events, routing, ARP, and other files can be transferred using the EnerVista software to a computer or to a USB flash drive when using the graphical front panel. These files can be requested by technical support staff.

To retrieve a file using EnerVista software:

1. If the CyberSentry option is enabled, log in to the EnerVista software using the Administrator role.
2. In the Online Window area of EnerVista, access **Maintenance > Retrieve File**. The window opens.
3. Note the destination folder to which the file is to be saved at the top and change it if required. You can copy the path or open the folder for convenience at this time.
4. Select the file to download from the UR device.

- Click the **Read File** button. The file is saved to the destination folder. The EnerVista window remains open to download additional files.

To retrieve a file using a USB drive:

- Insert the USB drive into the bottom USB port on the graphical front panel. The page displays on the front panel.
- Using the Up or Down pushbuttons on the front panel, select the file.
- Press the **COPY** pushbutton. The files are copied from the L30 to the USB drive.

NOTICE

Do not unplug the USB drive while copying is in progress, else the USB drive can be compromised.

- When done, to exit unplug the USB drive or press the **ESCAPE** pushbutton.

11.3.1 CyberSentry security event files

CyberSentry security events are available in the following two files: SECURITY_EVENTS.CSV and SETTING_CHANGES.LOG.

11.3.1.1 Security events file

The figure shows the content for the SECURITY_EVENTS.CSV file.

Figure 11-3: Security events file

	A	B	C	D	E	F	G	H	I	J
1	FORMAT	EVENT_INFO_1	Event Number	Data/Time	Username	IP Address	Role	Activity Value	Change Method	
2		EVENT_INFO_1	71	Feb 08 2016 10:07:20.893820	Observer	10.14.127.1	0	14	5	
3		EVENT_INFO_1	72	Feb 08 2016 10:07:20.931321	Observer	10.14.127.1	0	15	5	
4		EVENT_INFO_1	73	Feb 08 2016 10:07:41.314660	Administrator	10.14.127.1	1	14	5	
5		EVENT_INFO_1	74	Feb 08 2016 10:07:54.383404	Administrator	10.14.127.1	1	10	5	
6		EVENT_INFO_1	75	Feb 08 2016 10:07:58.187574	Administrator	10.14.127.1	1	9	5	
7		EVENT_INFO_1	76	Feb 08 2016 10:08:01.991740	Administrator	10.14.127.1	1	6	5	
8		EVENT_INFO_1	77	Feb 08 2016 10:08:42.908413	Administrator	10.14.127.1	1	6	5	
9		EVENT_INFO_1	78	Feb 08 2016 10:08:43.493822	Administrator	10.14.127.1	1	6	5	
10		EVENT_INFO_1	79	Feb 08 2016 10:09:46.908404	Administrator	10.14.127.1	1	6	5	
11		EVENT_INFO_1	80	Feb 08 2016 10:14:44.958406	Keypad	0.0.0.0	3	14	1	

Time — Local time.

Activity — The actual security event.

- 1 = Authentication Failed
- 2 = User Lockout
- 3 = FW Upgrade
- 4 = FW Lock
- 5 = Settings Lock
- 6 = Settings Change, this can fill the entire event log. Hence it is supported by the already existing SETTINGS_CHANGE.LOG file. This event is not required.
- 7 = Clear Oscillography command
- 8 = Clear Data Logger command
- 9 = Clear Demand Records command
- 10 = Clear Energy command
- 11 = Reset Unauthorized Access
- 12 = Clear Teleprotection Counters
- 13 = Clear All Records
- 14 = Role Log out
- 15 = Role Log in

11.3.1.2 Setting changes file

The SETTING_CHANGES.LOG file stores all the setting changes. A total of 1024 events are stored in a circular buffer in non-volatile memory.

Figure 11-4: Setting changes file

```

SETTING_CHANGES.LOG - Notepad
File Edit Format View Help
FORMAT_CHANGE_INFO,Data/Time,Old Value,New Value,Data Item,Modbus Address
CHANGE_INFO,Feb 05 2016 11:06:41.550070,No,No,Clear All Relay Records Command,0xC434
CHANGE_INFO,Feb 05 2016 11:08:30.535489, 1.0s, 1.1s,Flash Message Time,0x4050
CHANGE_INFO,Feb 05 2016 11:09:01.877154,No,No,Event Recorder Clear Command,0x3406
CHANGE_INFO,Feb 05 2016 11:09:10.243824,No,No,Oscillography Clear Data,0x3011
CHANGE_INFO,Feb 05 2016 11:10:05.820902,Virt Op 1,VirtOp1 IOPT,Virtual Output x Name,0xC130
CHANGE_INFO,Feb 05 2016 11:18:28.745903,No,No,Energy Clear Command,0x1D60
CHANGE_INFO,Feb 05 2016 11:18:32.960484,No,No,Reset Unauthorized Access,0x2230
CHANGE_INFO,Feb 05 2016 11:21:31.975071, 1.1s, 1.2s,Flash Message Time,0x4050
CHANGE_INFO,Feb 05 2016 11:22:09.393817,Disabled,Enabled,Virtual Output x Events,0xC136
CHANGE_INFO,Feb 05 2016 11:22:09.995902,Virt Op 2,VirtOp RST1,Virtual Output x Name,0xC138
CHANGE_INFO,Feb 05 2016 11:22:09.997997,Disabled,Enabled,Virtual Output x Events,0xC138
CHANGE_INFO,Feb 05 2016 11:25:59.914652,Relay-1,Markham Site,Relay Name,0x43E1

```

11.4 Convert device settings

Settings files can be upgraded or downgraded to other firmware versions. For example, version 7.4 settings can be upgraded to version 7.6.

Settings are reset to factory default upon conversion.

When using IEC 61850, additional configuration is required. Contact GE for guidance before converting settings.

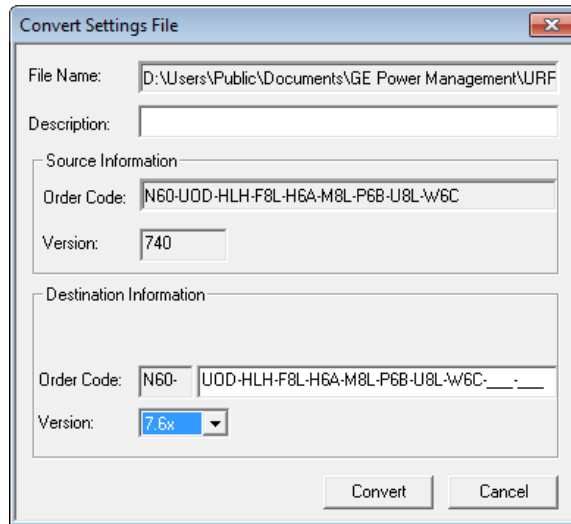
To convert settings:

1. If not already in the Offline Window area, right-click the online device in the EnerVista software and select the **Add Device to Offline Window** option. This copies the settings to the Offline Window area. Any message about file repair usually means that settings were missing in the original file and have been added with default values to the new file.
2. Make a copy of the settings file in the Offline Window area by right-clicking the file and selecting **Duplicate Device**. A copy of the file is made and the file name start with "Copy of." Optionally rename the file by right-clicking it and selecting the **Rename Device** option.
3. Convert the settings by right-clicking one of the files in the Offline Window and selecting the **Convert Device Settings** option.

GE recommends converting settings in firmware steps, for example when converting from 6.0 to 7.4x, convert first to 7.0 then 7.4 in order to follow embedded conversion rules and keep settings.

The settings convert and a report generates.

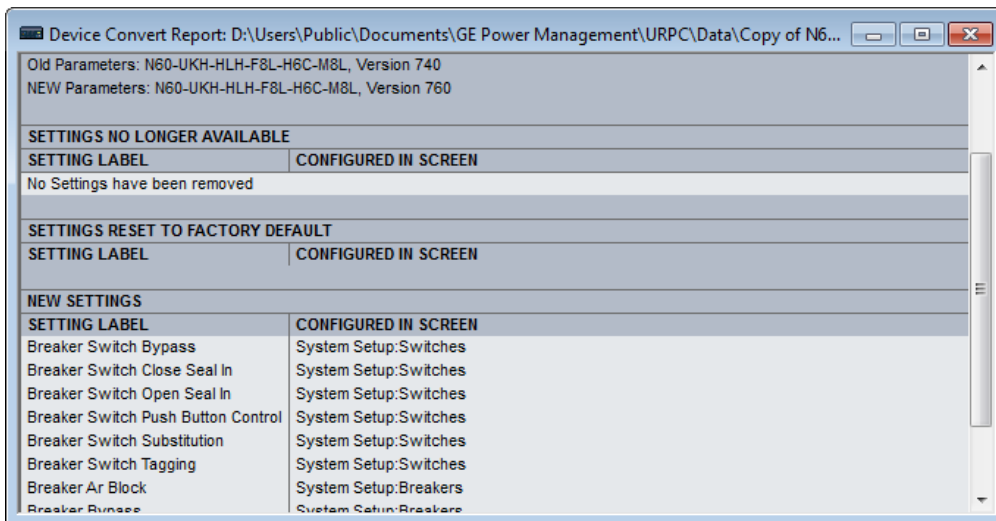
Figure 11-5: Upgrade settings



- Review the conversion report. The values of all settings that have been defaulted during conversion are not listed in the conversion report; to find the value of a setting before conversion, inspect the device backup file made before conversion.

In the example shown here, settings have been reset to factory defaults and several settings are new in firmware version 7.6 under **Settings > System Setup > Switches** and **Breakers**.

Figure 11-6: Conversion report



- Change settings in the new file, for example by looking at the original file.
- Write the converted file to the device, for example by dragging and dropping from the Offline Window to the Online Window.
- Check settings and operation.

11.5 Copy settings to other device

Settings from one L30 device can be copied to another L30 device for rapid deployment. The order codes must match. See the Settings File section at the beginning of the Interfaces chapter for a list of settings not deployed, such as IP address.

To apply settings to another device:

1. Right-click the device in the Online window and select the **Add Device to Offline Window** option. A window opens.
2. Check the file path and name the file, then click the **Receive** button. An example is to save the files in D:\Users\Public\Public Documents\GE Power Management\URPC\Data\ and to name the source device L30_Deployment. At the prompt, confirm the action. The settings are saved in .cid, .icd, and .urs files, and the entry displays in the Offline window area.
3. Right-click the device in the Offline window area and select the **Duplicate Device** option. The device is copied with a prefix of "Copy of." Multiple duplicates results in files being named "Copy of Copy of" for example, which can be avoided by deleting the folder copies from the path shown on mouse-over.
4. Right-click the copied device and rename it.
5. Right-click the copied device and select the **Edit Device Properties** option. Make the changes for the new device.
6. Send the file to new device by dragging and dropping it into the Online Window area. Or right-click and select the **Write Settings to Device** option.
7. Update the remaining settings, such as IP address.

11.6 Compare settings

Settings are comparable against default values and between two UR devices.

Some of the IEC 61850 settings use floating point data, which guarantees accurate representation of real numbers up to seven digits. Numbers with more than seven digits are approximated within a certain precision. This can result in differences between what is entered and what is saved, and for example results in differences shown on a settings comparison report.

When comparing two settings files with the graphical front panel, all graphical front panel features are compared except for the single-line diagrams.

11.6.1 Compare against defaults

To compare settings against default values:

1. Right-click the device in the Offline Window area and select **Compare Settings With Defaults**. The file generates and the number of differences displays.
2. To save the report, click **File > Save As**, select the TXT, PDF, or CSV format from the drop-down list, and enter a name for the file.

In the figure, the first entry (red) is from the device, while the second (green) is the default value.

Figure 11-7: Device settings compared with default values

#		Setting Name	Group	Module	Item	Value
1	-	Contact Input Debounce Time	1	1	1	2.0 ms
2	+	Contact Input Debounce Time	1	1	1	6.0 ms
3	-	Contact Input Debounce Time	1	2	1	2.0 ms
4	+	Contact Input Debounce Time	1	2	1	6.0 ms
5	-	Contact Input Debounce Time	1	3	1	2.0 ms
6	+	Contact Input Debounce Time	1	3	1	6.0 ms

11.6.2 Compare two devices

Preferences are set under **File > Preferences** as follows:

- **Comparison Report: Sequential File 1, File 2 Layout** — When disabled (default), the report shows only what differs, as shown in the previous figure. When enabled, the report indicates differences by device.

Figure 11-8: Device settings compared between two devices, displayed sequentially

```

1, File2 , Existing 7.40 IEC61850 settings removed., ____, New IEC61850 settings added with default values.
2, File2 , Bkr Phase A Open, 1__1__1, 0 (OFF)
3, File2 , Bkr Phase B Open, 1__1__1, 0 (OFF)
4, File2 , Bkr Phase C Open, 1__1__1, 0 (OFF)
5, File2 , Breaker Restrike Block, 1__1__1, 0 (OFF)
6, File2 , Breaker Restrike Block, 1__2__1, 0 (OFF)
7, File2 , Breaker Restrike Brk Open, 1__1__1, 0 (OFF)
8, File2 , Breaker Restrike Brk Open, 1__2__1, 0 (OFF)
9, File2 , Breaker Restrike Cls Cmd, 1__1__1, 0 (OFF)
10, File2 , Breaker Restrike Cls Cmd, 1__2__1, 0 (OFF)

```

There are two ways to compare devices: devices in the Offline area or between Online and Offline devices.

To compare settings of two devices in the Offline Window area:

1. Right-click a first device in the Offline Window area and select **Compare Two Devices**.
2. In the window that opens, select a second device and click the **Receive** button. The file generates and the number of differences displays.
3. To save the report, click **File > Save As**, select the TXT, PDF, or CSV format from the drop-down list, and enter a name for the file.

To compare settings between Online and Offline devices:

1. Right-click a device in the Online Window area and select **Compare with Device**.
2. In the window that opens, enter a path/file name at the bottom of the window.
3. Select the second device.
4. Click the **OK** button. The file generates, and the differences are highlighted in red, which is for the first device.

11.7 Back up and restore settings

Back up a copy of the in-service settings for each commissioned UR device, so as to revert to the commissioned settings after inadvertent, unauthorized, or temporary setting changes are made, after the settings defaulted due to firmware upgrade, or when the device has to be replaced. This section describes how to backup settings to a file and how to use that file to restore the settings to the original relay or to a replacement relay.

11.7.1 Back up settings

The following file types can be saved:

- URS — UR settings file — When the IEC 61850 option is not present
- IID — Instantiated IED capability description file — Actual settings on UR
- ICD — IED Capability Description file — Default settings on UR
- CID — Configured IED description file — Settings sent to the UR (may or may not contain the present settings)

UR device settings can be saved in a backup URS file using the EnerVista UR Setup software. The URS file is the standard UR settings file. For an introduction to settings files in the URS format, see the beginning of the Interfaces chapter.

When the IEC 61850 option is present, the settings can be saved alternatively in a backup IID file either using the EnerVista UR Setup software in online mode or by using any of the supported file transfer protocols. The IID file is one of several IEC 61850 Substation Configuration Language (SCL) file types; see the IEC 61850 chapter in the UR Series Communications Guide for an introduction to SCL.

"TBD" displays when a setting in a modeled element is configured with a non-modeled operand. For example, Phase IOC is modeled in a firmware release, while the LED operands are not modeled. If the block setting of the Phase IOC is configured with LED operands, its displays as TBD in IID and CID files, the web interface, or in an MMS client.

The options that display in the EnerVista software when right-clicking depend on device options.

Preferences are set in the **File > Preferences > IEC 61850** menu. There are two options as follows:

- **Preserve custom attributes when importing SCD/CID files** — Applies to the **Add Device to Offline Window** option. When enabled, the IID file also is to be copied to the computer. The IID file that is retrieved from the relay is therefore assumed to be in synchronization with the resulting .urs file, and in fact in this situation the IID file on the computer is a copy of the IID file that was read from the online device. When disabled, the IID file on the computer is to be left unchanged. The location of the IID file is C:\ProgramData\GE Power Management\urpc\Offline, for example.
- **Do not update IID file when updating SCL files** — When enabled (default), an IID file is not to be created on the computer and if one is already present there, it is neither removed nor updated. Have this option enabled when you want to keep the IID file from the UR device instead of from another tool. The location of the file is C:\ProgramData\GE Power Management\urpc\Offline, for example.

An Environment backup stores a list of sites and devices in the Online and Offline Window areas. Settings files are not contained within the environment file. If a settings file is moved, renamed, or deleted after the backup, it is removed from the Offline Window during the restore.

To save a settings file in the URS format in EnerVista Online Window:

1. In EnerVista, connect to the device in the Online Window area.
2. Right-click the device name in the Online Window area and select **Add Device to Offline Window**. A window opens.
3. Select or enter a file name and location, and click the **Receive** button. A .urs file is created in the Offline Window area.

To create a new settings file in the URS format in EnerVista Offline Window:

1. In EnerVista, right-click in the Offline Window area and select **New Device**. A window opens.
2. Change the file name at the end of the **Path** field, keeping the .urs extension.
3. From the **Associate File with Device** drop-down list, select the UR device. Other fields complete automatically. Otherwise, when you do not select a device from the drop-down list, all fields need to be completed manually and only devices that match the entered order code and version display in the list.
4. The **Serial # Lock** field is the serial number of the intended device. It ensures that the settings file is sent only to the specific relay that matches the serial number.
5. Click the **OK** button to create the .urs file in the Offline Window area.

To save settings in the IID format in EnerVista Online Window:

1. In EnerVista, connect to the device in the Online Window area.
2. Right-click the device name in the Online Window area and select **Read IID File**. The option is not present when the device does not have the IEC 61850 option. A window opens when successful.
3. Select or enter a file name and location, and click the **Receive** button. A .iid file is created.

To save settings in the IID format in EnerVista Offline Window:

1. In EnerVista, right-click the device in the Offline Window area.
2. Select the **Create IID File** option for firmware below 7.3. The option is not always available. Select the **Save As** option for firmware 7.3 and later, and select the IID option from drop-down list.

No file is generated. The IID file on the computer is copied to the location specified.

3. If the **Do not update IID file when updating SCL files** preference is enabled under **File > Preferences > IEC 61850**, then a message displays to that effect. This means that there is no IID file available on the computer to be copied, so a new one is generated.

To save settings in the IID format using TFTP:

1. On a computer on the same subnetwork as the UR device, open a command window.
2. Enter

```
TFTP <IP address> GET ur.iid <destination>
```

where

<IP address> is the IP address of the UR device

ur.iid is the internal name of the IID file in the UR device

<destination> is the path and file name of the IID file. If omitted, the file is saved as ur.iid in the command window default directory.

An example is

```
TFTP 192.168.1.101 GET ur.iid Feeder1.iid
```

To save settings in the ICD format in EnerVista Online Window:

1. In EnerVista, right-click the device in the Online Window area.
2. Select the **Read ICD File** option. A window opens.
3. Enter a path/name for the file, and click the **Save** button.

To save settings in the ICD format in EnerVista Offline Window:

1. In EnerVista, right-click the device in the Offline Window area.
2. Select the **Create ICD File** option. Or select the **Save As** option, and select the ICD option from drop-down list.
You can be prompted to specify if the file is for firmware version 7.12 or later.
The file is saved to the location specified.

To save settings in the CID format in EnerVista Online Window:

1. In EnerVista, right-click the device in the Online Window area.
2. Select the **Read ICD File** option. A window opens.
3. Enter a path/name for the file, and click the **Save** button.

To save settings in the CID format in EnerVista Offline Window:

1. In EnerVista, right-click the device in the Offline Window area.
2. Select the **Save As** option, which displays for firmware 7.3 and later, and select the CID option from the drop-down list.
The file is copied from the computer to the location specified.

To save list of sites and devices with an Environment backup:

1. In EnerVista, click **File > Environment > Backup**. A window opens.
2. Name and save the .ENV file.

11.7.2 Restore settings

UR device settings can be restored to the values they were at when a URS backup file was created using the EnerVista UR Setup software. When the IEC 61850 option is present, the settings can alternatively be to the values they were at when an IID type backup was created either using the EnerVista UR Setup software in online mode or by using any of the supported file transfer protocols. Note that TFTP cannot be used here, as TFTP "put" mode is disabled for security reasons.

