GE
Digital Energy

L30 Line Current Differential System

UR Series Instruction Manual

L30 revision: 7.1x

Manual P/N: 1601-9050-Z2 (GEK-119520A)

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GE Multilin's Quality Management System is registered to ISO 9001:2008

QMI # 005094
UL # A3775

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L30 Line Current Differential System UR Series Instruction Manual revision 7.1x.

Part number: 1601-9050-Z2 (September 2013)

1. GETTING STARTED

2. PRODUCT DESCRIPTION

3. HARDWARE

4. HUMAN INTERFACES

5. SETTINGS

Use this chapter for initial setup of your new L30 Line Current Differential System.

1.1.1 CAUTIONS AND WARNINGS

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.

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

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

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

NOTICE — Indicates practices not related to personal injury.

a) GENERAL CAUTIONS AND WARNINGS

The following general safety precautions and warnings apply.

DANGER — **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 AC current, and voltage input match the ratings specified on the relay nameplate. Do not apply current or voltage in excess of the specified limits.

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.

CAUTION — **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.

1.1.2 INSPECTION PROCEDURE

1. Open the relay packaging and inspect the unit for physical damage.
2. View the rear nameplate and verify that the correct model has been ordered and delivered.

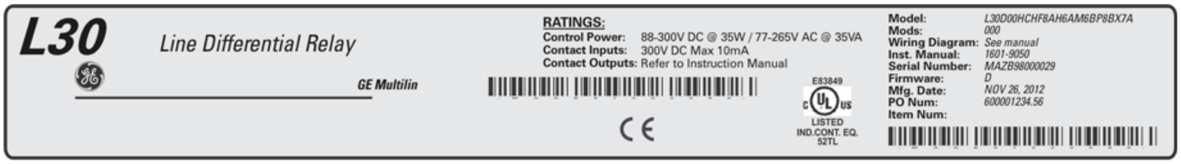

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Figure 1–1: REAR NAMEPLATE (EXAMPLE)

3. Ensure that the following items are included:
   - Instruction manual (if ordered)
   - GE EnerVista™ CD (includes the EnerVista UR Setup software and manuals in PDF format)
   - Mounting screws
4. If there is any noticeable physical damage, or any of the contents listed are missing, please contact GE Digital Energy immediately as follows.

GE DIGITAL ENERGY CONTACT INFORMATION AND CALL CENTER FOR PRODUCT SUPPORT:

GE Digital Energy
650 Markland Street
Markham, Ontario
Canada L6C 0M1

TELEPHONE: Worldwide +1 905 927 7070
Europe/Middle East/Africa +34 94 485 88 54
North America toll-free 1 800 547 8629
FAX: +1 905 927 5098
E-MAIL: Worldwide multilin.tech@ge.com
Europe multilin.tech.euro@ge.com
HOME PAGE: http://www.gedigitalenergy.com/multilin

For updates to the instruction manual, firmware, and software, visit the GE Digital Energy website.

1.2.1 INTRODUCTION TO THE UR

The GE Universal Relay (UR) series is a new generation of digital, modular, and multifunction equipment that is easily incorporated into automation systems, at both the station and enterprise levels.

1.2.2 HARDWARE ARCHITECTURE

a) UR BASIC DESIGN

The UR is a digital-based device containing a central processing unit (CPU) that handles multiple types of input and output signals. The UR device can communicate over a local area network (LAN) with an operator interface, a programming device, or another UR device.

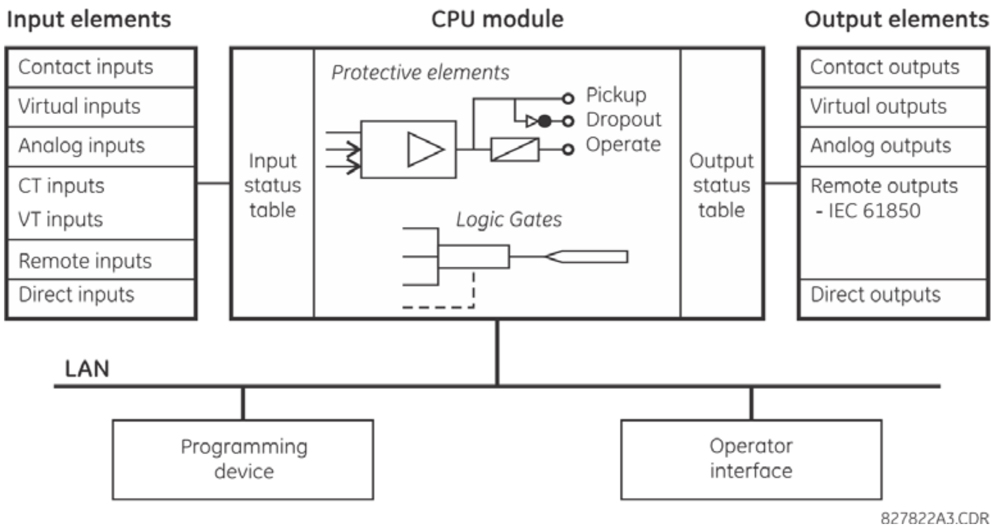


Figure 1–2: UR BLOCK DIAGRAM

The **CPU module** contains firmware that provides protection elements in the form of logic algorithms, as well as programmable logic gates, timers, and latches for control features.

Input elements accept a variety of analog or digital signals from the field. The UR isolates and converts these signals into logic signals used by the relay.

Output elements convert and isolate the logic signals generated by the relay into digital or analog signals that can be used to control field devices.

The software and unit are backwards-compatible with UR devices.

b) UR SIGNAL TYPES

The **contact inputs and outputs** are digital signals associated with connections to hard-wired contacts. Both ‘wet’ and ‘dry’ contacts are supported.

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.

The **analog inputs and outputs** are signals that are associated with transducers, such as Resistance Temperature Detectors (RTDs).

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

The **remote inputs and outputs** provide a means of sharing digital point state information between remote UR-series devices. The remote outputs interface to the remote inputs of other UR-series devices. Remote outputs are FlexLogic operands inserted into IEC 61850 GSSE and GOOSE messages.

The **direct inputs and outputs** provide a means of sharing digital point states between a number of UR-series IEDs over dedicated fiber (single or multimode), RS422, or G.703 interface. No switching equipment is required as the IEDs are connected directly in a ring or redundant (dual) ring configuration. This feature is optimized for speed and intended for pilot-aided schemes, distributed logic applications, or the extension of the input/output capabilities of a single relay chassis.

c) UR SCAN OPERATION

The UR-series devices operate in a cyclic scan fashion. The device reads the inputs into an input status table, solves the logic program (FlexLogic equation), and then sets each output to the appropriate state in an output status table. Any resulting task execution is priority interrupt-driven.

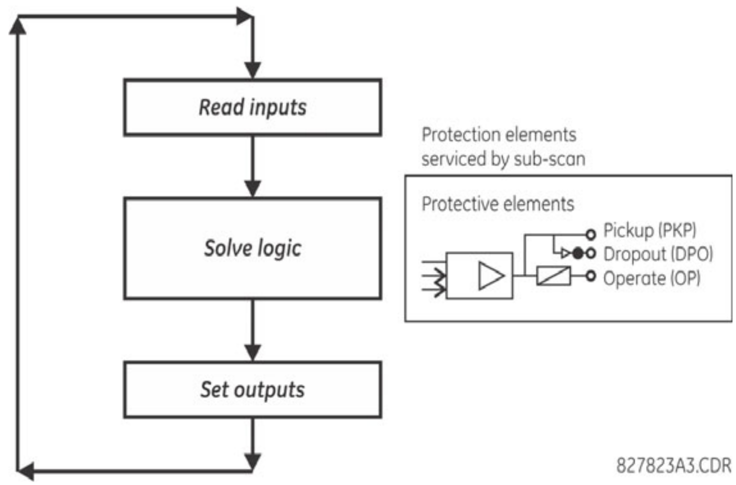


Figure 1–3: UR-SERIES SCAN OPERATION

1.2.3 SOFTWARE ARCHITECTURE

Firmware is the software embedded in the relay and is designed in functional modules that can be installed in any relay as required. This is achieved with object-oriented design and programming (OOD/OOP) techniques.

Object-oriented techniques involve the use of *objects* and *classes*. An object is defined as “a logical entity that contains both data and code that manipulates that data”. A class is the generalized form of similar objects. By using this concept, one can create a protection class with the protection elements as objects of the class, such as time overcurrent, instantaneous overcurrent, current differential, undervoltage, overvoltage, underfrequency, and distance. These objects represent completely self-contained software modules. The same object-class concept can be used for metering, input/output control, software interface, communications, or any functional entity in the system.

Employing OOD/OOP in the software architecture of the L30 achieves the same features as the hardware architecture: modularity, scalability, and flexibility. The application software for any UR-series device (for example, feeder protection, transformer protection, distance protection) is constructed by combining objects from the various functional classes. This results in a common interface across the UR series.

1.2.4 IMPORTANT CONCEPTS

As described above, the architecture of the UR-series relays differ from previous devices. To achieve a general understanding of this device, some sections of Chapter 5 are quite helpful. The most important functions of the relay are contained in “elements”. A description of the UR-series elements can be found in the *Introduction to elements* section in chapter 5. Examples of simple elements, and some of the organization of this manual, can be found in the *Control elements* section of chapter 5. A description of how digital signals are used and routed within the relay is contained in the *Introduction to FlexLogic* section in chapter 5.

1.3.1 PC REQUIREMENTS

The relay front panel or the EnerVista UR Setup software can be used to communicate with the relay. The EnerVista UR Setup 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 UR Setup software are as follows:

- Pentium 4 (Core Duo recommended)
- Windows XP with Service Pack 2 (Service Pack 3 recommended), Windows 7, or Windows Server 2008 Release 2 64-bit
- 1 GB of RAM (2 GB recommended)
- 500 MB free hard drive space (1 GB recommended)
- 1024 x 768 display (1280 x 800 recommended)

The following qualified modems have been tested to be compliant with the L30 and the EnerVista UR Setup software:

- US Robotics external 56K FaxModem 5686
- US Robotics external Sportster 56K X2
- PCTEL 2304WT V.92 MDC internal modem

1.3.2 INSTALLATION

After ensuring that the requirements for using EnerVista UR Setup are met (previous section), install the EnerVista UR Setup software from the GE EnerVista DVD. Or download the UR EnerVista software from http://www.gedigitalenergy.com/multilin and install it.

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 in EnerVista under **Maintenance > Update Firmware**.

To install the UR EnerVista software from the DVD:

1. Insert the GE EnerVista 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 1–4: ADDING UR DEVICE IN LAUNCHPAD WINDOW

5. In the EnerVista Launch Pad window, click the **Add Product** button and select the appropriate product, shown as follows. Select the **Web** option to ensure the most recent software release, or select **CD** if you do not have a web connec-

tion, then click the **Add Now** button to list software items for the product. EnerVista Launchpad then obtains the software from the Internet or DVD and automatically starts the installation program.

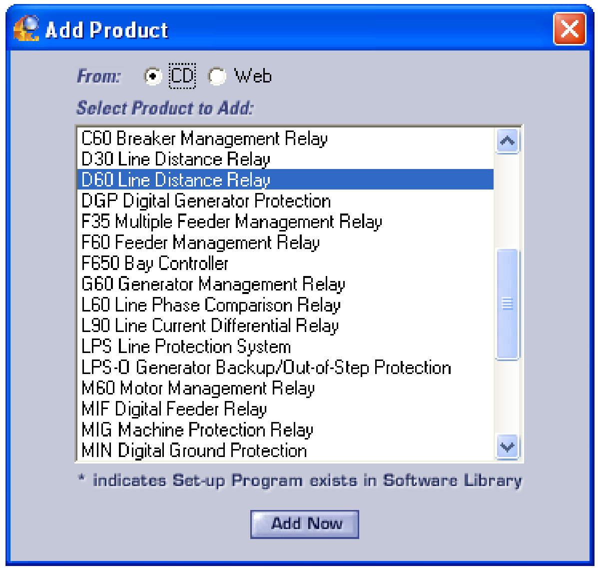


Figure 1–5: IDENTIFYING THE UR DEVICE TYPE

6. Select the complete path, including the new directory name, where the EnerVista UR Setup is to be installed.
7. Click the **Next** button to begin the installation. The files are installed in the directory indicated, and the installation program automatically creates icons and adds EnerVista UR Setup to the Windows start menu.
8. Click **Finish** to complete the installation. The UR device is added to the list of installed intelligent electronic devices (IEDs) in the EnerVista Launchpad window, as shown.

Figure 1–6: UR DEVICE ADDED TO LAUNCHPAD WINDOW

1.3.3 CONFIGURING THE L30 FOR SOFTWARE ACCESS

a) OVERVIEW

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

- To configure the L30 for remote access via the rear RS485 port, see the *Configuring Serial Communications* section.
- To configure the L30 for remote access via the rear Ethernet port, see the *Configuring Ethernet Communications* section. An Ethernet module must be specified at the time of ordering.
- To configure the L30 for local access with a laptop through either the front RS232 port or rear Ethernet port, see the *Using the Quick Connect Feature* section.

b) CONFIGURING SERIAL COMMUNICATIONS

A GE Multilin F485 converter (or compatible RS232-to-RS485 converter) is required. See the F485 instruction manual for details.

1. Connect a serial cable to the RS485 terminal on the back of the UR device.
2. In the EnerVista Launchpad software on the computer, select the UR device to start the software.
3. Click the **Device Setup** button to open the Device Setup window, and click the **Add Site** button to define a new site.
4. Enter a site name in the **Site Name** field. Optionally add a short description of the site along with the display order of devices defined for the site. This example uses “Location 1” as the site name. When done, click the **OK** button. The new site appears in the upper-left list in the EnerVista UR Setup window.
5. Click the **Device Setup** button, then select the new site to re-open the Device Setup window.
6. Click the **Add Device** button to define the new device.
7. Enter a name in the "Device Name” field and a description (optional) of the site.
8. Select “Serial” from the **Interface** drop-down list. This displays a number of interface parameters that must be entered for serial communications.

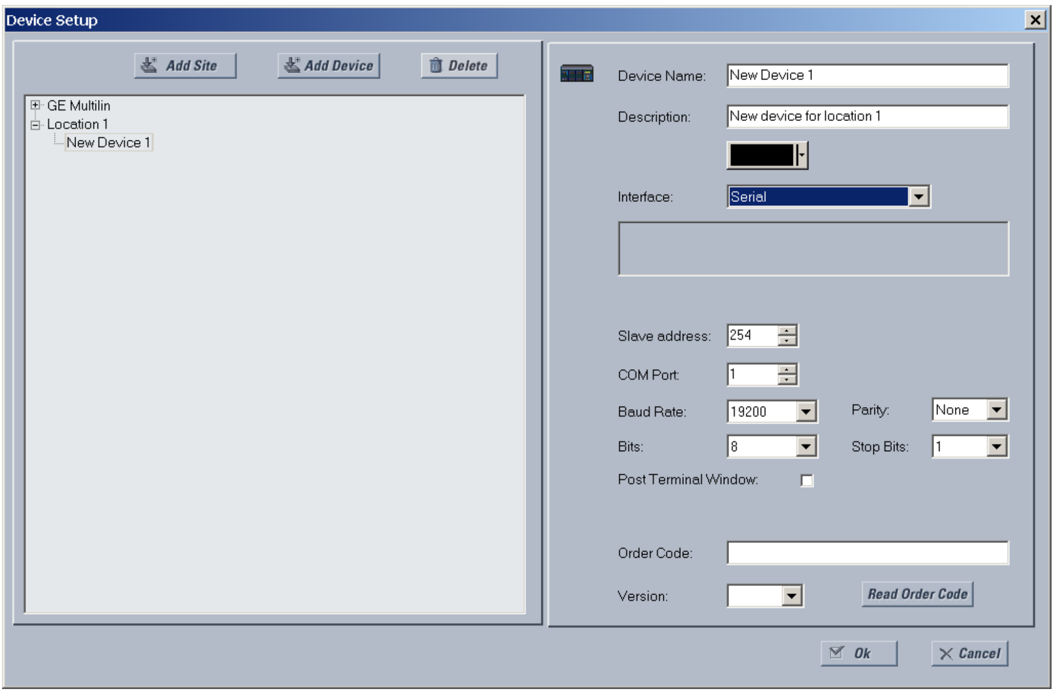


Figure 1–7: CONFIGURING SERIAL COMMUNICATIONS

9. Enter the relay slave address, COM port, baud rate, and parity settings from the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ SERIAL PORTS** menu in their respective fields.
10. Click the **Read Order Code** button to connect to the L30 device and upload the order code. If a communications error occurs, ensure that the EnerVista UR Setup serial communications values entered in the previous step correspond to the relay setting values.
11. Click the **OK** button when the relay order code has been received. The new device is added to the Site List window (or Online window) located in the top left corner of the main EnerVista UR Setup window.

The device has now been configured for RS232 communications. Proceed to the *Connecting to the L30* section to begin communication.

c) CONFIGURING ETHERNET COMMUNICATIONS

Before starting, verify that the Ethernet network cable is properly connected to the Ethernet port on the back of the relay. To setup the relay for Ethernet communications, you define a Site, then add the relay as a Device at that site.The computer and UR device must be on the same subnet.

12. Select the “UR” device from the EnerVista Launchpad to start EnerVista UR Setup.
13. Click the **Device Setup** button to open the Device Setup window, then click the **Add Site** button to define a new site.
14. Enter the desired site name in the “Site Name” field. If desired, a short description of site can also be entered along with the display order of devices defined for the site. In this example, we use “Location 2” as the site name. Click the **OK** button when complete.
15. The new site appears in the upper-left list in the EnerVista UR Setup window. Click the **Device Setup** button then select the new site to re-open the Device Setup window.
16. Click the **Add Device** button to define the new device.
17. Enter the desired name in the “Device Name” field and a description (optional) of the site.
18. Select “Ethernet” from the **Interface** drop-down list. This displays a number of interface parameters that must be entered for proper Ethernet functionality.

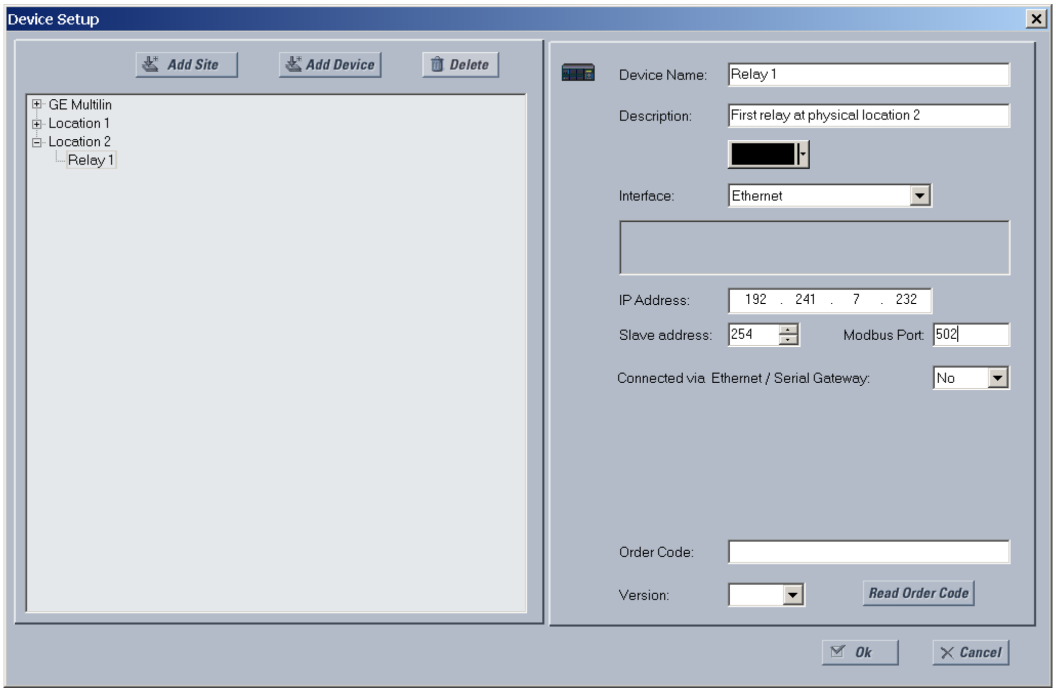


Figure 1–8: CONFIGURING ETHERNET COMMUNICATIONS

19. Enter the relay IP address specified in the SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK ⇨ IP ADDRESS in the “IP Address” field.
20. Enter the relay slave address and Modbus port address values from the respective settings in the SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ MODBUS PROTOCOL menu.
21. Click the **Read Order Code** button to connect to the L30 device and upload the order code. If an communications error occurs, ensure that the three EnerVista UR Setup values entered in the previous steps correspond to the relay setting values.
22. Click **OK** when the relay order code has been received. The new device is added to the Site List window (or Online window) located in the top left corner of the main EnerVista UR Setup window.

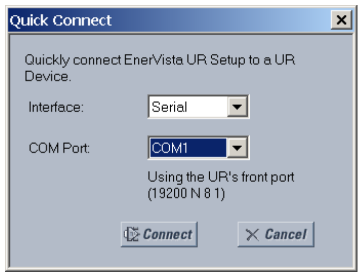
The Site Device has now been configured for Ethernet communications. Proceed to the *Connecting to the L30* section to begin communications.

1.3.4 USING THE QUICK CONNECT FEATURE

a) USING QUICK CONNECT VIA THE FRONT PANEL RS232 PORT

Before starting, verify that the serial cable is properly connected from the computer to the front panel RS232 port with a straight-through 9-pin to 9-pin RS232 cable.

1. Verify that the latest version of the EnerVista UR Setup software is installed (available from the GE EnerVista CD or online from http://www.gedigitalenergy.com/multilin). See the *Software Installation* section if not already installed.
2. Select the “UR” device from the EnerVista Launchpad to start EnerVista UR Setup.
3. Click the **Quick Connect** button to open the Quick Connect dialog box.



4. Select the **Serial** interface and the correct COM Port, then click **Connect**.
5. The EnerVista UR Setup software creates a site named “Quick Connect” with a corresponding device also named “Quick Connect” and displays them at the upper-left of the screen. Expand the sections to view data directly from the L30 device.

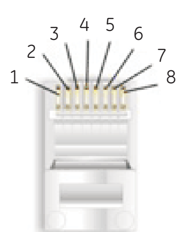
Each time that the EnerVista UR Setup software is initialized, click the **Quick Connect** button to establish direct communications to the L30 device. This ensures that configuration of the EnerVista UR Setup software matches the L30 model number.

b) USING QUICK CONNECT VIA THE REAR ETHERNET PORTS

To use the Quick Connect feature to access the L30 from a computer through Ethernet, first assign an IP address to the relay from the front panel keyboard.

1. Press the MENU key until the SETTINGS menu displays.
2. Navigate to the SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK ⇨ IP ADDRESS setting.
3. Enter an IP address, for example “1.1.1.1,” and select 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.

Next, use an Ethernet cross-over cable to connect the computer to the rear Ethernet port. In case you need it, the figure shows the pinout for an Ethernet cross-over cable.



END 1		
Pin	Wire color	Diagram
1	White/orange	
2	Orange	
3	White/green	
4	Blue	
5	White/blue	
6	Green	
7	White/brown	
8	Brown	

END 2		
Pin	Wire color	Diagram
1	White/green	
2	Green	
3	White/orange	
4	Blue	
5	White/blue	
6	Orange	
7	White/brown	
8	Brown	

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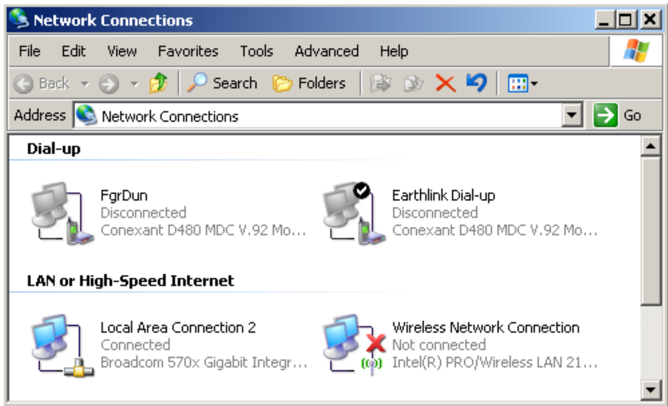
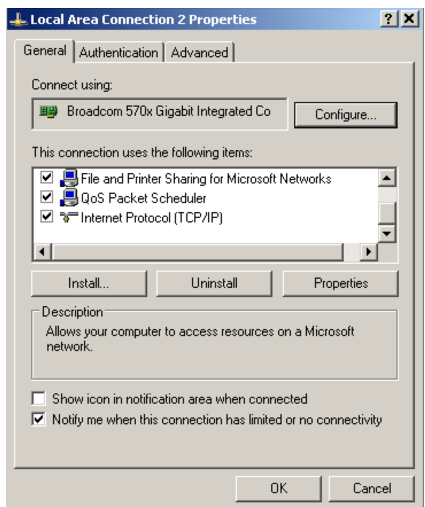
Figure 1–9: ETHERNET CROSS-OVER CABLE PIN LAYOUT

Now, assign the computer an IP address compatible with the relay’s IP address.

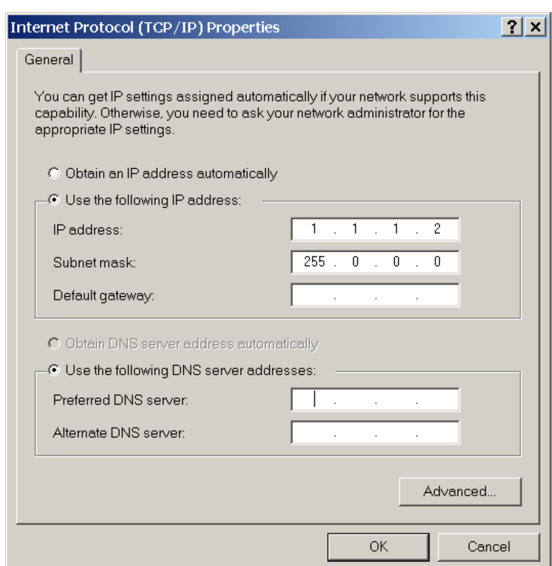
1. From the Windows desktop, right-click the **My Network Places** icon and select **Properties** to open the network connections window.



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 by selecting **Start > Run** from the Windows **Start** menu and typing “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 laptop 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 laptop 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:

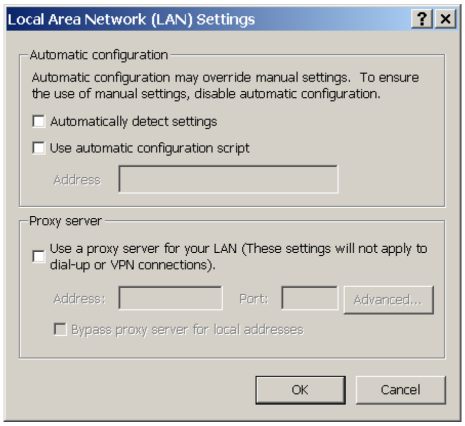
```
Pinging 1.1.1.1 with 32 bytes of data:

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

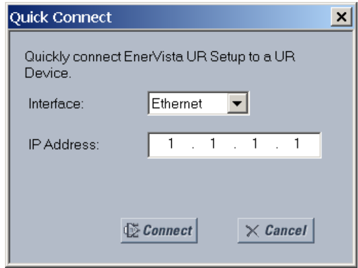


4. Ensure that the “Use a proxy server for your LAN” box is not checked.

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

1. Start the Internet Explorer software.
2. Select the “UR” device from the EnerVista Launchpad to start EnerVista UR Setup.

3. Click the **Quick Connect** button to open the Quick Connect dialog box.

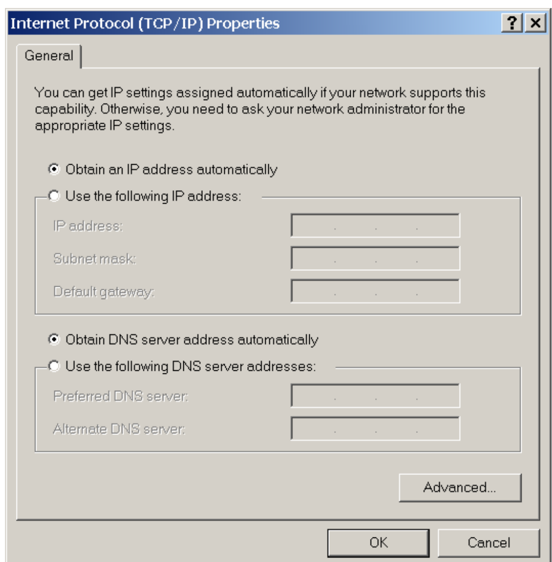


4. Select the **Ethernet** interface and enter the IP address assigned to the L30, then click the **Connect** button. The EnerVista UR Setup software creates a site named “Quick Connect” with a corresponding device also named “Quick Connect” and displays them at the upper-left of the screen.
5. Expand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

Each time 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:

1. From the Windows desktop, right-click the **My Network Places** icon and select **Properties** to open the network connections window.
2. 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 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.

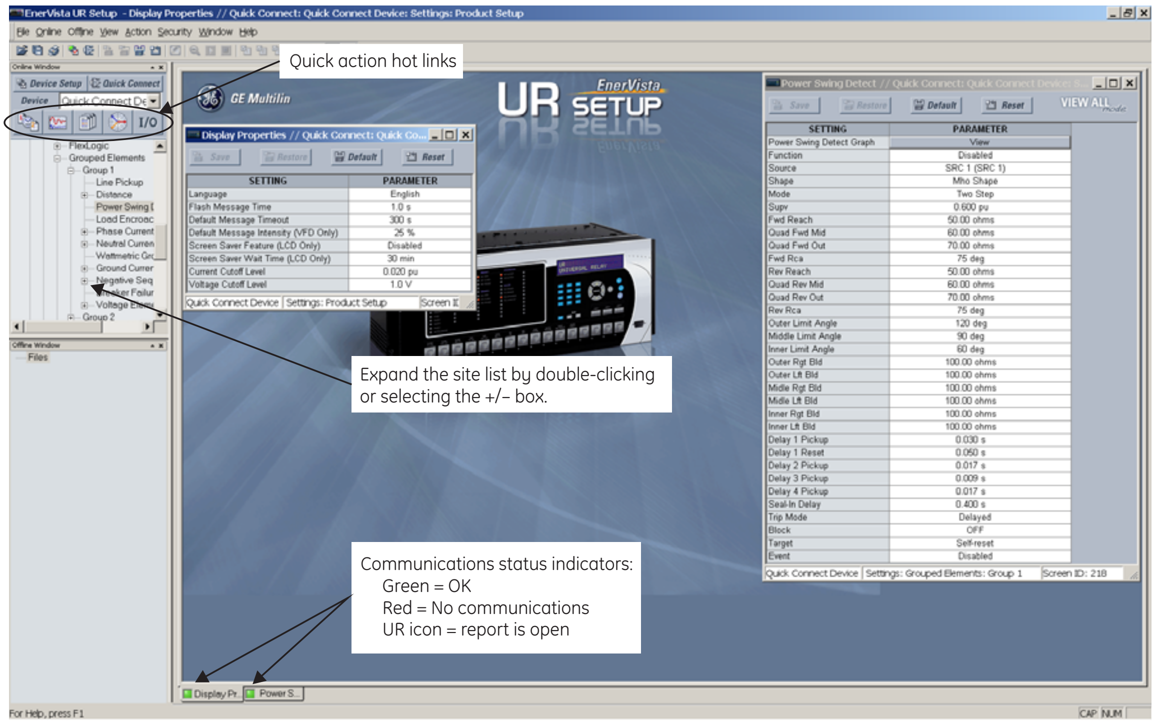
AUTOMATIC DISCOVERY OF ETHERNET DEVICES

The EnerVista UR Setup software can automatically discover and communicate to all UR-series IEDs located on an Ethernet network.

Using the Quick Connect feature, a single click of the mouse triggers the software to automatically detect any UR-series relays located on the network. The EnerVista UR Setup software then proceeds to configure all settings and order code options in the **Device Setup** menu. This feature allows the user to identify and interrogate all UR-series devices at a location.

1.3.5 CONNECTING TO THE L30 RELAY

1. Open the Display Properties window through the Site List tree as shown. The Display Properties window opens with a status indicator on the lower left of the EnerVista UR Setup window.



842743A3.CDR

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 setup for communications (steps A and B earlier).

   If a relay icon appears in place of the status indicator, than a report (such as an oscillography or event record) is open. Close the report to re-display the green status indicator.

3. The Display Properties settings can now be edited, printed, or changed.

NOTE

See chapter 4 in this manual or the EnerVista UR Setup Help File for information about the using the EnerVista UR Setup software interface.

QUICK ACTION HOT LINKS

The EnerVista UR Setup software has several quick action buttons to provide instant access to several functions that are often performed when using L30 relays. From the online window, users can select the relay to interrogate from a pull-down window, then click the button for the action they want to perform. The following quick action functions are available:

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

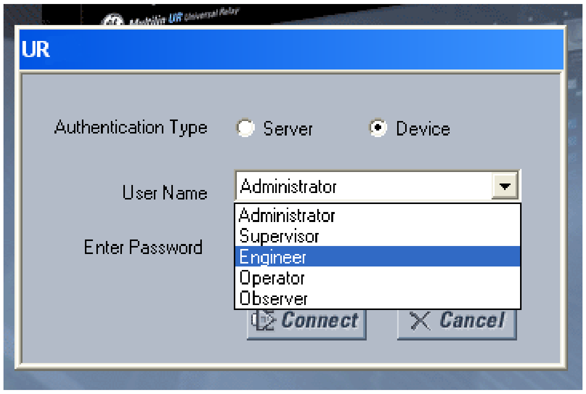
1.3.6 SETTING UP CYBERSENTRY AND CHANGING DEFAULT PASSWORD

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. 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). 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. The appendix called RADIUS Server gives an example of how to setup a simple RADIUS server. Once both the RADIUS server and the parameters for connecting UR to the server have been configured, you can choose server authentication on the login screen of EnerVista.

Figure 1–10: LOGIN SCREEN FOR CYBERSENTRY

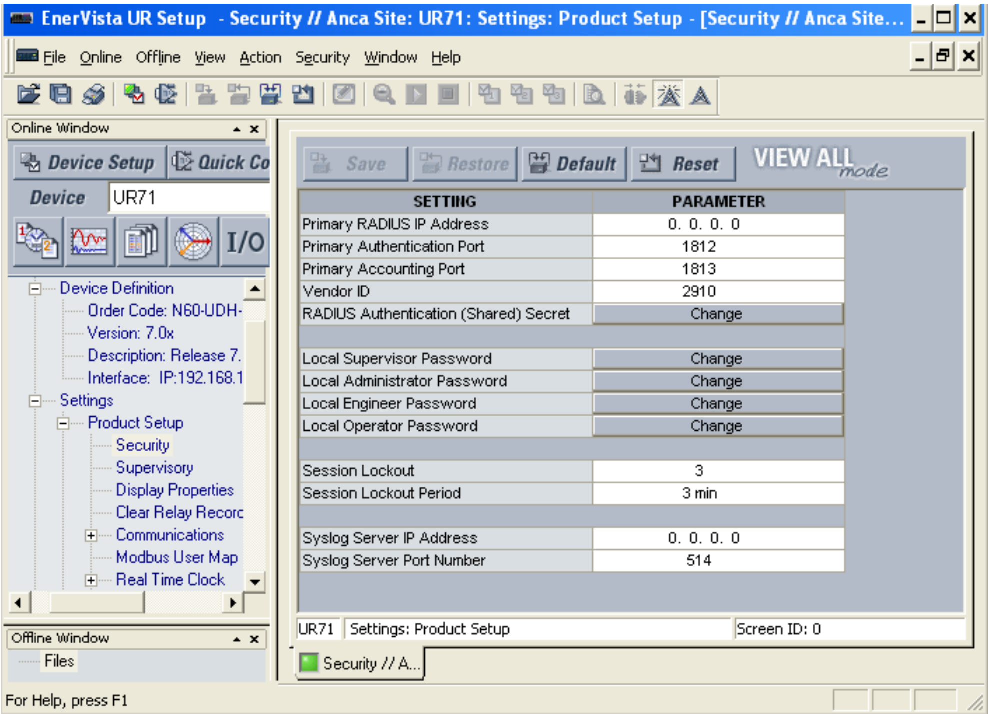


During the commissioning phase, you have the option to bypass the use of passwords. Do so by enabling the Bypass Access setting under **SETTINGS > PRODUCT SETUP > SECURITY > SUPERVISORY**. Be sure to disable this bypass setting after commissioning the device.

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.

Figure 1–11: CHANGING THE DEFAULT PASSWORD



1

1.4.1 MOUNTING AND WIRING

See Chapter 3: Hardware for mounting and wiring instructions.

1.4.2 COMMUNICATIONS

The EnerVista UR Setup software communicates to the relay via the faceplate RS232 port or the rear panel RS485 / Ethernet ports. To communicate via the faceplate RS232 port, a standard straight-through serial cable is used. The DB-9 male end is connected to the relay and the DB-9 or DB-25 female end is connected to the computer COM2 port as described in the *CPU communications ports* section of chapter 3.

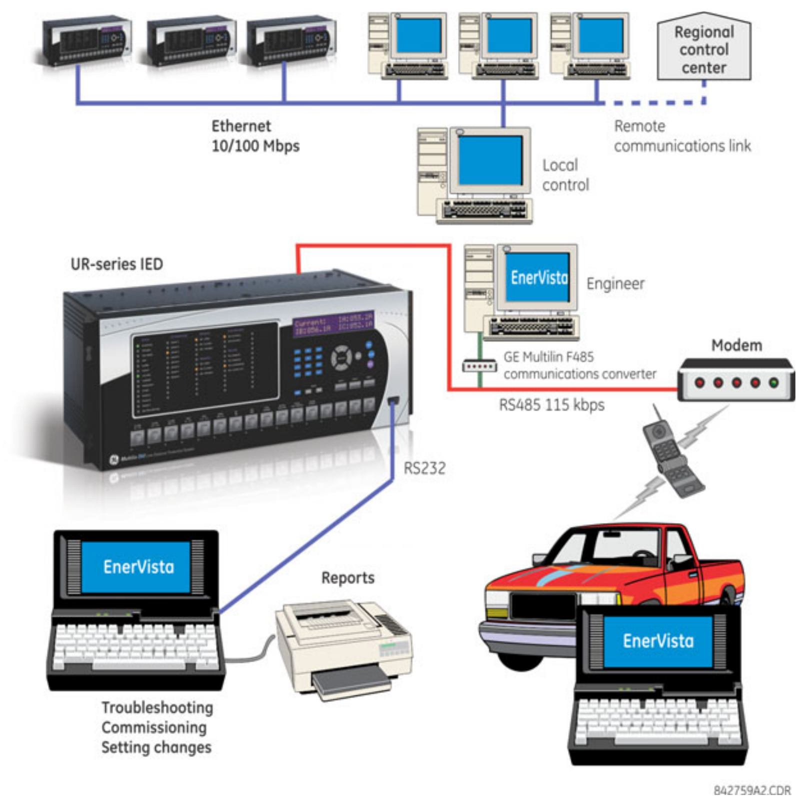


Figure 1–12: RELAY COMMUNICATION OPTIONS

To communicate through the L30 rear RS485 port from a computer RS232 port, the GE Multilin 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 (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 communications 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 the chapter 3.

1.4.3 FACEPLATE DISPLAY

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

1.5.1 FACEPLATE KEYPAD

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 logical subgroups.

The MESSAGE keys navigate through the subgroups. 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 altered setting values.

1.5.2 MENU NAVIGATION

Press the MENU key to select a header display page (top-level menu). The header title appears momentarily followed by a header display page menu item. Each press of the MENU key advances through the following main heading pages:

- Actual values
- Settings
- Commands
- Targets
- User displays (when enabled)

1.5.3 MENU HIERARCHY

The setting and actual value messages are arranged hierarchically. The header display pages are indicated by double scroll bar characters (■■), while sub-header pages are indicated by single scroll bar characters (■). The header display pages represent the highest level of the hierarchy and the sub-header display pages fall below this level. The MESSAGE UP and DOWN keys move within a group of headers, sub-headers, setting values, or actual values. Continually pressing the MESSAGE RIGHT key from a header display displays specific information for the header category. Conversely, continually pressing the MESSAGE LEFT key from a setting value or actual value display returns to the header display.

1.5.4 RELAY ACTIVATION

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

Select the menu message **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ INSTALLATION ⇨ RELAY SETTINGS**