To restore completely, a few settings need to be entered manually either via EnerVista UR Setup or via the UR device front panel. If the restore operation is to be via Ethernet, first the UR device must have its IP address settings entered via the front panel. These are located at **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **NETWORK 1(3)** and **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **IPv4 ROUTE TABLE 1(6)** ⇒ **DEFAULT IPv4 ROUTE** ⇒ **GATEWAY ADDRESS**.

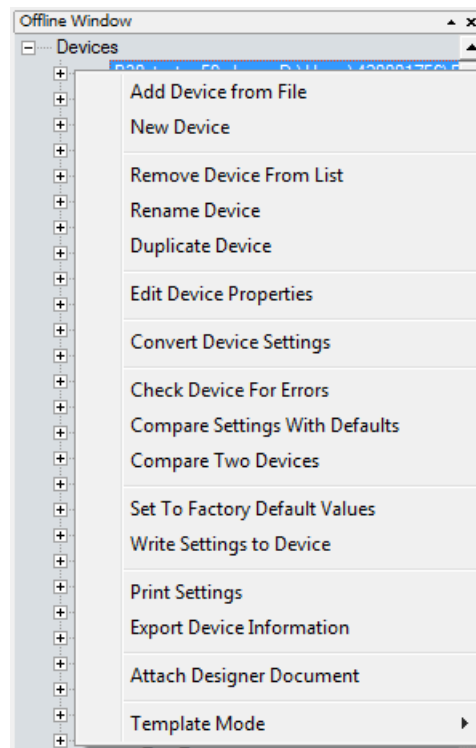
When importing a file, it cannot have a blank numeric value. All numeric values must be non-blank, otherwise the file is rejected.

URS and IID procedures are outlined here.

To restore settings from a URS file:

1. In EnerVista, connect to the device in the Online Window area.
2. Right-click the .urs file in the Offline Window area and select **Add Device from File** to locate a file, and/or drag-and-drop the file from the Offline Window area to the device in the Online Window area.

Figure 11-9: Restoring a URS settings file



3. Two prompts are possible, first that the URS file does not include the complete IEC 61850 configuration and that it needs to be recreated if you continue. This means that the URS file is from UR version 7.30 or higher, has the IEC 61850 software option in the order code, but any IEC 61850 content will be compromised and will need to be configured. Second, a message can display that the URS file is part of a device folder and to use the device's CID file. This means that the URS file is from UR version 7.3 or higher, has the IEC 61850 software option in the order code, and is part of the device folder. The user is trying to add a URS file from inside a device's folder. Instead, the user needs to use the CID file from the device folder.

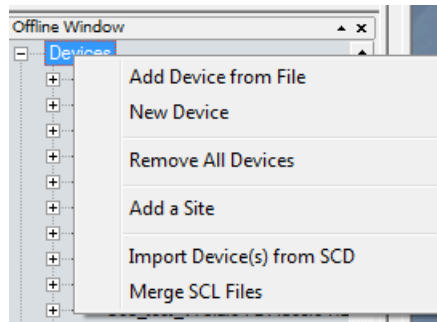
These messages display because the roles of the protection engineer and network engineer can be separate. The former can require a URS file, while the latter can require stored Modbus settings and protection schemes.

4. Manually copy the remaining settings, outlined as follows.

To restore settings from an IID file using EnerVista software:

1. In Windows, make a copy the IID file with a cid extension.
2. Connect to the device in the Online Window area.
3. In the Offline Window area, right-click **Devices** and select **Import Devices from SCD**.

Figure 11-10: Importing an SCD or CID file



4. Navigate to and select the file with .cid extension. When prompted, enter a file name to give to an intermediate URS file. The URS file is added to the Offline Window area.
5. Drag the imported file in the Offline Window to the device in the Online Window. Note that the **RELAY SETTINGS** value also is written to a device, and the accepting relay is put into "Programmed" or "Not Programmed" mode as configured in the offline file.
6. Manually copy the remaining settings, outlined as follows.

To restore settings from an IID using SFTP:

1. In Windows, make a copy the IID file with a cid extension.
2. On a computer on the same subnetwork as the UR device, open a SFTP client application, such as WinSCP. Note that TFTP cannot be used here.
3. Use the device's IP address as the host name.
4. If the device has the CyberSentry option, use the User Name of "Administrator" or "Engineer", and the password programmed for the selected role. The default password is "ChangeMe1#" (without quotation marks).
5. If the device does not have the CyberSentry option, use the User Name of "Setting", and the password programmed for the Setting role. The default password is "ChangeMe1#" (without quotation marks).
6. Upload the backup file copy with the CID extension. WinSCP uses drag-and-drop or copy-and-paste for this.
7. Manually copy the remaining settings, outlined as follows.

To manually copy remaining settings:

1. Settings listed in section 4.1.2 Settings Files are not transferred to the UR device with settings files. Enter them manually either via the front panel or via EnerVista UR Setup software. The values that these settings had at the time the backup was created are contained within the backup file, accessed through EnerVista UR Setup software.

To restore the list of sites and devices from an Environment backup:

1. In EnerVista, click **File > Environment > Restore**. A window opens.
2. Select the .ENV file to restore.

11.8 Upgrade software

In general, the latest releases of the EnerVista software can be used with all firmware versions. For example, EnerVista software released for UR 7.4 can be used to access multiple UR devices that have version 7.4x, 7.2x, and 6.0x firmware installed.

Existing installations do not need to be uninstalled before upgrade.

You can also downgrade the software; use the same procedure.

To upgrade the EnerVista software:

1. If a beta version of the EnerVista UR Setup software is installed, uninstall it, for example using the Windows Control Panel.
2. For Windows 10, disconnect any USB cable to the L30, else the UR USB drivers do not install correctly.
3. Download the latest EnerVista software and/or firmware from <http://www.gegridsolutions.com/app/ViewFiles.aspx?prod=urfamily&type=7>
4. Double-click the file and complete the wizard. The software installs.
5. Access the software and check the version number under **Help > About**. If the new version does not display, try uninstalling the software and reinstalling the new versions.
6. For Windows 10, to finish installing the UR USB driver, open **Device Manager > Ports**, then plug in the USB cable (to connect the relay and computer). A new port starting with "GE Virtual Serial Port" is available. If available, click the **OK** button to complete the installation.

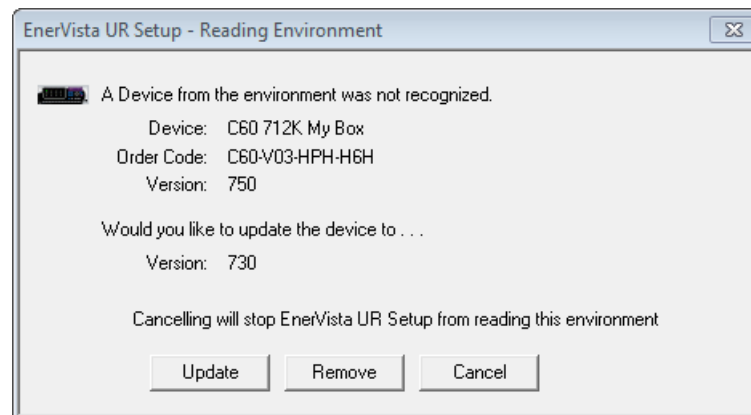
If not available, uninstall the existing GE USB driver in the **Device Manager > Ports**. (Right-click and "Uninstall.")

When complete, unplug and re-plug the USB cable connecting the UR device. The "GE Virtual Serial Port" driver is now available.

A message can display about a version not being supported. An example is when upgrading from version 7.12K to 7.4x. The 7.12K entry is removed from the Offline Window area.

A message can display in the EnerVista software upon launch that "a device from the environment was not recognized." This means that a device is online and its firmware version conflicts with the software version. In the example shown, a C60 with firmware version 7.5x is online, but the software version is 7.3x. Updating removed incompatible files and changed the device to version 7.3x, after which you need to make the order codes consistent as outlined next.

Figure 11-11: Mismatch in order code between software and device



To make the order codes consistent:

1. In EnerVista, click the **Device Setup** button. The window opens.
2. Expand the entry for the UR device.
3. Click the **Read Order Code** button. The order code and version of the device are populated to the software.
4. Click the **OK** button to save the change.

11.9 Upgrade firmware

If upgrading both EnerVista software and L30 firmware, upgrade the software first.

The firmware of the L30 device can be upgraded, locally or remotely, using the EnerVista software.

Upgrades are possible for the same release (such as 7.01 to 7.02) and from one firmware version to another (such as 7.2 to 7.3). When upgrading to another firmware version, check the release notes for compatibility. Release notes are located in the Support Documents section of the website at

<http://www.gegridolutions.com/app/ViewFiles.aspx?prod=urfamily&type=9>

If you are upgrading from version 7.0 or 7.1 to 7.2 or later, some CPU modules require a new boot version. Update this first. You can also downgrade firmware; use the same procedure.

To upgrade the firmware using EnerVista software:

1. If required, download the boot file and/or firmware from <http://www.gegridolutions.com/app/ViewFiles.aspx?prod=urfamily&type=7>
The firmware and boot files are .bin files.
2. Navigate to **Settings > Product Setup > Security** and ensure that the **Remote Setting Authorized** and **Local Setting Authorized** settings are "ON." On the front panel of the device, the path is **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **SECURITY** ⇒ **DUAL PERMISSION SECURITY ACCESS**.
If using CyberSentry security, also ensure that the relay and firmware are not locked under the **Settings > Product Setup > Security > Supervisory** settings. A Supervisor role is required for these settings.
3. In EnerVista, back up the device settings by right-clicking the device and selecting **Add Device to Offline Window**. In the window that displays, select an existing file to overwrite, or enter a name for a new settings file and optionally a location for the new file. Click the **Receive** button to start the backup.
If an "Incompatible device order codes or versions" message displays, it means that you are trying to overwrite a file for another product. You access the **Convert Device Settings** option by right-clicking the file in the **Offline Window** area at the lower left. GE recommends converting settings in firmware steps, for example when converting from 6.0 to 7.4x, convert first to 7.0 then 7.4 in order to follow embedded conversion rules and keep settings. Note that the values of all settings that have been defaulted during conversion are not listed in the conversion report; to find the value of a setting before conversion, inspect the device backups made before conversion.
4. In EnerVista, navigate to **Maintenance > Update Firmware**.
First select the boot file if applicable, locating the .bin file, and proceed. Restart the device, the EnerVista software, and refresh the order code in EnerVista under the **Device Setup** button.
To update the firmware, click **Maintenance > Update Firmware**, select the firmware update by locating the .bin file, and proceed with the update.
When asked if upgrading over the Internet, the difference is the flash memory buffer size each time the software sends data to the relay. Yes means that the flash memory buffer size is 256 bytes. No means that it is 1024 bytes, which is faster.
If a warning message displays about the firmware not being supported by the EnerVista software, it means that the firmware is a later version than the software. Upgrade the software to the same or later version as the firmware, then try again.
If an "Unable to put relay in flash mode" message displays, set the **Settings > Product Setup > Security > Dual Permission Security Access > Remote Setting Authorized** and **Local Setting Authorized** settings to "ON" and try again.
When the update is finished, the relay restarts automatically. The upgrade process takes about 10 minutes when using a graphical front panel because of writing to the front panel.
5. Restart the EnerVista software, and refresh the order code in EnerVista under the **Device Setup** button.
6. Verify the boot and firmware version while the device is starting up or in EnerVista under **Actual Values > Product Info > Firmware Revisions**. The boot revision is not the same as the firmware revision, and the firmware revision reflects the UR release, for example firmware revision 7.40 is UR release 7.40.
7. Set the device to "programmed" under **Settings > Product Setup > Installation**. A self-test error displays on the device

until this is done.

8. If you changed the **Remote Setting Authorized**, the **Local Setting Authorized** settings, or relay lock settings, return them to their previous settings.
9. To apply any previously saved settings, right-click the saved settings file in the **Offline Window** area and select **Write to Device**.



The field-programmable gate array (FPGA) can be upgraded under **Maintenance > Update FPGA** when the device is connected via serial cable and the firmware revision is 7.0 or higher.

Modbus addresses assigned to firmware modules, features, settings, and corresponding data items (that is, default values, minimum/maximum values, data type, and item size) can change slightly from version to version of firmware. The addresses are rearranged when new features are added or existing features are enhanced or modified. The EEPROM DATA ERROR message displayed after upgrading/downgrading the firmware is a resettable, self-test message intended to inform users that the Modbus addresses have changed with the upgraded firmware. This message does not signal any problems when appearing after firmware upgrades.

11.10 Replace front panel

This section outlines how to install a graphical front panel. It can also be used for the new enhanced horizontal front panel introduced in November 2017, which uses a screw to close it and internal hinge screws as per the graphical front panel.

A graphical front panel with a seven-inch (17.8 cm) color display and USB port is available for horizontal units. When purchased separately as a retrofit for an existing relay, there is one kit for an enhanced front panel replacement and another kit for the standard front panel replacement, with mounting brackets differing between the two kits. A kit includes the graphical front panel, mounting brackets, and screws. The graphical front panel requires CPU module type W or module type T, U, or V (newer type that has two connector slots on the front of the module--the second is difficult to see), upgrades of software and firmware, then a settings update to recognize the graphical front panel.

The graphical front panel can replace a standard front panel on newer models where the hinges are not riveted to the chassis. It cannot replace a standard front panel where the hinges are riveted onto the chassis; both front panel and chassis require replacement. See the photo later in this section of the riveted hinges.

The following procedures are outlined:

- Remove front panel
- Install graphical front panel
- Replace CPU module
- Upgrade software and firmware, then update setting



Withdraw or insert a module only when control power has been removed from the unit, and be sure to insert only the correct module type into a slot, else personal injury, damage to the unit or connected equipment, or undesired operation can result.



To avoid damage to the equipment, use proper electrostatic discharge protection (for example, a static strap) when coming in contact with modules while the relay is energized.

To remove an (old) enhanced or standard front panel:

1. In the EnerVista software or on the front panel, access **Settings > Product Setup > Communications > Network** and record the IP address and subnet mask of the port(s) being used. Record the gateway address under **Default IPv4 Route**.
2. Turn off power to the unit. Hot-swapping of the front panel is not supported.
3. For an enhanced front panel, loosen the thumb screw and open slightly the front panel.
For a standard front panel, lift up the black plastic latch on the right side of the front panel and open slightly the front panel.

Figure 11-12: Loosen thumb screw on enhanced front panel to open



Figure 11-13: Lift latch on standard front panel to open



4. With a Phillips screwdriver, unscrew and remove the mounting bracket on the right side of the unit. The bracket for the enhanced front panel looks similar to that for the graphical front panel, but they are not the same.

Figure 11-14: Remove enhanced front panel mounting bracket on right side

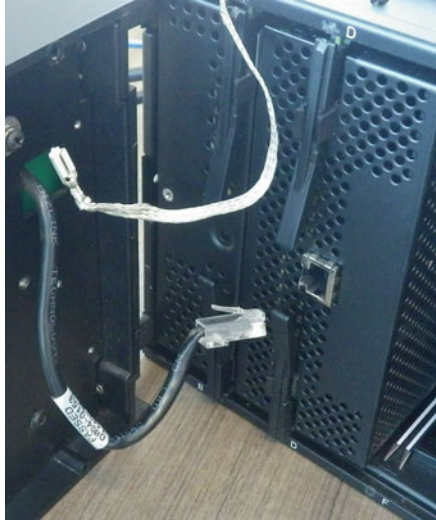


Figure 11-15: Remove standard front panel mounting bracket on right side



5. Open the front panel. Unplug or unscrew the grey ground cable from the front panel. Unplug the RJ45 connector from the CPU module in the second slot on the left.

Figure 11-16: Disconnected ground cable and CPU connector



6. Unscrew and remove the mounting bracket with the front panel from the left side.

Figure 11-17: Unscrew enhanced front panel mounting bracket on left side



Figure 11-18: Unscrew standard front panel mounting bracket on left side

(note riveted hinges with red arrows - cannot replace this front panel)



The front panel has been removed.

To install the graphical front panel:

1. With power to the unit off, screw the left mounting bracket to the outside of the relay. The power supply module can remain in the first slot.

Figure 11-19: Attach mounting bracket to relay on left side (no power supply module in first slot)



2. Screw the right mounting bracket to the right side of the relay.

Figure 11-20: Attach mounting bracket to relay on right side

3. Attach the graphical front panel hinge to the left mounting bracket using the nuts provided.

Figure 11-21: Attach to left mounting bracket inside relay

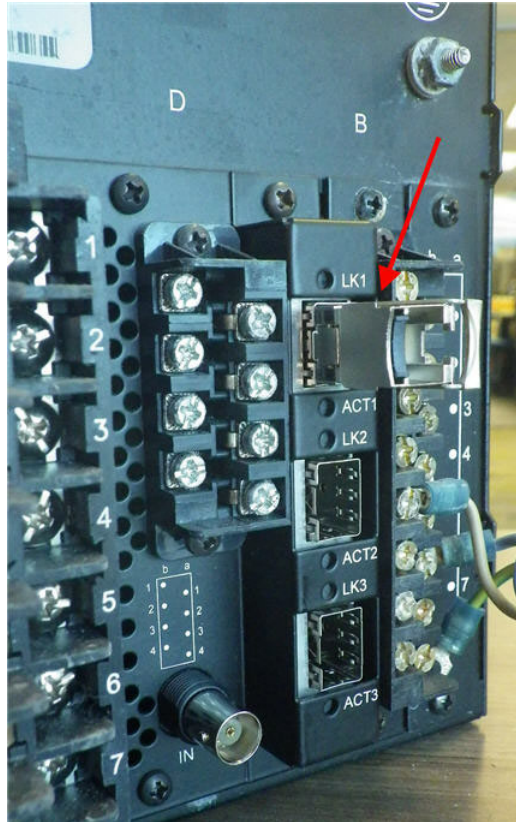
4. Close the front panel without tightening the screw to the mounting bracket.
5. Optionally remove the protective plastic film on the graphical front panel. It is normally peeled off, but also can be left on.

The graphical front panel has been installed but not connected.

To replace the CPU module:

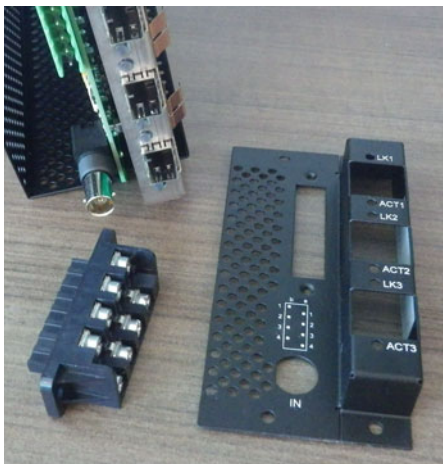
1. With power to the unit off, at the back of the CPU module in the second slot, disconnect any cables. Remove the silver SFP connector(s) from the CPU module, and keep it handy. Then remove the CPU module by sliding the module out from the front of the relay. (See the next section for instructions.)

Figure 11-22: Remove silver SFP connector (shown here under LK1 label)



2. At the front of the relay, insert the new CPU module in the second slot. The new CPU has two connection slots on the front. Ensure that the RS485 connector and the black cover plate are not on the back of the CPU module before sliding the module into the front of the relay.

Figure 11-23: Rear of a CPU module before insertion without RS485 connector or cover plate



3. Once the module is in place, connect the graphical front panel to the CPU module (ground and upper connector) and close the front panel. There are two connections possible on the front of the CPU module: upper for the graphical front panel and lower for the enhanced and standard front panels. The upper connection is black with holes, similar to the cover, so it is difficult to see.

Figure 11-24: Connect graphical front panel to top connection on CPU module



4. Tighten the embedded screw on the right side of the graphical front panel to the mounting bracket.

Figure 11-25: Screw to attach graphical front panel to mounting bracket



5. At the back of the CPU module, attach the new black cover plate to the back of the relay, then connect the new RS485 connector.
Insert the silver SFP connector(s) at the back of the CPU module, then connect any Ethernet connection(s).
6. Power up the relay. If the graphical front panel does not power up immediately, disconnect power, open the front

panel, then check that the graphical front panel is plugged into the upper connection, not the lower silver connection on the CPU module.

To upgrade software and firmware.

1. Upgrade the EnerVista software as outlined in this chapter.
2. Input the IP address and subnet mask of the relay on the front panel under **Settings > Product Setup > Communications > Network**, and input the gateway address under **Default IPv4 Route**.
3. Upgrade the firmware in the EnerVista software as outlined in this chapter, for example under **Maintenance > Update Firmware**.

If you see error messages after the upgrade, disconnect power to the relay and shut down the software, then start both again. If you see a flashing message about front panel communications trouble, check the connection of the graphical front panel to the CPU module.

4. In the EnerVista software, click the **Device Setup** button and refresh the order code for the device.
5. Set the relay to Programmed mode under **Settings > Product Setup > Installation**.
6. Update the EnerVista software to recognize the graphical front panel under **Maintenance > Change Front Panel**. This setting does not display for units already with a graphical front panel.

11.11 Replace module

This section outlines how to replace a module.

WARNING Withdraw or insert a module only when control power has been removed from the unit, and be sure to insert only the correct module type into a slot, else personal injury, damage to the unit or connected equipment, or undesired operation can result.

NOTICE To avoid damage to the equipment, use proper electrostatic discharge protection (for example, a static strap) when coming in contact with modules while the relay is energized.

The relay, being modular in design, allows for the withdrawal and insertion of modules. Replace modules only with like modules in their original factory configured slots.

To replace a module:

1. Open the enhanced front panel to the left once the thumb screw has been removed. This allows for easy access of the modules for withdrawal. The new wide-angle hinge assembly in the enhanced front panel opens completely and allows easy access to all modules in the L30.

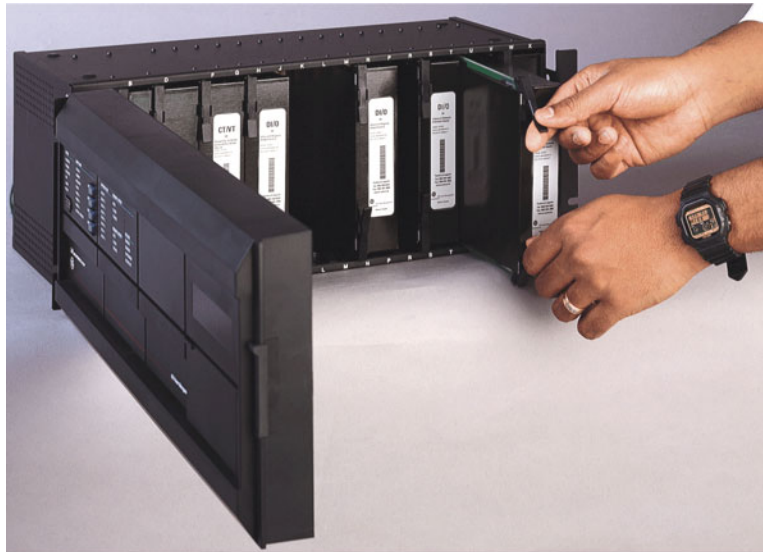
Figure 11-26: Modules inside relay with front cover open (enhanced front panel)



842812A1.CDR

The standard front panel can be opened to the left once the black plastic sliding latch on the right side has been pushed up, as shown below.

Figure 11-27: Removing module (standard front panel)



842760A1.CDR

2. With power to the unit off, disconnect individually the connections at the front and back of the module before removing the module from the chassis.
For any Process Card/process bus module in slot H for use with a HardFiber Brick, also remove the two screws at the back that attach the module to the chassis.
3. To properly remove a module, pull simultaneously the ejector/inserter clips, located at the top and bottom of the module. Record the original location of the module to ensure that the same or replacement module is inserted into the correct slot. While modules with current input provide automatic shorting of external CT circuits, for CT/VT modules it is recommended to short/isolate external circuits accordingly for maximum safety.
4. To properly insert a module, ensure that the correct module type is inserted into the correct slot position. The ejector/insertor clips located at the top and at the bottom of each module must be in the disengaged position as the module is smoothly inserted into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module is fully inserted.



When adding a module (versus replacing a module), check that settings have not changed. Depending on the module, settings can reset to default values.

11.12 Battery

A battery powers the real time clock on startup of the device.

When required, the battery can be replaced. The power supply module contains the battery. The battery type is 3 V cylindrical.

11.12.1 Replace battery for SH/SL power supply

When required, the battery can be replaced. The power supply module contains the battery.



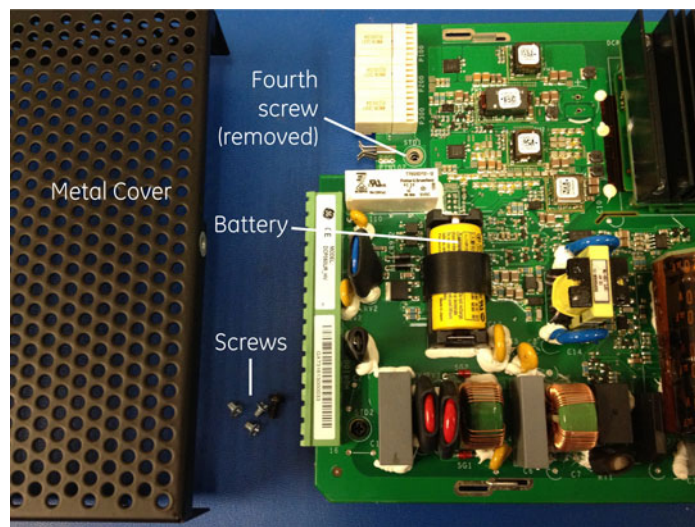
To avoid injury, ensure that the unit has been powered off for a minimum of three minutes before replacing the battery.

Risk of fire if battery is replaced with incorrect type or polarity.

To replace the battery:

1. Turn off the power to the unit.
2. Wait a minimum of three minutes to ensure that there is no power to the battery.
3. As outlined in the previous section, open the unit by sliding up the plastic latch on the right side of the front panel (standard front panel) or unscrewing the panel (enhanced front panel).
4. For the standard front panel, it needs to be removed in order to access the power supply module, which is typically in the first slot on the left side and blocked by the hinge of the front panel. To remove the front panel, unscrew the bracket on the left side of the unit.
5. Remove the power supply module by simultaneously pulling the ejector clips at the top and bottom of the module and sliding it out.
6. Unscrew all four screws (not three) that attach the metal cover to the module. The fourth screw is at the back end of the module, on the opposite side from the clips, beside the white electronics part (see figure).
7. Slide the metal cover away from the clips about 0.5 cm (1/8 inch) and remove the cover.
8. Unclip the black plastic holder that keeps the battery in place. The plastic clips into the socket at the bottom on both sides—pull the plastic away from the battery. Use a flat-head screwdriver if you cannot unclip the plastic with your fingers.
9. Replace the battery with the identical make and model. For example, do not use a rechargeable battery. Observe the + and - polarity of the battery and replace it with the same polarity as marked on the battery holder.

Figure 11-28: Battery location on SH/SL power supply module



859717A1.cdr

10. Reinstall the battery holder and the metal cover, and reinsert the power supply module into the unit.
11. Power on the unit.
12. Dispose of the old battery as outlined in the next section.

11.12.2 Dispose of battery



11.12.2.1 EN Battery disposal

This product contains a battery that cannot be disposed of as unsorted municipal waste in the European Union. See the product documentation for specific battery information. The battery is marked with this symbol, which may include lettering to indicate cadmium (Cd), lead (Pb), or mercury (Hg). For proper recycling return the battery to your supplier or to a designated collection point. For more information see: www.recyclethis.info.

11.12.2.2 CS Nakládání s bateriemi

Tento produkt obsahuje baterie, které nemohou být zneškodněny v Evropské unii jako netříděný komunální odpad. Viz dokumentace k produktu pro informace pro konkrétní baterie. Baterie je označena tímto symbolem, který může zahrnovat i uvedena písmena, kadmium (Cd), olovo (Pb), nebo rtuť (Hg). Pro správnou recyklaci baterií vraťte svémudodavateli nebo na určeném sběrném místě. Pro více informací viz: www.recyclethis.info.

11.12.2.3 DA Batteri affald

Denne produkt indeholder et batteri som ikke kan bortskaffes sammen med almindeligt husholdningsaffald i Europa. Se produktinformation for specifikke informationer om batteriet. Batteriet er forsynet med indgraveret symboler for hvad batteriet indeholder: kadmium (Cd), bly (Pb) og kviksølv (Hg). Europæiske brugere af elektrisk udstyr skal aflevere kasserede produkter til genbrug eller til leverandøren. Yderligere oplysninger findes på webstedet www.recyclethis.info.

11.12.2.4 DE Entsorgung von Batterien

Dieses Produkt beinhaltet eine Batterie, die nicht als unsortierter städtischer Abfall in der europäischen Union entsorgt werden darf. Beachten Sie die spezifischen Batterie-Informationen in der Produktdokumentation. Die Batterie ist mit diesem Symbol gekennzeichnet, welches auch Hinweise auf möglicherweise enthaltene Stoffe wie Kadmium (Cd), Blei (Pb) oder Quecksilber (Hektogramm) darstellt. Für die korrekte Wiederverwertung bringen Sie diese Batterie zu Ihrem lokalen Lieferanten zurück oder entsorgen Sie das Produkt an den gekennzeichneten Sammelstellen. Weitere Informationen hierzu finden Sie auf der folgenden Website: www.recyclethis.info.

11.12.2.5 EL Απόρριψη μπαταριών

Αυτό το προϊόν περιέχει μια μπαταρία που δεν πρέπει να απορρίπτεται σε δημόσια συστήματα απόρριψης στην Ευρωπαϊκή Κοινότητα. Δείτε την τεκμηρίωση του προϊόντος για συγκεκριμένες πληροφορίες που αφορούν τη μπαταρία. Η μπαταρία είναι φέρει σήμανση με αυτό το σύμβολο, το οποίο μπορεί να περιλαμβάνει γράμματα για να δηλώσουν το κάδμιο (Cd), τον μόλυβδο (Pb), ή τον υδράργυρο (Hg). Για την κατάλληλη ανακύκλωση επιστρέψτε την μπαταρία στον προμηθευτή σας ή σε καθορισμένο σημείο συλλογής. Για περισσότερες πληροφορίες δείτε: www.recyclethis.info.

11.12.2.6 ES Eliminación de baterías

Este producto contiene una batería que no se pueda eliminar como basura normal sin clasificar en la Unión Europea. Examine la documentación del producto para la información específica de la batería. La batería se marca con este símbolo, que puede incluir siglas para indicar el cadmio (Cd), el plomo (Pb), o el mercurio (Hg). Para el reciclaje apropiado, devuelva este producto a su distribuidor ó deshágase de él en los puntos de reciclaje designados. Para mas información : www.recyclethis.info.

11.12.2.7 ET Patareide kõrvaldamine

Käesolev toode sisaldab patareisid, mida Euroopa Liidus ei tohi kõrvaldada sorteerimata olmejäätmetena. Andmeid patareide kohta vaadake toote dokumentatsioonist. Patareid on määrgistatud käesoleva sümboliga, millel võib olla kaadmiumi (Cd), pliid (Pb) või elavhõbedat (Hg) tähistavad tähed. Nõuetekohaseks ringlusse võtmiseks tagastage patarei tarnijale või kindlaksmääratud vastuvõtupunkti. Lisainformatsiooni saab Internetist aadressil: www.recyclethis.info.

11.12.2.8 FI Paristoje ja akkujen hävittäminen

Tuote sisältää pariston, jota ei saa hävittää Euroopan Unionin alueella talousjätteen mukana. Tarkista tuoteselosteesta tuotteen tiedot. Paristo on merkitty tällä symbolilla ja saattaa sisältää kadmiumia (Cd), lyijyä (Pb) tai elohopeaa (Hg). Oikean kierrätystavan varmistamiseksi palauta tuote paikalliselle jälleenmyyjälle tai palauta se paristojen keräyspisteeseen. Lisätietoja sivuilla www.recyclethis.info.

11.12.2.9 FR Élimination des piles

Ce produit contient une batterie qui ne peuvent être éliminés comme déchets municipaux non triés dans l'Union européenne. Voir la documentation du produit au niveau des renseignements sur la pile. La batterie est marqué de ce symbole, qui comprennent les indications cadmium (Cd), plomb (Pb), ou mercure (Hg). Pour le recyclage, retourner la batterie à votre fournisseur ou à un point de collecte. Pour plus d'informations, voir: www.recyclethis.info.

11.12.2.10 HU Akkumulátor hulladék kezelése

Ezen termék akkumulátort tartalmaz, amely az Európai Unió belül csak a kijelölt módon és helyen dobható ki. A termékben illetve a mellékelt ismertetőn olvasható a kadmium (Cd), ólom (Pb) vagy higany (Hg) tartalomra utaló betűjelzés. A hulladék akkumulátor leadható a termék forgalmazójánál új akkumulátor vásárlásakor, vagy a kijelölt elektronikai hulladékdudvarokban. További információ a www.recyclethis.info oldalon.

11.12.2.11 IT Smaltimento batterie

Questo prodotto contiene una batteria che non può essere smaltita nei comuni contenitori per lo smaltimento rifiuti, nell'Unione Europea. Controllate la documentazione del prodotto per le informazioni specifiche sulla batteria. La batteria è contrassegnata con questo simbolo e può includere alcuni caratteri ad indicare la presenza di cadmio (Cd), piombo (Pb) oppure mercurio (Hg). Per il corretto smaltimento, potete restituirli al vostro fornitore locale, oppure rivolgervi e consegnarli presso i centri di raccolta preposti. Per maggiori informazioni vedere: www.recyclethis.info.

11.12.2.12 LT Baterijų šalinimas

Šios įrangos sudėtyje yra baterijų, kurias draudžiama šalinti Europos Sąjungos viešose nerūšiuotų atliekų šalinimo sistemose. Informaciją apie baterijas galite rasti įrangos techninėje dokumentacijoje. Baterijos žymimos šiuo simboliu, papildomai gali būti nurodoma kad baterijų sudėtyje yra kadmio (Cd), švino (Pb) ar gyvsidabrio (Hg). Eksploatavimui nebetinkamas baterijas pristatykite į tam skirtas surinkimo vietas arba grąžinkite jas tiesioginiam tiekėjui, kad jos būtų tinkamai utilizuotos. Daugiau informacijos rasite šioje interneto svetainėje: www.recyclethis.info.

11.12.2.13 LV Bateriju likvidēšana

Šis produkts satur bateriju vai akumulatoru, kuru nedrīkst izmest Eiropas Savienībā esošajās sadzīves atkritumu sistēmās. Sk. produkta dokumentācijā, kur ir norādīta konkrēta informācija par bateriju vai akumulatoru. Baterijas vai akumulatora marķējumā ir šis simbols, kas var ietvert burtus, kuri norāda kadmiju (Cd), svīnu (Pb) vai dzīvsudrabu (Hg). Pēc ekspluatācijas laika beigām baterijas vai akumulatori jānodod piegādātājam vai specializētā bateriju savākšanas vietā. Sīkāku informāciju var iegūt vietnē: www.recyclethis.info.

11.12.2.14 NL Verwijderen van batterijen

Dit product bevat een batterij welke niet kan verwijderd worden via de gemeentelijke huisvuilscheiding in de Europese Gemeenschap. Gelieve de product documentatie te controleren voor specifieke batterij informatie. De batterijen met deze label kunnen volgende indictaies bevatten cadium (Cd), lood (Pb) of kwik (Hg). Voor correcte vorm van kringloop, geef je de producten terug aan jou locale leverancier of geef het af aan een gespecialiseerde verzamelpunt. Meer informatie vindt u op de volgende website: www.recyclethis.info.

11.12.2.15 NO Retur av batteri

Dette produkt inneholder et batteri som ikke kan kastes med usortert kommunalt søppel i den Europeiske Unionen. Se produktdokumentasjonen for spesifikk batteriinformasjon. Batteriet er merket med dette symbolet som kan inkludere symboler for å indikere at kadmium (Cd), bly (Pb), eller kvikksølv (Hg) forekommer. Returner batteriet til leverandøren din eller til et dedikert oppsamlingspunkt for korrekt gjenvinning. For mer informasjon se: www.recyclethis.info.

11.12.2.16 PL Pozbywanie się zużytych baterii

Ten produkt zawiera baterie, które w Unii Europejskiej mogą być usuwane tylko jako posegregowane odpady komunalne. Dokładne informacje dotyczące użytych baterii znajdują się w dokumentacji produktu. Baterie oznaczone tym symbolem mogą zawierać dodatkowe oznaczenia literowe wskazujące na zawartość kadmu (Cd), ołowiu (Pb) lub rtęci (Hg). Dla zapewnienia właściwej utylizacji, należy zwrócić baterie do dostawcy albo do wyznaczonego punktu zbiórki. Więcej informacji można znaleźć na stronie internetowej www.recyclethis.info.

11.12.2.17 PT Eliminação de Baterias

Este produto contém uma bateria que não pode ser considerado lixo municipal na União Europeia. Consulte a documentação do produto para obter informação específica da bateria. A bateria é identificada por meio de este símbolo, que pode incluir a rotulagem para indicar o cádmio (Cd), chumbo (Pb), ou o mercúrio (Hg). Para uma reciclagem apropriada envie a bateria para o seu fornecedor ou para um ponto de recolha designado. Para mais informação veja: www.recyclethis.info.

11.12.2.18 RU Утилизация батарей

Согласно европейской директиве об отходах электрического и электронного оборудования, продукты, содержащие батареи, нельзя утилизировать как обычные отходы на территории ЕС. Более подробную информацию вы найдете в документации к продукту. На этом символе могут присутствовать буквы, которые означают, что батарея содержит кадмий (Cd), свинец (Pb) или ртуть (Hg). Для надлежащей утилизации по окончании срока эксплуатации пользователь должен вернуть батареи локальному поставщику или сдать в специальный пункт приема. Подробности можно найти на веб-сайте: www.recyclethis.info.

11.12.2.19 SK Zaobchádzanie s batériami

Tento produkt obsahuje batériu, s ktorou sa v Európskej únii nesmie nakladať ako s netriedeným komunálnym odpadom. Dokumentácia k produktu obsahuje špecifické informácie o batérii. Batéria je označená týmto symbolom, ktorý môže obsahovať písmená na označenie kadmia (Cd), olova (Pb), alebo ortuti (Hg). Na správnu recykláciu vráťte batériu vášmu lokálnemu dodávateľovi alebo na určené zberné miesto. Pre viac informácií pozrite: www.recyclethis.info.

11.12.2.20 SL Odlaganje baterij

Ta izdelek vsebuje baterijo, ki je v Evropski uniji ni dovoljeno odstranjevati kot nesortiran komunalni odpad. Za posebne informacije o bateriji glejte dokumentacijo izdelka. Baterija je označena s tem simbolom, ki lahko vključuje napise, ki označujejo kadmij (Cd), svinec (Pb) ali živo srebro (Hg). Za ustrezno recikliranje baterijo vrnite dobavitelju ali jo odstranite na določenem zbirališču. Za več informacij obiščite spletno stran: www.recyclethis.info.

11.12.2.21 SV Kassering av batteri

Denna produkt innehåller ett batteri som inte får kastas i allmänna sophanteringssystem inom den europeiska unionen. Se produktdokumentationen för specifik batteriinformation. Batteriet är märkt med denna symbol, vilket kan innebära att det innehåller kadmium (Cd), bly (Pb) eller kvicksilver (Hg). För korrekt återvinning skall batteriet returneras till leverantören eller till en därför avsedd deponering. För mer information, se: www.recyclethis.info.

11.12.2.22 TR Pil Geri Dönüşümü

Bu ürün Avrupa Birliği genel atık sistemlerine atılmaması gereken pil içermektedir. Daha detaylı pil bilgisi için ürünün kataloğunu inceleyiniz. Bu sembolle işaretlenmiş piller Kadmiyum(Cd), Kurşun(Pb) ya da Civa(Hg) içerebilir. Doğru geri dönüşüm için ürünü yerel tedarikçinize geri veriniz ya da özel işaretlenmiş toplama noktalarına atınız. Daha fazla bilgi için: www.recyclethis.info.

11.12.2.23 Global contacts

North America	905-294-6222
Latin America	+55 11 3614 1700
Europe, Middle East, Africa	+(34) 94 485 88 00
Asia	+86-21-2401-3208
India	+91 80 41314617

From GE Part Number 1604-0021-A1, GE Publication Number GEK-113574.

11.13 Clear files and data after uninstall

The unit can be decommissioned by turning off power to the unit and disconnecting the wires to it.