```
RELAY SETTINGS:
Not Programmed
```

1. To put the relay in the “Programmed” state, press either of the VALUE keys once and then press ENTER. The faceplate Trouble LED turns off and the In Service LED turns on.

The settings for the relay can be programmed manually (see *Chapter 5*) via the faceplate keypad or remotely via the EnerVista UR Setup software (see the EnerVista UR Setup help file).

1.5.5 RELAY PASSWORDS

a) PASSWORD SECURITY

It is recommended that passwords be set for each security level and assigned to specific personnel. There are two user security access levels, COMMAND and SETTING.

1. COMMAND

The COMMAND access level restricts the user from making any settings changes, but allows the user to perform the following operations:

- Change state of virtual inputs
- Clear event records
- Clear oscillography records
- Operate user-programmable pushbuttons

2. SETTING

The SETTING access level allows the user to make any changes to any of the setting values.

NOTE: See the Changing Settings section in Chapter 4 for complete instructions on setting security-level passwords.

b) CYBERSENTRY

When the CyberSentry option is purchased, advanced security services are available, using either device authentication or server authentication using RADIUS. When this option is purchased, the basic password security is disabled automatically. For more information, see the CyberSentry content in the Security section of the next chapter.

1.5.6 FLEXLOGIC CUSTOMIZATION

FlexLogic equation editing is required for setting user-defined logic for customizing the relay operations. See the *FlexLogic* section in Chapter 5.

1.5.7 COMMISSIONING

The L30 requires minimal maintenance after it is commissioned into service. Since the L30 is a microprocessor-based relay, its characteristics do not change over time. As such, no further functional tests are required.

The L30 performs a number of continual self-tests and takes the necessary action in case of any major errors (see the *Relay Self-tests* section in chapter 7). However, it is recommended that L30 maintenance be scheduled with other system maintenance. This maintenance can involve in-service, out-of-service, or unscheduled maintenance.

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.

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.

Unscheduled maintenance, such as a disturbance causing system interruption:

1. View the event recorder and oscillography or fault report for correct operation of inputs, outputs, and elements.

If it is concluded that the relay or one of its modules is of concern, contact GE Multilin for service.

2.1.1 OVERVIEW

The L30 Line Current Differential System 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.

In addition to current differential protection, the relay provides multiple backup protection for phase and ground faults. For overcurrent protection, the time overcurrent curves may 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).

Table 2–1: DEVICE NUMBERS AND FUNCTIONS

DEVICE NUMBER	FUNCTION
25	Synchrocheck
27P	Phase undervoltage
27X	Auxiliary undervoltage
50BF	Breaker failure
50DD	Adaptive fault detector
50G	Ground instantaneous overcurrent
50N	Neutral instantaneous overcurrent
50P	Phase instantaneous overcurrent
50_2	Negative-sequence instantaneous overcurrent
51G	Ground time overcurrent
51N	Neutral time overcurrent
51P	Phase time overcurrent

DEVICE NUMBER	FUNCTION
51_2	Negative-sequence time overcurrent
52	AC circuit breaker
59P	Phase overvoltage
59_2	Negative-sequence overvoltage
59X	Auxiliary overvoltage
67N	Neutral directional overcurrent
67P	Phase directional overcurrent
79	Automatic recloser
81U	Underfrequency
87L	Segregated line current differential
87LG	Ground differential

2

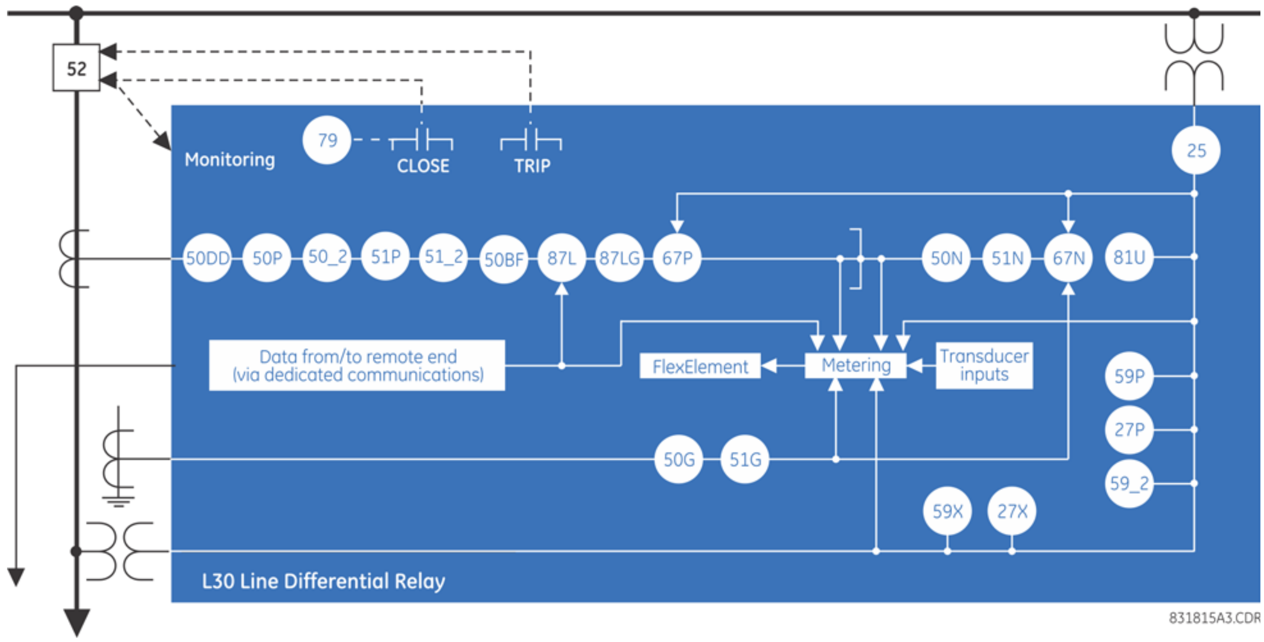


Figure 2–1: SINGLE LINE DIAGRAM

Table 2–2: OTHER DEVICE FUNCTIONS

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

2.1.2 FEATURES

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

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

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

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

MONITORING:

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

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

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

2.1.3 SECURITY

The following security features are available:

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

a) 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.

b) PASSWORD SECURITY

Password security is a basic security feature present in the default offering of the product.

Two levels of password security are provided: command and setting.

The following operations are under command password supervision:

- Operating the breakers via faceplate 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

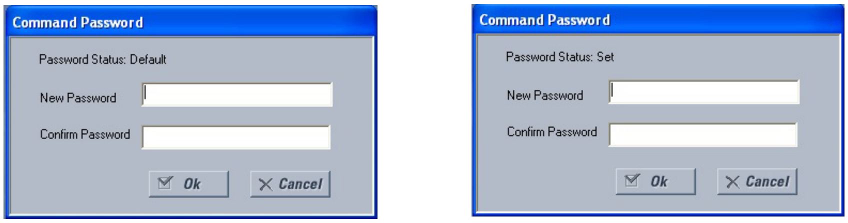
The following operations are under setting password supervision:

- Changing any setting

- Test mode operation

The command and setting passwords are defaulted to “0” when the relay is shipped from the factory. When a password is set to “0”, the password security feature is disabled. As shown in the figures, the window indicates when the password is at the default and when the password has been set.

Figure 2–2: WINDOW INDICATES DEFAULT PASSWORD (LEFT) AND PASSWORD SET (RIGHT)



The L30 supports password entry from a local or remote connection. Local access is defined as any access to settings or commands via the faceplate interface. This includes both keypad entry and the through the faceplate RS232 port. Remote access is defined as any access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. Any changes to the local or remote passwords 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 faceplate, the local password applies.

Events are logged in the Event Recorder. The FlexLogic operands and events are updated every five seconds.

c) CYBERSENTRY SECURITY

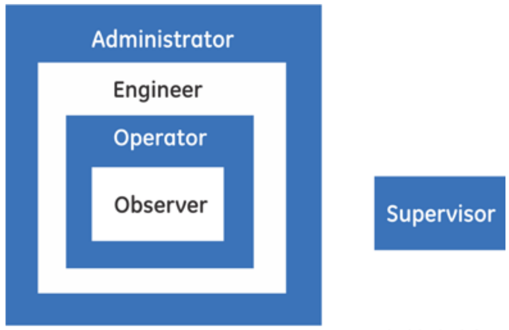
CyberSentry Embedded Security is a software option that provides advanced security services. When this option is purchased, the basic password security is disabled automatically.

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).
- 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.

Example: Administrative functions can be segmented away from common operator functions, or engineering type access, all of which are defined by separate roles, as shown in the following figure, so that access of UR devices by multiple personnel within a substation is allowed. Permission for each role are outlined in the next section.

Figure 2–3: CYBERSENTRY USER ROLES



There are two types of authentication supported by CyberSentry that can be used 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 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) 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 only.

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 are displayed in plain text by the EnerVista software or UR device, nor are they ever transmitted without cryptographic protection.

CYBERSENTRY USER ROLES

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

Example: Observer cannot write any settings.

The table lists the roles that are supported and their corresponding capabilities.

Table 2–3: PERMISSIONS BY USER ROLE FOR CYBERSENTRY

Roles	Administrator	Engineer	Operator	Supervisor	Observer
	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

Roles	Administrator	Engineer	Operator	Supervisor	Observer
|--------------- 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 test	RW	RW	R	R	R
|--------------- Control Pushbuttons	RW	RW	R	R	R
|--------------- User programmable Pushbuttons	RW	RW	R	R	R
|--------------- Flex states	RW	RW	R	R	R
|--------------- User definable dis-plays	RW	RW	R	R	R
|--------------- Direct I/O	RW	RW	R	R	R
|--------------- Tele-protection	RW	RW	R	R	R
|--------------- Installation	RW	RW	R	R	R
|------------ **System Setup**	RW	RW	R	R	R
|------------ **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 Input	RW	RW	R	R	R
|--------------- Contact Input thresh-old	RW	RW	R	R	R
|--------------- Virtual Inputs	RW	RW	R	R	R
|--------------- Contact Output	RW	RW	R	R	R
|--------------- Virtual Output	RW	RW	R	R	R
|--------------- Remote Devices	RW	RW	R	R	R
|--------------- Remote Inputs	RW	RW	R	R	R
|--------------- Remote DPS input	RW	RW	R	R	R
|--------------- Remote Output DNA Bit Pair	RW	RW	R	R	R
|--------------- Remote Output user Bit Pair	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
|--------------- IEC61850 GOOSE Analogs	RW	RW	R	R	R
|--------------- IEC61850 GOOSE Integers	RW	RW	R	R	R
|------------ **Transducer I/O**	RW	RW	R	R	R
|------------ **Testing**	RW	RW	R	R	R

<table>
<tr><th>Roles</th><th>Administrator</th><th>Engineer</th><th>Operator</th><th>Supervisor</th><th>Observer</th></tr>
<tr><td>|------------ Front Panel Labels Designer</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>|------------ Protection Summary</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>Commands</td><td>RW</td><td>RW</td><td>RW</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Virtual Inputs</td><td>RW</td><td>RW</td><td>RW</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Clear Records</td><td>RW</td><td>RW</td><td>RW</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Set date and time</td><td>RW</td><td>RW</td><td>RW</td><td>R</td><td>R</td></tr>
<tr><td>User Displays</td><td>R</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>Targets</td><td>R</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>Actual Values</td><td>R</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Front Panel Labels Designer</td><td>R</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Status</td><td>R</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Metereing</td><td>R</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Transducer I/O</td><td>R</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Records</td><td>R</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Product Info</td><td>R</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>Maintenance</td><td>RW</td><td>RW</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Modbus Analyzer</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>|------------ Change Front Panel</td><td>RW</td><td>RW</td><td>RW</td><td>R</td><td>R</td></tr>
<tr><td>|------------ Update Firmware</td><td>Yes</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td>|------------ Retrieve File</td><td>Yes</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
</table>

Table Notes:

1. RW = read and write access
2. R = read access
3. Supervisor = RW (default), Administrator = R (default), Administrator = RW (only if Supervisor role is disabled)
4. NA = the permission is not enforced by CyberSentry Security

CYBERSENTRY SERVER AUTHENTICATION

The UR has been designed to automatically direct 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 automatically detects whether an authentication request is to be handled remotely or locally. As there are only five local accounts possible on the UR, if the user ID credential does not match one of the five local accounts, the UR automatically forwards 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.

2.1.4 ORDERING

a) OVERVIEW

The L30 is available as a 19-inch rack horizontal mount or reduced-size (¾) vertical unit and consists of the following modules: power supply, CPU, CT/VT, digital input and output, transducer input and output, and inter-relay communications. Each of these modules can be supplied in a number of configurations specified at the time of ordering. The information required to completely specify the relay is provided in the following tables (see chapter 3 for full details of relay modules).

NOTE

Order codes are subject to change without notice. See the ordering page at http://www.gedigitalenergy.com/multilin/order.htm for the latest options.

The order code structure is dependent on the mounting option (horizontal or vertical) and the type of CT/VT modules (enhanced diagnostic CT/VT modules or HardFiber^{TM} process bus modules). The order code options are described in the following sub-sections.

b) ORDER CODES WITH ENHANCED CT/VT MODULES

The order codes for the horizontal mount units are shown below.

Table 2–4: L30 ORDER CODES (HORIZONTAL UNITS)

L30 - * ** - * * * - F ** - H ** - L ** - N ** - S ** - U ** - W/X **		Full Size Horizontal Mount
BASE UNIT	L30	Base Unit
CPU	T	RS485 and Three Multi-mode fiber 100Base-FX (SFP with LC)
	U	RS485 and Two Multi-mode fiber 100Base-FX (SFP with LC), One 10/100Base-T (SFP with RJ45)
	V	RS485 and Three 10/100Base-T (SFP with RJ45)
SOFTWARE	00	No software options
	03	IEC 61850
	06	One phasor measurement unit (PMU)
	07	IEC 61850 and one phasor measurement unit (PMU)
	18	Synchrocheck and three-pole autoreclose
	19	Synchrocheck, three-pole autoreclose, IEC 61850, and one phasor measurement unit (PMU)
	24	In-zone transformer protection
	25	In-zone transformer protection and IEC 61850
	26	In-zone transformer protection and and one phasor measurement unit (PMU)
	27	In-zone transformer protection, IEC 61850, and one phasor measurement unit (PMU)
	A0	CyberSentry Lvl 1
	A3	CyberSentry Lvl 1 and IEC 61850
	A4	CyberSentry Lvl 1 and IEC 61850 and Ethernet Global Data (EGD)
	A6	CyberSentry Lvl 1 and phasor measurement unit (PMU)
	A7	CyberSentry Lvl 1 and IEC 61850 and phasor measurement unit (PMU)
	AI	CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck
	AJ	CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck ane one PMU
	AO	CyberSentry Lvl 1 and In-zone transformer protection
	AP	CyberSentry Lvl 1 and IEC 61850 and In-zone transformer protection
	AQ	CyberSentry Lvl 1 and phasor measurement unit (PMU) and In-zone transformer protection
	AR	CyberSentry Lvl 1 and IEC 61850 and (PMU) and In-zone transformer protection
	B0	IEEE 1588
	B3	IEEE 1588 and IEC 61850
	B4	IEEE 1588 and IEC 61850 and Ethernet Global Data (EGD)
	B6	IEEE 1588 and phasor measurement unit (PMU)
	B7	IEEE 1588 and IEC 61850 and phasor measurement unit (PMU)
	BI	IEEE 1588 and three-pole autoreclose and synchrocheck
	BJ	IEEE 1588 and three-pole autoreclose and synchrocheck ane one PMU
	BO	IEEE 1588 and In-zone transformer protection
	BP	IEEE 1588 and IEC 61850 and In-zone transformer protection
	BQ	IEEE 1588 and phasor measurement unit (PMU) and In-zone transformer protection
	BR	IEEE 1588 and IEC 61850 and (PMU) and In-zone transformer protection
	C0	Parallel Redundancy Protocol (PRP)
	C3	PRP and IEC 61850
	C6	PRP and PMU
	C7	PRP, IEC 61850, and PMU
	CI	PRP, three-pole autoreclose, and synchrocheck
	CJ	PRP, three-pole autoreclose, PMU, and synchrocheck
	CO	PRP and in-zone transformer protection
	CP	PRP, in-zone transformer protection, and IEC 61850
	CQ	PRP, in-zone transformer protection, and PMU
	CR	PRP, in-zone transformer protection, IEC 61850, and PMU
	D0	IEEE 1588 and CyberSentry Lvl 1
	D3	IEEE 1588 and CyberSentry Lvl 1 and IEC 61850
	D4	IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and Ethernet Global Data (EGD)
	D6	IEEE 1588 and CyberSentry Lvl 1 and phasor measurement unit (PMU)
	D7	IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and phasor measurement unit (PMU)
	DI	IEEE 1588 and CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck
	DJ	IEEE 1588 and CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck and PMU
	DO	IEEE 1588 and CyberSentry Lvl 1 and In-zone transformer protection
	DP	IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and In-zone transformer protection
	DQ	IEEE 1588 and CyberSentry Lvl 1 and one PMU and In-zone transformer protection
	DR	IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and PMU and In-zone transformer protection
	E0	IEEE 1588 and PRP
	E3	IEEE 1588, PRP, IEC 61850
	E6	IEEE 1588, PRP, and PMU
	E7	IEEE 1588, PRP, IEC 61850, and PMU
	EI	IEEE 1588, PRP, three-pole autoreclose, and synchrocheck
	EJ	IEEE 1588, PRP, three-pole autoreclose, PMU, and synchrocheck
	EO	IEEE 1588, PRP, and in-zone transformer protection
	EP	IEEE 1588, PRP, in-zone transformer protection, and IEC 61850
	EQ	IEEE 1588, PRP, in-zone transformer protection, and PMU
	ER	IEEE 1588, PRP, in-zone transformer protection, IEC 61850, and PMU
	F0	PRP and CyberSentry Lvl 1
	F3	PRP, CyberSentry Lvl 1, and IEC 61850
	F6	PRP, CyberSentry Lvl 1, and PMU
	F7	PRP, CyberSentry Lvl 1, IEC 61850, and PMU
	FI	PRP, CyberSentry Lvl 1, three-pole autoreclose, and synchrocheck
	FJ	PRP, CyberSentry Lvl 1, three-pole autoreclose, PMU, and synchrocheck
	FO	PRP, CyberSentry Lvl 1, in-zone transformer protection
	FP	PRP, CyberSentry Lvl 1, in-zone transformer protection, and IEC 61850
	FQ	PRP, CyberSentry Lvl 1, in-zone transformer protection, and PMU
	FR	PRP, CyberSentry Lvl 1, in-zone transformer protection, IEC 61850, and PMU
	G0	IEEE 1588, PRP, and CyberSentry Lvl 1
	G3	IEEE 1588, PRP, CyberSentry Lvl 1, and IEC 61850
	G6	IEEE 1588, PRP, CyberSentry Lvl 1, and PMU
	G7	IEEE 1588, PRP, CyberSentry Lvl 1, IEC 61850, and PMU
	GI	IEEE 1588, PRP, CyberSentry Lvl 1, three-pole autoreclose, and synchrocheck
	GJ	IEEE 1588, PRP, CyberSentry Lvl 1, three-pole autoreclose, PMU, and synchrocheck
	GO	IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection
	GP	IEEE 1588 PRP, CyberSentry Lvl 1, in-zone transformer protection, and IEC 61850
	GQ	IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection, and PMU
	GR	IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection, IEC 61850, and PMU
MOUNT/COATING	H	Horizontal (19" rack)
	A	Horizontal (19" rack) with harsh environmental coating
FACEPLATE/ DISPLAY	C	English display
	D	French display
	R	Russian display
	A	Chinese display
	P	English display with 4 small and 12 large programmable pushbuttons
	G	French display with 4 small and 12 large programmable pushbuttons
	S	Russian display with 4 small and 12 large programmable pushbuttons
	B	Chinese display with 4 small and 12 large programmable pushbuttons
	K	Enhanced front panel with English display
	M	Enhanced front panel with French display
	Q	Enhanced front panel with Russian display
	U	Enhanced front panel with Chinese display
	L	Enhanced front panel with English display and user-programmable pushbuttons
	N	Enhanced front panel with French display and user-programmable pushbuttons
	T	Enhanced front panel with Russian display and user-programmable pushbuttons
	V	Enhanced front panel with Chinese display and user-programmable pushbuttons
	W	Enhanced front panel with Turkish display
	Y	Enhanced front panel with Turkish display and user-programmable pushbuttons
POWER SUPPLY (redundant supply must be same type as main supply)	H	125 / 250 V AC/DC power supply
	H RH	125 / 250 V AC/DC with redundant 125 / 250 V AC/DC power supply
	L	24 to 48 V (DC only) power supply
	L RL	24 to 48 V (DC only) with redundant 24 to 48 V DC power supply
ENHANCED DIAGNOSTICS CT/VT DSP (requires all DSP to be enhanced diagnostic)	8L	Standard 4CT/4VT with enhanced diagnostics (required for PMU option)
	8N	Standard 8CT with enhanced diagnostics (required for PMU option)
DIGITAL INPUTS/OUTPUTS	XX XX XX XX XX	No Module
	4A 4A 4A 4A 4A	4 Solid-State (no monitoring) MOSFET outputs
	4B 4B 4B 4B 4B	4 Solid-State (voltage with optional current) MOSFET outputs
	4C 4C 4C 4C 4C	4 Solid-State (current with optional voltage) MOSFET outputs
	4D 4D 4D 4D 4D	16 digital inputs with Auto-Burnishing
	4L 4L 4L 4L 4L	14 Form-A (no monitoring) Latching outputs
	67 67 67 67 67	8 Form-A (no monitoring) outputs

2

Table 2–4: L30 ORDER CODES (HORIZONTAL UNITS)

	L30	*	**	*	*	*	*	F **	H **	L **	N **	S **	U **	W/X **	Full Size Horizontal Mount
BASE UNIT	L30														Base Unit
									6A	6A	6A	6A	6A		2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 digital inputs
									6B	6B	6B	6B	6B		2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
									6C	6C	6C	6C	6C		8 Form-C outputs
									6D	6D	6D	6D	6D		16 digital inputs
									6E	6E	6E	6E	6E		4 Form-C outputs, 8 digital inputs
									6F	6F	6F	6F	6F		8 Fast Form-C outputs
									6G	6G	6G	6G	6G		4 Form-A (voltage with optional current) outputs, 8 digital inputs
									6H	6H	6H	6H	6H		6 Form-A (voltage with optional current) outputs, 4 digital inputs
									6K	6K	6K	6K	6K		4 Form-C and 4 Fast Form-C outputs
									6L	6L	6L	6L	6L		2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 digital inputs
									6M	6M	6M	6M	6M		2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
									6N	6N	6N	6N	6N		4 Form-A (current with optional voltage) outputs, 8 digital inputs
									6P	6P	6P	6P	6P		6 Form-A (current with optional voltage) outputs, 4 digital inputs
									6R	6R	6R	6R	6R		2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs
									6S	6S	6S	6S	6S		2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
									6T	6T	6T	6T	6T		4 Form-A (no monitoring) outputs, 8 digital inputs
									6U	6U	6U	6U	6U		6 Form-A (no monitoring) outputs, 4 digital inputs
									6V	6V	6V	6V	6V		2 Form-A outputs, 1 Form-C output, 1 Form-A latching output, 8 digital inputs
TRANSDUCER INPUTS/OUTPUTS (select a maximum of 3 per unit)									5A	5A	5A	5A	5A		4 dcmA inputs, 4 dcmA outputs (only one 5A module is allowed)
									5C	5C	5C	5C	5C		8 RTD inputs
									5D	5D	5D	5D	5D		4 RTD inputs, 4 dcmA outputs (only one 5D module is allowed)
									5E	5E	5E	5E	5E		4 RTD inputs, 4 dcmA inputs
									5F	5F	5F	5F	5F		8 dcmA inputs
INTER-RELAY COMMUNICATIONS (select a maximum of 1 per unit)														2A	C37.94SM, 1300nm single-mode, ELED, 1 channel single-mode
														2B	C37.94SM, 1300nm 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
														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, multi-mode, LED, 1 Channel
														7B	1300 nm, multi-mode, 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, multi-mode
														7F	Channel 1 - G.703; Channel 2 - 1300 nm, multi-mode
														7G	Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
														7H	820 nm, multi-mode, LED, 2 Channels
														7I	1300 nm, multi-mode, 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, multi-mode, LED
														7M	Channel 1 - RS422; Channel 2 - 1300 nm, multi-mode, 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

The order codes for the reduced size vertical mount units are shown below.

Table 2–5: L30 ORDER CODES (REDUCED SIZE VERTICAL UNITS)

	L30	*	**	*	*	*	*	F **	H **	L **	N **	R **	Reduced Size Vertical Mount
BASE UNIT	L30												Base Unit
CPU		T											RS485 and Three Multi-mode fiber 100Base-FX (SFP with LC)
		U											RS485 and Two Multi-mode fiber 100Base-FX (SFP with LC), One 10/100Base-T (SFP with RJ45)
		V											RS485 and Three 10/100Base-T (SFP with RJ45)
SOFTWARE			00										No software options
			03										IEC 61850
			06										Phasor measurement unit (PMU)
			07										IEC 61850 and phasor measurement unit (PMU)
			18										Synchrocheck and three-pole autoreclose
			19										Synchrocheck, three-pole autoreclose, IEC 61850, and one phasor measurement unit (PMU)
			24										In-zone transformer protection
			25										In-zone transformer protection and IEC 61850
			26										In-zone transformer protection and and one phasor measurement unit (PMU)
			27										In-zone transformer protection, IEC 61850, and one phasor measurement unit (PMU)
			A0										CyberSentry Lvl 1
			A3										CyberSentry Lvl 1 and IEC 61850
			A4										CyberSentry Lvl 1 and IEC 61850 and Ethernet Global Data (EGD)
			A6										CyberSentry Lvl 1 and phasor measurement unit (PMU)
			A7										CyberSentry Lvl 1 and IEC 61850 and phasor measurement unit (PMU)
			AI										CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck
			AJ										CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck ane one PMU
			AO										CyberSentry Lvl 1 and In-zone transformer protection
			AP										CyberSentry Lvl 1 and IEC 61850 and In-zone transformer protection
			AQ										CyberSentry Lvl 1 and phasor measurement unit (PMU) and In-zone transformer protection
			AR										CyberSentry Lvl 1 and IEC 61850 and (PMU) and In-zone transformer protection
			B0										IEEE 1588
			B3										IEEE 1588 and IEC 61850
			B4										IEEE 1588 and IEC 61850 and Ethernet Global Data (EGD)
			B6										IEEE 1588 and phasor measurement unit (PMU)
			B7										IEEE 1588 and IEC 61850 and phasor measurement unit (PMU)
			BI										IEEE 1588 and three-pole autoreclose and synchrocheck
			BJ										IEEE 1588 and three-pole autoreclose and synchrocheck ane one PMU
			BO										IEEE 1588 and In-zone transformer protection
			BP										IEEE 1588 and IEC 61850 and In-zone transformer protection
			BQ										IEEE 1588 and phasor measurement unit (PMU) and In-zone transformer protection
			BR										IEEE 1588 and IEC 61850 and (PMU) and In-zone transformer protection
			C0										Parallel Redundancy Protocol (PRP)
			C3										PRP and IEC 61850
			C6										PRP and PMU
			C7										PRP, IEC 61850, and PMU
			CI										PRP, three-pole autoreclose, and synchrocheck
			CJ										PRP, three-pole autoreclose, PMU, and synchrocheck
			CO										PRP and in-zone transformer protection
			CP										PRP, in-zone transformer protection, and IEC 61850
			CQ										PRP, in-zone transformer protection, and PMU
			CR										PRP, in-zone transformer protection, IEC 61850, and PMU
			D0										IEEE 1588 and CyberSentry Lvl 1
			D3										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850
			D4										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and Ethernet Global Data (EGD)
			D6										IEEE 1588 and CyberSentry Lvl 1 and phasor measurement unit (PMU)
			D7										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and phasor measurement unit (PMU)
			DI										IEEE 1588 and CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck
			DJ										IEEE 1588 and CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck and PMU
			DO										IEEE 1588 and CyberSentry Lvl 1 and In-zone transformer protection
			DP										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and In-zone transformer protection
			DQ										IEEE 1588 and CyberSentry Lvl 1 and one PMU and In-zone transformer protection
			DR										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and PMU and In-zone transformer protection
			E0										IEEE 1588 and PRP
			E3										IEEE 1588, PRP, IEC 61850
			E6										IEEE 1588, PRP, and PMU
			E7										IEEE 1588, PRP, IEC 61850, and PMU

Table 2–5: L30 ORDER CODES (REDUCED SIZE VERTICAL UNITS)

	EI									IEEE 1588, PRP, three-pole autoreclose, and synchrocheck
	EJ									IEEE 1588, PRP, three-pole autoreclose, PMU, and synchrocheck
	EO									IEEE 1588, PRP, and in-zone transformer protection
	EP									IEEE 1588, PRP, in-zone transformer protection, and IEC 61850
	EQ									IEEE 1588, PRP, in-zone transformer protection, and PMU
	ER									IEEE 1588, PRP, in-zone transformer protection, IEC 61850, and PMU
	F0									PRP and CyberSentry Lvl 1
	F3									PRP, CyberSentry Lvl 1, and IEC 61850
	F6									PRP, CyberSentry Lvl 1, and PMU
	F7									PRP, CyberSentry Lvl 1, IEC 61850, and PMU
	FI									PRP, CyberSentry Lvl 1, three-pole autoreclose, and synchrocheck
	FJ									PRP, CyberSentry Lvl 1, three-pole autoreclose, PMU, and synchrocheck
	FO									PRP, CyberSentry Lvl 1, in-zone transformer protection
	FP									PRP, CyberSentry Lvl 1, in-zone transformer protection, and IEC 61850
	FQ									PRP, CyberSentry Lvl 1, in-zone transformer protection, and PMU
	FR									PRP, CyberSentry Lvl 1, in-zone transformer protection, IEC 61850, and PMU
	G0									IEEE 1588, PRP, and CyberSentry Lvl 1
	G3									IEEE 1588, PRP, CyberSentry Lvl 1, and IEC 61850
	G6									IEEE 1588, PRP, CyberSentry Lvl 1, and PMU
	G7									IEEE 1588, PRP, CyberSentry Lvl 1, IEC 61850, and PMU
	GI									IEEE 1588, PRP, CyberSentry Lvl 1, three-pole autoreclose, and synchrocheck
	GJ									IEEE 1588, PRP, CyberSentry Lvl 1, three-pole autoreclose, PMU, and synchrocheck
	GO									IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection
	GP									IEEE 1588 PRP, CyberSentry Lvl 1, in-zone transformer protection, and IEC 61850
	GQ									IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection, and PMU
	GR									IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection, IEC 61850, and PMU
MOUNT/COATING		V								Vertical (3/4 rack)
		B								Vertical (3/4 rack) with harsh environmental coating
FACEPLATE/ DISPLAY			F							English display
			D							French display
			R							Russian display
			A							Chinese display
			K							Enhanced front panel with English display
			M							Enhanced front panel with French display
			Q							Enhanced front panel with Russian display
			U							Enhanced front panel with Chinese display
			L							Enhanced front panel with English display and user-programmable pushbuttons
			N							Enhanced front panel with French display and user-programmable pushbuttons
			T							Enhanced front panel with Russian display and user-programmable pushbuttons
			V							Enhanced front panel with Chinese display and user-programmable pushbuttons
			W							Enhanced front panel with Turkish display
			Y							Enhanced front panel with Turkish display and user-programmable pushbuttons
POWER SUPPLY				H						125 / 250 V AC/DC power supply
				L						24 to 48 V (DC only) power supply
ENHANCED DIAGNOSTICS CT/VT DSP					8L					Standard 4CT/4VT with enhanced diagnostics (required for PMU option)
(requires all DSP to be enhanced diagnostic)					8N					Standard 8CT with enhanced diagnostics (required for PMU option)
DIGITAL INPUTS/ OUTPUTS						XX	XX	XX		No Module
						4A	4A	4A		4 Solid-State (no monitoring) MOSFET outputs
						4B	4B	4B		4 Solid-State (voltage with optional current) MOSFET outputs
						4C	4C	4C		4 Solid-State (current with optional voltage) MOSFET outputs
						4D	4D	4D		16 digital inputs with Auto-Burnishing
						4L	4L	4L		14 Form-A (no monitoring) Latching outputs
						67	67	67		8 Form-A (no monitoring) outputs
						6A	6A	6A		2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 digital inputs
						6B	6B	6B		2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
						6C	6C	6C		8 Form-C outputs
						6D	6D	6D		16 digital inputs
						6E	6E	6E		4 Form-C outputs, 8 digital inputs
						6F	6F	6F		8 Fast Form-C outputs
						6G	6G	6G		4 Form-A (voltage with optional current) outputs, 8 digital inputs
						6H	6H	6H		6 Form-A (voltage with optional current) outputs, 4 digital inputs
						6K	6K	6K		4 Form-C and 4 Fast Form-C outputs
						6L	6L	6L		2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 digital inputs
						6M	6M	6M		2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
						6N	6N	6N		4 Form-A (current with optional voltage) outputs, 8 digital inputs
						6P	6P	6P		6 Form-A (current with optional voltage) outputs, 4 digital inputs
						6R	6R	6R		2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs
						6S	6S	6S		2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
						6T	6T	6T		4 Form-A (no monitoring) outputs, 8 digital inputs
						6U	6U	6U		6 Form-A (no monitoring) outputs, 4 digital inputs
						6V	6V	6V		2 Form-A outputs, 1 Form-C output, 1 Form-A latching output, 8 digital inputs
TRANSDUCER INPUTS/OUTPUTS						5A	5A	5A		4 dcmA inputs, 4 dcmA outputs (only one 5A module is allowed)
(select a maximum of 3 per unit)						5C	5C	5C		8 RTD inputs
						5D	5D	5D		4 RTD inputs, 4 dcmA outputs (only one 5D module is allowed)
						5E	5E	5E		4 RTD inputs, 4 dcmA inputs
						5F	5F	5F		8 dcmA inputs
INTER-RELAY COMMUNICATIONS									2A	C37.94SM, 1300nm single-mode, ELED, 1 channel single-mode
(select a maximum of 1 per unit)									2B	C37.94SM, 1300nm 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
									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, multi-mode, LED, 1 Channel
									7B	1300 nm, multi-mode, 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, multi-mode
									7F	Channel 1 - G.703; Channel 2 - 1300 nm, multi-mode
									7G	Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
									7H	820 nm, multi-mode, LED, 2 Channels
									7I	1300 nm, multi-mode, 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, multi-mode, LED
									7M	Channel 1 - RS422; Channel 2 - 1300 nm, multi-mode, 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

c) ORDER CODES WITH PROCESS BUS MODULES

The order codes for the horizontal mount units with the process bus module are shown below.

Table 2–6: L30 ORDER CODES (HORIZONTAL UNITS WITH PROCESS BUS)

	L30	- *	**	- *	*	*	- F **	- H **	- L **	- N **	- S **	- W/X **		Full Size Horizontal Mount
BASE UNIT	L30													Base Unit
CPU		T												RS485 and Three Multi-mode fiber 100Base-FX (SFP with LC)
		U												RS485 and Two Multi-mode fiber 100Base-FX (SFP with LC), One 10/100Base-T (SFP with RJ45)
		V												RS485 and Three 10/100Base-T (SFP with RJ45)
SOFTWARE			00											No software options

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Table 2–6: L30 ORDER CODES (HORIZONTAL UNITS WITH PROCESS BUS)

	L30	*	**	*	*	*	F **	H **	L **	N **	S **	W/X **	Full Size Horizontal Mount
BASE UNIT	L30												Base Unit
			03										IEC 61850
			06										One phasor measurement unit (PMU)
			07										IEC 61850 and one phasor measurement unit (PMU)
			18										Synchrocheck and three-pole autoreclose
			19										Synchrocheck, three-pole autoreclose, IEC 61850, and one phasor measurement unit (PMU)
			24										In-zone transformer protection
			25										In-zone transformer protection and IEC 61850
			26										In-zone transformer protection and and one phasor measurement unit (PMU)
			27										In-zone transformer protection, IEC 61850, and one phasor measurement unit (PMU)
			A0										CyberSentry Lvl 1
			A3										CyberSentry Lvl 1 and IEC 61850
			A4										CyberSentry Lvl 1 and IEC 61850 and Ethernet Global Data (EGD)
			A6										CyberSentry Lvl 1 and phasor measurement unit (PMU)
			A7										CyberSentry Lvl 1 and IEC 61850 and phasor measurement unit (PMU)
			AI										CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck
			AJ										CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck ane one PMU
			AO										CyberSentry Lvl 1 and In-zone transformer protection
			AP										CyberSentry Lvl 1 and IEC 61850 and In-zone transformer protection
			AQ										CyberSentry Lvl 1 and phasor measurement unit (PMU) and In-zone transformer protection
			AR										CyberSentry Lvl 1 and IEC 61850 and (PMU) and In-zone transformer protection
			B0										IEEE 1588
			B3										IEEE 1588 and IEC 61850
			B4										IEEE 1588 and IEC 61850 and Ethernet Global Data (EGD)
			B6										IEEE 1588 and phasor measurement unit (PMU)
			B7										IEEE 1588 and IEC 61850 and phasor measurement unit (PMU)
			BI										IEEE 1588 and three-pole autoreclose and synchrocheck
			BJ										IEEE 1588 and three-pole autoreclose and synchrocheck ane one PMU
			BO										IEEE 1588 and In-zone transformer protection
			BP										IEEE 1588 and IEC 61850 and In-zone transformer protection
			BQ										IEEE 1588 and phasor measurement unit (PMU) and In-zone transformer protection
			BR										IEEE 1588 and IEC 61850 and (PMU) and In-zone transformer protection
			C0										Parallel Redundancy Protocol (PRP)
			C3										PRP and IEC 61850
			C6										PRP and PMU
			C7										PRP, IEC 61850, and PMU
			CI										PRP, three-pole autoreclose, and synchrocheck
			CJ										PRP, three-pole autoreclose, PMU, and synchrocheck
			CO										PRP and in-zone transformer protection
			CP										PRP, in-zone transformer protection, and IEC 61850
			CQ										PRP, in-zone transformer protection, and PMU
			CR										PRP, in-zone transformer protection, IEC 61850, and PMU
			D0										IEEE 1588 and CyberSentry Lvl 1
			D3										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850
			D4										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and Ethernet Global Data (EGD)
			D6										IEEE 1588 and CyberSentry Lvl 1 and phasor measurement unit (PMU)
			D7										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and phasor measurement unit (PMU)
			DI										IEEE 1588 and CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck
			DJ										IEEE 1588 and CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck and PMU
			DO										IEEE 1588 and CyberSentry Lvl 1 and In-zone transformer protection
			DP										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and In-zone transformer protection
			DQ										IEEE 1588 and CyberSentry Lvl 1 and one PMU and In-zone transformer protection
			DR										IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and PMU and In-zone transformer protection
			E0										IEEE 1588 and PRP
			E3										IEEE 1588, PRP, IEC 61850
			E6										IEEE 1588, PRP, and PMU
			E7										IEEE 1588, PRP, IEC 61850, and PMU
			EI										IEEE 1588, PRP, three-pole autoreclose, and synchrocheck
			EJ										IEEE 1588, PRP, three-pole autoreclose, PMU, and synchrocheck
			EO										IEEE 1588, PRP, and in-zone transformer protection
			EP										IEEE 1588, PRP, in-zone transformer protection, and IEC 61850
			EQ										IEEE 1588, PRP, in-zone transformer protection, and PMU
			ER										IEEE 1588, PRP, in-zone transformer protection, IEC 61850, and PMU
			F0										PRP and CyberSentry Lvl 1
			F3										PRP, CyberSentry Lvl 1, and IEC 61850
			F6										PRP, CyberSentry Lvl 1, and PMU
			F7										PRP, CyberSentry Lvl 1, IEC 61850, and PMU
			FI										PRP, CyberSentry Lvl 1, three-pole autoreclose, and synchrocheck
			FJ										PRP, CyberSentry Lvl 1, three-pole autoreclose, PMU, and synchrocheck
			FO										PRP, CyberSentry Lvl 1, in-zone transformer protection
			FP										PRP, CyberSentry Lvl 1, in-zone transformer protection, and IEC 61850
			FQ										PRP, CyberSentry Lvl 1, in-zone transformer protection, and PMU
			FR										PRP, CyberSentry Lvl 1, in-zone transformer protection, IEC 61850, and PMU
			G0										IEEE 1588, PRP, and CyberSentry Lvl 1
			G3										IEEE 1588, PRP, CyberSentry Lvl 1, and IEC 61850
			G6										IEEE 1588, PRP, CyberSentry Lvl 1, and PMU
			G7										IEEE 1588, PRP, CyberSentry Lvl 1, IEC 61850, and PMU
			GI										IEEE 1588, PRP, CyberSentry Lvl 1, three-pole autoreclose, and synchrocheck
			GJ										IEEE 1588, PRP, CyberSentry Lvl 1, three-pole autoreclose, PMU, and synchrocheck
			GO										IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection
			GP										IEEE 1588 PRP, CyberSentry Lvl 1, in-zone transformer protection, and IEC 61850
			GQ										IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection, and PMU
			GR										IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection, IEC 61850, and PMU
MOUNT/COATING				H									Horizontal (19” rack)
				A									Horizontal (19” rack) with harsh environmental coating
FACEPLATE/ DISPLAY					C								English display
					D								French display
					R								Russian display
					A								Chinese display
					P								English display with 4 small and 12 large programmable pushbuttons
					G								French display with 4 small and 12 large programmable pushbuttons
					S								Russian display with 4 small and 12 large programmable pushbuttons
					B								Chinese display with 4 small and 12 large programmable pushbuttons
					K								Enhanced front panel with English display
					M								Enhanced front panel with French display
					Q								Enhanced front panel with Russian display
					U								Enhanced front panel with Chinese display
					L								Enhanced front panel with English display and user-programmable pushbuttons
					N								Enhanced front panel with French display and user-programmable pushbuttons
					T								Enhanced front panel with Russian display and user-programmable pushbuttons
					V								Enhanced front panel with Chinese display and user-programmable pushbuttons
					W								Enhanced front panel with Turkish display
					Y								Enhanced front panel with Turkish display and user-programmable pushbuttons
POWER SUPPLY (redundant supply must be same type as main supply)						H							125 / 250 V AC/DC power supply
						H						RH	125 / 250 V AC/DC with redundant 125 / 250 V AC/DC power supply
						L							24 to 48 V (DC only) power supply
						L						RL	24 to 48 V (DC only) with redundant 24 to 48 V DC power supply
PROCESS BUS MODULE								81					Eight-port digital process bus module
DIGITAL INPUTS/OUTPUTS							XX		XX	XX	XX	XX	No Module
										4A	4A		4 Solid-State (no monitoring) MOSFET outputs
										4B	4B		4 Solid-State (voltage with optional current) MOSFET outputs
										4C	4C		4 Solid-State (current with optional voltage) MOSFET outputs
										4D	4D		16 digital inputs with Auto-Burnishing
										4L	4L		14 Form-A (no monitoring) Latching outputs
										67	67		8 Form-A (no monitoring) outputs
										6A	6A		2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 digital inputs
										6B	6B		2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
										6C	6C		8 Form-C outputs
										6D	6D		16 digital inputs
										6E	6E		4 Form-C outputs, 8 digital inputs
										6F	6F		8 Fast Form-C outputs
										6G	6G		4 Form-A (voltage with optional current) outputs, 8 digital inputs
										6H	6H		6 Form-A (voltage with optional current) outputs, 4 digital inputs
										6K	6K		4 Form-C and 4 Fast Form-C outputs
										6L	6L		2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 digital inputs
										6M	6M		2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
										6N	6N		4 Form-A (current with optional voltage) outputs, 8 digital inputs
										6P	6P		6 Form-A (current with optional voltage) outputs, 4 digital inputs
										6R	6R		2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs

Table 2–6: L30 ORDER CODES (HORIZONTAL UNITS WITH PROCESS BUS)

	L30 - * ** - * * * * - F ** - H ** - L **	- N **	- S **	- W/X **	Full Size Horizontal Mount
BASE UNIT	L30				Base Unit
		6S	6S		2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
		6T	6T		4 Form-A (no monitoring) outputs, 8 digital inputs
		6U	6U		6 Form-A (no monitoring) outputs, 4 digital inputs
		6V	6V		2 Form-A outputs, 1 Form-C output, 1 Form-A latching output, 8 digital inputs
INTER-RELAY COMMUNICATIONS (select a maximum of 1 per unit)				2A	C37.94SM, 1300nm single-mode, ELED, 1 channel single-mode
				2B	C37.94SM, 1300nm 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
				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, multi-mode, LED, 1 Channel
				7B	1300 nm, multi-mode, 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, multi-mode
				7F	Channel 1 - G.703; Channel 2 - 1300 nm, multi-mode
				7G	Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
				7H	820 nm, multi-mode, LED, 2 Channels
				7I	1300 nm, multi-mode, 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, multi-mode, LED
				7M	Channel 1 - RS422; Channel 2 - 1300 nm, multi-mode, 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

The order codes for the reduced size vertical mount units with the process bus module are shown below.

Table 2–7: L30 ORDER CODES (REDUCED SIZE VERTICAL UNITS WITH PROCESS BUS)

	L30	- *	**	- * * * * - F ** - H ** - L ** - N ** - R **	Reduced Size Vertical Mount
BASE UNIT	L30				Base Unit
CPU		T			RS485 and Three Multi-mode fiber 100Base-FX (SFP with LC)
		U			RS485 and Two Multi-mode fiber 100Base-FX (SFP with LC), One 10/100Base-T (SFP with RJ45)
		V			RS485 and Three 10/100Base-T (SFP with RJ45)
SOFTWARE			00		No software options
			03		IEC 61850
			06		Phasor measurement unit (PMU)
			07		IEC 61850 and phasor measurement unit (PMU)
			18		Synchrocheck and three-pole autoreclose
			19		Synchrocheck, three-pole autoreclose, IEC 61850, and one phasor measurement unit (PMU)
			24		In-zone transformer protection
			25		In-zone transformer protection and IEC 61850
			26		In-zone transformer protection and and one phasor measurement unit (PMU)
			27		In-zone transformer protection, IEC 61850, and one phasor measurement unit (PMU)
			A0		CyberSentry Lvl 1
			A3		CyberSentry Lvl 1 and IEC 61850
			A4		CyberSentry Lvl 1 and IEC 61850 and Ethernet Global Data (EGD)
			A6		CyberSentry Lvl 1 and phasor measurement unit (PMU)
			A7		CyberSentry Lvl 1 and IEC 61850 and phasor measurement unit (PMU)
			AI		CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck
			AJ		CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck ane one PMU
			AO		CyberSentry Lvl 1 and In-zone transformer protection
			AP		CyberSentry Lvl 1 and IEC 61850 and In-zone transformer protection
			AQ		CyberSentry Lvl 1 and phasor measurement unit (PMU) and In-zone transformer protection
			AR		CyberSentry Lvl 1 and IEC 61850 and (PMU) and In-zone transformer protection
			B0		IEEE 1588
			B3		IEEE 1588 and IEC 61850
			B4		IEEE 1588 and IEC 61850 and Ethernet Global Data (EGD)
			B6		IEEE 1588 and phasor measurement unit (PMU)
			B7		IEEE 1588 and IEC 61850 and phasor measurement unit (PMU)
			BI		IEEE 1588 and three-pole autoreclose and synchrocheck
			BJ		IEEE 1588 and three-pole autoreclose and synchrocheck ane one PMU
			BO		IEEE 1588 and In-zone transformer protection
			BP		IEEE 1588 and IEC 61850 and In-zone transformer protection
			BQ		IEEE 1588 and phasor measurement unit (PMU) and In-zone transformer protection
			BR		IEEE 1588 and IEC 61850 and (PMU) and In-zone transformer protection
			C0		Parallel Redundancy Protocol (PRP)
			C3		PRP and IEC 61850
			C6		PRP and PMU
			C7		PRP, IEC 61850, and PMU
			CI		PRP, three-pole autoreclose, and synchrocheck
			CJ		PRP, three-pole autoreclose, PMU, and synchrocheck
			CO		PRP and in-zone transformer protection
			CP		PRP, in-zone transformer protection, and IEC 61850
			CQ		PRP, in-zone transformer protection, and PMU
			CR		PRP, in-zone transformer protection, IEC 61850, and PMU
			D0		IEEE 1588 and CyberSentry Lvl 1
			D3		IEEE 1588 and CyberSentry Lvl 1 and IEC 61850
			D4		IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and Ethernet Global Data (EGD)
			D6		IEEE 1588 and CyberSentry Lvl 1 and phasor measurement unit (PMU)
			D7		IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and phasor measurement unit (PMU)
			DI		IEEE 1588 and CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck
			DJ		IEEE 1588 and CyberSentry Lvl 1 and three-pole autoreclose and synchrocheck and PMU
			DO		IEEE 1588 and CyberSentry Lvl 1 and In-zone transformer protection
			DP		IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and In-zone transformer protection
			DQ		IEEE 1588 and CyberSentry Lvl 1 and one PMU and In-zone transformer protection
			DR		IEEE 1588 and CyberSentry Lvl 1 and IEC 61850 and PMU and In-zone transformer protection
			E0		IEEE 1588 and PRP
			E3		IEEE 1588, PRP, IEC 61850
			E6		IEEE 1588, PRP, and PMU
			E7		IEEE 1588, PRP, IEC 61850, and PMU
			EI		IEEE 1588, PRP, three-pole autoreclose, and synchrocheck
			EJ		IEEE 1588, PRP, three-pole autoreclose, PMU, and synchrocheck
			EO		IEEE 1588, PRP, and in-zone transformer protection
			EP		IEEE 1588, PRP, in-zone transformer protection, and IEC 61850
			EQ		IEEE 1588, PRP, in-zone transformer protection, and PMU
			ER		IEEE 1588, PRP, in-zone transformer protection, IEC 61850, and PMU
			F0		PRP and CyberSentry Lvl 1
			F3		PRP, CyberSentry Lvl 1, and IEC 61850
			F6		PRP, CyberSentry Lvl 1, and PMU
			F7		PRP, CyberSentry Lvl 1, IEC 61850, and PMU
			FI		PRP, CyberSentry Lvl 1, three-pole autoreclose, and synchrocheck
			FJ		PRP, CyberSentry Lvl 1, three-pole autoreclose, PMU, and synchrocheck
			FO		PRP, CyberSentry Lvl 1, in-zone transformer protection
			FP		PRP, CyberSentry Lvl 1, in-zone transformer protection, and IEC 61850
			FQ		PRP, CyberSentry Lvl 1, in-zone transformer protection, and PMU
			FR		PRP, CyberSentry Lvl 1, in-zone transformer protection, IEC 61850, and PMU
			G0		IEEE 1588, PRP, and CyberSentry Lvl 1
			G3		IEEE 1588, PRP, CyberSentry Lvl 1, and IEC 61850
			G6		IEEE 1588, PRP, CyberSentry Lvl 1, and PMU

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Table 2–7: L30 ORDER CODES (REDUCED SIZE VERTICAL UNITS WITH PROCESS BUS)

	G7	IEEE 1588, PRP, CyberSentry Lvl 1, IEC 61850, and PMU
	GI	IEEE 1588, PRP, CyberSentry Lvl 1, three-pole autoreclose, and synchrocheck
	GJ	IEEE 1588, PRP, CyberSentry Lvl 1, three-pole autoreclose, PMU, and synchrocheck
	GO	IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection
	GP	IEEE 1588 PRP, CyberSentry Lvl 1, in-zone transformer protection, and IEC 61850
	GQ	IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection, and PMU
	GR	IEEE 1588, PRP, CyberSentry Lvl 1, in-zone transformer protection, IEC 61850, and PMU
MOUNT/COATING	V	Vertical (3/4 rack)
	B	Vertical (3/4 rack) with harsh environmental coating
FACEPLATE/ DISPLAY	F	English display
	D	French display
	R	Russian display
	A	Chinese display
	K	Enhanced front panel with English display
	M	Enhanced front panel with French display
	Q	Enhanced front panel with Russian display
	U	Enhanced front panel with Chinese display
	L	Enhanced front panel with English display and user-programmable pushbuttons
	N	Enhanced front panel with French display and user-programmable pushbuttons
	T	Enhanced front panel with Russian display and user-programmable pushbuttons
	V	Enhanced front panel with Chinese display and user-programmable pushbuttons
	W	Enhanced front panel with Turkish display
	Y	Enhanced front panel with Turkish display and user-programmable pushbuttons
POWER SUPPLY	H	125 / 250 V AC/DC power supply
	L	24 to 48 V (DC only) power supply
PROCESS BUS MODULE	81	Eight-port digital process bus module
DIGITAL INPUTS/OUTPUTS	XX XX XX XX	No Module
	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 digital 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 digital inputs
	6B	2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
	6C	8 Form-C outputs
	6D	16 digital inputs
	6E	4 Form-C outputs, 8 digital inputs
	6F	8 Fast Form-C outputs
	6G	4 Form-A (voltage with optional current) outputs, 8 digital inputs
	6H	6 Form-A (voltage with optional current) outputs, 4 digital 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 digital inputs
	6M	2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
	6N	4 Form-A (current with optional voltage) outputs, 8 digital inputs
	6P	6 Form-A (current with optional voltage) outputs, 4 digital inputs
	6R	2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs
	6S	2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
	6T	4 Form-A (no monitoring) outputs, 8 digital inputs
	6U	6 Form-A (no monitoring) outputs, 4 digital inputs
	6V	2 Form-A outputs, 1 Form-C output, 1 Form-A latching output, 8 digital inputs
INTER-RELAY COMMUNICATIONS (select a maximum of 1 per unit)	2A	C37.94SM, 1300nm single-mode, ELED, 1 channel single-mode
	2B	C37.94SM, 1300nm 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
	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, multi-mode, LED, 1 Channel
	7B	1300 nm, multi-mode, 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, multi-mode
	7F	Channel 1 - G.703; Channel 2 - 1300 nm, multi-mode
	7G	Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
	7H	820 nm, multi-mode, LED, 2 Channels
	7I	1300 nm, multi-mode, 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, multi-mode, LED
	7M	Channel 1 - RS422; Channel 2 - 1300 nm, multi-mode, 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

2.1.5 REPLACEMENT MODULES

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

NOTE

Not all replacement modules may be applicable to the L30 relay. Only the modules specified in the order codes are available as replacement modules.

NOTE

Replacement module codes are subject to change without notice. See the ordering page at http://www.gedigitalenergy.com/multilin/order.htm for the latest L30 ordering options.

The replacement module order codes for the horizontal mount units are shown below.

Table 2–8: ORDER CODES FOR REPLACEMENT MODULES, HORIZONTAL UNITS

	UR -	**	- *	
POWER SUPPLY (redundant supply only available in horizontal units; must be same type as main supply)		RH	H	Redundant 125 / 250 V AC/DC
		RL	H	Redundant 24 to 48 V (DC only)
CPU		T		RS485 with 3 100Base-FX Ethernet, multimode, SFP with LC
		U		RS485 with 1 100Base-T Ethernet, SFP RJ-45 + 2 100Base-FX Ethernet, multimode, SFP with LC
		V		RS485 with 3 100Base-T Ethernet, SFP with RJ-45
FACEPLATE/DISPLAY		3C		Horizontal faceplate with keypad and English display
		3D		Horizontal faceplate with keypad and French display
		3R		Horizontal faceplate with keypad and Russian display
		3A		Horizontal faceplate with keypad and Chinese display
		3P		Horizontal faceplate with keypad, user-programmable pushbuttons, and English display
		3G		Horizontal faceplate with keypad, user-programmable pushbuttons, and French display
		3S		Horizontal faceplate with keypad, user-programmable pushbuttons, and Russian display
		3B		Horizontal faceplate with keypad, user-programmable pushbuttons, 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
DIGITAL INPUTS AND OUTPUTS		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 digital 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 digital inputs
		6B		2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
		6C		8 Form-C outputs
		6D		16 digital inputs
		6E		4 Form-C outputs, 8 digital inputs
		6F		8 Fast Form-C outputs
		6G		4 Form-A (voltage with optional current) outputs, 8 digital inputs
		6H		6 Form-A (voltage with optional current) outputs, 4 digital 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 digital inputs
		6M		2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
		6N		4 Form-A (current with optional voltage) outputs, 8 digital inputs
		6P		6 Form-A (current with optional voltage) outputs, 4 digital inputs
		6R		2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs
		6S		2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
		6T		4 Form-A (no monitoring) outputs, 8 digital inputs
		6U		6 Form-A (no monitoring) outputs, 4 digital inputs
		6V		2 Form-A outputs, 1 Form-C output, 2 Form-A (no monitoring) latching outputs, 8 digital inputs
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, 1300nm single-mode, ELED, 1 channel single-mode
		2B		C37.94SM, 1300nm 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
		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, multi-mode, LED, 1 Channel
		7B		1300 nm, multi-mode, 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, multi-mode
		7F		Channel 1 - G.703; Channel 2 - 1300 nm, multi-mode
		7G		Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
		7H		820 nm, multi-mode, LED, 2 Channels
		7I		1300 nm, multi-mode, 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, multi-mode, LED
		7M		Channel 1 - RS422; Channel 2 - 1300 nm, multi-mode, 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

The replacement module order codes for the reduced-size vertical mount units are shown below.

Table 2–9: ORDER CODES FOR REPLACEMENT MODULES, VERTICAL UNITS

	UR - **	- *	
POWER SUPPLY	RH	V	125 / 250 V AC/DC
	RL	V	24 to 48 V (DC only)
CPU	T		RS485 with 3 100Base-FX Ethernet, multimode, SFP with LC
	U		RS485 with 1 100Base-T Ethernet, SFP RJ-45 + 2 100Base-FX Ethernet, multimode, SFP with LC
	V		RS485 with 3 100Base-T Ethernet, SFP with RJ-45
FACEPLATE/DISPLAY	3F		Vertical faceplate with keypad and English display
	3D		Vertical faceplate with keypad and French display
	3R		Vertical faceplate with keypad and Russian display
	3K		Vertical faceplate 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
DIGITAL INPUTS/OUTPUTS	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 digital 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 digital inputs
	6B		2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
	6C		8 Form-C outputs
	6D		16 digital inputs
	6E		4 Form-C outputs, 8 digital inputs
	6F		8 Fast Form-C outputs
	6G		4 Form-A (voltage with optional current) outputs, 8 digital inputs
	6H		6 Form-A (voltage with optional current) outputs, 4 digital 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 digital inputs
	6M		2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
	6N		4 Form-A (current with optional voltage) outputs, 8 digital inputs
	6P		6 Form-A (current with optional voltage) outputs, 4 digital inputs
	6R		2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs
	6S		2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
	6T		4 Form-A (no monitoring) outputs, 8 digital inputs
	6U		6 Form-A (no monitoring) outputs, 4 digital inputs
	6V		2 Form-A outputs, 1 Form-C output, 2 Form-A (no monitoring) latching outputs, 8 digital inputs
CT/VT MODULES (NOT AVAILABLE FOR THE C30)	8L		Standard 4CT/4VT with enhanced diagnostics
	8N		Standard 8CT with enhanced diagnostics
INTER-RELAY COMMUNICATIONS	2A		C37.94SM, 1300nm single-mode, ELED, 1 channel single-mode
	2B		C37.94SM, 1300nm 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
	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, multi-mode, LED, 1 Channel
	7B		1300 nm, multi-mode, 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, multi-mode
	7F		Channel 1 - G.703; Channel 2 - 1300 nm, multi-mode
	7G		Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
	7H		820 nm, multi-mode, LED, 2 Channels
	7I		1300 nm, multi-mode, 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, multi-mode, LED
	7M		Channel 1 - RS422; Channel 2 - 1300 nm, multi-mode, 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

2.2.1 INTER-RELAY COMMUNICATIONS

Dedicated inter-relay communications may 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. The fiber optic options include:
  - 820 nm multi-mode fiber with an LED transmitter
  - 1300 nm multi-mode 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 multi-mode 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 will provide 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 may operate as slave relays. All master relays in the scheme will be equal, and each will perform all functions. Each L30 relay in the scheme will determine 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 relay 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 relay 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 will then “broadcast” the direct transfer trip (DTT) signal to all other terminals.

The slave L30 Relay 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.

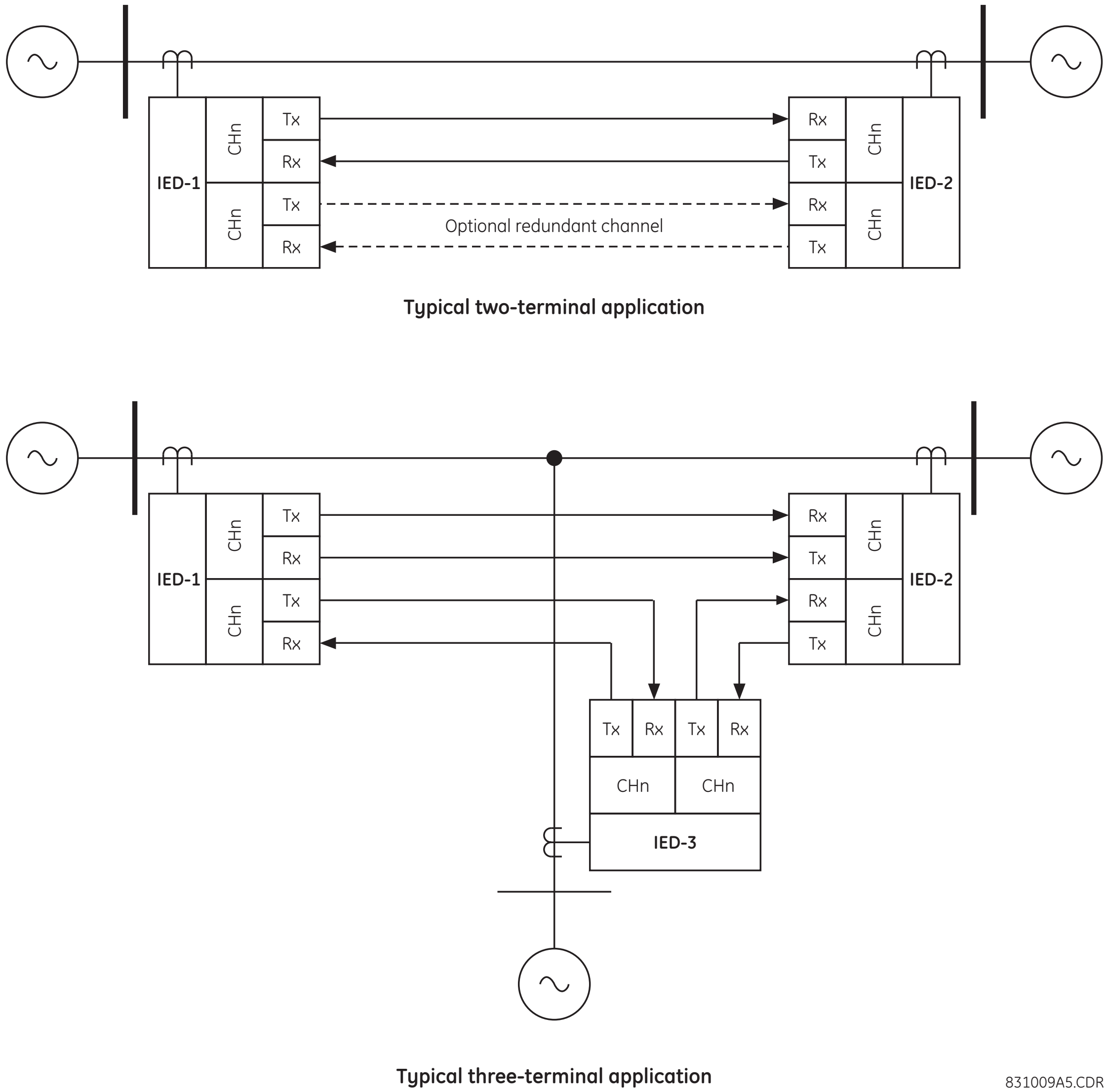

Figure 2–4: COMMUNICATIONS PATHS

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 will prevent 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 assigned an unique ID to prevent advertent 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 will 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 between the L30 relays at the line terminals using the pilot communications channel. The user may 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.

2.3.1 PROTECTION AND CONTROL FUNCTIONS

- **Current differential protection**: The current differential algorithms used in the L30 Line Current Differential System are based on the Fourier transform *phaselet* approach and an adaptive statistical restraint. The L30 uses per-phase differential at 64 kbps with two phaselets per cycle. A detailed description of the current differential algorithms is found in chapter 8. The current differential protection can be set in a percentage differential scheme with a single or dual slope.
- **Backup protection**: In addition to the primary current differential protection, the L30 Line Current Differential System incorporates backup functions that operate on the local relay current only, such as directional phase overcurrent, directional neutral overcurrent, negative-sequence overcurrent, undervoltage, overvoltage, and distance protection.
- **Multiple setting groups**: The relay can store six groups of settings. They may be selected by user command, a configurable contact input or a FlexLogic equation to allow the relay to respond to changing conditions.
- **User-programmable logic**: In addition to the built-in protection logic, the relay may be programmed by the user via FlexLogic equations.
- **Configurable inputs and outputs**: All of the contact converter inputs (digital inputs) to the relay may be assigned by the user to directly block a protection element, operate an output relay or serve as an input to FlexLogic equations. All of the outputs, except for the self test critical alarm contacts, may also be assigned by the user.

2.3.2 METERING AND MONITORING FUNCTIONS

- **Metering**: The relay measures all input currents and calculates both phasors and symmetrical components. When AC potential is applied to the relay via the optional voltage inputs, metering data includes phase and neutral current, phase voltage, three phase and per phase W, VA, and var, and power factor. Frequency is measured on either current or voltage inputs. They may be called onto the local display or accessed via a computer. All terminal current phasors and differential currents are also displayed at all relays, allowing the user opportunity to analyze correct polarization of currents at all terminals.
- **Event records**: The relay has a sequence of events recorder which combines the recording of snapshot data and oscillography data. Events consist of a broad range of change of state occurrences, including input contact changes, measuring-element pickup and operation, FlexLogic equation changes, and self-test status. The relay stores up to 1024 events with the date and time stamped to the nearest microsecond. This provides the information needed to determine a sequence of events, which can reduce troubleshooting time and simplify report generation after system events.
- **Oscillography**: The relay stores oscillography data at a sampling rate of 64 times per cycle. The relay can store a maximum of 64 records. Each oscillography file includes a sampled data report consisting of:
  - Instantaneous sample of the selected currents and voltages (if AC potential is used),
  - The status of each selected contact input.
  - The status of each selected contact output.
  - The status of each selected measuring function.
  - The status of various selected logic signals, including virtual inputs and outputs.

  The captured oscillography data files can be accessed via the remote communications ports on the relay.
- **CT failure and current unbalance alarm**: The relay has current unbalance alarm logic. The unbalance alarm may be supervised by a zero-sequence voltage detector. The user may block the relay from tripping when the current unbalance alarm operates.
- **Trip circuit monitor**: On those outputs designed for trip duty, a trip voltage monitor will continuously measure the DC voltage across output contacts to determine if the associated trip circuit is intact. If the voltage dips below the minimum voltage or the breaker fails to open or close after a trip command, an alarm can be activated.
- **Self-test**: The most comprehensive self testing of the relay is performed during a power-up. Because the system is not performing any protection activities at power-up, tests that would be disruptive to protection processing may be performed. The processors in the CPU and all CT/VT modules participate in startup self-testing. Self-testing checks approximately 85 to 90% of the hardware, and CRC/check-sum verification of all PROMs is performed. The proces-

sors communicate their results to each other so that if any failures are detected, they can be reported to the user. Each processor must successfully complete its self tests before the relay begins protection activities.

During both startup and normal operation, the CPU polls all plug-in modules and checks that every one answers the poll. The CPU compares the module types that identify themselves to the relay order code stored in memory and declares an alarm if a module is either non-responding or the wrong type for the specific slot. When running under normal power system conditions, the relay processors will have idle time. During this time, each processor performs background self-tests that are not disruptive to the foreground processing.

2.3.3 OTHER FUNCTIONS

a) ALARMS

The relay contains a dedicated alarm relay, the critical failure alarm, housed in the power supply module. This output relay is not user programmable. This relay has form-C contacts and is energized under normal operating conditions. The critical failure alarm will become de-energized if the relay self test algorithms detect a failure that would prevent the relay from properly protecting the transmission line.

b) LOCAL USER INTERFACE

The local user interface (on the faceplate) consists of a 2 × 20 liquid crystal display (LCD) and keypad. The keypad and display may be used to view data from the relay, to change settings in the relay, or to perform control actions. Also, the faceplate provides LED indications of status and events.

c) TIME SYNCHRONIZATION

The relay includes a clock which can run freely from the internal oscillator or be synchronized from an external IRIG-B signal. With the external signal, all relays wired to the same synchronizing signal will be synchronized to within 0.1 millisecond.

d) FUNCTION DIAGRAMS

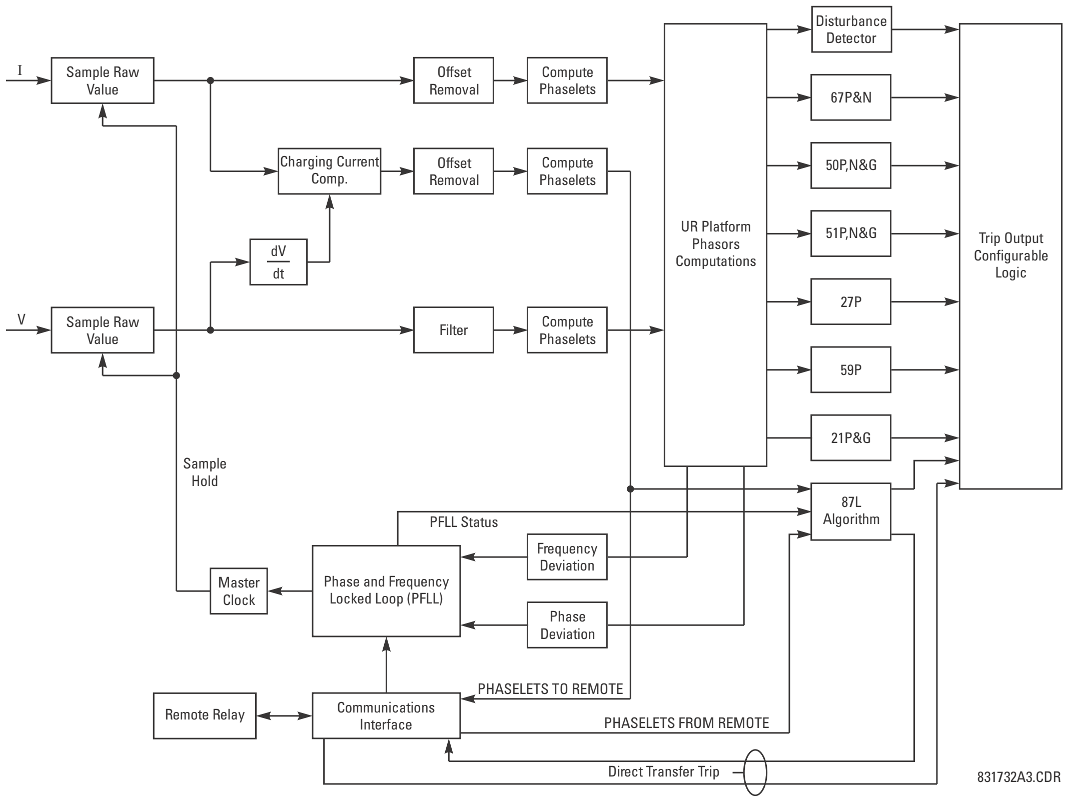

Figure 2–5: L30 BLOCK DIAGRAM

2.4.1 PROTECTION ELEMENTS

NOTE

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 IEDs or power system devices via communications or different output contacts. If not specified, operate times are given here for a 60 Hz system at nominal system frequency. Operate times for a 50 Hz system are 1.2 times longer.

LINE CURRENT DIFFERENTIAL (87L)

Application:	2 or 3 terminal line, series compensated line, tapped line, with charging current compensation
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%
Breakpoint between slopes:	0.0 to 20.0 pu in steps of 0.1
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
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

PHASE/NEUTRAL/GROUND TOC

Current:	Phasor or RMS
Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	97% to 98% of pickup
Level accuracy:	
for 0.1 to 2.0 × CT:	±0.5% of reading or ±0.4% of rated (whichever is greater)
for > 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^2t; 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 x pickup:	±3.5% of operate time or ±½ cycle (whichever is greater) from pickup to operate

PHASE/NEUTRAL/GROUND IOC

Pickup level:	0.000 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:	0.000 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 x CT rating ±1.5% of reading > 2.0 x 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^2t; 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 x pickup:	±3.5% of operate time or ±½ cycle (whichever is greater) from pickup to operate

NEGATIVE SEQUENCE IOC

Current:	Phasor
Pickup level:	0.000 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: 0.000 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: 0.000 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 (0.1s base curve)

Curve multiplier: Time dial = 0.00 to 600.00 in steps of 0.01

Curve timing accuracy

at <0.90 x pickup: ±3.5% of operate time or ±1/2 cycle (whichever is greater) from pickup to operate

AUXILIARY UNDERVOLTAGE

Pickup level: 0.000 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 x pickup: ±3.5% of operate time or ±1/2 cycle (whichever is greater) from pickup to operate

PHASE OVERVOLTAGE

Voltage: Phasor only

Pickup level: 0.000 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)

AUXILIARY OVERVOLTAGE

Pickup level: 0.000 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: 0.000 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: ±3% of operate time or ±20 ms, whichever is greater

Operate time: <30 ms at 1.10 × 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: ±3% of operate time or ±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, test method, etc., and may vary by ±0.5 cycles.

BREAKER FAILURE

Mode: 1-pole, 3-pole

Current supervision: phase, neutral current

Current supv. pickup: 0.001 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 × CT rating: ±0.75% of reading or ±2% of rated (whichever is greater)

above 2 × CT rating: ±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 kA2-cycle in steps of 1

Fault duration accuracy: 0.25 of a power cycle

Availability: 1 per CT bank with a minimum of 2

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)

AUTORECLOSURE

Single breaker applications, 3-pole tripping schemes

Up to 4 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

2.4.2 USER-PROGRAMMABLE ELEMENTS

FLEXLOGIC

Programming language: Reverse Polish Notation with graphical visualization (keypad programmable)

Lines of code: 512

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

LED TEST

Initiation: from any digital 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

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 & 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

Number: 48 plus trip and alarm

Programmability: from any logical variable, contact, or virtual input

Reset mode: self-reset or latched

USER-DEFINABLE DISPLAYS

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

Number of pushbuttons: 7
Operation: drive FlexLogic operands

USER-PROGRAMMABLE PUSHBUTTONS (OPTIONAL)

Number of pushbuttons: 12 (standard faceplate); 16 (enhanced faceplate)
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

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2.4.3 MONITORING

OSCILLOGRAPHY

Maximum records: 64
Sampling rate: 64 samples per power cycle
Triggers: any element pickup, dropout, or operate; digital input change of state; digital output change of state; FlexLogic equation
Data: AC input channels; element state; digital input state; digital 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; digital input change of state; digital 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 bank
Method: 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
$METHOD_{\%error}$ + see chapter 8
$RELAY\ ACCURACY_{\%error}$ + (1.5%)

PHASOR MEASUREMENT UNIT

Output format:	per IEEE C37.118 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 specifications sections
Network reporting format:	16-bit integer (for C37.118) or 32-bit IEEE floating point numbers
Network reporting style:	rectangular (real and imaginary for C37.188) or polar (magnitude and angle) coordinates
Post-filtering:	none, 3-point, 5-point, 7-point
Calibration:	±5° (angle) and ±5% (magnitude)

2.4.4 METERING

RMS CURRENT: PHASE, NEUTRAL, AND GROUND

Accuracy at	
0.1 to 2.0 × CT rating:	±0.25% of reading or ±0.1% of rated (whichever is greater)
> 2.0 × CT rating:	±1.0% of reading

RMS VOLTAGE

Accuracy:	±0.5% of reading from 10 to 208 V

REAL POWER (WATTS)

Accuracy at 0.1 to 1.5 x CT rating and 0.8 to 1.2 x VT rating:	±1.0% of reading at –1.0 ≤ PF< –0.8 and 0.8 < PF ≤ 10

REACTIVE POWER (VARS)

Accuracy at 0.1 to 1.5 x CT rating and 0.8 to 1.2 x VT rating:	±1.0% of reading at –0.2 ≤ PF ≤ 0.2

APPARENT POWER (VA)

Accuracy at 0.1 to 1.5 x CT rating and 0.8 to 1.2 x VT rating:	±1.0% of reading

FREQUENCY

Accuracy at	
V = 0.8 to 1.2 pu:	±0.01 Hz (when voltage signal is used for frequency measurement)
I = 0.1 to 0.25 pu:	±0.05 Hz
I > 0.25 pu:	±0.02 Hz (when current signal is used for frequency measurement)

2.4.5 INPUTS

AC CURRENT

CT rated primary:	1 to 50000 A
CT rated secondary:	1 A 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 4xInom; URs equipped with 24 CT inputs have a maximum operating temp. of 50°C
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: 3 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: 3 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 & 120 Ω Nickel, 10 Ω Copper
Sensing current: 5 mA
Range: –50 to +250°C
Accuracy: ±2°C
Isolation: 36 V pk-pk

IRIG-B INPUT

Amplitude modulation: 1 to 10 V pk-pk
DC shift: TTL–Compatible
Input impedance: 50 kΩ
Isolation: 2 kV

REMOTE INPUTS (IEC 61850 GSSE/GOOSE)

Input points: 32, configured from 64 incoming bit pairs
Remote devices: 16
Default states on loss of comms.: On, Off, Latest/Off, Latest/On
Remote DPS inputs: 5

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2.4.6 POWER SUPPLY

LOW RANGE

Nominal DC voltage: 24 to 48 V
Minimum DC voltage: 20 V
Maximum DC voltage: 60 V
Voltage loss hold-up: 20 ms duration at nominal
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 nominal

ALL RANGES

Volt withstand: 2 × Highest Nominal Voltage for 10 ms
Power consumption: typical = 15 to 20 W/VA
maximum = 50 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

2.4.7 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 KΩ	50 KΩ
120 V DC	5 KΩ	2 KΩ
48 V DC	2 KΩ	2 KΩ
24 V DC	2 KΩ	2 KΩ

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 μs

Maximum voltage: 265 V DC

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:

	UL508	Utility application (autoreclose scheme)	Industrial application
Operations/ interval	5000 ops / 1 s-On, 9 s-Off	5 ops / 0.2 s-On, 0.2 s-Off within 1 minute	10000 ops / 0.2 s-On, 30 s-Off
	1000 ops / 0.5 s-On, 0.5 s-Off		
Break capability (0 to 250 V DC)	3.2 A L/R = 10 ms	10 A L/R = 40 ms	10 A L/R = 40 ms
	1.6 A 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: ±300 Vpk

REMOTE OUTPUTS (IEC 61850 GSSE/GOOSE)

Standard output points: 32

User output points: 32

DCMA OUTPUTS

Range: –1 to 1 mA, 0 to 1 mA, 4 to 20 mA

Max. load resistance: 12 kΩ for –1 to 1 mA range
12 kΩ for 0 to 1 mA range
600 Ω for 4 to 20 mA range

Accuracy: ±0.75% of full-scale for 0 to 1 mA range
±0.5% of full-scale for –1 to 1 mA range
±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 pu in steps of 0.001

2.4.8 COMMUNICATIONS

RS232

Front port: 19.2 kbps, Modbus RTU

RS485

1 rear port: Up to 115 kbps, Modbus RTU, isolated together at 36 Vpk

Typical distance: 1200 m

Isolation: 2 kV

ETHERNET (FIBER)

PARAMETER	FIBER TYPE
	100MB MULTI-MODE
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
Duplex	full/half
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

2.4.9 INTER-RELAY COMMUNICATIONS

SHIELDED TWISTED-PAIR INTERFACE OPTIONS

INTERFACE TYPE	TYPICAL DISTANCE
RS422	1200 m
G.703	100 m

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

LINK POWER BUDGET

EMITTER, FIBER TYPE	TRANSMIT POWER	RECEIVED SENSITIVITY	POWER BUDGET
820 nm LED, Multimode	–20 dBm	–30 dBm	10 dB
1300 nm LED, Multimode	–21 dBm	–30 dBm	9 dB
1300 nm ELED, Singlemode	–23 dBm	–32 dBm	9 dB
1300 nm Laser, Singlemode	–1 dBm	–30 dBm	29 dB
1550 nm Laser, Singlemode	+5 dBm	–30 dBm	35 dB

NOTE: These 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 1dB / 5°C.

MAXIMUM OPTICAL INPUT POWER

EMITTER, FIBER TYPE	MAX. OPTICAL INPUT POWER
820 nm LED, Multimode	–7.6 dBm
1300 nm LED, Multimode	–11 dBm
1300 nm ELED, Singlemode	–14 dBm
1300 nm Laser, Singlemode	–14 dBm
1550 nm Laser, Singlemode	–14 dBm

TYPICAL LINK DISTANCE

EMITTER TYPE	CABLE TYPE	CONNECTOR TYPE	TYPICAL DISTANCE
820 nm LED, multimode	62.5/125 µm	ST	1.65 km
1300 nm LED, multimode	62.5/125 µm	ST	3.8 km
1300 nm ELED, single mode	9/125 µm	ST	11.4 km
1300 nm Laser, single mode	9/125 µm	ST	64 km
1550 nm Laser, single-mode	9/125 µm	ST	105 km

NOTE

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 may vary.

CONNECTOR LOSSES (TOTAL OF BOTH ENDS)

ST connector 2 dB

FIBER LOSSES

820 nm multimode	3 dB/km
1300 nm multimode	1 dB/km
1300 nm singlemode	0.35 dB/km
1550 nm singlemode	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

2.4.10 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

2.4.11 TYPE TESTS

L30 TYPE TESTS

TEST	REFERENCE STANDARD	TEST LEVEL
Dielectric voltage withstand	EN60255-5	2.2 kV
Impulse voltage withstand	EN60255-5	5 kV
Damped oscillatory	IEC61000-4-18 / IEC60255-22-1	2.5 kV CM, 1 kV DM
Electrostatic discharge	EN61000-4-2 / IEC60255-22-2	Level 3
RF immunity	EN61000-4-3 / IEC60255-22-3	Level 3
Fast transient disturbance	EN61000-4-4 / IEC60255-22-4	Class A and B
Surge immunity	EN61000-4-5 / IEC60255-22-5	Level 3 and 4
Conducted RF immunity	EN61000-4-6 / IEC60255-22-6	Level 3
Power frequency immunity	EN61000-4-7 / IEC60255-22-7	Class A and B
Voltage interruption and ripple DC	IEC60255-11	12% ripple, 200 ms interrupts
Radiated and conducted emissions	CISPR11 / CISPR22 / IEC60255-25	Class A
Sinusoidal vibration	IEC60255-21-1	Class 1
Shock and bump	IEC60255-21-2	Class 1
Seismic	IEC60255-21-3	Class 1
Power magnetic immunity	IEC61000-4-8	Level 5
Pulse magnetic immunity	IEC61000-4-9	Level 4
Damped magnetic immunity	IEC61000-4-10	Level 4
Voltage dip and interruption	IEC61000-4-11	0, 40, 70, 80% dips; 250 / 300 cycle interrupts
Damped oscillatory	IEC61000-4-12	2.5 kV CM, 1 kV DM
Conducted RF immunity, 0 to 150 kHz	IEC61000-4-16	Level 4
Voltage ripple	IEC61000-4-17	15% ripple
Ingress protection	IEC60529	IP40 front, IP10 back
Cold	IEC60068-2-1	–40°C for 16 hours
Hot	IEC60068-2-2	85°C for 16 hours
Humidity	IEC60068-2-30	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	UL508	e83849 NKCR
Safety	UL C22.2-14	e83849 NKCR7
Safety	UL1053	e83849 NKCR

2.4.12 PRODUCTION TESTS

THERMAL

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

2.4.13 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

2.4.14 MAINTENANCE

MOUNTING

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

CLEANING

Normally, cleaning is not required; but for situations where dust has accumulated on the faceplate display, a dry cloth can be used.

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.

3.1.1 PANEL CUTOUT

a) HORIZONTAL UNITS

The L30 Line Current Differential System is available as a 19-inch rack horizontal mount unit with a removable faceplate. The faceplate can be specified as either standard or enhanced at the time of ordering. The enhanced faceplate contains additional user-programmable pushbuttons and LED indicators.

The modular design allows the relay to be easily upgraded or repaired by a qualified service person. The faceplate is hinged to allow easy access to the removable modules, and is itself removable to allow mounting on doors with limited rear depth.

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

The relay must be mounted such that the faceplate sits semi-flush with the panel or switchgear door, allowing the operator access to the keypad and the RS232 communications port. The relay is secured to the panel with the use of four screws supplied with the relay.

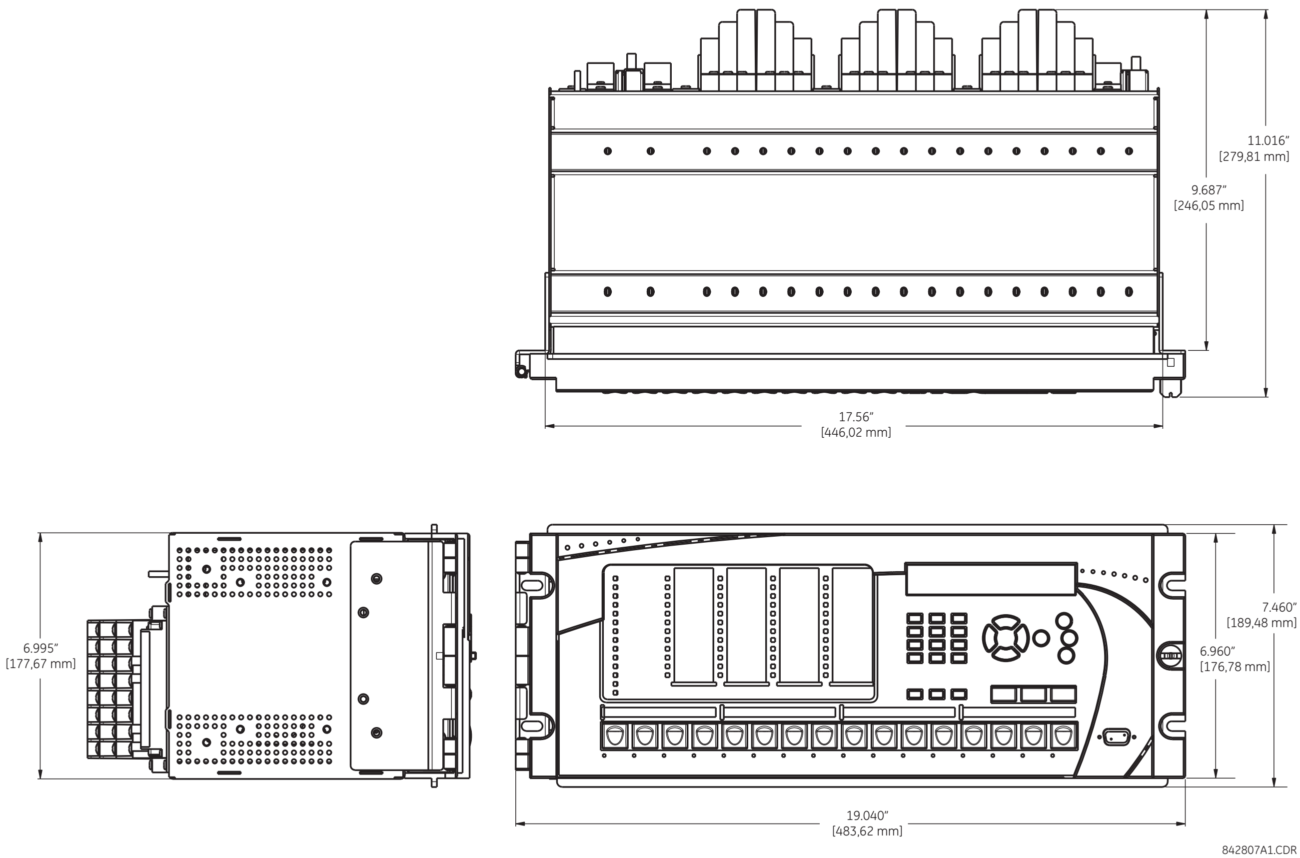


Figure 3–1: L30 HORIZONTAL DIMENSIONS (ENHANCED PANEL)

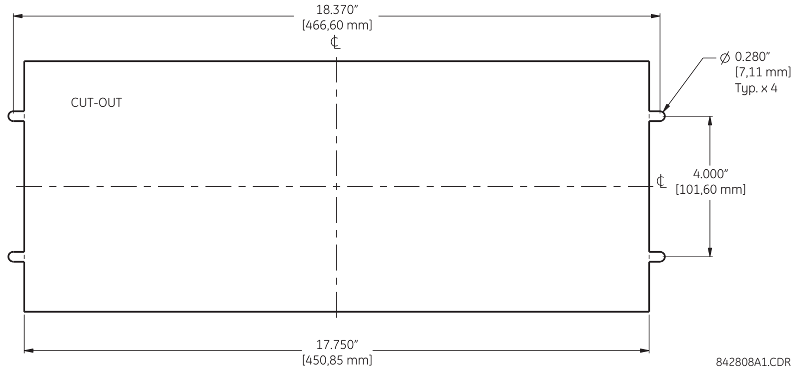


Figure 3–2: L30 HORIZONTAL MOUNTING (ENHANCED PANEL)

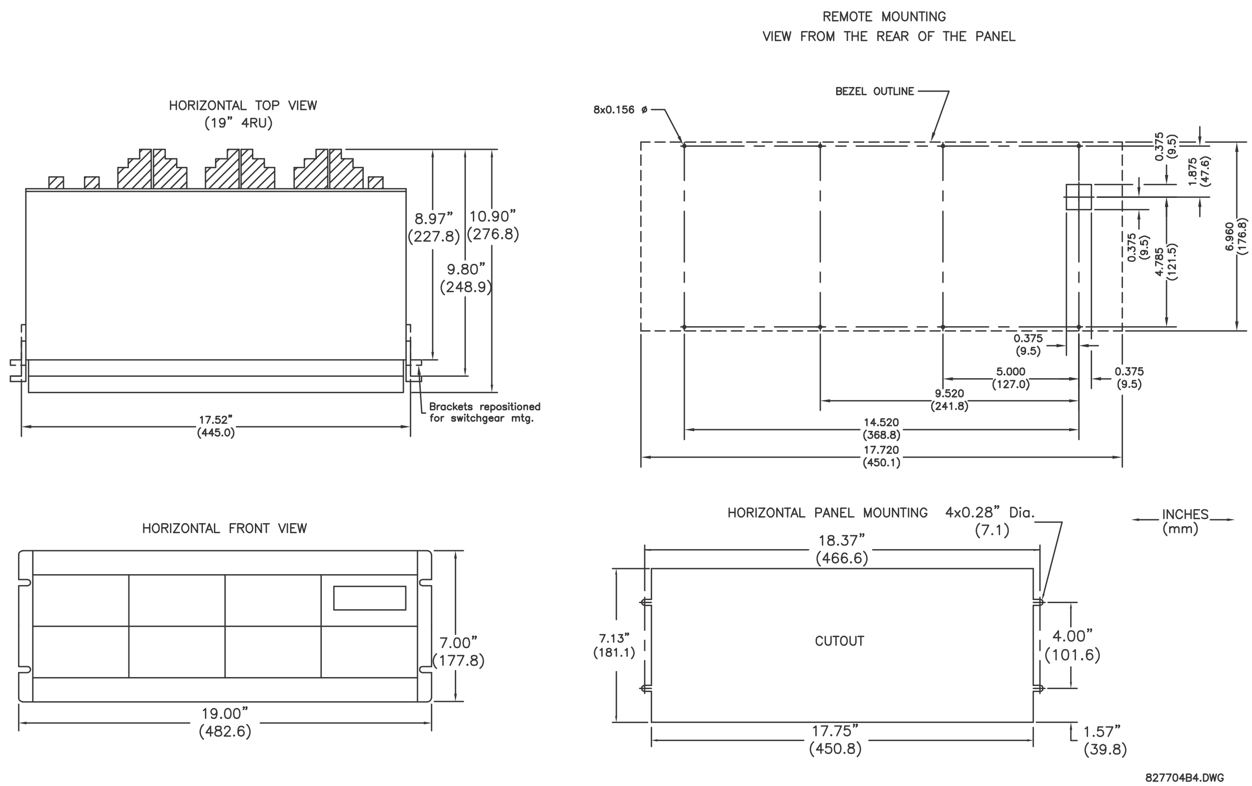


Figure 3–3: L30 HORIZONTAL MOUNTING AND DIMENSIONS (STANDARD PANEL)

b) VERTICAL UNITS

The L30 Line Current Differential System is available as a reduced size (¾) vertical mount unit, with a removable faceplate. The faceplate can be specified as either standard or enhanced at the time of ordering. The enhanced faceplate contains additional user-programmable pushbuttons and LED indicators.

The modular design allows the relay to be easily upgraded or repaired by a qualified service person. The faceplate is hinged to allow easy access to the removable modules, and is itself removable to allow mounting on doors with limited rear depth.

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

The relay must be mounted such that the faceplate sits semi-flush with the panel or switchgear door, allowing the operator access to the keypad and the RS232 communications port. The relay is secured to the panel with the use of four screws supplied with the relay.

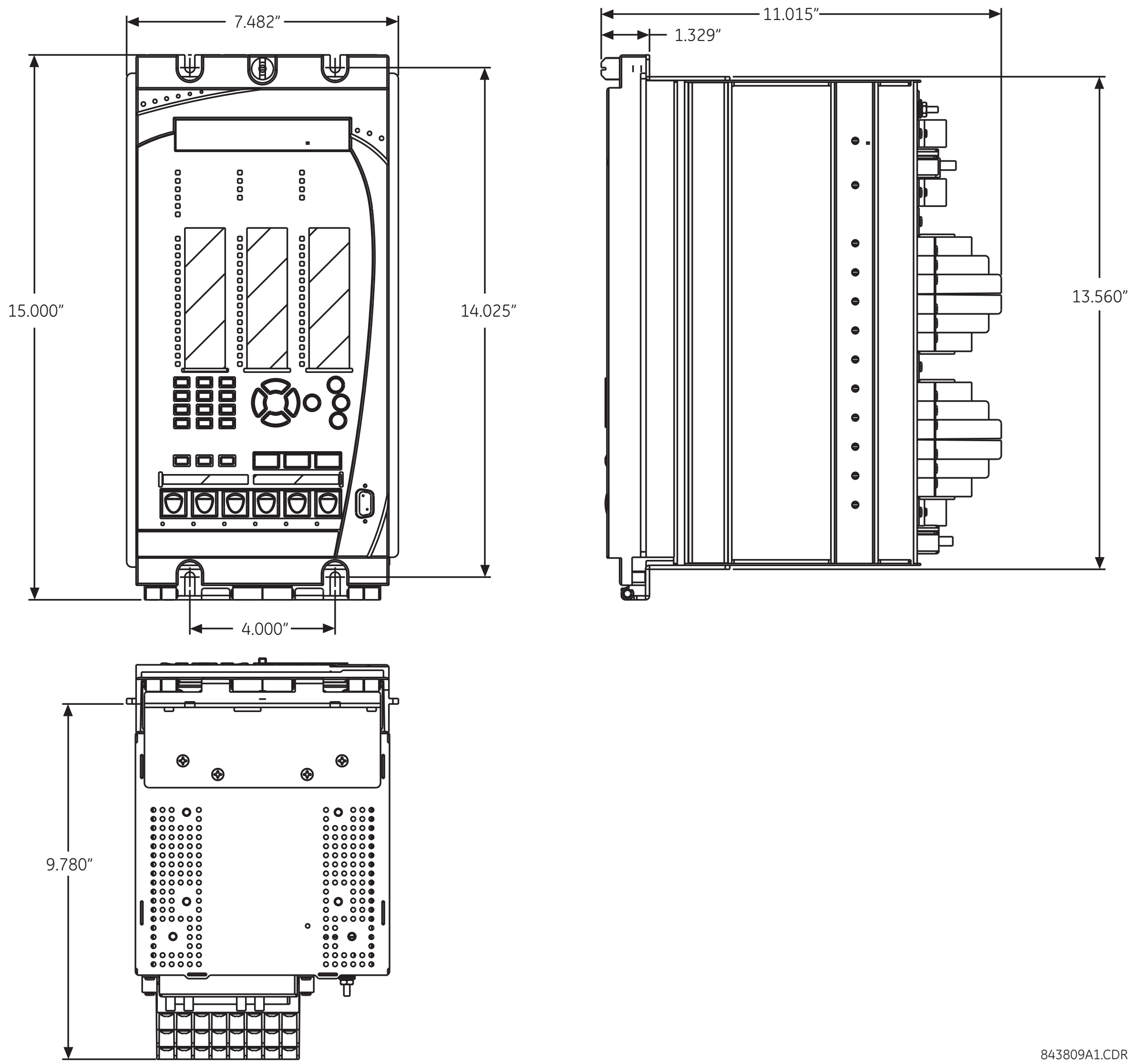


Figure 3–4: L30 VERTICAL DIMENSIONS (ENHANCED PANEL)

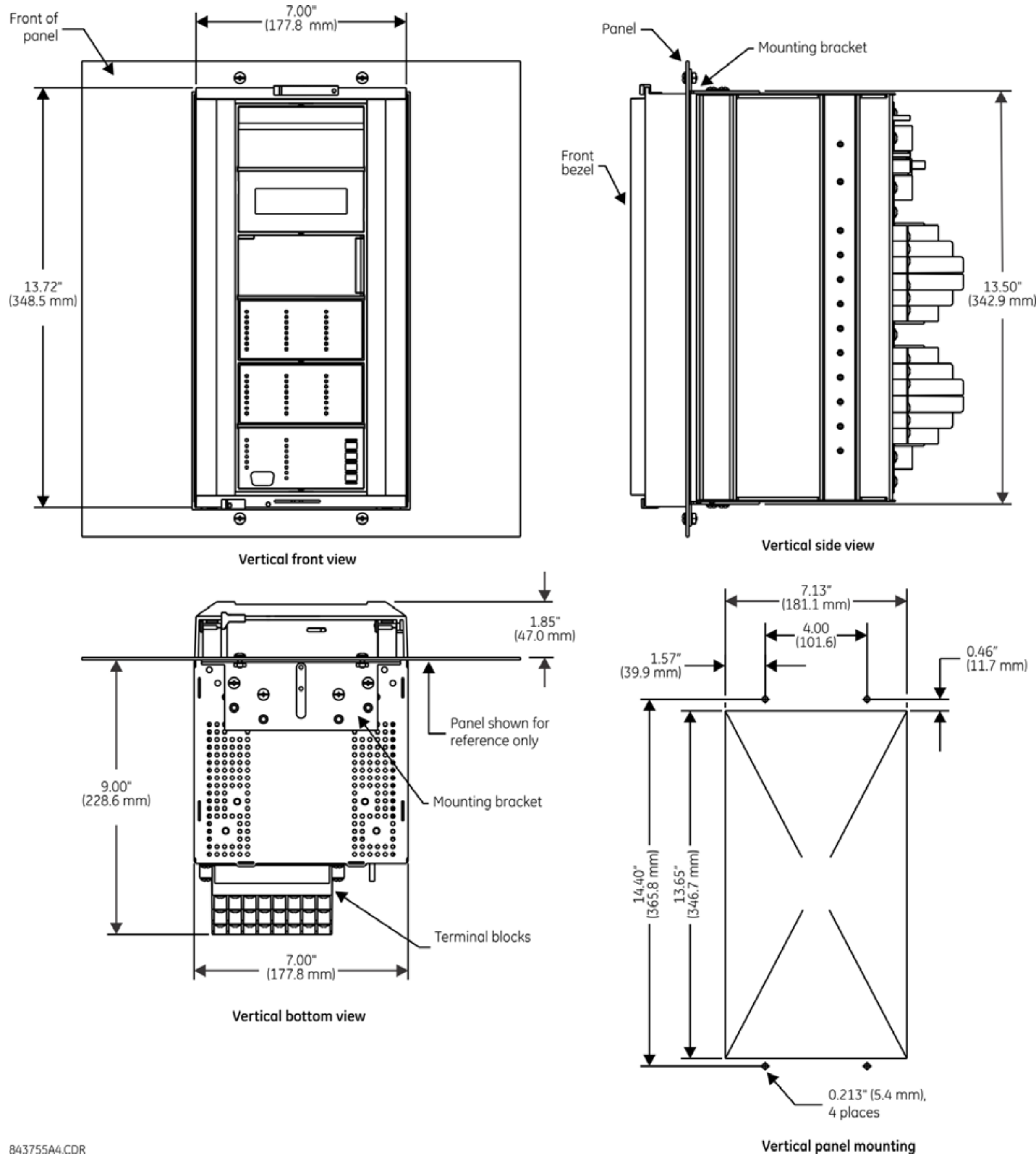


Figure 3–5: L30 VERTICAL MOUNTING AND DIMENSIONS (STANDARD PANEL)

For details on side mounting L30 devices with the enhanced front panel, refer to the following documents available online from the GE Multilin website.

- GEK-113180: UR-series UR-V side-mounting front panel assembly instructions.
- GEK-113181: Connecting the side-mounted UR-V enhanced front panel to a vertical UR-series device.
- GEK-113182: Connecting the side-mounted UR-V enhanced front panel to a vertically-mounted horizontal UR-series device.

For details on side mounting L30 devices with the standard front panel, refer to the figures below.

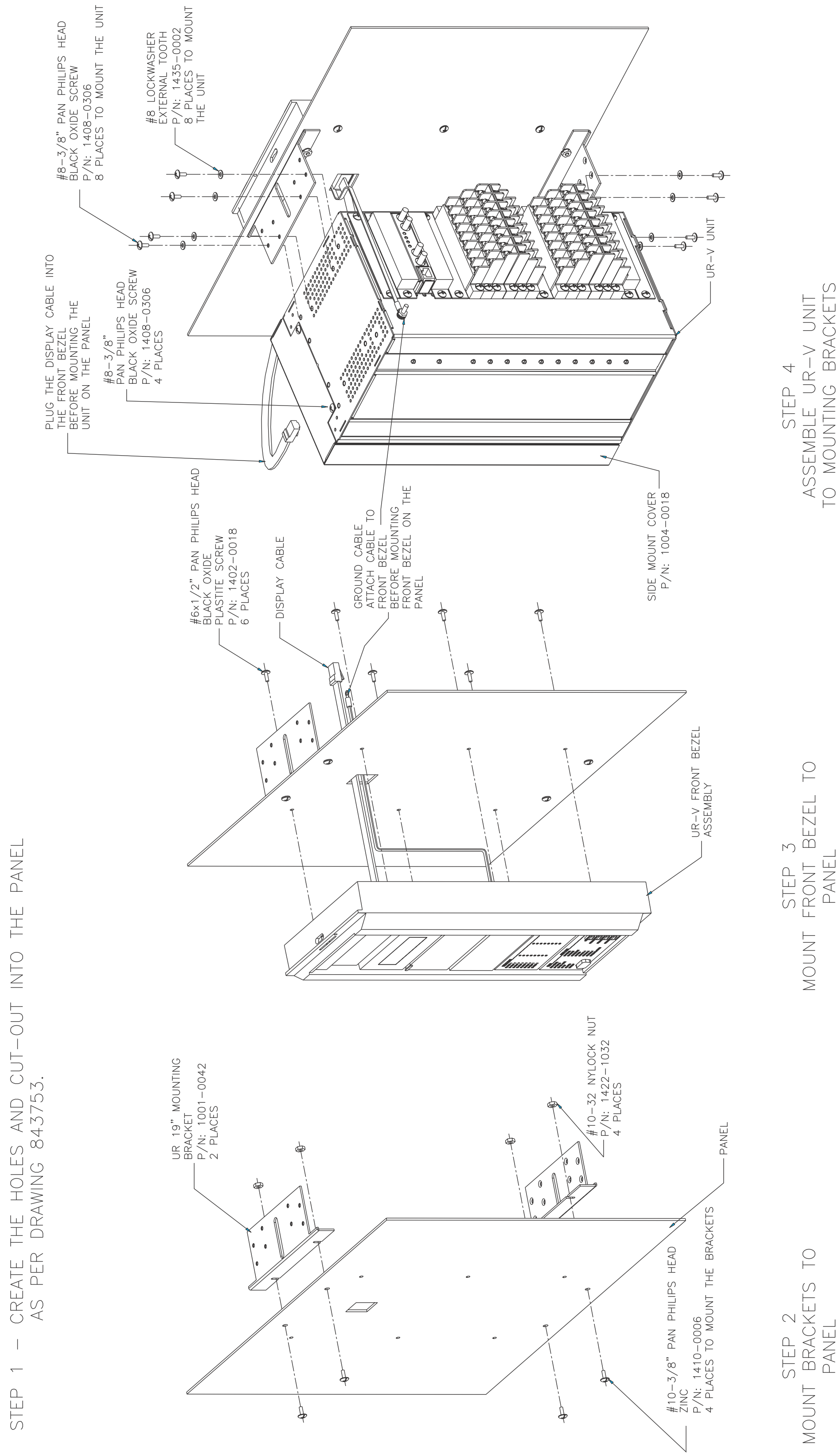


Figure 3–6: L30 VERTICAL SIDE MOUNTING INSTALLATION (STANDARD PANEL)

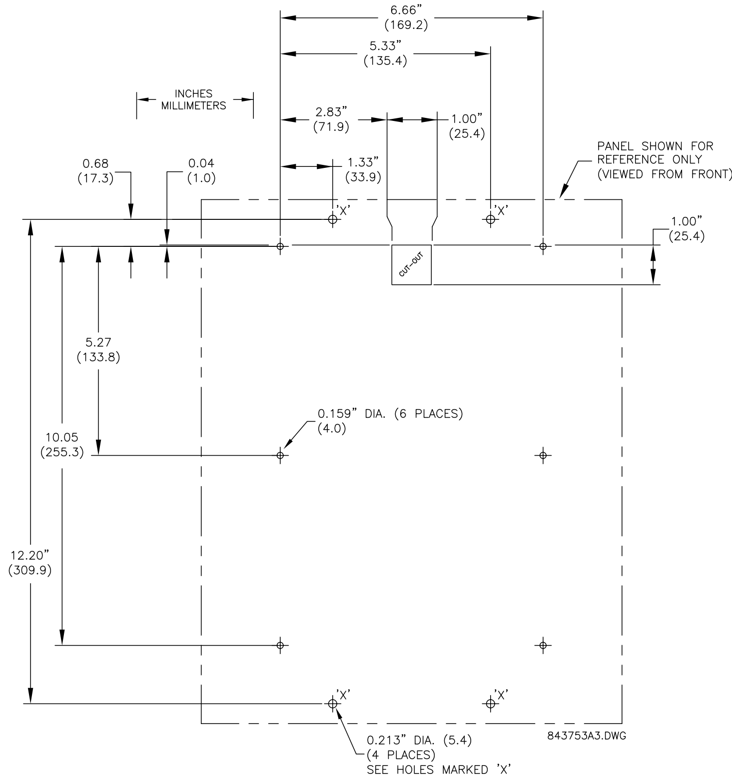


Figure 3–7: L30 VERTICAL SIDE MOUNTING REAR DIMENSIONS (STANDARD PANEL)

3.1.2 REAR TERMINAL LAYOUT

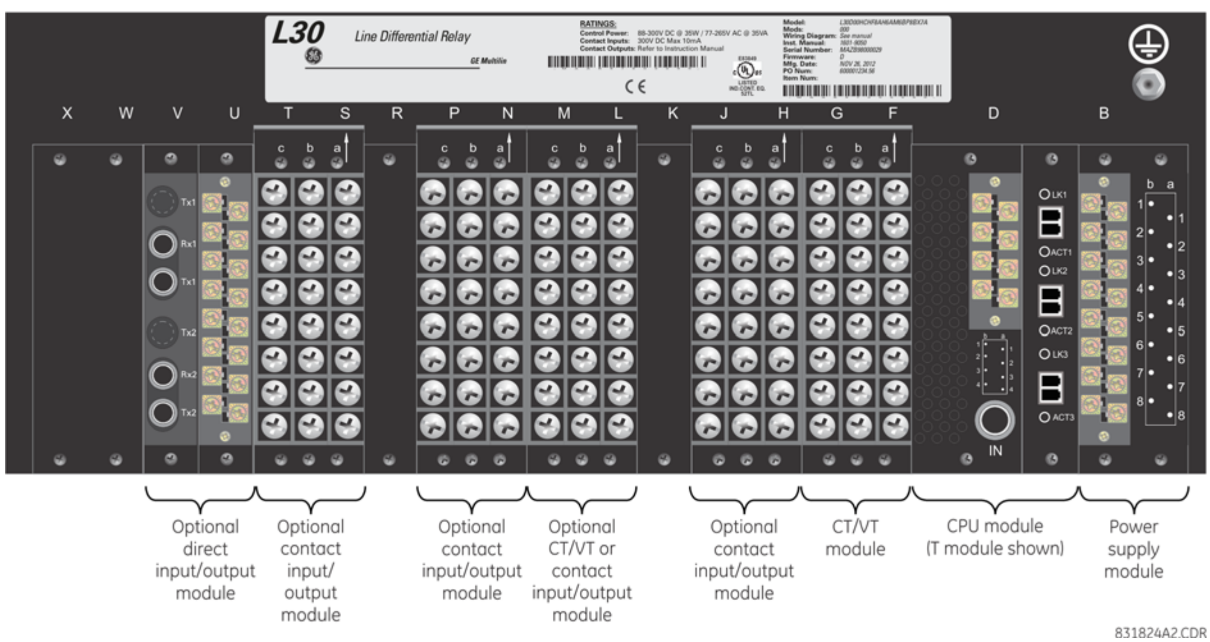


Figure 3–8: REAR TERMINAL VIEW

WARNING **Do not touch any rear terminals while the relay is energized.**

NOTICE The small form-factor pluggable ports (SFPs) are pluggable transceivers. Do not use non-validated transceivers or install validated transceivers in the wrong Ethernet slot, else damage can occur.

The relay follows a convention with respect to terminal number assignments which are three characters long assigned in order 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) which is indicated by an arrow marker on the terminal block. See the following figure for an example of rear terminal assignments.

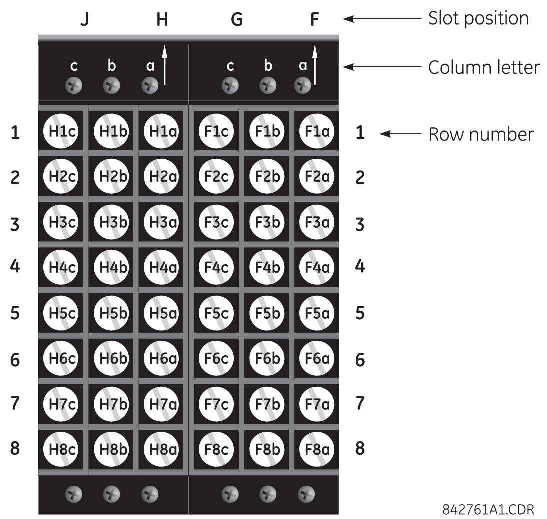


Figure 3–9: EXAMPLE OF MODULES IN F AND H SLOTS

3.2.1 TYPICAL WIRING

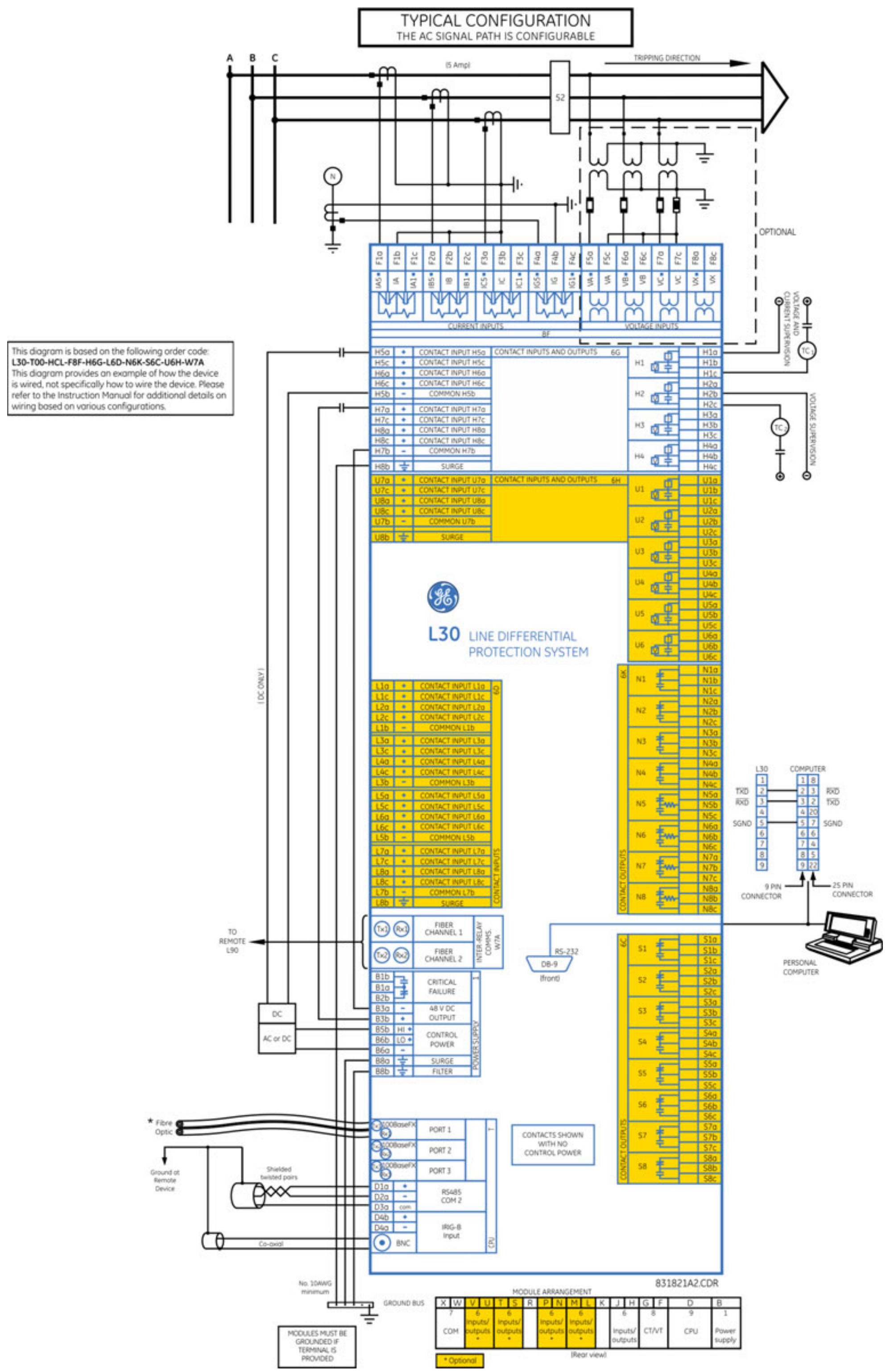


Figure 3–10: TYPICAL WIRING DIAGRAM (T MODULE SHOWN FOR CPU)

3.2.2 DIELECTRIC STRENGTH

The dielectric strength of the UR-series module hardware is shown in the following table:

Table 3–1: DIELECTRIC STRENGTH OF UR-SERIES MODULE HARDWARE

MODULE TYPE	MODULE FUNCTION	TERMINALS		DIELECTRIC STRENGTH (AC)
		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	Reserved	N/A	N/A	N/A
5	Analog inputs/outputs	All except 8b	Chassis	< 50 V DC
6	Digital 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 a period longer than the specified one minute.

3.2.3 CONTROL POWER

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

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

The power supply module can be ordered for two possible voltage ranges, with or without a redundant power option. Each range has a dedicated input connection for proper operation. The ranges are as shown below (see the *Technical specifications* section of chapter 2 for additional 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 on-going self-test diagnostic checks detect a critical failure (see the *Self-test errors* section in chapter 7) or control power is lost, the relay is de-energize.

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 become 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 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:

LED INDICATION	POWER SUPPLY
CONTINUOUS ON	OK
ON / OFF CYCLING	Failure
OFF	Failure

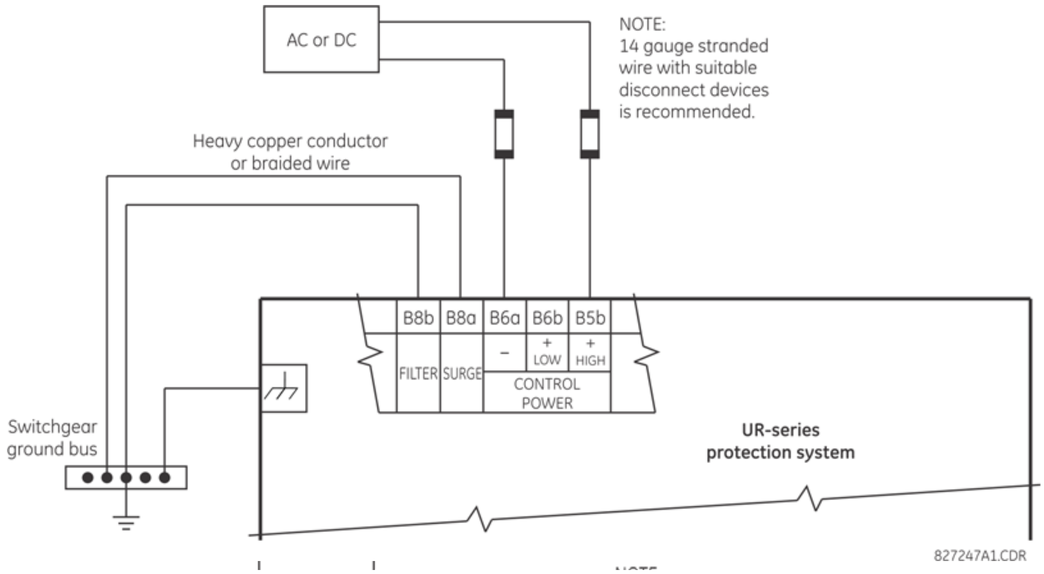


Figure 3–11: CONTROL POWER CONNECTION

3.2.4 CT AND VT MODULES

A CT/VT module can have 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 labeled 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 channel 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 nominal current of 1 A or 5 A matches the secondary rating of the connected CTs. Unmatched CTs may result in equipment damage or inadequate protection.

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 may be used.

The above modules are available with enhanced diagnostics. These modules 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 below. Twisted-pair cabling on the zero-sequence CT is recommended.

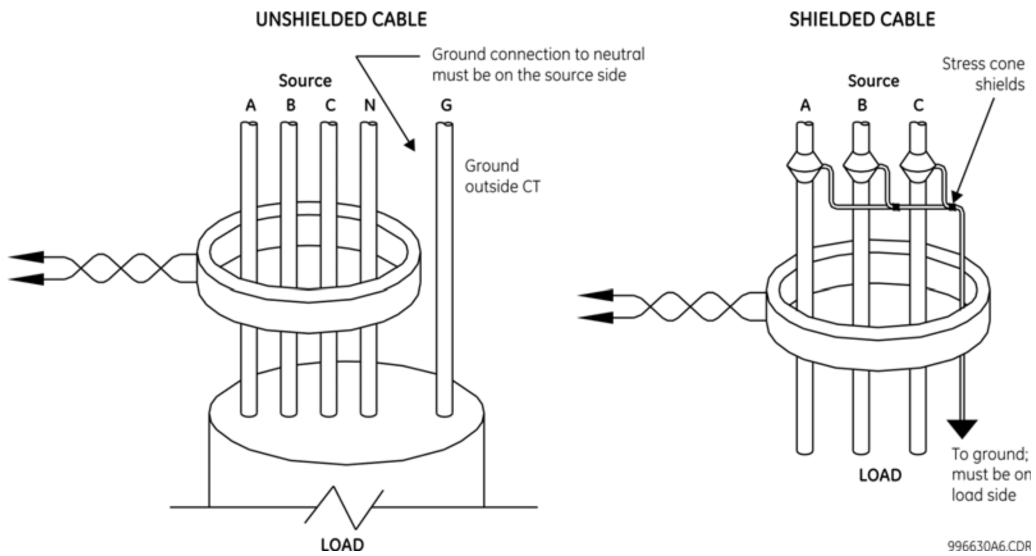


Figure 3–12: ZERO-SEQUENCE CORE BALANCE CT INSTALLATION

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.

NOTE: Substitute the tilde “~” symbol with the slot position of the module in the following figure.

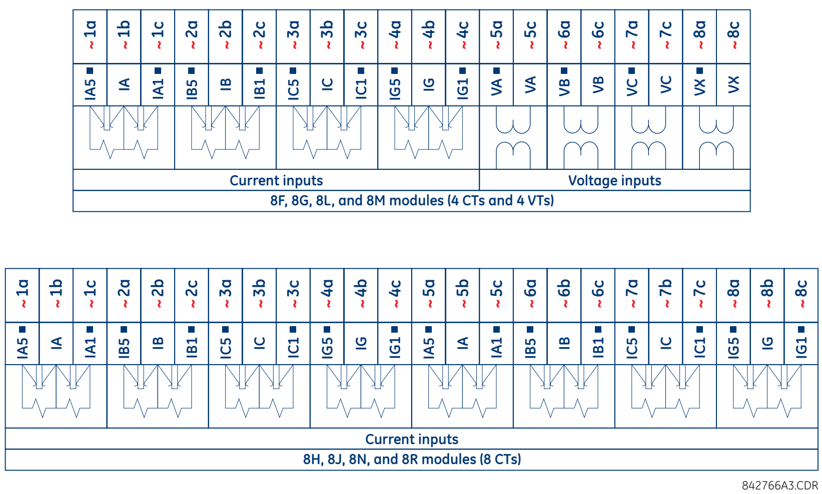


Figure 3–13: CT/VT MODULE WIRING

3.2.5 PROCESS BUS MODULES

The L30 can be ordered with a process bus interface module. This module is designed to interface with the GE Multilin HardFiber system, allowing bidirectional IEC 61850 fiber optic communications with up to eight HardFiber merging units, known as Bricks. The HardFiber system has been designed to integrate seamlessly with the existing UR-series applications, including protection functions, FlexLogic, metering, and communications.

The IEC 61850 process bus system offers the following benefits:

- Reduces labor associated with design, installation, and testing of protection and control applications using the L30 by reducing the number of individual copper terminations
- Integrates seamlessly with existing L30 applications, since the IEC 61850 process bus interface module replaces the traditional CT/VT modules
- Communicates using open standard IEC 61850 messaging

For additional details on the HardFiber system, see GE publication GEK-113658: HardFiber Process Bus System Instruction Manual.

3.2.6 CONTACT INPUTS AND OUTPUTS

Every contact input/output module has 24 terminal connections. They are arranged 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 L30 has two versions of grouping: four inputs per common return and two inputs per common return. When a contact input/output module is ordered, four inputs per common is used. The four inputs per common allows for high-density inputs in combination with outputs, with a compromise of four inputs sharing one common. If the inputs must be isolated per row, then two inputs per common return should be selected (4D module).

The tables and diagrams on the following pages illustrate the module types (6A, etc.) 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 the current is above about 1 to 2.5 mA, and the current monitor is set to “On = 1” when the current 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.

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.

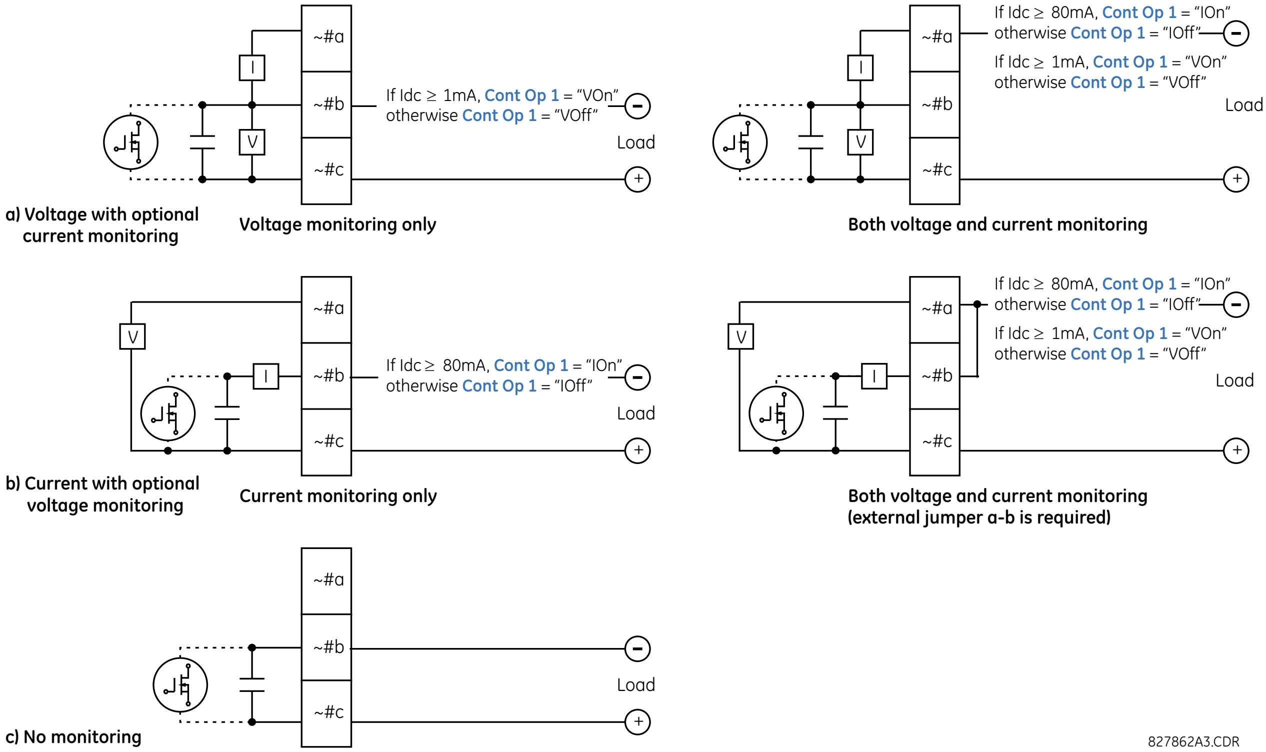


Figure 3–14: FORM-A AND SOLID-STATE CONTACT OUTPUTS WITH VOLTAGE AND CURRENT MONITORING

The operation of voltage and current monitors is reflected with the corresponding FlexLogic operands (CONT OP # VON, CONT OP # VOFF, and CONT OP # ION) which 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.

Refer to 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.

⚠WARNING **Consider relay contacts unsafe to touch when the unit is energized. If the relay contacts need to be used for low voltage accessible applications, ensure proper insulation levels.**

NOTE

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 may 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.

NOTE

Wherever a tilde "~" symbol appears, substitute with the slot position of the module; wherever 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, the FlexLogic operand driving the contact output should be given 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).

3

Table 3–2: 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
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6F MODULE	
TERMINAL ASSIGNMENT	OUTPUT
~1	Fast Form-C
~2	Fast Form-C
~3	Fast Form-C
~4	Fast Form-C
~5	Fast Form-C
~6	Fast Form-C
~7	Fast Form-C
~8	Fast Form-C

~6G 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

~6H 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

~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

~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 3–15: CONTACT INPUT AND OUTPUT MODULE WIRING (1 of 2)

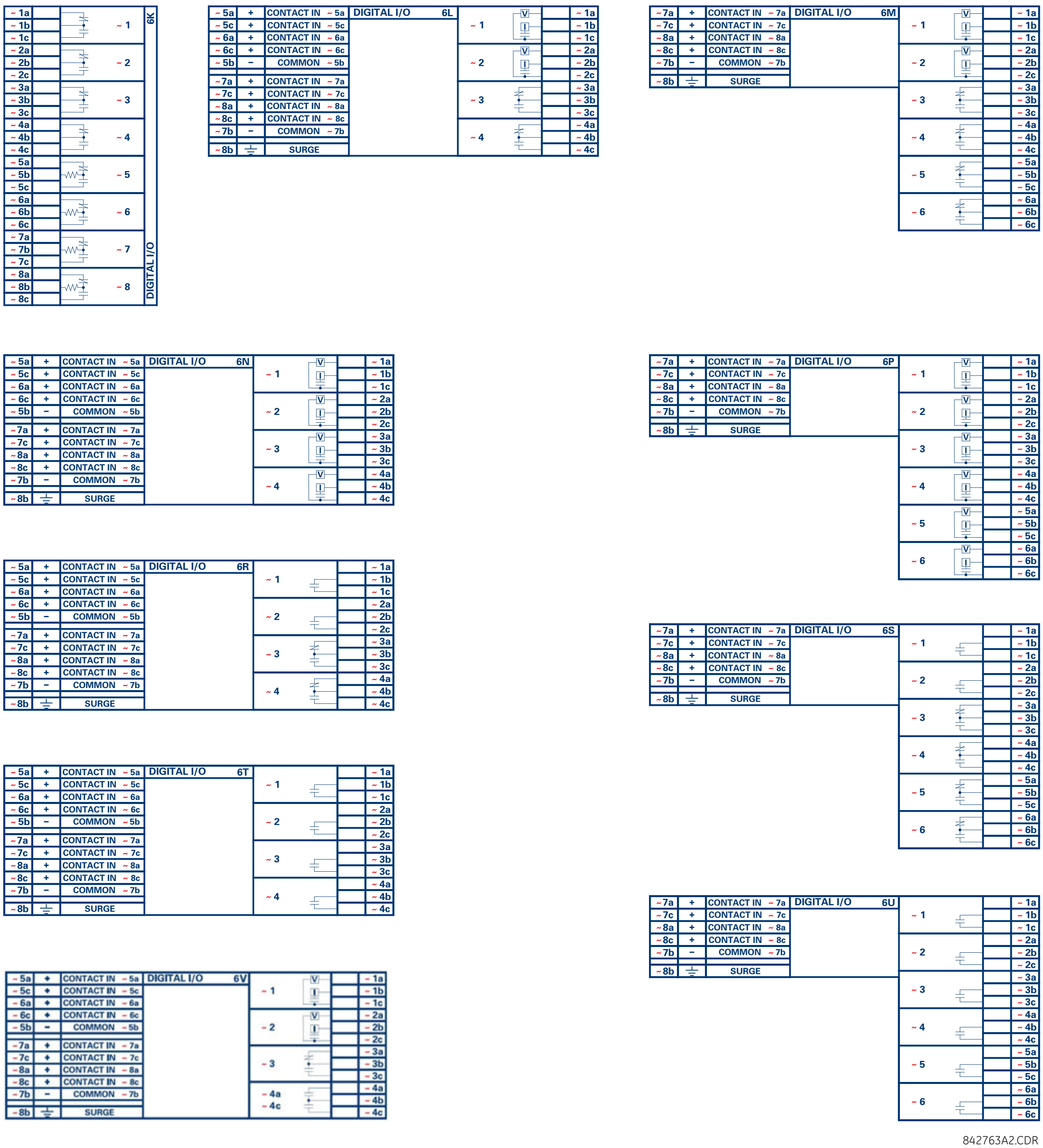


Figure 3–16: CONTACT INPUT AND OUTPUT MODULE WIRING (2 of 2)

NOTICE For proper functionality, observe correct polarity for all contact input and solid state output connections.

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 which 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.

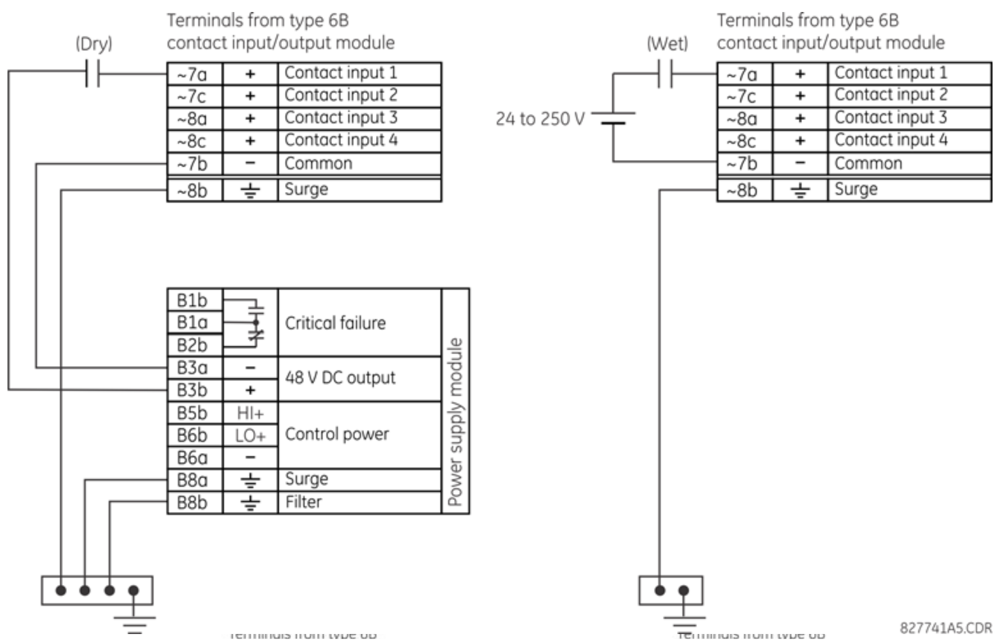


Figure 3–17: DRY AND WET CONTACT INPUT CONNECTIONS

NOTE: Wherever a tilde “~” symbol appears, substitute with the slot position of the module.

Contact outputs can be ordered as form-A or form-C. The form-A contacts can be connected for external circuit supervision. These contacts are provided with voltage and current monitoring circuits used to detect the loss of DC voltage in the circuit, and the presence of DC current flowing through the contacts when the form-A contact closes. 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.

NOTE: 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.

USE OF CONTACT INPUTS WITH AUTO-BURNISHING

The contact inputs sense a change of the 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 the 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 5 second delay after a contact input changes state.

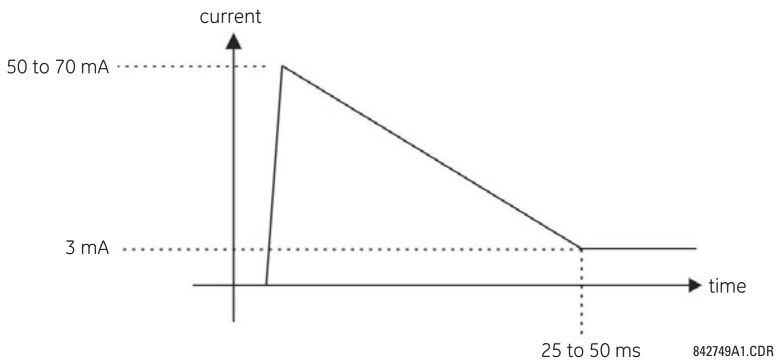


Figure 3–18: CURRENT THROUGH CONTACT INPUTS WITH AUTO-BURNISHING

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 was sensed. Then, within 25 to 50 ms, this current is slowly reduced to 3 mA as indicated above. 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 (refer to 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.

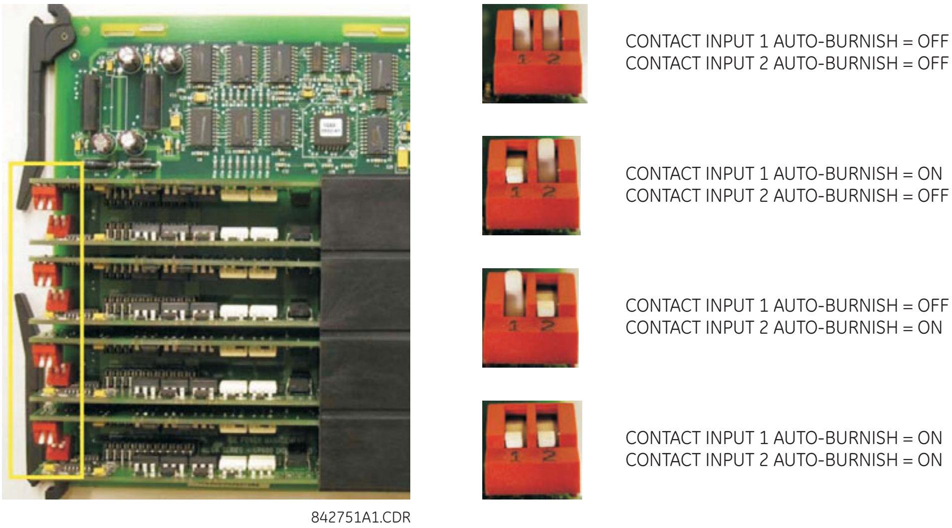


Figure 3–19: AUTO-BURNISH DIP SWITCHES

NOTE

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

3.2.7 TRANSDUCER INPUTS AND OUTPUTS

Transducer input modules can receive input signals from external dcmA output transducers (dcmA In) or resistance temperature detectors (RTD). Hardware and software is 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.

Every transducer input/output module has a total of 24 terminal connections. These connections are arranged as three terminals per row with a total of 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 figure below illustrates the transducer module types (5A, 5C, 5D, 5E, and 5F) and channel arrangements that can be ordered for the relay.

NOTE

Wherever a tilde "~" symbol appears, substitute with the slot position of the module.

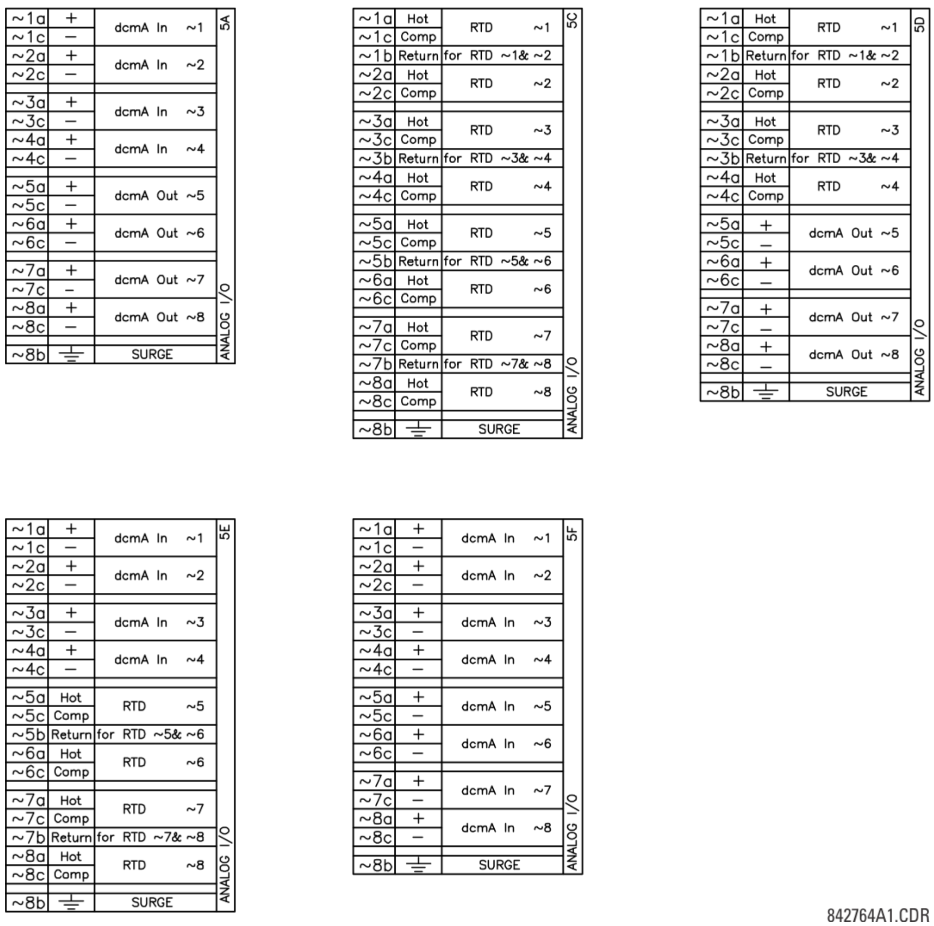


Figure 3–20: TRANSDUCER INPUT/OUTPUT MODULE WIRING

3.2.8 RS232 FACEPLATE PORT

A 9-pin RS232C serial port is located on the L30 faceplate 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 both 9-pin and 25-pin connectors.

NOTE: The baud rate for this port is fixed at **19200 bps**.

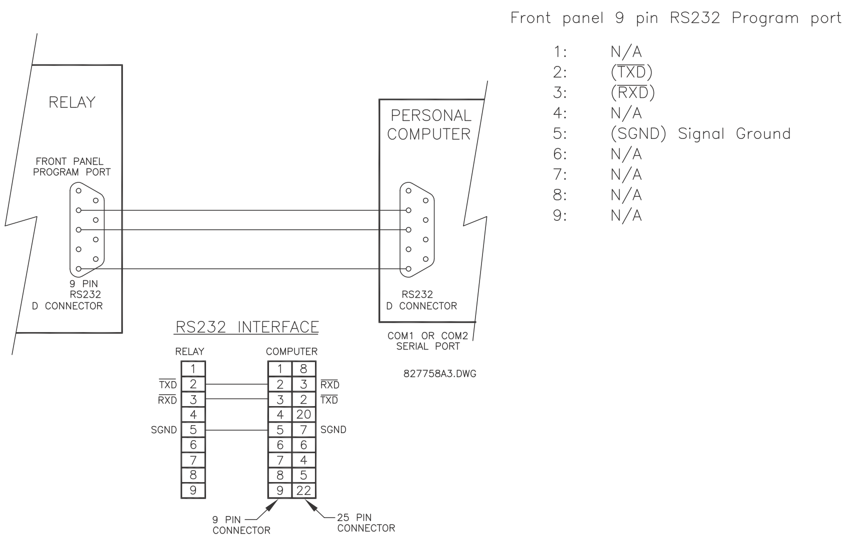


Figure 3–21: RS232 FACEPLATE PORT CONNECTION

3.2.9 CPU COMMUNICATION PORTS

a) OPTIONS

In addition to the faceplate RS232 port, the L30 provides a rear RS485 communication port.

NOTE: The CPU modules do not require a surge ground connection.

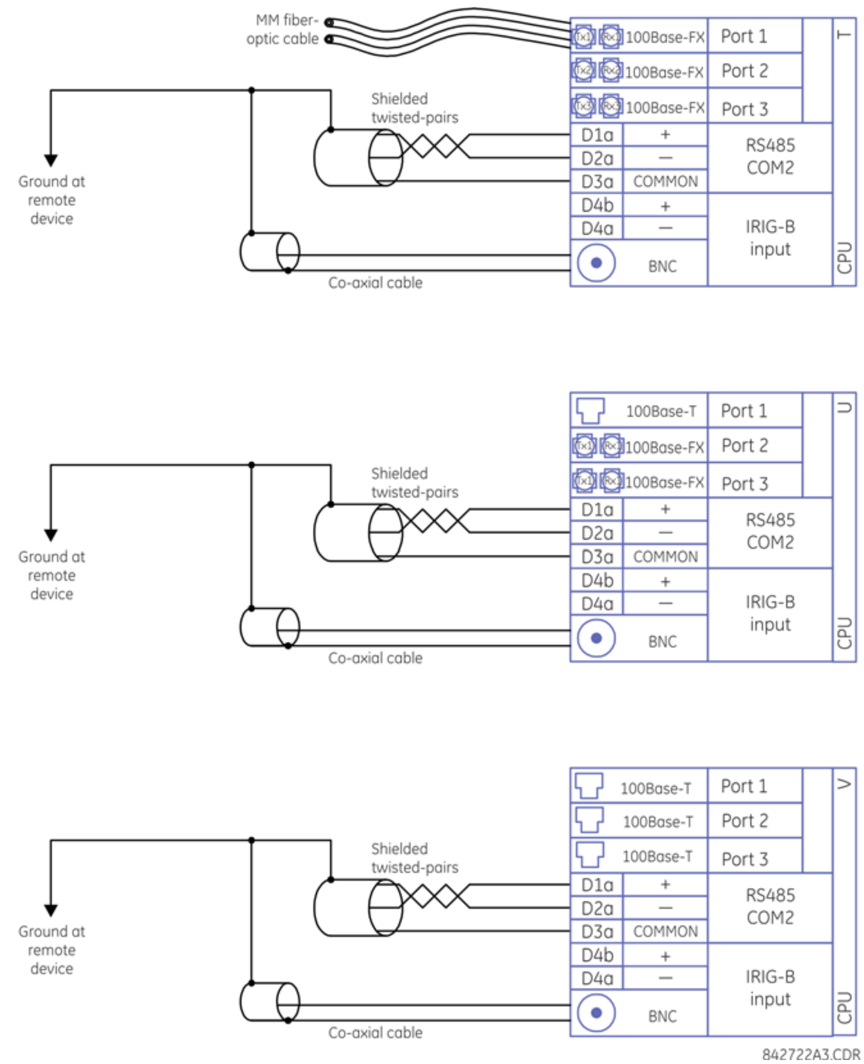


Figure 3–22: CPU MODULE COMMUNICATIONS WIRING

b) RS485 PORTS

RS485 data transmission and reception are accomplished over a single twisted pair 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 PLC is possible.

To minimize errors from noise, the use of shielded twisted pair wire is recommended. Correct polarity must also 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 internally provided at both communication ports. An isolated power supply with an optocoupled data interface also acts to reduce noise coupling. To ensure maximum reliability, all equipment should have similar transient protection devices installed.

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

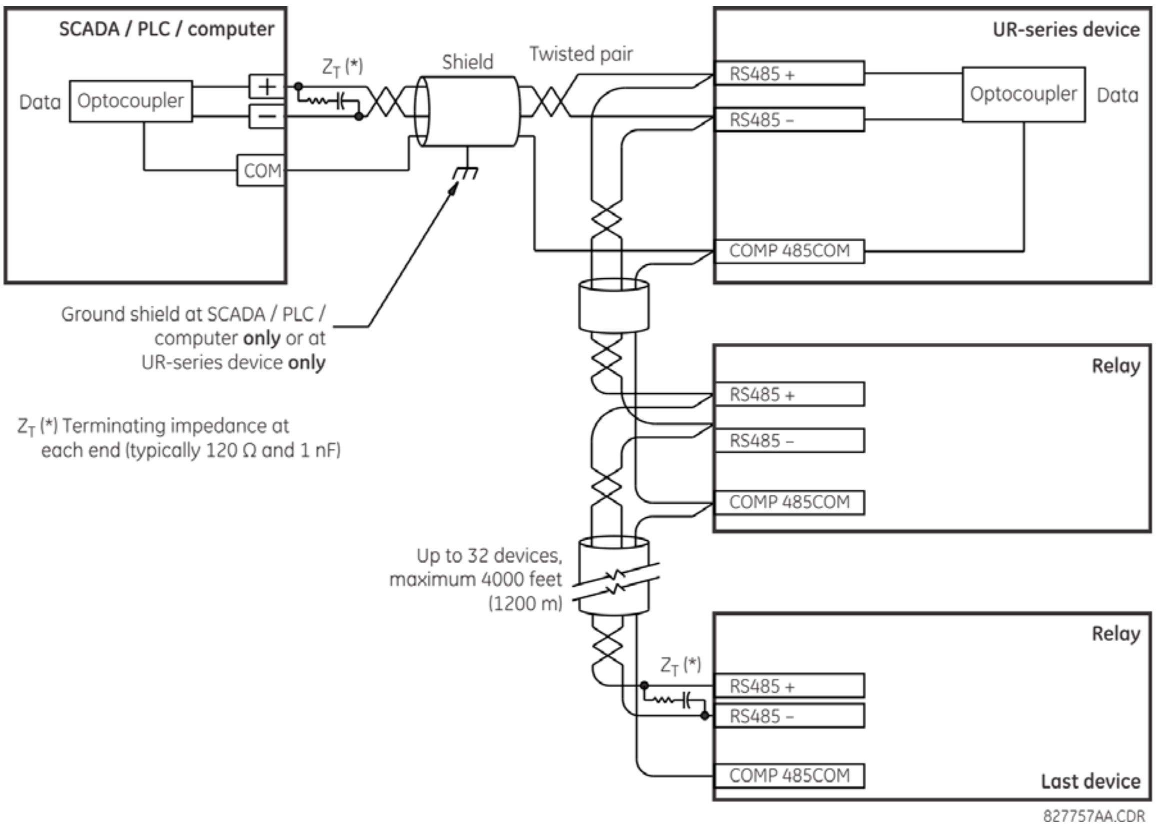


Figure 3–23: RS485 SERIAL CONNECTION

c) 100BASE-FX FIBER OPTIC PORTS

NOTE

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.

⚠CAUTION

Observing any fiber transmitter output can injure the eye.

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 multi-mode.

The fiber optic port is designed such that the response times do not vary for any core that is 100 µm or less in diameter, 62.5 µm for 100 Mbps. For optical power budgeting, splices are required every 1 km for the transmitter/receiver pair. When splicing optical fibers, the diameter and numerical aperture of each fiber must be the same.

3.2.10 IRIG-B

IRIG-B is a standard time code format that allows stamping of events to be synchronized among connected devices within 1 millisecond. The IRIG time code formats are serial, width-modulated codes that can be either DC level shifted or amplitude modulated (AM). Third party equipment is available for generating the IRIG-B signal; this equipment can use a GPS satellite system to obtain the time reference so that devices at different geographic locations can be synchronized.

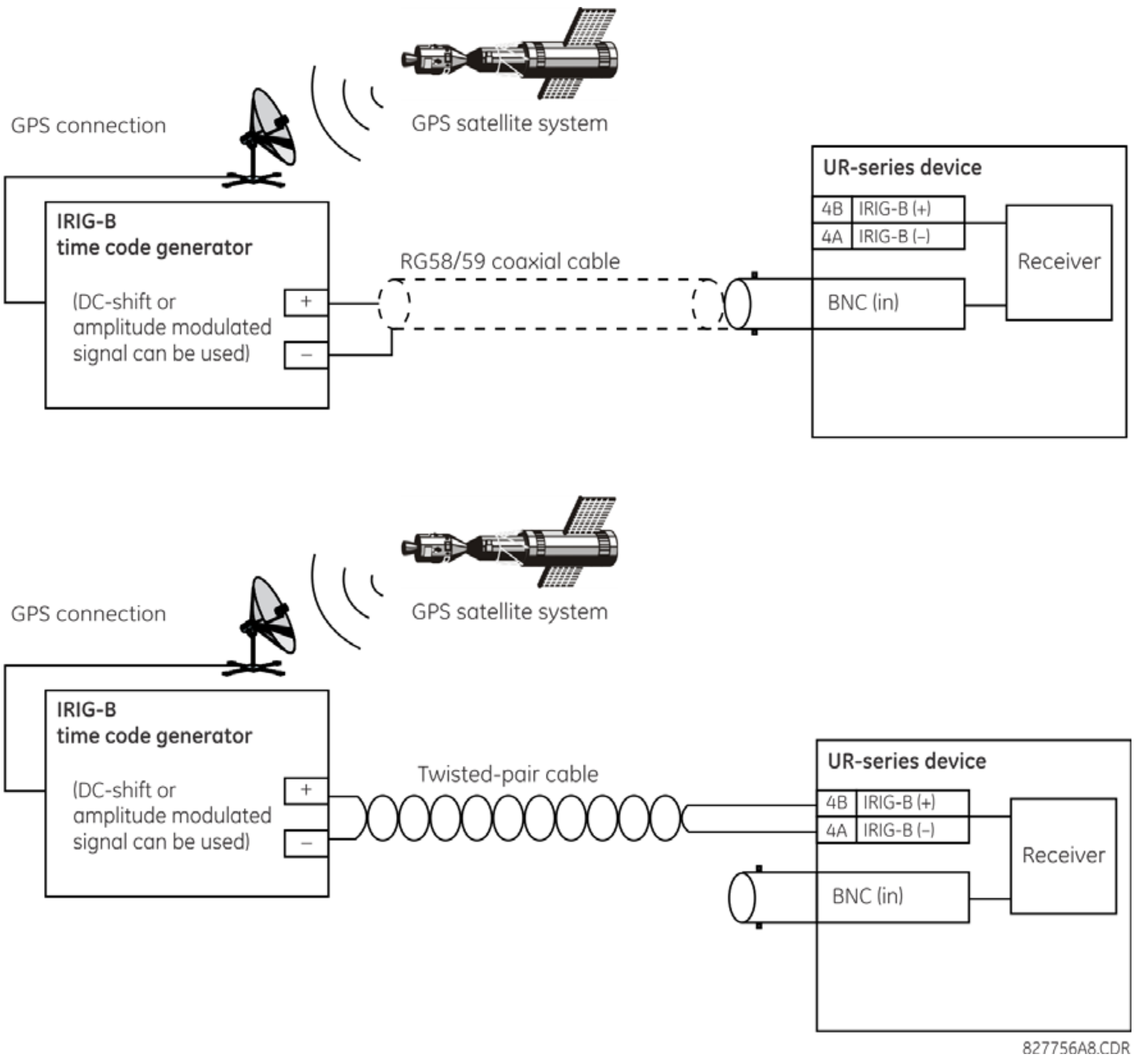


Figure 3–24: OPTIONS FOR THE IRIG-B CONNECTION

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

NOTE: Using an amplitude modulated receiver also causes errors of up to 1 ms in metered synchrophasor values.

3.3.1 DESCRIPTION

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 as shown in the table below.

Table 3–3: CHANNEL COMMUNICATION OPTIONS

MODULE	SPECIFICATION
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, 1 channel
2F	Bi-phase, 2 channel
2G	IEEE C37.94, 820 nm, 128 kbps, multi-mode, LED, 1 channel
2H	IEEE C37.94, 820 nm, 128 kbps, multi-mode, LED, 2 channels
2S	Managed Ethernet switch with high voltage power supply
2T	Managed Ethernet switch with low voltage power supply
72	1550 nm, single-mode, laser, 1 channel
73	1550 nm, single-mode, laser, 2 channels
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, multi-mode, LED, 1 channel
77	IEEE C37.94, 820 nm, 64 kbps, multi-mode, LED, 2 channels
7A	820 nm, multi-mode, LED, 1 channel
7B	1300 nm, multi-mode, 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, multi-mode
7F	Channel 1: G.703, Channel 2: 1300 nm, multi-mode
7G	Channel 1: G.703, Channel 2: 1300 nm, single-mode ELED
7H	820 nm, multi-mode, LED, 2 channels
7I	1300 nm, multi-mode, LED, 2 channels
7J	1300 nm, single-mode, ELED, 2 channels
7K	1300 nm, single-mode, LASER, 2 channels
7L	Channel 1: RS422, channel: 820 nm, multi-mode, LED
7M	Channel 1: RS422, channel 2: 1300 nm, multi-mode, 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

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

NOTE

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

NOTE

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.

⚠CAUTION

Observing any fiber transmitter output can injure the eye.

3.3.2 FIBER: LED AND ELED TRANSMITTERS

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

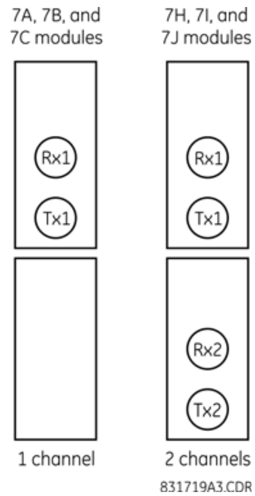


Figure 3–25: LED AND ELED FIBER MODULES

3.3.3 FIBER-LASER TRANSMITTERS

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

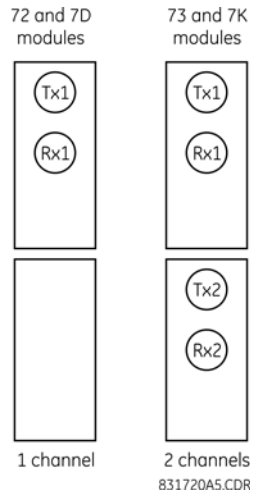


Figure 3–26: LASER FIBER MODULES

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.

3.3.4 G.703 INTERFACE

a) DESCRIPTION

The following figure shows the 64K ITU G.703 co-directional interface configuration.

NOTE: 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 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 internally connected to ground. Thus, if pin X1a or X6a is used, do not ground at the other end. This interface module is protected by surge suppression devices.

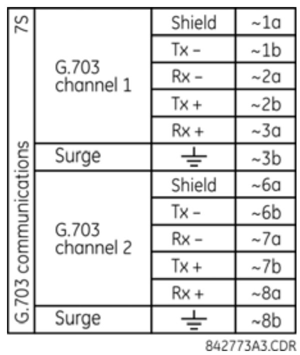


Figure 3–27: G.703 INTERFACE CONFIGURATION

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 assignments* section earlier in this chapter. All pin interconnections are to be maintained for a connection to a multiplexer.

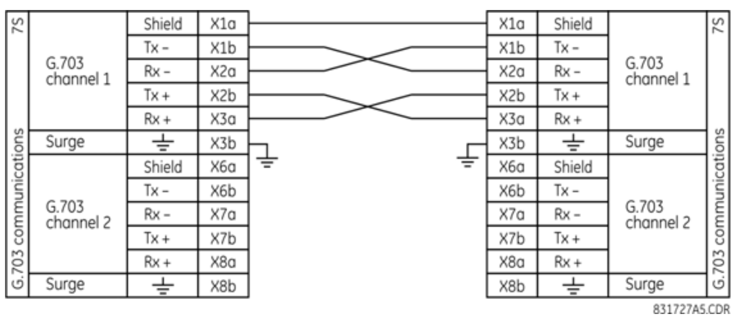


Figure 3–28: TYPICAL PIN INTERCONNECTION BETWEEN TWO G.703 INTERFACES

NOTE: Pin nomenclature can differ from one manufacturer to another. Therefore, it is not uncommon to see pinouts numbered TxA, TxB, RxA and RxB. In such cases, it can be assumed that “A” is equivalent to “+” and “B” is equivalent to “–”.

b) 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/inserter 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 (channel 1, channel 2) to the desired 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/inserter 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.

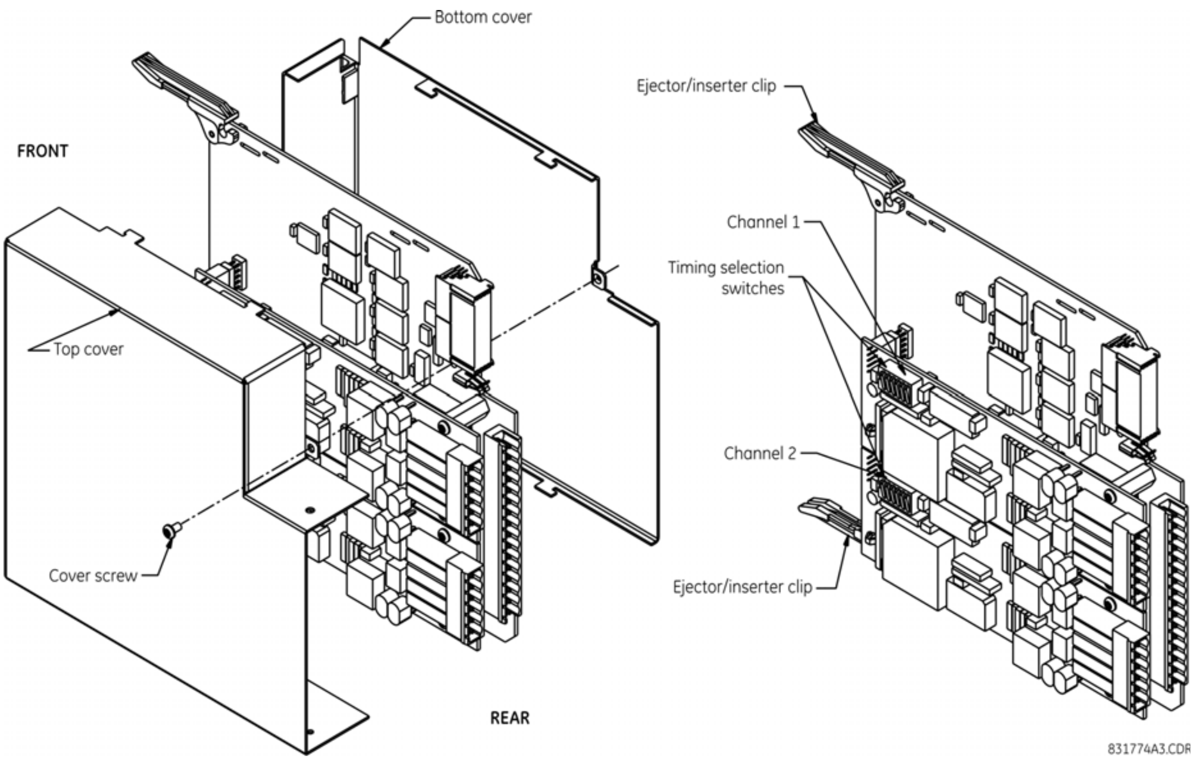


Figure 3–29: G.703 TIMING SELECTION SWITCH SETTING

Table 3–4: 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

c) G.703 OCTET TIMING

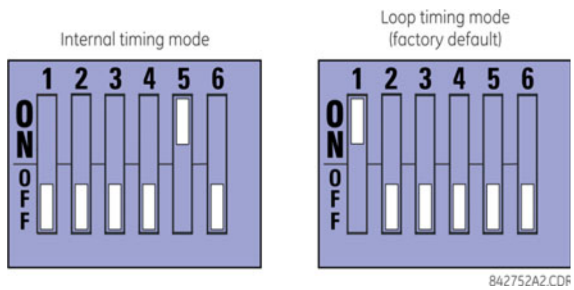
If octet timing is enabled (ON), this 8 kHz signal is asserted during the violation of bit 8 (LSB) necessary for connecting to higher order systems. When L30s are connected back-to-back, octet timing is disabled (OFF).

d) 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, the G.703 timing selection should be in the internal timing mode for back-to-back (UR-to-UR) connections. For back-to-back connections, set for 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, the G.703 timing selection should be in 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 below:



3

e) 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 which 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.

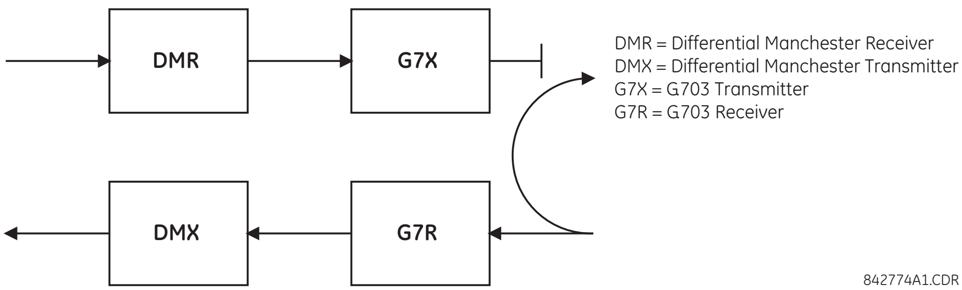


Figure 3–30: G.703 MINIMUM REMOTE LOOPBACK MODE

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.

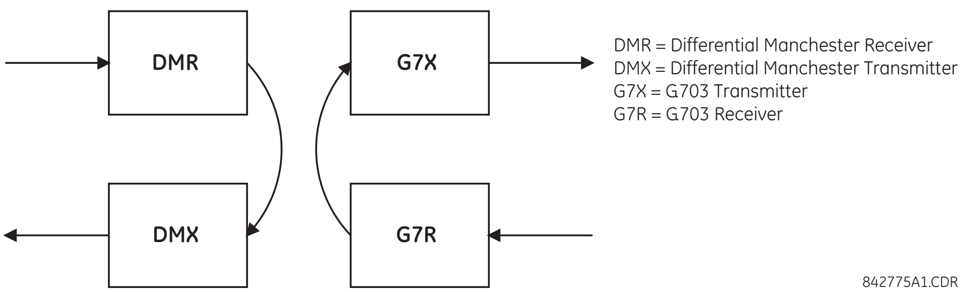


Figure 3–31: G.703 DUAL LOOPBACK MODE

3.3.5 RS422 INTERFACE

a) DESCRIPTION

There are three RS422 inter-relay communications modules available: single-channel RS422 (module 7T), dual-channel RS422 (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.

NOTE: 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 internally connected 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.

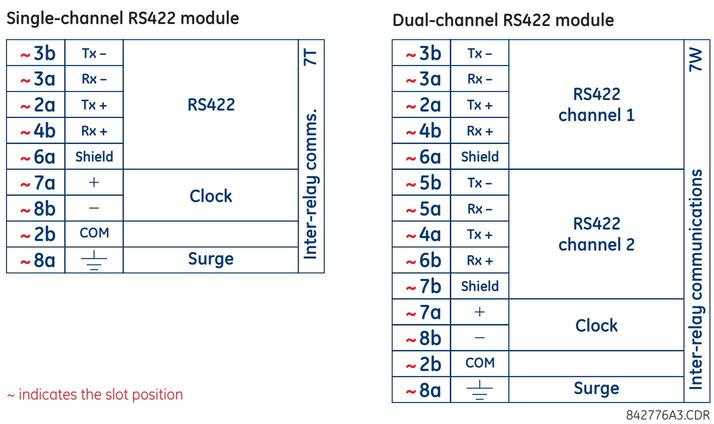


Figure 3–32: RS422 INTERFACE CONNECTIONS

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.

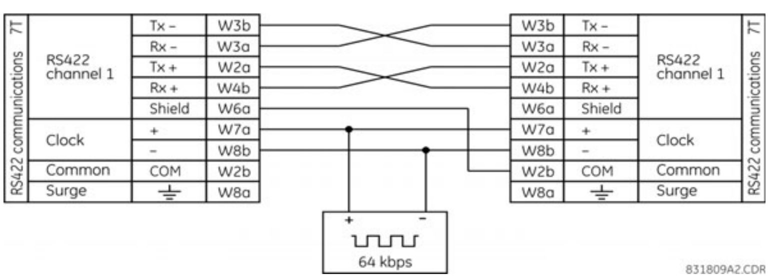


Figure 3–33: TYPICAL PIN INTERCONNECTION BETWEEN TWO RS422 INTERFACES

b) 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 fashion 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 to 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 fashion. In addition, the send timing outputs of data module 1 is 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 are 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 as shown below. If the terminal timing feature is not available or this type of connection is not desired, the G.703 interface is a viable option that does not impose timing restrictions.

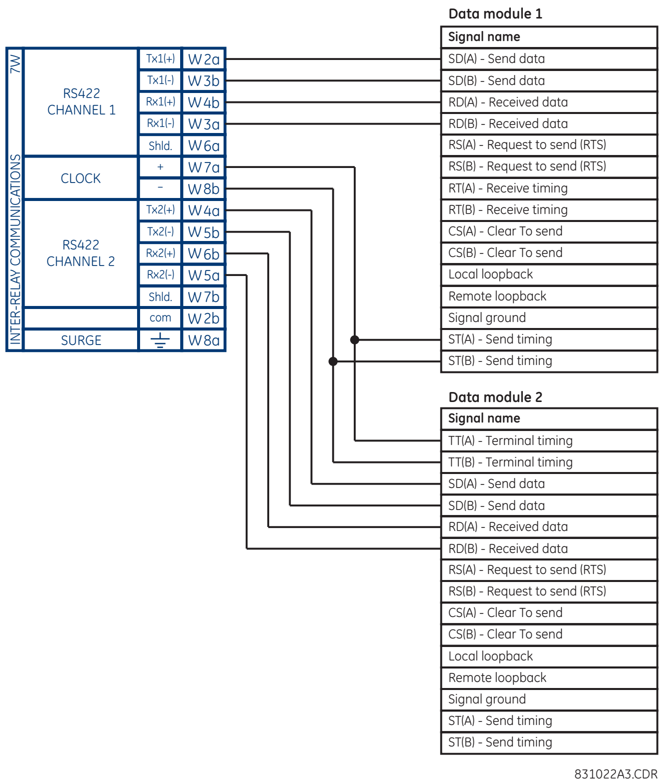


Figure 3–34: TIMING CONFIGURATION FOR RS422 TWO-CHANNEL, THREE-TERMINAL APPLICATION

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 above since they vary by manufacturer.

c) 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.

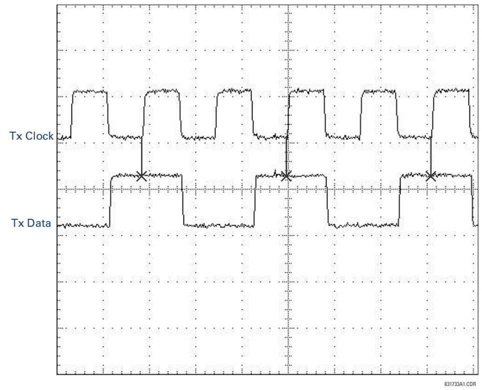


Figure 3–35: CLOCK AND DATA TRANSITIONS

d) 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 DPLL (digital phase lock loop) 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 SCC (serial communication controller) receive clock.

3.3.6 RS422 AND FIBER INTERFACE

The following figure shows the combined RS422 plus fiberoptic interface configuration at 64K 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 20-24 twisted shielded pair is recommended for external RS422 connections and 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.

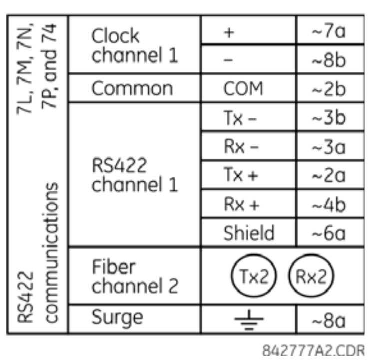


Figure 3–36: RS422 AND FIBER INTERFACE CONNECTION

Connections shown above are for multiplexers configured as DCE (data communications equipment) units.

3.3.7 G.703 AND FIBER INTERFACE

The figure below shows the combined G.703 plus fiberoptic 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 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 additional 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.

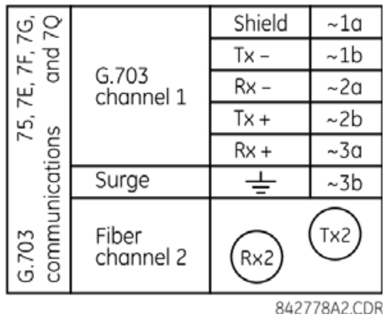


Figure 3–37: G.703 AND FIBER INTERFACE CONNECTION

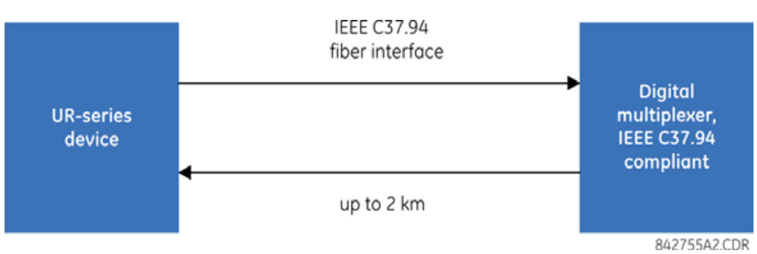
3.3.8 IEEE C37.94 INTERFACE

The UR-series IEEE C37.94 communication modules (modules types 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. This data is typically 64 kbps, but the standard provides for speeds up to 64*n* kbps, where *n* = 1, 2,…, 12. The UR-series C37.94 communication modules are either 64 kbps (with *n* fixed at 1) for 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.

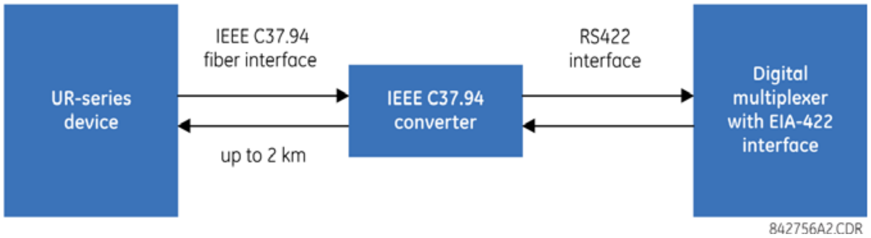
The specifications for the module are as follows:.

- IEEE standard: C37.94 for 2 × 64 kbps optical fiber interface (for 76 and 77 modules)
- Fiber optic cable type: 50 mm or 62.5 mm core diameter optical fiber
- Fiber optic mode: multi-mode
- Fiber optic cable length: up to 2 km
- Fiber optic connector: type ST
- Wavelength: 830 ±40 nm
- Connection: as per all fiber optic connections, a Tx to Rx connection is required

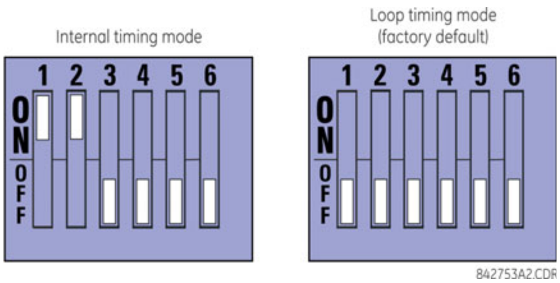
The UR-series C37.94 communication module can be connected directly to any compliant digital multiplexer that supports the IEEE C37.94 standard as shown below.



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, as shown below.



The UR-series C37.94 communication module has six switches that are used to set the clock configuration. The functions of these control switches are shown below.



For the internal timing mode, the system clock is generated internally. Therefore, the timing switch selection should be 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, the timing selection should be in 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 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/inserter 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 (channel 1, channel 2) to the desired timing modes (see description above).
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/inserter 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.

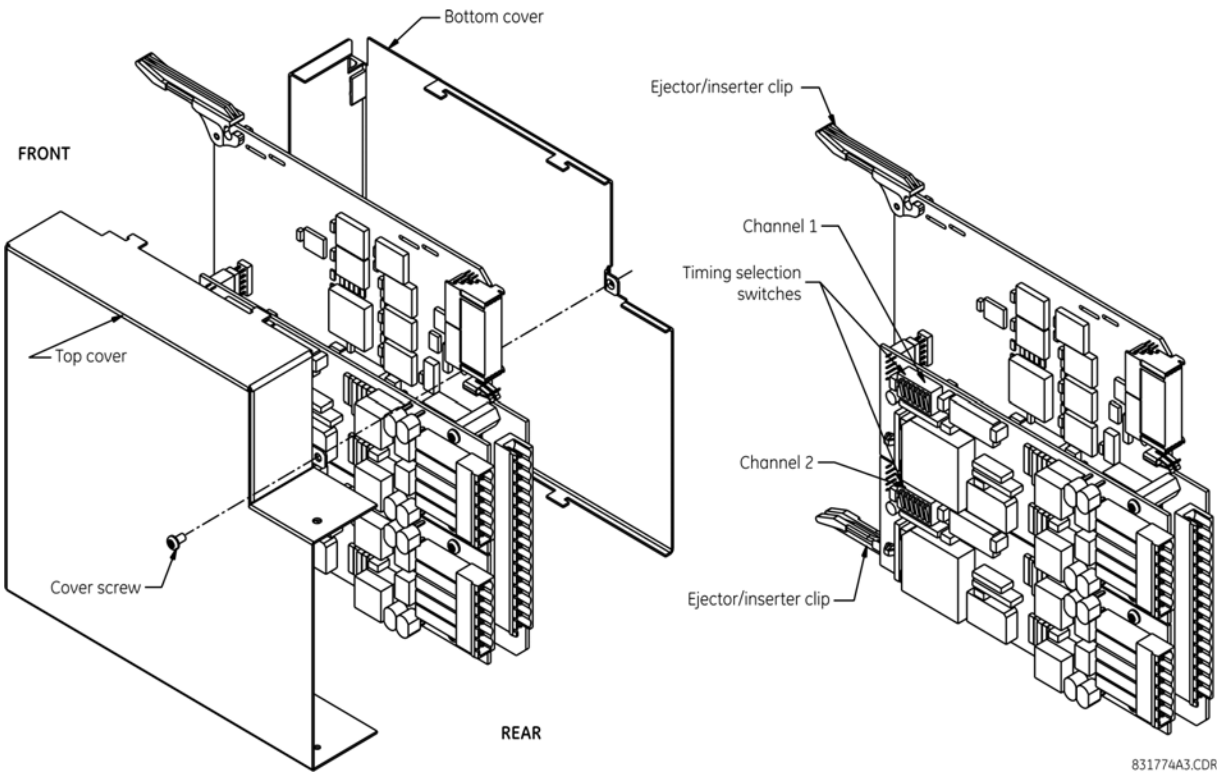


Figure 3–38: IEEE C37.94 TIMING SELECTION SWITCH SETTING

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

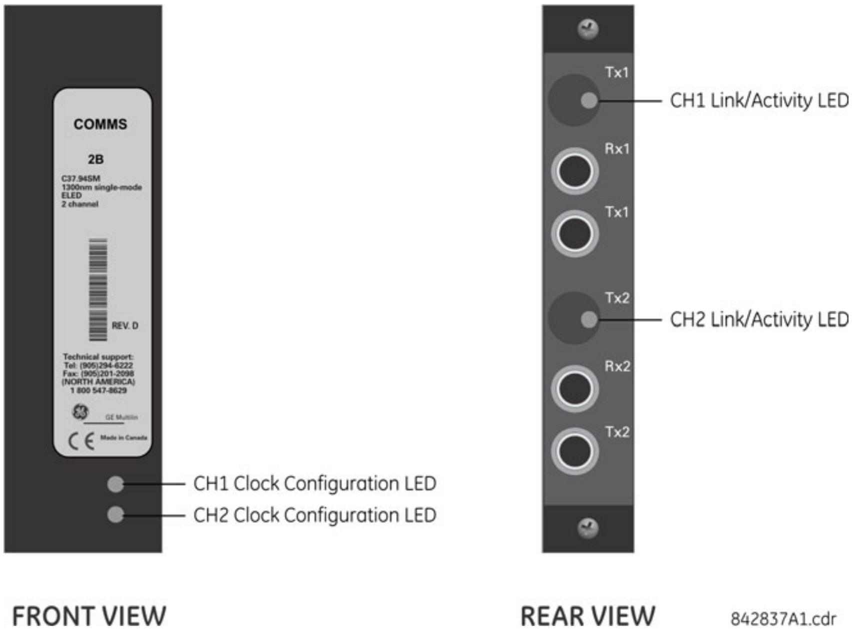


Figure 3–39: STATUS LEDS

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

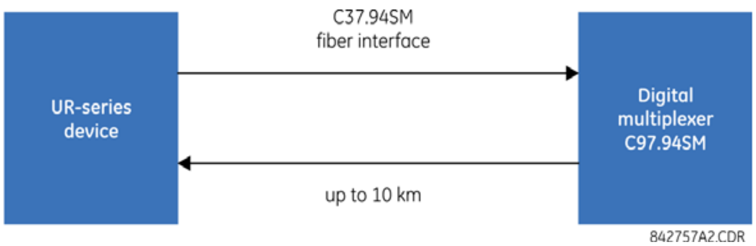
3.3.9 C37.94SM INTERFACE

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,…, 12. The UR-series C37.94SM communication module is 64 kbps only with n fixed at 1. 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.

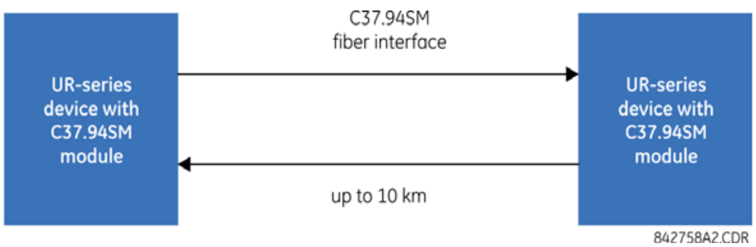
The specifications for the module are as follows:

- 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 μm 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 ±40 nm
- Connection: as per all fiber optic connections, a Tx to Rx connection is required

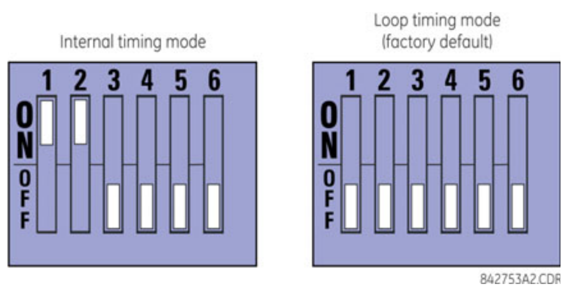
The UR-series C37.94SM communication module can be connected *directly* to any compliant digital multiplexer that supports C37.94SM as shown below.



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



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



For the internal timing mode, the system clock is generated internally. Therefore, the timing switch selection should be 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, the timing selection should be in 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 (modules 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/inserter 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 (channel 1, channel 2) to the desired timing modes (see description above).
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/inserter 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.

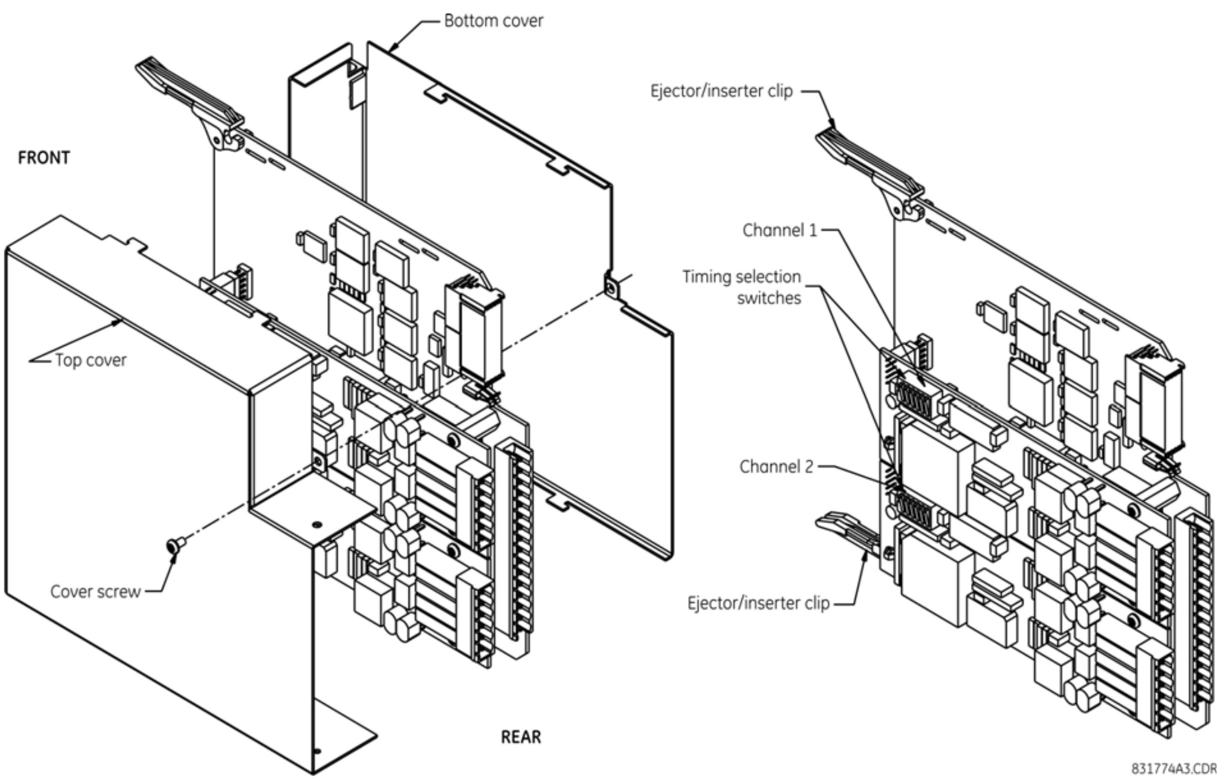


Figure 3–40: C37.94SM TIMING SELECTION SWITCH SETTING

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

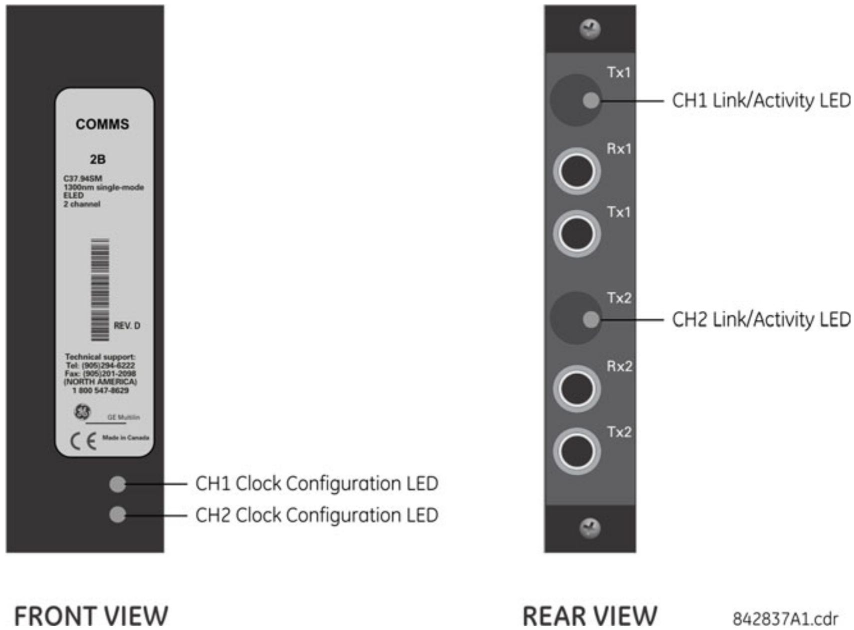


Figure 3–41: STATUS LEDS

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

4.1.1 INTRODUCTION

The EnerVista UR Setup software provides a graphical user interface (GUI) as one of two human interfaces to a UR device. The alternate human interface is implemented via the device's faceplate keypad and display (see the *Faceplate interface* section in this chapter).

The EnerVista UR Setup software provides a single facility to configure, monitor, maintain, and troubleshoot the operation of relay functions, connected over local or wide area communication 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, you can communicate with the device in real-time.

The EnerVista UR Setup software is provided with every L30 relay and runs on Microsoft Windows XP, 7, and Server 2008. This chapter provides a summary of the basic EnerVista UR Setup software interface features. The EnerVista UR Setup Help File provides details for getting started and using the EnerVista UR Setup software interface.

4.1.2 CREATING A SITE LIST

To start using the EnerVista UR Setup software, site and device definition are required. See the EnerVista UR Setup Help File or refer to the *Connecting EnerVista UR Setup with the L30* section in Chapter 1 for details.

4.1.3 ENERVISTA UR SETUP OVERVIEW

a) ENGAGING A DEVICE

The EnerVista UR Setup software can be used in online mode (relay connected) to directly communicate with the L30 relay. Communicating relays are organized and grouped by communication interfaces and into sites. Sites can contain any number of relays selected from the UR-series of relays.

b) USING SETTINGS FILES

The EnerVista UR Setup software interface supports three ways of handling changes to relay settings:

- In offline mode (relay disconnected) to create or edit relay settings files for later download to communicating relays
- While connected to a communicating relay to directly modify any relay settings via relay data view windows, and then save the settings to the relay
- You can create/edit settings files and then write them to the relay while the interface is connected to the relay

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
- 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 IP 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
IEC61850 Config GOOSE ConfRev
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.

c) CREATING AND EDITING FLEXLOGIC™

You create or edit a FlexLogic equation in order to customize the relay. You can subsequently view the automatically generated logic diagram.

d) VIEWING ACTUAL VALUES

You can view real-time relay data such as input/output status and measured parameters.

e) VIEWING TRIGGERED EVENTS

While the interface is in either online or offline mode, you can view and analyze data generated by triggered specified parameters, via one of the following:

- **Event recorder**

  The event recorder captures contextual data associated with the last 1024 events, listed in chronological order 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.

f) FILE SUPPORT

- **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 tree menu, it is added back to the Settings List tree menu.
- **Drag and Drop:** The Site List and Settings List control bar windows are each mutually a drag source and a drop target for device-order-code-compatible files or individual menu items. Also, the Settings List control bar window and any Windows Explorer directory folder are each mutually a file drag source and drop target.

  New files that are dropped into the Settings List window are added to the tree, which is automatically sorted alphabetically with respect to settings file names. Files or individual menu items that are dropped in the selected device menu in the Site List window are automatically sent to the online communicating device.

g) FIRMWARE UPGRADES

The firmware of a L30 device can be upgraded, locally or remotely, via the EnerVista UR Setup software. The corresponding instructions are provided by the EnerVista UR Setup Help file under the topic “Upgrading Firmware”.

NOTE

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.

4.1.4 ENERVISTA UR SETUP MAIN WINDOW

The EnerVista UR Setup software main window supports the following primary display components:

1. Title bar that shows the pathname of the active data view
2. Main window menu bar
3. Main window tool bar
4. Site list control bar window
5. Settings list control bar window
6. Device data view windows, with common tool bar
7. Settings file data view windows, with common tool bar
8. Workspace area with data view tabs
9. Status bar
10. Quick action hot links

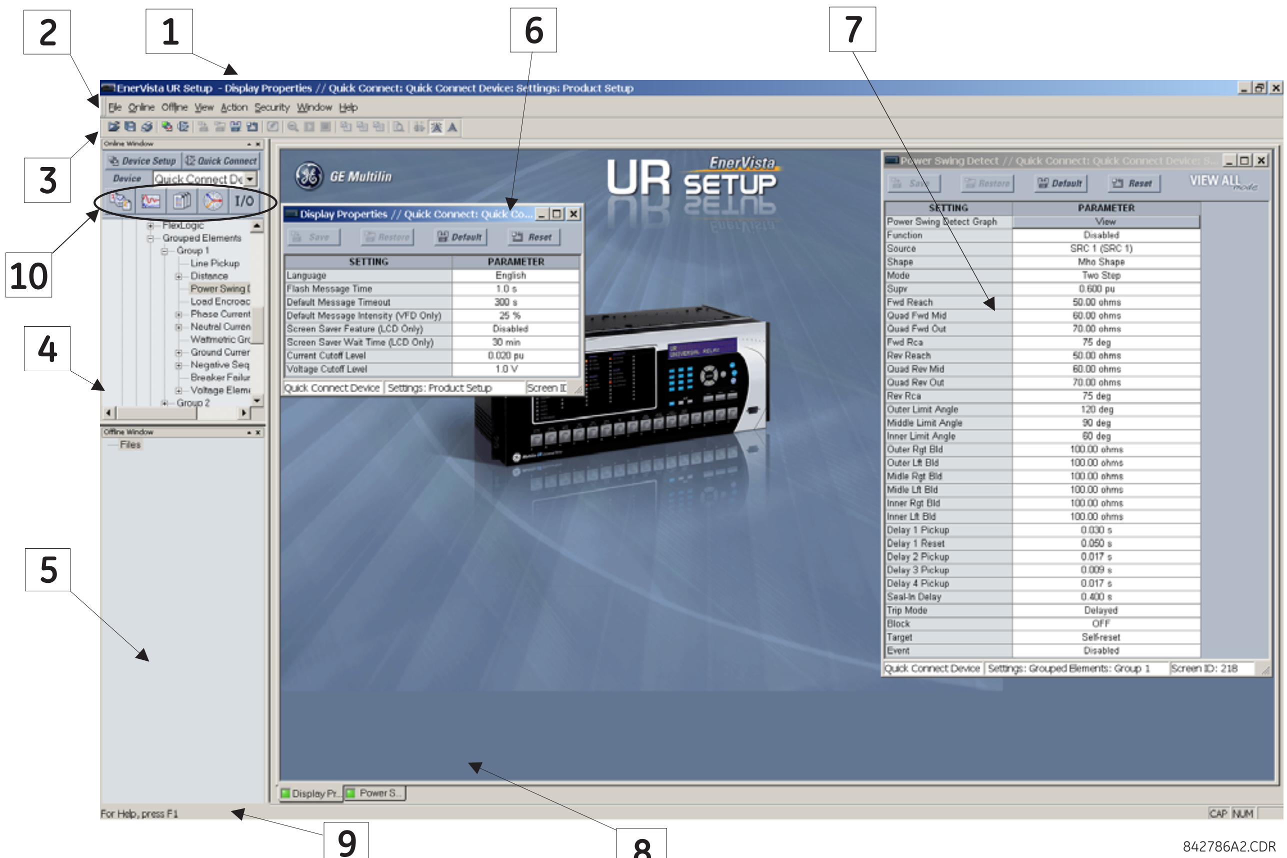


Figure 4–1: ENERVISTA UR SETUP SOFTWARE MAIN WINDOW

4.2.1 SETTINGS TEMPLATES

Setting file templates simplify the configuration and commissioning of multiple relays that protect similar assets. An example of this is a substation that has ten similar feeders protected by ten UR-series F60 relays.

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

The remaining settings (typically 10% or less) can be specified as editable and be 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 EnerVista UR Setup. 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.

Settings files conversion from previous firmware versions is supported.

4

a) ENABLING THE SETTINGS TEMPLATE

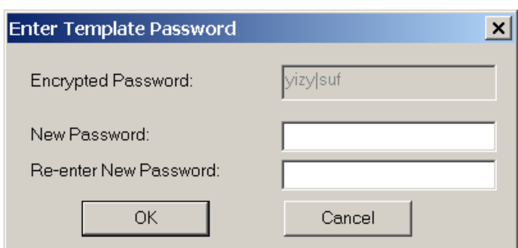
The settings file template feature is disabled by default. The following procedure describes how to enable the settings template for UR-series settings files.

1. Select a settings file from the offline window of the EnerVista UR Setup main screen.
2. 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 tree displayed in light blue. The settings file is now in template editing mode.

Alternatively, the settings template can also be applied to online settings. The following procedure describes this process.

1. Select an installed device from the online window of the EnerVista UR Setup main screen.
2. Right-click the selected 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.

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.

b) EDITING 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. Select an installed device or a settings file from the tree menu on the left of the EnerVista UR Setup main screen.
2. Select the **Template Mode > Edit Template** option to place the device in template editing mode.
3. Enter the template password then click **OK**.
4. Open the relevant settings windows that contain 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 also indicates that EnerVista UR Setup is in **EDIT mode**. The following example shows the phase time overcurrent settings window in edit mode.

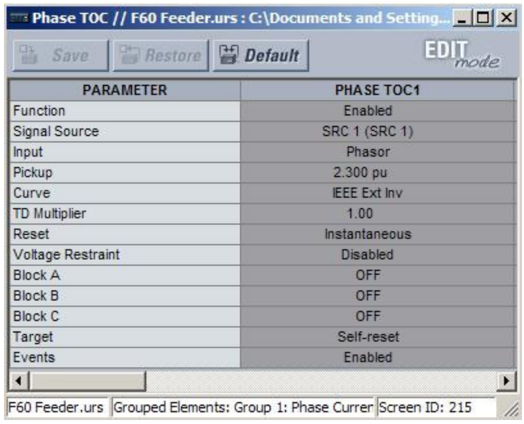


Figure 4–2: SETTINGS TEMPLATE VIEW, ALL SETTINGS SPECIFIED AS LOCKED

5. Specify the settings to make viewable by clicking them.

   The setting available to view is displayed against a yellow background as shown below.

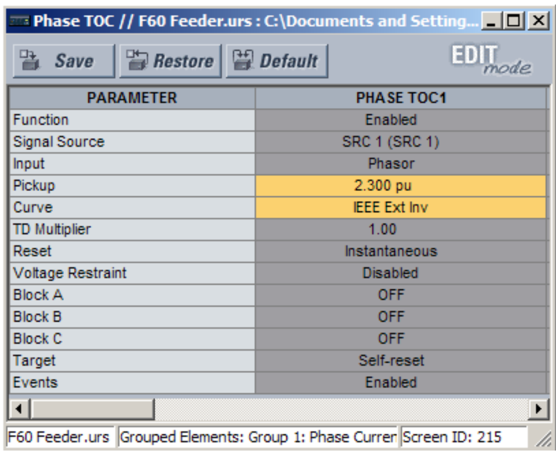


Figure 4–3: SETTINGS TEMPLATE VIEW, TWO SETTINGS SPECIFIED AS EDITABLE

6. Click on **Save** to save changes to the settings template.
7. Proceed through the settings tree to specify all viewable settings.

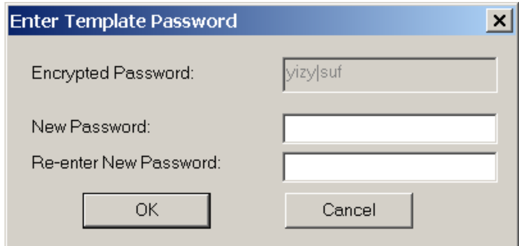
c) ADDING PASSWORD PROTECTION TO A TEMPLATE

It is highly recommended that templates be saved with password protection to maximize security.

The following procedure describes how to add password protection to a settings file template.

1. Select a settings file from the offline window on the left of the EnerVista UR Setup main screen.
2. Selecting the **Template Mode > Password Protect Template** option.

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



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

The settings file template is now secured with password protection.

NOTE: 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.

d) VIEWING 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

Use the following procedure to only display settings available for editing:

1. Select an installed device or a settings file from the tree menu on the left of the EnerVista UR Setup main screen.
2. Apply the template by selecting the **Template Mode > View In Template Mode** option.
3. Enter the template password 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 below.

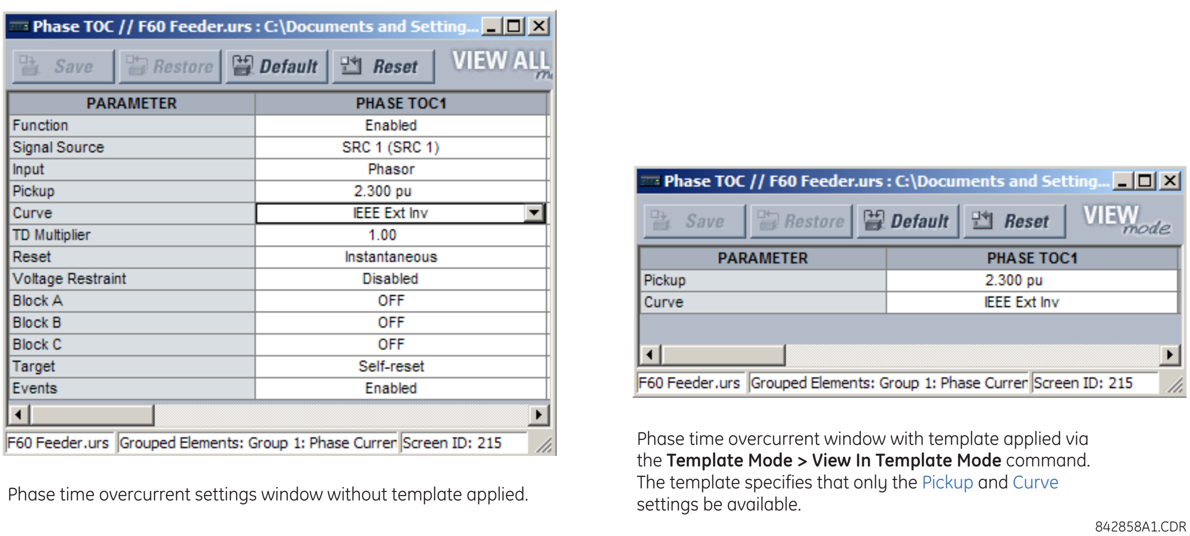


Figure 4–4: APPLYING TEMPLATES VIA THE VIEW IN TEMPLATE MODE COMMAND

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

Typical settings tree view without template applied.

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

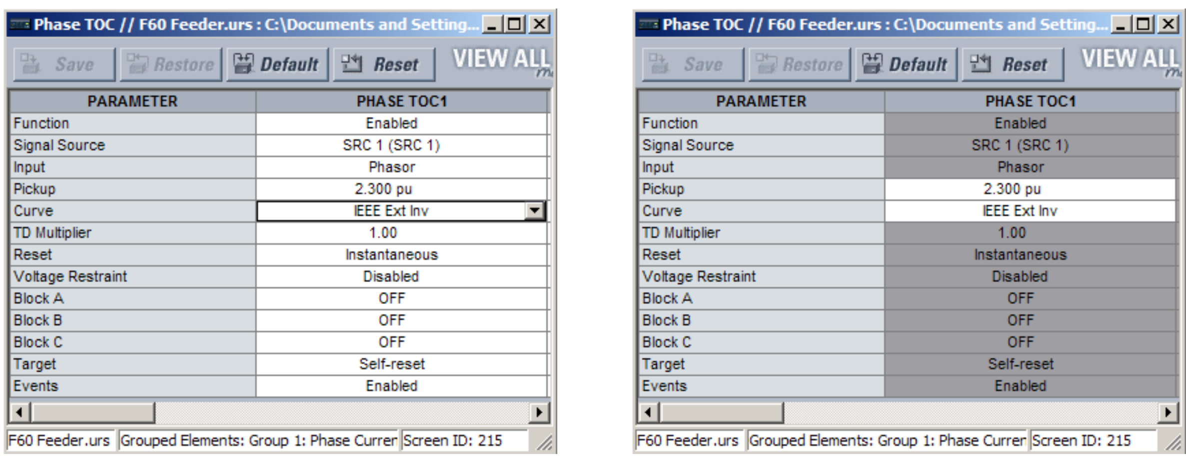
842860A1.CDR

Figure 4–5: APPLYING TEMPLATES VIA THE VIEW IN TEMPLATE MODE SETTINGS COMMAND

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

1. Select an installed device or a settings file from the tree menu on the left of the EnerVista UR Setup main screen.
2. Apply the template by selecting the **Template Mode > View All Settings** option.
3. 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 below.



Phase time overcurrent settings window without template applied.

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.

842859A1.CDR

Figure 4–6: APPLYING TEMPLATES VIA THE VIEW ALL SETTINGS COMMAND

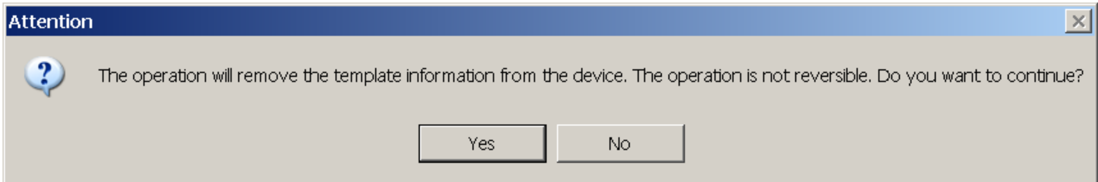
e) REMOVING THE SETTINGS TEMPLATE

It can be necessary at some point to remove a settings template. Once a template is removed, it cannot be reapplied and it is necessary to define a new settings template.

1. Select an installed device or settings file from the tree menu on the left of the EnerVista UR Setup main screen.
2. Select the **Template Mode > Remove Settings Template** option.
3. Enter the template password and click **OK** to continue.

4

4. Verify one more time that you want to remove the template by clicking **Yes**.



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

4.2.2 SECURING AND LOCKING FLEXLOGIC EQUATIONS

The UR allows users to secure parts or all of a FlexLogic equation, 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.

4

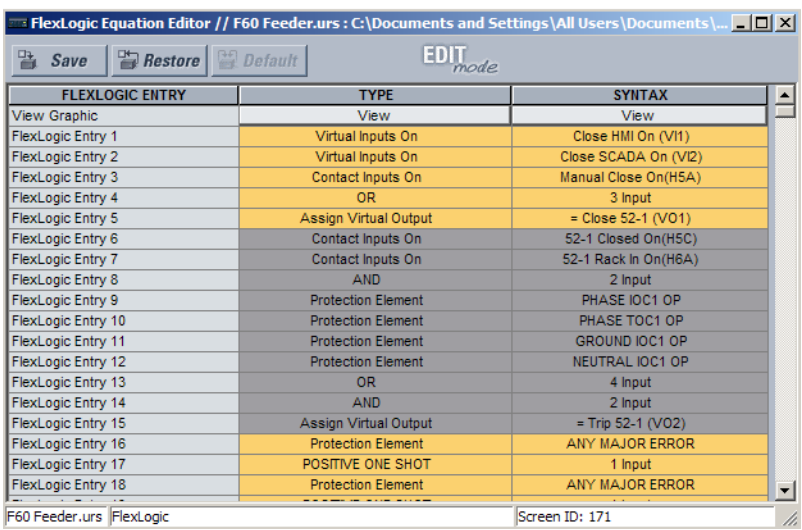
a) LOCKING FLEXLOGIC EQUATION ENTRIES

The following procedure describes how 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. Select the **FlexLogic > FlexLogic Equation Editor** settings menu item.

   By default, all FlexLogic entries are specified as viewable and displayed against a yellow background. The icon on the upper right of the window also indicates that EnerVista UR Setup is in **EDIT mode**.
3. Specify which entries to lock by clicking on them.

   The locked entries are displayed against a grey background as shown in the example below.

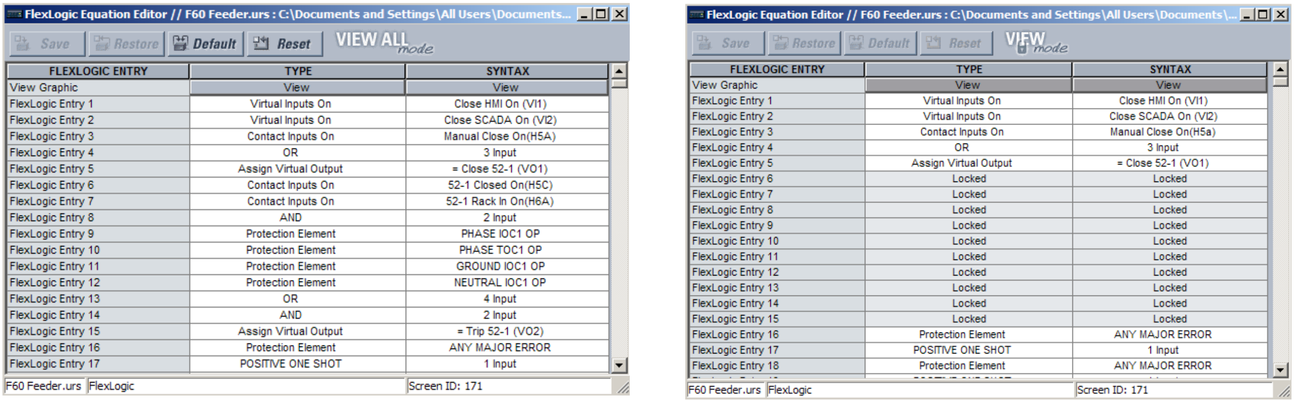


FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Inputs On	Close HMI On (VI1)
FlexLogic Entry 2	Virtual Inputs On	Close SCADA On (VI2)
FlexLogic Entry 3	Contact Inputs On	Manual Close On(H5A)
FlexLogic Entry 4	OR	3 Input
FlexLogic Entry 5	Assign Virtual Output	= Close 52-1 (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

Figure 4–7: LOCKING FLEXLOGIC ENTRIES IN EDIT MODE

4. Click on **Save** to save and apply changes to the settings template.
5. Select the **Template Mode > View In Template Mode** option to view the template.
6. Apply a password to the template then click **OK** to secure the FlexLogic equation.

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 in the above procedure is shown below.



Typical FlexLogic™ entries without template applied.

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

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Figure 4–8: LOCKING FLEXLOGIC ENTRIES THROUGH SETTING TEMPLATES

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

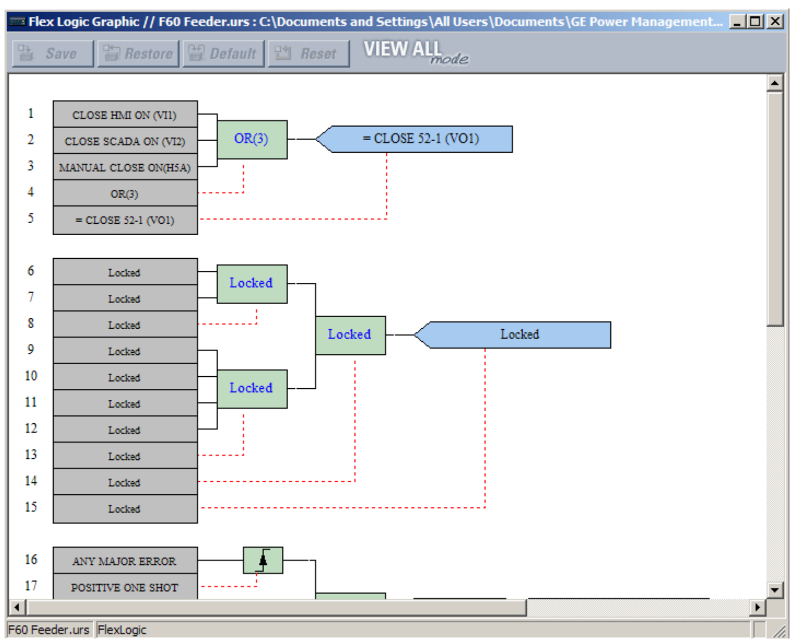

Figure 4–9: SECURED FLEXLOGIC IN GRAPHICAL VIEW

b) LOCKING FLEXLOGIC EQUATIONS TO A SERIAL NUMBER

A settings file and associated FlexLogic equations can also be locked to a specific UR serial number. Once the desired FlexLogic entries in a settings file have been secured, use the following procedure to lock the settings file to a specific serial number.

1. Select the settings file in the offline window.
2. Right-click on the file and select the **Edit Settings File Properties** item.

The following window is displayed.

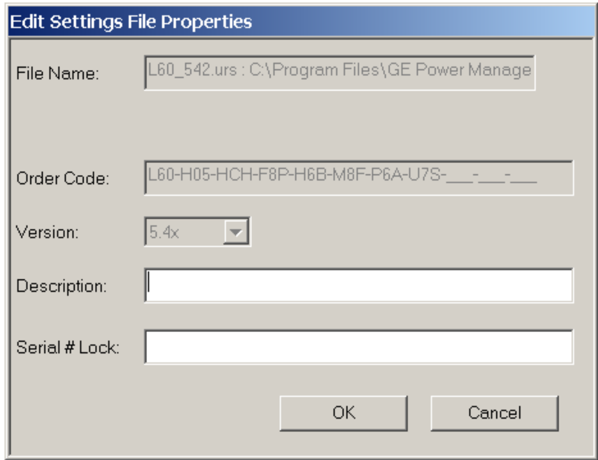

Figure 4–10: TYPICAL SETTINGS FILE PROPERTIES WINDOW

4

3. Enter the serial number of the L30 device to lock to the settings file in the **Serial # Lock** field.

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

4.2.3 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 PC. 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.

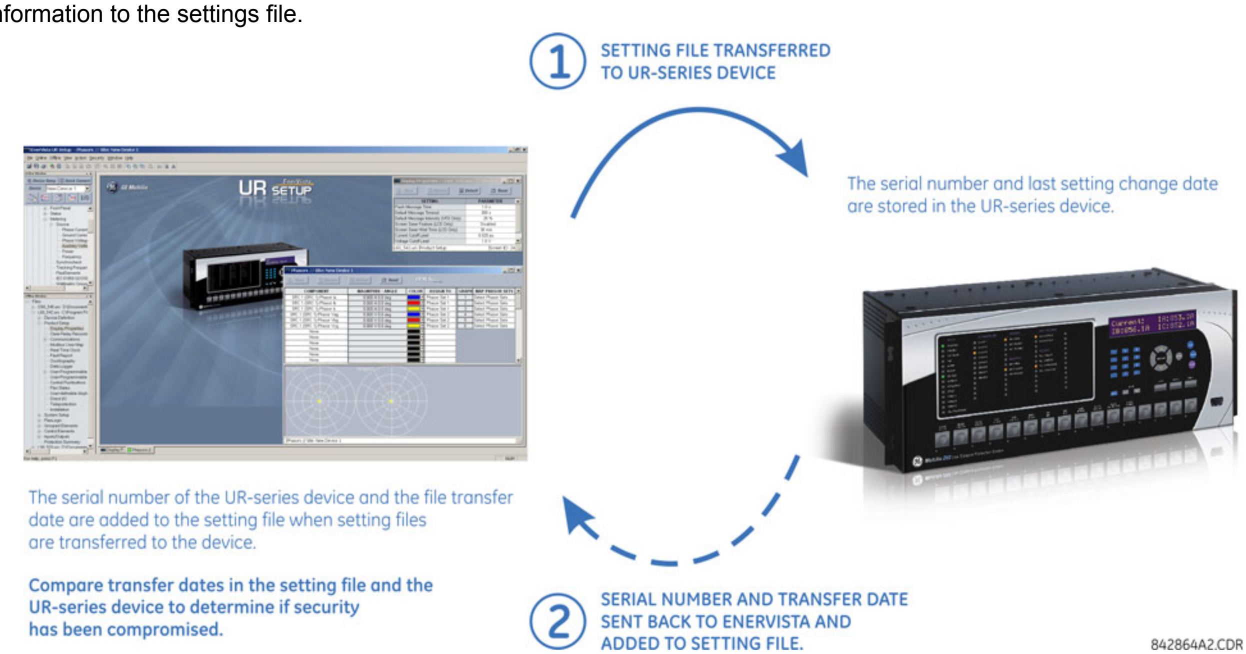

Figure 4–11: SETTINGS FILE TRACEABILITY MECHANISM

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

1. The transfer date of a setting file written to a L30 is logged in the relay and can be viewed via EnerVista UR Setup or the front panel display. Likewise, the transfer date of a setting file saved to a local PC is logged in EnerVista UR Setup.
2. 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.

a) 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 below.

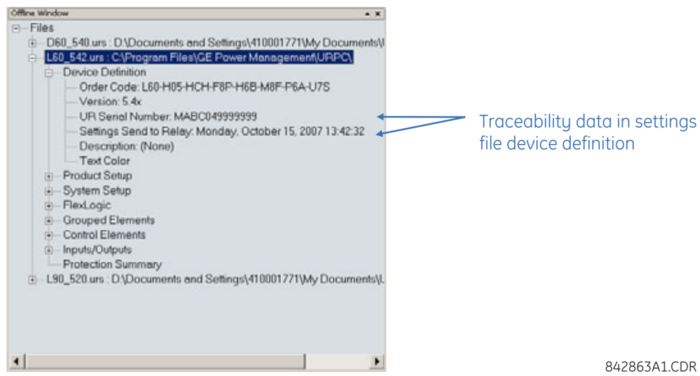

Figure 4–12: DEVICE DEFINITION SHOWING TRACEABILITY DATA

This information is also available in printed settings file reports as shown in the example below.

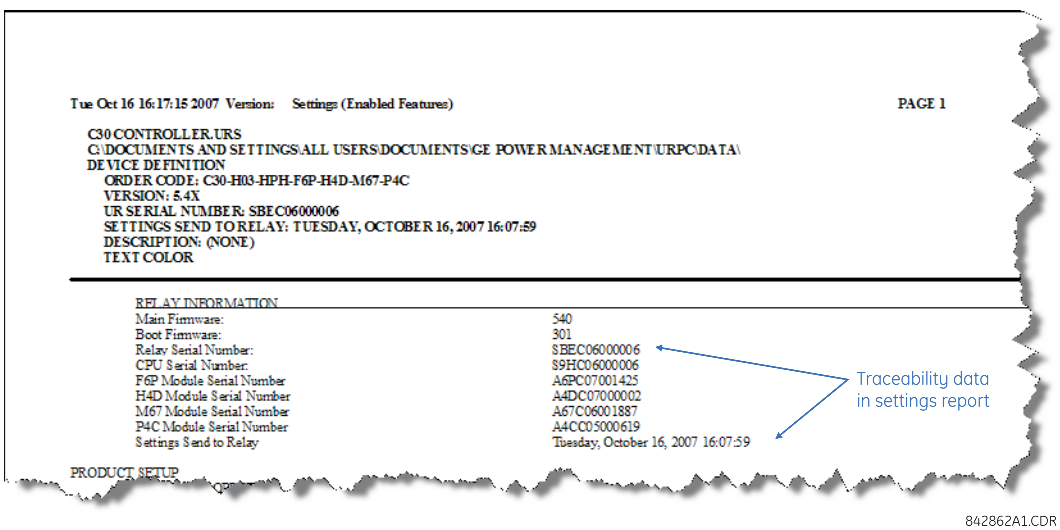

Figure 4–13: SETTINGS FILE REPORT SHOWING TRACEABILITY DATA

b) 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 UR Setup online window as shown in the example below.

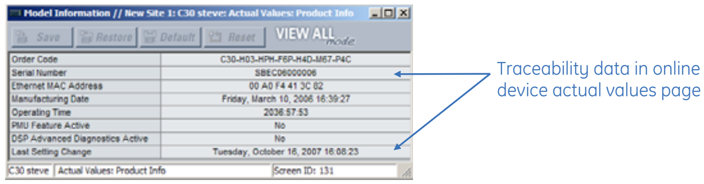

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Figure 4–14: TRACEABILITY DATA IN ACTUAL VALUES WINDOW

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

c) 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.

4.3.1 FACEPLATE

a) ENHANCED FACEPLATE

The front panel interface is one of two supported interfaces, the other interface being EnerVista UR Setup software. The front panel interface consists of LED panels, an RS232 port, keypad, LCD display, control pushbuttons, and optional user-programmable pushbuttons.

The faceplate is hinged to allow easy access to the removable modules.

Figure 4–15: UR-SERIES ENHANCED FACEPLATE

b) STANDARD FACEPLATE

There are two interfaces: the front panel and the EnerVista UR Setup software. The front panel interface consists of LED panels, an RS232 port, keypad, LCD display, control pushbuttons, and optional user-programmable pushbuttons.

The faceplate is hinged to allow easy access to the removable modules. There is also a removable dust cover that fits over the faceplate that must be removed in order to access the keypad panel. The following figure shows the horizontal arrangement of the faceplate panels.

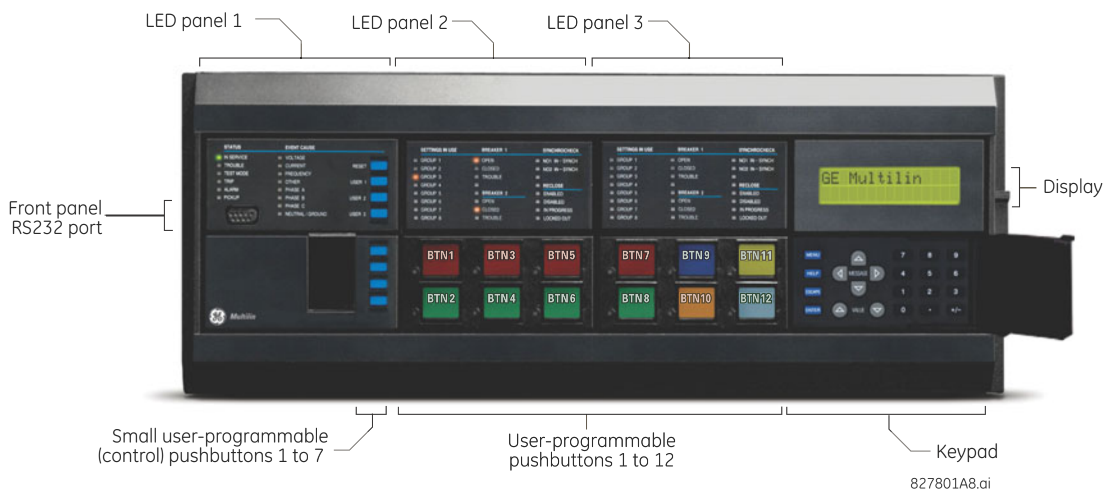

Figure 4–16: UR-SERIES STANDARD HORIZONTAL FACEPLATE PANELS

The following figure shows the vertical arrangement of the faceplate panels for relays ordered with the vertical option.

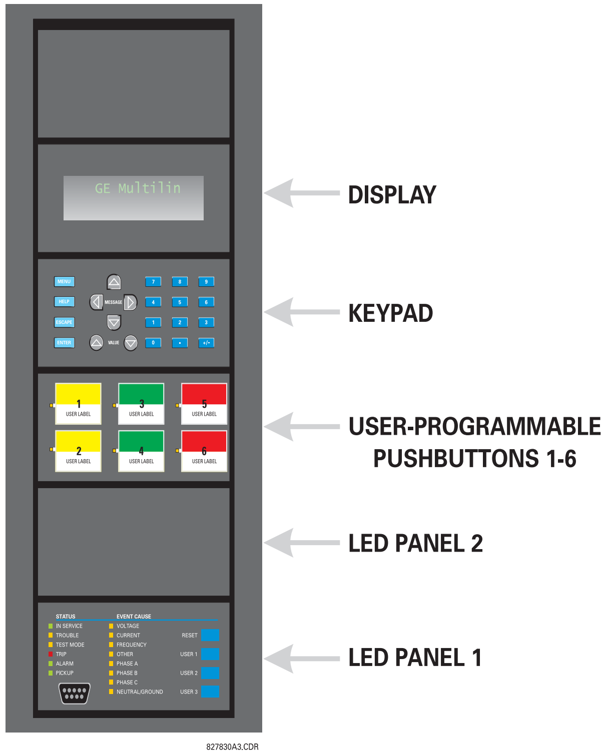

Figure 4–17: UR-SERIES STANDARD VERTICAL FACEPLATE PANELS

4.3.2 LED INDICATORS

a) ENHANCED FACEPLATE

The enhanced front panel display provides five columns of LED indicators. The first column contains 14 status and event cause LEDs, and 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 RS232 port is intended for connection to a portable PC.

The USER keys are used by the breaker control feature.

Figure 4–18: TYPICAL LED INDICATOR PANEL FOR ENHANCED FACEPLATE

The status indicators in the first column are described below.

- **IN SERVICE**: This LED indicates that control power is applied, all monitored inputs, outputs, and internal systems are OK, and that the device has been programmed.

- **TROUBLE**: This LED indicates that the relay has detected an internal problem.
- **TEST MODE**: This LED indicates that the relay is in test mode.
- **TRIP**: This LED indicates that the FlexLogic operand serving as a trip switch has operated. This indicator always latches; as such, a reset command must be initiated to allow the latch to be reset.
- **ALARM**: This LED indicates that the FlexLogic operand serving as an alarm switch has operated. This indicator is never latched.
- **PICKUP**: This LED indicates that an element is picked up. This indicator is never latched.

The event cause indicators in the first column are described below.

Events 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 operate 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 remain 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, etc. 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. Refer to the *User-programmable LEDs* section in chapter 5 for the settings used to program the operation of the LEDs on these panels.

b) STANDARD FACEPLATE

The standard faceplate 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.

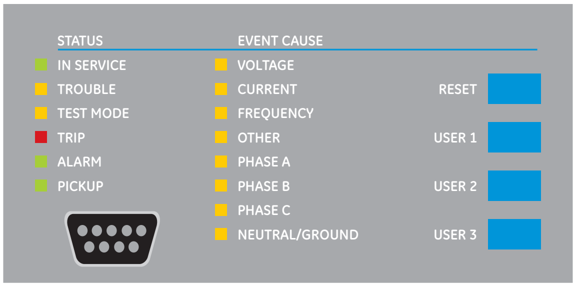

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Figure 4–19: LED PANEL 1

STATUS INDICATORS:

- **IN SERVICE**: Indicates that control power is applied; all monitored inputs/outputs and internal systems are OK; the relay has been programmed.
- **TROUBLE**: Indicates that the relay has detected an internal problem.
- **TEST MODE**: Indicates that the relay is in test mode.
- **TRIP**: Indicates that the selected FlexLogic operand serving as a Trip switch has operated. This indicator always latches; the reset command must be initiated to allow the latch to be reset.
- **ALARM**: Indicates that the selected FlexLogic operand serving as an Alarm switch has operated. This indicator is never latched.
- **PICKUP**: Indicates that an element is picked up. This indicator is never latched.

EVENT CAUSE INDICATORS:

Events 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 operate 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 remain on until the RESET button on the front panel is pressed after the operand is reset.

4

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, etc. 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 provide 48 amber LED indicators whose operation is controlled by the user. Support for applying a customized label beside every LED is provided.

User customization of LED operation is of maximum benefit in installations where languages other than English are used to communicate with operators. Refer to the *User-programmable LEDs* section in chapter 5 for the settings used to program the operation of the LEDs on these panels.

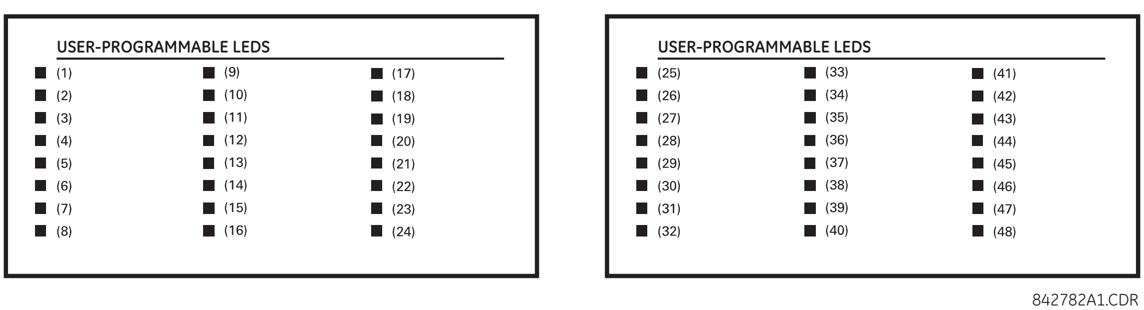


Figure 4–20: LED PANELS 2 AND 3 (INDEX TEMPLATE)

DEFAULT LABELS FOR LED PANEL 2:

The default labels are intended to represent:

- **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(2) 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 following section.

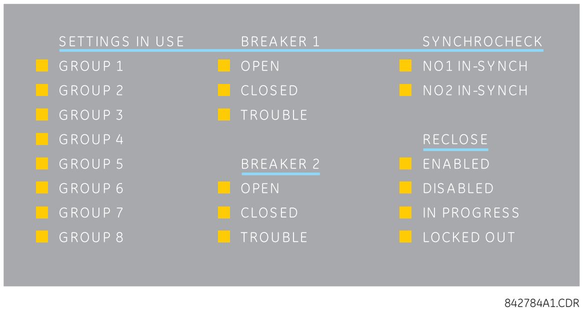


Figure 4–21: LED PANEL 2 (DEFAULT LABELS)

4.3.3 CUSTOM LABELING OF LEDS

a) ENHANCED FACEPLATE

The following procedure requires these pre-requisites:

- EnerVista UR Setup software is installed and operational
- The L30 settings have been saved to a settings file
- The L30 front panel label cutout sheet (GE Multilin part number 1006-0047) has been downloaded from http://www.gedigitalenergy.com/products/support/ur/URLEDenhanced.doc and printed
- Small-bladed knife

To create custom LED labels for the enhanced front panel display:

1. Start the EnerVista UR Setup software.

2. Select the **Front Panel Report** item at the bottom of the menu tree for the settings file. The front panel report window displays.

Figure 4–22: FRONT PANEL REPORT WINDOW

3. Enter the text to appear next to each LED and above each user-programmable pushbuttons in the fields provided.
4. Feed the L30 front panel label cutout sheet into a printer and press the **Print** button in the front panel report window.
5. When printing is complete, fold the sheet along the perforated lines and punch out the labels.
6. Remove the L30 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.

NOTE

It is important that the tool be used EXACTLY as shown below, with the printed side containing the GE part number facing the user.

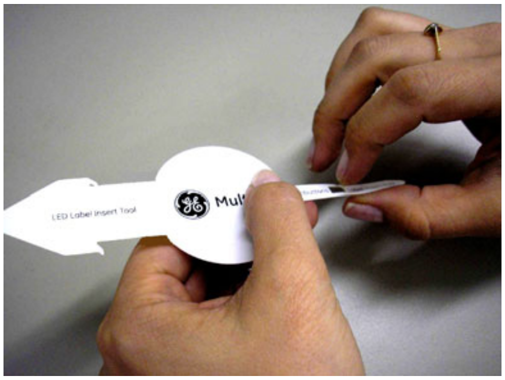
The label package shipped with every L30 contains the three default labels shown below, the custom label template sheet, and the label removal tool.

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, follow the procedures below to remove the original labels and insert the new ones.

The following procedure describes how to setup and use the label removal tool.

1. Bend the tabs at the left end of the tool upwards as shown below.

2. Bend the tab at the center of the tool tail as shown below.



The following procedure describes how to remove the LED labels from the L30 enhanced front panel and insert the custom labels.

1. Use the knife to lift the LED label and slide the label tool underneath. Make sure the bent tabs are pointing away from the relay.

2. Slide the label tool under the LED label until the tabs snap out as shown below. This attaches the label tool to the LED label.

3. Remove the tool and attached LED label as shown below.

4. Slide the new LED label inside the pocket until the text is properly aligned with the LEDs, as shown below.

4

The following procedure describes how to remove the user-programmable pushbutton labels from the L30 enhanced front panel and insert the custom labels.

1. Use the knife to lift the pushbutton label and slide the tail of the label tool underneath, as shown below. Make sure the bent tab is pointing away from the relay.

2. Slide the label tool under the user-programmable pushbutton label until the tabs snap out as shown below. This attaches the label tool to the user-programmable pushbutton label.

3. Remove the tool and attached user-programmable pushbutton label as shown below.

4

4. Slide the new user-programmable pushbutton label inside the pocket until the text is properly aligned with the buttons, as shown below.

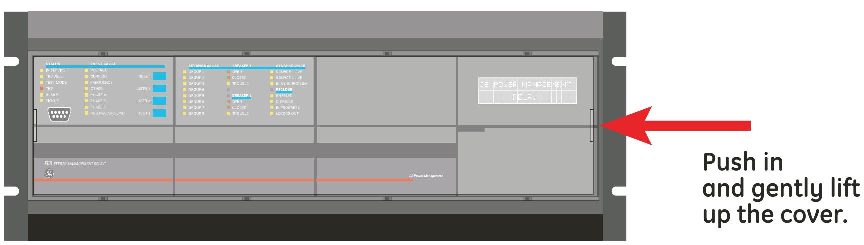
b) STANDARD FACEPLATE

Custom labeling of an LED-only panel is facilitated through a Microsoft Word file available from the following URL:

http://www.gedigitalenergy.com/products/support/ur/GET-8494A.doc

This file provides templates and instructions for creating appropriate labeling for the LED panel. The following procedures are contained in the downloadable file. The panel templates provide relative LED locations and located example text (x) edit boxes. The following procedure demonstrates how to install/uninstall the custom panel labeling.

1. Remove the clear Lexan Front Cover (GE Multilin part number: 1501-0014).



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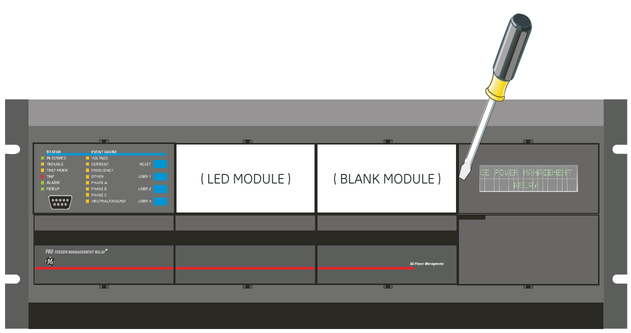
2. Pop out the LED module and/or the blank module with a screwdriver as shown below. Be careful not to damage the plastic covers.



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3. Place the left side of the customized module back to the front panel frame, then snap back the right side.
4. Put the clear Lexan front cover back into place.

The following items are required to customize the L30 display module:

- Black and white or color printer (color preferred)
- Microsoft Word 97 or later software for editing the template
- 1 each of: 8.5" x 11" white paper, exacto knife, ruler, custom display module (GE Multilin Part Number: 1516-0069), and a custom module cover (GE Multilin Part Number: 1502-0015)

The following procedure describes how to customize the L30 display module:

1. Open the LED panel customization template with Microsoft Word. Add text in places of the **LED x** text placeholders on the template(s). Delete unused place holders as required.
2. When complete, save the Word file to your computer for future use.
3. Print the template(s) to a local printer.
4. From the printout, cut-out the Background Template from the three windows, using the cropmarks as a guide.
5. Put the Background Template on top of the custom display module (GE Multilin Part Number: 1513-0069) and snap the clear custom module cover (GE Multilin Part Number: 1502-0015) over it and the templates.

4.3.4 DISPLAY

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

4.3.5 KEYPAD

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 logical subgroups.

The MESSAGE keys navigate through the subgroups. 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 altered setting values.

4.3.6 BREAKER CONTROL

a) INTRODUCTION

The L30 can interface with associated circuit breakers. In many cases the application monitors the state of the breaker, that can be presented on faceplate LEDs, along with a breaker trouble indication. Breaker operations can be manually initiated from faceplate keypad or automatically initiated from a FlexLogic operand. A setting is provided to assign names to each breaker; this user-assigned name is used 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.

For the following discussion it is assumed the **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ BREAKERS ⇨ BREAKER 1(2) ⇨ BREAKER FUNCTION** setting is "Enabled" for each breaker.

b) CONTROL MODE SELECTION AND MONITORING

Installations can require that a breaker is 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 the **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ BREAKERS ⇨ BREAKER 1(2) ⇨⇩ BREAKER 1(2) PUSH BUTTON CONTROL** setting is “Enabled” for each breaker.

c) FACEPLATE (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.

d) CONTROL OF TWO BREAKERS

For the following example setup, the **(Name)** field represents the user-programmed variable name.

For this application (setup shown below), 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 is used to manually close the breaker and the USER 3 key is used to manually open 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; i.e. 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 is displayed 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 items **(1)**, **(2)** and **(3)** below:

4

(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 aborts the breaker control function.

e) 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 above for two breakers.

4.3.7 MENUS

a) NAVIGATION

Press the MENU key to select a header display page (top-level menu). The header title appears momentarily followed by a header display page menu item. Each press of the MENU key advances through the following main heading pages:

- Actual values
- Settings
- Commands
- Targets
- User displays (when enabled)

b) HIERARCHY

The setting and actual value messages are arranged hierarchically. The header display pages are indicated by double scroll bar characters (■■), while sub-header pages are indicated by single scroll bar characters (■). The header display pages represent the highest level of the hierarchy and the sub-header display pages fall below this level. The MESSAGE UP and DOWN keys move within a group of headers, sub-headers, setting values, or actual values. Continually pressing the MESSAGE RIGHT key from a header display displays specific information for the header category. Conversely, continually pressing the MESSAGE LEFT key from a setting value or actual value display returns to the header display.

HIGHEST LEVEL **LOWEST LEVEL (SETTING VALUE)**