Files can be cleared after uninstalling the EnerVista software or UR device, for example to comply with data security regulations.

On the computer, settings files can be identified by the .urs extension. To clear the current settings file, create a default settings file, write it to the relay, then delete all other .urs files. For the existing installation, upgrading the firmware overwrites the flash memory. Other files can be in standard formats, such as COMTRADE or .csv.

You cannot erase directly the flash memory, but all records and settings in that memory can be deleted. Do this using the **SETTINGS ⇒ PRODUCT SETUP ⇒ CLEAR RELAY RECORDS** command.

To uninstall the EnerVista software, use the built-in computer function, such as Control Panel > Programs and Features. Look for EnerVista UR Setup in the list.

11.14 Repairs

The battery and modules inside the case can be replaced without return of the device to the factory. The firmware and software can be upgraded without return of the device to the factory.

Fuses in the power supply module are not field-replaceable.

Files can be requested for use by technical support staff, for example the Service Report (click the icon in the software or connect a USB drive to the graphical front panel) or under **Maintenance > Retrieve File**, as outlined elsewhere in this document.

For issues not solved by troubleshooting, the process to return the device to the factory for repair is as follows:

- Contact a GE Grid Solutions Technical Support Center. Contact information is found in the first chapter.
- Obtain a Return Materials Authorization (RMA) number from the Technical Support Center.
- Verify that the RMA and Commercial Invoice received have the correct information.
- Tightly pack the unit in a box with bubble wrap, foam material, or styrofoam inserts or packaging peanuts to cushion the item(s). You may also use double boxing whereby you place the box in a larger box that contains at least 5 cm of cushioning material.
- Ship the unit by courier or freight forwarder, along with the Commercial Invoice and RMA, to the factory.

GE GRID SOLUTIONS
 650 MARKLAND STREET
 MARKHAM, ONTARIO
 CANADA L6C 0M1
 ATTN: SERVICE DEPT.
 RMA# : _____

Customers are responsible for shipping costs to the factory, regardless of whether the unit is under warranty.

- Fax a copy of the shipping information to the GE Grid Solutions service department in Canada at +1 905 927 5098.

Use the detailed return procedure outlined at

https://www.gegridsolutions.com/multilin/support/ret_proc.htm

The current warranty and return information are outlined at

<https://www.gegridsolutions.com/multilin/warranty.htm>

11.15 Storage

Store the unit indoors in a cool, dry place. If possible, store in the original packaging. Follow the storage temperature range outlined in the Specifications.

NOTICE

To avoid deterioration of electrolytic capacitors, power up units that are stored in a de-energized state once per year, for one hour continuously.

11.16 Disposal

Other than the battery, there are no special requirements for disposal of the unit at the end its service life. For customers located in the European Union, dispose of the battery as outlined earlier. To prevent non-intended use of the unit, remove the modules, dismantle the unit, and recycle the metal when possible.

L30 Line Current Differential System

Appendix A: FlexAnalog operands

This appendix outlines FlexAnalog parameters.

A.1 FlexAnalog items

A FlexAnalog parameter is an analog parameter.

FlexAnalog items are also viewable in a web browser. Enter the IP address of the UR, access the **Device Information Menu** option, then the **FlexAnalog Parameter Listing** option. Entries displayed online depend on order code.

Table A-1: FlexAnalog data items

Address	FlexAnalog name	Units	Description
5688	Channel 1 Asymmetry	ms	Channel 1 asymmetry
5690	Channel 2 Asymmetry	ms	Channel 2 asymmetry
5824	Field RTD 1 Value	---	Field RTD 1 value
5825	Field RTD 2 Value	---	Field RTD 2 value
5826	Field RTD 3 Value	---	Field RTD 3 value
5827	Field RTD 4 Value	---	Field RTD 4 value
5828	Field RTD 5 Value	---	Field RTD 5 value
5829	Field RTD 6 Value	---	Field RTD 6 value
5830	Field RTD 7 Value	---	Field RTD 7 value
5831	Field RTD 8 Value	---	Field RTD 8 value
5832	Field TDR 1 Value	---	Field TDR 1 value
5834	Field TDR 2 Value	---	Field TDR 2 value
5836	Field TDR 3 Value	---	Field TDR 3 value
5838	Field TDR 4 Value	---	Field TDR 4 value
5840	Field TDR 5 Value	---	Field TDR 5 value
5842	Field TDR 6 Value	---	Field TDR 6 value
5844	Field TDR 7 Value	---	Field TDR 7 value
5846	Field TDR 8 Value	---	Field TDR 8 value
5856	Freq Rate 1 Value	Hz/s	Frequency rate of change 1 actual value
5860	Freq Rate 2 Value	Hz/s	Frequency rate of change 2 actual value
6144	SRC 1 Ia RMS	Amps	Source 1 phase A current RMS

A

Address	FlexAnalog name	Units	Description
6146	SRC 1 Ib RMS	Amps	Source 1 phase B current RMS
6148	SRC 1 Ic RMS	Amps	Source 1 phase C current RMS
6150	SRC 1 In RMS	Amps	Source 1 neutral current RMS
6152	SRC 1 Ia Mag	Amps	Source 1 phase A current magnitude
6154	SRC 1 Ia Angle	Degrees	Source 1 phase A current angle
6155	SRC 1 Ib Mag	Amps	Source 1 phase B current magnitude
6157	SRC 1 Ib Angle	Degrees	Source 1 phase B current angle
6158	SRC 1 Ic Mag	Amps	Source 1 phase C current magnitude
6160	SRC 1 Ic Angle	Degrees	Source 1 phase C current angle
6161	SRC 1 In Mag	Amps	Source 1 neutral current magnitude
6163	SRC 1 In Angle	Degrees	Source 1 neutral current angle
6164	SRC 1 Ig RMS	Amps	Source 1 ground current RMS
6166	SRC 1 Ig Mag	Amps	Source 1 ground current magnitude
6168	SRC 1 Ig Angle	Degrees	Source 1 ground current angle
6169	SRC 1 I ₀ Mag	Amps	Source 1 zero-sequence current magnitude
6171	SRC 1 I ₀ Angle	Degrees	Source 1 zero-sequence current angle
6172	SRC 1 I ₁ Mag	Amps	Source 1 positive-sequence current magnitude
6174	SRC 1 I ₁ Angle	Degrees	Source 1 positive-sequence current angle
6175	SRC 1 I ₂ Mag	Amps	Source 1 negative-sequence current magnitude
6177	SRC 1 I ₂ Angle	Degrees	Source 1 negative-sequence current angle
6178	SRC 1 Igd Mag	Amps	Source 1 differential ground current magnitude
6180	SRC 1 Igd Angle	Degrees	Source 1 differential ground current angle
6208	SRC 2 Ia RMS	Amps	Source 2 phase A current RMS
6210	SRC 2 Ib RMS	Amps	Source 2 phase B current RMS
6212	SRC 2 Ic RMS	Amps	Source 2 phase C current RMS
6214	SRC 2 In RMS	Amps	Source 2 neutral current RMS
6216	SRC 2 Ia Mag	Amps	Source 2 phase A current magnitude
6218	SRC 2 Ia Angle	Degrees	Source 2 phase A current angle
6219	SRC 2 Ib Mag	Amps	Source 2 phase B current magnitude
6221	SRC 2 Ib Angle	Degrees	Source 2 phase B current angle
6222	SRC 2 Ic Mag	Amps	Source 2 phase C current magnitude
6224	SRC 2 Ic Angle	Degrees	Source 2 phase C current angle
6225	SRC 2 In Mag	Amps	Source 2 neutral current magnitude
6227	SRC 2 In Angle	Degrees	Source 2 neutral current angle
6228	SRC 2 Ig RMS	Amps	Source 2 ground current RMS
6230	SRC 2 Ig Mag	Amps	Source 2 ground current magnitude
6232	SRC 2 Ig Angle	Degrees	Source 2 ground current angle
6233	SRC 2 I ₀ Mag	Amps	Source 2 zero-sequence current magnitude
6235	SRC 2 I ₀ Angle	Degrees	Source 2 zero-sequence current angle
6236	SRC 2 I ₁ Mag	Amps	Source 2 positive-sequence current magnitude
6238	SRC 2 I ₁ Angle	Degrees	Source 2 positive-sequence current angle
6239	SRC 2 I ₂ Mag	Amps	Source 2 negative-sequence current magnitude
6241	SRC 2 I ₂ Angle	Degrees	Source 2 negative-sequence current angle
6242	SRC 2 Igd Mag	Amps	Source 2 differential ground current magnitude
6244	SRC 2 Igd Angle	Degrees	Source 2 differential ground current angle
6656	SRC 1 Vag RMS	Volts	Source 1 phase AG voltage RMS
6658	SRC 1 Vbg RMS	Volts	Source 1 phase BG voltage RMS

Address	FlexAnalog name	Units	Description
6660	SRC 1 Vcg RMS	Volts	Source 1 phase CG voltage RMS
6662	SRC 1 Vag Mag	Volts	Source 1 phase AG voltage magnitude
6664	SRC 1 Vag Angle	Degrees	Source 1 phase AG voltage angle
6665	SRC 1 Vbg Mag	Volts	Source 1 phase BG voltage magnitude
6667	SRC 1 Vbg Angle	Degrees	Source 1 phase BG voltage angle
6668	SRC 1 Vcg Mag	Volts	Source 1 phase CG voltage magnitude
6670	SRC 1 Vcg Angle	Degrees	Source 1 phase CG voltage angle
6671	SRC 1 Vab RMS	Volts	Source 1 phase AB voltage RMS
6673	SRC 1 Vbc RMS	Volts	Source 1 phase BC voltage RMS
6675	SRC 1 Vca RMS	Volts	Source 1 phase CA voltage RMS
6677	SRC 1 Vab Mag	Volts	Source 1 phase AB voltage magnitude
6679	SRC 1 Vab Angle	Degrees	Source 1 phase AB voltage angle
6680	SRC 1 Vbc Mag	Volts	Source 1 phase BC voltage magnitude
6682	SRC 1 Vbc Angle	Degrees	Source 1 phase BC voltage angle
6683	SRC 1 Vca Mag	Volts	Source 1 phase CA voltage magnitude
6685	SRC 1 Vca Angle	Degrees	Source 1 phase CA voltage angle
6686	SRC 1 Vx RMS	Volts	Source 1 auxiliary voltage RMS
6688	SRC 1 Vx Mag	Volts	Source 1 auxiliary voltage magnitude
6690	SRC 1 Vx Angle	Degrees	Source 1 auxiliary voltage angle
6691	SRC 1 V_0 Mag	Volts	Source 1 zero-sequence voltage magnitude
6693	SRC 1 V_0 Angle	Degrees	Source 1 zero-sequence voltage angle
6694	SRC 1 V_1 Mag	Volts	Source 1 positive-sequence voltage magnitude
6696	SRC 1 V_1 Angle	Degrees	Source 1 positive-sequence voltage angle
6697	SRC 1 V_2 Mag	Volts	Source 1 negative-sequence voltage magnitude
6699	SRC 1 V_2 Angle	Degrees	Source 1 negative-sequence voltage angle
6720	SRC 2 Vag RMS	Volts	Source 2 phase AG voltage RMS
6722	SRC 2 Vbg RMS	Volts	Source 2 phase BG voltage RMS
6724	SRC 2 Vcg RMS	Volts	Source 2 phase CG voltage RMS
6726	SRC 2 Vag Mag	Volts	Source 2 phase AG voltage magnitude
6728	SRC 2 Vag Angle	Degrees	Source 2 phase AG voltage angle
6729	SRC 2 Vbg Mag	Volts	Source 2 phase BG voltage magnitude
6731	SRC 2 Vbg Angle	Degrees	Source 2 phase BG voltage angle
6732	SRC 2 Vcg Mag	Volts	Source 2 phase CG voltage magnitude
6734	SRC 2 Vcg Angle	Degrees	Source 2 phase CG voltage angle
6735	SRC 2 Vab RMS	Volts	Source 2 phase AB voltage RMS
6737	SRC 2 Vbc RMS	Volts	Source 2 phase BC voltage RMS
6739	SRC 2 Vca RMS	Volts	Source 2 phase CA voltage RMS
6741	SRC 2 Vab Mag	Volts	Source 2 phase AB voltage magnitude
6743	SRC 2 Vab Angle	Degrees	Source 2 phase AB voltage angle
6744	SRC 2 Vbc Mag	Volts	Source 2 phase BC voltage magnitude
6746	SRC 2 Vbc Angle	Degrees	Source 2 phase BC voltage angle
6747	SRC 2 Vca Mag	Volts	Source 2 phase CA voltage magnitude
6749	SRC 2 Vca Angle	Degrees	Source 2 phase CA voltage angle
6750	SRC 2 Vx RMS	Volts	Source 2 auxiliary voltage RMS
6752	SRC 2 Vx Mag	Volts	Source 2 auxiliary voltage magnitude
6754	SRC 2 Vx Angle	Degrees	Source 2 auxiliary voltage angle
6755	SRC 2 V_0 Mag	Volts	Source 2 zero-sequence voltage magnitude



Address	FlexAnalog name	Units	Description
6757	SRC 2 V_0 Angle	Degrees	Source 2 zero-sequence voltage angle
6758	SRC 2 V_1 Mag	Volts	Source 2 positive-sequence voltage magnitude
6760	SRC 2 V_1 Angle	Degrees	Source 2 positive-sequence voltage angle
6761	SRC 2 V_2 Mag	Volts	Source 2 negative-sequence voltage magnitude
6763	SRC 2 V_2 Angle	Degrees	Source 2 negative-sequence voltage angle
7168	SRC 1 P	Watts	Source 1 three-phase real power
7170	SRC 1 Pa	Watts	Source 1 phase A real power
7172	SRC 1 Pb	Watts	Source 1 phase B real power
7174	SRC 1 Pc	Watts	Source 1 phase C real power
7176	SRC 1 Q	Vars	Source 1 three-phase reactive power
7178	SRC 1 Qa	Vars	Source 1 phase A reactive power
7180	SRC 1 Qb	Vars	Source 1 phase B reactive power
7182	SRC 1 Qc	Vars	Source 1 phase C reactive power
7184	SRC 1 S	VA	Source 1 three-phase apparent power
7186	SRC 1 Sa	VA	Source 1 phase A apparent power
7188	SRC 1 Sb	VA	Source 1 phase B apparent power
7190	SRC 1 Sc	VA	Source 1 phase C apparent power
7192	SRC 1 PF	---	Source 1 three-phase power factor
7193	SRC 1 Phase A PF	---	Source 1 phase A power factor
7194	SRC 1 Phase B PF	---	Source 1 phase B power factor
7195	SRC 1 Phase C PF	---	Source 1 phase C power factor
7200	SRC 2 P	Watts	Source 2 three-phase real power
7202	SRC 2 Pa	Watts	Source 2 phase A real power
7204	SRC 2 Pb	Watts	Source 2 phase B real power
7206	SRC 2 Pc	Watts	Source 2 phase C real power
7208	SRC 2 Q	Vars	Source 2 three-phase reactive power
7210	SRC 2 Qa	Vars	Source 2 phase A reactive power
7212	SRC 2 Qb	Vars	Source 2 phase B reactive power
7214	SRC 2 Qc	Vars	Source 2 phase C reactive power
7216	SRC 2 S	VA	Source 2 three-phase apparent power
7218	SRC 2 Sa	VA	Source 2 phase A apparent power
7220	SRC 2 Sb	VA	Source 2 phase B apparent power
7222	SRC 2 Sc	VA	Source 2 phase C apparent power
7224	SRC 2 PF	---	Source 2 three-phase power factor
7225	SRC 2 Phase A PF	---	Source 2 phase A power factor
7226	SRC 2 Phase B PF	---	Source 2 phase B power factor
7227	SRC 2 Phase C PF	---	Source 2 phase C power factor
7552	SRC 1 Frequency	Hz	Source 1 frequency
7554	SRC 2 Frequency	Hz	Source 2 frequency
8064	SRC 1 Va THD	%	Source 1 phase A voltage total harmonic distortion (THD)
8065	SRC 1 Va Harm[2]	%	Source 1 phase A voltage second harmonic
8066	SRC 1 Va Harm[3]	%	Source 1 phase A voltage third harmonic
8067	SRC 1 Va Harm[4]	%	Source 1 phase A voltage fourth harmonic
8068	SRC 1 Va Harm[5]	%	Source 1 phase A voltage fifth harmonic
8069	SRC 1 Va Harm[6]	%	Source 1 phase A voltage sixth harmonic
8070	SRC 1 Va Harm[7]	%	Source 1 phase A voltage seventh harmonic
8071	SRC 1 Va Harm[8]	%	Source 1 phase A voltage eighth harmonic

Address	FlexAnalog name	Units	Description
8072	SRC 1 Va Harm[9]	%	Source 1 phase A voltage ninth harmonic
8073	SRC 1 Va Harm[10]	%	Source 1 phase A voltage tenth harmonic
8074	SRC 1 Va Harm[11]	%	Source 1 phase A voltage eleventh harmonic
8075	SRC 1 Va Harm[12]	%	Source 1 phase A voltage twelfth harmonic
8076	SRC 1 Va Harm[13]	%	Source 1 phase A voltage thirteenth harmonic
8077	SRC 1 Va Harm[14]	%	Source 1 phase A voltage fourteenth harmonic
8078	SRC 1 Va Harm[15]	%	Source 1 phase A voltage fifteenth harmonic
8079	SRC 1 Va Harm[16]	%	Source 1 phase A voltage sixteenth harmonic
8080	SRC 1 Va Harm[17]	%	Source 1 phase A voltage seventeenth harmonic
8081	SRC 1 Va Harm[18]	%	Source 1 phase A voltage eighteenth harmonic
8082	SRC 1 Va Harm[19]	%	Source 1 phase A voltage nineteenth harmonic
8083	SRC 1 Va Harm[20]	%	Source 1 phase A voltage twentieth harmonic
8084	SRC 1 Va Harm[21]	%	Source 1 phase A voltage twenty-first harmonic
8085	SRC 1 Va Harm[22]	%	Source 1 phase A voltage twenty-second harmonic
8086	SRC 1 Va Harm[23]	%	Source 1 phase A voltage twenty-third harmonic
8087	SRC 1 Va Harm[24]	%	Source 1 phase A voltage twenty-fourth harmonic
8088	SRC 1 Va Harm[25]	%	Source 1 phase A voltage twenty-fifth harmonic
8089	SRC 1 Vb THD	%	Source 1 phase B voltage total harmonic distortion (THD)
8090	SRC 1 Vb Harm[2]	%	Source 1 phase B voltage second harmonic
8091	SRC 1 Vb Harm[3]	%	Source 1 phase B voltage third harmonic
8092	SRC 1 Vb Harm[4]	%	Source 1 phase B voltage fourth harmonic
8093	SRC 1 Vb Harm[5]	%	Source 1 phase B voltage fifth harmonic
8094	SRC 1 Vb Harm[6]	%	Source 1 phase B voltage sixth harmonic
8095	SRC 1 Vb Harm[7]	%	Source 1 phase B voltage seventh harmonic
8096	SRC 1 Vb Harm[8]	%	Source 1 phase B voltage eighth harmonic
8097	SRC 1 Vb Harm[9]	%	Source 1 phase B voltage ninth harmonic
8098	SRC 1 Vb Harm[10]	%	Source 1 phase B voltage tenth harmonic
8099	SRC 1 Vb Harm[11]	%	Source 1 phase B voltage eleventh harmonic
8100	SRC 1 Vb Harm[12]	%	Source 1 phase B voltage twelfth harmonic
8101	SRC 1 Vb Harm[13]	%	Source 1 phase B voltage thirteenth harmonic
8102	SRC 1 Vb Harm[14]	%	Source 1 phase B voltage fourteenth harmonic
8103	SRC 1 Vb Harm[15]	%	Source 1 phase B voltage fifteenth harmonic
8104	SRC 1 Vb Harm[16]	%	Source 1 phase B voltage sixteenth harmonic
8105	SRC 1 Vb Harm[17]	%	Source 1 phase B voltage seventeenth harmonic
8106	SRC 1 Vb Harm[18]	%	Source 1 phase B voltage eighteenth harmonic
8107	SRC 1 Vb Harm[19]	%	Source 1 phase B voltage nineteenth harmonic
8108	SRC 1 Vb Harm[20]	%	Source 1 phase B voltage twentieth harmonic
8109	SRC 1 Vb Harm[21]	%	Source 1 phase B voltage twenty-first harmonic
8110	SRC 1 Vb Harm[22]	%	Source 1 phase B voltage twenty-second harmonic
8111	SRC 1 Vb Harm[23]	%	Source 1 phase B voltage twenty-third harmonic
8112	SRC 1 Vb Harm[24]	%	Source 1 phase B voltage twenty-fourth harmonic
8113	SRC 1 Vb Harm[25]	%	Source 1 phase B voltage twenty-fifth harmonic
8114	SRC 1 Vc THD	%	Source 1 phase C voltage total harmonic distortion (THD)
8115	SRC 1 Vc Harm[2]	%	Source 1 phase C voltage second harmonic
8116	SRC 1 Vc Harm[3]	%	Source 1 phase C voltage third harmonic
8117	SRC 1 Vc Harm[4]	%	Source 1 phase C voltage fourth harmonic
8118	SRC 1 Vc Harm[5]	%	Source 1 phase C voltage fifth harmonic



Address	FlexAnalog name	Units	Description
8119	SRC 1 Vc Harm[6]	%	Source 1 phase C voltage sixth harmonic
8120	SRC 1 Vc Harm[7]	%	Source 1 phase C voltage seventh harmonic
8121	SRC 1 Vc Harm[8]	%	Source 1 phase C voltage eighth harmonic
8122	SRC 1 Vc Harm[9]	%	Source 1 phase C voltage ninth harmonic
8123	SRC 1 Vc Harm[10]	%	Source 1 phase C voltage tenth harmonic
8124	SRC 1 Vc Harm[11]	%	Source 1 phase C voltage eleventh harmonic
8125	SRC 1 Vc Harm[12]	%	Source 1 phase C voltage twelfth harmonic
8126	SRC 1 Vc Harm[13]	%	Source 1 phase C voltage thirteenth harmonic
8127	SRC 1 Vc Harm[14]	%	Source 1 phase C voltage fourteenth harmonic
8128	SRC 1 Vc Harm[15]	%	Source 1 phase C voltage fifteenth harmonic
8129	SRC 1 Vc Harm[16]	%	Source 1 phase C voltage sixteenth harmonic
8130	SRC 1 Vc Harm[17]	%	Source 1 phase C voltage seventeenth harmonic
8131	SRC 1 Vc Harm[18]	%	Source 1 phase C voltage eighteenth harmonic
8132	SRC 1 Vc Harm[19]	%	Source 1 phase C voltage nineteenth harmonic
8133	SRC 1 Vc Harm[20]	%	Source 1 phase C voltage twentieth harmonic
8134	SRC 1 Vc Harm[21]	%	Source 1 phase C voltage twenty-first harmonic
8135	SRC 1 Vc Harm[22]	%	Source 1 phase C voltage twenty-second harmonic
8136	SRC 1 Vc Harm[23]	%	Source 1 phase C voltage twenty-third harmonic
8137	SRC 1 Vc Harm[24]	%	Source 1 phase C voltage twenty-fourth harmonic
8138	SRC 1 Vc Harm[25]	%	Source 1 phase C voltage twenty-fifth harmonic
8139	SRC 2 Va THD	%	Source 2 phase A voltage total harmonic distortion (THD)
8140	SRC 2 Va Harm[2]	%	Source 2 phase A voltage second harmonic
8141	SRC 2 Va Harm[3]	%	Source 2 phase A voltage third harmonic
8142	SRC 2 Va Harm[4]	%	Source 2 phase A voltage fourth harmonic
8143	SRC 2 Va Harm[5]	%	Source 2 phase A voltage fifth harmonic
8144	SRC 2 Va Harm[6]	%	Source 2 phase A voltage sixth harmonic
8145	SRC 2 Va Harm[7]	%	Source 2 phase A voltage seventh harmonic
8146	SRC 2 Va Harm[8]	%	Source 2 phase A voltage eighth harmonic
8147	SRC 2 Va Harm[9]	%	Source 2 phase A voltage ninth harmonic
8148	SRC 2 Va Harm[10]	%	Source 2 phase A voltage tenth harmonic
8149	SRC 2 Va Harm[11]	%	Source 2 phase A voltage eleventh harmonic
8150	SRC 2 Va Harm[12]	%	Source 2 phase A voltage twelfth harmonic
8151	SRC 2 Va Harm[13]	%	Source 2 phase A voltage thirteenth harmonic
8152	SRC 2 Va Harm[14]	%	Source 2 phase A voltage fourteenth harmonic
8153	SRC 2 Va Harm[15]	%	Source 2 phase A voltage fifteenth harmonic
8154	SRC 2 Va Harm[16]	%	Source 2 phase A voltage sixteenth harmonic
8155	SRC 2 Va Harm[17]	%	Source 2 phase A voltage seventeenth harmonic
8156	SRC 2 Va Harm[18]	%	Source 2 phase A voltage eighteenth harmonic
8157	SRC 2 Va Harm[19]	%	Source 2 phase A voltage nineteenth harmonic
8158	SRC 2 Va Harm[20]	%	Source 2 phase A voltage twentieth harmonic
8159	SRC 2 Va Harm[21]	%	Source 2 phase A voltage twenty-first harmonic
8160	SRC 2 Va Harm[22]	%	Source 2 phase A voltage twenty-second harmonic
8161	SRC 2 Va Harm[23]	%	Source 2 phase A voltage twenty-third harmonic
8162	SRC 2 Va Harm[24]	%	Source 2 phase A voltage twenty-fourth harmonic
8163	SRC 2 Va Harm[25]	%	Source 2 phase A voltage twenty-fifth harmonic
8164	SRC 2 Vb THD	%	Source 2 phase B voltage total harmonic distortion (THD)
8165	SRC 2 Vb Harm[2]	%	Source 2 phase B voltage second harmonic

Address	FlexAnalog name	Units	Description
8166	SRC 2 Vb Harm[3]	%	Source 2 phase B voltage third harmonic
8167	SRC 2 Vb Harm[4]	%	Source 2 phase B voltage fourth harmonic
8168	SRC 2 Vb Harm[5]	%	Source 2 phase B voltage fifth harmonic
8169	SRC 2 Vb Harm[6]	%	Source 2 phase B voltage sixth harmonic
8170	SRC 2 Vb Harm[7]	%	Source 2 phase B voltage seventh harmonic
8171	SRC 2 Vb Harm[8]	%	Source 2 phase B voltage eighth harmonic
8172	SRC 2 Vb Harm[9]	%	Source 2 phase B voltage ninth harmonic
8173	SRC 2 Vb Harm[10]	%	Source 2 phase B voltage tenth harmonic
8174	SRC 2 Vb Harm[11]	%	Source 2 phase B voltage eleventh harmonic
8175	SRC 2 Vb Harm[12]	%	Source 2 phase B voltage twelfth harmonic
8176	SRC 2 Vb Harm[13]	%	Source 2 phase B voltage thirteenth harmonic
8177	SRC 2 Vb Harm[14]	%	Source 2 phase B voltage fourteenth harmonic
8178	SRC 2 Vb Harm[15]	%	Source 2 phase B voltage fifteenth harmonic
8179	SRC 2 Vb Harm[16]	%	Source 2 phase B voltage sixteenth harmonic
8180	SRC 2 Vb Harm[17]	%	Source 2 phase B voltage seventeenth harmonic
8181	SRC 2 Vb Harm[18]	%	Source 2 phase B voltage eighteenth harmonic
8182	SRC 2 Vb Harm[19]	%	Source 2 phase B voltage nineteenth harmonic
8183	SRC 2 Vb Harm[20]	%	Source 2 phase B voltage twentieth harmonic
8184	SRC 2 Vb Harm[21]	%	Source 2 phase B voltage twenty-first harmonic
8185	SRC 2 Vb Harm[22]	%	Source 2 phase B voltage twenty-second harmonic
8186	SRC 2 Vb Harm[23]	%	Source 2 phase B voltage twenty-third harmonic
8187	SRC 2 Vb Harm[24]	%	Source 2 phase B voltage twenty-fourth harmonic
8188	SRC 2 Vb Harm[25]	%	Source 2 phase B voltage twenty-fifth harmonic
8189	SRC 2 Vc THD	%	Source 2 phase C voltage total harmonic distortion (THD)
8190	SRC 2 Vc Harm[2]	%	Source 2 phase C voltage second harmonic
8191	SRC 2 Vc Harm[3]	%	Source 2 phase C voltage third harmonic
8192	SRC 2 Vc Harm[4]	%	Source 2 phase C voltage fourth harmonic
8193	SRC 2 Vc Harm[5]	%	Source 2 phase C voltage fifth harmonic
8194	SRC 2 Vc Harm[6]	%	Source 2 phase C voltage sixth harmonic
8195	SRC 2 Vc Harm[7]	%	Source 2 phase C voltage seventh harmonic
8196	SRC 2 Vc Harm[8]	%	Source 2 phase C voltage eighth harmonic
8197	SRC 2 Vc Harm[9]	%	Source 2 phase C voltage ninth harmonic
8198	SRC 2 Vc Harm[10]	%	Source 2 phase C voltage tenth harmonic
8199	SRC 2 Vc Harm[11]	%	Source 2 phase C voltage eleventh harmonic
8200	SRC 2 Vc Harm[12]	%	Source 2 phase C voltage twelfth harmonic
8201	SRC 2 Vc Harm[13]	%	Source 2 phase C voltage thirteenth harmonic
8202	SRC 2 Vc Harm[14]	%	Source 2 phase C voltage fourteenth harmonic
8203	SRC 2 Vc Harm[15]	%	Source 2 phase C voltage fifteenth harmonic
8204	SRC 2 Vc Harm[16]	%	Source 2 phase C voltage sixteenth harmonic
8205	SRC 2 Vc Harm[17]	%	Source 2 phase C voltage seventeenth harmonic
8206	SRC 2 Vc Harm[18]	%	Source 2 phase C voltage eighteenth harmonic
8207	SRC 2 Vc Harm[19]	%	Source 2 phase C voltage nineteenth harmonic
8208	SRC 2 Vc Harm[20]	%	Source 2 phase C voltage twentieth harmonic
8209	SRC 2 Vc Harm[21]	%	Source 2 phase C voltage twenty-first harmonic
8210	SRC 2 Vc Harm[22]	%	Source 2 phase C voltage twenty-second harmonic
8211	SRC 2 Vc Harm[23]	%	Source 2 phase C voltage twenty-third harmonic
8212	SRC 2 Vc Harm[24]	%	Source 2 phase C voltage twenty-fourth harmonic

A

Address	FlexAnalog name	Units	Description
8213	SRC 2 Vc Harm[25]	%	Source 2 phase C voltage twenty-fifth harmonic
9024	Prefault Ia Mag [1]	Amps	Fault 1 pre-fault phase A current magnitude
9026	Prefault Ia Ang [1]	Degrees	Fault 1 pre-fault phase A current angle
9027	Prefault Ib Mag [1]	Amps	Fault 1 pre-fault phase B current magnitude
9029	Prefault Ib Ang [1]	Degrees	Fault 1 pre-fault phase B current angle
9030	Prefault Ic Mag [1]	Amps	Fault 1 pre-fault phase C current magnitude
9032	Prefault Ic Ang [1]	Degrees	Fault 1 pre-fault phase C current angle
9033	Prefault Va Mag [1]	Volts	Fault 1 pre-fault phase A voltage magnitude
9035	Prefault Va Ang [1]	Degrees	Fault 1 pre-fault phase A voltage angle
9036	Prefault Vb Mag [1]	Volts	Fault 1 pre-fault phase B voltage magnitude
9038	Prefault Vb Ang [1]	Degrees	Fault 1 pre-fault phase B voltage angle
9039	Prefault Vc Mag [1]	Volts	Fault 1 pre-fault phase C voltage magnitude
9041	Prefault Vc Ang [1]	Degrees	Fault 1 pre-fault phase C voltage angle
9042	Fault Ia Mag [1]	Amps	Fault 1 post-fault phase A current magnitude
9044	Fault Ia Ang [1]	Degrees	Fault 1 post-fault phase A current angle
9045	Fault Ib Mag [1]	Amps	Fault 1 post-fault phase B current magnitude
9047	Fault Ib Ang [1]	Degrees	Fault 1 post-fault phase B current angle
9048	Fault Ic Mag [1]	Amps	Fault 1 post-fault phase C current magnitude
9050	Fault Ic Ang [1]	Degrees	Fault 1 post-fault phase C current angle
9051	Fault Va Mag [1]	Volts	Fault 1 post-fault phase A voltage magnitude
9053	Fault Va Ang [1]	Degrees	Fault 1 post-fault phase A voltage angle
9054	Fault Vb Mag [1]	Volts	Fault 1 post-fault phase B voltage magnitude
9056	Fault Vb Ang [1]	Degrees	Fault 1 post-fault phase B voltage angle
9057	Fault Vc Mag [1]	Volts	Fault 1 post-fault phase C voltage magnitude
9059	Fault Vc Ang [1]	Degrees	Fault 1 post-fault phase C voltage angle
9060	Fault Type [1]	---	Fault 1 type
9061	Fault Location [1]	---	Fault 1 location
9344	Local IA Mag	Amps	Local terminal phase A current magnitude
9346	Local IB Mag	Amps	Local terminal phase B current magnitude
9348	Local IC Mag	Amps	Local terminal phase C current magnitude
9350	Terminal 1 IA Mag	Amps	Remote terminal 1 phase A current magnitude
9352	Terminal 1 IB Mag	Amps	Remote terminal 1 phase B current magnitude
9354	Terminal 1 IC Mag	Amps	Remote terminal 1 phase C current magnitude
9356	Terminal 2 IA Mag	Amps	Remote terminal 2 phase A current magnitude
9358	Terminal 2 IB Mag	Amps	Remote terminal 2 phase B current magnitude
9360	Terminal 2 IC Mag	Amps	Remote terminal 2 phase C current magnitude
9362	Diff Curr IA Mag	Amps	Differential current phase A magnitude
9364	Diff Curr IB Mag	Amps	Differential current phase B magnitude
9366	Diff Curr IC Mag	Amps	Differential current phase C magnitude
9368	Local IA Angle	Degrees	Local terminal current phase A angle
9369	Local IB Angle	Degrees	Local terminal current phase B angle
9370	Local IC Angle	Degrees	Local terminal current phase C angle
9371	Terminal 1 IA Angle	Degrees	Remote terminal 1 current phase A angle
9372	Terminal 1 IB Angle	Degrees	Remote terminal 1 current phase B angle
9373	Terminal 1 IC Angle	Degrees	Remote terminal 1 current phase C angle
9374	Terminal 2 IA Angle	Degrees	Remote terminal 2 current phase A angle
9375	Terminal 2 IB Angle	Degrees	Remote terminal 2 current phase B angle

Address	FlexAnalog name	Units	Description
9376	Terminal 2 IC Angle	Degrees	Remote terminal 2 current phase C angle
9377	Diff Curr IA Angle	Degrees	Differential current phase A angle
9378	Diff Curr IB Angle	Degrees	Differential current phase B angle
9379	Diff Curr IC Angle	Degrees	Differential current phase C angle
9380	Op Square Curr IA	Amps	Phase A operating square current
9382	Op Square Curr IB	Amps	Phase B operating square current
9384	Op Square Curr IC	Amps	Phase C operating square current
9386	Rest Square Curr IA	Amps	Phase A restraint square current
9388	Rest Square Curr IB	Amps	Phase B restraint square current
9390	Rest Square Curr IC	Amps	Phase C restraint square current
9392	Rest Curr IA	Amps	Restraint current IA
9394	Rest Curr IB	Amps	Restraint current IB
9396	Rest Curr IC	Amps	Restraint current IC
9398	Diff Curr IG Mag	Amps	Differential current IG Magnitude
9400	Diff Curr IG Angle	Degrees	Differential current IG Angle
9401	Rest Curr IG	Amps	Restraint current IG
9400	Local IG Mag	Amps	Local IG magnitude
9405	Local IG Angle	Degrees	Local IG angle
9406	Terminal 1 IG Mag	Amps	Remote 1 IG magnitude
9408	Terminal 1 IG Angle	Degrees	Remote 1 IG angle
9409	Terminal 2 IG Mag	Amps	Remote 2 IG magnitude
9411	Terminal 2 IG Angle	Amps	Remote 2 IG angle
9421	87L Harm2 Iad Mag	Amps	Current differential second harmonic Iad magnitude
9423	87L Harm2 Ibd Mag	Amps	Current differential second harmonic Ibd magnitude
9425	87L Harm2 Icd Mag	Amps	Current differential second harmonic Icd magnitude
9581	PMU 1 Va Mag	Volts	Phasor measurement unit 1 phase A voltage magnitude
9583	PMU 1 Va Angle	Degrees	Phasor measurement unit 1 phase A voltage angle
9584	PMU 1 Vb Mag	Volts	Phasor measurement unit 1 phase B voltage magnitude
9586	PMU 1 Vb Angle	Degrees	Phasor measurement unit 1 phase B voltage angle
9587	PMU 1 Vc Mag	Volts	Phasor measurement unit 1 phase C voltage magnitude
9589	PMU 1 Vc Angle	Degrees	Phasor measurement unit 1 phase C voltage angle
9590	PMU 1 Vx Mag	Volts	Phasor measurement unit 1 auxiliary voltage magnitude
9592	PMU 1 Vx Angle	Degrees	Phasor measurement unit 1 auxiliary voltage angle
9593	PMU 1 V1 Mag	Volts	Phasor measurement unit 1 positive-sequence voltage magnitude
9595	PMU 1 V1 Angle	Degrees	Phasor measurement unit 1 positive-sequence voltage angle
9596	PMU 1 V2 Mag	Volts	Phasor measurement unit 1 negative-sequence voltage magnitude
9598	PMU 1 V2 Angle	Degrees	Phasor measurement unit 1 negative-sequence voltage angle
9599	PMU 1 V0 Mag	Volts	Phasor measurement unit 1 zero-sequence voltage magnitude
9601	PMU 1 V0 Angle	Degrees	Phasor measurement unit 1 zero-sequence voltage angle
9602	PMU 1 Ia Mag	Amps	Phasor measurement unit 1 phase A current magnitude
9604	PMU 1 Ia Angle	Degrees	Phasor measurement unit 1 phase A current angle
9605	PMU 1 Ib Mag	Amps	Phasor measurement unit 1 phase B current magnitude
9607	PMU 1 Ib Angle	Degrees	Phasor measurement unit 1 phase B current angle
9608	PMU 1 Ic Mag	Amps	Phasor measurement unit 1 phase C current magnitude
9610	PMU 1 Ic Angle	Degrees	Phasor measurement unit 1 phase C current angle
9611	PMU 1 Ig Mag	Amps	Phasor measurement unit 1 ground current magnitude
9613	PMU 1 Ig Angle	Degrees	Phasor measurement unit 1 ground current angle