```
■■ SETTINGS          ◄►   ■ PASSWORD      ◄►   ACCESS LEVEL:
■■ PRODUCT SETUP          ■ SECURITY           Restricted
        ▲▼
■■ SETTINGS
■■
```

c) EXAMPLE MENU NAVIGATION

■■ ACTUAL VALUES ■■ STATUS	Press the MENU key until the header for the first Actual Values page appears. This page contains system and relay status information. Repeatedly press the MESSAGE keys to display the other actual value headers.
⇩	
■■ SETTINGS ■■ PRODUCT SETUP	Press the MENU key until the header for the first page of Settings appears. This page contains settings to configure the relay.
⇩	
■■ SETTINGS ■■	Press the MESSAGE DOWN key to move to the next Settings page. This page contains settings for . Repeatedly press the MESSAGE UP and DOWN keys to display the other setting headers and then back to the first Settings page header.
⇩	
■ PASSWORD ■ SECURITY	From the Settings page one header (Product Setup), press the MESSAGE RIGHT key once to display the first sub-header (Password Security).
⇩	
ACCESS LEVEL: Restricted	Press the MESSAGE RIGHT key once more and this will display the first setting for Password Security. Pressing the MESSAGE DOWN key repeatedly will display the remaining setting messages for this sub-header.
⇩	
■ PASSWORD ■ SECURITY	Press the MESSAGE LEFT key once to move back to the first sub-header message.
⇩	
■ DISPLAY ■ PROPERTIES	Pressing the MESSAGE DOWN key displays the second setting sub-header associated with the Product Setup header.
⇩	
FLASH MESSAGE TIME: 1.0 s	Press the MESSAGE RIGHT key once more to display the first setting for Display Properties.
⇩	
DEFAULT MESSAGE INTENSITY: 25%	To view the remaining settings associated with the Display Properties subheader, repeatedly press the MESSAGE DOWN key. The last message appears as shown.

4

4.3.8 CHANGING SETTINGS

a) ENTERING 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:   1.0 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 HELP 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 that of any electronic 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 key or pressing the ESCAPE key, returns the original value to the display.
- **VALUE keys**: The VALUE UP key increments the displayed value by the step value, up to the maximum value allowed. While at the maximum value, pressing the VALUE UP key again allows the setting selection to continue upward from the minimum value. The VALUE DOWN key decrements the displayed value by the step value, down to the minimum value. While at the minimum value, pressing the VALUE DOWN key again allows the setting selection to continue downward from the maximum value.

4