Address	FlexAnalog name	Units	Description
9614	PMU 1 I1 Mag	Amps	Phasor measurement unit 1 positive-sequence current magnitude
9616	PMU 1 I1 Angle	Degrees	Phasor measurement unit 1 positive-sequence current angle
9617	PMU 1 I2 Mag	Amps	Phasor measurement unit 1 negative-sequence current magnitude
9619	PMU 1 I2 Angle	Degrees	Phasor measurement unit 1 negative-sequence current angle
9620	PMU 1 I0 Mag	Amps	Phasor measurement unit 1 zero-sequence current magnitude
9622	PMU 1 I0 Angle	Degrees	Phasor measurement unit 1 zero-sequence current angle
9623	PMU 1 Freq	Hz	Phasor measurement unit 1 frequency
9625	PMU 1 df dt	Hz/s	Phasor measurement unit 1 rate of change of frequency
9626	PMU 1 Conf Ch	---	Phasor measurement unit 1 configuration change counter
10240	SRC 1 Ia THD	%	Source 1 phase A current total harmonic distortion
10241	SRC 1 Ia Harm[2]	%	Source 1 phase A current second harmonic
10242	SRC 1 Ia Harm[3]	%	Source 1 phase A current third harmonic
10243	SRC 1 Ia Harm[4]	%	Source 1 phase A current fourth harmonic
10244	SRC 1 Ia Harm[5]	%	Source 1 phase A current fifth harmonic
10245	SRC 1 Ia Harm[6]	%	Source 1 phase A current sixth harmonic
10246	SRC 1 Ia Harm[7]	%	Source 1 phase A current seventh harmonic
10247	SRC 1 Ia Harm[8]	%	Source 1 phase A current eighth harmonic
10248	SRC 1 Ia Harm[9]	%	Source 1 phase A current ninth harmonic
10249	SRC 1 Ia Harm[10]	%	Source 1 phase A current tenth harmonic
10250	SRC 1 Ia Harm[11]	%	Source 1 phase A current eleventh harmonic
10251	SRC 1 Ia Harm[12]	%	Source 1 phase A current twelfth harmonic
10252	SRC 1 Ia Harm[13]	%	Source 1 phase A current thirteenth harmonic
10253	SRC 1 Ia Harm[14]	%	Source 1 phase A current fourteenth harmonic
10254	SRC 1 Ia Harm[15]	%	Source 1 phase A current fifteenth harmonic
10255	SRC 1 Ia Harm[16]	%	Source 1 phase A current sixteenth harmonic
10256	SRC 1 Ia Harm[17]	%	Source 1 phase A current seventeenth harmonic
10257	SRC 1 Ia Harm[18]	%	Source 1 phase A current eighteenth harmonic
10258	SRC 1 Ia Harm[19]	%	Source 1 phase A current nineteenth harmonic
10259	SRC 1 Ia Harm[20]	%	Source 1 phase A current twentieth harmonic
10260	SRC 1 Ia Harm[21]	%	Source 1 phase A current twenty-first harmonic
10261	SRC 1 Ia Harm[22]	%	Source 1 phase A current twenty-second harmonic
10262	SRC 1 Ia Harm[23]	%	Source 1 phase A current twenty-third harmonic
10263	SRC 1 Ia Harm[24]	%	Source 1 phase A current twenty-fourth harmonic
10264	SRC 1 Ia Harm[25]	%	Source 1 phase A current twenty-fifth harmonic
10273	SRC 1 Ib THD	%	Source 1 phase B current total harmonic distortion
10274	SRC 1 Ib Harm[2]	%	Source 1 phase B current second harmonic
10275	SRC 1 Ib Harm[3]	%	Source 1 phase B current third harmonic
10276	SRC 1 Ib Harm[4]	%	Source 1 phase B current fourth harmonic
10277	SRC 1 Ib Harm[5]	%	Source 1 phase B current fifth harmonic
10278	SRC 1 Ib Harm[6]	%	Source 1 phase B current sixth harmonic
10279	SRC 1 Ib Harm[7]	%	Source 1 phase B current seventh harmonic
10280	SRC 1 Ib Harm[8]	%	Source 1 phase B current eighth harmonic
10281	SRC 1 Ib Harm[9]	%	Source 1 phase B current ninth harmonic
10282	SRC 1 Ib Harm[10]	%	Source 1 phase B current tenth harmonic
10283	SRC 1 Ib Harm[11]	%	Source 1 phase B current eleventh harmonic
10284	SRC 1 Ib Harm[12]	%	Source 1 phase B current twelfth harmonic
10285	SRC 1 Ib Harm[13]	%	Source 1 phase B current thirteenth harmonic

Address	FlexAnalog name	Units	Description
10286	SRC 1 Ib Harm[14]	%	Source 1 phase B current fourteenth harmonic
10287	SRC 1 Ib Harm[15]	%	Source 1 phase B current fifteenth harmonic
10288	SRC 1 Ib Harm[16]	%	Source 1 phase B current sixteenth harmonic
10289	SRC 1 Ib Harm[17]	%	Source 1 phase B current seventeenth harmonic
10290	SRC 1 Ib Harm[18]	%	Source 1 phase B current eighteenth harmonic
10291	SRC 1 Ib Harm[19]	%	Source 1 phase B current nineteenth harmonic
10292	SRC 1 Ib Harm[20]	%	Source 1 phase B current twentieth harmonic
10293	SRC 1 Ib Harm[21]	%	Source 1 phase B current twenty-first harmonic
10294	SRC 1 Ib Harm[22]	%	Source 1 phase B current twenty-second harmonic
10295	SRC 1 Ib Harm[23]	%	Source 1 phase B current twenty-third harmonic
10296	SRC 1 Ib Harm[24]	%	Source 1 phase B current twenty-fourth harmonic
10297	SRC 1 Ib Harm[25]	%	Source 1 phase B current twenty-fifth harmonic
10306	SRC 1 Ic THD	%	Source 1 phase C current total harmonic distortion
10307	SRC 1 Ic Harm[2]	%	Source 1 phase C current second harmonic
10308	SRC 1 Ic Harm[3]	%	Source 1 phase C current third harmonic
10309	SRC 1 Ic Harm[4]	%	Source 1 phase C current fourth harmonic
10310	SRC 1 Ic Harm[5]	%	Source 1 phase C current fifth harmonic
10311	SRC 1 Ic Harm[6]	%	Source 1 phase C current sixth harmonic
10312	SRC 1 Ic Harm[7]	%	Source 1 phase C current seventh harmonic
10313	SRC 1 Ic Harm[8]	%	Source 1 phase C current eighth harmonic
10314	SRC 1 Ic Harm[9]	%	Source 1 phase C current ninth harmonic
10315	SRC 1 Ic Harm[10]	%	Source 1 phase C current tenth harmonic
10316	SRC 1 Ic Harm[11]	%	Source 1 phase C current eleventh harmonic
10317	SRC 1 Ic Harm[12]	%	Source 1 phase C current twelfth harmonic
10318	SRC 1 Ic Harm[13]	%	Source 1 phase C current thirteenth harmonic
10319	SRC 1 Ic Harm[14]	%	Source 1 phase C current fourteenth harmonic
10320	SRC 1 Ic Harm[15]	%	Source 1 phase C current fifteenth harmonic
10321	SRC 1 Ic Harm[16]	%	Source 1 phase C current sixteenth harmonic
10322	SRC 1 Ic Harm[17]	%	Source 1 phase C current seventeenth harmonic
10323	SRC 1 Ic Harm[18]	%	Source 1 phase C current eighteenth harmonic
10324	SRC 1 Ic Harm[19]	%	Source 1 phase C current nineteenth harmonic
10325	SRC 1 Ic Harm[20]	%	Source 1 phase C current twentieth harmonic
10326	SRC 1 Ic Harm[21]	%	Source 1 phase C current twenty-first harmonic
10327	SRC 1 Ic Harm[22]	%	Source 1 phase C current twenty-second harmonic
10328	SRC 1 Ic Harm[23]	%	Source 1 phase C current twenty-third harmonic
10329	SRC 1 Ic Harm[24]	%	Source 1 phase C current twenty-fourth harmonic
10330	SRC 1 Ic Harm[25]	%	Source 1 phase C current twenty-fifth harmonic
10339	SRC 2 Ia THD	%	Source 2 phase A current total harmonic distortion
10340	SRC 2 Ia Harm[2]	%	Source 2 phase A current second harmonic
10341	SRC 2 Ia Harm[3]	%	Source 2 phase A current third harmonic
10342	SRC 2 Ia Harm[4]	%	Source 2 phase A current fourth harmonic
10343	SRC 2 Ia Harm[5]	%	Source 2 phase A current fifth harmonic
10344	SRC 2 Ia Harm[6]	%	Source 2 phase A current sixth harmonic
10345	SRC 2 Ia Harm[7]	%	Source 2 phase A current seventh harmonic
10346	SRC 2 Ia Harm[8]	%	Source 2 phase A current eighth harmonic
10347	SRC 2 Ia Harm[9]	%	Source 2 phase A current ninth harmonic
10348	SRC 2 Ia Harm[10]	%	Source 2 phase A current tenth harmonic

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Address	FlexAnalog name	Units	Description
10349	SRC 2 Ia Harm[11]	%	Source 2 phase A current eleventh harmonic
10350	SRC 2 Ia Harm[12]	%	Source 2 phase A current twelfth harmonic
10351	SRC 2 Ia Harm[13]	%	Source 2 phase A current thirteenth harmonic
10352	SRC 2 Ia Harm[14]	%	Source 2 phase A current fourteenth harmonic
10353	SRC 2 Ia Harm[15]	%	Source 2 phase A current fifteenth harmonic
10354	SRC 2 Ia Harm[16]	%	Source 2 phase A current sixteenth harmonic
10355	SRC 2 Ia Harm[17]	%	Source 2 phase A current seventeenth harmonic
10356	SRC 2 Ia Harm[18]	%	Source 2 phase A current eighteenth harmonic
10357	SRC 2 Ia Harm[19]	%	Source 2 phase A current nineteenth harmonic
10358	SRC 2 Ia Harm[20]	%	Source 2 phase A current twentieth harmonic
10359	SRC 2 Ia Harm[21]	%	Source 2 phase A current twenty-first harmonic
10360	SRC 2 Ia Harm[22]	%	Source 2 phase A current twenty-second harmonic
10361	SRC 2 Ia Harm[23]	%	Source 2 phase A current twenty-third harmonic
10362	SRC 2 Ia Harm[24]	%	Source 2 phase A current twenty-fourth harmonic
10363	SRC 2 Ia Harm[25]	%	Source 2 phase A current twenty-fifth harmonic
10372	SRC 2 Ib THD	%	Source 2 phase B current total harmonic distortion
10373	SRC 2 Ib Harm[2]	%	Source 2 phase B current second harmonic
10374	SRC 2 Ib Harm[3]	%	Source 2 phase B current third harmonic
10375	SRC 2 Ib Harm[4]	%	Source 2 phase B current fourth harmonic
10376	SRC 2 Ib Harm[5]	%	Source 2 phase B current fifth harmonic
10377	SRC 2 Ib Harm[6]	%	Source 2 phase B current sixth harmonic
10378	SRC 2 Ib Harm[7]	%	Source 2 phase B current seventh harmonic
10379	SRC 2 Ib Harm[8]	%	Source 2 phase B current eighth harmonic
10380	SRC 2 Ib Harm[9]	%	Source 2 phase B current ninth harmonic
10381	SRC 2 Ib Harm[10]	%	Source 2 phase B current tenth harmonic
10382	SRC 2 Ib Harm[11]	%	Source 2 phase B current eleventh harmonic
10383	SRC 2 Ib Harm[12]	%	Source 2 phase B current twelfth harmonic
10384	SRC 2 Ib Harm[13]	%	Source 2 phase B current thirteenth harmonic
10385	SRC 2 Ib Harm[14]	%	Source 2 phase B current fourteenth harmonic
10386	SRC 2 Ib Harm[15]	%	Source 2 phase B current fifteenth harmonic
10387	SRC 2 Ib Harm[16]	%	Source 2 phase B current sixteenth harmonic
10388	SRC 2 Ib Harm[17]	%	Source 2 phase B current seventeenth harmonic
10389	SRC 2 Ib Harm[18]	%	Source 2 phase B current eighteenth harmonic
10390	SRC 2 Ib Harm[19]	%	Source 2 phase B current nineteenth harmonic
10391	SRC 2 Ib Harm[20]	%	Source 2 phase B current twentieth harmonic
10392	SRC 2 Ib Harm[21]	%	Source 2 phase B current twenty-first harmonic
10393	SRC 2 Ib Harm[22]	%	Source 2 phase B current twenty-second harmonic
10394	SRC 2 Ib Harm[23]	%	Source 2 phase B current twenty-third harmonic
10395	SRC 2 Ib Harm[24]	%	Source 2 phase B current twenty-fourth harmonic
10396	SRC 2 Ib Harm[25]	%	Source 2 phase B current twenty-fifth harmonic
10405	SRC 2 Ic THD	%	Source 2 phase C current total harmonic distortion
10406	SRC 2 Ic Harm[2]	%	Source 2 phase C current second harmonic
10407	SRC 2 Ic Harm[3]	%	Source 2 phase C current third harmonic
10408	SRC 2 Ic Harm[4]	%	Source 2 phase C current fourth harmonic
10409	SRC 2 Ic Harm[5]	%	Source 2 phase C current fifth harmonic
10410	SRC 2 Ic Harm[6]	%	Source 2 phase C current sixth harmonic
10411	SRC 2 Ic Harm[7]	%	Source 2 phase C current seventh harmonic

Address	FlexAnalog name	Units	Description
10412	SRC 2 Ic Harm[8]	%	Source 2 phase C current eighth harmonic
10413	SRC 2 Ic Harm[9]	%	Source 2 phase C current ninth harmonic
10414	SRC 2 Ic Harm[10]	%	Source 2 phase C current tenth harmonic
10415	SRC 2 Ic Harm[11]	%	Source 2 phase C current eleventh harmonic
10416	SRC 2 Ic Harm[12]	%	Source 2 phase C current twelfth harmonic
10417	SRC 2 Ic Harm[13]	%	Source 2 phase C current thirteenth harmonic
10418	SRC 2 Ic Harm[14]	%	Source 2 phase C current fourteenth harmonic
10419	SRC 2 Ic Harm[15]	%	Source 2 phase C current fifteenth harmonic
10420	SRC 2 Ic Harm[16]	%	Source 2 phase C current sixteenth harmonic
10421	SRC 2 Ic Harm[17]	%	Source 2 phase C current seventeenth harmonic
10422	SRC 2 Ic Harm[18]	%	Source 2 phase C current eighteenth harmonic
10423	SRC 2 Ic Harm[19]	%	Source 2 phase C current nineteenth harmonic
10424	SRC 2 Ic Harm[20]	%	Source 2 phase C current twentieth harmonic
10425	SRC 2 Ic Harm[21]	%	Source 2 phase C current twenty-first harmonic
10426	SRC 2 Ic Harm[22]	%	Source 2 phase C current twenty-second harmonic
10427	SRC 2 Ic Harm[23]	%	Source 2 phase C current twenty-third harmonic
10428	SRC 2 Ic Harm[24]	%	Source 2 phase C current twenty-fourth harmonic
10429	SRC 2 Ic Harm[25]	%	Source 2 phase C current twenty-fifth harmonic
10848	Synchchk 1 Delta V	Volts	Synchrocheck 1 delta voltage
10850	Synchchk 1 Delta Phs	Degrees	Synchrocheck 1 delta phase
10851	Synchchk 1 SSCP DPh	Degrees	Synchrocheck 1 synchsscope
10852	Synchchk 1 Delta F	Hz	Synchrocheck 1 delta frequency
10853	Synchchk 1 V1 Mag	Volts	Synchrocheck 1 V1 mag
10855	Synchchk 1 V1 Ang	Degrees	Synchrocheck 1 V1 angle
10856	Synchchk 1 V2 Mag	Volts	Synchrocheck 1 V2 mag
10858	Synchchk 1 V2 Ang	Degrees	Synchrocheck 1 V2 angle
10859	Synchchk 1 V2' Mag	Volts	Synchrocheck 1 V2_mag
10861	Synchchk 1 V2' Ang	Degrees	Synchrocheck 1 V2_angle
10862	Synchchk 1 Delta' Phs	Degrees	Synchrocheck 1 delta_phase
10863	Synchchk 1 SSCP DPh'	Degrees	Synchrocheck 1 _synchsscope
10864	Synchchk 2 Delta V	Volts	Synchrocheck 2 delta voltage
10866	Synchchk 2 Delta Phs	Degrees	Synchrocheck 2 delta phase
10867	Synchchk 2 SSCP DPh	Degrees	Synchrocheck 2 synchsscope
10868	Synchchk 2 Delta F	Hz	Synchrocheck 2 delta frequency
10869	Synchchk 2 V1 Mag	Volts	Synchrocheck 2 V1 mag
10871	Synchchk 2 V1 Ang	Degrees	Synchrocheck 2 V1 angle
10872	Synchchk 2 V2 Mag	Volts	Synchrocheck 2 V2 mag
10874	Synchchk 2 V2 Ang	Degrees	Synchrocheck 2 V2 angle
10875	Synchchk 2 V2' Mag	Volts	Synchrocheck 2 V2_mag
10877	Synchchk 2 V2' Ang	Degrees	Synchrocheck 2 V2_angle
10878	Synchchk 2 Delta' Phs	Degrees	Synchrocheck 2 delta_phase
10879	Synchchk 2 SSCP DPh'	Degrees	Synchrocheck 2 _synchsscope
10880	Synchchk 3 Delta V	Volts	Synchrocheck 3 delta voltage
10882	Synchchk 3 Delta Phs	Degrees	Synchrocheck 3 delta phase
10883	Synchchk 3 SSCP DPh	Degrees	Synchrocheck 3 synchsscope
10884	Synchchk 3 Delta F	Volts	Synchrocheck 3 delta frequency
10885	Synchchk 3 V1 Mag	Volts	Synchrocheck 3 V1 mag

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Address	FlexAnalog name	Units	Description
10887	Synchchk 3 V1 Ang	Degrees	Synchrocheck 3 V1 angle
10888	Synchchk 3 V2 Mag	Volts	Synchrocheck 3 V2 mag
10890	Synchchk 3 V2 Ang	Degrees	Synchrocheck 3 V2 angle
10891	Synchchk 3 V2' Mag	Volts	Synchrocheck 3 V2_mag
10893	Synchchk 3 V2' Ang	Degrees	Synchrocheck 3 V2_angle
10894	Synchchk 3 Delta' Phs	Degrees	Synchrocheck 3 delta_phase
10895	Synchchk 3 SSCP DPH'	Degrees	Synchrocheck 3 _synscope
10896	Synchchk 4 Delta V	Volts	Synchrocheck 4 delta voltage
10898	Synchchk 4 Delta Phs	Degrees	Synchrocheck 4 delta phase
10899	Synchchk 4 SSCP DPh	Degrees	Synchrocheck 4 synscope
10900	Synchchk 4 Delta F	Hz	Synchrocheck 4 delta frequency
10901	Synchchk 4 V1 Mag	Volts	Synchrocheck 4 V1 mag
10903	Synchchk 4 V1 Ang	Degrees	Synchrocheck 4 V1 angle
10904	Synchchk 4 V2 Mag	Volts	Synchrocheck 4 V2 mag
10906	Synchchk 4 V2 Ang	Degrees	Synchrocheck 4 V2 angle
10907	Synchchk 4 V2' Mag	Volts	Synchrocheck 4 V2_mag
10909	Synchchk 4 V2' Ang	Degrees	Synchrocheck 4 V2_angle
10910	Synchchk 4 Delta' Phs	Degrees	Synchrocheck 4 delta_phase
10911	Synchchk 4 SSCP DPH'	Degrees	Synchrocheck 4 _synscope
12032	Brk 1 Acc Arc Amp A	kA2-cyc	Breaker 1 Acc arcing amp phase A
12034	Brk 1 Acc Arc Amp B	kA2-cyc	Breaker 1 Acc arcing amp phase B
12036	Brk 1 Acc Arc Amp C	kA2-cyc	Breaker 1 Acc arcing amp phase C
12038	Brk 1 Op Time A	ms	Breaker 1 operating time phase A
12039	Brk 1 Op Time B	ms	Breaker 1 operating time phase B
12040	Brk 1 Op Time C	ms	Breaker 1 operating time phase C
12041	Brk 1 Op Time	ms	Breaker 1 operating time
12042	Brk 1 Arc Amp A	kA2-cyc	Breaker 1 arcing amp phase A
12044	Brk 1 Arc Amp B	kA2-cyc	Breaker 1 arcing amp phase B
12046	Brk 1 Arc Amp C	kA2-cyc	Breaker 1 arcing amp phase C
12048	Brk 1 Amp Max A	kA2-cyc	Breaker 1 amp max phase A
12050	Brk 1 Amp Max B	kA2-cyc	Breaker 1 amp max phase B
12052	Brk 1 Amp Max C	kA2-cyc	Breaker 1 amp max phase C
12054	Brk 2 Acc Arc Amp A	kA2-cyc	Breaker 2 Acc arcing amp phase A
12056	Brk 2 Acc Arc Amp B	kA2-cyc	Breaker 2 Acc arcing amp phase B
12058	Brk 2 Acc Arc Amp C	kA2-cyc	Breaker 2 Acc arcing amp phase C
12060	Brk 2 Op Time A	ms	Breaker 2 operating time phase A
12061	Brk 2 Op Time B	ms	Breaker 2 operating time phase B
12062	Brk 2 Op Time C	ms	Breaker 2 operating time phase C
12063	Brk 2 Op Time	ms	Breaker 2 operating time
12064	Brk 2 Arc Amp A	kA2-cyc	Breaker 2 arcing amp phase A
12066	Brk 2 Arc Amp B	kA2-cyc	Breaker 2 arcing amp phase B
12068	Brk 2 Arc Amp C	kA2-cyc	Breaker 2 arcing amp phase C
12070	Brk 2 Amp Max A	kA2-cyc	Breaker 2 amp max phase A
12072	Brk 2 Amp Max B	kA2-cyc	Breaker 2 amp max phase B
12074	Brk 2 Amp Max C	kA2-cyc	Breaker 2 amp max phase C
12306	Oscill Num Triggers	---	Oscillography number of triggers
13504	DCmA Ip 1	mA	DCmA input 1 actual value