```
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. Therefore, press ENTER to store the new value in memory. This flash message momentarily appears as confirmation of the storing process. Numerical values which contain decimal places are rounded-off if more decimal place digits are entered than specified by the step value.

b) ENTERING ENUMERATION DATA

Enumeration settings have data values which are part of a set, whose members are explicitly defined by a name. A set is comprised of 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 key displays the next selection while the VALUE DOWN key displays the previous selection.

```
ACCESS LEVEL:
Setting
```

If the **ACCESS LEVEL** needs to be "Setting", press the VALUE keys until the proper selection is displayed. 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 of the storing process.

c) ENTERING ALPHANUMERIC TEXT

Text settings have data values which are fixed in length, but user-defined in character. 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: to 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.

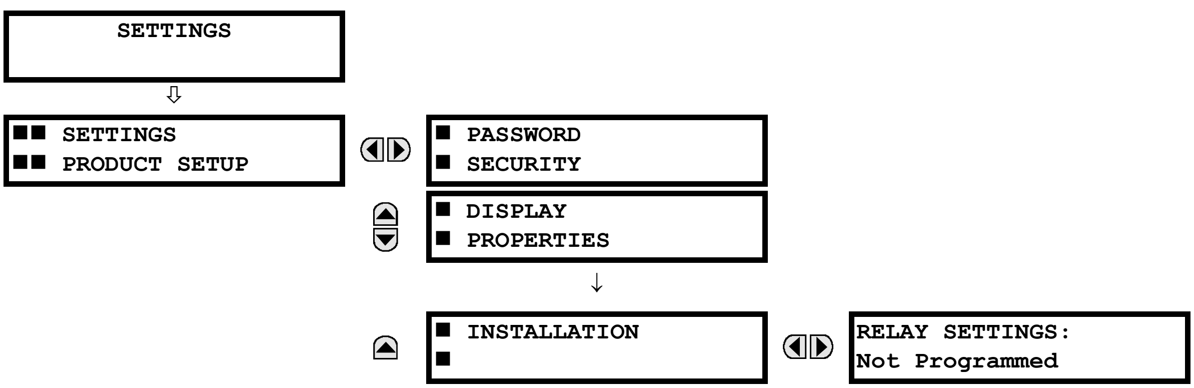
d) ACTIVATING THE RELAY

```
RELAY SETTINGS:
Not Programmed
```

When the relay is powered up, the Trouble LED is on, the In Service LED off, and this message displayed, indicating 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 in the "Programmed" state.

To change the **RELAY SETTINGS**: "Not Programmed" mode to "Programmed", proceed as follows:

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 key until the **PASSWORD SECURITY** message appears on the display.
3. Press the MESSAGE DOWN key until the **INSTALLATION** message appears on the display.
4. Press the MESSAGE RIGHT key until the **RELAY SETTINGS: Not Programmed** message is displayed.



5. After the **RELAY SETTINGS: Not Programmed** message appears on the display, press the VALUE keys change the selection to "Programmed".
6. Press the ENTER key.

```
RELAY SETTINGS:        RELAY SETTINGS:        NEW SETTING
Not Programmed         Programmed             HAS BEEN STORED
```

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

e) ENTERING INITIAL PASSWORDS

The information in this section refers to password security. For information on how to set or change CyberSentry passwords, see the Settings > Product Setup > Security > CyberSentry section in the next chapter.

4

The L30 supports password entry from a local or remote connection.

Local access is defined as any access to settings or commands via the faceplate interface. This includes both keypad entry and the faceplate RS232 connection. Remote access is defined as any access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. Any changes to the local or remote passwords enables this functionality.

To enter the initial setting (or command) password, proceed as follows:

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 key until the **ACCESS LEVEL** message appears on the display.
3. Press the MESSAGE DOWN key until the **CHANGE LOCAL PASSWORDS** message appears on the display.
4. Press the MESSAGE RIGHT key until the **CHANGE SETTING PASSWORD** or **CHANGE COMMAND PASSWORD** message appears on the display.

```
■■ PASSWORD          ◄►   ACCESS LEVEL:
■■ SECURITY               Restricted

                     ◄►   ■ CHANGE LOCAL       ◄►   CHANGE COMMAND
                          ■ PASSWORDS               PASSWORD: No

                                               ▲▼   CHANGE SETTING
                                                    PASSWORD: No

                                               ▲▼   ENCRYPTED COMMAND
                                                    PASSWORD: ---------

                                               ▲    ENCRYPTED SETTING
                                                    PASSWORD: ---------
```

5. After the **CHANGE...PASSWORD** message appears on the display, press the VALUE UP or DOWN key to change the selection to "Yes".
6. Press the ENTER key and the display prompts you to **ENTER NEW PASSWORD**.
7. Type in a numerical password (up to 10 characters) and press the ENTER key.
8. When the **VERIFY NEW PASSWORD** is displayed, re-type in the same password and press ENTER.

```
CHANGE SETTING
PASSWORD: No

CHANGE SETTING            ENTER NEW                 VERIFY NEW
PASSWORD: Yes             PASSWORD: ##########      PASSWORD: ##########

                                                    NEW PASSWORD
                                                    HAS BEEN STORED
```

9. When the **NEW PASSWORD HAS BEEN STORED** message appears, your new Setting (or Command) Password will be active.

f) CHANGING EXISTING PASSWORD

To change an existing password, follow the instructions in the previous section with the following exception. A message prompts you to type in the existing password (for each security level) before a new password can be entered.

g) INVALID PASSWORD ENTRY

When an incorrect command or setting password has been entered via the faceplate interface three times within a 3-minute time span, the LOCAL ACCESS DENIED FlexLogic operand is set to "On" and the L30 does not allow settings or command level access via the faceplate interface for the next five minutes, or in the event that an incorrect Command Or Setting password has been entered via the any external communications interface three times within a 3-minute time span, 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 the next five minutes.

In the event that an incorrect Command or Setting password has been entered via the any external communications interface three times within a three-minute time span, 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 the next ten minutes. The REMOTE ACCESS DENIED FlexLogic operand is set to “Off” after the expiration of the ten-minute timeout.

5.1.1 SETTINGS MENU

■■ SETTINGS ■■ PRODUCT SETUP	■ SECURITY ■	See page 5-8.
	■ DISPLAY ■ PROPERTIES	See page 5-23.
	■ CLEAR RELAY ■ RECORDS	See page 5-25.
	■ COMMUNICATIONS ■	See page 5-26.
	■ MODBUS USER MAP ■	See page 5-55.
	■ REAL TIME ■ CLOCK	See page 5-56.
	■ FAULT REPORTS ■	See page 5-61.
	■ OSCILLOGRAPHY ■	See page 5-63.
	■ DATA LOGGER ■	See page 5-65.
	■ USER-PROGRAMMABLE ■ LEDS	See page 5-66.
	■ USER-PROGRAMMABLE ■ SELF TESTS	See page 5-69.
	■ CONTROL ■ PUSHBUTTONS	See page 5-70.
	■ USER-PROGRAMMABLE ■ PUSHBUTTONS	See page 5-72.
	■ FLEX STATE ■ PARAMETERS	See page 5-77.
	■ USER-DEFINABLE ■ DISPLAYS	See page 5-78.
	■ INSTALLATION ■	See page 5-80.
■■ SETTINGS ■■ SYSTEM SETUP	■ AC INPUTS ■	See page 5-82.
	■ POWER SYSTEM ■	See page 5-83.
	■ SIGNAL SOURCES ■	See page 5-84.
	■ 87L POWER SYSTEM ■	See page 5-87.
	■ BREAKERS ■	See page 5-93.

5

	SWITCHES	See page 5-97.
	FLEXCURVES	See page 5-100.
	PHASOR MEASUREMENT UNIT	See page 5-107.
SETTINGS FLEXLOGIC	FLEXLOGIC EQUATION EDITOR	See page 5-143.
	FLEXLOGIC TIMERS	See page 5-143.
	FLEXELEMENTS	See page 5-144.
	NON-VOLATILE LATCHES	See page 5-148.
SETTINGS GROUPED ELEMENTS	SETTING GROUP 1	See page 5-149.
	SETTING GROUP 2	
	↓	
	SETTING GROUP 6	
SETTINGS CONTROL ELEMENTS	TRIP BUS	See page 5-195.
	SETTING GROUPS	See page 5-197.
	SELECTOR SWITCH	See page 5-199.
	UNDERFREQUENCY	See page 5-205.
	SYNCHROCHECK	See page 5-206.
	AUTORECLOSE	See page 5-210.
	DIGITAL ELEMENTS	See page 5-216.
	DIGITAL COUNTERS	See page 5-219.
	MONITORING ELEMENTS	See page 5-221.
SETTINGS INPUTS / OUTPUTS	CONTACT INPUTS	See page 5-232.

	■ VIRTUAL INPUTS ■	See page 5-234.
	■ CONTACT OUTPUTS ■	See page 5-235.
	■ VIRTUAL OUTPUTS ■	See page 5-237.
	■ REMOTE DEVICES ■	See page 5-238.
	■ REMOTE INPUTS ■	See page 5-240.
	■ REMOTE DPS INPUTS ■	See page 5-241.
	■ REMOTE OUTPUTS ■ DNA BIT PAIRS	See page 5-241.
	■ REMOTE OUTPUTS ■ UserSt BIT PAIRS	See page 5-242.
	■ DIRECT ■	See page 5-242.
	■ RESETTING ■	See page 5-245.
	■ IEC 61850 ■ GOOSE ANALOGS	See page 5-245.
	■ IEC 61850 ■ GOOSE UINTEGERS	See page 5-246.
■■ SETTINGS ■■ TRANSDUCER I/O	■ DCMA INPUTS ■	See page 5-247.
	■ RTD INPUTS ■	See page 5-248.
	■ DCMA OUTPUTS ■	See page 5-250.
■■ SETTINGS ■■ TESTING	TEST MODE FUNCTION: Disabled	See page 5-253.
	TEST MODE FORCING: On	See page 5-253.
	■ FORCE CONTACT ■ INPUTS	See page 5-254.
	■ FORCE CONTACT ■ OUTPUTS	See page 5-255.
	■ CHANNEL TESTS ■	See page 5-256.
	■ PMU ■ TEST VALUES	See page 5-256.

5

5.1.2 INTRODUCTION TO ELEMENTS

In the design of UR relays, 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 will set the output to logic 1, also referred to as *setting the flag*. A single comparator may 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 parameter actual values as the input.

NOTE

The exception to the above rule are the 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 the element logic diagram. This includes the inputs, settings, fixed logic, and the output operands generated (abbreviations used on scheme logic diagrams are defined in Appendix F).

Some settings for current and voltage elements are specified in per-unit (pu) calculated quantities:

pu quantity = (actual quantity) / (base quantity)

For current elements, the *base quantity* is the nominal secondary or primary current of the CT.

Where the current source is the sum of two CTs with different ratios, the base quantity will be the common secondary or primary current to which the sum is scaled (that is, normalized to the larger of the two rated CT inputs). For example, if CT1 = 300 / 5 A and CT2 = 100 / 5 A, then in order to sum these, CT2 is scaled to the CT1 ratio. In this case, the base quantity will be 5 A secondary or 300 A primary.

For voltage elements the base quantity is the nominal primary voltage of the protected system which corresponds (based on VT ratio and connection) to secondary VT voltage applied to the relay.

For example, on a system with a 13.8 kV nominal primary voltage and with 14400:120 V delta-connected VTs, the secondary nominal voltage (1 pu) would be:

$$\frac{13800}{14400} \times 120 = 115 \text{ V} \qquad \textbf{(EQ 5.1)}$$

For wye-connected VTs, the secondary nominal voltage (1 pu) would be:

$$\frac{13800}{14400} \times \frac{120}{\sqrt{3}} = 66.4 \text{ V} \qquad \textbf{(EQ 5.2)}$$

Many settings are common to most elements and are discussed below:

- **FUNCTION setting:** This setting programs the element to be operational when selected as “Enabled”. The factory default is “Disabled”. Once programmed to “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 parameter or set of parameters to be monitored.
- **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 may be provided to define the range of the measured parameters which will cause the element to pickup.
- **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 faceplate 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 will remain 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 could happen when the element is in the operate state if the reset delay time is not 0.

5.1.3 INTRODUCTION TO AC SOURCES

a) BACKGROUND

The L30 may 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 3I_0 residual currents may be required for the circuit relaying and metering functions. For a three-winding transformer application, it may be required to calculate watts and vars for each of three windings, using voltage from different sets of VTs. These requirements can be satisfied with a single UR, equipped with sufficient CT and VT input channels, by selecting the 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 parameter(s) to measure is partially performed by the design of a measuring element or protection/control comparator by identifying the type of parameter (fundamental frequency phasor, harmonic phasor, symmetrical component, total waveform RMS magnitude, phase-phase or phase-ground voltage, etc.) to measure. The user completes the process by selecting the instrument transformer input channels to use and some of the parameters calculated from these channels. The input parameters available include the summation of currents from multiple input channels. For the summed currents of phase, 3I_0, 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 UR series 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 may contain all or some of the following signals: three-phase currents, single-phase ground current, three-phase voltages and an auxiliary voltage from a single VT for checking for synchronism.

To illustrate the concept of sources, as applied to current inputs only, consider the breaker-and-a-half scheme below. In this application, the current flows as shown by the arrows. Some current flows through the upper bus bar to some other location or power equipment, and some current flows into transformer winding 1. The current into winding 1 is the phasor sum (or difference) of the currents in CT1 and CT2 (whether the sum or difference is used depends on the relative polarity of the CT connections). The same considerations apply to transformer winding 2. The protection elements require access to the net current for transformer protection, but some elements may need access to the individual currents from CT1 and CT2.

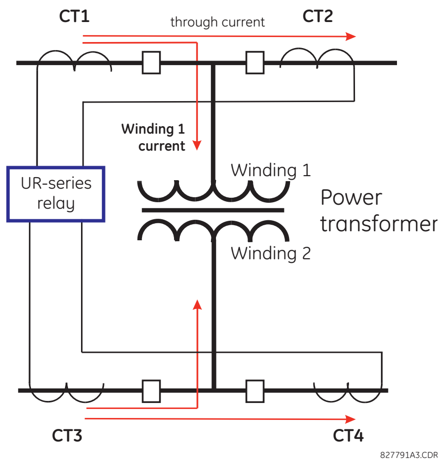


Figure 5–1: BREAKER-AND-A-HALF SCHEME

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 UR series of relays, provisions have been included for all the current signals to be brought to the UR device where grouping, ratio correction and summation are applied internally via configuration settings.

A major advantage of using internal summation is that the individual currents are available to the protection device; for example, as additional information to calculate a restraint current, or to allow the provision of additional protection 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 will be 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 given a specific name through the settings, and becomes available to protection and metering elements in the UR platform. Individual names can be given to each source to help identify them more clearly for later use. For example, in the scheme shown in the above diagram, the user configures one source to be the sum of CT1 and CT2 and can name this source as “Wdg1 I”.

Once the sources have been configured, the user has them available as selections for the choice of input signal for the protection elements and as metered quantities.

b) CT/VT MODULE CONFIGURATION

CT and 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 may 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 three 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 shown below.

ITEM	MAXIMUM NUMBER
CT/VT Module	2
CT Bank (3 phase channels, 1 ground channel)	8
VT Bank (3 phase channels, 1 auxiliary channel)	4

5

c) CT/VT INPUT CHANNEL CONFIGURATION

Upon relay startup, configuration settings for every bank of current or voltage input channels in the relay are automatically generated from the order code. Within each bank, a channel identification label is automatically assigned 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.

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 set of three channels.

Upon startup, the CPU configures the settings required to characterize the current and voltage inputs, and will display them in the appropriate section in the sequence of the banks (as described above) as follows for a maximum configuration: F1, F5, L1, L5, S1, and S5.

The above section explains how the input channels are identified and configured to the specific application instrument transformers and the connections of these transformers. The specific parameters to be used by each measuring element and comparator, and some actual values are controlled by selecting a specific source. The source is a group of current and voltage input channels selected by the user to facilitate this selection. With this mechanism, a user does not have to make multiple selections of voltage and current for those elements that need both parameters, such as a distance element or a watt calculation. It also gathers associated parameters for display purposes.

The basic idea of arranging a source is to select a point on the power system where information is of interest. An application example of the grouping of parameters in a source is a transformer winding, on which a three phase voltage is measured, and the sum of the currents from CTs on each of two breakers is required to measure the winding current flow.

5.2.1 SECURITY

a) SECURITY OVERVIEW

The following security features are available:

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

b) LOST PASSWORD

If all passwords are lost, recovery is possible by resetting the unit to default values.

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 > Commands Relay Maintenance > Service Command**.
3. Change the default password of ChangeMe1# as outlined in the Set Up CyberSentry and Change Default Password section in the first chapter.

c) PASSWORD REQUIREMENTS

For password security and CyberSentry security, 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 6 to 20 characters in length
- Password must contain characters from three of the following four categories:

  - English uppercase characters (A through Z)

  - English lowercase characters (a through z)

  - Base 10 digits (0 through 9)

  - Non-alphabetic characters (for example, ~, !, @, #, $,%, &)

d) PASSWORD SECURITY

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY

■ SECURITY ■	◁▷	ACCESS LEVEL: Restricted	Range: Restricted, Command, Setting, Factory Service (for factory use only)
MESSAGE	△▽	■ CHANGE LOCAL ■ PASSWORDS	See page 5-9.
MESSAGE	△▽	■ ACCESS ■ SUPERVISION	See page 5-10.
MESSAGE	△▽	■ DUAL PERMISSION ■ SECURITY ACCESS	See page 5-11.
MESSAGE	△	PASSWORD ACCESS EVENTS: Disabled	Range: Disabled, Enabled

The L30 supports password entry from a local or remote connection.

Local access is defined as any access to settings or commands via the faceplate interface. This includes both keypad entry and the through the faceplate RS232 port. Remote access is defined as any access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. Any changes to the local or remote passwords 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 faceplate, the local password must be used.

The **PASSWORD ACCESS EVENTS** settings allows recording of password access events in the event recorder.

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 UR Setup 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

NOTE: A command or setting write operation is required to update the state of all the remote and local security operands shown above.

5

LOCAL PASSWORDS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩ CHANGE LOCAL PASSWORDS

■ CHANGE LOCAL ■ PASSWORDS		CHANGE COMMAND PASSWORD: No	Range: No, Yes
	MESSAGE	CHANGE SETTING PASSWORD: No	Range: No, Yes
	MESSAGE	ENCRYPTED COMMAND PASSWORD: ----------	Range: 0 to 9999999999 Note: ---------- indicates no password
	MESSAGE	ENCRYPTED SETTING PASSWORD: ----------	Range: 0 to 9999999999 Note: ---------- indicates no password

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 will be allowed. Accessibility automatically reverts to the “Restricted” level according to the access level timeout setting values.

NOTE: If the setting and command passwords are identical, then this one password allows access to both commands and settings.

NOTE: If a remote connection is established, local passcodes are not visible.

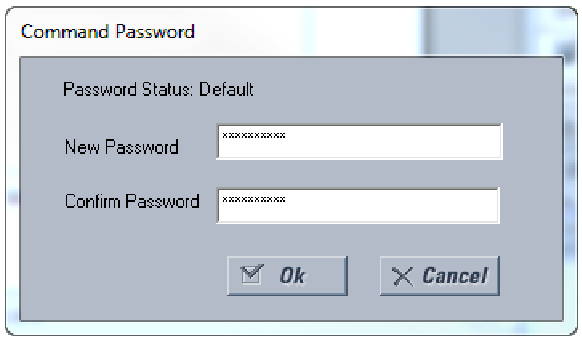
REMOTE PASSWORDS

The remote password settings are visible only from a remote connection via the EnerVista UR Setup software.

Proper passwords are required to enable each command or setting level access.

To set the command or setting password:

1. In the EnerVista software, 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 at the beginning of the 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 is meets requirements.



NOTE: If you establish a local connection to the relay (serial), you cannot view remote passcodes.

ACCESS SUPERVISION

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩ ACCESS SUPERVISION

■ ACCESS ■ SUPERVISION		■ ACCESS LEVEL ■ TIMEOUTS	
	MESSAGE	INVALID ATTEMPTS BEFORE LOCKOUT: 3	*Range: 2 to 5 in steps of 1*
	MESSAGE	PASSWORD LOCKOUT DURATION: 5 min	*Range: 5 to 60 minutes in steps of 1*

The following access supervision settings are available.

- **INVALID ATTEMPTS BEFORE LOCKOUT**: This setting specifies the number of times 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 will lockout 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. Should password verification fail 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, the command level should be password-protected. The operand does not generate events or targets.

The access level timeout settings are shown below.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩ ACCESS SUPERVISION ⇨ ACCESS LEVEL TIMEOUTS

■ ACCESS LEVEL ■ TIMEOUTS	◀▶	COMMAND LEVEL ACCESS TIMEOUT: 5 min	*Range: 5 to 480 minutes in steps of 1*
MESSAGE	▲	SETTING LEVEL ACCESS TIMEOUT: 30 min	*Range: 5 to 480 minutes in steps of 1*

These settings allow the user to specify the length of inactivity required before returning to the restricted access level. Note that the access level will set as restricted if 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

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩ DUAL PERMISSION SECURITY ACCESS

■ DUAL PERMISSION ■ SECURITY ACCESS	◀▶	LOCAL SETTING AUTH: On	*Range: selected FlexLogic operands (see below)*
MESSAGE	▲▼	REMOTE SETTING AUTH: On	*Range: FlexLogic operand*
MESSAGE	▲	ACCESS AUTH TIMEOUT: 30 min.	*Range: 5 to 480 minutes in steps of 1*

The dual permission security access feature provides a mechanism for customers to prevent unauthorized or unintended upload of settings to a relay through the local or remote interfaces 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 (set as 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 is displayed on the front panel.
- **REMOTE SETTING AUTH**: This setting is used for remote (Ethernet or RS485 interfaces) 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.
- **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 continuously monitored 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 is updated every 5 seconds.

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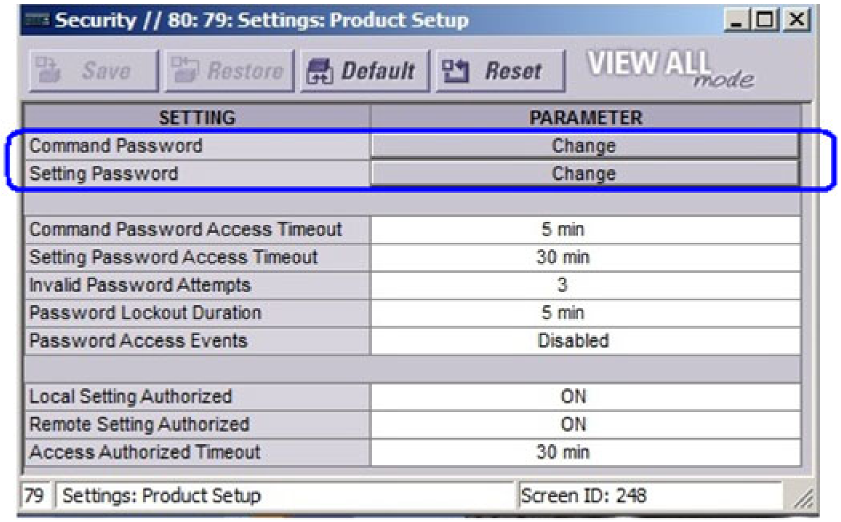
The following settings are available through the remote (EnerVista UR Setup) interface only. Select the **Settings > Product Setup > Security** menu item to display the security settings window.



The **Remote Settings Authorized** setting is used for remote (Ethernet or RS485 interfaces) 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.

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The **Access Authorized Timeout** setting represents the timeout delay remote setting access. This setting is applicable 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 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 is updated every 5 seconds.

e) ENERVISTA SECURITY

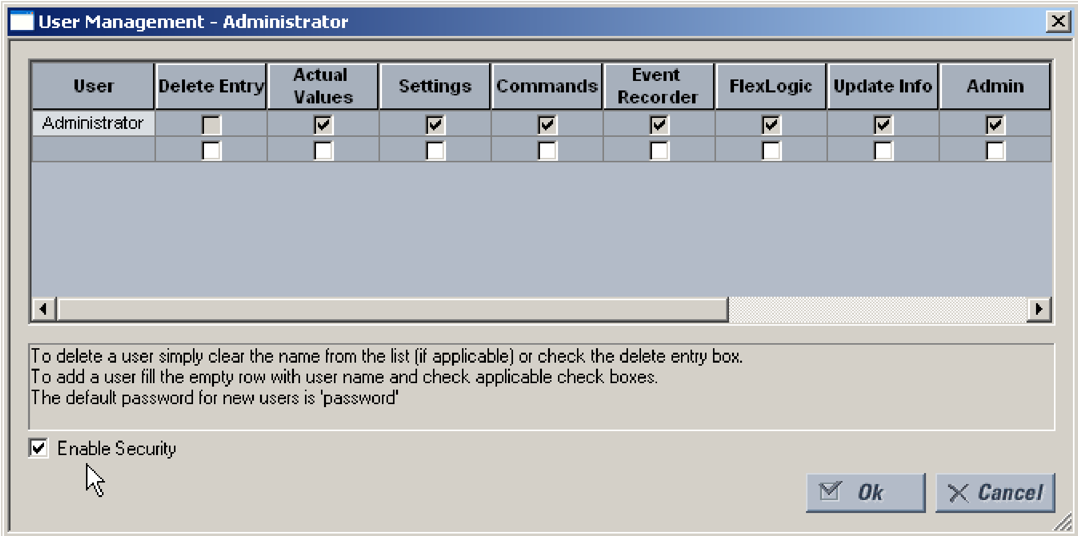
ENABLING THE SECURITY MANAGEMENT SYSTEM

The EnerVista security system allows an administrator to manage access privileges of multiple users to the EnerVista application.

It is disabled by default to allow the administrator direct access to the EnerVista software 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 item to open the user management window.



2. Check the **Enable Security** box in the lower-left corner to enable the security management system.

Security is now enabled for the EnerVista UR Setup software. Upon starting the software, users are now required to enter a username and password.

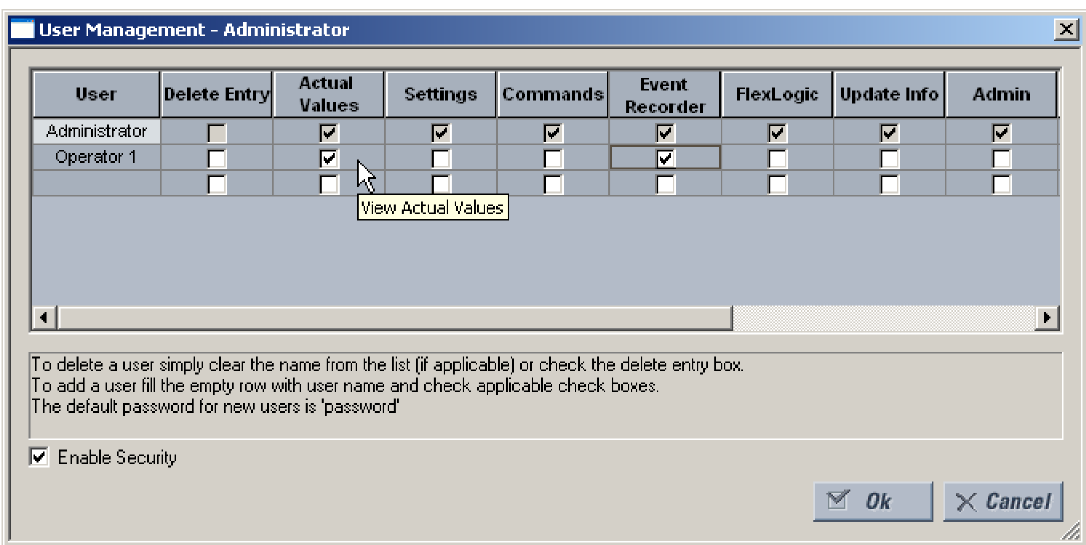
ADDING A NEW USER

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 user accounts:

1. Select the **Security > User Management** menu item to open the user management window.
2. Enter a username in the **User** field. The username must be 4 to 20 characters in length.
3. Select the user access rights by enabling the check box of one or more of the 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 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 checked, even if the Update Info field is checked.
Admin	The user is an EnerVista UR Setup administrator, therefore receiving all of the administrative rights. Exercise caution when granting administrator rights.

4. Click **OK** to add the user account to the security management system.

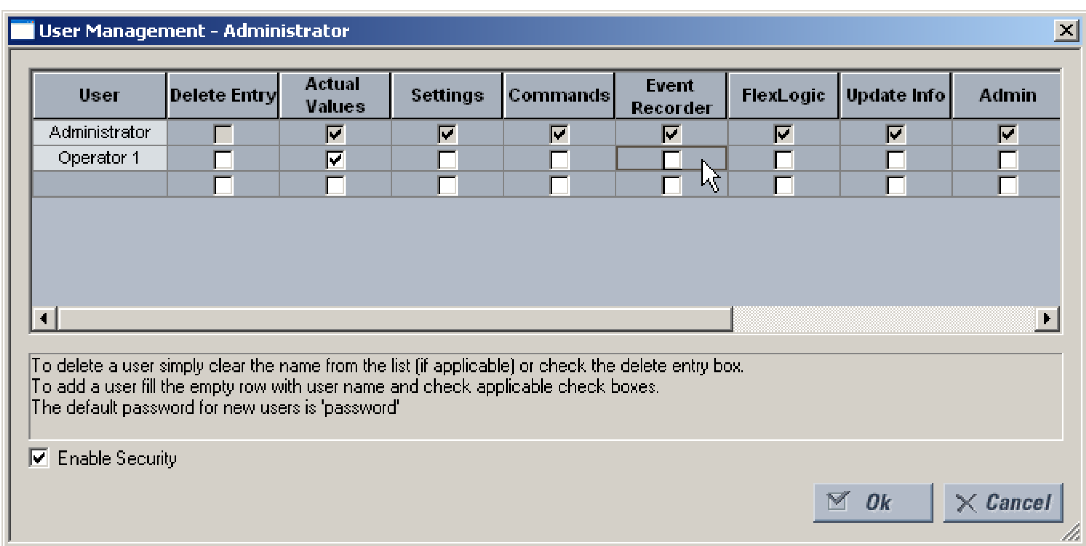
MODIFYING USER PRIVILEGES

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

To modify user privileges:

1. Select the **Security > User Management** menu item to open the user management window.
2. Locate the username in the **User** field.
3. 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

Table 5–2: ACCESS RIGHTS SUMMARY

FIELD	DESCRIPTION
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 checked, even if the Update Info field is checked.
Admin	The user is an EnerVista UR Setup administrator, therefore receiving all of the administrative rights. Exercise caution when granting administrator rights.

4. Click **OK** to save the changes.

f) CYBERSENTRY SECURITY

The EnerVista software provides the means to configure and authenticate UR using either device or server authentication. The access to various pieces of functionality depends on user role.

The login screen of EnerVista has two options for access to the UR, server and device authentication.

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 built-in roles (Administrator, Engineer, Supervisor, Observer, Operator) as login accounts and the associated passwords are stored on the UR 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.

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 are they ever transmitted without cryptographic protection.

CYBERSENTRY SETTINGS THROUGH ENERVISTA

CyberSentry security settings are configured under **Device > Settings > Product Setup > Security**.

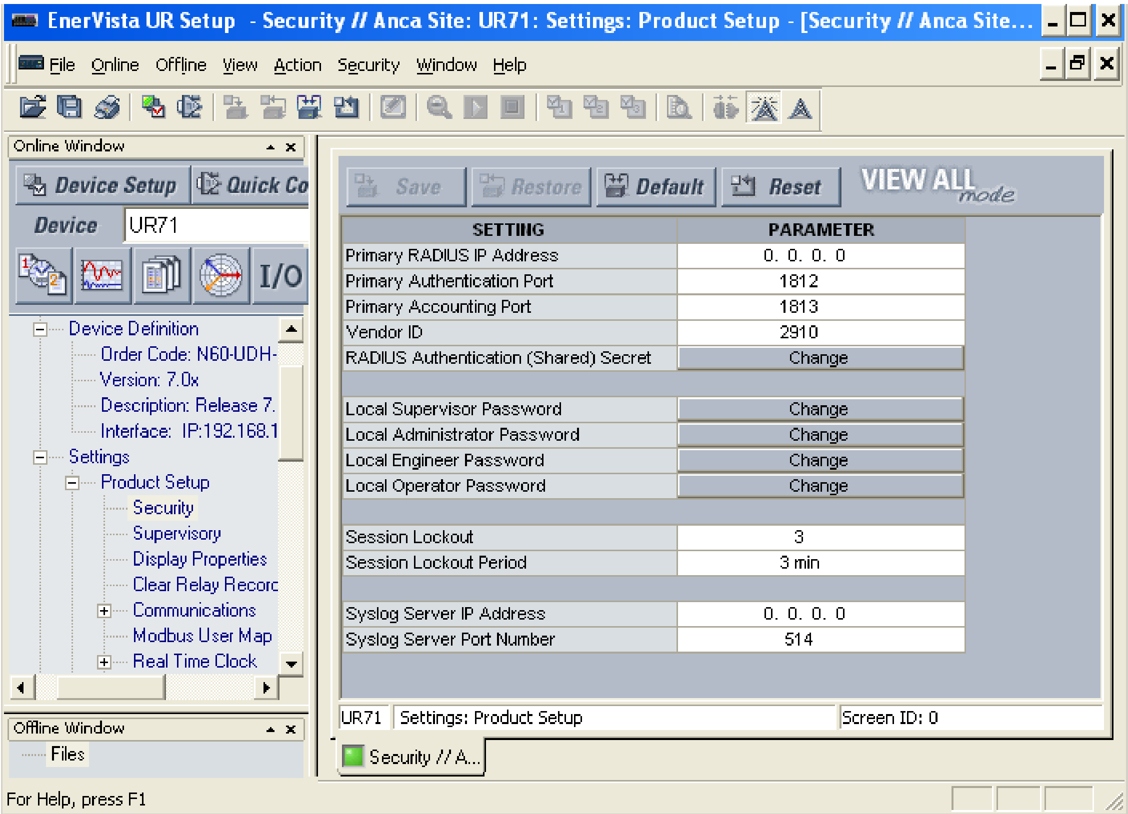


Figure 5–2: CYBERSENTRY SECURITY PANEL

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For the **Device > Settings > Product Setup > Supervisory** option, the panel looks like the following.

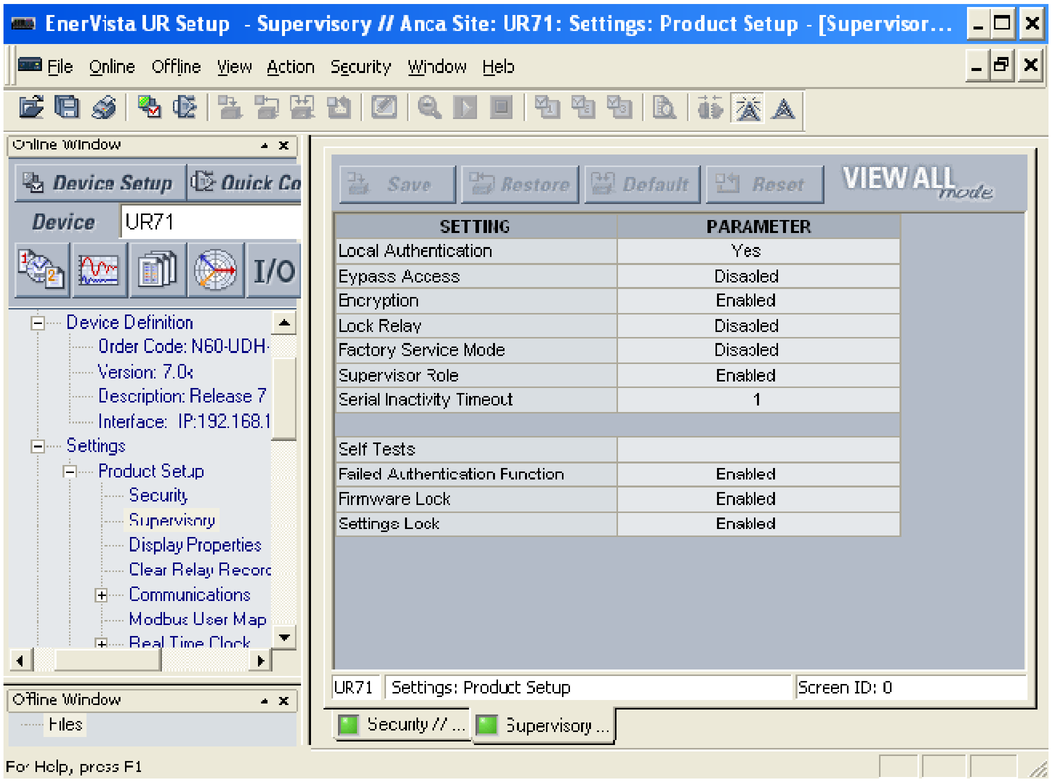

Figure 5–3: SUPERVISORY PANEL

For the Security panel, the following settings are available.

RADIUS Server Settings

SETTING NAME	DESCRIPTION	MIN	MAX	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.	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 (Shared) Secret	Shared secret used in authentication. It displays as asterisks. This setting must meet the CyberSentry password requirements.	See the following password section for requirements	See the following password section for requirements	N/A	-	Administrator
RADIUS Authentication Method	Authentication method used by RADIUS server. Currently fixed to EAP-TTLS.	EAP-TTLS	EAP-TTLS	EAP-TTLS	-	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 following password section for requirements	245 characters	N/A	-	Administrator

General Security Settings

SETTING NAME	DESCRIPTION	MIN	MAX	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
Firmware Locked	Indicates if the device receives firmware upgrades. If Yes 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.	No	Yes	Yes	-	Administrator
Factory Service Mode	When enabled (checkbox selected), 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 (checkbox selected), 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	Ensure 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 following password section for requirements	See the following password section for requirements	Change Me1#	Text	The specified role and Administrator, except for Supervisor, where it is only itself

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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 Boolean value indicating if the device can receive a firmware upgrade. If Yes and a firmware upgrade attempt is made, the device alarm activates. If No the device alarm does not activate. On each firmware upgrade this setting goes back to the default.	No	Yes	Yes	-	Administrator
Settings lock	A Boolean value indicating if the device can accept any settings changes. If Yes and a settings change attempt is made, the device alarm activates. If No, the device alarm does not activate.	No	Yes	Yes	-	Supervisor (Administrator if Supervisor has been disabled)

CYBERSENTRY SETTINGS THROUGH THE FRONT PANEL

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY

■ SECURITY ■		LOGIN: None	Range: Administrator, Engineer, Supervisor, Operator, Factory (for factory use only), None
	MESSAGE	■ CHANGE LOCAL ■ PASSWORDS	See page 5-20.
	MESSAGE	■ SESSION ■ SETTINGS	See page 5-20.
	MESSAGE	■ RESTORE DEFAULTS ■	See page 5-20.
	MESSAGE	■ SUPERVISORY ■	See page 5-21.
	MESSAGE	SYSLOG IP ADDRESS: 0.0.0.0	Range: 0.0.0.0, 255.255.255.255
	MESSAGE	SYSLOG PORT NUMBER: 514	Range: 1 to 65535

Login: This setting is applicable for *Device Authentication* only. This setting allows a user to login with a specific role, see descriptions below. For the Supervisor role, the “Supervisor Role” setting should be enabled.

Whenever a new role is logged in, the user is prompted with a display to enter a password. Passwords must obey the requirements specified the Password Requirements section in chapter 8.The UR device supports five roles. All roles have their corresponding passwords. The Observer role is the only role that does not require a password.

The roles are defined as follows:

- Administrator: Complete read and 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 and write access to all settings and commands with the exception of 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 command 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 Supervisor can set the Settings and Firmware Lock in the Security Settings. This role also has the ability to forcefully logoff 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 UR 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.

NOTE: The Factory service role is not available and is intended for factory use only.

Local Passwords

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩ CHANGE LOCAL PASSWORDS

■ CHANGE LOCAL ■ PASSWORDS	◀▶	LOGIN: None	Range: 20 Alphanumeric Characters
MESSAGE	▲▼	NEW PASSWORD:	Range: 20 Alphanumeric Characters
MESSAGE	▲	CONFIRM PASSWORD:	Range: 20 Alphanumeric Characters

The Change Local Passwords menu is shown on the front panel and Enervista on a successful login of Administrator role.

The "login setting" in this menu is similar to the login setting described in **PATH: SETTINGS > PRODUCT SETUP > SECURITY** except for the factory role.

Passwords are stored in text format. No encryption is applied.

NOTE: **Notes:**

- 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.
- 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

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩ SESSION SETTINGS

■ SESSION ■ SETTINGS	◀▶	SESSION LOCKOUT: 3	Range: 0 to 99
MESSAGE	▲	SESSION LOCKOUT PERIOD: 3 min	Range: 0 to 9999 minutes

The following session settings are available.

- **SESSION LOCKOUT**: This setting specifies the number of failed authentications (the default is three and the maximum is 99) 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 (the default is three and the maximum is 9999). A value of 0 means that there is no lockout period.

Restore Defaults

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩ RESTORE DEFAULTS

■ 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

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩SUPERVISORY

■ SUPERVISORY ■	DEVICE AUTHENTICATION:Yes	*Range: Yes, No*
MESSAGE	BYPASS ACCESS: Disabled	*Range: Local, Remote, Local and Remote, Disabled*
MESSAGE	LOCK RELAY: Disabled	*Range: Enabled, Disabled*
MESSAGE	FACTORY SERVICE: MODE: Disabled	*Range: Enabled, Disabled*
MESSAGE	■ SELF TESTS ■	See below
MESSAGE	SUPERVISOR ROLE: Disabled	*Range: Enabled, Disabled*
MESSAGE	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 setting 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

Lock Relay: This setting uses a Boolean value (Enable/Disable) to indicate if the device accepts setting changes and whether the device can receive a firmware upgrade. This setting can be changed only by the Supervisor role, if it is enabled or by the Administrator if the Supervisor role is disabled. The Supervisor role enables this setting for the relay to start accepting setting changes or command changes or firmware upgrade. After all the setting changes are applied or commands executed, the Supervisor disables to lock setting changes.

Example: If this setting is "Yes" and an attempt is made to change settings or upgrade the firmware, the UR device denies the setting changes and denies upgrading the firmware. If this setting is "No", the UR device accepts setting changes and firmware upgrade.

This role is disabled by default.

Factory Service Mode: When enabled (i.e., "Yes" is selected) 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 (i.e., "Yes" is selected) the Supervisor role is active. When "No" is selected this role is disabled. To disabled this setting a Supervisor authentication is necessary. If disabled, the Supervisor role is not allowed to log on. 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 his role after authentication, the Supervisor session remains valid until he switches to another role using MMI or until he ends 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.

a) SELF TESTS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩SUPERVISORY ⇨SELF TESTS

■ SELF TESTS ■	◀▶	■ FAILED ■ AUTHENTICATE	See below
MESSAGE	▲▼	FIRMWARE LOCK: Enabled	*Range: Enabled, Disabled*
MESSAGE	▲▼	SETTINGS LOCK: Enabled	*Range: Enabled, Disabled*

Failed Authentications: 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 FIRMWARE UPGRADE” setting is set to “Yes” 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.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY ⇨⇩SUPERVISORY ⇨SELF TESTS ⇨FAILED AUTHENTICATE

■ FAILED ■ AUTHENTICATE	◀▶	FAILED AUTHENTICATE: Enabled	*Range: Enabled, Disabled*

CYBERSENTRY SETUP

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 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.

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 gives an example of how to setup a simple RADIUS server. Once both the RADIUS server and the parameters for connecting 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.

NOTICE 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 no allow multiple instances (Administrator, Supervisor, Engineer, Operator) must switch to None (equivalent to a logout) when they are done in order to log out.

NOTICE For all user roles except Observer, only one instance can be logged in at one 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.
5. 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:

1. 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**.

5.2.2 DISPLAY PROPERTIES

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ DISPLAY PROPERTIES

■ DISPLAY ■ PROPERTIES		LANGUAGE: English	Range: *English; English, French; English, Russian; English, Chinese (range dependent on order code)*
	MESSAGE	FLASH MESSAGE TIME: 1.0 s	Range: *0.5 to 10.0 s in steps of 0.1*
	MESSAGE	DEFAULT MESSAGE TIMEOUT: 300 s	Range: *10 to 900 s in steps of 1*
	MESSAGE	DEFAULT MESSAGE INTENSITY: 25 %	Range: *25%, 50%, 75%, 100%* *Visible only if a VFD is installed*
	MESSAGE	SCREEN SAVER FEATURE: Disabled	Range: *Disabled, Enabled* *Visible only if an LCD is installed*
	MESSAGE	SCREEN SAVER WAIT TIME: 30 min	Range: *1 to 65535 min. in steps of 1* *Visible only if an LCD is installed*
	MESSAGE	CURRENT CUT-OFF LEVEL: 0.020 pu	Range: *0.002 to 0.020 pu in steps of 0.001*
	MESSAGE	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. The range is dependent on the order code of the relay.
- **FLASH MESSAGE TIME**: Flash messages are status, warning, error, or information messages displayed for several seconds in response to certain key presses during setting programming. These messages override any normal messages. The duration of a flash message on the display can be changed to accommodate different reading rates.
- **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 via this setting to ensure messages remain on the screen long enough during programming or reading of actual values.
- **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.
- **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 is turned off after the **DEFAULT MESSAGE TIMEOUT** followed by the **SCREEN SAVER WAIT TIME**, providing that no keys have been pressed and no target messages are active. When a keypress occurs or a target becomes active, the LCD backlighting is turned on.
- **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 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 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 that 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.

5

- **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 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 as shown below. For Delta connections:

$$\text{3-phase power cut-off} = \frac{\sqrt{3} \times \textbf{CURRENT CUT-OFF LEVEL} \times \textbf{VOLTAGE CUT-OFF LEVEL} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}} \quad \textbf{(EQ 5.3)}$$

For Wye connections:

$$\text{3-phase power cut-off} = \frac{3 \times \textbf{CURRENT CUT-OFF LEVEL} \times \textbf{VOLTAGE CUT-OFF LEVEL} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}} \quad \textbf{(EQ 5.4)}$$

$$\text{per-phase power cut-off} = \frac{\textbf{CURRENT CUT-OFF LEVEL} \times \textbf{VOLTAGE CUT-OFF LEVEL} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}} \quad \textbf{(EQ 5.5)}$$

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** x **PHASE VT RATIO** = 66.4 V x 208 = 13811.2 V

The power cut-off is therefore:

power cut-off = (**CURRENT CUT-OFF LEVEL** × **VOLTAGE CUT-OFF LEVEL** × CT primary × VT primary)/VT secondary
= ($\sqrt{3}$ × 0.02 pu × 1.0 V × 100 A × 13811.2 V) / 66.4 V
= 720.5 watts

Any calculated power value below this cut-off will not be displayed. As well, the three-phase energy data will not accumulate if the total power from all three phases does not exceed the power cut-off.

NOTE

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.

5.2.3 CLEAR RELAY RECORDS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ CLEAR RELAY RECORDS

■ CLEAR RELAY ■ RECORDS		CLEAR FAULT REPORTS: Off	Range: FlexLogic operand
	MESSAGE	CLEAR EVENT RECORDS: Off	Range: FlexLogic operand
	MESSAGE	CLEAR OSCILLOGRAPHY? No	Range: FlexLogic operand
	MESSAGE	CLEAR DATA LOGGER: Off	Range: FlexLogic operand
	MESSAGE	CLEAR ARC AMPS 1: Off	Range: FlexLogic operand
	MESSAGE	CLEAR ARC AMPS 2: Off	Range: FlexLogic operand
	MESSAGE	CLEAR CHNL STATUS: Off	Range: FlexLogic operand
	MESSAGE	RESET UNAUTH ACCESS: Off	Range: FlexLogic operand

Selected records can be cleared from user-programmable conditions with FlexLogic operands. Assigning user-programmable pushbuttons to clear specific records are typical applications 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, the following settings should be applied.

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”

5.2.4 COMMUNICATIONS

a) MAIN MENU

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS

■ COMMUNICATIONS ■		■ SERIAL PORTS ■	See below.
	MESSAGE	■ NETWORK ■	See page 5–29.
	MESSAGE	■ ROUTING ■	See page 5–31.
	MESSAGE	■ MODBUS PROTOCOL ■	See page 5–34.
	MESSAGE	■ DNP PROTOCOL ■	See page 5–34.
	MESSAGE	■ DNP / IEC104 ■ POINT LISTS	See page 5–37.
	MESSAGE	■ IEC 61850 PROTOCOL ■	See page 5–38.
	MESSAGE	■ WEB SERVER ■ HTTP PROTOCOL	See page 5–53.
	MESSAGE	■ TFTP PROTOCOL ■	See page 5–53.
	MESSAGE	■ IEC 60870-5-104 ■ PROTOCOL	See page 5–54.

b) SERIAL PORTS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨ SERIAL PORTS

■ SERIAL PORTS ■		RS485 COM2 BAUD RATE: 19200	*Range: 300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 57600, 115200*
	MESSAGE	RS485 COM2 PARITY: None	*Range: None, Odd, Even*
	MESSAGE	RS485 COM2 RESPONSE MIN TIME: 0 ms	*Range: 0 to 1000 ms in steps of 10*

The L30 is equipped with up to two independent serial communication ports. The faceplate RS232 port is intended for local use and is fixed at 19200 baud and no parity. The rear COM2 port is RS485. The RS485 port 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 EnerVista UR Setup. This software can 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.

NOTE

For the RS485 port, the minimum time before the port transmits after receiving data from a host can be set. This feature allows operation with hosts which hold the RS485 transmitter active for some time after each transmission.

c) ETHERNET NETWORK TOPOLOGY

When using more than one Ethernet port, configure each to belong to a different network or subnet using the IP addresses and mask, else 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

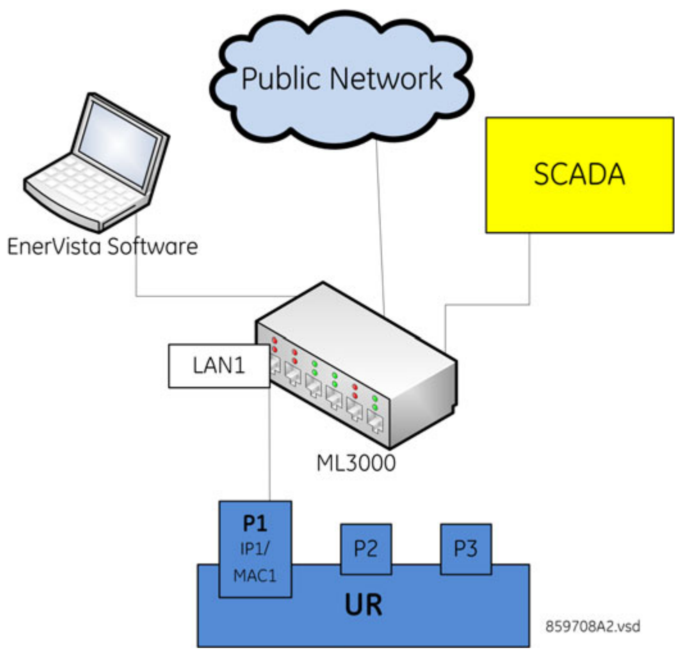
IP3/Mask3: 10.3.1.2/255.0.0.0

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 5–4: NETWORK CONFIGURATION FOR SINGLE LAN



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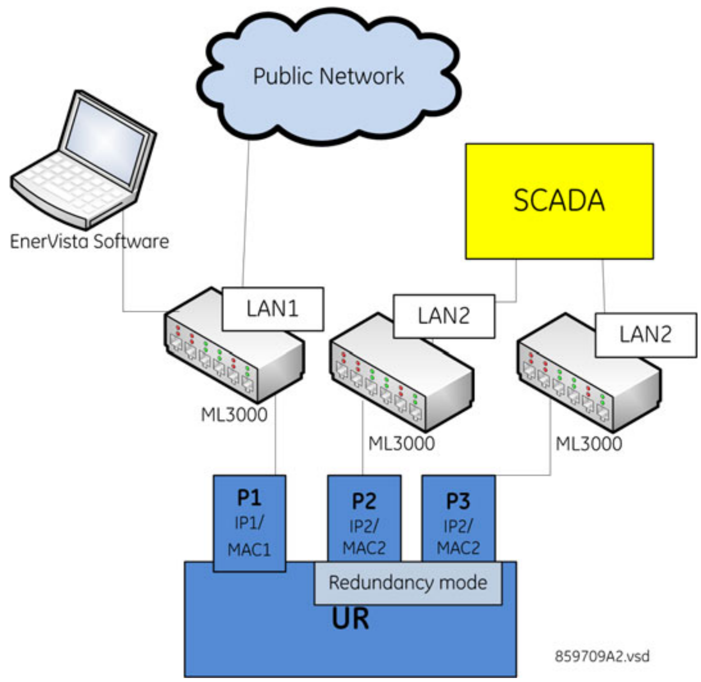
Multiple LANS, with Redundancy

The topology in the following figure 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 and LAN3, to which P2 and respectively P3 are connected and configured to work in redundant mode. In this configuration, P3 uses the IP and MAC address of P2.

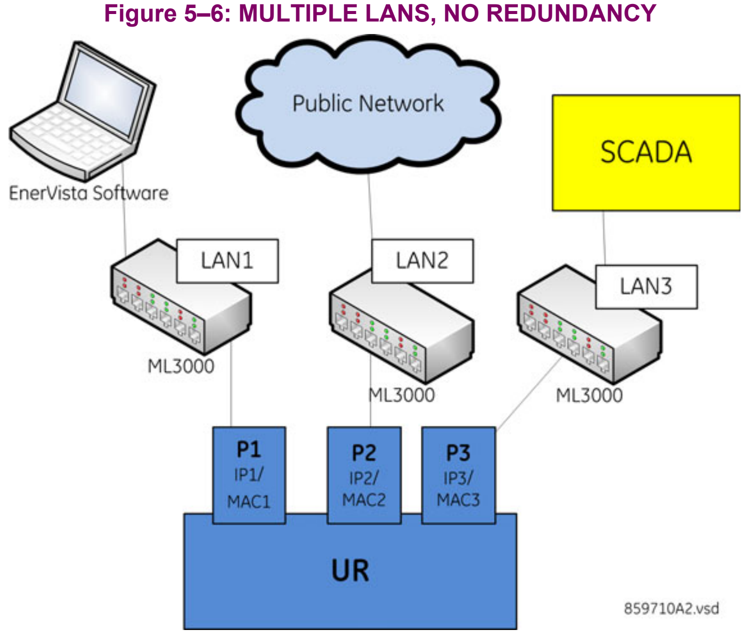
Figure 5–5: MULTIPLE LANS, WITH REDUNDANCY



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 5–6: MULTIPLE LANS, NO REDUNDANCY



5

d) 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.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK 1(3)

Menu	Key	Setting	Range
■ NETWORK PORT 1 ■	◁▷	PRT1 IP ADDRESS: 127.0.0.1	Range: Standard IPV4 address format
MESSAGE	△▽	PRT1 SUBNET IP MASK: 255.0.0.0	Range: Standard IPV4 address format
MESSAGE	△	PRT1 GOOSE ENABLED: Enabled	Range: Enabled, Disabled

Menu	Key	Setting	Range
■ NETWORK PORT 2 ■	◁▷	PRT2 IP ADDRESS: 127.0.0.1	Range: Standard IPV4 address format
MESSAGE	△▽	PRT2 SUBNET IP MASK: 255.0.0.0	Range: Standard IPV4 address format
MESSAGE	△▽	PRT2 REDUNDANCY: None	Range: None, Failover, PRP None, Failover (if no PRP license)
MESSAGE	△▽	PRT2 PRP MCST ADDR: 01-15-4E-00-01-00	Range: 01-15-4E-00-01-00 to 01-15-4E-00-01-FF
MESSAGE	△	PRT2 GOOSE ENABLED: Enabled	Range: Enabled, Disabled

Menu	Key	Setting	Range
■ NETWORK PORT 3 ■	◁▷	PRT3 IP ADDRESS: 127.0.0.1	Range: Standard IPV4 address format
MESSAGE	△▽	PRT3 SUBNET IP MASK: 255.0.0.0	Range: Standard IPV4 address format
MESSAGE	△	PRT3 GOOSE ENABLED: Enabled	Range: Enabled, Disabled

The IP addresses are used with the DNP, Modbus/TCP, IEC 61580, IEC 60870-5-104, TFTP, HTTP, and PRP protocols. The next section explains PRP.

NOTE

Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

PRT1 (2 OR 3) IP ADDRESS: This setting sets the ports 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 ports IPv4 subnet mask in standard IPV4 format. This setting is valid on port 3 if port 2 **REDUNDANCY** is set to None.

PRT2 REDUNDANCY is available when the hardware has multiple ports (modules T, U, and V). It 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 available 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 port 2 and the switch is good, communications automatically switch back to port 2 and port 3 goes back into 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.

NOTE

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 this setting change to take effect, restart the unit.

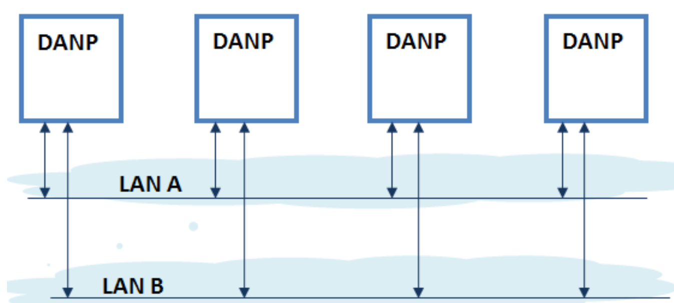
PRT2 PRP MCST ADDR: This setting allows the user to change the multicast address used by the PRP supervision frames. The setting applies to UR CPUs that support multiple ports (T, U, and V). This setting is available if the hardware has multiple ports and **REDUNDANCY** is set to PRP.

e) PARALLEL REDUNDANCY PROTOCOL (PRP)

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 the 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 technique. 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 still 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 5–7: EXAMPLE OF PARALLEL REDUNDANT NETWORK



PRP uses specialized nodes called doubly attached nodes (DANPs) for handling the duplicated frames. DANPs devices have an additional module, called 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. 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 only 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 only PRP-1.

The relay implements PRP on two of its Ethernet ports, specifically Port 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 (Port 2 and 3) operate in redundant mode. In this mode, Port 3 uses the Mac, IP address, and mask of Port 2.

f) ROUTING

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ ROUTING 1(6)

```
■ IPV4 ROUTING            IPV4 DEFAULT ROUTE
■ TABLE

             MESSAGE      IPV4 STATIC
                          NETWORK ROUTE 1
                                 ↓
             MESSAGE      IPV4 STATIC
                          NETWORK ROUTE 6
```

A default route and a maximum number of 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.

```
■ IPV4 DEFAULT ROUTE      GATEWAY ADDRESS      Range: Standard IPV4 unicast address format
■                         127.0.0.1
```

```
■ IPV4 STATIC             RT1 DESTINATION:     Range: Standard IPV4 address format
■ NETWORK ROUTE 1         127.0.0.1

             MESSAGE      RT1 NET MASK:        Range: Standard IPV4 subnet mask format
                          255.0.0.0

             MESSAGE      RT1 GATEWAY:         Range: Standard IPV4 unicast address format
                          127.0.0.1
```

Configure the network IP and subnet settings before configuring the routing settings.

ADDING AND DELETING 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 UR.

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 must be also kept on default values.

By default, the value of the route gateway address is 127.0.0.1. This means 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.

To delete a route:

1. Replace the route destination with the default loopback address (127.0.0.1). When deleting a route, the mask and gateway must be also brought back to default values.
2. Delete the default route by replacing the default gateway with the default value 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 and RtMask = RtDestination
  Example of good configuration: RtDestination = 10.1.1.0; Rt Mask = 255.255.255.0
  Example of bad configuration: RtDestination = 10.1.1.1; Rt Mask = 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 and Prt1Mask = Prt1IP and Prt1Mask || RtGwy and Prt2Mask = Prt2IP and Prt2Mask || RtGwy and Prt3Mask = Prt3IP and Prt3Mask

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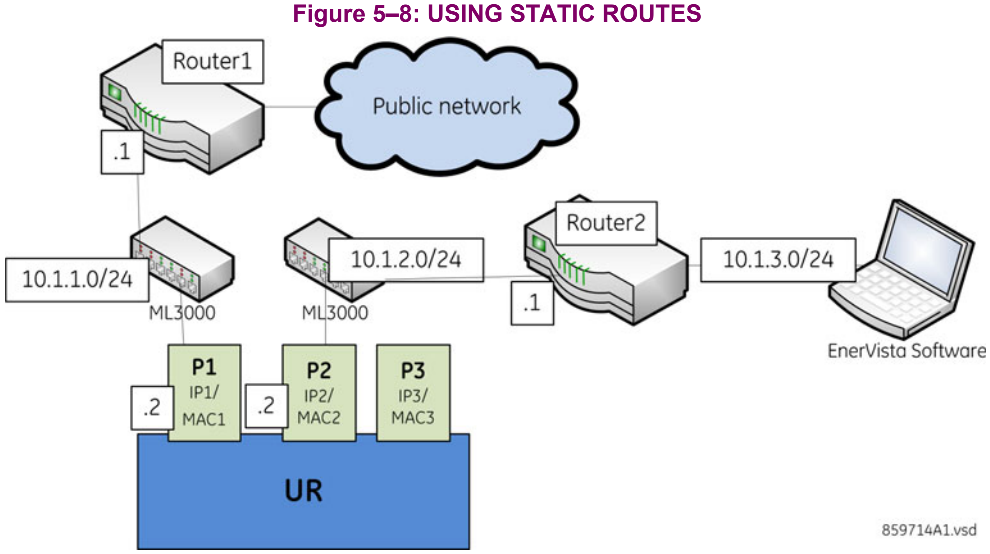
ROUTING BEHAVIOR COMPARED TO PREVIOUS RELEASES

Prior to release 7.10, the UR 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.

Figure 5–8: USING 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. Router 1 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 Router 2. Router 2 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 Router 1. Hence a destination unreachable message was received from the router.

The configuration starting 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 laptop 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 Router 2, which has knowledge about 10.1.3.0 and is able to route packets coming from 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 5–3: 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 5–4: 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

g) MODBUS PROTOCOL

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ MODBUS PROTOCOL

■ MODBUS PROTOCOL ■	◁▷	MODBUS SLAVE ADDRESS: 254	Range: 0 to 254 in steps of 1
	MESSAGE	MODBUS TCP PORT NUMBER: 502	Range: 0 to 65535 in steps of 1

The serial communication ports utilize the Modbus protocol, unless configured for DNP operation (see descriptions below). This allows the EnerVista UR Setup software to be used. The UR operates as a Modbus slave device only. When using Modbus protocol on the RS232 port, the L30 responds regardless of the **MODBUS SLAVE ADDRESS** programmed. For the RS485 port, each L30 must have a unique address from 1 to 254. Address 0 is the broadcast address which all Modbus slave devices listen to. Addresses do not have to be sequential, but no two devices can have the same address or conflicts resulting in errors will occur. Generally, each device added to the link should use the next higher address starting at 1. See Appendix B for more information on the Modbus protocol.

A value of 0 closes the port. When the Modbus port is set to 0, communicate with the relay using the front panel or serial port.

NOTE

When a 0 value is involved in a change, the changes to the MODBUS TCP PORT NUMBER setting take effect when the L30 is restarted.

h) DNP PROTOCOL

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP PROTOCOL

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■ DNP PROTOCOL ■	◁▷	■ DNP CHANNELS ■	Range: see sub-menu below
	MESSAGE	DNP ADDRESS: 1	Range: 0 to 65519 in steps of 1
	MESSAGE	■ DNP NETWORK ■ CLIENT ADDRESSES	Range: see sub-menu below
	MESSAGE	DNP TCP/UDP PORT NUMBER: 20000	Range: 0 to 65535 in steps of 1
	MESSAGE	DNP UNSOL RESPONSE FUNCTION: Disabled	Range: Enabled, Disabled
	MESSAGE	DNP UNSOL RESPONSE TIMEOUT: 5 s	Range: 0 to 60 s in steps of 1
	MESSAGE	DNP UNSOL RESPONSE MAX RETRIES: 10	Range: 1 to 255 in steps of 1
	MESSAGE	DNP UNSOL RESPONSE DEST ADDRESS: 1	Range: 0 to 65519 in steps of 1
	MESSAGE	DNP CURRENT SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
	MESSAGE	DNP VOLTAGE SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
	MESSAGE	DNP POWER SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
	MESSAGE	DNP ENERGY SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
	MESSAGE	DNP PF SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000

MESSAGE	▲▼	DNP OTHER SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
MESSAGE	▲▼	DNP CURRENT DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
MESSAGE	▲▼	DNP VOLTAGE DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
MESSAGE	▲▼	DNP POWER DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
MESSAGE	▲▼	DNP ENERGY DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
MESSAGE	▲▼	DNP PF DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
MESSAGE	▲▼	DNP OTHER DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
MESSAGE	▲▼	DNP TIME SYNC IIN PERIOD: 1440 min	Range: 1 to 10080 min. in steps of 1
MESSAGE	▲▼	DNP MESSAGE FRAGMENT SIZE: 240	Range: 30 to 2048 in steps of 1
MESSAGE	▲▼	DNP OBJECT 1 DEFAULT VARIATION: 2	Range: 1, 2
MESSAGE	▲▼	DNP OBJECT 2 DEFAULT VARIATION: 2	Range: 1, 2, 3
MESSAGE	▲▼	DNP OBJECT 20 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6
MESSAGE	▲▼	DNP OBJECT 21 DEFAULT VARIATION: 1	Range: 1, 2, 9, 10
MESSAGE	▲▼	DNP OBJECT 22 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6
MESSAGE	▲▼	DNP OBJECT 23 DEFAULT VARIATION: 2	Range: 1, 2, 5, 6
MESSAGE	▲▼	DNP OBJECT 30 DEFAULT VARIATION: 1	Range: 1, 2, 3, 4, 5
MESSAGE	▲▼	DNP OBJECT 32 DEFAULT VARIATION: 1	Range: 1, 2, 3, 4, 5, 7
MESSAGE	▲▼	DNP NUMBER OF PAIRED CONTROL POINTS: 0	Range: 0 to 32 in steps of 1
MESSAGE	▲	DNP TCP CONNECTION TIMEOUT: 120 s	Range: 10 to 7200 s in steps of 1

The L30 supports the Distributed Network Protocol (DNP) version 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.

NOTE: The IEC 60870-5-104 and DNP protocols cannot be used simultaneously. When the IEC 60870-5-104 FUNCTION setting is set to "Enabled", the DNP protocol is not operational. When this setting is changed it does not become active until power to the relay has been cycled (off-to-on).

The DNP Channels sub-menu is shown below.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP PROTOCOL ⇨ DNP CHANNELS

■ DNP CHANNELS ■	◀▶	DNP CHANNEL 1 PORT: NETWORK	Range: NONE, COM2 - RS485, FRONT PANEL - RS232, NETWORK - TCP, NETWORK - UDP
MESSAGE	▲	DNP CHANNEL 2 PORT: COM2 - RS485	Range: NONE, COM2 - RS485, FRONT PANEL - RS232, NETWORK - TCP, NETWORK - UDP

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, the Modbus protocol is disabled on that port. When this setting is set to “Network - TCP”, the DNP protocol can be used over TCP/IP on channels 1 or 2. When this value is set to “Network - UDP”, the DNP protocol can be used over UDP/IP on channel 1 only. Refer to *Appendix E* for additional information on the DNP protocol.

NOTE: Changes to the DNP CHANNEL 1 PORT and DNP CHANNEL 2 PORT settings take effect only after power has been cycled to the relay.

The **DNP NETWORK CLIENT ADDRESS** settings can force the L30 to respond to a maximum of five specific DNP masters. The settings in this sub-menu are shown below.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP PROTOCOL ⇨ DNP NETWORK CLIENT ADDRESSES

■ DNP NETWORK ■ CLIENT ADDRESSES	◀▶	CLIENT ADDRESS 1: 0.0.0.0	Range: standard IP address
MESSAGE	▲▼	CLIENT ADDRESS 2: 0.0.0.0	Range: standard IP address
MESSAGE	▲▼	CLIENT ADDRESS 3: 0.0.0.0	Range: standard IP address
MESSAGE	▲▼	CLIENT ADDRESS 4: 0.0.0.0	Range: standard IP address
MESSAGE	▲	CLIENT ADDRESS 5: 0.0.0.0	Range: standard IP address

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The **DNP UNSOL RESPONSE FUNCTION** should be “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 unsolicited 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 will be returned with values 1000 times smaller (for example, a value of 72000 V on the L30 will be 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 will be 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 should be 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. Whenever power is removed and re-applied to the L30, the default deadbands will be in effect.

NOTE: 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 can provide for more robust data transfer over noisy communication channels.

NOTE

When the DNP data points (analog inputs and/or binary inputs) are configured for Ethernet-enabled relays, check the "DNP Points Lists" L30 web page to view the points lists. This page can be viewed with a web browser by entering the L30 IP address to access the L30 "Main Menu", then by selecting the "Device Information Menu" > "DNP Points Lists" menu item.

The **DNP OBJECT 1 DEFAULT VARIATION** to **DNP OBJECT 32 DEFAULT VARIATION** settings allow the user to 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. Refer to the *DNP implementation* section in appendix E for additional details.

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 from 0 to 32 binary output paired controls. Points not configured as paired operate on a one-to-one basis.

The **DNP ADDRESS** setting is the DNP slave address. This number identifies the L30 on a DNP communications link. Each DNP slave should be assigned a unique address.

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 will be aborted by the L30. This frees up the connection to be re-used by a client.

NOTE

Relay power must be re-cycled after changing the **DNP TCP CONNECTION TIMEOUT** setting for the changes to take effect.

i) DNP / IEC 60870-5-104 POINT LISTS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP / IEC104 POINT LISTS

■ DNP / IEC104 ■ POINT LISTS		■ BINARY INPUT / MSP ■ POINTS	Range: see sub-menu below
	MESSAGE	■ ANALOG INPUT / MME ■ POINTS	Range: see sub-menu below

The binary and analog inputs points for the DNP protocol, or the MSP and MME points for IEC 60870-5-104 protocol, can configured to a maximum of 256 points. 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) is shown below.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP / IEC104 POINT LISTS ⇨ BINARY INPUT / MSP POINTS

■ BINARY INPUT / MSP ■ POINTS		Point: 0 Off	Range: FlexLogic operand
	MESSAGE	Point: 1 Off	Range: FlexLogic operand
		↓	
	MESSAGE	Point: 255 Off	Range: FlexLogic operand

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. Refer to the *Introduction to FlexLogic* section in this chapter for the full range of assignable operands.

The menu for the analog input points (DNP) or MME points (IEC 60870-5-104) is shown below.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP / IEC104 POINT LISTS ⇨⇩ ANALOG INPUT / MME POINTS

■ ANALOG INPUT / MME ■ POINTS		Point: 0 Off	Range: any FlexAnalog parameter
MESSAGE		Point: 1 Off	Range: any FlexAnalog parameter
		↓	
MESSAGE		Point: 255 Off	Range: any FlexAnalog parameter

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. Refer to Appendix A: *FlexAnalog Parameters* for the full range of assignable parameters.

NOTE: 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.

NOTE: Changes to the DNP / IEC 60870-5-104 point lists will not take effect until the L30 is restarted.

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j) IEC 61850 PROTOCOL

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL

■ IEC 61850 PROTOCOL ■		■ GSSE / GOOSE ■ CONFIGURATION
MESSAGE		■ SERVER ■ CONFIGURATION
MESSAGE		■ IEC 61850 LOGICAL ■ NODE NAME PREFIXES
MESSAGE		■ MMXU DEADBANDS ■
MESSAGE		■ GGIO1 STATUS ■ CONFIGURATION
MESSAGE		■ GGIO2 CONTROL ■ CONFIGURATION
MESSAGE		■ GGIO4 ANALOG ■ CONFIGURATION
MESSAGE		■ GGIO5 UINTEGER ■ CONFIGURATION
MESSAGE		■ REPORT CONTROL ■ CONFIGURATION
MESSAGE		■ XCBR ■ CONFIGURATION
MESSAGE		■ XSWI ■ CONFIGURATION

The L30 Line Current Differential System is provided with optional IEC 61850 communications capability. This feature is specified as a software option at the time of ordering. Refer to the *Ordering* section of chapter 2 for additional details.

NOTICE Use independent ports for IEC 61850 communication and take care when configuring the settings, else loss of protection or misoperation of the relay can result.

The L30 supports the Manufacturing Message Specification (MMS) protocol as specified by IEC 61850. MMS is supported over two protocol stacks: TCP/IP over Ethernet. The L30 operates as an IEC 61850 server. The *Remote inputs and outputs* section in this chapter describe the peer-to-peer GSSE/GOOSE message scheme.

The GSSE/GOOSE configuration main menu is divided into two areas: transmission and reception.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION

■ GSSE / GOOSE ■ CONFIGURATION		■ TRANSMISSION ■	
	MESSAGE	■ RECEPTION ■	

The main transmission menu is shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION

■ TRANSMISSION ■		■ GENERAL ■	
	MESSAGE	■ GSSE ■	
	MESSAGE	■ FIXED GOOSE ■	
	MESSAGE	■ CONFIGURABLE ■ GOOSE	

The general transmission settings are shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨ GENERAL

■ GENERAL ■		DEFAULT GSSE/GOOSE UPDATE TIME: 60 s	*Range: 1 to 60 s in steps of 1*

The **DEFAULT GSSE/GOOSE UPDATE TIME** sets the time between GSSE or GOOSE messages when there are no remote output state changes to be sent. When remote output data changes, GSSE or GOOSE messages are sent immediately. This setting controls the steady-state *heartbeat* time interval.

The **DEFAULT GSSE/GOOSE UPDATE TIME** setting is applicable to GSSE, fixed L30 GOOSE, and configurable GOOSE.

The GSSE settings are shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ GSSE

■ GSSE ■		GSSE FUNCTION: Enabled	*Range: Enabled, Disabled*
	MESSAGE	GSSE ID: GSSEOut	*Range: 65-character ASCII string*
	MESSAGE	DESTINATION MAC: 000000000000	*Range: standard MAC address*

These settings are applicable to GSSE only. If the fixed GOOSE function is enabled, GSSE messages are not transmitted.

The **GSSE ID** setting represents the IEC 61850 GSSE application ID name string sent as part of each GSSE message. This string identifies the GSSE message to the receiving device. In L30 releases previous to 5.0x, this name string was represented by the **RELAY NAME** setting.

The fixed GOOSE settings are shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ FIXED GOOSE

■ FIXED GOOSE ■	◀▶	GOOSE FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE	▲▼	GOOSE ID: GOOSEOut	Range: 65-character ASCII string
MESSAGE	▲▼	DESTINATION MAC: 000000000000	Range: standard MAC address
MESSAGE	▲▼	GOOSE VLAN PRIORITY: 4	Range: 0 to 7 in steps of 1
MESSAGE	▲▼	GOOSE VLAN ID: 0	Range: 0 to 4095 in steps of 1
MESSAGE	▲	GOOSE ETYPE APPID: 0	Range: 0 to 16383 in steps of 1

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These settings are applicable to fixed (DNA/UserSt) GOOSE only.

The **GOOSE ID** setting represents the IEC 61850 GOOSE application ID (GoID) name string sent as part of each GOOSE message. This string identifies the GOOSE message to the receiving device. In revisions previous to 5.0x, this name string was represented by the **RELAY NAME** setting.

The **DESTINATION MAC** setting allows the destination Ethernet MAC address to be set. This address must be a multicast address; the least significant bit of the first byte must be set. In L30 releases previous to 5.0x, the destination Ethernet MAC address was determined automatically by taking the sending MAC address (that is, the unique, local MAC address of the L30) and setting the multicast bit.

The **GOOSE VLAN PRIORITY** setting indicates the Ethernet priority of GOOSE messages. This allows GOOSE messages to have higher priority than other Ethernet data. The **GOOSE ETYPE APPID** setting allows the selection of a specific application ID for each GOOSE sending device. This value can be left at its default if the feature is not required. Both the **GOOSE VLAN PRIORITY** and **GOOSE ETYPE APPID** settings are required by IEC 61850.

The configurable GOOSE settings are shown below.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1(8)

■ CONFIGURABLE ■ GOOSE 1		CONFIG GSE 1 FUNCTION: Enabled	Range: *Enabled, Disabled*
	MESSAGE	CONFIG GSE 1 ID: GOOSEOut_1	Range: *65-character ASCII string*
	MESSAGE	CONFIG GSE 1 DST MAC: 000000000000	Range: *standard MAC address*
	MESSAGE	CONFIG GSE 1 VLAN PRIORITY: 4	Range: *0 to 7 in steps of 1*
	MESSAGE	CONFIG GSE 1 VLAN ID: 0	Range: *0 to 4095 in steps of 1*
	MESSAGE	CONFIG GSE 1 ETYPE APPID: 0	Range: *0 to 16383 in steps of 1*
	MESSAGE	CONFIG GSE 1 CONFREV: 1	Range: *0 to 4294967295 in steps of 1*
	MESSAGE	CONFIG GSE 1 RESTRANS CURVE: Relaxed	Range: *Aggressive, Medium, Relaxed, Heartbeat*
	MESSAGE	■ CONFIG GSE 1 ■ DATASET ITEMS	Range: *64 data items; each can be set to all valid MMS data item references for transmitted data*

The configurable GOOSE settings allow the L30 to be configured to transmit a number of different datasets within IEC 61850 GOOSE messages. Up to eight different configurable datasets can be configured and transmitted. This is useful for intercommunication between L30 IEDs and devices from other manufacturers that support IEC 61850.

The configurable GOOSE feature allows for the configuration of the datasets to be transmitted or received from the L30. The L30 supports the configuration of eight (8) transmission and reception datasets, allowing for the optimization of data transfer between devices.

Items programmed for dataset 1 and 2 will have changes in their status transmitted as soon as the change is detected. Datasets 1 and 2 should be used for high-speed transmission of data that is required for applications such as transfer tripping, blocking, and breaker fail initiate. At least one digital status value needs to be configured in the required dataset to enable transmission of configured data. Configuring analog data only to dataset 1 or 2 will not activate transmission.

Items programmed for datasets 3 through 8 will have changes in their status transmitted at a maximum rate of every 100 ms. Datasets 3 through 8 will regularly analyze each data item configured within them every 100 ms to identify if any changes have been made. If any changes in the data items are detected, these changes will be transmitted through a GOOSE message. If there are no changes detected during this 100 ms period, no GOOSE message will be sent.

For all datasets 1 through 8, the integrity GOOSE message will still continue to be sent at the pre-configured rate even if no changes in the data items are detected.

The GOOSE functionality was enhanced to prevent the relay from flooding a communications network with GOOSE messages due to an oscillation being created that is triggering a message.

The L30 has the ability of detecting if a data item in one of the GOOSE datasets is erroneously oscillating. This can be caused by events such as errors in logic programming, inputs improperly being asserted and de-asserted, or failed station components. If erroneously oscillation is detected, the L30 will stop sending GOOSE messages from the dataset for a minimum period of one second. Should the oscillation persist after the one second time-out period, the L30 will continue to block transmission of the dataset. The L30 will assert the **MAINTENANCE ALERT: GGIO Ind XXX oscill** self-test error message on the front panel display, where **XXX** denotes the data item detected as oscillating.

For versions 5.70 and higher, the L30 supports four retransmission schemes: aggressive, medium, relaxed, and heartbeat. The aggressive scheme is only supported in fast type 1A GOOSE messages (GOOSEOut 1 and GOOSEOut 2). For slow GOOSE messages (GOOSEOut 3 to GOOSEOut 8) the aggressive scheme is the same as the medium scheme.

The details about each scheme are shown in the following table.

Table 5–5: GOOSE RETRANSMISSION SCHEMES

SCHEME	SQ NUM	TIME FROM THE EVENT	TIME BETWEEN MESSAGES	COMMENT	TIME ALLOWED TO LIVE IN MESSAGE
Aggressive	0	0 ms	0 ms	Event	2000 ms
	1	4 ms	4 ms	T1	2000 ms
	2	8 ms	4 ms	T1	2000 ms
	3	16 ms	8 ms	T2	Heartbeat * 4.5
	4	Heartbeat	Heartbeat	T0	Heartbeat * 4.5
	5	Heartbeat	Heartbeat	T0	Heartbeat * 4.5
Medium	0	0 ms	0 ms	Event	2000 ms
	1	16 ms	16 ms	T1	2000 ms
	2	32 ms	16 ms	T1	2000 ms
	3	64 ms	32 ms	T2	Heartbeat * 4.5
	4	Heartbeat	Heartbeat	T0	Heartbeat * 4.5
	5	Heartbeat	Heartbeat	T0	Heartbeat * 4.5
Relaxed	0	0 ms	0 ms	Event	2000 ms
	1	100 ms	100 ms	T1	2000 ms
	2	200 ms	100 ms	T1	2000 ms
	3	700 ms	500 ms	T2	Heartbeat * 4.5
	4	Heartbeat	Heartbeat	T0	Heartbeat * 4.5
	5	Heartbeat	Heartbeat	T0	Heartbeat * 4.5
Heartbeat	0	0 ms	0 ms	Event	2000 ms
	1	Heartbeat	Heartbeat	T1	2000 ms
	2	Heartbeat	Heartbeat	T1	2000 ms
	3	Heartbeat	Heartbeat	T2	Heartbeat * 4.5
	4	Heartbeat	Heartbeat	T0	Heartbeat * 4.5
	5	Heartbeat	Heartbeat	T0	Heartbeat * 4.5

The configurable GOOSE feature is recommended for applications that require GOOSE data transfer between UR-series IEDs and devices from other manufacturers. Fixed GOOSE is recommended for applications that require GOOSE data transfer between UR-series IEDs.

IEC 61850 GOOSE messaging contains a number of configurable parameters, all of which must be correct to achieve the successful transfer of data. It is critical that the configured datasets at the transmission and reception devices are an exact match in terms of data structure, and that the GOOSE addresses and name strings match exactly. Manual configuration is possible, but third-party substation configuration software may be used to automate the process. The EnerVista UR Setup software can produce IEC 61850 ICD files and import IEC 61850 SCD files produced by a substation configurator (refer to the *IEC 61850 IED configuration* section later in this appendix).

The following example illustrates the configuration required to transfer IEC 61850 data items between two devices. The general steps required for transmission configuration are:

1. Configure the transmission dataset.
2. Configure the GOOSE service settings.
3. Configure the data.

The general steps required for reception configuration are:

1. Configure the reception dataset.
2. Configure the GOOSE service settings.
3. Configure the data.

This example shows how to configure the transmission and reception of three IEC 61850 data items: a single point status value, its associated quality flags, and a floating point analog value.

The following procedure illustrates the transmission configuration.

1. Configure the transmission dataset by making the following changes in the **PRODUCT SETUP ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1 ⇨⇩ CONFIG GSE 1 DATASET ITEMS** settings menu:
   - Set **ITEM 1** to “GGIO1.ST.Ind1.q” to indicate quality flags for GGIO1 status indication 1.
   - Set **ITEM 2** to “GGIO1.ST.Ind1.stVal” to indicate the status value for GGIO1 status indication 1.
   - Set **ITEM 3** to “MMXU1.MX.Hz.mag.f” to indicate the analog frequency magnitude for MMXU1 (the metered frequency for SRC1).

   The transmission dataset now contains a quality flag, a single point status Boolean value, and a floating point analog value. The reception dataset on the receiving device must exactly match this structure.
2. Configure the GOOSE service settings by making the following changes in the **PRODUCT SETUP ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1** settings menu:
   - Set **CONFIG GSE 1 FUNCTION** to “Enabled”.
   - Set **CONFIG GSE 1 ID** to an appropriate descriptive string (the default value is “GOOSEOut_1”).
   - Set **CONFIG GSE 1 DST MAC** to a multicast address (for example, 01 00 00 12 34 56).
   - Set the **CONFIG GSE 1 VLAN PRIORITY**; the default value of “4” is OK for this example.
   - Set the **CONFIG GSE 1 VLAN ID** value; the default value is “0”, but some switches may require this value to be “1”.
   - Set the **CONFIG GSE 1 ETYPE APPID** value. This setting represents the ETHERTYPE application ID and must match the configuration on the receiver (the default value is “0”).
   - Set the **CONFIG GSE 1 CONFREV** value. This value changes automatically as described in IEC 61850 part 7-2. For this example it can be left at its default value.
3. Configure the data by making the following changes in the **PRODUCT SETUP ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨ GGIO1 STATUS CONFIGURATION** settings menu:
   - Set **GGIO1 INDICATION 1** to a FlexLogic operand used to provide the status of GGIO1.ST.Ind1.stVal (for example, a contact input, virtual input, a protection element status, etc.).
4. Configure the MMXU1 Hz Deadband by making the following changes in the **PRODUCT SETUP ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ MMXU DEADBANDS⇨⇩ MMXU1 DEADBANDS** settings menu:
   - Set **MMXU1 HZ DEADBAND** to “0.050%”. This will result in an update to the MMXU1.MX.mag.f analog value with a change greater than 45 mHz, from the previous MMXU1.MX.mag.f value, in the source frequency.

The L30 must be rebooted (control power removed and re-applied) before these settings take effect.

The following procedure illustrates the reception configuration.

1. Configure the reception dataset by making the following changes in the **PRODUCT SETUP ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨⇩ RECEPTION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1 ⇨⇩ CONFIG GSE 1 DATASET ITEMS** settings menu:
   - Set **ITEM 1** to “GGIO3.ST.Ind1.q” to indicate quality flags for GGIO3 status indication 1.
   - Set **ITEM 2** to “GGIO3.ST.Ind1.stVal” to indicate the status value for GGIO3 status indication 1.
   - Set **ITEM 3** to “GGIO3.MX.AnIn1.mag.f” to indicate the analog magnitude for GGIO3 analog input 1.

   The reception dataset now contains a quality flag, a single point status Boolean value, and a floating point analog value. This matches the transmission dataset configuration above.
2. Configure the GOOSE service settings by making the following changes in the **INPUTS/OUTPUTS ⇨⇩ REMOTE DEVICES ⇨⇩ REMOTE DEVICE 1** settings menu:
   - Set **REMOTE DEVICE 1 ID** to match the GOOSE ID string for the transmitting device. Enter “GOOSEOut_1”.

– Set **REMOTE DEVICE 1 ETYPE APPID** to match the ETHERTYPE application ID from the transmitting device. This is “0” in the example above.

– Set the **REMOTE DEVICE 1 DATASET** value. This value represents the dataset number in use. Since we are using configurable GOOSE 1 in this example, program this value as “GOOSEIn 1”.

3. Configure the Boolean data by making the following changes in the **INPUTS/OUTPUTS ⇨⇩ REMOTE INPUTS ⇨⇩ REMOTE INPUT 1** settings menu:

– Set **REMOTE IN 1 DEVICE** to “GOOSEOut_1”.

– Set **REMOTE IN 1 ITEM** to “Dataset Item 2”. This assigns the value of the GGIO3.ST.Ind1.stVal single point status item to remote input 1.

4. Configure the analog data by making the following changes in the **INPUTS/OUTPUTS ⇨⇩ IEC 61850 GOOSE ANALOG INPUTS** settings menu:

– Set the **IEC61850 GOOSE ANALOG INPUT 1 DEFAULT VALUE** to “60.000”.

– Enter “Hz” for the **IEC61850 GOOSE ANALOG INPUT 1 UNITS** setting.

The GOOSE analog input 1 can now be used as a FlexAnalog value in a FlexElement or in other settings. The L30 must be rebooted (control power removed and re-applied) before these settings take effect.

The value of GOOSE analog input 1 in the receiving device will be determined by the MMXU1.MX.Hz.mag.f value in the sending device. This MMXU value is determined by the source 1 frequency value and the MMXU Hz deadband setting of the sending device.

Remote input 1 can now be used in FlexLogic equations or other settings. The L30 must be rebooted (control power removed and re-applied) before these settings take effect.

The value of remote input 1 (Boolean on or off) in the receiving device will be determined by the GGIO1.ST.Ind1.stVal value in the sending device. The above settings will be automatically populated by the EnerVista UR Setup software when a complete SCD file is created by third party substation configurator software.

For intercommunication between L30 IEDs, the fixed (DNA/UserSt) dataset can be used. The DNA/UserSt dataset contains the same DNA and UserSt bit pairs that are included in GSSE messages. All GOOSE messages transmitted by the L30 (DNA/UserSt dataset and configurable datasets) use the IEC 61850 GOOSE messaging services (for example, VLAN support).

NOTE

Set the **CONFIG GSE 1 FUNCTION** function to “Disabled” when configuration changes are required. Once changes are entered, return the **CONFIG GSE 1 FUNCTION** to “Enabled” and restart the unit for changes to take effect.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1(8) ⇨⇩ CONFIG GSE 1(64) DATA ITEMS

■ CONFIG GSE 1 ■ DATASET ITEMS	◀▶	ITEM 1: GGIO1.ST.Ind1.stVal	*Range: all valid MMS data item references for transmitted data*
MESSAGE	▲▼	ITEM 2: GGIO1.ST.IndPos1.stV	*Range: all valid MMS data item references for transmitted data*
MESSAGE	▲▼	ITEM 3: None	*Range: all valid MMS data item references for transmitted data*
		↓	
MESSAGE	▲	ITEM 64: None	*Range: all valid MMS data item references for transmitted data*

To create a configurable GOOSE dataset that contains an IEC 61850 Single Point Status indication and its associated quality flags, the following dataset items can be selected: “GGIO1.ST.Ind1.stVal” and “GGIO1.ST.Ind1.q”. The L30 will then create a dataset containing these two data items. The status value for GGIO1.ST.Ind1.stVal is determined by the FlexLogic operand assigned to GGIO1 indication 1. Changes to this operand will result in the transmission of GOOSE messages containing the defined dataset.

The main reception menu is applicable to configurable GOOSE only and contains the configurable GOOSE dataset items for reception:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ RECEPTION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1(16) ⇨⇩ CONFIG GSE 1(32) DATA ITEMS

■ CONFIG GSE 1 ■ DATASET ITEMS		ITEM 1: GGIO3.ST.Ind1.stVal	*Range: all valid MMS data item references for transmitted data*
	MESSAGE	ITEM 2: GGIO3.ST.IndPos1.stV	*Range: all valid MMS data item references for transmitted data*
	MESSAGE	ITEM 3: None	*Range: all valid MMS data item references for transmitted data*
		↓	
	MESSAGE	ITEM 32: None	*Range: all valid MMS data item references for transmitted data*

The configurable GOOSE settings allow the L30 to be configured to receive a number of different datasets within IEC 61850 GOOSE messages. Up to sixteen different configurable datasets can be configured for reception. This is useful for intercommunication between L30 IEDs and devices from other manufacturers that support IEC 61850.

For intercommunication between L30 IEDs, the fixed (DNA/UserSt) dataset can be used. The DNA/UserSt dataset contains the same DNA and UserSt bit pairs that are included in GSSE messages.

To set up a L30 to receive a configurable GOOSE dataset that contains two IEC 61850 single point status indications, the following dataset items can be selected (for example, for configurable GOOSE dataset 1): "GGIO3.ST.Ind1.stVal" and "GGIO3.ST.Ind2.stVal". The L30 will then create a dataset containing these two data items. The Boolean status values from these data items can be utilized as remote input FlexLogic operands. First, the **REMOTE DEVICE 1(16) DATASET** setting must be set to contain dataset "GOOSEIn 1" (that is, the first configurable dataset). Then **REMOTE IN 1(16) ITEM** settings must be set to "Dataset Item 1" and "Dataset Item 2". These remote input FlexLogic operands will then change state in accordance with the status values of the data items in the configured dataset.

Double-point status values may be included in the GOOSE dataset. Received values are populated in the GGIO3.ST.IndPos1.stVal and higher items.

Floating point analog values originating from MMXU logical nodes may be included in GOOSE datasets. Deadband (non-instantaneous) values can be transmitted. Received values are used to populate the GGIO3.MX.AnIn1 and higher items. Received values are also available as FlexAnalog parameters (GOOSE analog In1 and up).

NOTE

GGIO3.MX.AnIn1 to GGIO3.MX.AnIn32 can only be used once for all sixteen reception datasets.

The main menu for the IEC 61850 server configuration is shown below.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ SERVER CONFIGURATION

■ SERVER ■ CONFIGURATION	IED NAME: IECDevice	Range: up to 32 alphanumeric characters
MESSAGE	LD INST: LDInst	Range: up to 32 alphanumeric characters
MESSAGE	IEC/MMS TCP PORT NUMBER: 102	Range: 0 to 65535 in steps of 1
MESSAGE	INCLUDE NON-IEC DATA: Enabled	Range: Disabled, Enabled
MESSAGE	SERVER SCANNING: Disabled	Range: Disabled, Enabled
MESSAGE	LOCATION: LPHD DC PHV-Nam Location	Range: up to 80 alphanumeric characters
MESSAGE	LATITUDE:	Range: -90.000 to 90.000 deg in steps of 0.001 deg
MESSAGE	LONGITUDE:	Range: -180.000 to 180.000 deg in steps of 0.001 deg
MESSAGE	ALTITUDE:	Range: 0 to 10,0000 m in steps of 1 m

The **IED NAME** and **LD INST** settings represent the MMS domain name (IEC 61850 logical device) where all IEC/MMS logical nodes are located. Valid characters for these values are upper and lowercase letters, numbers, and the underscore (_) character, and the first character in the string must be a letter. This conforms to the IEC 61850 standard. The **LOCATION** is a variable string and can be composed of ASCII characters. This string appears within the PhyName of the LPHD node.

The **IEC/MMS TCP PORT NUMBER** setting allows the user to change the TCP port number for MMS connections. The **INCLUDE NON-IEC DATA** setting determines whether or not the "UR" MMS domain will be available. This domain contains a large number of UR-series specific data items that are not available in the IEC 61850 logical nodes. This data does not follow the IEC 61850 naming conventions. For communications schemes that strictly follow the IEC 61850 standard, this setting should be "Disabled".

NOTE

When a 0 value is involved in a change, the changes to the **IEC/MMS TCP PORT NUMBER** setting take effect when the L30 is restarted.

The **SERVER SCANNING** feature should be set to "Disabled" when IEC 61850 client/server functionality is not required. IEC 61850 has two modes of functionality: GOOSE/GSSE inter-device communication and client/server communication. If the GOOSE/GSSE functionality is required without the IEC 61850 client server feature, then server scanning can be disabled to increase CPU resources. When server scanning is disabled, there is no updating of the IEC 61850 logical node status values in the L30. Clients are still able to connect to the server (L30 relay), but most data values are not updated. This setting does not affect GOOSE/GSSE operation.

NOTE

Changes to the **IED NAME** setting, **LD INST** setting, and GOOSE dataset take effect when the L30 is restarted.