Address	FlexAnalog name	Units	Description
13506	DCmA Ip 2	mA	DCmA input 2 actual value
13508	DCmA Ip 3	mA	DCmA input 3 actual value
13510	DCmA Ip 4	mA	DCmA input 4 actual value
13512	DCmA Ip 5	mA	DCmA input 5 actual value
13514	DCmA Ip 6	mA	DCmA input 6 actual value
13516	DCmA Ip 7	mA	DCmA input 7 actual value
13518	DCmA Ip 8	mA	DCmA input 8 actual value
13520	DCmA Ip 9	mA	DCmA input 9 actual value
13522	DCmA Ip 10	mA	DCmA input 10 actual value
13524	DCmA Ip 11	mA	DCmA input 11 actual value
13526	DCmA Ip 12	mA	DCmA input 12 actual value
13528	DCmA Ip 13	mA	DCmA input 13 actual value
13530	DCmA Ip 14	mA	DCmA input 14 actual value
13532	DCmA Ip 15	mA	DCmA input 15 actual value
13534	DCmA Ip 16	mA	DCmA input 16 actual value
13536	DCmA Ip 17	mA	DCmA input 17 actual value
13538	DCmA Ip 18	mA	DCmA input 18 actual value
13540	DCmA Ip 19	mA	DCmA input 19 actual value
13542	DCmA Ip 20	mA	DCmA input 20 actual value
13544	DCmA Ip 21	mA	DCmA input 21 actual value
13546	DCmA Ip 22	mA	DCmA input 22 actual value
13548	DCmA Ip 23	mA	DCmA input 23 actual value
13550	DCmA Ip 24	mA	DCmA input 24 actual value
13552	RTD Ip 1	---	RTD input 1 actual value
13553	RTD Ip 2	---	RTD input 2 actual value
13554	RTD Ip 3	---	RTD input 3 actual value
13555	RTD Ip 4	---	RTD input 4 actual value
13556	RTD Ip 5	---	RTD input 5 actual value
13557	RTD Ip 6	---	RTD input 6 actual value
13558	RTD Ip 7	---	RTD input 7 actual value
13559	RTD Ip 8	---	RTD input 8 actual value
13560	RTD Ip 9	---	RTD input 9 actual value
13561	RTD Ip 10	---	RTD input 10 actual value
13562	RTD Ip 11	---	RTD input 11 actual value
13563	RTD Ip 12	---	RTD input 12 actual value
13564	RTD Ip 13	---	RTD input 13 actual value
13565	RTD Ip 14	---	RTD input 14 actual value
13566	RTD Ip 15	---	RTD input 15 actual value
13567	RTD Ip 16	---	RTD input 16 actual value
13568	RTD Ip 17	---	RTD input 17 actual value
13569	RTD Ip 18	---	RTD input 18 actual value
13570	RTD Ip 19	---	RTD input 19 actual value
13571	RTD Ip 20	---	RTD input 20 actual value
13572	RTD Ip 21	---	RTD input 21 actual value
13573	RTD Ip 22	---	RTD input 22 actual value
13574	RTD Ip 23	---	RTD input 23 actual value
13575	RTD Ip 24	---	RTD input 24 actual value



Address	FlexAnalog name	Units	Description
13576	RTD Ip 25	---	RTD input 25 actual value
13577	RTD Ip 26	---	RTD input 26 actual value
13578	RTD Ip 27	---	RTD input 27 actual value
13579	RTD Ip 28	---	RTD input 28 actual value
13580	RTD Ip 29	---	RTD input 29 actual value
13581	RTD Ip 30	---	RTD input 30 actual value
13582	RTD Ip 31	---	RTD input 31 actual value
13583	RTD Ip 32	---	RTD input 32 actual value
13584	RTD Ip 33	---	RTD input 33 actual value
13585	RTD Ip 34	---	RTD input 34 actual value
13586	RTD Ip 35	---	RTD input 35 actual value
13587	RTD Ip 36	---	RTD input 36 actual value
13588	RTD Ip 37	---	RTD input 37 actual value
13589	RTD Ip 38	---	RTD input 38 actual value
13590	RTD Ip 39	---	RTD input 39 actual value
13591	RTD Ip 40	---	RTD input 40 actual value
13592	RTD Ip 41	---	RTD input 41 actual value
13593	RTD Ip 42	---	RTD input 42 actual value
13594	RTD Ip 43	---	RTD input 43 actual value
13595	RTD Ip 44	---	RTD input 44 actual value
13596	RTD Ip 45	---	RTD input 45 actual value
13597	RTD Ip 46	---	RTD input 46 actual value
13598	RTD Ip 47	---	RTD input 47 actual value
13599	RTD Ip 48	---	RTD input 48 actual value
13600	Ohm Inputs 1 Value	Ohms	Ohm inputs 1 value
13601	Ohm Inputs 2 Value	Ohms	Ohm inputs 2 value
14189	PTP-IRIG-B Delta	ns	PTP time minus IRIG-B time
24432	Communications Group	---	Groups communications group
24447	Active Setting Group	---	Current setting group
32768	Tracking Frequency	Hz	Terminal tracking frequency
39168	FlexElement 1 Value	---	FlexElement 1 actual value
39170	FlexElement 2 Value	---	FlexElement 2 actual value
39172	FlexElement 3 Value	---	FlexElement 3 actual value
39174	FlexElement 4 Value	---	FlexElement 4 actual value
39176	FlexElement 5 Value	---	FlexElement 5 actual value
39178	FlexElement 6 Value	---	FlexElement 6 actual value
39180	FlexElement 7 Value	---	FlexElement 7 actual value
39182	FlexElement 8 Value	---	FlexElement 8 actual value
41138	V0 3rd Harmonic 1	Volts	VTFF 1 V0 3rd Harmonic
41140	V0 3rd Harmonic 2	Volts	VTFF 2 V0 3rd Harmonic
45584	RxGOOSE Analog 1	---	RxGOOSE analog input 1
45586	RxGOOSE Analog 2	---	RxGOOSE analog input 2
45588	RxGOOSE Analog 3	---	RxGOOSE analog input 3
45590	RxGOOSE Analog 4	---	RxGOOSE analog input 4
45592	RxGOOSE Analog 5	---	RxGOOSE analog input 5
45594	RxGOOSE Analog 6	---	RxGOOSE analog input 6
45596	RxGOOSE Analog 7	---	RxGOOSE analog input 7

Address	FlexAnalog name	Units	Description
45598	RxGOOSE Analog 8	---	RxGOOSE analog input 8
45600	RxGOOSE Analog 9	---	RxGOOSE analog input 9
45602	RxGOOSE Analog 10	---	RxGOOSE analog input 10
45604	RxGOOSE Analog 11	---	RxGOOSE analog input 11
45606	RxGOOSE Analog 12	---	RxGOOSE analog input 12
45608	RxGOOSE Analog 13	---	RxGOOSE analog input 13
45610	RxGOOSE Analog 14	---	RxGOOSE analog input 14
45612	RxGOOSE Analog 15	---	RxGOOSE analog input 15
45614	RxGOOSE Analog 16	---	RxGOOSE analog input 16
45616	RxGOOSE Analog 17	---	RxGOOSE analog input 17
45618	RxGOOSE Analog 18	---	RxGOOSE analog input 18
45620	RxGOOSE Analog 19	---	RxGOOSE analog input 19
45622	RxGOOSE Analog 20	---	RxGOOSE analog input 20
45624	RxGOOSE Analog 21	---	RxGOOSE analog input 21
45626	RxGOOSE Analog 22	---	RxGOOSE analog input 22
45628	RxGOOSE Analog 23	---	RxGOOSE analog input 23
45630	RxGOOSE Analog 24	---	RxGOOSE analog input 24
45632	RxGOOSE Analog 25	---	RxGOOSE analog input 25
45634	RxGOOSE Analog 26	---	RxGOOSE analog input 26
45636	RxGOOSE Analog 27	---	RxGOOSE analog input 27
45638	RxGOOSE Analog 28	---	RxGOOSE analog input 28
45640	RxGOOSE Analog 29	---	RxGOOSE analog input 29
45642	RxGOOSE Analog 30	---	RxGOOSE analog input 30
45644	RxGOOSE Analog 31	---	RxGOOSE analog input 31
45646	RxGOOSE Analog 32	---	RxGOOSE analog input 32
61439	PMU Num Triggers	---	Phasor measurement unit recording number of triggers



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Appendix B: RADIUS server configuration

This appendix outlines how to set up a RADIUS server for user authentication.

B.1 RADIUS server configuration

The following procedure is an example of how to set up a simple RADIUS server. You install the RADIUS server software on a separate computer. In this example, we use FreeRADIUS third-party software.

1. Download and install FreeRADIUS from www.freeradius.net as the RADIUS server. This is a Windows 32-bit installation that is known to work. If you try another third-party tool and it does not work, use the FreeRADIUS software from freeradius.net.

2. Open the radius.conf file in the <Path_to_Radius>\etc\raddb folder, locate the "bind_address" field, and enter your RADIUS server IP address. An example is

```
bind_address = 10.14.61.109
```

Text editor software that supports direct editing and saving of UNIX text encodings and line breaks, such as EditPad Lite, is needed for this editing.

3. In the users.conf file in the <Path_to_Radius>\etc\raddb folder, add the following text to configure a user "Tester" with an Administrator role.

```
Tester                User-Password == "testpw"  
                    GE-PDC-USER-RoLe = Administrator,
```

4. In the clients.conf file in the <Path_to_Radius>\etc\raddb folder, add the following text to define the UR as a RADIUS client, where the client IP address is 10.0.0.2, the subnet mask is 255.255.255.0, the shared secret specified here is also configured on the UR device for successful authentication, and the shortname is a short, optional alias that can be used in place of the IP address.

```
client 10.0.0.2/24 {  
    secret = testing123  
    shortname = private-network-1  
}
```

5. In the <Path_to_Radius>\etc\raddb folder, create a file called dictionary.ge and add the following content.

```
# #####  
# GE VSAS  
#####
```

```
VENDOR                GE                2910
```

```
# Management authorization
```

```

BEGIN-VENDOR                                GE

# Role ID
ATTRIBUTE                                GE-UR-Role    1            integer

# GE-UR-ROLE values
VALUE GE-UR-Role    Administrator    1
VALUE GE-UR-Role    Supervisor        2
VALUE GE-UR-Role    Engineer           3
VALUE GE-UR-Role    Operator           4
VALUE GE-UR-Role    Observer           5

END-VENDOR                                GE
#####
    
```

B

- In the dictionary file in the <Path_to_Radius>\etc\raddb folder, add the following line.

```
$INCLUDE dictionary.ge
```

For example, the file can look like the following:

```
$INCLUDE ../share\freeradius\dictionary
$INCLUDE dictionary.ge
```

- For the first start, run the RADIUS server in debug mode to ensure that there are no compiling errors.

```
<Path_to_Radius>/start_radiusd_debug.bat
```

- Set up the RADIUS parameters on the UR as follows.
 - If logging in, select **Device** for the **Authentication Type**, and use Administrator for the **User Name**. The default password is "ChangeMe1#".
 - Access **Settings > Product Setup > Security**. Configure the IP address and ports for the RADIUS server. Leave the GE vendor ID field at the default of 2910. Update the RADIUS shared secret as specified in the clients.conf file. Restart the relay for the IP address and port changes to take effect.
- Verify operation. Log in to the UR software as follows. In the login window, select **Server** as the **Authentication Type**, enter the user name entered (for example user name Tester and password "testpw"). Check that the RADIUS server log file shows the access with an "Access-Accept" entry.

Recall that if you tried another third-party tool and it did not work, you can use the FreeRADIUS software from freeradius.net.

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Appendix C: Command line interface

This appendix outlines command line access to the software.

C.1 Command line interface

SetupCLI is a command line interface to communicate with the EnerVista UR Setup software. Commands can be sent from a DOS prompt or a Windows batch file.

The interface is installed with the EnerVista software. Its default location is similar to
C:\Program Files\EnerVista\Tools\SetupCLI

The EnerVista software needs to be installed on a computer to run the command line interface. The command line interface does not provide a remote connection to a computer running the EnerVista software.

Items to note are as follows:

- Works with EnerVista UR Setup version 6.10 and later
- Available in English only
- The graphical user interface of the software is not available concurrently with the command line interface
- It does not support concurrent commands
- It has limited functionality with CyberSentry
- It does not interface with UR Engineer
- It does not work when EnerVista UR Setup security is enabled, meaning when login is required

Command syntax is as follows:

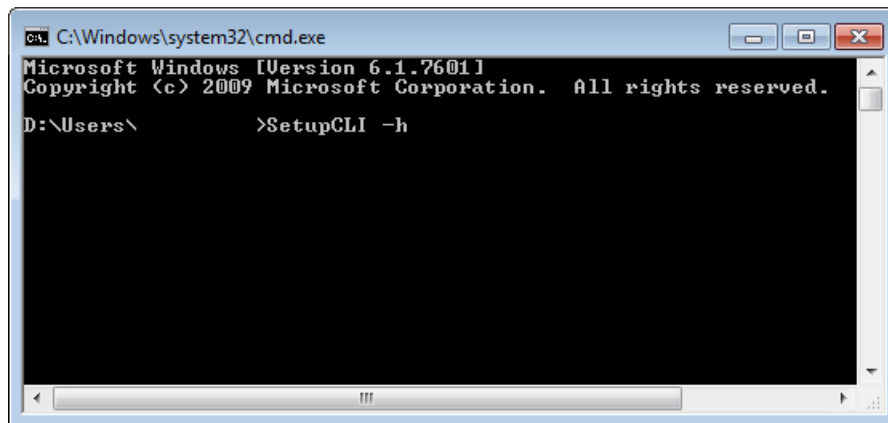
- Options enclosed in [] are optional
- Values enclosed in < > are replaced with your own values
- <Application> is replaced with the EnerVista software to receive the command. Use "URPC" for EnerVista UR Setup.
- <device> is the UR device name, as displayed in the **Device Name** field of the Device Setup window and listed in the Online Window. Use quotes with spaces, such as "B30 Belfort".
- "-s" can be used with any command to suppress error messages
- All commands, their return codes, and error description are logged in the file
C:\ProgramData\EnerVista\Tools\SetupCLI\SetupCLI.log
- When the Supervisor account is enabled, the 'Lock Relay' setting must first be changed to No before the putsettings, inservice, or reboot command can be used. This setting cannot be changed using the command line interface.
- Use quotes ("") to enclose any parameter containing a space

- Commands, options, and parameters are case sensitive
- All commands have a return code of 0-255. 0 indicates success and 1-255 indicate different errors
- If SetupCLI is automated (in a batch file), make sure that only a single batch is running at a time. SetupCLI does not support concurrent operations.

To run the command line interface:

1. In Windows, click the **Start** button, enter **cmd**, and press the **Enter** key. After prompting for permission, the Windows command window opens.
2. Enter **SetupCLI** followed by the action to execute. An example of use is to enter "SetupCLI -h" to display help, specifically the commands and explanations outlined here.

Figure C-1: Command line interface run in the command window



SetupCLI -h

Display help.

It displays the content outline here.

SetupCLI <Application> start [-c] [-s]

Launch application with name <Application>.

To start in client mode, which is the graphical user interface, include option '-c'. Before use, the software must be idle without any windows open. Any activity or open windows can cause unexpected behavior. When in client mode, do not use Launchpad's Site Management feature.

To suppress errors, include option -s.

Example: SetupCLI URPC start -c

SetupCLI <Application> exit [-s]

Exit application with name <Application>.

Example: SetupCLI URPC exit

SetupCLI <Application> login -d <device> [-A <authentication type>] [-a <account>] -w <password> [-s]

Authenticate with device <device> using password <password>.

For non-CyberSentry devices — Set <authentication type> to "traditional". Note that <authentication type> defaults to "traditional" if not specified. Set <account> to "COMMANDS" or "SETTINGS". If not specified, the SETTINGS account is used.

Example: SetupCLI URPC login -d "C30 Melbourne" -A traditional -a SETTINGS -w 1password1

Example of a batch file that checks for an error (this batch file uses standard batch file operations to check the return code (ERRORLEVEL) and jump to an error handler):

```
SetupCLI URPC start
SetupCLI URPC login -d demoDevice -a SETTINGS -w WrongPassword -A traditional
IF NOT ERRORLEVEL 0 GOTO FAILED
SetupCLI URPC putsettings -d demoDevice -f "example file.urs"
SetupCLI URPC inservice -d demoDevice
SetupCLI URPC reboot -d demoDevice
SetupCLI URPC exit
exit

:FAILED
echo Please try again
exit
```

For CyberSentry devices with local authentication — Set <authentication type> to "local" . Set <account> to "Supervisor", "Administrator", "Engineer", "Operator", or "Observer".

For CyberSentry devices with RADIUS authentication — Set <authentication type> to "radius". Set <account> to the user's account on the RADIUS server.

SetupCLI <Application> logout -d <device> [-s]

Log out of device <device>.

Example: SetupCLI URPC logout -d C30

SetupCLI <Application> getsettings -d <device> -f <File> [-s]

Read settings from device <device> and save them to the .urs file <File>. The <File> must not already exist. The default path to the output file is C:\Users\Public\Public Documents\GE Power Management\URPC\Data

Example: SetupCLI URPC getsettings -d C30 -f "C30 Markham.urs"

Example of a batch file to retrieve a settings file:

```
SetupCLI URPC start
SetupCLI URPC getsettings -d demoDevice -f C:\example.urs
SetupCLI URPC exit
```

Example of a batch file to retrieve a settings file from a relay that requires RADIUS authentication:

```
SetupCLI URPC start
SetupCLI URPC login -d demoDevice -a %1 -w %2 -A radius
SetupCLI URPC getsettings -d demoDevice -f "example file.urs"
SetupCLI URPC logout -d demoDevice
SetupCLI URPC exit
```

Although a user name and password could have been entered in this batch file, it would have created a security risk. Batch files allow you to pass in runtime parameters and refer to them in your script as %1, %2, and so on. For example, if this file is called example.bat, one calls it as follows: "example.bat MyUserName MyPassword"

SetupCLI <Application> putsettings -d <device> -f <File> [-s]

Write the settings file <File> to the device <device>.

For CyberSentry devices, putsettings is only supported for users with the "Administrator" role.

Example: SetupCLI URPC putsettings -d C30 -f "C30 Markham.urs"

SetupCLI <Application> compare -f <File1> -r <File2> -o <OutputFile> [-s]

Compare settings files <File1> and <File2>, and save output to <OutputFile>.

Example: SetupCLI URPC compare -f may.urs -r september.urs -o compared.txt

Batch file example that retrieves a settings file, compares it with an existing settings file, and opens the resulting comparison file:

```
SetupCLI URPC start
SetupCLI URPC getsettings -d demoDevice -f devicefile.urs
SetupCLI URPC compare -f existingfile.urs -r devicefile.urs -o output.txt
```

The output is similar to the following:

Comparing settings file aaa.urs : C:\Users\Public\Public Documents\GE Power Management\URPC\Data\ with bbb.urs : C:\Users\Public\Public Documents\GE Power Management\URPC\Data\

#	Setting Name	(Group,Module,Item)	Value
1 +	Default Message Timeout	(1,1,1)	= 299 s
2 -	Default Message Timeout	(1,1,1)	= 300 s
3 +	Flash Message Time	(1,1,1)	= 0.9 s
4 -	Flash Message Time	(1,1,1)	= 1.0 s

SetupCLI <Application> inservice -d <device> [-n] [-s]

Put the device in service. Include option -n to take the device out of service.