The main menu for the IEC 61850 logical node name prefixes is shown below.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ IEC 61850 LOGICAL NODE NAME PREFIXES

```
■ IEC 61850 LOGICAL              ■ PIOC LOGICAL NODE
■ NODE NAME PREFIXES             ■ NAME PREFIXES

                     MESSAGE     ■ PTOC LOGICAL NODE
                                 ■ NAME PREFIXES
                                        ↓
                     MESSAGE     ■ PTRC LOGICAL NODE
                                 ■ NAME PREFIXES
```

The IEC 61850 logical node name prefix settings are used to create name prefixes to uniquely identify each logical node. For example, the logical node "PTOC1" may have the name prefix "abc". The full logical node name will then be "abcMMXU1". Valid characters for the logical node name prefixes are upper and lowercase letters, numbers, and the underscore (_) character, and the first character in the prefix must be a letter. This conforms to the IEC 61850 standard.

Changes to the logical node prefixes will not take effect until the L30 is restarted.

The main menu for the IEC 61850 MMXU deadbands is shown below.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ MMXU DEADBANDS

```
■ MMXU DEADBANDS                 ■ MMXU1 DEADBANDS
■                                ■

                     MESSAGE     ■ MMXU2 DEADBANDS
                                 ■

                     MESSAGE     ■ MMXU3 DEADBANDS
                                 ■

                     MESSAGE     ■ MMXU4 DEADBANDS
                                 ■
```

The MMXU deadband settings represent the deadband values used to determine when the update the MMXU "mag" and "cVal" values from the associated "instmag" and "instcVal" values. The "mag" and "cVal" values are used for the IEC 61850 buffered and unbuffered reports. These settings correspond to the associated "db" data items in the CF functional constraint of the MMXU logical node, as per the IEC 61850 standard. According to IEC 61850-7-3, the db value "shall represent the percentage of difference between the maximum and minimum in units of 0.001%". Thus, it is important to know the maximum value for each MMXU measured quantity, since this represents the 100.00% value for the deadband.

The minimum value for all quantities is 0; the maximum values are as follows:

- phase current: 46 × phase CT primary setting
- neutral current: 46 × ground CT primary setting
- voltage: 275 × VT ratio setting
- power (real, reactive, and apparent): 46 × phase CT primary setting × 275 × VT ratio setting
- frequency: 90 Hz
- power factor: 2

The GGIO1 status configuration points are shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ GGIO1 STATUS CONFIGURATION

■ GGIO1 STATUS ■ CONFIGURATION		NUMBER OF STATUS POINTS IN GGIO1: 8	Range: 8 to 128 in steps of 8
MESSAGE		GGIO1 INDICATION 1 Off	Range: FlexLogic operand
MESSAGE		GGIO1 INDICATION 2 Off	Range: FlexLogic operand
MESSAGE		GGIO1 INDICATION 3 Off	Range: FlexLogic operand
		↓	
MESSAGE		GGIO1 INDICATION 128 Off	Range: FlexLogic operand

The **NUMBER OF STATUS POINTS IN GGIO1** setting specifies the number of “Ind” (single point status indications) that are instantiated in the GGIO1 logical node. Changes to the **NUMBER OF STATUS POINTS IN GGIO1** setting will not take effect until the L30 is restarted.

The GGIO2 control configuration points are shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ GGIO2 CONTROL CONFIGURATION ⇨ GGIO2 CF SPSCO 1(64)

5

■ GGIO2 CF SPCSO 1 ■		GGIO2 CF SPCSO 1 CTLMODEL: 1	Range: 0, 1, or 2

The GGIO2 control configuration settings are used to set the control model for each input. The available choices are “0” (status only), “1” (direct control), and “2” (SBO with normal security). The GGIO2 control points are used to control the L30 virtual inputs.

The GGIO4 analog configuration points are shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ GGIO4 ANALOG CONFIGURATION

■ GGIO4 ANALOG ■ CONFIGURATION		NUMBER OF ANALOG POINTS IN GGIO4: 8	Range: 4 to 32 in steps of 4
MESSAGE		■ GGIO4 ANALOG 1 ■ MEASURED VALUE	
MESSAGE		■ GGIO4 ANALOG 2 ■ MEASURED VALUE	
MESSAGE		■ GGIO4 ANALOG 3 ■ MEASURED VALUE	
		↓	
MESSAGE		■ GGIO4 ANALOG 32 ■ MEASURED VALUE	

The **NUMBER OF ANALOG POINTS** setting determines how many analog data points will exist in GGIO4. When this value is changed, the L30 must be rebooted in order to allow the GGIO4 logical node to be re-instantiated and contain the newly configured number of analog points.

The measured value settings for each of the 32 analog values are shown below.

PATH: SETTINGS ⇨ PRODUCT... ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ GGIO4 ANALOG CONFIGURATION ⇨ GGIO4 ANALOG 1(32) MEASURED VALUE

■ GGIO4 ANALOG 1 ■ MEASURED VALUE		ANALOG IN 1 VALUE: Off	Range:	any FlexAnalog value
	MESSAGE	ANALOG IN 1 DB: 0.000	Range:	0.000 to 100.000 in steps of 0.001
	MESSAGE	ANALOG IN 1 MIN: 0.000	Range:	–1000000000.000 to 1000000000.000 in steps of 0.001
	MESSAGE	ANALOG IN 1 MAX: 0.000	Range:	–1000000000.000 to 1000000000.000 in steps of 0.001

These settings are configured as follows.

- **ANALOG IN 1 VALUE**: This setting selects the FlexAnalog value to drive the instantaneous value of each GGIO4 analog status value (GGIO4.MX.AnIn1.instMag.f).
- **ANALOG IN 1 DB**: This setting specifies the deadband for each analog value. Refer to IEC 61850-7-1 and 61850-7-3 for details. 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 maximum and minimum values.
- **ANALOG IN 1 MIN**: This setting specifies the minimum value for each analog value. Refer to IEC 61850-7-1 and 61850-7-3 for details. This minimum value is used to determine the deadband. The deadband is used in the determination of the deadbanded magnitude from the instantaneous magnitude.
- **ANALOG IN 1 MAX**: This setting defines the maximum value for each analog value. Refer to IEC 61850-7-1 and 61850-7-3 for details. This maximum value is used to determine the deadband. The deadband is used in the determination of the deadbanded magnitude from the instantaneous magnitude.

NOTE

Note that the **ANALOG IN 1 MIN** and **ANALOG IN 1 MAX** settings are stored as IEEE 754 / IEC 60559 floating point numbers. Because of the large range of these settings, not all values can be stored. Some values may be rounded to the closest possible floating point number.

The GGIO5 integer configuration points are shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ GGIO5 ANALOG CONFIGURATION

■ GGIO5 UINTEGER ■ CONFIGURATION		GGIO5 UINT In 1: Off	Range:	Off, any FlexInteger™ parameter
	MESSAGE	GGIO5 UINT In 2: Off	Range:	Off, any FlexInteger parameter
	MESSAGE	GGIO5 UINT In 3: Off	Range:	Off, any FlexInteger parameter
		↓		
	MESSAGE	GGIO5 UINT 1n 16: Off	Range:	Off, any FlexInteger parameter

The GGIO5 logical node allows IEC 61850 client access to integer data values. This allows access to as many as 16 unsigned integer value points, associated timestamps, and quality flags. The method of configuration is similar to that of GGIO1 (binary status values). The settings allow the selection of FlexInteger values for each GGIO5 integer value point.

It is intended that clients use GGIO5 to access generic integer values from the L30. Additional settings are provided to allow the selection of the number of integer values available in GGIO5 (1 to 16), and to assign FlexInteger values to the GGIO5 integer inputs. The following setting is available for all GGIO5 configuration points.

- **GGIO5 UINT IN 1 VALUE**: This setting selects the FlexInteger value to drive each GGIO5 integer status value (GGIO5.ST.UIntIn1). This setting is stored as an 32-bit unsigned integer value.

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The report control configuration settings are shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ REPORT CONTROL CONFIGURATION ⇨ CONFIGURABLE REPORT 1 ⇨ REPORT 1 DATASET ITEMS

■ REPORT 1 ■ DATASET ITEMS	◁▷	ITEM 1:	*Range: all valid MMS data item references*
MESSAGE	△▽	ITEM 2:	*Range: as shown above*
MESSAGE	△▽	ITEM 3:	*Range: as shown above*
		↓	
MESSAGE	△	ITEM 64:	*Range: as shown above*

To create the dataset for logical node LN, program the **ITEM 1** to **ITEM 64** settings to a value from the list of IEC 61850 data attributes supported by the L30. Changes to the dataset will only take effect when the L30 is restarted. It is recommended to use reporting service from logical node LLN0 if a user needs some (but not all) data from already existing GGIO1, GGIO4, and MMXU4 points and their quantity is not greater than 64 minus the number items in this dataset.

The breaker configuration settings are shown below. Changes to these values take effect when the UR is restarted:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ XCBR CONFIGURATION

■ XCBR ■ CONFIGURATION		XCBR1 ST.LOC OPERAND Off	Range: FlexLogic operand
		↓	
MESSAGE		XCBR6 ST.LOC OPERAND Off	Range: FlexLogic operand
MESSAGE		CLEAR XCBR1 OpCnt: No	Range: No, Yes
		↓	
MESSAGE		CLEAR XCBR6 OpCnt: No	Range: No, Yes
MESSAGE		XCBR1 SYNCCHECK CLS: Off	Range: FlexLogic operand
		↓	
MESSAGE		XCBR6 SYNCCHECK CLS: Off	Range: FlexLogic operand
MESSAGE		XCBR1 INTERLOCK OPN: Off	Range: FlexLogic operand
		↓	
MESSAGE		XCBR6 INTERLOCK OPN: Off	Range: FlexLogic operand
MESSAGE		XCBR1 INTERLOCK CLS: Off	Range: FlexLogic operand
		↓	
MESSAGE		XCBR6 INTERLOCK CLS: Off	Range: FlexLogic operand
MESSAGE		XCBR1 Pos ctlModel: 2	Range: 0 to 4 (as per IEC 61850-7-3, ctlModel)
		↓	
MESSAGE		XCBR6 Pos ctlModel: 2	Range: 0 to 4 (as per IEC 61850-7-3, ctlModel)
MESSAGE		XCBR1 Pos sboTimeout: 30 s	Range: 2 to 60 seconds
		↓	
MESSAGE		XCBR6 Pos sboTimeout: 30 s	Range: 2 to 60 seconds

The XCBR1 ST.LOC OPERAND setting is used to inhibit 61850 control commands to close or open breaker through UR Breaker Control element. See the Breaker Control element logic diagram for more information.

The CLEAR XCBR1 OpCnt setting allows clearing the breaker operating counter. As breakers operate by opening and closing, the XCBR operating counter status attribute (OpCnt) increments with every operation. Frequent breaker operation can result in very large OpCnt values over time. This setting allows the OpCnt to be reset to “0” for XCBR1.

The XCBR1 SYNCCHECK CLS setting is used to supervise a close command with a synchrocheck condition within XCBR logical node. If a Close with SynchroCheck is requested (through a SelectWithValue service) and the SynchroCheck condition is not satisfied, a Negative Response (-Rsp) is issued with the REASON CODE of Blocked-by-synchrocheck.

The XCBR1 INTERLOCK OPN/CLS settings are used to assign an operand, which is linked into the EnaOpn or EnaCls INTERLOCKED inputs respectively of the XCBR. When this operand is asserted, XCBR logical node inhibits execution of the open and close commands respectively. If select before operate (SBO) with Extended Security is requested and Interlock condition exists, the UR responds with a Negative response (-Rsp) with the Reason Code Blocked-by-interlocking.

The XCBR1 Pos ctlModel setting is used to select control model per IEC 61850-7-3. The following control models are supported by URs:

0 — Status only

1 — Direct control with normal security (direct-operate)

2 — SBO control with normal security (operate-once)

3 — Direct control with enhanced security (direct-operate)

4 — SBO control with enhanced security (operate-once)

See IEC 61850-7-2 for complete details on these control models.

The XCBR1 Pos sboTimeout setting is used to select SBO timeout value. To be successful, the IEC 61850 "operate" command must be executed after the "select" command within the XCBR1 Pos sboTimeout setting value.

The disconnect switch configuration settings are shown below. Changes to these values will not take effect until the UR is restarted:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ XSWI CONFIGURATION

■ XSWI ■ CONFIGURATION		XSWI1 ST.LOC OPERAND Off	Range: FlexLogic operand
	MESSAGE	XSWI2 ST.LOC OPERAND Off	Range: FlexLogic operand
	MESSAGE	XSWI3 ST.LOC OPERAND Off	Range: FlexLogic operand
		↓	
	MESSAGE	XSWI24 ST.LOC OPERAND Off	Range: FlexLogic operand
	MESSAGE	CLEAR XSWI1 OpCnt: No	Range: No, Yes
	MESSAGE	CLEAR XSWI2 OpCnt: No	Range: No, Yes
	MESSAGE	CLEAR XSWI3 OpCnt: No	Range: No, Yes
		↓	
	MESSAGE	CLEAR XSWI24 OpCnt: No	Range: No, Yes

The CLEAR XSWI1 OpCnt setting represents the disconnect switch operating counter. As disconnect switches operate by opening and closing, the XSWI operating counter status attribute (OpCnt) increments with every operation. Frequent switch operation may result in very large OpCnt values over time. This setting allows the OpCnt to be reset to “0” for XSWI1.

NOTE

Since GSSE/GOOSE messages are multicast Ethernet by specification, they are not usually be forwarded by network routers. However, GOOSE messages may be forwarded by routers if the router has been configured for VLAN functionality.

k) WEB SERVER HTTP PROTOCOL

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ WEB SERVER HTTP PROTOCOL

■ WEB SERVER ■ HTTP PROTOCOL	◁▷	HTTP TCP PORT NUMBER: 80	*Range: 0 to 65535 in steps of 1*

The L30 contains an embedded web server and is capable of transferring web pages to a web browser such as Internet Explorer or Firefox. The web pages are organized as a series of menus that can be accessed starting at the L30 "Main Menu". Web pages are available showing DNP and IEC 60870-5-104 points lists, Modbus registers, event records, fault reports, and so on. First connect the UR and a computer to an Ethernet network, then enter the IP address of the L30 into the "Address" box of the web browser.

NOTE: When the port is set to 0, the change takes effect when the L30 is restarted.

l) TFTP PROTOCOL

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ TFTP PROTOCOL

■ TFTP PROTOCOL ■	◁▷	TFTP MAIN UDP PORT NUMBER: 69	*Range: 0 to 65535 in steps of 1*
MESSAGE	△▽	TFTP DATA UDP PORT 1 NUMBER: 0	*Range: 0 to 65535 in steps of 1*
MESSAGE	△	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 (event records, oscillography, etc.).

NOTE: When the **TFTP MAIN UDP PORT NUMBER** is set to 0, the change takes effect when the L30 is restarted.

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m) IEC 60870-5-104 PROTOCOL

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 60870-5-104 PROTOCOL

	Setting	Range
■ IEC 60870-5-104 ■ PROTOCOL	IEC 60870-5-104 FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE	IEC TCP PORT NUMBER: 2404	Range: 0 to 65535 in steps of 1
MESSAGE	■ IEC NETWORK ■ CLIENT ADDRESSES	Range: see sub-menu below
MESSAGE	IEC COMMON ADDRESS OF ASDU: 0	Range: 0 to 65535 in steps of 1
MESSAGE	IEC CYCLIC DATA PERIOD: 60 s	Range: 1 to 65535 s in steps of 1
MESSAGE	IEC CURRENT DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
MESSAGE	IEC VOLTAGE DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
MESSAGE	IEC POWER DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
MESSAGE	IEC ENERGY DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
MESSAGE	IEC PF DEFAULT THRESHOLD: 1.00	Range: 0.00 to 1.00
MESSAGE	IEC OTHER DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
MESSAGE	IEC REDUNDANCY ENABLED: No	Range: No, Yes

The L30 supports the IEC 60870-5-104 protocol. 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, no more than two masters should 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 should be 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.

NOTE: When the IEC port number is set to 0, the change takes effect when the L30 is restarted.

NOTE: The L30 relay does not support energy metering. As such, the **IEC ENERGY DEFAULT THRESHOLD** setting is not applicable.

NOTE: The IEC 60870-5-104 and DNP protocols cannot be used simultaneously. When the IEC 60870-5-104 FUNCTION setting is set to "Enabled", the DNP protocol does not operate. When this setting is changed, it takes effect when power to the relay is cycled (off-to-on).

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 60870-5-104 PROTOCOL ⇨⇩ IEC NETWORK CLIENT ADDRESSES

■ IEC NETWORK ■ CLIENT ADDRESSES		CLIENT ADDRESS 1: 0.0.0.0	Range: Standard IPV4 address format
MESSAGE		CLIENT ADDRESS 2: 0.0.0.0	Range: Standard IPV4 address format
MESSAGE		CLIENT ADDRESS 3: 0.0.0.0	Range: Standard IPV4 address format
MESSAGE		CLIENT ADDRESS 4: 0.0.0.0	Range: Standard IPV4 address format
MESSAGE		CLIENT ADDRESS 5: 0.0.0.0	Range: Standard IPV4 address format

The UR can specify a maximum of five clients for its IEC 104 connections. These are IP addresses for the controllers to which the UR can connect.

A maximum of two simultaneous connections are supported at any given time.

5.2.5 MODBUS USER MAP

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ MODBUS USER MAP

■ MODBUS USER MAP ■		ADDRESS 1: 0 VALUE: 0	Range: 0 to 65535 in steps of 1
MESSAGE		ADDRESS 2: 0 VALUE: 0	Range: 0 to 65535 in steps of 1
MESSAGE		ADDRESS 3: 0 VALUE: 0	Range: 0 to 65535 in steps of 1
		↓	
MESSAGE		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 desired address in the **ADDRESS** line (converted from hex to decimal format). The corresponding value 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.

5.2.6 REAL TIME CLOCK

a) MAIN MENU

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ REAL TIME CLOCK

■ REAL TIME ■ CLOCK		SYNCRONIZING SOURCE: None	*Range: None, PP/IRIG-B/PTP/SNTP, IRIG-B/PP/PTP/SNTP, PP/PTP/IRIG-B/SNTP*
	MESSAGE	REAL TIME CLOCK EVENTS: Disabled	*Range:Enabled, Disabled*
	MESSAGE	IRIG-B SIGNAL TYPE: None	*Range:None, DC Shift, Amplitude Modulated*
	MESSAGE	■ PRECISION TIME ■ PROTOCOL (1588)	See below
	MESSAGE	■ SNTP PROTOCOL ■	See below
	MESSAGE	■ LOCAL TIME ■	See below

The relay contains a real time clock (RTC) to create timestamps 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. 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 configures the priority sequence that the relay uses to determine which of the available external time sources synchronizes the RTC and the synchrophasor clock. A setting of None causes the RTC and the synchrophasor clock to free-run. A setting of PP/IRIGB/PTP/SNTP, IRIGB/PP/PTP/SNTP, or PP/PTP/IRIGB/SNTP 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. When a time source fails or recovers, the relay automatically transfers synchronization as required by this setting.

See the **COMMANDS ⇨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.

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.

To configure and enable PTP and/or SNTP, or to set local time parameters (for example time zone, daylight savings), use the following sections.

b) PRECISION TIME PROTOCOL (1588)

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ REAL TIME CLOCK ⇨⇩ PRECISION TIME PROTOCOL (1588)

	Display	Range
	■ PRECISION TIME ■ PROTOCOL (1588)	
	STRICT POWER PROFILE: Disabled	Range: Enabled, Disabled
MESSAGE	PTP DOMAIN NUMBER 0	Range: 0 to 255
MESSAGE	PTP VLAN PRIORITY 4	Range: 0 to 7
	PTP VLAN ID 0	Range: 0 to 4095
MESSAGE	■ PTP PORT 1 ■	

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ REAL TIME CLOCK ⇨⇩ PRECISION TIME PROTOCOL (1588) ⇨⇩ PTP PORT 1(3)

	Display	Range
MESSAGE	PORT 1 PTP FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE	PORT 1 PATH DELAY ADDER: 00000 ns	Range: 0 to 60 000 ns in steps of 1
MESSAGE	PORT 1 PATH DELAY ASYMMETRY: 0000 ns	Range: –1 000 to +1 000 ns in steps of 1

The UR 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.

NOTE

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 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 may 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. Should a clock on starting up discover it is “better” that the present grandmaster, it assumes the grandmaster role and the previous grandmaster reverts to slave.

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. 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. Should one of the network devices in the hierarchy not fully implement PP, the associated propagation delay and/or latency may not be compensated for, and the time received at the end-device could be in error by more than 100 µs.

See the **Settings > Product Setup > Real Time Clock** section of this manual 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.

STRICT POWER PROFILE

- Power profile (IEEE Std C37.238 2011) requires that the relay only select as a grandmaster power profile compliant clocks, that the delivered time have worst-case error of ±1 µs, and that the peer delay mechanism be implemented. With the strict power profile setting enabled, the relay will only select as master clocks displaying the IEEE_C37_238 identification codes. It will use a port only when the peer delay mechanism is operational. With the strict power profile setting disabled, the relay will use clocks without the power profile identification when no power profile clocks are present, and will use 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

- This setting should be set to the domain number of the grandmaster-capable clock(s) to be synchronized to. A network may 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 in accordance with PTP it be set to 7.
- Depending on the characteristics of the device to which the relay is directly linked, VLAN Priority may have no effect.
- This setting applies to all of the relay's PTP capable ports.

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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 may be left at its default value.
- Depending on the characteristics of the device to which the relay is directly linked, VLAN ID may 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, this setting should be 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 will be 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 will always completely correct for uncompensated delay. A setting can be chosen that will reduce worst-case error to half of the range between minimum and maximum uncompensated delay, if these values are known.

PORT 1 ... 3 PATH DELAY ASYMMETRY

- 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 this setting should be set to zero.
- In unusual cases where the length of the link is different in different directions, this setting should be set 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 9 000 ns and the that the delay from the switch to the relay is 11 000 ns, then the mean delay is 10 000 ns, and the path delay asymmetry is 11000 - 10000 = +1000 ns.

c) SNTP PROTOCOL

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ REAL TIME CLOCK ⇨⇩ SNTP PROTOCOL

■ SNTP PROTOCOL ■	◀▶	SNTP FUNCTION: Disabled	*Range: Enabled, Disabled*
MESSAGE	▲▼	SNTP SERVER IP ADDR: 0.0.0.0	*Range: Standard IP address format*
MESSAGE	▲	SNTP UDP PORT NUMBER: 123	*Range: 0 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 to provide an accurate time. Unicast SNTP is supported. The UR-series relays do not support the broadcast, multicast or anycast SNTP functionality.

The **SNTP FUNCTION** setting enables or disabled the SNTP feature on the L30.

To use SNTP, **SNTP SERVER IP ADDR** must be set 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.

The **SNTP UDP PORT NUMBER** is 123 for normal SNTP operation. If SNTP is not required, close the port by setting it to 0.

NOTE

When the **SNTP UDP PORT NUMBER** is set to 0, the change takes effect when the L30 is restarted.

d) LOCAL TIME

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ REAL TIME CLOCK ⇨⇩ LOCAL TIME

Menu		Setting	Range
■ LOCAL TIME ■	◀▶	LOCAL TIME OFFSET FROM UTC: 0.0 hrs	Range: –24.0 to 24.0 hrs in steps of 0.5
MESSAGE	▲▼	DAYLIGHT SAVINGS TIME: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	DST START MONTH: January	Range: January to December (all months)
MESSAGE	▲▼	DST START DAY: Sunday	Range: Sunday to Saturday (all days of the week)
MESSAGE	▲▼	DST START DAY INSTANCE: First	Range: First, Second, Third, Fourth, Last
MESSAGE	▲▼	DST START HOUR: 2	Range: 0 to 23
MESSAGE	▲▼	DST STOP MONTH: January	Range: January to December (all months)
MESSAGE	▲▼	DST STOP DAY: Sunday	Range: Sunday to Saturday (all days of the week)
MESSAGE	▲▼	DST STOP DAY INSTANCE: First	Range: First, Second, Third, Fourth, Last
MESSAGE	▲▼	DST STOP HOUR: 2	Range: 0 to 23

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The UR device 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 communication protocol times are not correct unless Local Time is configured for the current location. When the RTC is synchronized with IRIG-B, Local Time must be configured for the current location or else the timestamps may not be accurate. Furthermore, times reported in historical records and communication protocols may be incorrect if the Local Time setting is not configured properly.

The **LOCAL TIME OFFSET FROM UTC** setting is 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. When a communications protocol other than PTP provides UTC to local time offset (meaning IRIG-B), that offset is used instead of the local time and daylight time settings.

The **DAYLIGHT SAVINGS TIME (DST)** settings 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.

5.2.7 FAULT REPORTS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ FAULT REPORTS ⇨ FAULT REPORT 1

Menu		Setting	Range
■ FAULT REPORT 1 ■		FAULT REPORT 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
	MESSAGE	FAULT REPORT 1 TRIG: Off	Range: FlexLogic operand
	MESSAGE	FAULT REPORT 1 Z1 MAG: 3.00 Ω	Range: 0.01 to 250.00 ohms in steps of 0.01
	MESSAGE	FAULT REPORT 1 Z1 ANGLE: 75°	Range: 25 to 90° in steps of 1
	MESSAGE	FAULT REPORT 1 Z0 MAG: 9.00 Ω	Range: 0.01 to 650.00 ohms in steps of 0.01
	MESSAGE	FAULT REPORT 1 Z0 ANGLE: 75°	Range: 25 to 90° in steps of 1
	MESSAGE	FAULT REPORT 1 LINE LENGTH UNITS: km	Range: km, miles
	MESSAGE	FAULT REP 1 LENGTH (km): 100.0	Range: 0.0 to 2000.0 in steps of 0.1
	MESSAGE	FAULT REPORT 1 VT SUBSTITUTION: None	Range: None, I0, V0
	MESSAGE	FAULT REP 1 SYSTEM Z0 MAG: 2.00 Ω	Range: 0.01 to 650.00 ohms in steps of 0.01
	MESSAGE	FAULT REP 1 SYSTEM Z0 ANGLE: 75°	Range: 25 to 90° in steps of 1

The L30 relay supports one fault report and an associated fault locator. 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 3 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: 9 before trigger and 7 after trigger (only available via the relay webpage).
- Fault duration times for each breaker (created by the breaker arcing current feature).

The captured data also includes the fault type and the distance to the fault location, as well as the reclose shot number (when applicable) To include fault duration times in the fault report, the user must enable and configure 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, the disturbance detector should not be used 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 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 can not be triggered faster than every 20 ms.

Each fault report is stored as a file; the relay capacity is fifteen (15) files. An sixteenth (16th) trigger overwrites the oldest file.

The EnerVista UR Setup 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.

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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** and **FAULT REPORT 1 Z0 MAG** impedances are entered in secondary ohms.

The **FAULT REPORT 1 VT SUBSTITUTION** setting shall be 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 shall be set to “V0”. The method is still exact, as the fault locator would combine 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 additional details. It required to configure the delta and neutral voltages under the source indicated as input for the fault report. Also, the relay will check if the auxiliary signal configured is marked as “Vn” by the user (under VT setup), and inhibit 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 shall be 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 shall be trusted with accordingly. It should be kept in mind that grounding points in vicinity of the installation impact the system zero-sequence impedance (grounded loads, reactors, zig-zag transformers, shunt capacitor banks, etc.).

5.2.8 OSCILLOGRAPHY

a) MAIN MENU

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ OSCILLOGRAPHY

■ OSCILLOGRAPHY ■	NUMBER OF RECORDS: 15	*Range: 1 to 64 in steps of 1*
MESSAGE	TRIGGER MODE: Automatic Overwrite	*Range: Automatic Overwrite, Protected*
MESSAGE	TRIGGER POSITION: 50%	*Range: 0 to 100% in steps of 1*
MESSAGE	TRIGGER SOURCE: Off	*Range: FlexLogic operand*
MESSAGE	AC INPUT WAVEFORMS: 16 samples/cycle	*Range: Off; 8, 16, 32, 64 samples/cycle*
MESSAGE	■ DIGITAL CHANNELS ■	
MESSAGE	■ ANALOG CHANNELS ■	

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 may 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 5–6: OSCILLOGRAPHY CYCLES/RECORD EXAMPLE

RECORDS	CT/VTS	SAMPLE RATE	DIGITALS	ANALOGS	CYCLES/ RECORD
3	1	8	0	0	14663
3	1	16	16	0	6945
8	1	16	16	0	3472
8	1	16	16	4	2868
8	2	16	16	4	1691
8	2	16	63	16	1221
8	2	32	63	16	749
8	2	64	63	16	422
32	2	64	63	16	124

A new record may automatically overwrite an older record if **TRIGGER MODE** is set to “Automatic Overwrite”.

Set the **TRIGGER POSITION** to a percentage of the total buffer size (for example, 10%, 50%, 75%, etc.). A trigger position of 25% consists of 25% pre- and 75% post-trigger data. The **TRIGGER SOURCE** is always captured in oscillography and may be any FlexLogic parameter (element state, contact input, virtual output, etc.). The relay sampling rate is 64 samples per cycle.

The **AC INPUT WAVEFORMS** setting 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.

NOTE

When changes are made to the oscillography settings, all existing oscillography records will be CLEARED.

b) DIGITAL CHANNELS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ OSCILLOGRAPHY ⇨⇩ DIGITAL CHANNELS

■ DIGITAL CHANNELS ■	DIGITAL CHANNEL 1: Off	Range: FlexLogic operand
MESSAGE	DIGITAL CHANNEL 2: Off	Range: FlexLogic operand
MESSAGE	DIGITAL CHANNEL 3: Off	Range: FlexLogic operand
	↓	
MESSAGE	DIGITAL CHANNEL 63: Off	Range: FlexLogic operand

A **DIGITAL 1(63) CHANNEL** 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. Upon startup, the relay will automatically prepare the parameter list.

c) ANALOG CHANNELS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ OSCILLOGRAPHY ⇨⇩ ANALOG CHANNELS

■ ANALOG CHANNELS ■	ANALOG CHANNEL 1: Off	Range: Off, any FlexAnalog parameter See Appendix A for complete list.
MESSAGE	ANALOG CHANNEL 2: Off	Range: Off, any FlexAnalog parameter See Appendix A for complete list.
MESSAGE	ANALOG CHANNEL 3: Off	Range: Off, any FlexAnalog parameter See Appendix A for complete list.
	↓	
MESSAGE	ANALOG CHANNEL 16: Off	Range: Off, any FlexAnalog parameter See Appendix A for complete list.

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 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 will automatically prepare the parameter list. 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 quite time-consuming to scan through the list of parameters via the relay keypad and display - entering this number via the relay keypad will cause the corresponding parameter to be displayed.

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 will appear in the file; only the digital traces will appear.

5.2.9 DATA LOGGER

PATH: SETTINGS ⇨⇩ PRODUCT SETUP ⇨⇩ DATA LOGGER

Menu	Display	Range
■ DATA LOGGER ■	DATA LOGGER MODE: Continuous	Range: Continuous, Trigger
MESSAGE	DATA LOGGER TRIGGER: Off	Range: FlexLogic operand
MESSAGE	DATA LOGGER RATE: 60000 ms	Range: 15 to 3600000 ms in steps of 1
MESSAGE	DATA LOGGER CHNL 1: Off	Range: Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.
MESSAGE	DATA LOGGER CHNL 2: Off	Range: Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.
MESSAGE	DATA LOGGER CHNL 3: Off	Range: Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.
	↓	
MESSAGE	DATA LOGGER CHNL 16: Off	Range: Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.
MESSAGE	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 may 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, meaning that 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. Example storage capacities for a system frequency of 60 Hz are shown in the following table.

Table 5–7: DATA LOGGER STORAGE CAPACITY EXAMPLE

SAMPLING RATE	CHANNELS	DAYS	STORAGE CAPACITY
15 ms	1	0.1	954 s
	8	0.1	120 s
	9	0.1	107 s
	16	0.1	60 s
1000 ms	1	0.7	65457 s
	8	0.1	8182 s
	9	0.1	7273 s
	16	0.1	4091 s
60000 ms	1	45.4	3927420 s
	8	5.6	490920 s
	9	5	436380 s
	16	2.8	254460 s
3600000 ms	1	2727.5	235645200 s
	8	340.9	29455200 s
	9	303	26182800 s

NOTE

Changing any setting affecting data logger operation will clear any data that is currently in the log.

- **DATA LOGGER MODE**: This setting configures the mode in which the data logger will operate. When set to "Continuous", the data logger will actively record any configured channels at the rate as defined by the **DATA LOGGER RATE**. The data logger will be idle in this mode if no channels are configured. When set to "Trigger", the data logger will begin to record any configured channels at the instance of the rising edge of the **DATA LOGGER TRIGGER** source FlexLogic operand. *The data logger will ignore all subsequent triggers* and will continue 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 will also stop the current record and reset 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. The **DATA LOGGER TRIGGER** 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 will be 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 will automatically prepare 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 quite time-consuming to scan through the list of parameters via the relay keypad/display – entering this number via the relay keypad will cause the corresponding parameter to be displayed.
- **DATA LOGGER CONFIG:** This display presents the total amount of time the Data Logger can record the channels not selected to "Off" without over-writing old data.

5.2.10 USER-PROGRAMMABLE LEDS

a) MAIN MENU

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE LEDS

■ USER-PROGRAMMABLE ■ LEDS	◄►	■ LED TEST ■	See below
MESSAGE	▲▼	■ TRIP & ALARM LEDS ■	See page 5-68.
MESSAGE	▲▼	■ USER-PROGRAMMABLE ■ LED1	See page 5-68.
MESSAGE	▲▼	■ USER-PROGRAMMABLE ■ LED2	
		↓	
MESSAGE	▲	■ USER-PROGRAMMABLE ■ LED48	

The 48 amber LEDs on relay panels 2 and 3 can be customized to illuminate when a selected FlexLogic operand is in the logic 1 state. The trip and alarm LEDs on panel 1 can also be customized in a similar manner. To ensure correct functionality of all LEDs, an LED test feature is also provided.

b) LED TEST

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE LEDS ⇨ LED TEST

■ LED TEST ■	◄►	LED TEST FUNCTION: Disabled	*Range: Disabled, Enabled.*
MESSAGE	▲	LED TEST CONTROL: Off	*Range: FlexLogic operand*

When enabled, the LED test can be initiated from any digital input or user-programmable condition such as 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.

The test consists of 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 1 minute. After 1 minute, the test will end.
2. All the LEDs are turned off, and then one LED at a time turns on for 1 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 1 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.

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 will 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.

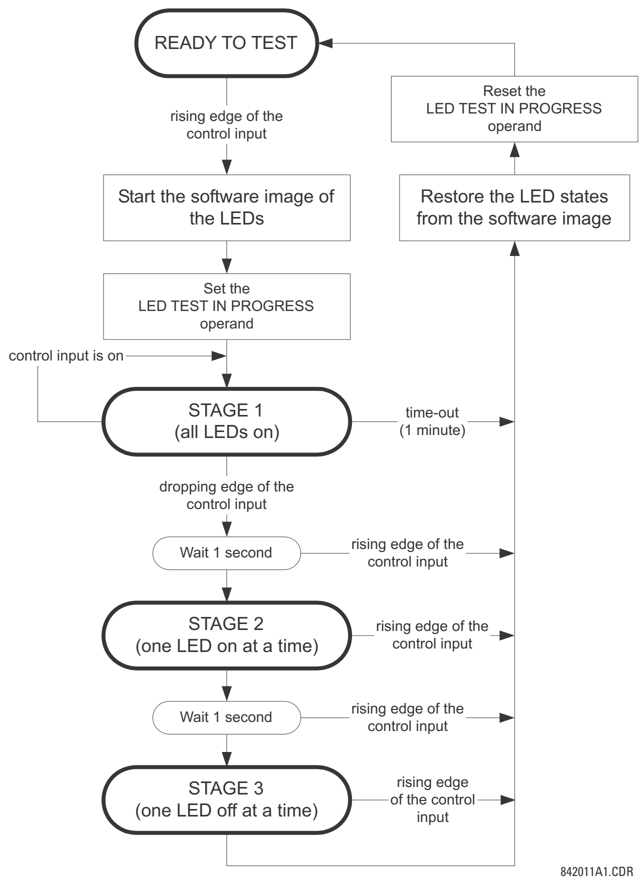

Figure 5–9: LED TEST SEQUENCE

APPLICATION EXAMPLE 1:

Assume one needs to check if any of the LEDs is "burned" through user-programmable pushbutton 1. The following settings should be applied. Configure user-programmable pushbutton 1 by making the following entries in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE PUSHBUTTONS ⇨ USER PUSHBUTTON 1** menu:

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 LEDS ⇨ LED TEST** menu:

LED TEST FUNCTION: "Enabled"
LED TEST CONTROL: "PUSHBUTTON 1 ON"

The test will be initiated when the user-programmable pushbutton 1 is pressed. The pushbutton should remain pressed for as long as the LEDs are being visually inspected. When finished, the pushbutton should be released. The relay will then automatically start stage 2. At this point forward, test may be aborted 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. Next, release the pushbutton to automatically start stage 2. Once stage 2 has started, the pushbutton can be released. When stage 2 is completed, stage 3 will automatically start. The test may be aborted at any time by pressing the pushbutton.

5

c) TRIP AND ALARM LEDS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE LEDS ⇨⇩ TRIP & ALARM LEDS

```
■ TRIP & ALARM LEDS          TRIP LED INPUT:        Range: FlexLogic operand
■                            Off

                   MESSAGE   ALARM LED INPUT:       Range: FlexLogic operand
                             Off
```

The trip and alarm LEDs are in the first LED column (enhanced faceplate) and on LED panel 1 (standard faceplate). Each indicator can be programmed to become illuminated when the selected FlexLogic operand is in the logic 1 state.

d) USER-PROGRAMMABLE LED 1(48)

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE LEDS ⇨⇩ USER-PROGRAMMABLE LED 1(48)

```
■ USER-PROGRAMMABLE          LED 1 OPERAND:         Range: FlexLogic operand
■ LED 1                      Off

                   MESSAGE   LED 1 TYPE:            Range: Self-Reset, Latched
                             Self-Reset
```

There are 48 amber LEDs across the relay faceplate 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 faceplate, 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 faceplate, 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

Refer to the *LED indicators* section in chapter 4 for additional 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 will track 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 faceplate RESET button, from a remote device via a communications channel, or from any programmed operand, even if the LED operand state de-asserts.

Table 5–8: 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

5.2.11 USER-PROGRAMMABLE SELF-TESTS

5

For user-programmable self-tests for CyberSentry, use the **Setup > Security > Supervisory** menu instead.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE SELF TESTS

■ USER-PROGRAMMABLE ■ SELF TESTS	REMOTE DEVICE OFF FUNCTION: Enabled	Range: Disabled, Enabled.
MESSAGE	FIRST ETHERNET FAIL FUNCTION: Disabled	Range: Disabled, Enabled.
MESSAGE	SEC. ETHERNET FAIL FUNCTION: Disabled	Range: Disabled, Enabled.
MESSAGE	THIRD ETHERNET FAIL FUNCTION: Disabled	Range: Disabled, Enabled.
MESSAGE	BATTERY FAIL FUNCTION: Enabled	Range: Disabled, Enabled.
MESSAGE	SNTP FAIL FUNCTION: Enabled	Range: Disabled, Enabled.
MESSAGE	IRIG-B FAIL FUNCTION: Enabled	Range: Disabled, Enabled.
MESSAGE	PTP FAIL FUNCTION: Enabled	Range: Disabled, Enabled.
MESSAGE	SFP MODULE FAIL FUNCTION: Disabled	Range: Disabled, Enabled.

All major self-test alarms are reported automatically with their corresponding FlexLogic operands, events, and targets. Most of the minor alarms can be disabled if desired.

When in the “Disabled” mode, minor alarms will not assert a FlexLogic operand, write to the event recorder, or display target messages. Moreover, they will not trigger the **ANY MINOR ALARM** or **ANY SELF-TEST** messages. When in the “Enabled” mode, minor alarms continue to function along with other major and minor alarms. Refer to the *Relay self-tests* section in chapter 7 for additional information on major and minor self-test alarms.

5.2.12 CONTROL PUSHBUTTONS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ CONTROL PUSHBUTTONS ⇨ CONTROL PUSHBUTTON 1(7)

■ CONTROL ■ PUSHBUTTON 1	CONTROL PUSHBUTTON 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	CONTROL PUSHBUTTON 1 EVENTS: Disabled	*Range: Disabled, Enabled*

There are three standard control pushbuttons, labeled 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 though user-programmable displays.

The location of the control pushbuttons are shown in the following figures.

Figure 5–10: CONTROL PUSHBUTTONS (ENHANCED FACEPLATE)

An additional four control pushbuttons are included on the standard faceplate when the L30 is ordered with the twelve user-programmable pushbutton option.

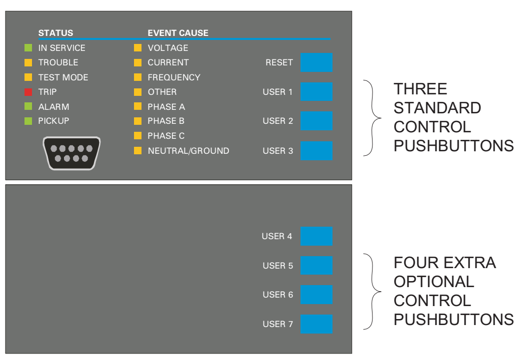

Figure 5–11: CONTROL PUSHBUTTONS (STANDARD FACEPLATE)

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. These operands should be configured appropriately to perform the desired function. The 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 will be recognized by various features that may 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 faceplate 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 below. If configured for manual control, breaker control typically uses the larger, optional user-programmable pushbuttons, making the control pushbuttons available for other user applications.

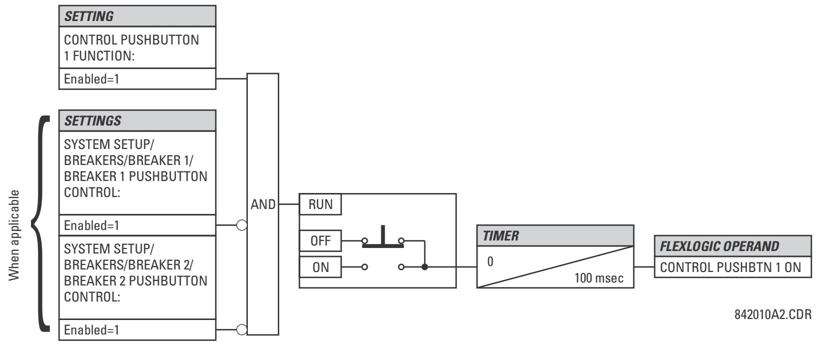

Figure 5–12: CONTROL PUSHBUTTON LOGIC

5.2.13 USER-PROGRAMMABLE PUSHBUTTONS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE PUSHBUTTONS ⇨ USER PUSHBUTTON 1(16)

■ USER PUSHBUTTON 1 ■	PUSHBUTTON 1 FUNCTION: Disabled	Range: Self-Reset, Latched, Disabled
MESSAGE	PUSHBTN 1 ID TEXT:	Range: Up to 20 alphanumeric characters
MESSAGE	PUSHBTN 1 ON TEXT:	Range: Up to 20 alphanumeric characters
MESSAGE	PUSHBTN 1 OFF TEXT:	Range: Up to 20 alphanumeric characters
MESSAGE	PUSHBTN 1 HOLD: 0.0 s	Range: 0.0 to 10.0 s in steps of 0.1
MESSAGE	PUSHBTN 1 SET: Off	Range: FlexLogic operand
MESSAGE	PUSHBTN 1 RESET: Off	Range: FlexLogic operand
MESSAGE	PUSHBTN 1 AUTORST: Disabled	Range: Disabled, Enabled
MESSAGE	PUSHBTN 1 AUTORST DELAY: 1.0 s	Range: 0.2 to 600.0 s in steps of 0.1
MESSAGE	PUSHBTN 1 REMOTE: Off	Range: FlexLogic operand
MESSAGE	PUSHBTN 1 LOCAL: Off	Range: FlexLogic operand
MESSAGE	PUSHBTN 1 DROP-OUT TIME: 0.00 s	Range: 0 to 60.00 s in steps of 0.05
MESSAGE	PUSHBTN 1 LED CTL: Off	Range: FlexLogic operand
MESSAGE	PUSHBTN 1 MESSAGE: Disabled	Range: Disabled, Normal, High Priority
MESSAGE	PUSHBUTTON 1 EVENTS: Disabled	Range: Disabled, Enabled

The optional user-programmable pushbuttons (specified in the order code) provide an easy and error-free method of entering digital state (on, off) information. The number of available pushbuttons is dependent on the faceplate module ordered with the relay.

- Type P faceplate: standard horizontal faceplate with 12 user-programmable pushbuttons.
- Type Q faceplate: enhanced horizontal faceplate with 16 user-programmable pushbuttons.

The digital state can be entered locally (by directly pressing the front panel pushbutton) or remotely (via FlexLogic operands) into FlexLogic equations, protection elements, and control elements. Typical applications include breaker control, autorecloser blocking, and setting groups changes. The user-programmable pushbuttons are under the control level of password protection.

The user-configurable pushbuttons for the enhanced faceplate are shown below.

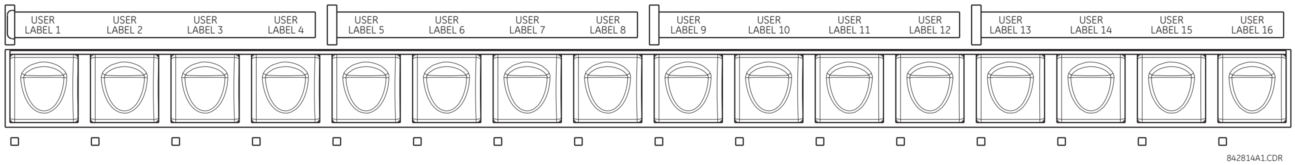

Figure 5–13: USER-PROGRAMMABLE PUSHBUTTONS (ENHANCED FACEPLATE)

The user-configurable pushbuttons for the standard faceplate are shown below.

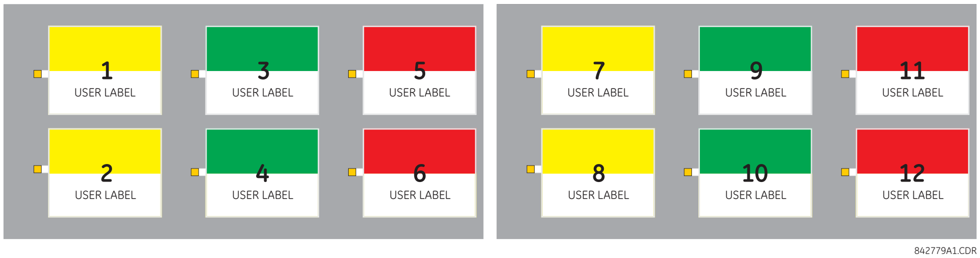

Figure 5–14: USER-PROGRAMMABLE PUSHBUTTONS (STANDARD FACEPLATE)

Both the standard and enhanced faceplate pushbuttons can be custom labeled with a factory-provided template, available online at http://www.gedigitalenergy.com/multilin. The EnerVista UR Setup software can also be used to create labels for the enhanced faceplate.

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 will be 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 pushbuttons can be automatically controlled by activating the operands assigned to the **PUSHBTN 1 SET** (for latched and self-reset mode) and **PUSHBTN 1 RESET** (for latched mode only) settings. The pushbutton reset status is declared when the PUSHBUTTON 1 OFF operand is asserted. The activation and deactivation of user-programmable pushbuttons is dependent 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 or by directly pressing the associated front panel pushbutton. The pushbutton maintains the set state until deactivated by the reset command or after a user-specified time delay. 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 or by directly pressing the associated active front panel pushbutton.

  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 pushbutton will remain active for the time it is pressed (the *pulse duration*) 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 remains assigned to the **PUSHBTN 1 SET** setting has no effect on the pulse duration.

  The pushbutton is reset (deactivated) in self-reset mode when the dropout delay specified in the **PUSHBTN 1 DROP-OUT TIME** setting expires.

NOTE

The pulse duration of the remote set, remote reset, or local 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 may 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, respectively. If local locking is applied, the pushbutton will ignore set and reset commands executed through the front panel pushbuttons. If remote locking is applied, the pushbutton will ignore set and reset commands executed through FlexLogic operands.

The locking functions are not applied to the autorestart feature. In this case, the inhibit function can be used in SBO control operations to prevent the pushbutton function from being activated and ensuring "one-at-a-time" select operation.

The locking functions can also be used to prevent 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 and displayed as target messages. In latched mode, user-defined messages can also be associated with each pushbutton and displayed when the pushbutton is on or changing to off.

- **PUSHBUTTON 1 FUNCTION**: This setting selects the characteristic of the pushbutton. If set to "Disabled", the pushbutton is not active and the corresponding FlexLogic operands (both "On" and "Off") are de-asserted. If set to "Self-Reset", the control logic is activated by the pulse (longer than 100 ms) issued when the pushbutton is being physically pressed or virtually pressed via a FlexLogic operand assigned to the **PUSHBTN 1 SET** setting.

  When in "Self-Reset" mode and activated locally, the pushbutton control logic asserts the "On" corresponding FlexLogic operand as long as the pushbutton is being physically pressed, and after being released the deactivation of the operand is delayed by the drop out timer. The "Off" operand is asserted when the pushbutton element is deactivated. If the pushbutton is activated remotely, the control logic of the pushbutton asserts the corresponding "On" FlexLogic operand only for the time period specified by the **PUSHBTN 1 DROP-OUT TIME** setting.

  If set to "Latched", the control logic alternates the state of the corresponding FlexLogic operand between "On" and "Off" on each button press or by virtually activating the pushbutton (assigning set and reset operands). When in the "Latched" mode, the states of the FlexLogic operands are stored in a non-volatile memory. Should the power supply be lost, the correct state of the pushbutton is retained upon subsequent power up of the relay.

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- **PUSHBTN 1 ID TEXT:** This setting specifies the top 20-character line of the user-programmable message and is intended to provide ID information of the pushbutton. Refer to the *User-definable displays* section for instructions on how to enter alphanumeric characters from the keypad.
- **PUSHBTN 1 ON TEXT:** This setting specifies the bottom 20-character line of the user-programmable message and is displayed when the pushbutton is in the "on" position. Refer to the *User-definable displays* section for instructions on entering alphanumeric characters from the keypad.
- **PUSHBTN 1 OFF TEXT:** This setting specifies the bottom 20-character line of the user-programmable message and is displayed when the pushbutton is activated from the on to the off position and the **PUSHBUTTON 1 FUNCTION** is "Latched". This message is not displayed 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.
- **PUSHBTN 1 HOLD**: This setting specifies the time required for a pushbutton to be pressed before it is deemed active. This timer is reset upon release of the pushbutton. Note that any pushbutton operation will require the pushbutton to be pressed a minimum of 50 ms. This minimum time is required prior to activating the pushbutton hold timer.
- **PUSHBTN 1 SET**: This setting assigns the FlexLogic operand serving to operate the pushbutton element and to assert PUSHBUTTON 1 ON operand. The duration of the incoming set signal must be at least 100 ms.
- **PUSHBTN 1 RESET**: This setting assigns the FlexLogic operand serving to reset pushbutton element and to assert PUSHBUTTON 1 OFF operand. This setting is applicable only if pushbutton is in latched mode. The duration of the incoming reset signal must be at least 50 ms.
- **PUSHBTN 1 AUTORST**: This setting enables the user-programmable pushbutton autoreset feature. This setting is applicable only if the pushbutton is in the "Latched" mode.
- **PUSHBTN 1 AUTORST DELAY**: This setting specifies the time delay for automatic reset of the pushbutton when in the latched mode.
- **PUSHBTN 1 REMOTE**: This setting assigns the FlexLogic operand serving to inhibit 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 pushbutton operation from the front panel pushbuttons. This locking 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 push-button active status after the pushbutton has been released. When activated remotely, this setting specifies the entire activation time of the pushbutton status; the length of time the operand remains on has no effect on the pulse duration. This setting is required to set the duration of the pushbutton operating pulse.
- **PUSHBTN 1 LED CTL**: This setting assigns the FlexLogic operand serving to drive pushbutton LED. If this setting is "Off", then LED operation is directly linked to PUSHBUTTON 1 ON operand.
- **PUSHBTN 1 MESSAGE**: If pushbutton message is set to "High Priority", the message programmed in the **PUSHBTN 1 ID** and **PUSHBTN 1 ON TEXT** settings will be displayed undisturbed as long as PUSHBUTTON 1 ON operand is asserted. The high priority option is not applicable to the **PUSHBTN 1 OFF TEXT** setting.

  This message can be temporary removed if any front panel keypad button is pressed. However, ten seconds of keypad inactivity will restore the message if the PUSHBUTTON 1 ON operand is still active.

  If the **PUSHBTN 1 MESSAGE** is set to "Normal", the message programmed in the **PUSHBTN 1 ID** and **PUSHBTN 1 ON TEXT** settings will be displayed as long as PUSHBUTTON 1 ON operand is asserted, but not longer than time period specified by **FLASH MESSAGE TIME** setting. After the flash time is expired, the default message or other active target message is displayed. The instantaneous reset of the flash message will be executed if any relay front panel button is pressed or any new target or message becomes active.

  The **PUSHBTN 1 OFF TEXT** setting is linked to PUSHBUTTON 1 OFF operand and will be displayed in conjunction with **PUSHBTN 1 ID** only if pushbutton element is in the "Latched" mode. The **PUSHBTN 1 OFF TEXT** message will be displayed as "Normal" if the **PUSHBTN 1 MESSAGE** setting is "High Priority" or "Normal".
- **PUSHBUTTON 1 EVENTS**: If this setting is enabled, each pushbutton state change will be logged as an event into event recorder.

The user-programmable pushbutton logic is shown below.

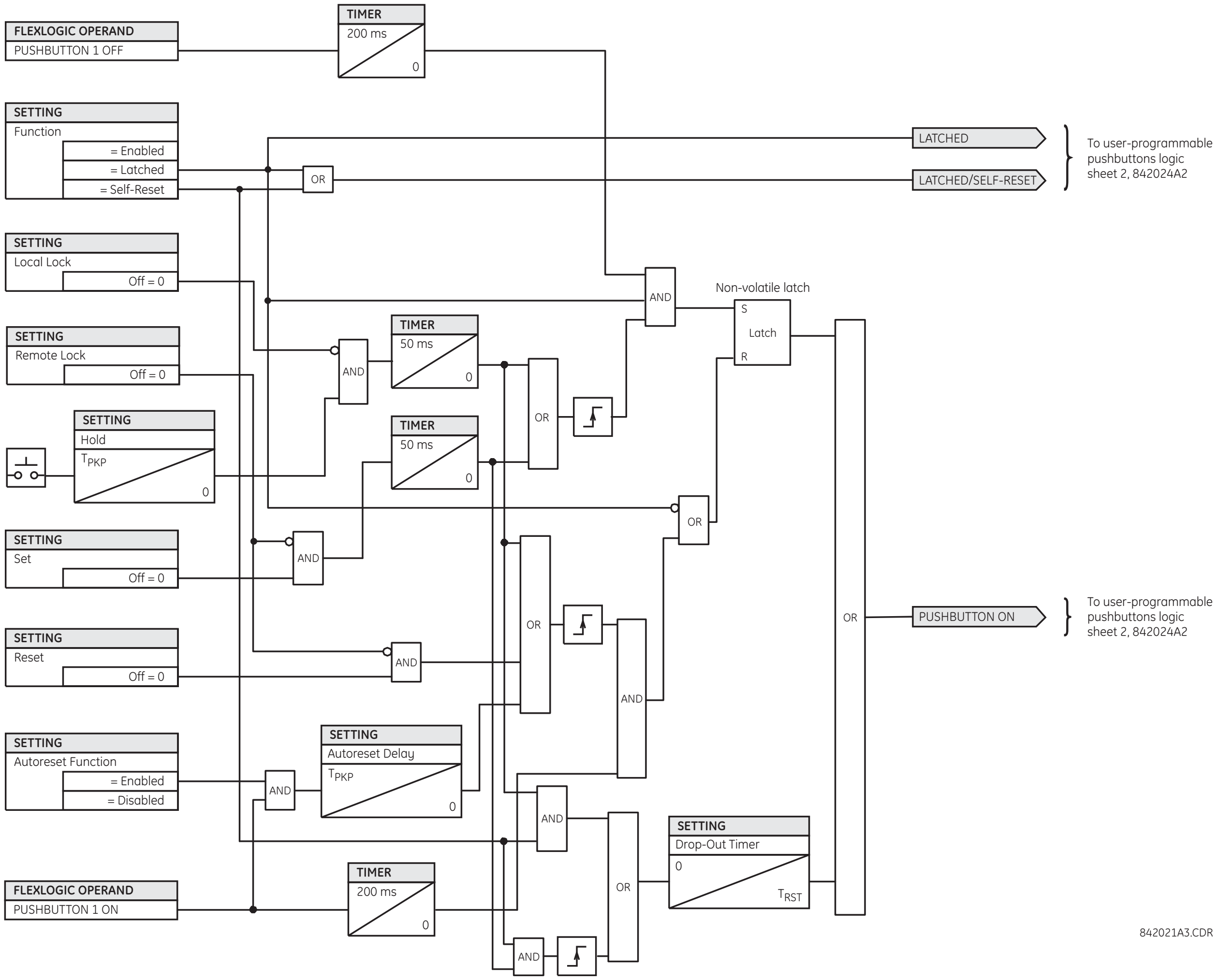

Figure 5–15: USER-PROGRAMMABLE PUSHBUTTON LOGIC (Sheet 1 of 2)

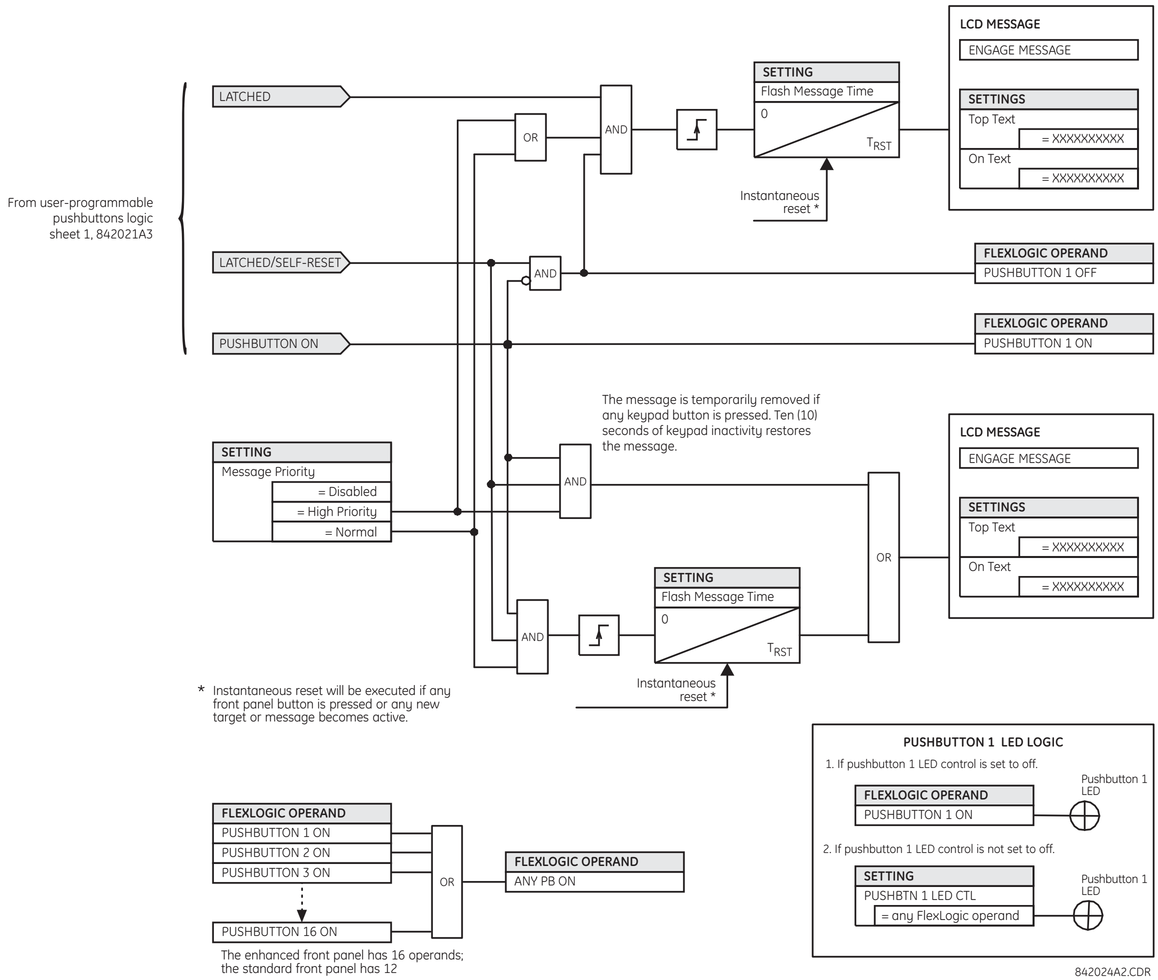

Figure 5–16: USER-PROGRAMMABLE PUSHBUTTON LOGIC (Sheet 2 of 2)

NOTE

User-programmable pushbuttons require a type HP or HQ faceplate. If an HP or HQ type faceplate was ordered separately, the relay order code must be changed to indicate the correct faceplate option. This can be done via EnerVista UR Setup with the **Maintenance > Enable Pushbutton** command.

5.2.14 FLEX STATE PARAMETERS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ FLEX STATE PARAMETERS

■ FLEX STATE ■ PARAMETERS	◁▷	PARAMETER 1: Off	*Range: FlexLogic operand*
MESSAGE	△▽	PARAMETER 2: Off	*Range: FlexLogic operand*
MESSAGE	△▽	PARAMETER 3: Off	*Range: FlexLogic operand*
		↓	
MESSAGE	△	PARAMETER 256: Off	*Range: FlexLogic operand*

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 may be read out in a single Modbus register. The state bits can be configured so that all of the states which are of interest to the user are available in a minimum number of Modbus registers.

The state bits may 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. There are sixteen registers to accommodate the 256 state bits.

5.2.15 USER-DEFINABLE DISPLAYS

a) MAIN MENU

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-DEFINABLE DISPLAYS

■ USER-DEFINABLE ■ DISPLAYS		INVOKE AND SCROLL: Off	*Range: FlexLogic operand*
	MESSAGE	■ USER DISPLAY 1 ■	*Range: up to 20 alphanumeric characters*
	MESSAGE	■ USER DISPLAY 3 ■	*Range: up to 20 alphanumeric characters*
	MESSAGE	■ USER DISPLAY 2 ■	*Range: up to 20 alphanumeric characters*
		↓	
	MESSAGE	■ USER DISPLAY 16 ■	*Range: up to 20 alphanumeric characters*

This menu provides a mechanism for manually creating up to 16 user-defined information displays in a convenient viewing sequence in the **USER DISPLAYS** 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.

Once programmed, the user-definable displays can be viewed in two ways.

- **KEYPAD**: Use the MENU key to select the **USER DISPLAYS** 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 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 key operate concurrently.

  When the default timer expires (set by the **DEFAULT MESSAGE TIMEOUT** setting), the relay will start 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.

b) USER DISPLAY 1 THROUGH 16

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-DEFINABLE DISPLAYS ⇨ USER DISPLAY 1(16)

■ USER DISPLAY 1 ■		DISP 1 TOP LINE:	Range: up to 20 alphanumeric characters
	MESSAGE	DISP 1 BOTTOM LINE:	Range: up to 20 alphanumeric characters
	MESSAGE	DISP 1 ITEM 1 0	Range: 0 to 65535 in steps of 1
	MESSAGE	DISP 1 ITEM 2 0	Range: 0 to 65535 in steps of 1
	MESSAGE	DISP 1 ITEM 3 0	Range: 0 to 65535 in steps of 1
	MESSAGE	DISP 1 ITEM 4 0	Range: 0 to 65535 in steps of 1
	MESSAGE	DISP 1 ITEM 5: 0	Range: 0 to 65535 in steps of 1

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 will then prompt **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 may subsequently be edited.

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 may be entered from the faceplate keypad or the EnerVista UR Setup interface (preferred for convenience). The following procedure shows how to enter text characters in the top and bottom lines from the faceplate 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 may 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 faceplate 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 UR Setup 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 will 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 user display setup and result is shown below:

■ USER DISPLAY 1 ■		DISP 1 TOP LINE: Current X ~ A	Shows user-defined text with first tilde marker.
MESSAGE		DISP 1 BOTTOM LINE: Current Y ~ A	Shows user-defined text with second tilde marker.
MESSAGE		DISP 1 ITEM 1: 6016	Shows decimal form of user-selected Modbus register address, corresponding to first tilde marker.
MESSAGE		DISP 1 ITEM 2: 6357	Shows decimal form of user-selected Modbus register address, corresponding to second tilde marker.
MESSAGE		DISP 1 ITEM 3: 0	This item is not being used. There is no corresponding tilde marker in top or bottom lines.
MESSAGE		DISP 1 ITEM 4: 0	This item is not being used. There is no corresponding tilde marker in top or bottom lines.
MESSAGE		DISP 1 ITEM 5: 0	This item is not being used. There is no corresponding tilde marker in top or bottom lines.
USER DISPLAYS	→	Current X 0.850 Current Y 0.327 A	Shows the resultant display content.

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NOTE

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.

5.2.16 INSTALLATION

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ INSTALLATION

■ INSTALLATION ■		RELAY SETTINGS: Not Programmed	*Range: Not Programmed, Programmed*
MESSAGE		RELAY NAME: Relay-1	*Range: up to 20 alphanumeric characters*

To safeguard against the installation of a relay without any entered settings, the unit will not allow signaling of any output relay until **RELAY SETTINGS** is set to "Programmed". This setting is defaulted to "Not Programmed" when at the factory. The **UNIT NOT PROGRAMMED** self-test error message is displayed until the relay is put into the "Programmed" state.

The **RELAY NAME** setting allows the user to uniquely identify a relay. This name will appear on generated reports.

5.3.1 REMOTE RESOURCES CONFIGURATION

When L30 is ordered with a process card module as a part of HardFiber system, then an additional **Remote Resources** menu tree is available in EnerVista UR Setup software to allow configuration of the HardFiber system.

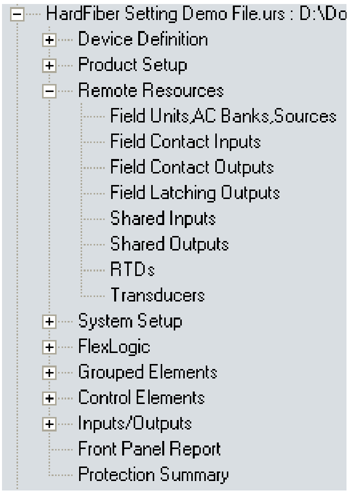

Figure 5–17: REMOTE RESOURCES CONFIGURATION MENU

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 UR Setup 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 GE publication number GEK-113658: HardFiber Process Bus System Instruction Manual.

5.4.1 AC INPUTS

a) CURRENT BANKS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨ CURRENT BANK F1(L5)

■ CURRENT BANK F1 ■	PHASE CT F1 PRIMARY: 1 A	*Range: 1 to 65000 A in steps of 1*
MESSAGE	PHASE CT F1 SECONDARY: 1 A	*Range: 1 A, 5 A*
MESSAGE	GROUND CT F1 PRIMARY: 1 A	*Range: 1 to 65000 A in steps of 1*
MESSAGE	GROUND CT F1 SECONDARY: 1 A	*Range: 1 A, 5 A*

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**, **L**} and ***a*** = {**1**, **5**}.

See the *Introduction to AC Sources* section at the beginning of this chapter for additional 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 (IA + IB + IC = neutral current = 3Io) 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 may 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 may be used. In this case, the sensitive ground CT primary rating must be entered. Refer to 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.
- L1: CT bank with 800:1 ratio.

The following rule applies:

$$\text{SRC 1} = \text{F1} + \text{F5} + \text{L1} \quad \textbf{(EQ 5.6)}$$

1 pu is the highest primary current. In this case, 1000 is entered and the secondary current from the 500:1 ratio CT will be 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 will operate on 1000 A primary.

The same rule applies for current sums from CTs with different secondary taps (5 A and 1 A).

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b) VOLTAGE BANKS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨⇩ VOLTAGE BANK F5(L5)

■ VOLTAGE BANK F5 ■		PHASE VT F5 CONNECTION: Wye	Range: Wye, Delta
MESSAGE		PHASE VT F5 SECONDARY: 66.4 V	Range: 25.0 to 240.0 V in steps of 0.1
MESSAGE		PHASE VT F5 RATIO: 1.00 :1	Range: 1.00 to 24000.00 in steps of 0.01
MESSAGE		AUXILIARY VT F5 CONNECTION: Vag	Range: Vn, Vag, Vbg, Vcg, Vab, Vbc, Vca
MESSAGE		AUXILIARY VT F5 SECONDARY: 66.4 V	Range: 25.0 to 240.0 V in steps of 0.1
MESSAGE		AUXILIARY VT F5 RATIO: 1.00 :1	Range: 1.00 to 24000.00 in steps of 0.01

bank 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**, **L**} and ***a*** = {**5**}.

See the *Introduction to AC sources* section at the beginning of this chapter for additional 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 would be entered as "Delta".

NOTE

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 would be 115; that is, (13800 / 14400) × 120. For a wye connection, the voltage value entered must be the phase to neutral voltage which would be 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 would be 120; that is, 14400 / 120.

5.4.2 POWER SYSTEM

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ POWER SYSTEM

■ POWER SYSTEM ■		NOMINAL FREQUENCY: 60 Hz	Range: 25 to 60 Hz in steps of 1
MESSAGE		PHASE ROTATION: ABC	Range: ABC, ACB
MESSAGE		FREQUENCY AND PHASE REFERENCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE		FREQUENCY TRACKING: Enabled	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 may 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. Note that this setting informs the relay of the actual system phase sequence, either ABC or ACB. CT and VT inputs on the relay, labeled 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 that are 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 will always display zero degrees and all other phase angles will be 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.

NOTE

FREQUENCY TRACKING is set to **"**Disabled**"** only in unusual circumstances; consult the factory for special variable-frequency applications.

NOTE

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.

NOTE

The nominal system frequency should be selected 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 L30 algorithm (see the *Theory of operation* chapter). Whenever the 87L function is "Disabled", the frequency tracking mechanism reverts to the UR-series mechanism which uses the **FREQUENCY TRACKING** setting to provide frequency tracking for all other elements and functions.

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5.4.3 SIGNAL SOURCES

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES ⇨ SOURCE 1(4)

■ SOURCE 1 ■		SOURCE 1 NAME: SRC 1	Range: *up to six alphanumeric characters*
MESSAGE		SOURCE 1 PHASE CT: None	Range: *None, F1, F5, F1+F5,... up to a combination of any 6 CTs. Only Phase CT inputs are displayed.*
MESSAGE		SOURCE 1 GROUND CT: None	Range: *None, F1, F5, F1+F5,... up to a combination of any 6 CTs. Only Ground CT inputs are displayed.*
MESSAGE		SOURCE 1 PHASE VT: None	Range: *None, F5, L5* *Only phase voltage inputs will be displayed.*
MESSAGE		SOURCE 1 AUX VT: None	Range: *None, F5, L5* *Only auxiliary voltage inputs will be 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. Refer to the *Introduction to AC sources* section at the beginning of this chapter for additional details on this concept.

It is possible to select the sum of all CT combinations. The first channel displayed is the CT to which all others will be 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 will be summed together.

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 may 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.

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 will be displayed here. All parameters contained within a configured source are displayed in the sources section of the actual values.

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 scheme logic is as follows:

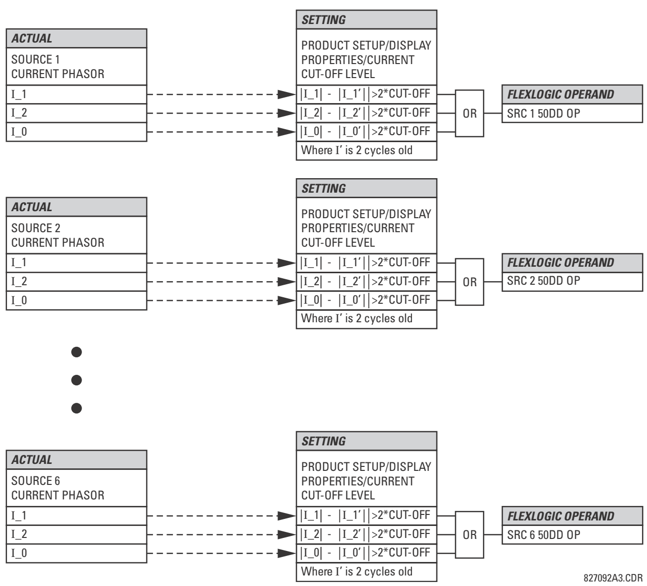

Figure 5–18: DISTURBANCE DETECTOR LOGIC DIAGRAM

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.

EXAMPLE USE OF SOURCES:

An example of the use of sources is shown in the diagram below. A relay could have the following hardware configuration:

INCREASING SLOT POSITION LETTER -->		
CT/VT MODULE 1	**CT/VT MODULE 2**	**CT/VT MODULE 3**
CTs	VTs	not applicable

This configuration could 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.

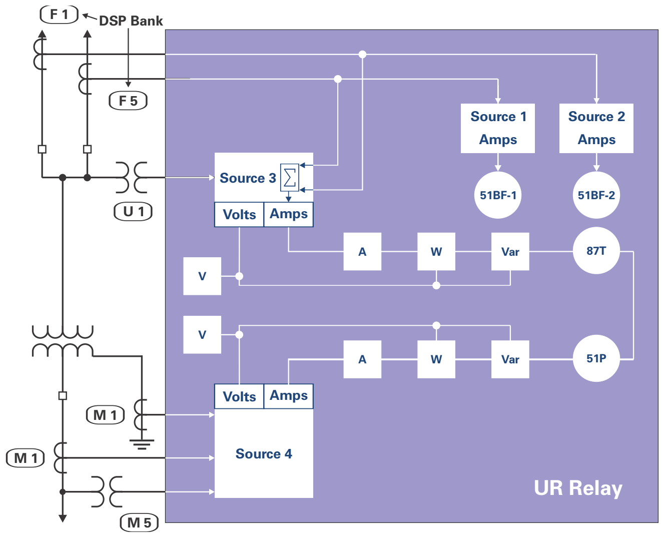

Figure 5–19: EXAMPLE USE OF SOURCES

	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

5.4.4 87L POWER SYSTEM

a) MAIN MENU

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ 87L POWER SYSTEM

		Setting	Range
■ 87L POWER SYSTEM ■		NUMBER OF TERMINALS: 2	Range: 2, 3
MESSAGE		NUMBER OF CHANNELS: 1	Range: 1, 2
MESSAGE		CHARGING CURRENT COMPENSATN: Disabled	Range: Disabled, Enabled
MESSAGE		POS SEQ CAPACITIVE REACTANCE: 0.100 kΩ	Range: 0.100 to 65.535 kΩ in steps of 0.001
MESSAGE		ZERO SEQ CAPACITIVE REACTANCE: 0.100 kΩ	Range: 0.100 to 65.535 kΩ in steps of 0.001
MESSAGE		ZERO SEQ CURRENT REMOVAL: Disabled	Range: Disabled, Enabled
MESSAGE		LOCAL RELAY ID NUMBER: 0	Range: 0 to 255 in steps of 1
MESSAGE		TERMINAL 1 RELAY ID NUMBER: 0	Range: 0 to 255 in steps of 1
MESSAGE		TERMINAL 2 RELAY ID NUMBER: 0	Range: 0 to 255 in steps of 1
MESSAGE		CHNL ASYM COMP: Off	Range: FlexLogic operand
MESSAGE		BLOCK GPS TIME REF: Off	Range: FlexLogic operand
MESSAGE		MAX CHNL ASYMMETRY: 1.5 ms	Range: 0.0 to 10.0 ms in steps of 0.1
MESSAGE		ROUND TRIP TIME CHANGE: 1.5 ms	Range: 0.0 to 10.0 ms in steps of 0.1
MESSAGE		■ IN-ZONE ■ TRANSFORMER	See page 5-92.

NOTE

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 the terminals of the associated protected line.
- **NUMBER OF CHANNELS:** This setting should correspond to the type of communications module installed. If the relay is applied on two terminal lines with a single communications channel, this setting should be selected as "1". For a two terminal line with a second redundant channel for increased dependability, or for three terminal line applications, this setting should be selected as "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's critical to ensure that three-phase line voltage is assigned to this source. The following diagram shows possible configurations.

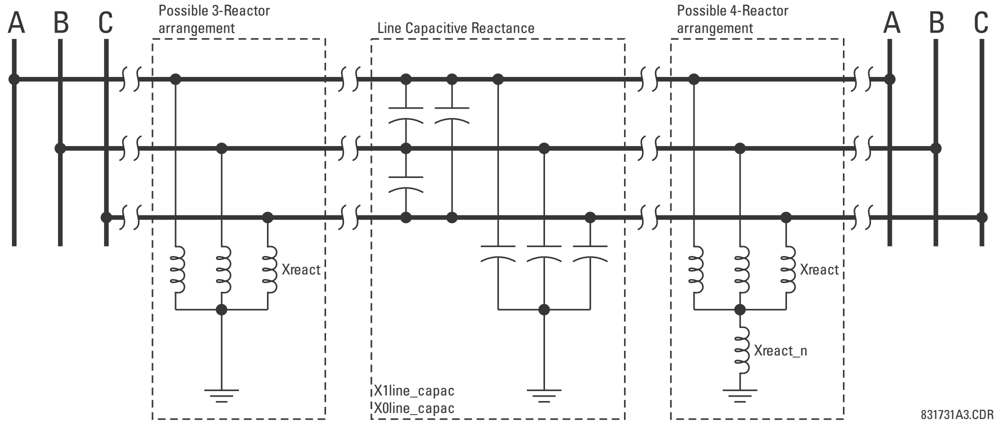

Figure 5–20: CHARGING CURRENT COMPENSATION CONFIGURATIONS

- **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 should be entered in **primary kohms** for the total line length. Details of the charging current compensation algorithm can be found in Chapter 8: *Theory of operation*.

  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 should be calculated as follows:

  1. **Three-reactor arrangement:** three identical line reactors (X_{react}) solidly connected phase to ground:

$$X_{C1} = \frac{X_{1line\_capac} \cdot X_{react}}{X_{react} - X_{1line\_capac}}, \quad X_{C0} = \frac{X_{0line\_capac} \cdot X_{react}}{X_{react} - X_{0line\_capac}} \qquad \textbf{(EQ 5.7)}$$

  2. **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.

$$X_{C1} = \frac{X_{1line\_capac} \cdot X_{react}}{X_{react} - X_{1line\_capac}}, \quad X_{C0} = \frac{X_{0line\_capac} \cdot (X_{react} + 3X_{react\_n})}{X_{react} + 3X_{react\_n} - X_{0line\_capac}} \qquad \textbf{(EQ 5.8)}$$

  X_{1line_capac} = the total line positive-sequence capacitive reactance
  X_{0line_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 using in the above equations. If the reactors installed at both ends of the line are different, the following equations apply:

  1. **For 2 terminal line:** $X_{react} = 1/\left(\frac{1}{X_{react\_terminal1}} + \frac{1}{X_{react\_terminal2}}\right)$
  2. **For 3 terminal line:** $X_{react} = 1/\left(\frac{1}{X_{react\_terminal1}} + \frac{1}{X_{react\_terminal2}} + \frac{1}{X_{react\_terminal3}}\right)$

  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 using in the above equations. If the reactors installed at both ends of the line are different, the following equations apply:

  1. **For 2 terminal line:** $X_{react\_n} = 1/\left(\frac{1}{X_{react\_n\_terminal1}} + \frac{1}{X_{react\_n\_terminal2}}\right)$
  2. **For 3 terminal line:** $X_{react\_n} = 1/\left(\frac{1}{X_{react\_n\_terminal1}} + \frac{1}{X_{react\_\_n\_terminal2}} + \frac{1}{X_{react\_n\_terminal3}}\right)$

NOTE: Charging current compensation calculations should 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 will cause a calculation error.

NOTE: 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 would create a spurious differential signal and may 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 may 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. Refer to chapter 9 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 a 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” at local relay ID setting indicates that the channel ID number is not to be checked. Refer to the *Current differential* section in this chapter for additional information.

  For two-terminal applications, only the **LOCAL ID NUMBER** and **TERMINAL 1 ID NUMBER** should be used. The **TERMINAL 2 ID NUMBER** is used for three-terminal applications.

- **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 if 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 chapter 9 for additional 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 LOCAL GPS TROUBLE signal is Off. The LOCAL GPS TROUBLE signal is On if the real time clock is not locked to global time via PP, PTP, or 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 μs.

  The **CHNL ASYM COMP** setting dynamically turns the GPS compensation on and off. A FlexLogic operand that combines several factors is typically 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 may be equipped with the fail-safe output relay. The L30 system requires a maximum error of 250 μs. The fail-safe output of the GPS receiver may 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** (GPS) 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 MAX 1 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 may decide to keep compensating if the pre-existing asymmetry was 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 may decide 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. The time reference may be not accurate due to problems with the GPS receiver. The user must to 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 may eventually cause relay misoperation. Verification from the manufacturer of receiver accuracy not worse than 250 μs and the presence of an alarm contact indicating loss of the satellite signal is strongly recommended. If the time reference accuracy cannot be guaranteed, it should be relayed to the L30 via contact inputs and GPS compensation effectively blocked 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 can 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 the channels, while the following per-channel FlexLogic operands are generated: 87L DIFF 1 MAX ASYM and 87L DIFF 2 MAX ASYM. These operands can be used to alarm on problems with communication equipment and/or to decide whether channel asymmetry compensation remains in operation should the GPS-based time reference be 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 can be also 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 should the GPS-based time reference be lost.

- **LOCAL GPS TROUBLE**: This 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 the a PTP source used for synchronizing indicate worst-case error greater than 250 μs, or accuracy less than 250 μs, or unknown accuracy/error (that is, not locked to an international time standard). Apply 2 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.

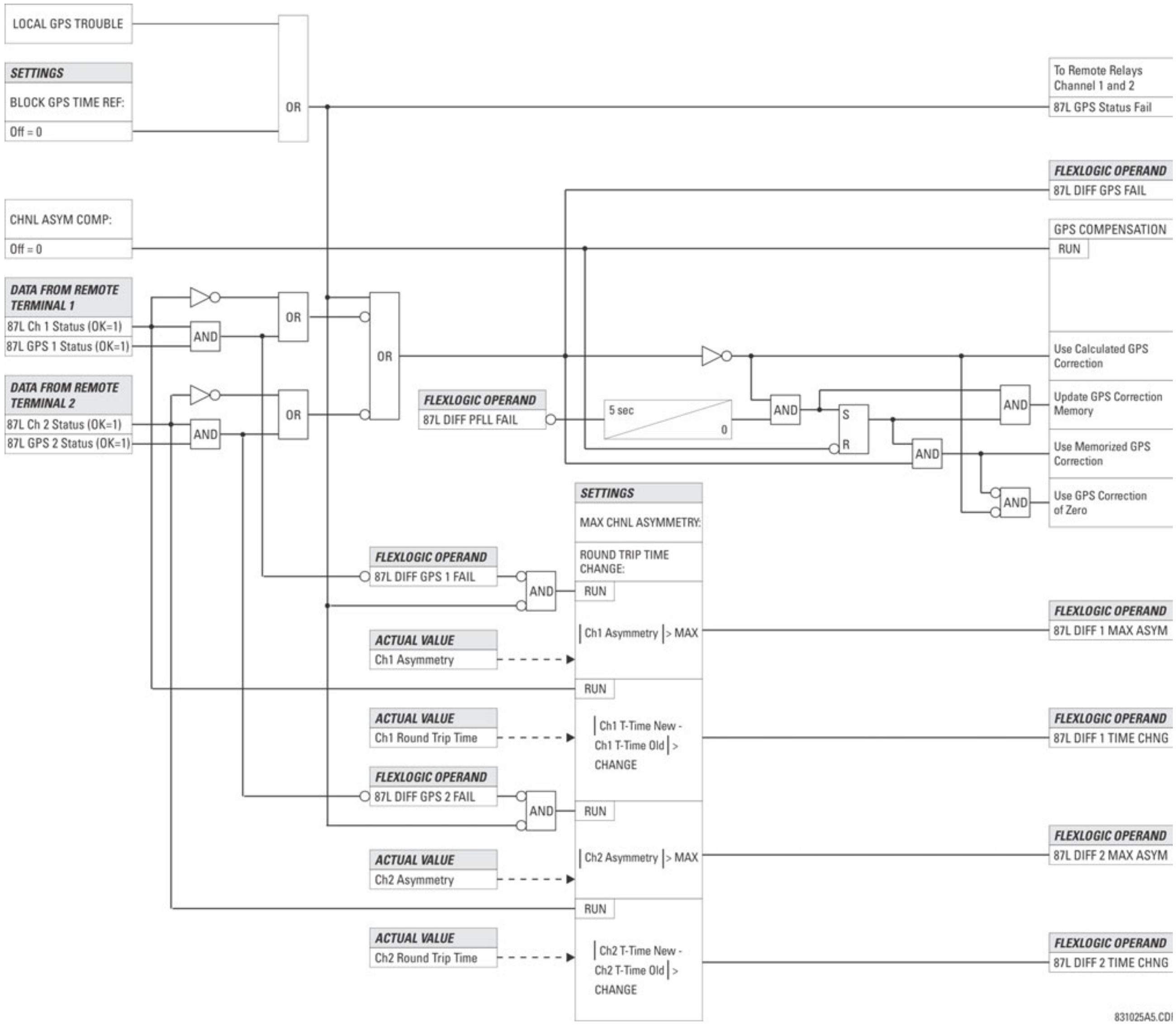

Figure 5–21: CHANNEL ASYMMETRY COMPENSATION LOGIC

b) IN-ZONE TRANSFORMER

PATH: 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°*
MESSAGE	▲	TRANSFORMER LOCATION: LOCAL-TAP	*Range: LOCAL-TAP, REM1-TAP, REM2-TAP*

The in-zone transformer settings described below 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, the **SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ LINE DIFFERENTIAL ELEMENTS ⇨ CURRENT DIFFERENTIAL ⇨⇩ CURRENT DIFF CT TAP** setting should be used. 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 is used to indicate 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 need to 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.
- **TRANSFORMER LOCATION**: This setting selects the transformer location and is applicable only if the **TRANSFORMER CONNECTION** setting is not programmed as “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 the “REM1-TAP” if the transformer is present between remote terminal 1 and the tap point.
  - Select the “REM2-TAP” if the transformer is present between remote terminal 2 and the tap point.

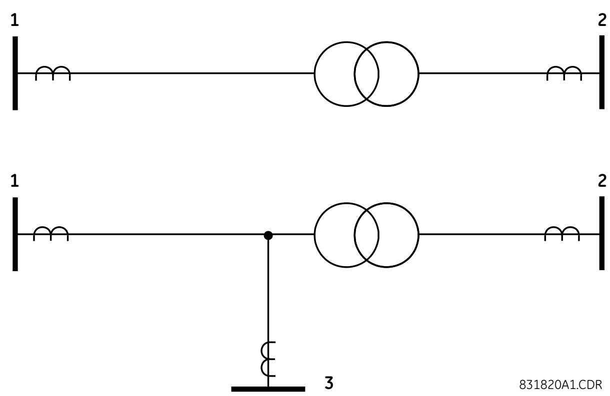

Figure 5–22: ILLUSTRATION OF IN-ZONE TRANSFORMER FOR TWO-TERMINAL AND THREE-TERMINAL LINES

NOTE

When the L90 ordered has in-zone functionality, it does not support the multi-ended fault locator.

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.

5

5.4.5 BREAKERS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ BREAKERS ⇨ BREAKER 1(2)

Menu	Key	Display	Range
■ BREAKER 1 ■	◁▷	BREAKER 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	BREAKER1 PUSH BUTTON CONTROL: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	BREAKER 1 NAME: Bkr 1	Range: up to 6 alphanumeric characters
MESSAGE	△▽	BREAKER 1 MODE: 3-Pole	Range: 3-Pole, 1-Pole
MESSAGE	△▽	BREAKER 1 OPEN: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 BLK OPEN: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 CLOSE: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 BLK CLOSE: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 ΦA/3P CLSD: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 ΦA/3P OPND: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 ΦB CLOSED: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 ΦB OPENED: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 ΦC CLOSED: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 ΦC OPENED: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 Toperate: 0.070 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	△▽	BREAKER 1 EXT ALARM: Off	Range: FlexLogic operand
MESSAGE	△▽	BREAKER 1 ALARM DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	△▽	MANUAL CLOSE RECAL1 TIME: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	△▽	BREAKER 1 OUT OF SV: Off	Range: FlexLogic operand
MESSAGE	△	BREAKER 1 EVENTS: Disabled	Range: Disabled, Enabled

5

A description of the operation of the breaker control and status monitoring features is provided in chapter 4. Only information concerning programming of the associated settings is covered here. These features are provided for two or more breakers; a user may use only those portions of the design relevant to a single breaker, which must be breaker 1.

The number of breaker control elements is dependent on the number of CT/VT modules specified with the L30. The following settings are available for each breaker control element.

- **BREAKER 1 FUNCTION:** This setting enables and disables the operation of the breaker control feature.
- **BREAKER1 PUSH BUTTON CONTROL:** Set to “Enable” to allow faceplate push button operations.
- **BREAKER 1 NAME:** Assign a user-defined name (up to six characters) to the breaker. This name will be used in flash messages related to breaker 1.
- **BREAKER 1 MODE:** This setting 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:** This setting selects an operand that creates a programmable signal to operate an output relay to open breaker 1.
- **BREAKER 1 BLK OPEN**: This setting selects an operand that prevents opening of the breaker. This setting can be used for select-before-operate functionality or to block operation from a panel switch or from SCADA.
- **BREAKER 1 CLOSE:** This setting selects an operand that creates a programmable signal to operate an output relay to close breaker 1.
- **BREAKER 1 BLK CLOSE**: This setting selects an operand that prevents closing of the breaker. This setting can be used for select-before-operate functionality or to block operation from a panel switch or from SCADA.
- **BREAKER 1 ΦA/3P CLOSED:** This setting selects an operand, usually a contact input connected to a breaker auxiliary position tracking mechanism. This input should be a normally-open 52/a status input to create a logic 1 when the breaker is closed. If the **BREAKER 1 MODE** setting is selected as “3-Pole”, this setting selects a single input as the operand used to track the breaker open or closed position. If the mode is selected as “1-Pole”, the input mentioned above is used to track phase A and the **BREAKER 1 ΦB** and **BREAKER 1 ΦC** settings select operands to track phases B and C, respectively.
- **BREAKER 1 ΦA/3P OPND:** This setting selects an operand, usually a contact input, that should be a normally-closed 52/b status input to create a logic 1 when the breaker is open. If a separate 52/b contact input is not available, then the inverted BREAKER 1 CLOSED status signal can be used.
- **BREAKER 1 ΦB 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 above for phase A.
- **BREAKER 1 ΦB 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 above for phase A.
- **BREAKER 1 ΦC 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 above for phase A.
- **BREAKER 1 ΦC 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 above 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 from 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.
- **BREAKER 1 ALARM DELAY:** This setting specifies the delay interval during which a disagreement of status among the three-pole position tracking operands will not declare a pole disagreement. This allows for non-simultaneous operation of the poles.
- **MANUAL CLOSE RECAL1 TIME:** This setting specifies the interval required to maintain setting changes in effect after an operator has initiated a manual close command to operate a circuit breaker.
- **BREAKER 1 OUT OF SV:** Selects an operand indicating that breaker 1 is out-of-service.

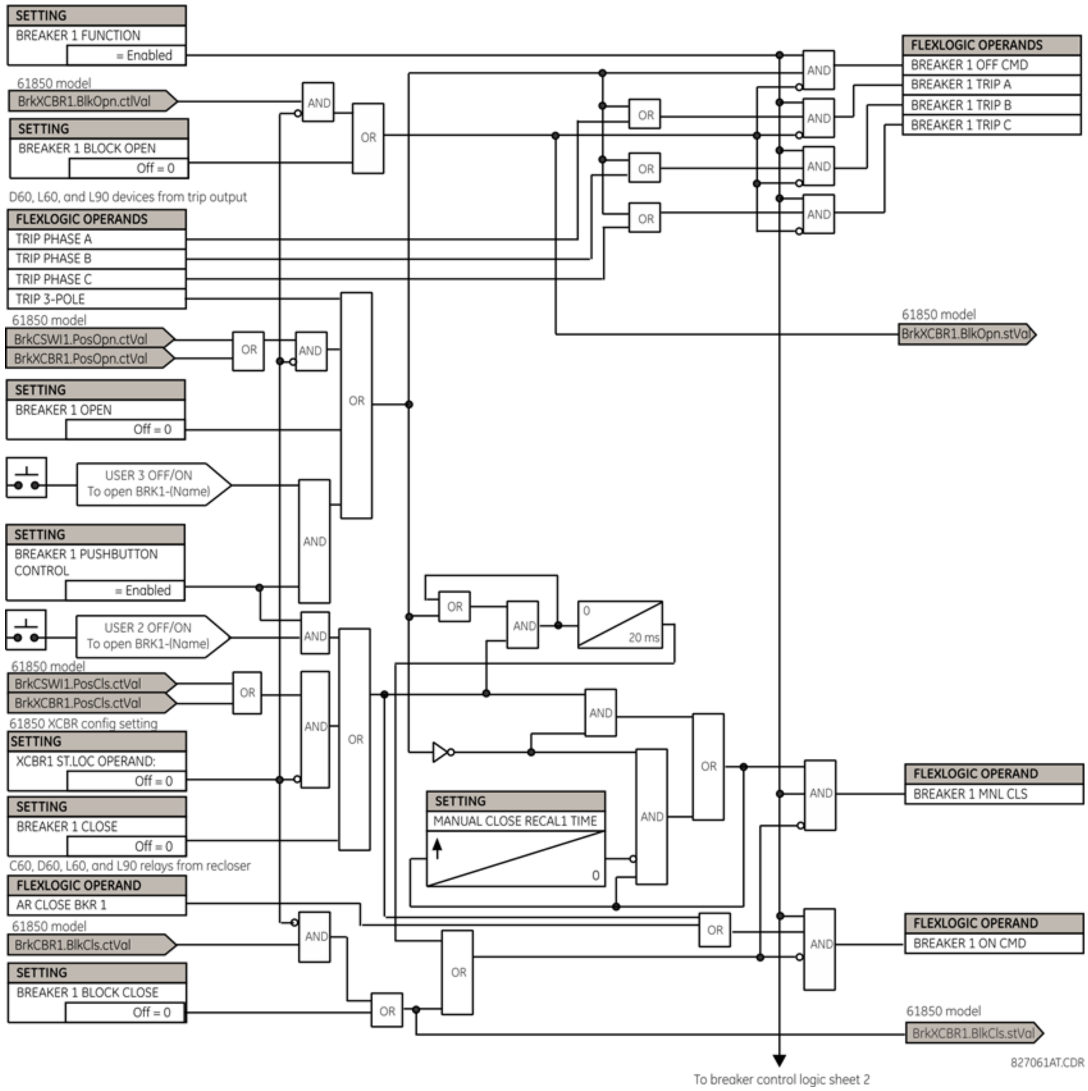

Figure 5–23: DUAL BREAKER CONTROL SCHEME LOGIC (Sheet 1 of 2)

NOTE: IEC 61850 functionality is permitted when the L30 is in “Programmed” mode and not in the local control mode.

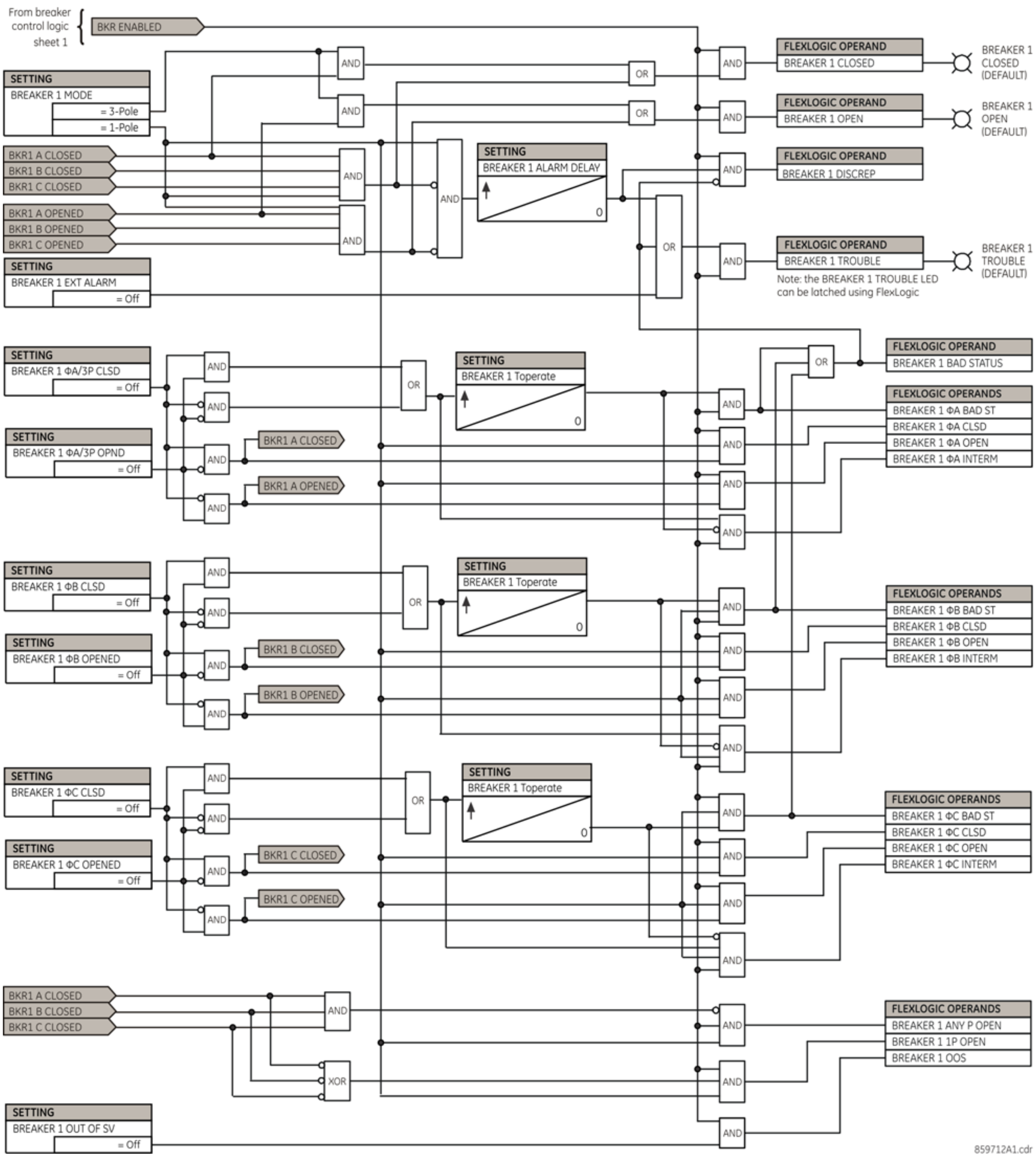

Figure 5–24: DUAL BREAKER CONTROL SCHEME LOGIC (Sheet 2 of 2)

The breaker element has direct hard-coded connections to 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 a blocking of open/close commands are provided. Note that IEC 61850 commands are event-driven and dwell time for these is one protection pass only. If you want to maintain the close/open command for a certain time, do so either on the contact outputs using the "Seal-in" setting or in FlexLogic.

5.4.6 DISCONNECT SWITCHES

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SWITCHES ⇨ SWITCH 1(8)

		Setting	Range
■ SWITCH 1 ■		SWITCH 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE		SWITCH 1 NAME: SW 1	Range: up to 6 alphanumeric characters
MESSAGE		SWITCH 1 MODE: 3-Pole	Range: 3-Pole, 1-Pole
MESSAGE		SWITCH 1 OPEN: Off	Range: FlexLogic operand
MESSAGE		SWITCH 1 BLK OPEN: Off	Range: FlexLogic operand
MESSAGE		SWITCH 1 CLOSE: Off	Range: FlexLogic operand
MESSAGE		SWITCH 1 BLK CLOSE: Off	Range: FlexLogic operand
MESSAGE		SWTCH 1 ΦA/3P CLSD: Off	Range: FlexLogic operand
MESSAGE		SWTCH 1 ΦA/3P OPND: Off	Range: FlexLogic operand
MESSAGE		SWITCH 1 ΦB CLOSED: Off	Range: FlexLogic operand
MESSAGE		SWITCH 1 ΦB OPENED: Off	Range: FlexLogic operand
MESSAGE		SWITCH 1 ΦC CLOSED: Off	Range: FlexLogic operand
MESSAGE		SWITCH 1 ΦC OPENED: Off	Range: FlexLogic operand
MESSAGE		SWITCH 1 Toperate: 0.070 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE		SWITCH 1 ALARM DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE		SWITCH 1 EVENTS: Disabled	Range: Disabled, Enabled

The disconnect switch 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 element can be used to create an 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. The number of available disconnect switches depends on the number of the CT/VT modules ordered with the L30.

- **SWITCH 1 FUNCTION:** This setting enables and disables the operation of the disconnect switch element.
- **SWITCH 1 NAME:** Assign a user-defined name (up to six characters) to the disconnect switch. This name will be 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.

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- **SWITCH 1 OPEN:** This setting selects an operand that creates a programmable signal to operate a contact output to open disconnect switch 1.
- **SWITCH 1 BLK OPEN**: This setting selects an operand that prevents opening of the disconnect switch. This setting can be used for select-before-operate functionality or to block operation from a panel switch or from SCADA.
- **SWITCH 1 CLOSE:** This setting selects an operand that creates a programmable signal to operate a contact output to close disconnect switch 1.
- **SWITCH 1 BLK CLOSE**: This setting selects an operand that prevents closing of the disconnect switch. This setting can be used for select-before-operate functionality or to block operation from a panel switch or from SCADA.
- **SWTCH 1 ΦA/3P CLSD:** This setting selects an operand, usually a contact input connected to a disconnect switch auxiliary position tracking mechanism. This input should be a normally-open 89/a status input to create 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 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 above is used to track phase A and the **SWITCH 1 ΦB** and **SWITCH 1 ΦC** settings select operands to track phases B and C, respectively.
- **SWTCH 1 ΦA/3P OPND:** This setting selects an operand, usually a contact input, that should be a normally-closed 89/b status input to create 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 ΦB 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 above for phase A.
- **SWITCH 1 ΦB 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 above for phase A.
- **SWITCH 1 ΦC 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 above for phase A.
- **SWITCH 1 ΦC 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 above for phase A.
- **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 from alarm or blocking purposes.
- **SWITCH 1 ALARM DELAY:** This setting specifies the delay interval during which a disagreement of status among the three-pole position tracking operands will not declare a pole disagreement. This allows for non-simultaneous operation of the poles.

NOTE

IEC 61850 functionality is permitted when the L30 is in “Programmed” mode and not in the local control mode.

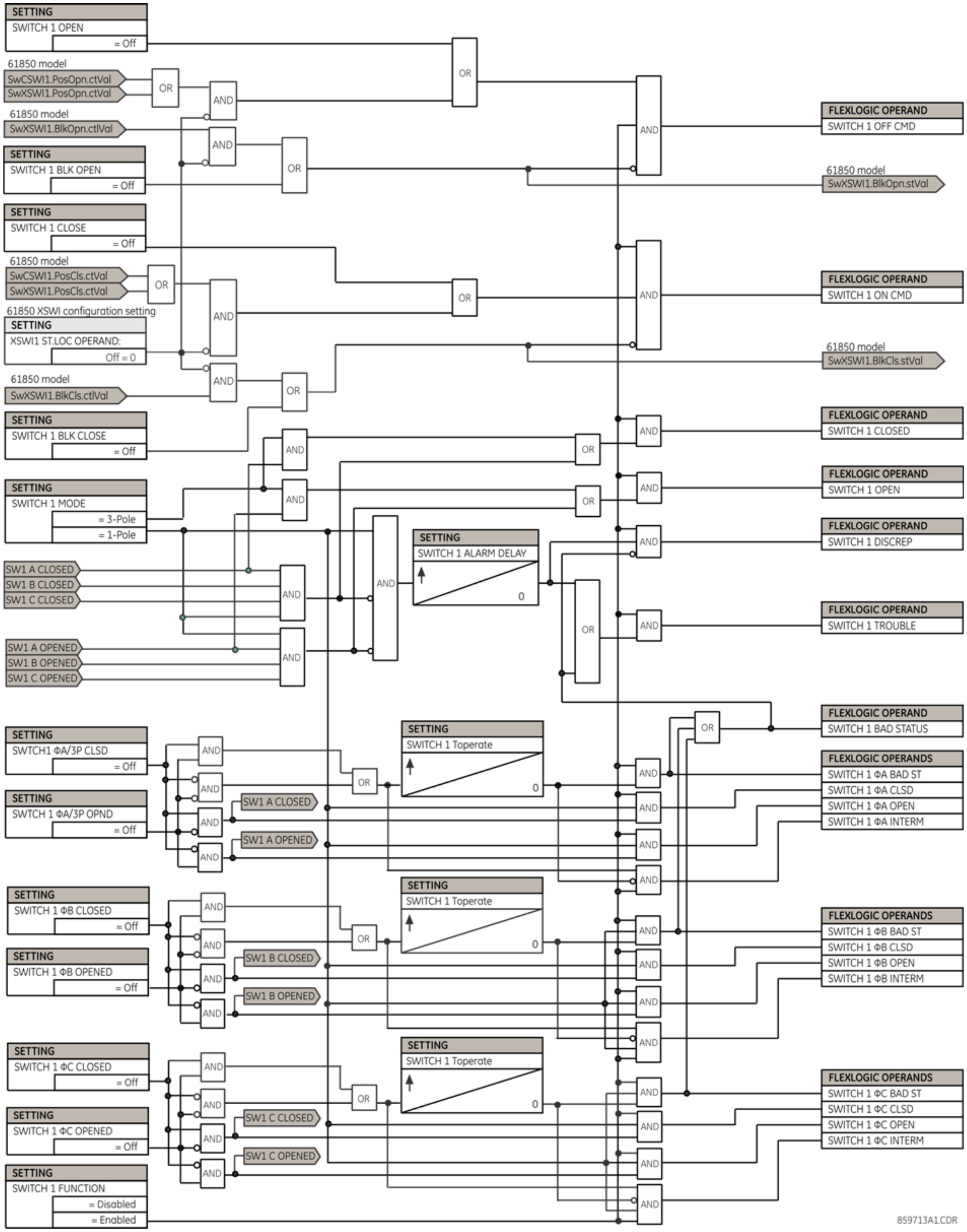

Figure 5–25: DISCONNECT SWITCH SCHEME LOGIC

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The switch element has direct hard-coded connections to IEC 61850 model as shown in the logic diagram. 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 a blocking open/close commands are provided. Note that IEC 61850 commands are event-driven and dwell time for these is one protection pass only. If you want to maintain close/open command for a certain time, do so either on the contact outputs using the "Seal-in" setting or in FlexLogic.

5.4.7 FLEXCURVES

a) SETTINGS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ FLEXCURVES ⇨ FLEXCURVE A(D)

```
■ FLEXCURVE A
■
```

```
FLEXCURVE A TIME AT
0.00 xPKP:       0 ms
```

Range: 0 to 65535 ms in steps of 1

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 desired protection curve (A, B, C, or D).

Table 5–9: 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	

NOTE

The relay using a given FlexCurve applies linear approximation for times between the user-entered points. Special care must be applied 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 may result in undesired behavior for the operating quantity that is close to 1.00 pu.

b) FLEXCURVE CONFIGURATION WITH ENERVISTA UR SETUP

The EnerVista UR Setup 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 **Import Data From** EnerVista UR Setup setting.

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.

c) 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 below appears when the Initialize From EnerVista UR Setup setting is set to “Recloser Curve” and the **Initialize FlexCurve** button is clicked.

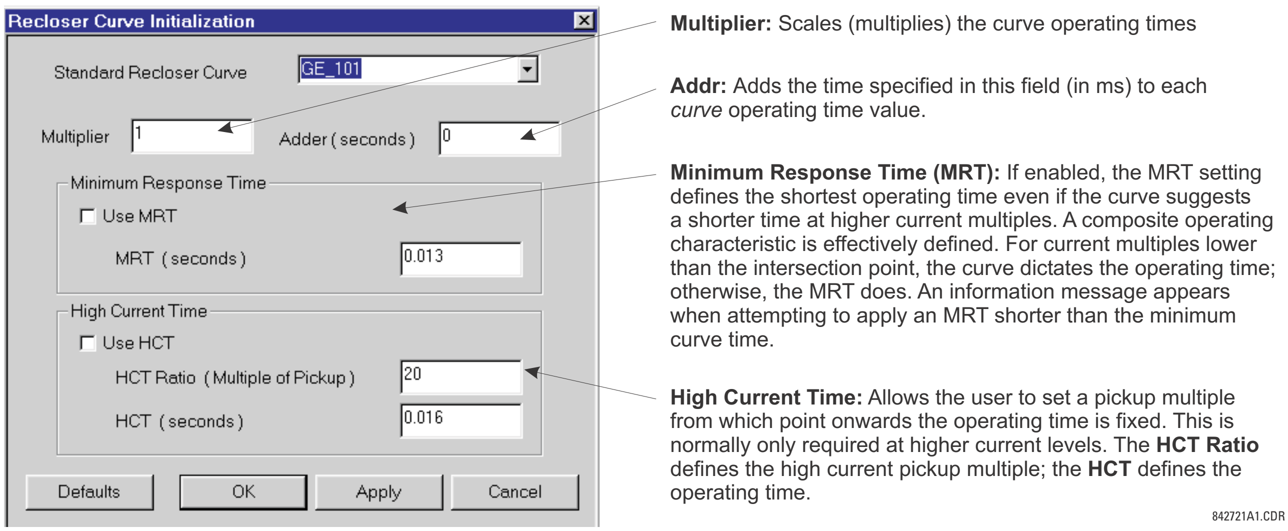

Figure 5–26: RECLOSER CURVE INITIALIZATION

NOTE

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.

d) 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 (8) times pickup with an operating time of 30 ms. At approximately four (4) times pickup, the curve operating time is equal to the MRT and from then onwards the operating time remains at 200 ms (see below).

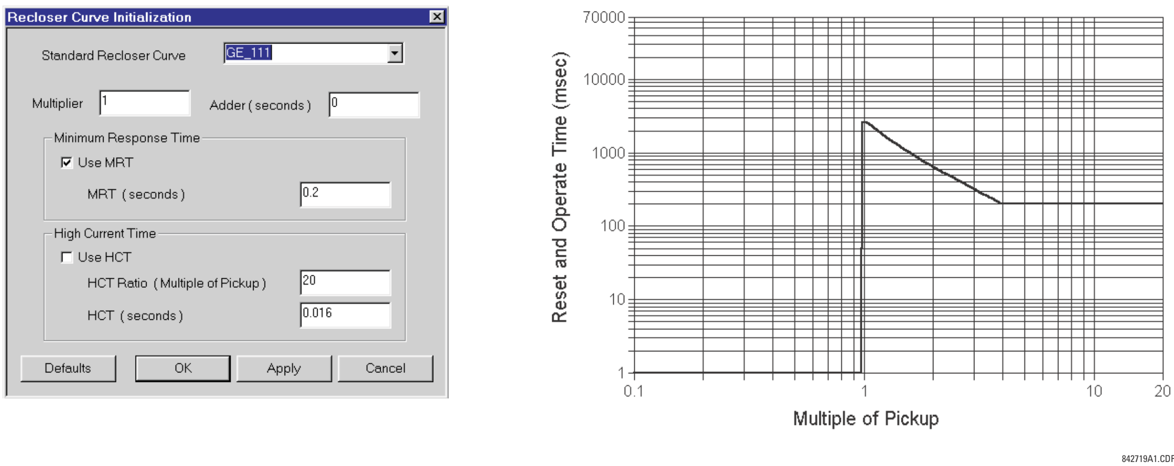

Figure 5–27: COMPOSITE RECLOSER CURVE WITH HCT DISABLED

With the HCT feature enabled, the operating time reduces to 30 ms for pickup multiples exceeding 8 times pickup.

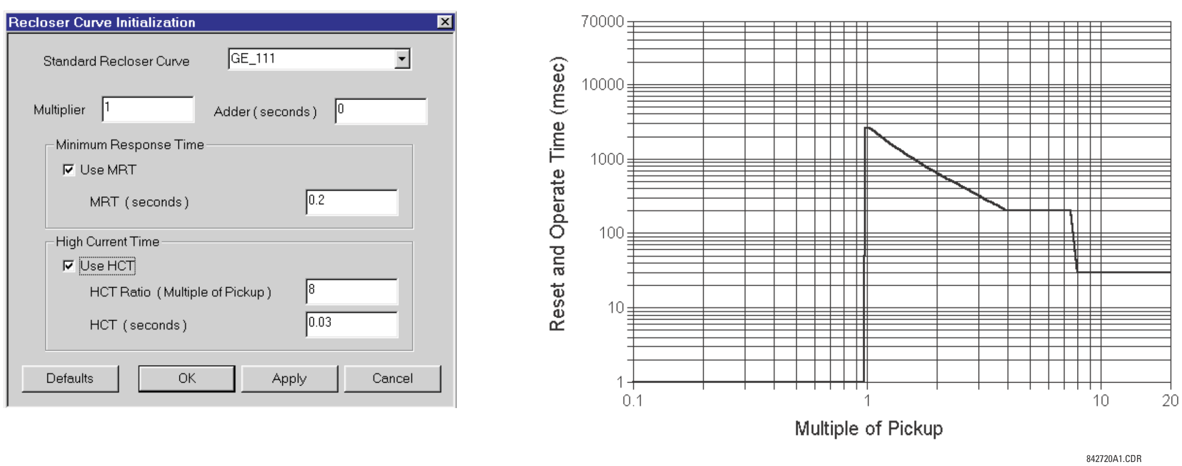

Figure 5–28: COMPOSITE RECLOSER CURVE WITH HCT ENABLED

NOTE

Configuring a composite curve with an increase in operating time at increased pickup multiples is not allowed. If this is attempted, the EnerVista UR Setup software generates an error message and discards the proposed changes.

e) STANDARD RECLOSER CURVES

The standard recloser curves available for the L30 are displayed in the following graphs.

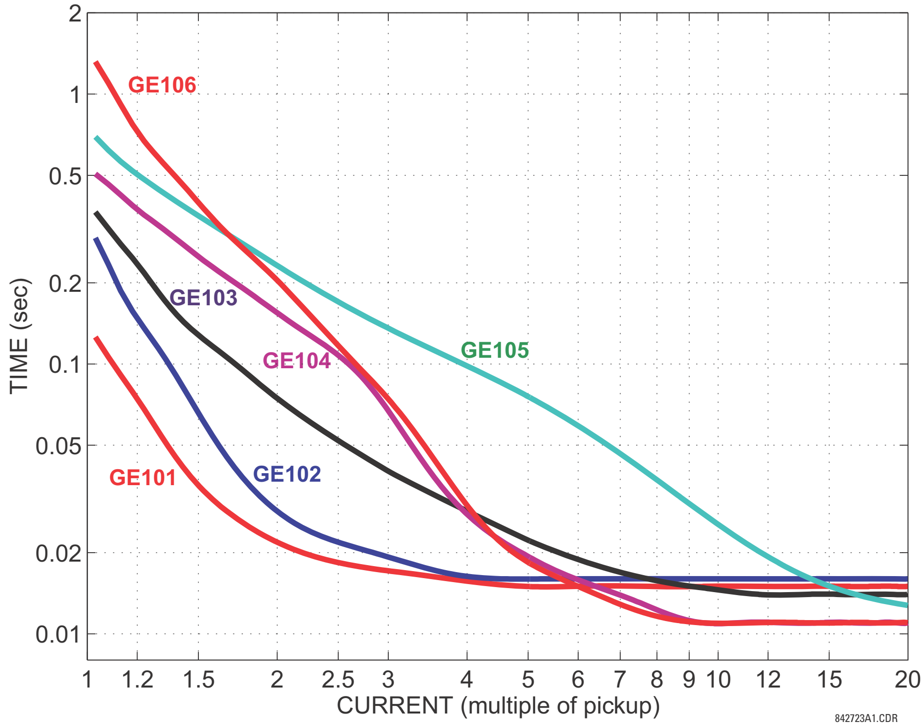

Figure 5–29: RECLOSER CURVES GE101 TO GE106

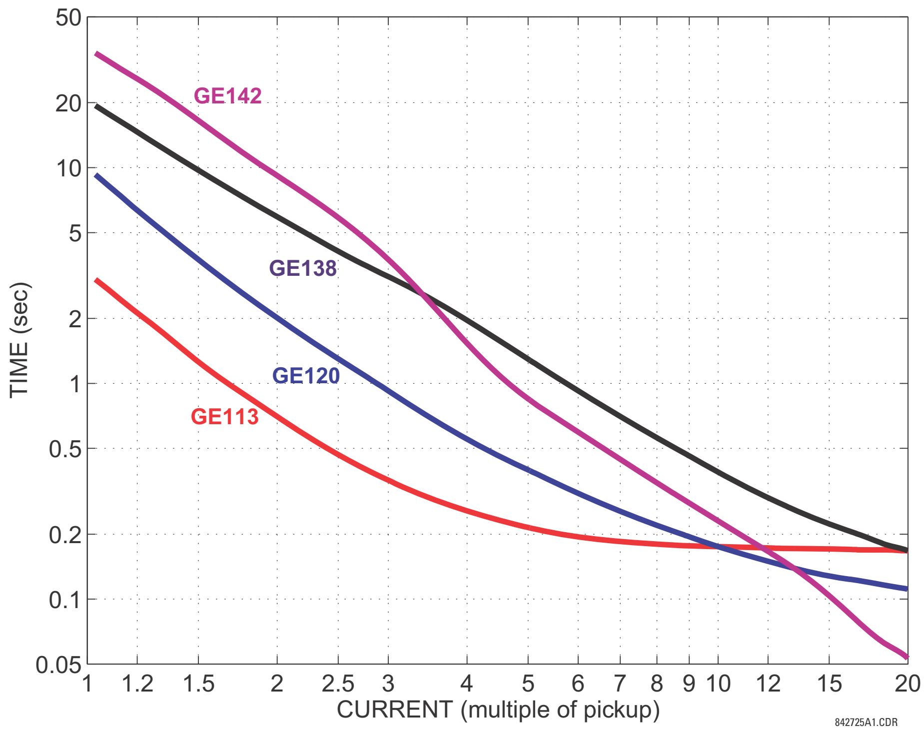

Figure 5–30: RECLOSER CURVES GE113, GE120, GE138 AND GE142

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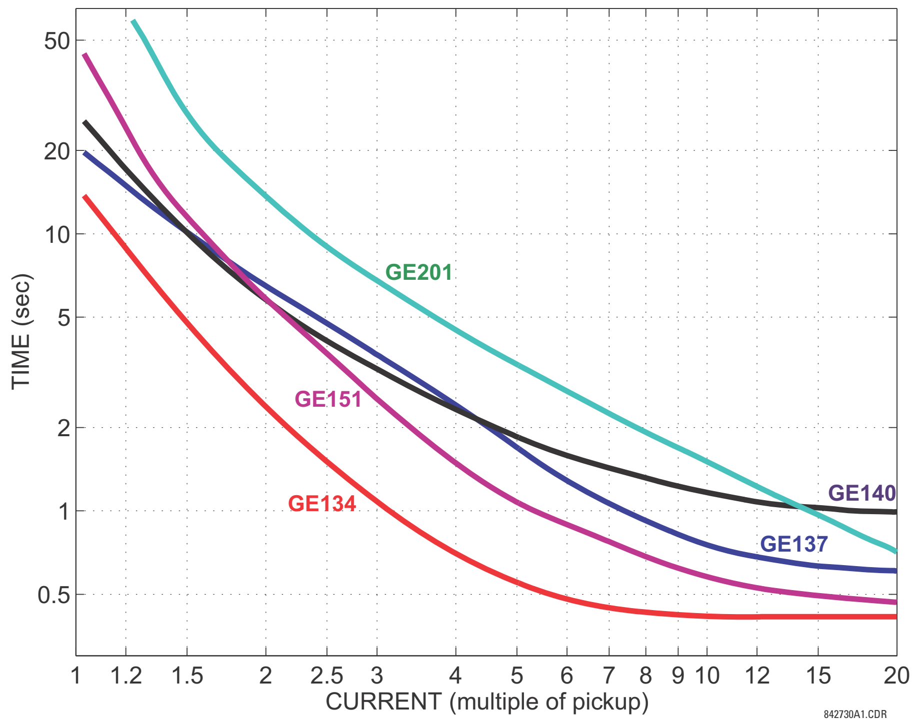

Figure 5–31: RECLOSER CURVES GE134, GE137, GE140, GE151 AND GE201

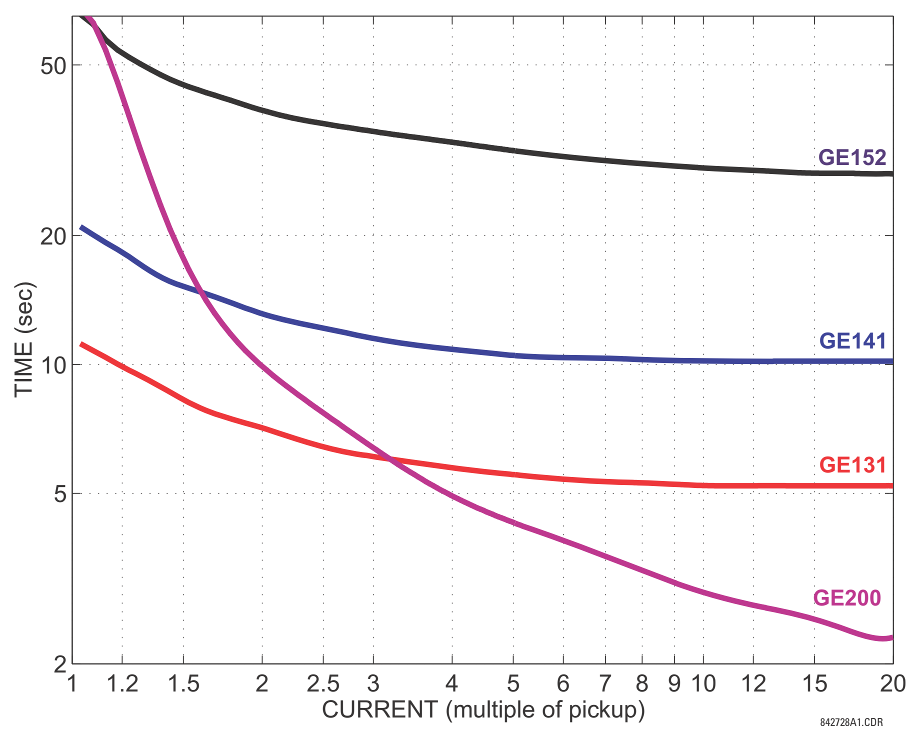

Figure 5–32: RECLOSER CURVES GE131, GE141, GE152, AND GE200

5

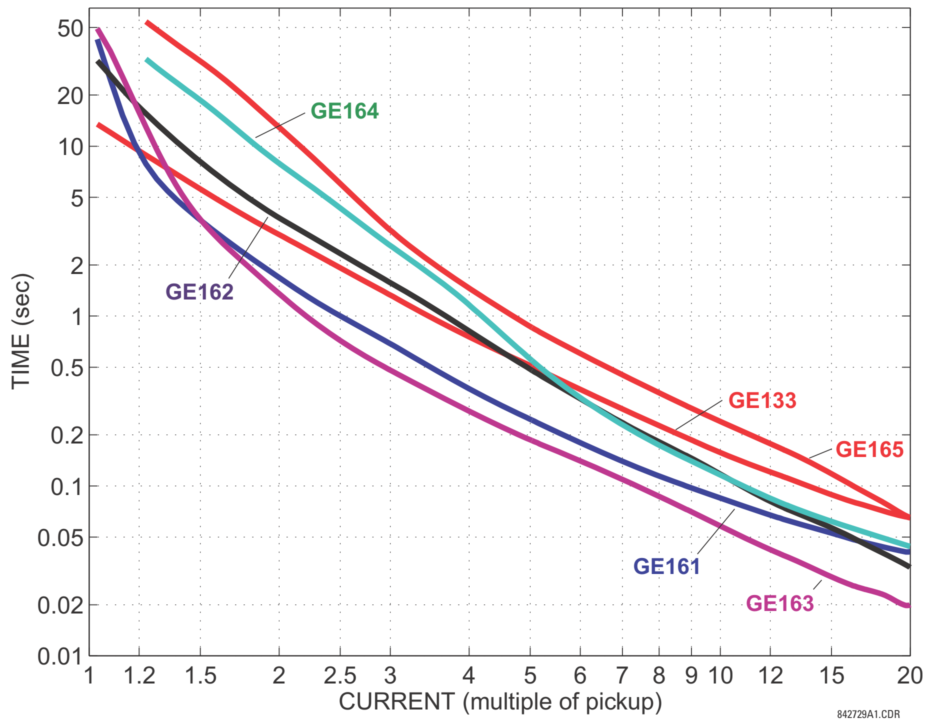

Figure 5–33: RECLOSER CURVES GE133, GE161, GE162, GE163, GE164 AND GE165

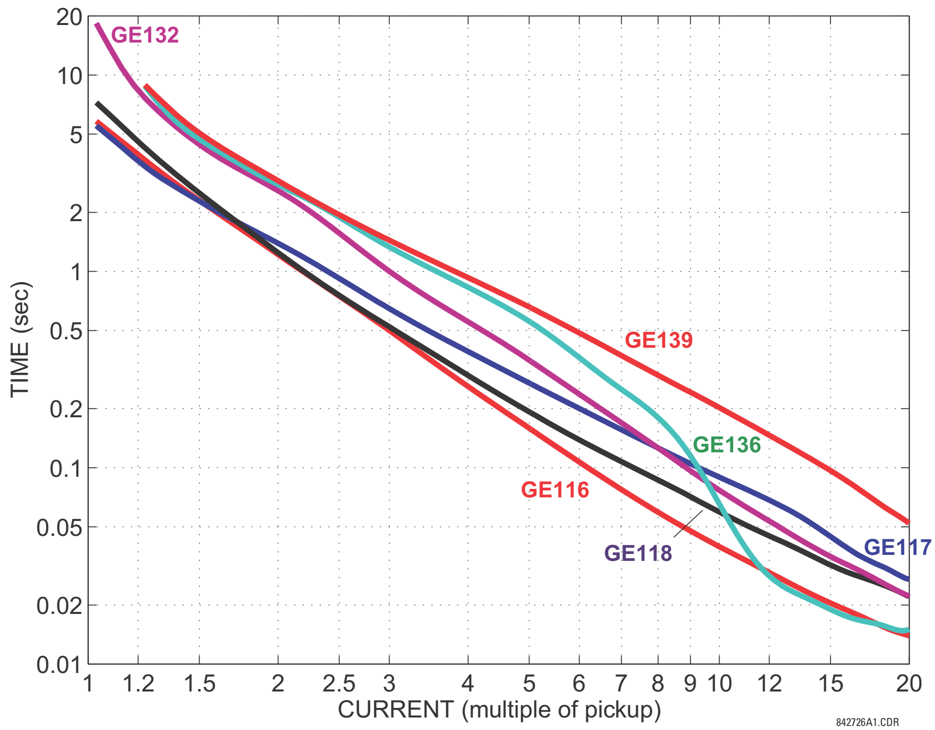

Figure 5–34: RECLOSER CURVES GE116, GE117, GE118, GE132, GE136, AND GE139

5

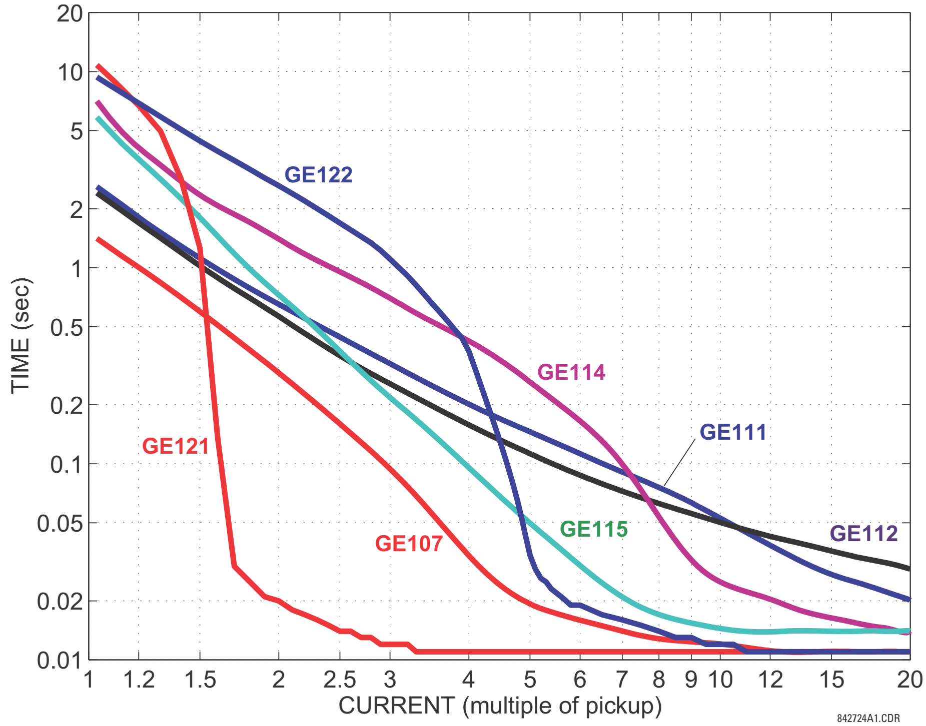

Figure 5–35: RECLOSER CURVES GE107, GE111, GE112, GE114, GE115, GE121, AND GE122

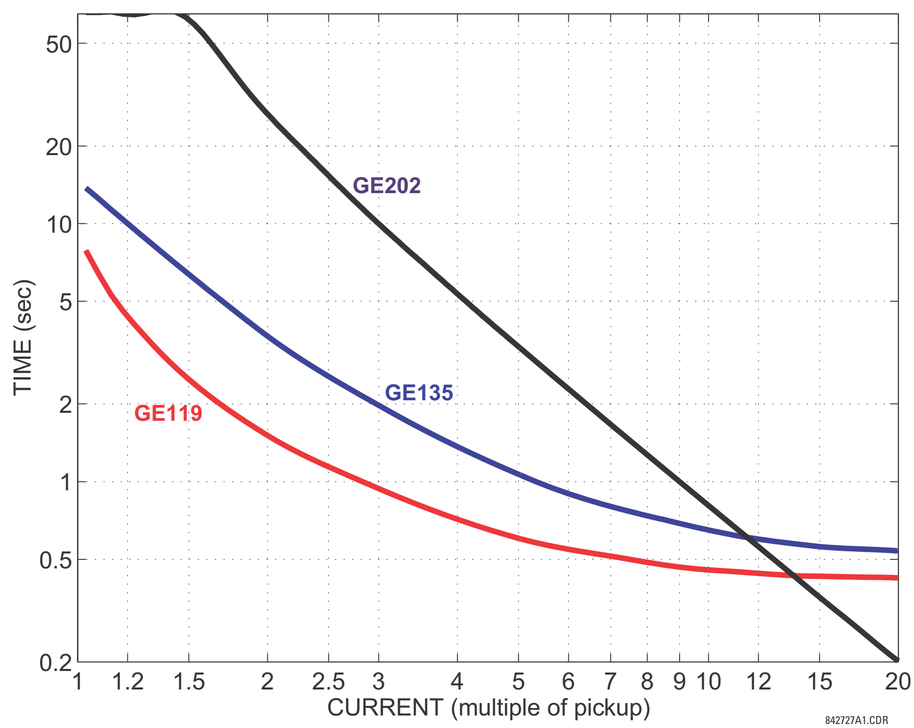

Figure 5–36: RECLOSER CURVES GE119, GE135, AND GE202

5.4.8 PHASOR MEASUREMENT UNIT

a) MAIN MENU

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT UNIT

■ PHASOR MEASUREMENT ■ UNIT		■ PHASOR MEASUREMENT ■ UNIT 1	See below.
	MESSAGE	■ AGGREGATOR ■ UNIT 1	See page 5-125.
	MESSAGE	■ IEC 90-5 MSVCB ■ CONFIGURATION	See page 5-127.

UR Synchrophasor Implementation

PHASORS are used within protection relays. If these phasors are referenced to a common time base they are referred to as a SYNCHROPHASOR. A vastly improved method for tracking power system dynamic phenomena for improved power system monitoring, protection, operation, and control can be realized if Synchrophasors from different locations within the power system are networked to a central location.

The L30 offers PMU features over two communication standards, IEC61850-9-5 and IEEE C37.118. The figure shows complete Synchrophasor implementation.

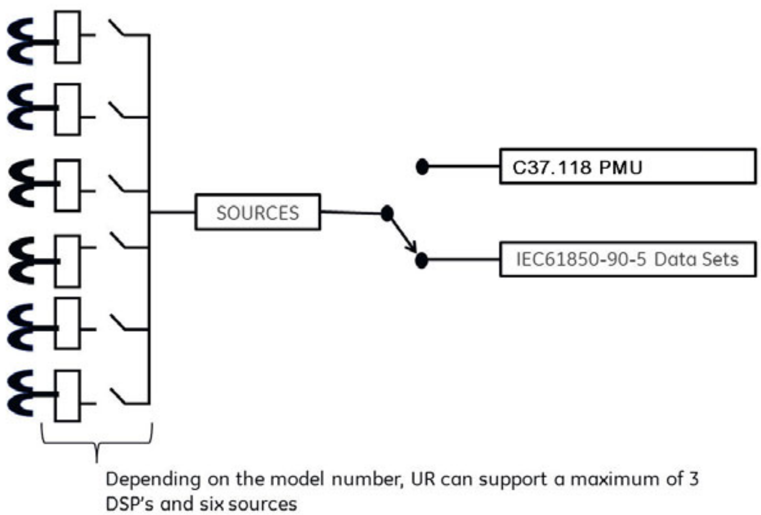

Figure 5–37: COMPLETE SYNCHROPHASOR IMPLEMENTATION

UR Implementation of IEC61850-90-5

Synchrophasor data as measured and calculated by phasor measurement units (PMUs) is very useful 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 desire to have a communication mechanism that is compliant with the concept of IEC 61850 has led to the development of IEC61850-90-5. The IEC61850-90-5 standard defines the packet structure for multicast routing of streamed Sampled Value (SV) known as R-SV.

Firmware versions 7.0 and above have a 90-5 based R-SV implementation equivalent in structure and configuration to that of the existing 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 two figures below depict the general data flow for the generation of synchrophasor data for IEC61850-90-5. In the first figure, when IEC61850-90-5 is selected all real and virtual sources are available for the IEC61850-90-5 PMUs.

Firmware version 7.0 allows the N60 to support a maximum of four Logical Device PMUs (Logical Device 2 through 5) and four aggregators (located in Logical Device 1 (LD1)), while other UR family members support one PMU and only one aggregator. The control blocks for the aggregators are located in LD1. A 64 char LDName setting is provided, see figure below..

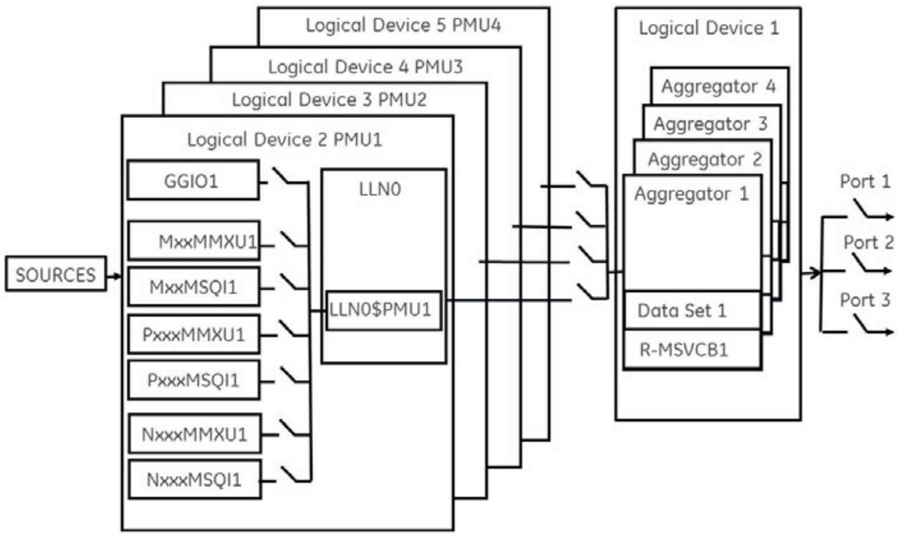

Figure 5–38: N60 SUPPORT FOR FOUR LOGICAL DEVICE PMUS

The specifics of implementation by model number is summarized in the table below.

Table 5–10: IMPLEMENTATION BY MODEL NUMBER

MODEL	NUMBER OF PMUS	NUMBER OF AGGREGATORS	NUMBER OF ANALOG INPUTS
N60	4	4	16
D60, F60, G60, L30, L90, T60	1	1	16

NOTE

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 phasor measurement unit to output proper synchrophasor values.

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, NxxMMXU, and one NxxMSQI logical node.

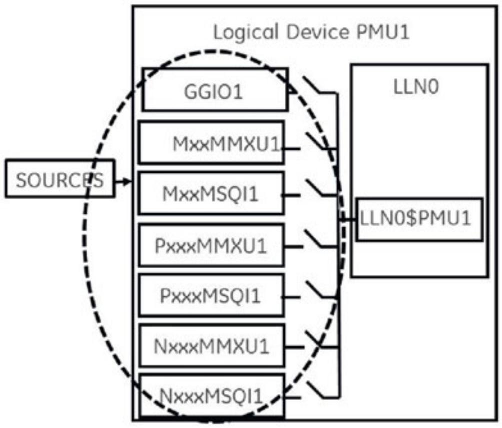

Figure 5–39: LOGICAL NODES SUPPORTED IN EACH LOGICAL DEVICE

The following is a summary of LNs that are in each Logical Device (LD2 through LD5):

- 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.

NOTE: 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 IEEC 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 below 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.

NOTE: 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 which 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 version 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.

NOTE

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 will be 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 version 7.0 only FCDA data is supported. The *Implementation by Model Number* table, see above**,** describes the maximum size of each PMU data set for version 7.0 using FCDA data (non-structured data).

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 figure above, Logical Nodes Supported in Each Logical Device. This data or list of items, see figure below, 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 will be a 64 character user setting. The 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 datset(s). For version 7.0 only FCDA data is supported.

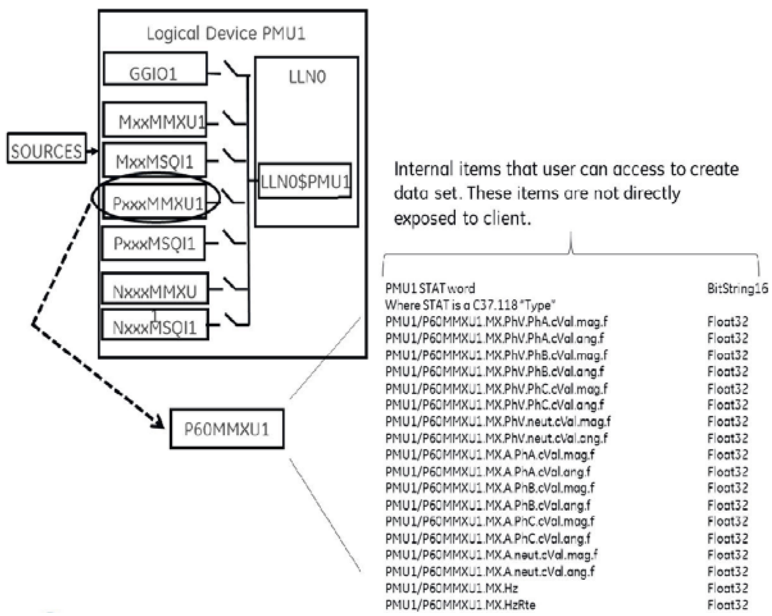

Figure 5–40: DATA SET CREATED FROM USER SELECTED INTERNAL ITEMS

EXAMPLE: THE 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.

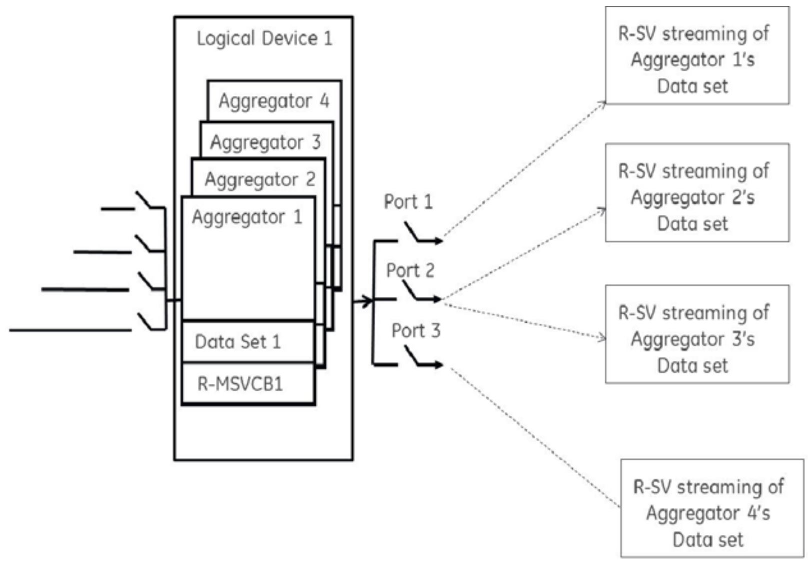

Figure 5–41: EXAMPLE OF AGGREGATOR DATA SETS

CONFIGURATION EXAMPLE: CFG-2 BASED CONFIGURATION (USING IEC61850-90-5)

The L30 is expected to send the CFG-2 file (IEEE C37.118 config. file) upon request from the upstream synchrophasor devices (e.g., P30) without stopping R-SV multicasting, see figure below. The primary domain controller (PDC) does not need to use a stop/start data stream command if the UR protocol is set to IEC61850-90-5 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).

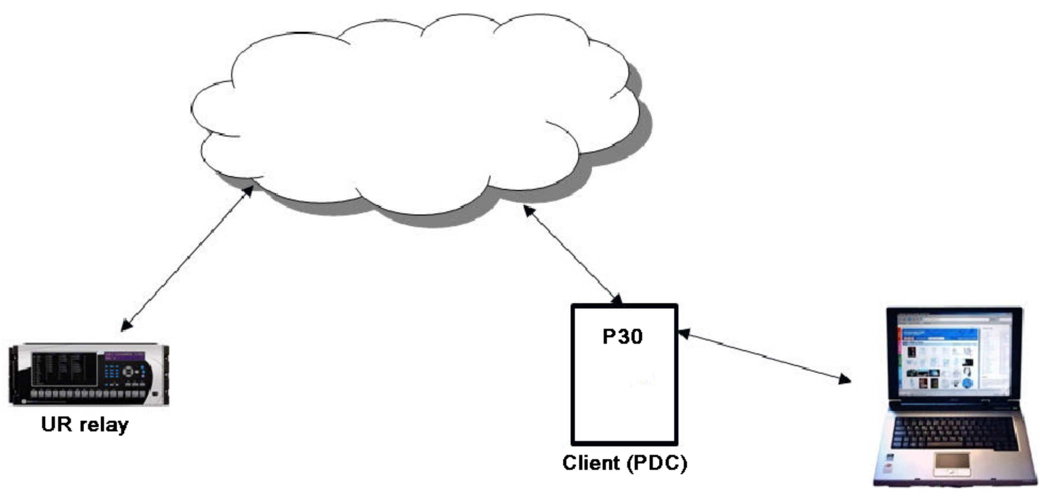

Figure 5–42: CFG-2 BASED CONFIGURATION SOLUTION

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 should presently be set to 2) is set as follows:

VALUE (DECIMAL)	# OF ASDUS
11	1
12	2
13	3
14	4

The PMU settings are organized in logical groups as follows.

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT UNIT ⇨⇩ PHASOR MEASUREMENT UNIT 1

■ PHASOR MEASUREMENT ■ UNIT 1		◀▶	■ PMU 1 BASIC ■ CONFIGURATION	See page 5-113.
	MESSAGE	▲▼	■ PMU 1 ■ CALIBRATION	See page 5-117.
	MESSAGE	▲▼	■ PMU 1 ■ TRIGGERING	See page 5-118.
	MESSAGE	▲	■ PMU 1 ■ RECORDING	See page 5-125.

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b) BASIC CONFIGURATION

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨PHASOR MEASUREMENT ⇨⇩BASIC CONFIGURATION ⇨PMU1

■ PMU 1 BASIC ■ CONFIGURATION	PMU 1 FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE	PMU 1 IDCODE: 1	Range: 1 to 65534 in steps of 1
MESSAGE	PMU 1 STN: GE-UR-PMU	Range: 32-character ASCII string truncated to 16 characters if mapped into C37.118 Default: GE-UR-PMU
MESSAGE	PMU 1 SIGNAL SOURCE: SRC 1	Range: Available signal sources
MESSAGE	PMU 1 CLASS: M-CLASS	Range: None, CLASS M, CLASS P
MESSAGE	PMU 1 RATE: 10/sec	Range:1/sec, 2/sec, 4/sec, 5/sec, 10/sec, 12/sec, 15/sec, 20/sec, 25/sec, 30/sec, 50/sec, 60/sec, 100/sec, 120/sec
MESSAGE	PMU 1 PHS-1: Off	Range: Available synchrophasor values
MESSAGE	PMU 1 PHS-1 NAME: GE-UR-PMU-PHS-1	Range: 16 -character ASCII string
	↓	
MESSAGE	PMU 1 PHS-14: Off	Range: Available synchrophasor values
MESSAGE	PMU 1 PHS-14: NAME: GE-UR-PMU-PHS-14	Range: 16 -character ASCII string
MESSAGE	PMU 1 A-CH-1: Off	Range: Available FlexAnalog values
MESSAGE	PMU 1 A-CH-1: NAME: AnalogChannel1	Range: 16 -character ASCII string
	↓	
MESSAGE	PMU 1 A-CH-16 (16): Off	Range: Available FlexAnalog values
MESSAGE	PMU 1 A-CH-16 (16): NAME: AnalogChannel16	Range: 16 -character ASCII string
MESSAGE	PMU 1 D-CH-1: Off	Range: Available FlexLogic operands
MESSAGE	PMU 1 D-CH-1 NAME: DigChannel1	Range: 16 character ASCII string
MESSAGE	PMU 1 D-CH-1 NORMAL STATE: Off	Range: Off, On
	↓	
MESSAGE	PMU 1 D-CH-16: Off	Range: FlexLogic operand
MESSAGE	PMU 1 REC D-CH-16 NAME: DigChannel16	Range: 16-character ASCII string

MESSAGE	▲	PMU 1 REC D-CH-16 NORMAL STATE: Off	Range: Off, On
MESSAGE	▲▼	■ 37.118 PMU 1 ■ CONFIGURATION	See below
MESSAGE	▲▼	■ 90-5 PMU 1 ■ CONFIGURATION	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. Note that any combination of voltages and currents can be configured as a source. The current channels could 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 could 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. Note that a reporting rate of 100 or 120 can only be selected for class P synchrophasors and if the system frequency is 50 Hz or 60 Hz, respectively.
- **PMU 1 NETWORK REPORTING 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; the user-selectable FlexAnalog channels are always transmitted as 16-bit integer values.
- **PMU 1 NETWORK REPORTING 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.
- **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).

- **PMU1 PHS-1** to **PMU1 PHS-14**: These settings specify synchrophasors to be transmitted from the superset of all synchronized measurements. The available synchrophasor values are tabulated below.

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
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.

- **PMU1 PHS-1 NM** to **PMU1 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.
- **PMU1 A-CH-1** to **PMU1 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 16 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.
- **PMU1 A-CH-1 NM** to **PMU1 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.
- **PMU1 D-CH-1** to **PMU1 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 sixteen 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 1and byte 2 MSB corresponding to digital channel 16.
- **PMU1 D-CH-1 NM** to **PMU1 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.
- **PMU1 D-CH-1 NORMAL STATE** to **PMU1 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.

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C37.118 PMU 1 CONFIGURATION

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨PHASOR MEASUREMENT ⇨⇩BASIC CONFIGURATION ⇨PMU 1 ⇨PMU 1 BASIC CONFIGURATION ⇨⇩37.118 PMU 1 CONFIGURATION

```
■ 37.118 PMU 1          PMU 1 FORMAT:        Range: Integer, Floating-point
■ CONFIGURATION         Integer

              MESSAGE   PMU 1 STYLE:         Range: Polar, Rectangular
                        Polar
```

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; the 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.