Example: SetupCLI URPC inservice -d C30

SetupCLI <Application> reboot -d <device> [-s]

Reboot the relay <device>. This is necessary after changing IEC 61850 settings and aggregator source settings.

Example: SetupCLI URPC reboot -d "C30_Instanbul"

SetupCLI <Application> adddevice -I <IP Address> -S <Slave Address> -P <Modbus Port>

Connect to a device using its IP address, slave address, and Modbus port. Show the device in the EnerVista interface under the SetupCLI Site as DEV@SETUP_CLI.

EnerVista UR Setup 7.30 or higher supports this command.

Figure C-2: Device added using IP address



The device is named as DEV@SETUP_CLI, which is used as the device name required by the <device> parameter of other SetupCLI commands.

The device name DEV@SETUP_CLI is always assigned to the device that is connected most recently by performing 'adddevice' command. It means that the Application only keeps up to one device named as DEV@SETUP_CLI, the 'adddevice' command disconnects/deletes the device DEV@SETUP_CLI that was connected previously by performing 'adddevice' command.

The device name DEV@SETUP_CLI is never used to configure/connect to a device through the graphical user interface.

Example of a batch file using a device IP address to retrieve its settings file:

```
SetupCLI URPC start
SetupCLI URPC adddevice -I 192.168.140.113 -S 113 -P 502
SetupCLI URPC getsettings -d DEV@SETUP_CLI -f C:\example.urs
SetupCLI URPC exit
```

After connecting the device using IP address, the device name DEV@SETUP_CLI is used to identify this device in 'getsettings' command.

Example of a batch file using a device IP address to retrieve a settings file when RADIUS authentication is required:

```
SetupCLI URPC start
SetupCLI URPC adddevice -I 192.168.140.113 -S 113 -P 502
SetupCLI URPC login -d DEV@SETUP_CLI -a %1 -w %2 -A radius
SetupCLI URPC getsettings -d DEV@SETUP_CLI -f "example file.urs"
SetupCLI URPC logout -d DEV@SETUP_CLI
SetupCLI URPC exit
```

DEV@SETUP_CLI has to be used as the device name in the commands followed by the 'adddevice' command.

C

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Appendix D: Miscellaneous

This chapter provides the warranty and revision history.

D.1 Warranty

For products shipped as of 1 October 2013, GE Grid Solutions warrants most of its GE manufactured products for 10 years. For warranty details including any limitations and disclaimers, see the Terms and Conditions at

<http://www.gegridsolutions.com/multilin/warranty.htm>

For products shipped before 1 October 2013, the standard 24-month warranty applies.

D.2 Revision history

The tables outline the releases and revision history of this document.

Table D-1: Revision history (English)

Manual P/N	L30 revision	Release date	ECO
1601-9050-T1	5.6x	27 June 2008	08-0390
1601-9050-U1	5.7x	29 May 2009	09-0938
1601-9050-U2	5.7x	30 September 2009	09-1165
1601-9050-V1	5.8x	29 May 2010	09-1457
1601-9050-V2	5.8x	04 January 2011	11-2237
1601-9050-W1	5.9x	12 January 2011	11-2227
1601-9050-X1	6.0x	21 December 2011	11-2840
1601-9050-X2	6.0x	5 April 2012	12-3254
1601-9050-Y1	7.0x	30 September 2012	12-3529
1601-9050-Y2	7.0x	11 November 2012	12-3601
1601-9050-Z1	7.1x	30 March 2013	13-0126
1601-9050-AA1	7.2x	1 August 2013	13-0401
1601-9050-AB1	7.3x	7 November 2014	14-1408
1601-9050-AB2	7.3x	1 September 2015	15-2215
1601-9050-AC1	7.40x	8 December 2016	16-3319

Manual P/N	L30 revision	Release date	ECO
1601-9050-AE1	7.41x	31 January 2017	17-3427
1601-9050-AE3	7.4x	28 April 2017	17-3561
1601-9050-AF1	7.6x	30 June 2017	17-3779
1601-9050-AF2	7.6x	31 October 2017	17-3935

Table D-2: Major changes for L30 manual version AF2 (English)

Page	Description
---	General revision
---	Added type W CPU module to order codes in chapter 2, installation chapter 3, Replace Front Panel section in chapter 10
---	Added Japanese and Polish languages and modules 6W and 6X to order codes in chapter 2. Module 6W allows 30 contact inputs, and Module 6X allows 18 outputs.
---	Updated Autoreclose 3P element number from 1 to 3 as per product in FlexLogic operands table, settings, actual values, features per product table, Modbus memory map
3-17	Added contact input and contact output modules 6W and 6X to Table 3-3 Contact Input and Output Module Assignments and to Figure 3-17 Contact Input and Output Module Wiring (Sheet 3 of 3)
5-297	Updated Thermal Overload Protection Logic diagram

Table D-3: Major changes for L30 manual version AF1 (English)

Page	Description
---	General revision
---	Updated "faceplate" to "front panel" for consistency and to reflect web site
---	Added graphical front panel option to order codes and specifications in chapter 2, Interfaces chapter 4, Settings chapter 5, Actual Values chapter 6
---	Added PEAP-GTC and PAP protocols for authenticating user logins when using a RADIUS server. Added to Settings > Product Setup > Security > RADIUS Authentication Method and to Modbus memory map and F codes.
---	Updated Contact Inputs from 96 to 120 and Contact Outputs from 64 to 72 in Product Description in chapter 2 and FlexLogic operands table in chapter 5
---	Updated Neutral Time Overcurrent element number from 2 to 6 in FlexLogic operands table, settings, features per product table, Modbus memory map
---	Updated Phase Time Overcurrent element number from 2 to 6 in FlexLogic operands table, settings, features per product table, Modbus memory map
---	Updated Current CT Settings number from 2 to 6 in FlexLogic operands table, settings, features per product table, and Modbus memory map
---	Updated Ground Instantaneous number from 4 to 12 in FlexLogic operands table, settings, features per product table, Modbus memory map
---	Updated Ground Time Overcurrent number from 2 to 6 in FlexLogic operands table, settings, features per product table, Modbus memory map
---	Updated Phase Instantaneous Overcurrent number from 4 to 12 in FlexLogic operands table, settings, features per product table, Modbus memory map
---	Updated Neutral Instantaneous Overcurrent from 4 to 12 in FlexLogic operands table, settings, features per product table, Modbus memory map
3-35	Updated RS422 and Fiber Interface Connection figure for the clock channels (from 7a and 7b to 1a and 1b)
3-66	Added Connect to a D400 Gateway section
4-43	Updated LED Labelling instructions for the new Front Panel Label Designer
4-50	Added Standard Front Panel section for labelling LEDs and pushbuttons
5-106	Added USB Port section to enable/disable the USB port on the graphical front panel
5-121	Updated User-programmable Pushbuttons section as per specifications
5-142	Updated Breakers section as per specifications
5-148	Updated Disconnect Switches section as per specifications
11-5	Added Convert Device Settings section

Page	Description
11-7	Added Copy Settings to Other Device section
11-15	Added Replace Front Panel section for retrofit with the new graphical front panel

Table D-4: Major changes for L30 manual version AE3 (English)

Page	Description
---	General revision
2-	Updated order codes
5-150	Updated PMU Basic Configuration settings
11-5	Added Copy Settings to Other Device section

Table D-5: Major changes for L30 manual version AE1 (English)

Page	Description
---	General revision
---	Added routable GOOSE content in chapters 2 and 5
3-35	Updated RS422 and Fiber Interface Connection figure for the clock channels (from 7a and 7b to 1a and 1b)
4-	Added Engineer content
5-	Updated IEC 61850 content
A-	Updated FlexAnalog table for most UR products

Table D-6: Major changes for L30 manual version AC1 (English)

Page	Description
---	General revision. Added online help and updated generic online help.
---	Deleted EAC logo from title page and deleted EAC certification from Approvals specifications because document not translated into Russian
---	Updated Breaker Arcing Current content, including FlexLogic operands table, settings, logic diagram, actual values, Modbus memory map
---	Updated Synchrocheck content including settings, logic diagram, actual values, and number of elements from four to six in interface chapter, FlexLogic operands table, settings, actual values, FlexAnalog table, features per product table, Modbus memory map, IMD tables
---	Updated Fault Report and Fault Location content, including settings, actual values, and theory of operation chapters, and Modbus memory map. Increased number of elements to two.
---	Added Frequency Rate of Change content to product description, specifications, FlexLogic operands table, settings, actual values, FlexAnalog table, features per product table, Modbus memory map, IMD table
---	Added (Source) Voltage Harmonics and THD Metering content to description, specifications, actual values, FlexElements table, Modbus memory map, IMD table
---	Added Source Current THD and Harmonics content to specifications, actual values, Modbus memory map
---	Added Incipient Cable Fault Detector content to product description, specifications, FlexLogic operands table, settings, actual values, features per product table, Modbus memory map, IMD table
---	Added Neutral Overvoltage content to product description, specifications, FlexLogic operands table, settings, actual values, features per product table, Modbus memory map, IMD table
---	Updated Autoreclose 3P number from 2 to 1 in FlexLogic operands table, settings, actual values, features per product table, Modbus memory map
2-2	Updated Figure 2-1 single-line diagram
2-15	Deleted software options A4, B4, D4 from order code tables. Added IEC 61850 to software options with Autoreclose plus Synchrocheck.
2-	Updated several specifications, such as TOC, IOC, number of FlexLogic lines
4-30	Added FlexLogic Design and Monitoring using Engineer section to end of Interfaces chapter
5-38	Added PRT FUNCTION settings in Network section to enable/disable each Ethernet port
5-49	Updated IEC 61850 section
5-61	Added Support for Routable GOOSE section

Page	Description
5-187	Updated number of FlexLogic lines from 512 to 1024 in FlexLogic Equation Editor settings section
11-1	Added Monitoring section
11-2	Added Retrieve Files section
C-	Added Command Line Interface appendix

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Abbreviations

A	Ampere	CPU	Central Processing Unit
AC	Alternating Current	CRC	Cyclic Redundancy Code/Check
A/D	Analog to Digital	CRL	Certificate Revocation List
AE	Accidental Energization, Application Entity	CRT, CRNT	Current
AMP	Ampere	CSA	Canadian Standards Association
ANG	Angle	CT	Current Transformer
ANSI	American National Standards Institute	CVT	Capacitive Voltage Transformer
AR	Automatic Reclosure		
ARP	Address Resolution Protocol	D/A	Digital to Analog
ASDU	Application-layer Service Data Unit	DC (dc)	Direct Current
ASYM	Asymmetry	DCE	Data Communications Equipment
AUTO	Automatic	DCS	Distributed Control System
AUX	Auxiliary	DD	Disturbance Detector
AVG	Average	DFLT	Default
AWG	American Wire Gauge	DGNST	Diagnostics
		DIFF	Differential
BCS	Best Clock Selector	DIR	Directional
BER	Bit Error Rate	DISCREP	Discrepancy
BF	Breaker Fail	DIST	Distance
BFI	Breaker Failure Initiate	DMD	Demand
BKR	Breaker	DNP	Distributed Network Protocol
BLK	Block	DPO	Dropout
BLKG	Blocking	DPS	Double-Point Status
BNC	Bayonet Neill-Concelman	DSP	Digital Signal Processor
BPNT	Breakpoint of a characteristic	DST	Daylight Savings Time
BRKR	Breaker	dt	Rate of Change
		DTT	Direct Transfer Trip
		DUTT	Direct Under-reaching Transfer Trip
CA	Certificate Authority		
CAP	Capacitor	EGD	Ethernet Global Data
CC	Coupling Capacitor	ENCRMNT	Encroachment
CCVT	Coupling Capacitor Voltage Transformer	EPRI	Electric Power Research Institute
CFG	Configure / Configurable	.EVT	Filename extension for event recorder files
.CFG	Filename extension for oscillography files	EXT	Extension, External
CHK	Check		
CHNL	Channel	F	Field
CID	Configured IED Description	FAIL	Failure
CLS	Close	FD	Fault Detector
CLSD	Closed	FDH	Fault Detector high-set
CMND	Command	FDL	Fault Detector low-set
CMPRSN	Comparison	FIR	Finite Impulse Response
CO	Contact Output	FLA	Full Load Current
COM	Communication	FO	Fiber Optic
COMM	Communications	FPGA	Field-programmable Gate Array
COMP	Compensated, Comparison	FREQ	Frequency
CONN	Connection	FSK	Frequency-Shift Keying
CONT	Continuous, Contact	FTP	File Transfer Protocol
CO-ORD	Coordination	FxE	FlexElement™

FWD	Forward	mA	MilliAmpere
G	Generator	MAG	Magnitude
GCM	Galois Counter Mode	MAN	Manual / Manually
GDOI	Group Domain of Interpretation	MAX	Maximum
GE	General Electric	Mb	Megabit
GND	Ground	MIC	Model Implementation Conformance
GNTR	Generator	MIN	Minimum, Minutes
GoCB	GOOSE Control Block	MMI	Man Machine Interface
GOOSE	General Object Oriented Substation Event	MMS	Manufacturing Message Specification
GPS	Global Positioning System	MRT	Minimum Response Time
GSU	Generator Step-Up	MSG	Message
		MTA	Maximum Torque Angle
HARM	Harmonic / Harmonics	MTR	Motor
HCT	High Current Time	MVA	MegaVolt-Ampere (total 3-phase)
HGF	High-Impedance Ground Fault (CT)	MVA_A	MegaVolt-Ampere (phase A)
HIZ	High-Impedance and Arcing Ground	MVA_B	MegaVolt-Ampere (phase B)
HMI	Human-Machine Interface	MVA_C	MegaVolt-Ampere (phase C)
HTTP	Hyper Text Transfer Protocol	MVAR	MegaVar (total 3-phase)
HV	High Voltage	MVAR_A	MegaVar (phase A)
HYB	Hybrid	MVAR_B	MegaVar (phase B)
Hz	Hertz	MVAR_C	MegaVar (phase C)
		MVARH	MegaVar-Hour
I	Instantaneous	MW	MegaWatt (total 3-phase)
I_0	Zero Sequence current	MW_A	MegaWatt (phase A)
I_1	Positive Sequence current	MW_B	MegaWatt (phase B)
I_2	Negative Sequence current	MW_C	MegaWatt (phase C)
IA	Phase A current	MWH	MegaWatt-Hour
IAB	Phase A minus B current	N	Neutral
IB	Phase B current	N/A, n/a	Not Applicable
IBC	Phase B minus C current	NEG	Negative
IC	Phase C current	NMPLT	Nameplate
ICA	Phase C minus A current	NOM	Nominal
ICD	IED Capability Description	NTR	Neutral
ID	Identification		
IED	Intelligent Electronic Device	O	Over
IEC	International Electrotechnical Commission	OC, O/C	Overcurrent
IEEE	Institute of Electrical and Electronic Engineers	OCSP	Online Certificate Status Protocol
IG	Ground (not residual) current	OF	Overload Factor
Igd	Differential Ground current	O/P, Op	Output
IGMP	Internet Group Management Protocol	OP	Operate
IID	Instantiated IED Capability Description	OPER	Operate
IN	CT Residual Current (3Io) or Input	OPERATG	Operating
INC SEQ	Incomplete Sequence	O/S	Operating System
INIT	Initiate	OSI	Open Systems Interconnect
INST	Instantaneous	OSB	Out-of-Step Blocking
INV	Inverse	OUT	Output
I/O	Input/Output	OV	Overvoltage
IOC	Instantaneous Overcurrent	OVERFREQ	Overfrequency
IOV	Instantaneous Overvoltage	OVL	Overload
IRC	Inter-Relay Communication		
IRIG	Inter-Range Instrumentation Group	P	Phase
ISO	International Standards Organization	PC	Phase Comparison, Personal Computer
IUV	Instantaneous Undervoltage	PCNT	Percent
		PF	Power Factor (total 3-phase)
K0	Zero Sequence Current Compensation	PF_A	Power Factor (phase A)
kA	kiloAmpere	PF_B	Power Factor (phase B)
KDC	Key Distribution Center	PF_C	Power Factor (phase C)
kV	kiloVolt	PFLL	Phase and Frequency Lock Loop
		PHS	Phase
LCD	Liquid Crystal Display	PICS	Protocol Implementation & Conformance Statement
LED	Light Emitting Diode		
LEO	Line End Open	PKI	Public Key Infrastructure
LFT BLD	Left Blinder	PKP	Pickup
LOOP	Loopback	PLC	Power Line Carrier
LPU	Line Pickup	POS	Positive
LRA	Locked-Rotor Current	POTT	Permissive Over-reaching Transfer Trip
LTC	Load Tap-Changer	PRESS	Pressure
LV	Low Voltage	PRI	Primary
		PROT	Protection
M	Machine	PRP	Parallel Redundancy Protocol
M2M	Machine to Machine	PSEL	Presentation Selector

ABBREVIATIONS

PTP	Precision Time Protocol	TSEL	Transport Selector
pu	Per Unit	TUC	Time Undercurrent
PUIB	Pickup Current Block	TUV	Time Undervoltage
PUIT	Pickup Current Trip	TX (Tx)	Transmit, Transmitter
PUSHBTN	Pushbutton	U	Under
PUTT	Permissive Under-reaching Transfer Trip	UC	Undercurrent
PWM	Pulse Width Modulated	UCA	Utility Communications Architecture
PWR	Power	UDP	User Datagram Protocol
QUAD	Quadrilateral	UL	Underwriters Laboratories
R	Rate, Reverse	UNBAL	Unbalance
RA	Registration Authority	UR	Universal Relay
RCA	Reach Characteristic Angle	URC	Universal Recloser Control
REF	Reference	.URS	Filename extension for settings files
REM	Remote	UV	Undervoltage
REV	Reverse	V/Hz	Volts per hertz
R-GOOSE	Routable GOOSE	V_0	Zero Sequence voltage
RI	Reclose Initiate	V_1	Positive Sequence voltage
RIP	Reclose In Progress	V_2	Negative Sequence voltage
RGT BLD	Right Blinder	VA	Phase A voltage
RMA	Return Materials Authorization	VAB	Phase A to B voltage
RMS	Root Mean Square	VAG	Phase A to Ground voltage
ROCOF	Rate of Change of Frequency	VARH	Var-hour voltage
ROD	Remote Open Detector	VB	Phase B voltage
RRTD	Remote Resistance Temperature Detector	VBA	Phase B to A voltage
RST	Reset	VBG	Phase B to Ground voltage
RSTR	Restrained	VC	Phase C voltage
RTD	Resistance Temperature Detector	VCA	Phase C to A voltage
RTU	Remote Terminal Unit	VCG	Phase C to Ground voltage
RX (Rx)	Receive, Receiver	VF	Variable Frequency
s	second	VIBR	Vibration
S	Sensitive	VT	Voltage Transformer
SAT	CT Saturation	VTFE	Voltage Transformer Fuse Failure
SBO	Select Before Operate	VTLOS	Voltage Transformer Loss Of Signal
SCADA	Supervisory Control and Data Acquisition	WDG	Winding
SCC	Serial Communication Controller	WH	Watt-hour
SCD	System Configuration Description	w/ opt	With Option
SCL	Substation Configuration Language	WGS	World Geodetic System
SCEP	Simple Certificate Enrollment Protocol	WRT	With Respect To
SEC	Secondary	X	Reactance
SEL	Select / Selector / Selection	XDUCER	Transducer
SENS	Sensitive	XFMR	Transformer
SEQ	Sequence	Z	Impedance, Zone
SFTP	Secure Shell (SSH) File Transfer Protocol, Secure File Transfer Protocol		
SIR	Source Impedance Ratio		
SNTP	Simple Network Time Protocol		
SRC	Source		
SSB	Single Side Band		
SSEL	Session Selector		
STATS	Statistics		
SUPN	Supervision		
SUPV	Supervise / Supervision		
SV	Supervision, Service		
SYNC	Synchrocheck		
SYNCHCHK	Synchrocheck		
T	Time, transformer		
TC	Thermal Capacity		
TCP	Transmission Control Protocol		
TCU	Thermal Capacity Used		
TD MULT	Time Dial Multiplier		
TEMP	Temperature		
TFTP	Trivial File Transfer Protocol		
THD	Total Harmonic Distortion		
TMR	Timer		
TOC	Time Overcurrent		
TOV	Time Overvoltage		
TRANS	Transient		
TRANSF	Transfer		

L30 Line Current Differential System

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