NOTE: With 90-5 PMU, the FORMAT and STYLE are Floating-point and Polar respectively, as specified in the IEC 61850 standard.

IEC 61850–90–5 PMU 1 CONFIGURATION

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨PHASOR MEASUREMENT ⇨⇩BASIC CONFIGURATION ⇨PMU1⇨PMU 1 BASIC CONFIGURATION ⇨⇩90 – 5 PMU 1 CONFIGURATION

■ 90–5 PMU 1 ■ CONFIGURATION	◁▷	PMU 1 LDINST: PMU1	*Range: 64 char ASCII text*

PMU1 LDINST: A user-defined visible string (maximum 64 char ASCII test) to assign Logical Device (LD) Inst for a PMU LD.

NOTE: 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.

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c) CALIBRATION

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT UNIT ⇨⇩ PHASOR MEASUREMENT UNIT 1 ⇨⇩ PMU 1 (to 4) CALIBRATION

■ PMU 1 ■ CALIBRATION	◀▶	PMU 1 VA CALIBRATION ANGLE: 0.00°	*Range: –5.00 to 5.00° in steps of 0.05*
MESSAGE	▲▼	PMU 1 VA CALIBRATION MAG: 100.0%	*Range: 95.0 to 105.0 in steps of 0.1%*
MESSAGE	▲▼	PMU 1 VB CALIBRATION ANGLE: 0.00°	*Range: –5.00 to 5.00° in steps of 0.05*
MESSAGE	▲▼	PMU 1 VB CALIBRATION MAG: 100.0%	*Range: 95.0 to 105.0 in steps of 0.1%*
MESSAGE	▲▼	PMU 1 VC CALIBRATION ANGLE: 0.00°	*Range: –5.00 to 5.00° in steps of 0.05*
MESSAGE	▲▼	PMU 1 VC CALIBRATION MAG: 100.0%	*Range: 95.0 to 105.0 in steps of 0.1%*
MESSAGE	▲▼	PMU 1 VX CALIBRATION ANGLE: 0.00°	*Range: –5.00 to 5.00° in steps of 0.05*
MESSAGE	▲▼	PMU 1 VX CALIBRATION MAG: 100.0%	*Range: 95.0 to 105.0 in steps of 0.1%*
MESSAGE	▲▼	PMU 1 IA CALIBRATION ANGLE: 0.00°	*Range: –5.00 to 5.00° in steps of 0.05*
MESSAGE	▲▼	PMU 1 IA CALIBRATION MAG: 100.0%	*Range: 95.0 to 105.0 in steps of 0.1%*
MESSAGE	▲▼	PMU 1 IB CALIBRATION ANGLE: 0.00°	*Range: –5.00 to 5.00° in steps of 0.05*
MESSAGE	▲▼	PMU 1 IB CALIBRATION MAG: 100.0%	*Range: 95.0 to 105.0 in steps of 0.1%*
MESSAGE	▲▼	PMU 1 IC CALIBRATION ANGLE: 0.00°	*Range: –5.00 to 5.00° in steps of 0.05*
MESSAGE	▲▼	PMU 1 IC CALIBRATION MAG: 100.0%	*Range: 95.0 to 105.0 in steps of 0.1%*
MESSAGE	▲▼	PMU 1 IG CALIBRATION ANGLE: 0.00°	*Range: –5.00 to 5.00° in steps of 0.05*
MESSAGE	▲▼	PMU 1 IG CALIBRATION MAG: 100.0%	*Range: 95.0 to 105.0 in steps of 0.1%*
MESSAGE	▲▼	PMU 1 SEQ VOLT SHIFT ANGLE: 0°	*Range: –180 to 180° in steps of 30*
MESSAGE	▲	PMU 1 SEQ CURR SHIFT ANGLE: 0°	*Range: –180 to 180° in steps of 30*

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 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 of the secondary signal lags the true signal; and negative value if the secondary signal leads the true signal.

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- **PMU 1 VA... IG CALIBRATION MAGNITUDE**: These settings recognize applications with protection class voltage and current sources, and 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, enter 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:
  1. When this setting is not “0°”, the phase and sequence voltages will not agree. Unlike sequence voltages, the phase voltages cannot be corrected in a general case, and therefore are reported as measured.
  2. 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.
  3. This setting applies to PMU data only. The L30 calculates symmetrical voltages independently for protection and control purposes without applying this correction.
  4. 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.

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d) PMU TRIGGERING OVERVIEW

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR... ⇨⇩ PHASOR MEASUREMENT UNIT 1 ⇨⇩ PMU 1 TRIGGERING

■ PMU 1 ■ TRIGGERING	◁▷	■ PMU 1 USER ■ TRIGGER	See page 5-119.
MESSAGE	△▽	■ PMU 1 FREQUENCY ■ TRIGGER	See page 5-119.
MESSAGE	△▽	■ PMU 1 VOLTAGE ■ TRIGGER	See page 5-120.
MESSAGE	△▽	■ PMU 1 CURRENT ■ TRIGGER	See page 5-121.
MESSAGE	△▽	■ PMU 1 POWER ■ TRIGGER	See page 5-122.
MESSAGE	△	■ PMU 1 df/dt ■ TRIGGER	See page 5-124.

Each logical phasor measurement unit (PMU) contains five triggering mechanisms to facilitate triggering of the associated PMU recorder, or cross-triggering of other PMUs of the system. They are:

- Overfrequency and underfrequency
- Overvoltage and undervoltage
- Overcurrent
- Overpower
- High rate of change of frequency

The pre-configured triggers could 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.

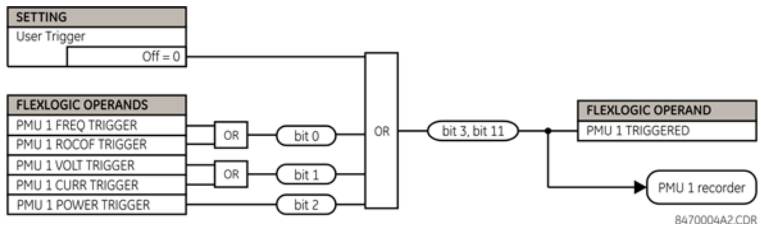

Figure 5–43: STAT BITS LOGIC

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.

e) USER TRIGGERING

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT... ⇨⇩ PMU 1 TRIGGERING ⇨⇩ PMU 1 USER TRIGGER

■ PMU 1 USER ■ TRIGGER	PMU1 USER TRIGGER: Off	*Range: FlexLogic operands*

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The user trigger allows customized triggering logic to be constructed from FlexLogic. The entire triggering logic is refreshed once every two power system cycles.

f) FREQUENCY TRIGGERING

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT... ⇨⇩ PMU 1 TRIGGERING ⇨⇩ PMU 1 FREQUENCY TRIGGER

■ PMU 1 FREQUENCY ■ TRIGGER	PMU 1 FREQ TRIGGER FUNCTION: Disabled	*Range: Enabled, Disabled*
MESSAGE	PMU 1 FREQ TRIGGER LOW-FREQ: 49.00 Hz	*Range: 20.00 to 70.00 Hz in steps of 0.01*
MESSAGE	PMU 1 FREQ TRIGGER HIGH-FREQ: 61.00 Hz	*Range: 20.00 to 70.00 Hz in steps of 0.01*
MESSAGE	PMU 1 FREQ TRIGGER PKP TIME: 0.10 s	*Range: 0.00 to 600.00 s in steps of 0.01*
MESSAGE	PMU 1 FREQ TRIGGER DPO TIME: 1.00 s	*Range: 0.00 to 600.00 s in steps of 0.01*
MESSAGE	PMU 1 FREQ TRIG BLK: Off	*Range: FlexLogic operand*
MESSAGE	PMU 1 FREQ TRIGGER TARGET: Self-Reset	*Range: Self-Reset, Latched, Disabled*
MESSAGE	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 either phase voltages, auxiliary voltage, phase currents and ground current, in this hierarchy, depending on the source configuration as per L30 standards. This element requires the frequency is 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**: This setting specifies the low threshold for the abnormal frequency trigger. The comparator applies a 0.02 Hz hysteresis.
- **PMU 1 FREQ TRIGGER HIGH-FREQ**: This setting specifies the high threshold for the abnormal frequency trigger. The comparator applies a 0.02 Hz hysteresis.
- **PMU 1 FREQ TRIGGER PKP TIME**: This setting could be used to filter out spurious conditions and avoid unnecessary triggering of the recorder.
- **PMU 1 FREQ TRIGGER DPO TIME**: This setting could be used to extend the trigger after the situation returned 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).

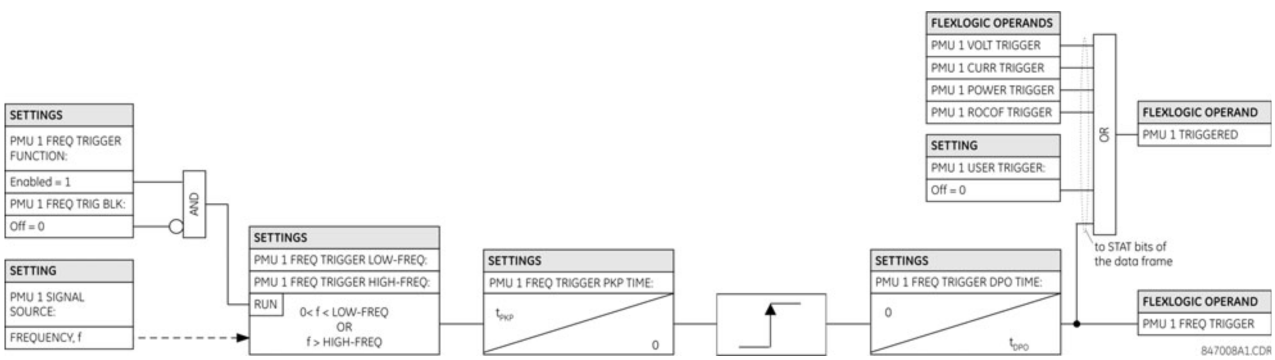

Figure 5–44: FREQUENCY TRIGGER SCHEME LOGIC

g) VOLTAGE TRIGGERING

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT... ⇨⇩ PMU 1 TRIGGERING ⇨⇩ PMU 1 VOLTAGE TRIGGER

■ PMU 1 VOLTAGE ■ TRIGGER	◀▶	PMU 1 VOLT TRIGGER FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE	▲▼	PMU 1 VOLT TRIGGER LOW-VOLT: 0.800 pu	Range: 0.250 to 1.250 pu in steps of 0.001
MESSAGE	▲▼	PMU 1 VOLT TRIGGER HIGH-VOLT: 1.200 pu	Range: 0.750 to 1.750 pu in steps of 0.001
MESSAGE	▲▼	PMU 1 VOLT TRIGGER PKP TIME: 0.10 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	▲▼	PMU 1 VOLT TRIGGER DPO TIME: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	▲▼	PMU 1 VOLT TRIG BLK: Off	Range: FlexLogic operand
MESSAGE	▲▼	PMU 1 VOLT TRIGGER TARGET: Self-Reset	Range: Self-Reset, Latched, Disabled
MESSAGE	▲	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 could 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**: This setting 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**: This setting 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**: This setting could be used to filter out spurious conditions and avoid unnecessary triggering of the recorder.
- **PMU 1 VOLT TRIGGER DPO TIME**: This setting could be used to extend the trigger after the situation returned 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).

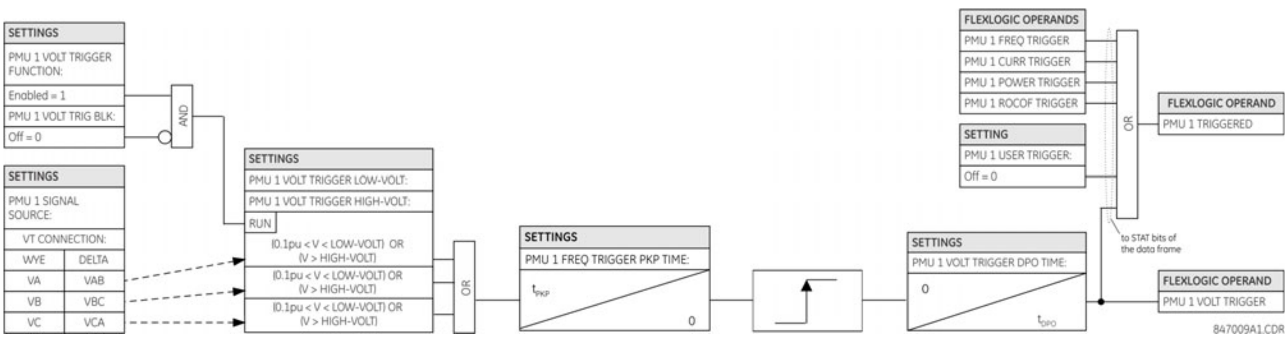

Figure 5–45: VOLTAGE TRIGGER SCHEME LOGIC

h) CURRENT TRIGGERING

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT... ⇨⇩ PMU 1 TRIGGERING ⇨⇩ PMU 1 CURRENT TRIGGER

■ PMU 1 CURRENT ■ TRIGGER		PMU 1 CURR TRIGGER FUNCTION: Disabled	*Range: Enabled, Disabled*
	MESSAGE	PMU 1 CURR TRIGGER PICKUP: 1.800 pu	*Range: 0.100 to 30.000 pu in steps of 0.001*
	MESSAGE	PMU 1 CURR TRIGGER PKP TIME: 0.10 s	*Range: 0.00 to 600.00 s in steps of 0.01*
	MESSAGE	PMU 1 CURR TRIGGER DPO TIME: 1.00 s	*Range: 0.00 to 600.00 s in steps of 0.01*
	MESSAGE	PMU 1 CURR TRIG BLK: Off	*Range: FlexLogic operand*
	MESSAGE	PMU 1 CURR TRIGGER TARGET: Self-Reset	*Range: Self-Reset, Latched, Disabled*
	MESSAGE	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 could trigger the recorder.

- **PMU 1 CURR TRIGGER PICKUP**: This setting 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**: This setting could be used to filter out spurious conditions and avoid unnecessary triggering of the recorder.
- **PMU 1 CURR TRIGGER DPO TIME**: This setting could be used to extend the trigger after the situation returned 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).

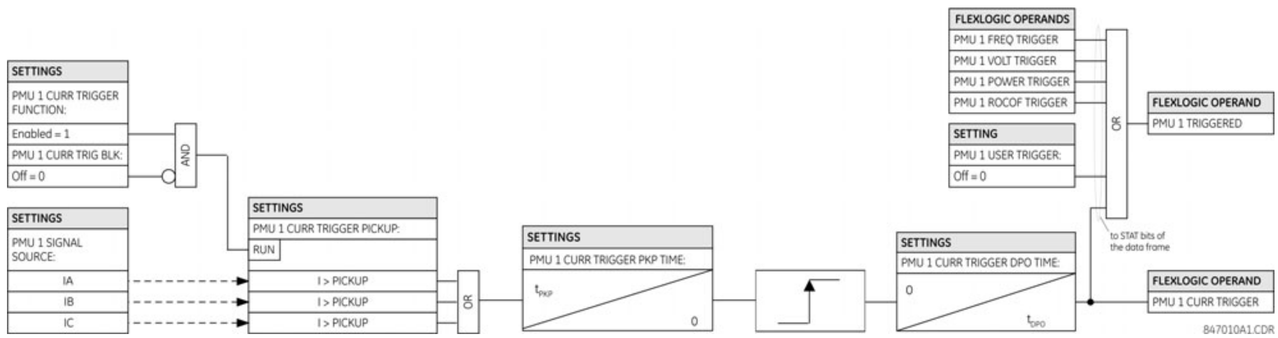

Figure 5–46: CURRENT TRIGGER SCHEME LOGIC

i) POWER TRIGGERING

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT... ⇨⇩ PMU 1 TRIGGERING ⇨⇩ PMU 1 POWER TRIGGER

■ PMU 1 POWER ■ TRIGGER	PMU 1 POWER TRIGGER FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE	PMU 1 POWER TRIGGER ACTIVE: 1.250 pu	Range: 0.250 to 3.000 pu in steps of 0.001
MESSAGE	PMU 1 POWER TRIGGER REACTIVE: 1.250 pu	Range: 0.250 to 3.000 pu in steps of 0.001
MESSAGE	PMU 1 POWER TRIGGER APPARENT: 1.250 pu	Range: 0.250 to 3.000 pu in steps of 0.001
MESSAGE	PMU 1 POWER TRIGGER PKP TIME: 0.10 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	PMU 1 POWER TRIGGER DPO TIME: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	PMU 1 PWR TRIG BLK: Off	Range: FlexLogic operand
MESSAGE	PMU 1 POWER TRIGGER TARGET: Self-Reset	Range: Self-Reset, Latched, Disabled
MESSAGE	PMU 1 POWER TRIGGER EVENTS: Disabled	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 between 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**: This setting 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 in case of wye-connected VTs and $\sqrt{3}$ times in case of delta-connected VTs. The comparator applies a 3% hysteresis.

- **PMU 1 POWER TRIGGER REACTIVE**: This setting 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 in case of wye-connected VTs and $\sqrt{3}$ times in case of delta-connected VTs. The comparator applies a 3% hysteresis.
- **PMU 1 POWER TRIGGER APPARENT**: This setting 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 in case of wye-connected VTs and $\sqrt{3}$ times in case of delta-connected VTs. The comparator applies a 3% hysteresis.
- **PMU 1 POWER TRIGGER PKP TIME**: This setting could be used to filter out spurious conditions and avoid unnecessary triggering of the recorder.
- **PMU 1 POWER TRIGGER DPO TIME**: This setting could be used to extend the trigger after the situation returned 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).

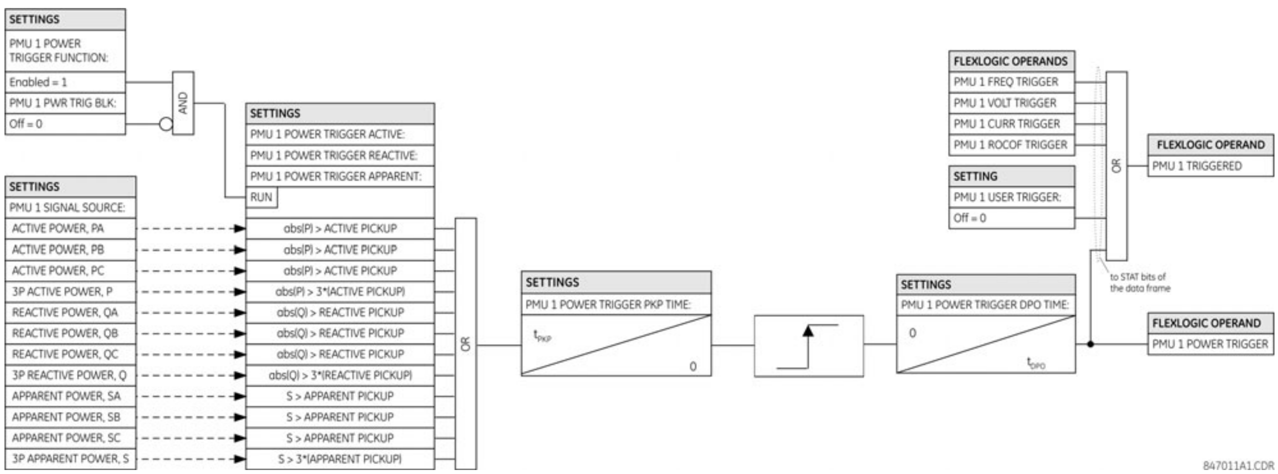

Figure 5–47: POWER TRIGGER SCHEME LOGIC

j) DF/DT TRIGGERING

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT... ⇨⇩ PMU 1 TRIGGERING ⇨⇩ PMU 1 df/dt TRIGGER

		Display	Range
■ PMU 1 df/dt ■ TRIGGER	◀▶	PMU 1 df/dt TRIGGER FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE	▲▼	PMU 1 df/dt TRIGGER RAISE: 0.25 Hz/s	Range: 0.10 to 15.00 Hz/s in steps of 0.01
MESSAGE	▲▼	PMU 1 df/dt TRIGGER FALL: 0.25 Hz/s	Range: 0.10 to 15.00 Hz/s in steps of 0.01
MESSAGE	▲▼	PMU 1 df/dt TRIGGER PKP TIME: 0.10 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	▲▼	PMU 1 df/dt TRIGGER DPO TIME: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	▲▼	PMU 1 df/dt TRG BLK: Off	Range: FlexLogic operand
MESSAGE	▲▼	PMU 1 df/dt TRIGGER TARGET: Self-Reset	Range: Self-Reset, Latched, Disabled
MESSAGE	▲	PMU 1 df/dt TRIGGER EVENTS: Disabled	Range: Enabled, Disabled

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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**: This setting 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**: This setting 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**: This setting could be used to filter out spurious conditions and avoid unnecessary triggering of the recorder.
- **PMU 1 df/dt TRIGGER DPO TIME**: This setting could be used to extend the trigger after the situation returned 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).

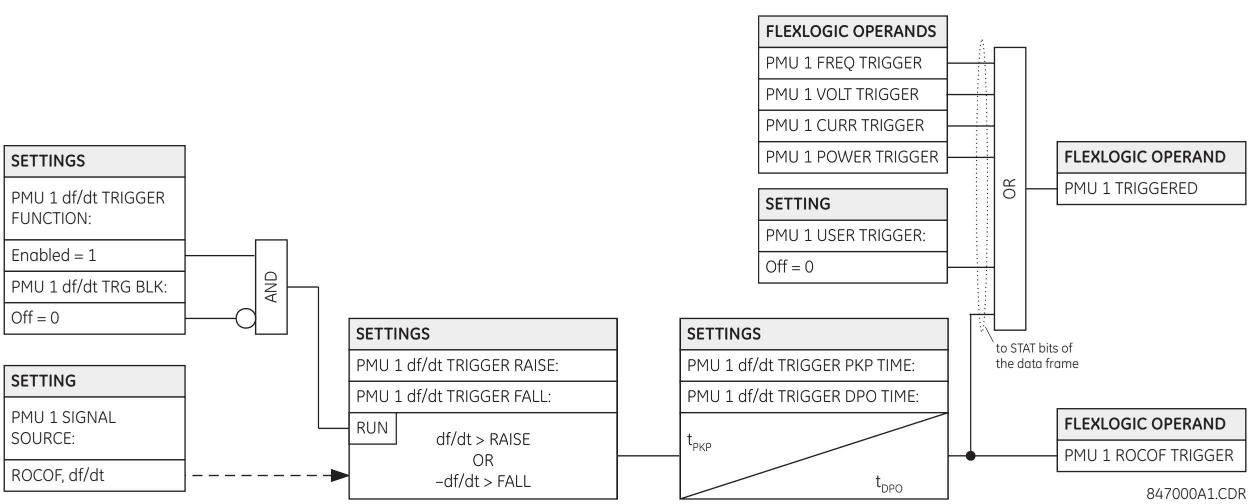

Figure 5–48: RATE OF CHANGE OF FREQUENCY TRIGGER SCHEME LOGIC

k) PMU RECORDING

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨ PHASOR MEASUREMENT⇨⇩ PHASOR MEASUREMENT UNIT1 ⇩ RECORDING PMU1

■ PMU 1 ■ RECORDING	◁▷	PMU 1 FUNCTION DISABLE	*Range: Enable, Disable*
MESSAGE	△▽	PMU 1 NO OF TIMED RECORDS: 10	*Range: 2 to 128 in steps of 1*
MESSAGE	△▽	PMU 1 TRIGGER MODE: AUTOMATIC OVERWRITE	*Range: Automatic Overwrite, Protected*
MESSAGE	△	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 (i.e., Aggregator 1).
- **PMU 1 NO OF TIMED RECORDS**: This setting specifies the number of timed records that are available for a given logical PMU 1(4). 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**: This setting specifies what happens when the recorder uses its entire available memory storage. Under the "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**: This setting specifies the amount of pre-trigger data as a percent of the entire record. This setting applies only to the timed mode of recording.

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l) AGGREGATORS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨PHASOR MEASUREMENT UNIT ⇨⇩ PMU AGGREGATOR 1

■ PMU AGGREGATOR 1 ■	◁▷	PMU AGGREGATOR 1 PROTOCOL: NONE	*Range: NONE, 37.118, IEC 61850-90-5* *Default: NONE*
MESSAGE	△▽	PMU AGGREGATOR 1: IDCODE: 1	*Range: 1 to 65534 in steps of 1* *Default: 1*
MESSAGE	△▽	PMU AGGREGATOR 1 INCLUDE PMU1: No	*Range: No, Yes* *Default: No*
MESSAGE	△▽	■ 37.118 AGGR 1 ■ CONFIGURATION	See below.
MESSAGE	△	■ 90-5 AGGR 1 ■ CONFIGURATION	See below.

NOTE: When the protocol selection is set via the software or keypad, all aggregators whose protocol is not set to None will be set to the last protocol saved (i.e., IEEE C37.118 or IEC 61850-90-5) to any aggregators, as both IEEE C37.118 and IEC 61850-90-5 simultaneous streaming of both R-SV values is not possible.

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT UNIT ⇨⇩ PMU AGGREGATOR 1 ⇩ 37.118 AGGR 1 CONFIGURATION

■ 37.118 AGGR 1 ■ CONFIGURATION	◁▷	PMU AGGREGATOR 1 TCP PORT: 4712	*Range: 1 to 65534* *Default: 4712*
MESSAGE	△▽	PMU AGGREGATOR 1 UDP PORT: 4713	*Range: 1 to 65534* *Default: 4713*
MESSAGE	△	PMU AGGREGATOR 1 PDC CONTROL: Disabled	*Range: Disabled, Enabled* *Default: Disabled*

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ PHASOR MEASUREMENT UNIT ⇨⇩ PMU AGGREGATOR 1 ⇩ 90-5 AGGR 1 CONFIGURATION

■ 90-5 AGGR 1 ■ CONFIGURATION	◁▷	PMU AGGREGATOR 1 NAME:	Range: 56 character ASCII text Default: Blank
MESSAGE	△▽	PMU AGGREGATOR1: PORT: 1	Range: 1, 2, 3 Default: 1
MESSAGE	△▽	PMU AGGREGATOR 1: UDP PORT: 102	Range: 1 to 65534 in steps of 1 Default: 102
MESSAGE	△	PMU AGGREGATOR 1: NUMBER OF ASDUs: 1	Range: 1 to 4 Default: 1

- **PMU AGGREGATOR1 PROTOCOL**: This setting selects if the IEEE C37.118 or IEC 61850 standard is used.
- **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 will not include PMU1 data set in the report if set to “No”.

C37.118 AGGREGATOR 1 CONFIGURATION

- **PMU AGGREGATOR1: TCP PORT**: This setting 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 AGGREGATOR1 UDP PORT**: This setting 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 AGGREGATOR1 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 table 2. The operands are asserted for 5 seconds following reception of the command frame. If the new command frame arrives within the 5 second period, the FlexLogic operands are updated, and the 5 second timer is re-started. 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.

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Table 5–11: 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.

IEC61850-90-5 AGGREGATOR 1 CONFIGURATION

- **PMU AGGREGATOR1: NAME:** A user-defined visible string of characters (max. 56) to identify the source of the stream. This value, concatenated with the Aggregator IDCode and Aggregator Class of Service, is mapped into the IEC61850 MSVID filed in the output stream.
- **AGGREGATOR1: PHYSICAL PORT:** This setting determines which physical ports through which the synchrophasor traffic will be transmitted. The range is 1, 2, 3.
- **PMU AGGREGATOR1: UDP:** This setting selects the UDP port number that is used by this dataset for network reporting. Default setting values for IEEE C37.118 and IEC 6150-90-5 are provided.
- **PMU AGGREGATOR1: #OF ASDUs:** This setting sets the number of ASDU's per from 1 through to 4. Refer to the table below.

Table 5–12: # OF ASDU

SETTINGS FOR # OF ASDU	TRANSMISSION
1	ASDU at T0 (current values)
2	ASDU at T-1 (previous values) + ASDU at T0 (current values)
3	values)+ ASDU at T-2 (previous values) + ASDU at T-1 (previous 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)

m) CONTROL BLOCKS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨PHASOR MEASUREMENT UNIT ⇨⇩ IEC 90 – 5 MSVCB01 CONFIGURATION

■ IEC 90-5 MSVCB ■ CONFIGURATION		MSVCB 1 SVENA: OFF	Range: FlexLogic operand
MESSAGE		MSVCB 1 CLIENT CTRL: OFF	Range: FlexLogic operand
MESSAGE		MSVCB 1 SVENA DEFLT: OFF	Range: FlexLogic operand
MESSAGE		MSVCB 1 CONFREV: 1	Range: 1 to 4294967295
MESSAGE		MSVCB 1 PRIORITY: 4	Range: 0 to 7
MESSAGE		MSVCB 1 IP CLASS: 46	Range: 0 to 252
MESSAGE		MSVCB 1 VID: 0	Range: 0 to 4095
MESSAGE		MSVCB 1 APPID: 0	Range: 0 to 16383
MESSAGE		MSVCB 1 DEST. IP: 224.0.0.0	Range: 0 to 255.255.255.255
MESSAGE		MSVCB 1 SECURITY: 0	Range: 0 to 2

- **MSVCB 1 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 logic for setting the SvEna control bit is shown in the following figure.

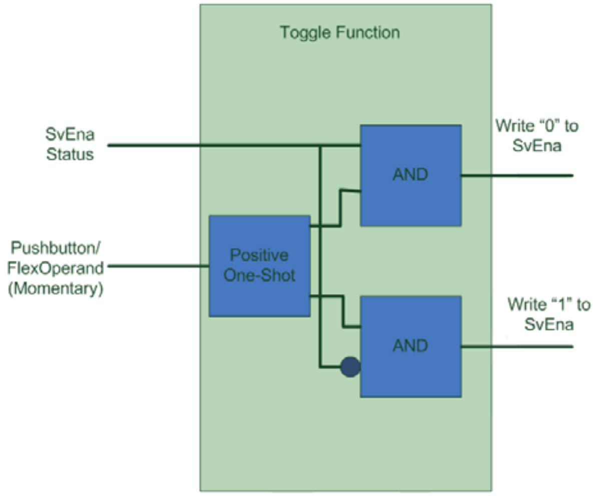

Figure 5–49: LOGIC FOR SETTING SVENA CONTROL BIT

- **MSVCB 1 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.
- **MSVCB 1 SVENA Default:** This setting sets the default state of the stream (On or Off) on power-up or restart.
- **MSVCB 1 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.
- **MSVCB 1 PRIORITY:** A value from 0 through 7: The default value is 4.
- **MSVCB 1 IP 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.
- **MSVCB 1 VID:** A range of values limited from 0 to 4095.
- **MSVCB 1 APPID:** This setting allows the selection of a specific application ID for each sending device.
- **MSVCB 1 DEST IP Address:** This is the destination multicast address 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, but the UR does not test the address entered.
- **MSVCB 1 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.

NOTE

Shaded settings in the table are not supported in firmware 7.0.

ENUMERATION	AUTHENTICATION	ENCRYPTION
0	no	no
1	yes	no
2	yes	yes

5.5.1 INTRODUCTION TO FLEXLOGIC

To provide maximum flexibility to the user, 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 digital input signals through elements or combinations of elements to digital outputs, is variable. The user has complete control of all variable logic through FlexLogic. In general, the system receives analog and digital inputs which it uses to produce analog and digital outputs. The major sub-systems of a generic UR-series relay involved in this process are shown below.

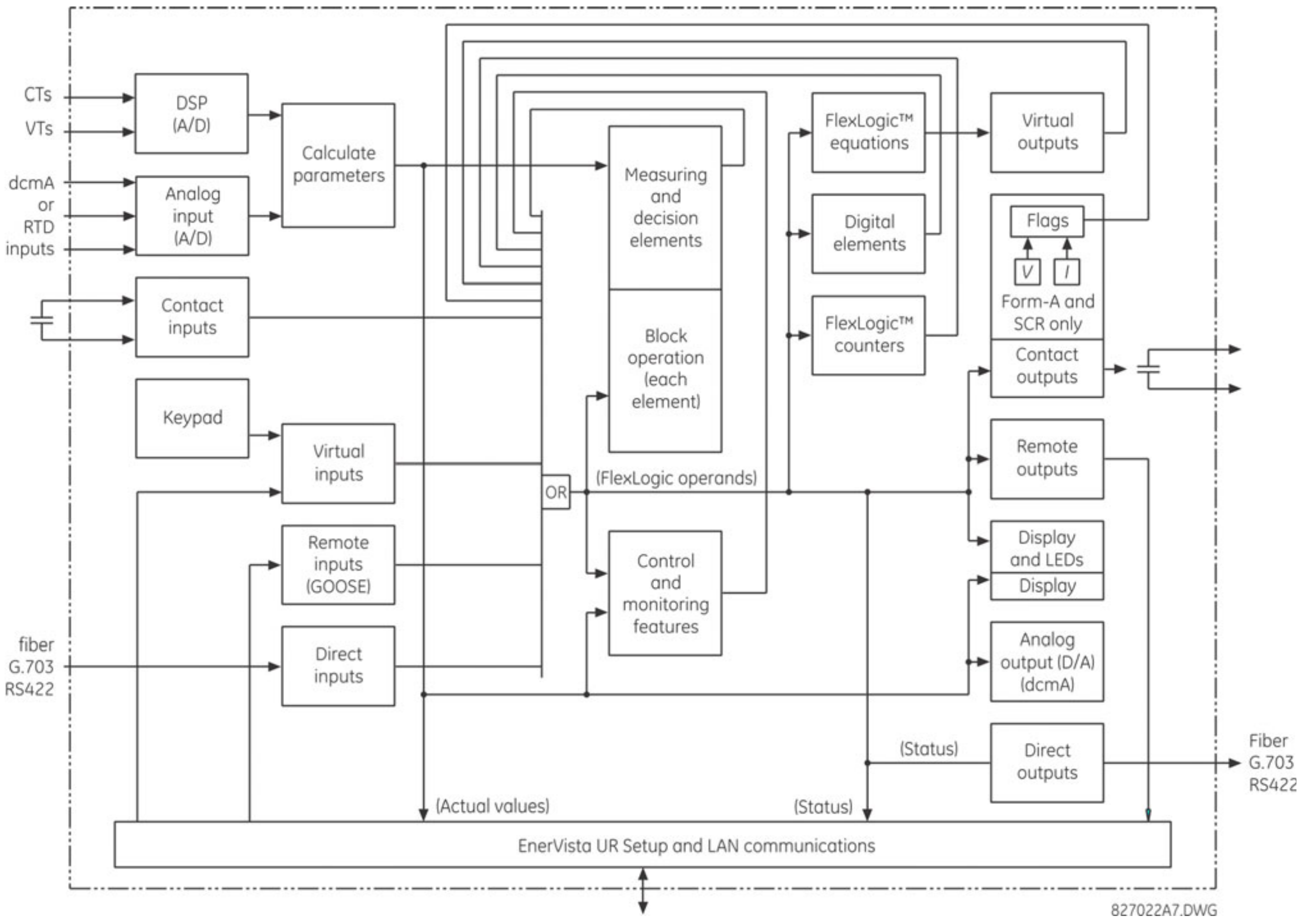

Figure 5–50: UR ARCHITECTURE OVERVIEW

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 desired, 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 presented above is required, it is implemented via FlexLogic. For example, if it is desired 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 which 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 specified 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, i.e. flag set) or 0 (=OFF, i.e. flag not set). Each equation is evaluated at least 4 times every power system cycle.

Some types of operands are present in the relay in multiple instances; e.g. contact and remote inputs. These types of operands are grouped together (for presentation purposes only) on the faceplate display. The characteristics of the different types of operands are listed in the table below.

Table 5–13: L30 FLEXLOGIC OPERAND TYPES

OPERAND TYPE	STATE	EXAMPLE FORMAT	CHARACTERISTICS [INPUT IS '1' (= ON) IF...]
Contact Input	On	Cont Ip On	Voltage is presently applied to the input (external contact closed).
	Off	Cont Ip Off	Voltage is presently not applied to the input (external contact open).
Contact Output (type Form-A contact only)	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 exists 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 which responds to rising values or below the pickup setting of an element which 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
Remote Input	On	REMOTE INPUT 1 On	The remote input 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 (i.e. evaluation of the equation which produces this virtual output results in a "1").

The operands available for this relay are listed alphabetically by types in the following table.

Table 5–14: L30 FLEXLOGIC OPERANDS (Sheet 1 of 7)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
CONTROL PUSHBUTTONS	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
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 is 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	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
	AR 2 to AR3	Same set of operands as shown for AR 1
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
	AUX OV2 to AUX OV3	Same set of operands as shown for AUX OV1
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 AUX UV3	Same set of operands as shown for AUX UV1
ELEMENT: Breaker arcing	BKR ARC 1 OP BKR ARC 2 OP	Breaker arcing current 1 has operated Breaker arcing current 2 has operated
ELEMENT Breaker failure	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
	BKR FAIL 2...	Same set of operands as shown for BKR FAIL 1

Table 5–14: L30 FLEXLOGIC OPERANDS (Sheet 2 of 7)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Breaker control	BREAKER 1 OFF CMD BREAKER 1 ON CMD BREAKER 1 ΦA BAD ST BREAKER 1 ΦA INTERM BREAKER 1 ΦA CLSD BREAKER 1 ΦA OPEN BREAKER 1 ΦB BAD ST BREAKER 1 ΦB INTERM BREAKER 1 ΦB CLSD BREAKER 1 ΦB OPEN BREAKER 1 ΦC BAD ST BREAKER 1 ΦC INTERM BREAKER 1 ΦC CLSD BREAKER 1 ΦC OPEN BREAKER 1 BAD STATUS BREAKER 1 CLOSED BREAKER 1 OPEN BREAKER 1 DISCREP BREAKER 1 TROUBLE 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 open command 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 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 2...	Same set of operands as shown for BREAKER 1
ELEMENT: Broken conductor	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
	BROKEN CONDUCT 2...	Same set of operands as shown for BROKEN CONDUCTOR 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 Counter 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 Dig Element 48	Same set of operands as shown for Dig Element 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 FxE	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	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 Non-volatile latches	LATCH 1 ON LATCH 1 OFF	Non-volatile latch 1 is ON (Logic = 1) Non-volatile latch 1 is OFF (Logic = 0)
	LATCH 2 to LATCH 16	Same set of operands as shown for LATCH 1
ELEMENT: Negative-sequence instantaneous overcurrent	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
	NEG SEQ IOC2	Same set of operands as shown for NEG SEQ IOC1

Table 5–14: L30 FLEXLOGIC OPERANDS (Sheet 3 of 7)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Negative-sequence overvoltage	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
	NEG SEQ OV2...	Same set of operands as shown for NEG SEQ OV1
ELEMENT: Negative-sequence time overcurrent	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
	NEG SEQ TOC2	Same set of operands as shown for NEG SEQ TOC1
ELEMENT: Neutral instantaneous overcurrent	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
	NEUTRAL IOC2	Same set of operands as shown for NEUTRAL IOC1
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	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
ELEMENT: Phase directional overcurrent	PH DIR1 BLK A PH DIR1 BLK B PH DIR1 BLK C PH DIR1 BLK	Phase A directional 1 block Phase B directional 1 block Phase C directional 1 block Phase directional 1 block
	PH DIR2	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 and higher	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
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 TOC6	Same set of operands as shown for PHASE TOC1

Table 5–14: L30 FLEXLOGIC OPERANDS (Sheet 4 of 7)

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	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 PMU 1 VOLT TRIGGER PMU 1 TRIGGERED	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 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 PMU ONE-SHOT OP PMU ONE-SHOT PENDING	Indicates the one-shot operation has been executed, and the present time is at least 30 seconds past the scheduled one-shot time Indicates the one-shot operation and remains asserted for 30 seconds afterwards 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 1 BIT ALARM SELECTOR 1 ALARM SELECTOR 1 PWR 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 Position of selector 1 has been pre-selected with the 3-bit control input but not acknowledged 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 above 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: Stub bus	STUB BUS OP	Stub bus is operated

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Table 5–14: L30 FLEXLOGIC OPERANDS (Sheet 5 of 7)

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 ΦA CLSD SWITCH 1 ΦA OPEN SWITCH 1 ΦA BAD ST SWITCH 1 ΦA INTERM SWITCH 1 ΦB CLSD SWITCH 1 ΦB OPEN SWITCH 1 ΦB BAD ST SWITCH 1 ΦB INTERM SWITCH 1 ΦC CLSD SWITCH 1 ΦC OPEN SWITCH 1 ΦC BAD ST SWITCH 1 ΦC INTERM SWITCH 1 BAD STATUS	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 52/a and 52/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 52/a and 52/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 52/a and 52/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 2...	Same set of operands as shown for SWITCH 1
ELEMENT: Synchrocheck	SYNC 1 DEAD S OP SYNC 1 DEAD S DPO SYNC 1 SYNC OP SYNC 1 SYNC DPO SYNC 1 CLS OP SYNC 1 CLS DPO SYNC 1 V1 ABOVE MIN SYNC 1 V1 BELOW MAX SYNC 1 V2 ABOVE MIN SYNC 1 V2 BELOW MAX	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
	SYNC 2	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
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...	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 above
FIXED OPERANDS	Off	Logic = 0. Does nothing and may 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.
INPUTS/OUTPUTS: Contact inputs	Cont Ip 1 On Cont Ip 2 On ↓ Cont Ip 1 Off Cont Ip 2 Off ↓	(will not appear unless ordered) (will not appear unless ordered) ↓ (will not appear unless ordered) (will not appear unless ordered) ↓
INPUTS/OUTPUTS: Contact outputs, current (from detector on form-A output only)	Cont Op 1 IOn Cont Op 2 IOn ↓	(will not appear unless ordered) (will not appear unless ordered) ↓
INPUTS/OUTPUTS: Contact outputs, voltage (from detector on form-A output only)	Cont Op 1 VOn Cont Op 2 VOn ↓	(will not appear unless ordered) (will not appear unless ordered) ↓
	Cont Op 1 VOff Cont Op 2 VOff ↓	(will not appear unless ordered) (will not appear unless ordered) ↓

Table 5–14: L30 FLEXLOGIC OPERANDS (Sheet 6 of 7)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
INPUTS/OUTPUTS: Direct input	Direct I/P 1-1 On ↓ Direct I/P 1-8 On	(appears only when an inter-relay communications card is used) ↓ (appears only when inter-relay communications card is used)
	Direct I/P 2-1 On ↓ Direct I/P 2-8 On	(appears only when inter-relay communications card is used) ↓ (appears only when inter-relay communications card is used)
INPUTS/OUTPUTS: Remote double-point status inputs	RemDPS Ip 1 BAD RemDPS Ip 1 INTERM RemDPS Ip 1 OFF RemDPS Ip 1 ON	Asserted while the remote double-point status input is in the bad state. Asserted while the remote double-point status input is in the intermediate state. Asserted while the remote double-point status input is off. Asserted while the remote double-point status input is on.
	REMDPS Ip 2...	Same set of operands as per REMDPS 1 above
INPUTS/OUTPUTS: Remote inputs	REMOTE INPUT 1 On REMOTE INPUT 2 On REMOTE INPUT 2 On ↓ REMOTE INPUT 32 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: Fixed front panel LEDs	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 the front panel PICKUP LED is on. Asserted when the front panel VOLTAGE LED is on. Asserted when the front panel CURRENT LED is on. Asserted when the front panel FREQUENCY LED is on. Asserted when the front panel OTHER LED is on. Asserted when the front panel PHASE A LED is on. Asserted when the front panel PHASE B LED is on. Asserted when the front panel PHASE C LED is on. Asserted when the front panel NEUTRAL/GROUND LED is on.
LED INDICATORS: LED test	LED TEST IN PROGRESS	An LED test has been initiated and has not finished.
LED INDICATORS: User-programmable LEDs	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.
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.
REMOTE DEVICES	REMOTE DEVICE 1 On REMOTE DEVICE 2 On REMOTE DEVICE 2 On ↓ REMOTE DEVICE 16 On	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
	REMOTE DEVICE 1 Off REMOTE DEVICE 2 Off REMOTE DEVICE 3 Off ↓ REMOTE DEVICE 16 Off	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1

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Table 5–14: L30 FLEXLOGIC OPERANDS (Sheet 7 of 7)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
RESETTING	RESET OP RESET OP (COMMS) RESET OP (OPERAND) RESET OP (PUSHBUTTON)	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.
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 LATCHING OUT ERROR MAINTENANCE ALERT FIRST ETHERNET FAIL PROCESS BUS FAILURE PTP FAILURE REMOTE DEVICE OFF RRTD COMM FAIL SECOND ETHERNET FAIL THIRD ETHERNET FAIL SNTP FAILURE SYSTEM EXCEPTION TEMP MONITOR UNIT NOT PROGRAMMED	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 not functioning. Return power supply module to manufacturer. 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 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 devices are not responding 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>relay settings setting is not programmed
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 twelve pushbuttons is in the “On” position
	PUSHBUTTON 2 to 12	Same set of operands as PUSHBUTTON 1

Some operands can be re-named by the user. These are the names of the breakers in the breaker control feature, the ID (identification) of contact inputs, 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 will appear in the relay list of operands. The default names are shown in the FlexLogic operands table above.

The characteristics of the logic gates are tabulated below, and the operators available in FlexLogic are listed in the Flex-Logic operators table.

Table 5–15: 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 5–16: 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) ↓ OR(16)	2 input OR gate ↓ 16 input OR gate	Operates on the 2 previous parameters. ↓ Operates on the 16 previous parameters.
	AND(2) ↓ AND(16)	2 input AND gate ↓ 16 input AND gate	Operates on the 2 previous parameters. ↓ Operates on the 16 previous parameters.
	NOR(2) ↓ NOR(16)	2 input NOR gate ↓ 16 input NOR gate	Operates on the 2 previous parameters. ↓ Operates on the 16 previous parameters.
	NAND(2) ↓ NAND(16)	2 input NAND gate ↓ 16 input NAND gate	Operates on the 2 previous parameters. ↓ 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 32	Timer set with FlexLogic timer 1 settings. ↓ Timer set with FlexLogic timer 32 settings.	The timer is started by the preceding parameter. The output of the timer is TIMER #.
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

5.5.2 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 which 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") may only be used once. If this rule is broken, a syntax error will be declared.

5.5.3 FLEXLOGIC EVALUATION

Each equation is evaluated in the order in which the parameters have been entered.

NOTE

FlexLogic provides latches which by definition have a memory action, remaining in the set state after the set input has been asserted. However, they are volatile; that is, they reset on the re-application of control power.

When making changes to settings, all FlexLogic equations are re-compiled whenever any new setting value is entered, so all latches are automatically reset. If it is necessary to re-initialize FlexLogic during testing, for example, it is suggested to power the unit down and then back up.

5.5.4 FLEXLOGIC EXAMPLE

This section provides an example of implementing logic for a typical application. The sequence of the steps is quite important as it should minimize the work necessary to develop the relay settings. Note that the example presented in the figure below is intended to demonstrate the procedure, not to solve a specific application situation.

In the example below, 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 only be properly assigned once.

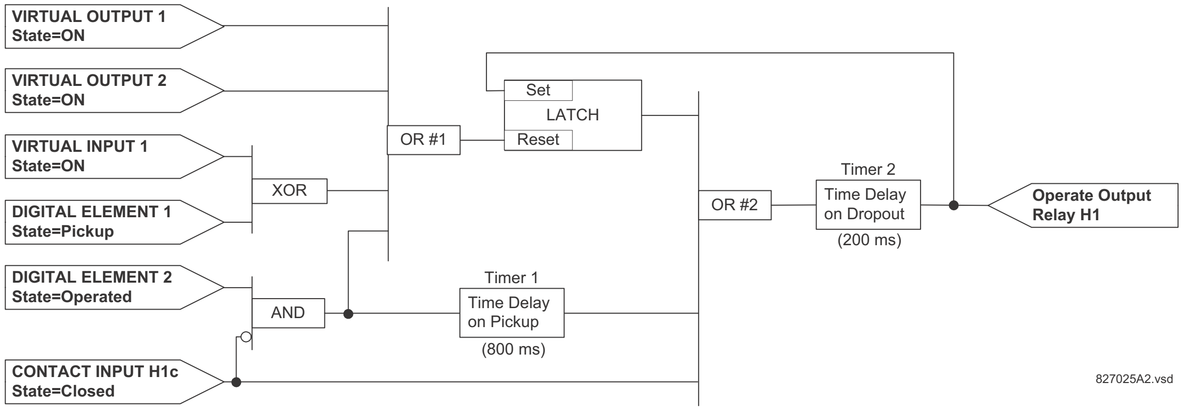

Figure 5–51: EXAMPLE LOGIC SCHEME

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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 this is 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 above, 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 (i.e. Virtual Output 3). The final output must also be assigned to a virtual output as virtual output 4, which will be 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 as shown below.

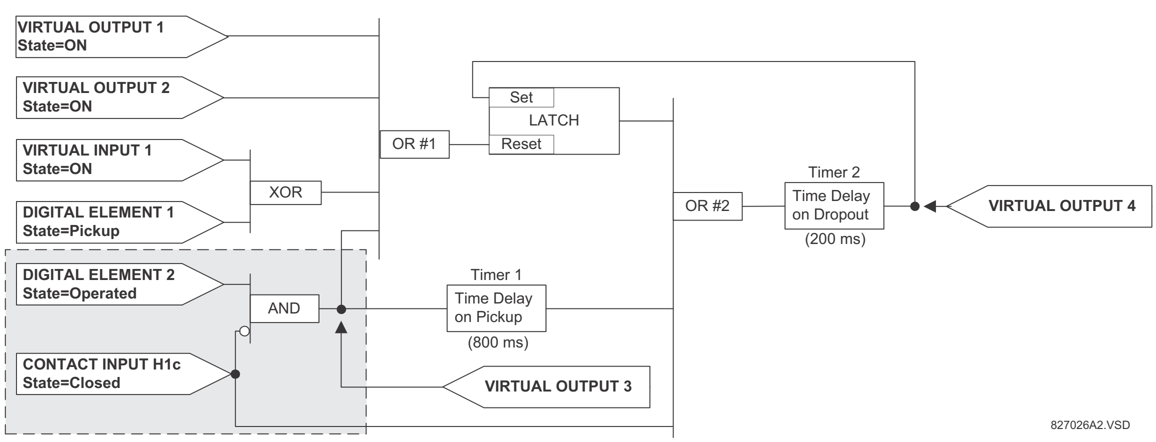

Figure 5–52: LOGIC EXAMPLE WITH VIRTUAL OUTPUTS

2. Prepare a logic diagram for the equation to produce virtual output 3, as this output will be used as an operand in the virtual output 4 equation (create the equation for every output that will be used as an operand first, so that when these operands are required they will already have been evaluated and assigned to a specific virtual output). The logic for virtual output 3 is shown below with the final output assigned.

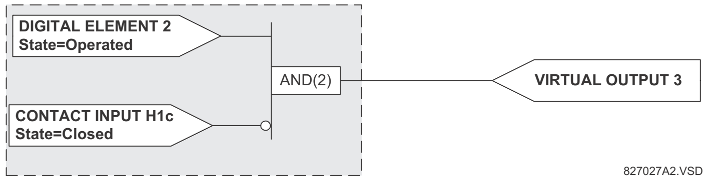

Figure 5–53: LOGIC FOR VIRTUAL OUTPUT 3

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, as shown below.

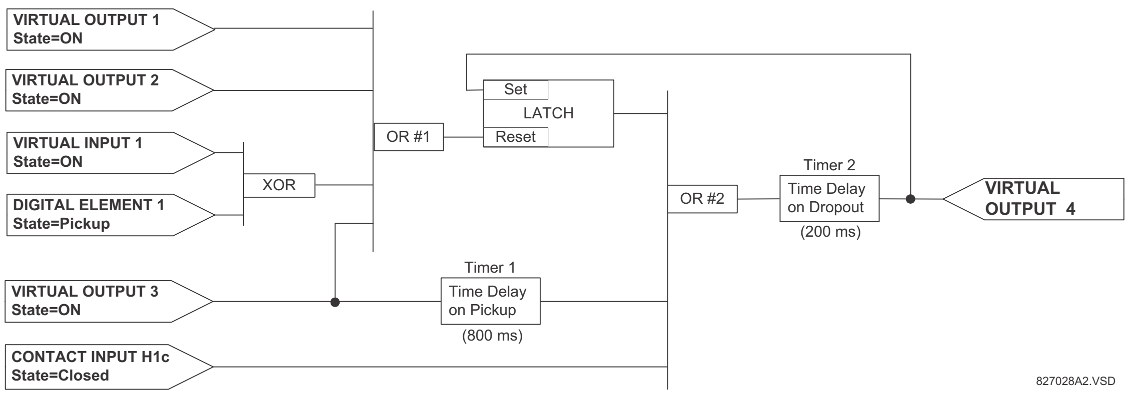

Figure 5–54: LOGIC FOR VIRTUAL OUTPUT 4

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 output will be 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, as shown below.

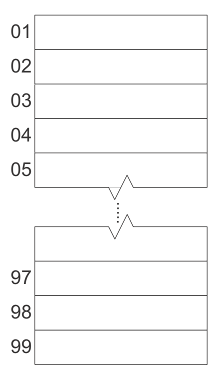

Figure 5–55: FLEXLOGIC WORKSHEET

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 will operate 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 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 can now form 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 will produce the required logic by converting the set of parameters into a logic diagram. The result of this process is shown below, which is compared to the logic for virtual output 3 diagram as a check.

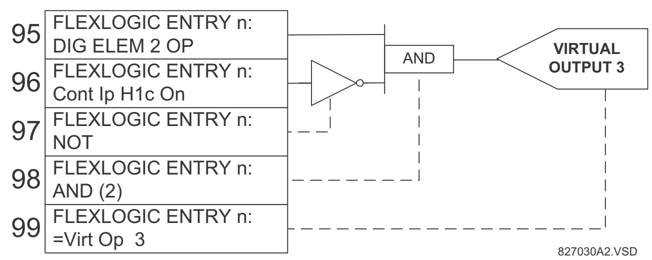

Figure 5–56: FLEXLOGIC EQUATION FOR VIRTUAL OUTPUT 3

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
```

It is now possible to check that the selection of parameters will produce the required logic by converting the set of parameters into a logic diagram. The result of this process is shown below, which is compared to the logic for virtual output 4 diagram as a check.

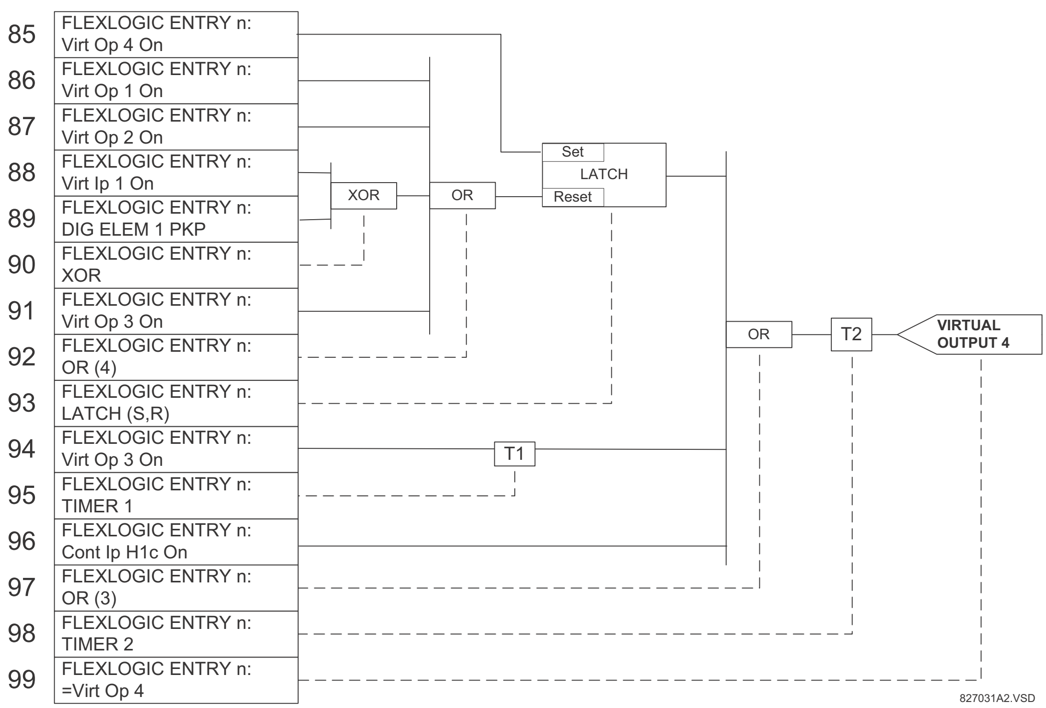

Figure 5–57: FLEXLOGIC EQUATION FOR VIRTUAL OUTPUT 4

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 will be used as inputs to operators are created before needed. In cases where a lot of processing is required to perform logic, this may be difficult to achieve, but in most cases will 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 order shown below:

```
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 the expression above, 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. The logic should always be tested after it is loaded into the relay, in the same fashion 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 will then only be 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.

5.5.5 FLEXLOGIC EQUATION EDITOR

PATH: SETTINGS ⇨⇩ FLEXLOGIC ⇨ FLEXLOGIC EQUATION EDITOR

■ FLEXLOGIC ■ EQUATION EDITOR		◁▷	FLEXLOGIC ENTRY 1: END	Range: FlexLogic operands
	MESSAGE	△▽	FLEXLOGIC ENTRY 2: END	Range: FlexLogic operands
			↓	
	MESSAGE	△	FLEXLOGIC ENTRY 512: END	Range: FlexLogic operands

There are 512 FlexLogic entries available, numbered from 1 to 512, with default END entry settings. If a "Disabled" Element is selected as a FlexLogic entry, the associated state flag will never be set to '1'. The '+/–' key may be used when editing FlexLogic equations from the keypad to quickly scan through the major parameter types.

5.5.6 FLEXLOGIC TIMERS

PATH: SETTINGS ⇨⇩ FLEXLOGIC ⇨⇩ FLEXLOGIC TIMERS ⇨ FLEXLOGIC TIMER 1(32)

■ FLEXLOGIC ■ TIMER 1		◁▷	TIMER 1 TYPE: millisecond	Range: millisecond, second, minute
	MESSAGE	△▽	TIMER 1 PICKUP DELAY: 0	Range: 0 to 60000 in steps of 1
	MESSAGE	△	TIMER 1 DROPOUT DELAY: 0	Range: 0 to 60000 in steps of 1

There are 32 identical FlexLogic timers available. These timers can be used as operators for FlexLogic equations.

- **TIMER 1 TYPE:** This setting is used to select the time measuring 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".

5.5.7 FLEXELEMENTS

PATH: SETTING ⇨⇩ FLEXLOGIC ⇨⇩ FLEXELEMENTS ⇨ FLEXELEMENT 1(8)

■ FLEXELEMENT 1 ■		FLEXELEMENT 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE		FLEXELEMENT 1 NAME: FxE1	Range: up to 6 alphanumeric characters
MESSAGE		FLEXELEMENT 1 +IN: Off	Range: Off, any analog actual value parameter
MESSAGE		FLEXELEMENT 1 -IN: Off	Range: Off, any analog actual value parameter
MESSAGE		FLEXELEMENT 1 INPUT MODE: Signed	Range: Signed, Absolute
MESSAGE		FLEXELEMENT 1 COMP MODE: Level	Range: Level, Delta
MESSAGE		FLEXELEMENT 1 DIRECTION: Over	Range: Over, Under
MESSAGE		FLEXELEMENT 1 PICKUP: 1.000 pu	Range: –90.000 to 90.000 pu in steps of 0.001
MESSAGE		FLEXELEMENT 1 HYSTERESIS: 3.0%	Range: 0.1 to 50.0% in steps of 0.1
MESSAGE		FLEXELEMENT 1 dt UNIT: milliseconds	Range: milliseconds, seconds, minutes
MESSAGE		FLEXELEMENT 1 dt: 20	Range: 20 to 86400 in steps of 1
MESSAGE		FLEXELEMENT 1 PKP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE		FLEXELEMENT 1 RST DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE		FLEXELEMENT 1 BLK: Off	Range: FlexLogic operand
MESSAGE		FLEXELEMENT 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE		FLEXELEMENT 1 EVENTS: Disabled	Range: Disabled, Enabled

A FlexElement is a universal comparator that can be 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 could be treated as a signed number or its absolute value could be used as per user's choice.

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 user's choice.

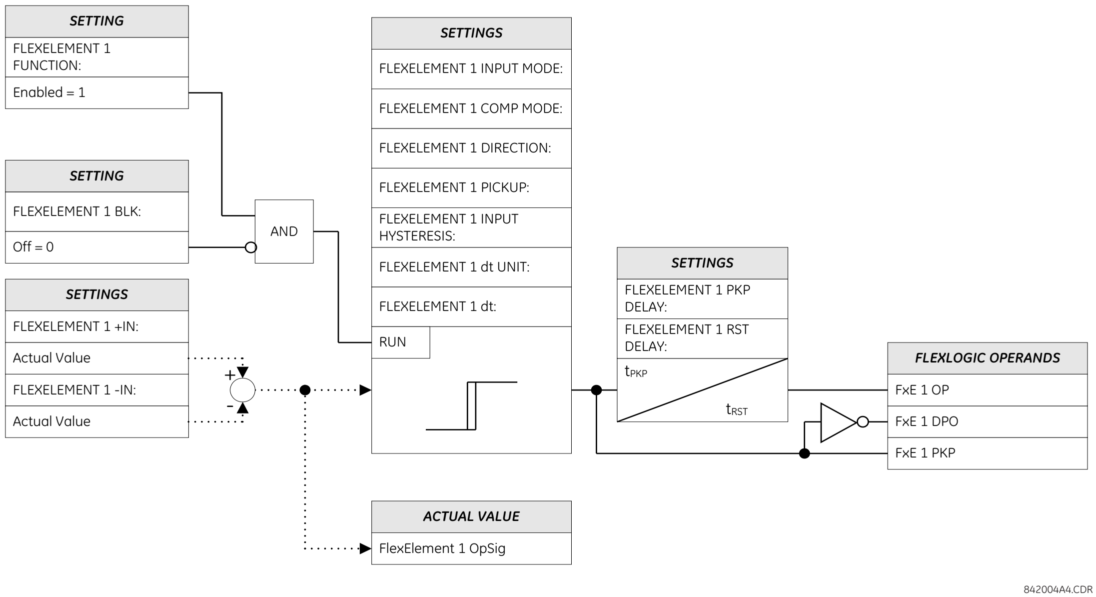

Figure 5–58: FLEXELEMENT SCHEME LOGIC

The **FLEXELEMENT 1 +IN** 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 will not assert its output operands.

This **FLEXELEMENT 1 –IN** setting 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 will not assert its output operands. This input should be 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 will 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 regardless of whether the signal increases of decreases.

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.

The **FLEXELEMENT 1 DIRECTION** setting 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.

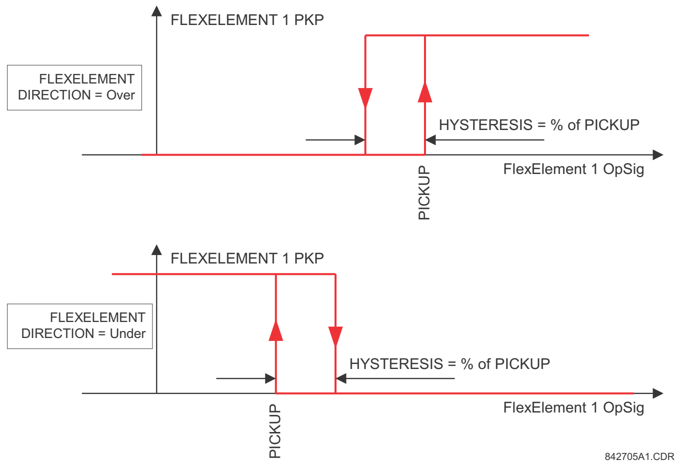

Figure 5–59: FLEXELEMENT DIRECTION, PICKUP, AND HYSTERESIS

In conjunction with the **FLEXELEMENT 1 INPUT MODE** setting the element could be programmed to provide two extra characteristics as shown in the figure below.

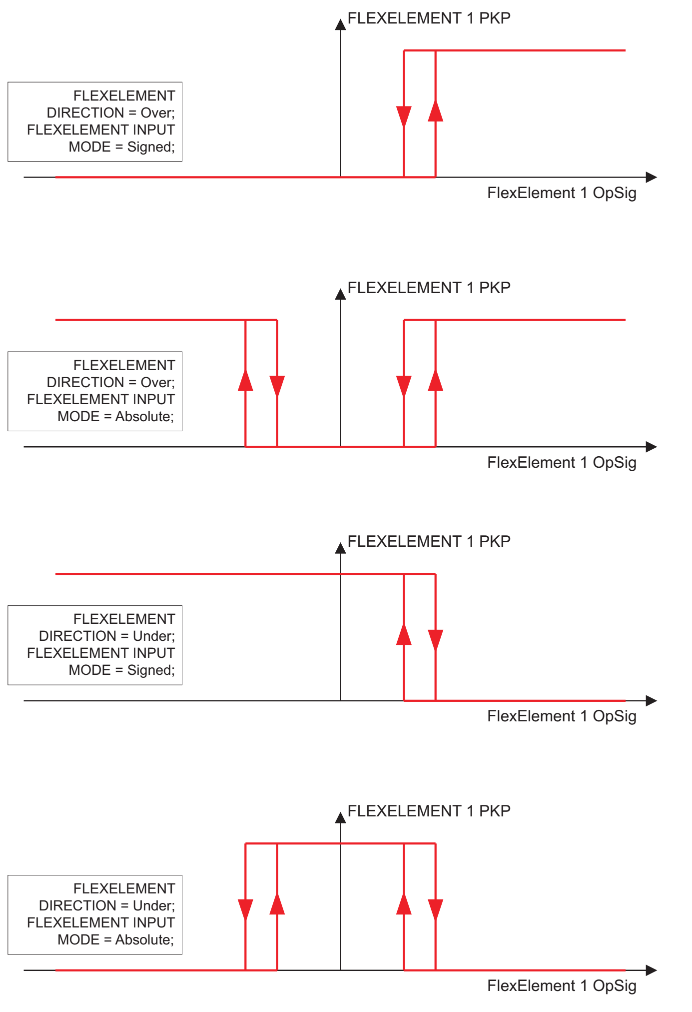

Figure 5–60: FLEXELEMENT INPUT MODE SETTING

The **FLEXELEMENT 1 PICKUP** 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.

The **FLEXELEMENT 1 HYSTERESIS** setting controls the element dropout. It should be noticed 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 5–17: FLEXELEMENT BASE UNITS

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
BREAKER ARCING AMPS (Brk X Arc Amp A, B, and C)	BASE = 2000 $kA^2 \times$ 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
FREQUENCY	f_{BASE} = 1 Hz
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 $V_{BASE} \times I_{BASE}$ for the +IN and –IN inputs
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

The **FLEXELEMENT 1 HYSTERESIS** 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.

The **FLEXELEMENT 1 DT UNIT** setting specifies the time unit for the setting **FLEXELEMENT 1 dt**. This setting is applicable only if **FLEXELEMENT 1 COMP MODE** is set to “Delta”. The **FLEXELEMENT 1 DT** setting 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”.

This **FLEXELEMENT 1 PKP DELAY** setting specifies the pickup delay of the element. The **FLEXELEMENT 1 RST DELAY** setting specifies the reset delay of the element.

5

5.5.8 NON-VOLATILE LATCHES

PATH: SETTINGS ⇨⇩ FLEXLOGIC ⇨⇩ NON-VOLATILE LATCHES ⇨ LATCH 1(16)

	Display	Range
■ LATCH 1 ■	LATCH 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	LATCH 1 TYPE: Reset Dominant	Range: Reset Dominant, Set Dominant
MESSAGE	LATCH 1 SET: Off	Range: FlexLogic operand
MESSAGE	LATCH 1 RESET: Off	Range: FlexLogic operand
MESSAGE	LATCH 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	LATCH 1 EVENTS: Disabled	Range: Disabled, Enabled

The non-volatile latches provide a permanent logical flag that is stored safely and will not reset upon reboot after the relay is powered down. Typical applications include sustaining operator commands or permanently block relay functions, such as Autorecloser, until a deliberate interface action resets the latch. The settings element operation is described below:

- **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.

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

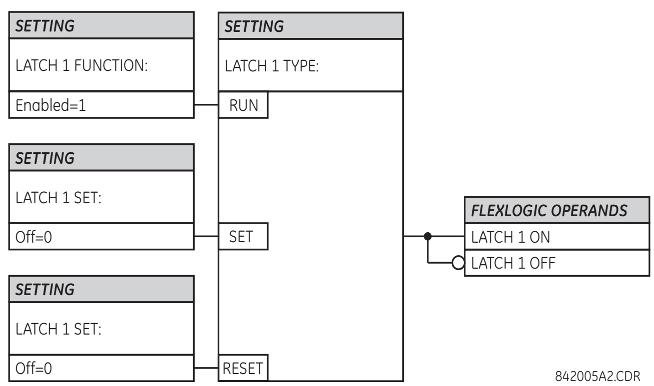

Figure 5–61: NON-VOLATILE LATCH OPERATION TABLE (N = 1 to 16) AND LOGIC

5.6.1 OVERVIEW

Each protection element can be assigned up to six different sets of settings according to setting group 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, season of the year, etc.). The active setting group can be preset or selected via 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.

5.6.2 SETTING GROUP

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6)

```
■ SETTING GROUP 1          ◀▶  ■ LINE DIFFERENTIAL       See page 5-149.
■                              ■ ELEMENTS
                   MESSAGE ▲▼  ■ PHASE CURRENT           See page 5-155.
                               ■
                   MESSAGE ▲▼  ■ NEUTRAL CURRENT         See page 5-166.
                               ■
                   MESSAGE ▲▼  ■ GROUND CURRENT          See page 5-173.
                               ■
                   MESSAGE ▲▼  ■ NEGATIVE SEQUENCE       See page 5-176.
                               ■ CURRENT
                   MESSAGE ▲▼  ■ BREAKER FAILURE         See page 5-178.
                               ■
                   MESSAGE ▲▼  ■ VOLTAGE ELEMENTS        See page 5-186.
                               ■
                   MESSAGE ▲   ■ SUPERVISING             See page 5-193.
                               ■ ELEMENTS
```

Each of the six setting group menus is identical. Setting group 1 (the default active group) automatically becomes active if no other group is active (see the *Control elements* section for additional details).

5.6.3 LINE DIFFERENTIAL ELEMENTS

a) MAIN MENU

PATH: SETTINGS ⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ LINE DIFFERENTIAL ELEMENTS

```
■ LINE DIFFERENTIAL        ◀▶  ■ CURRENT                 See page 5-150.
■ ELEMENTS                     ■ DIFFERENTIAL
                   MESSAGE ▲   ■ STUB BUS                See page 5-154.
                               ■
```

b) CURRENT DIFFERENTIAL

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ LINE DIFFERENTIAL... ⇨ CURRENT DIFFERENTIAL

	Display	Range
■ CURRENT ■ DIFFERENTIAL	CURRENT DIFF FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	CURRENT DIFF SIGNAL SOURCE 1: SRC 1	Range: SRC 1, SRC 2
MESSAGE	CURRENT DIFF BLOCK: Off	Range: FlexLogic operand
MESSAGE	CURRENT DIFF PICKUP: 0.20 pu	Range: 0.10 to 4.00 pu in steps of 0.01
MESSAGE	CURRENT DIFF CT TAP 1: 1.00	Range: 0.20 to 5.00 in steps of 0.01
MESSAGE	CURRENT DIFF CT TAP 2: 1.00	Range: 0.20 to 5.00 in steps of 0.01
MESSAGE	CURRENT DIFF RESTRAINT 1: 30%	Range: 1 to 50% in steps of 1
MESSAGE	CURRENT DIFF RESTRAINT 2: 50%	Range: 1 to 70% in steps of 1
MESSAGE	CURRENT DIFF BREAK PT: 1.0 pu	Range: 0.0 to 20.0 pu in steps of 0.1
MESSAGE	INRUSH INHIBIT MODE: Disabled	Range: Disabled, Per phase, 2-out-of-3, Average
MESSAGE	INRUSH INHIBIT LEVEL: 20% fo	Range: 1.0 to 40.0% f_0 in steps of 0.1
MESSAGE	CURRENT DIFF GND FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	CURRENT DIFF GND PICKUP: 0.10 pu	Range: 0.05 to 1.00 pu in steps of 0.01
MESSAGE	CURRENT DIFF GND RESTRAINT: 25%	Range: 1 to 50% in steps of 1
MESSAGE	CURRENT DIFF GND DELAY: 0.10 s	Range: 0.00 to 5.00 s in steps of 0.01
MESSAGE	CURRENT DIFF DTT: Enabled	Range: Disabled, Enabled
MESSAGE	CURRENT DIFF KEY DTT: Off	Range: FlexLogic operand
MESSAGE	CURRENT DIFF TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	CURRENT DIFF EVENTS: Disabled	Range: Disabled, Enabled

The following settings are available for current differential protection.

- **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 current differential pickup value.
- **CURRENT DIFF CT TAP 1** and **CURRENT DIFF CT TAP 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 2-terminal, two-channel applications use the same value for both TAP 1 and TAP 2 settings, and in 3-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 additional details.

  When in-zone power transformer is present, this setting should be calculated and used by taking into account the in-zone power transformer as follows.

$$\text{CT Tap} = \frac{\text{CT}_{\text{prim\_rem}} \times V_{\text{prim\_rem}}}{\text{CT}_{\text{prim\_loc}} \times V_{\text{prim\_loc}}} \quad \text{for remote terminals 1 and 2, respecitvely} \tag{EQ 5.9}$$

  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** and **CURRENT DIFF RESTRAINT 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 undesired tripping of the protected line. Reducing the second harmonic inhibit threshold may jeopardize dependability and speed of differential protection. When low, the second harmonic ratio causes problems in one phase only. This may be utilized as a mean 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 may 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 are equal at all terminals. Refer to the *Applications of settings* chapter for additional 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 will provide 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 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 set to “Enabled”.
- **CURRENT DIFF KEY DTT**: This setting selects an additional protection element (besides the current differential element; for example, distance element or breaker failure) which 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 exactly identical firmware revisions. For example, revision 5.62 in only compatible with 5.62, not 5.61 or 5.63.

5

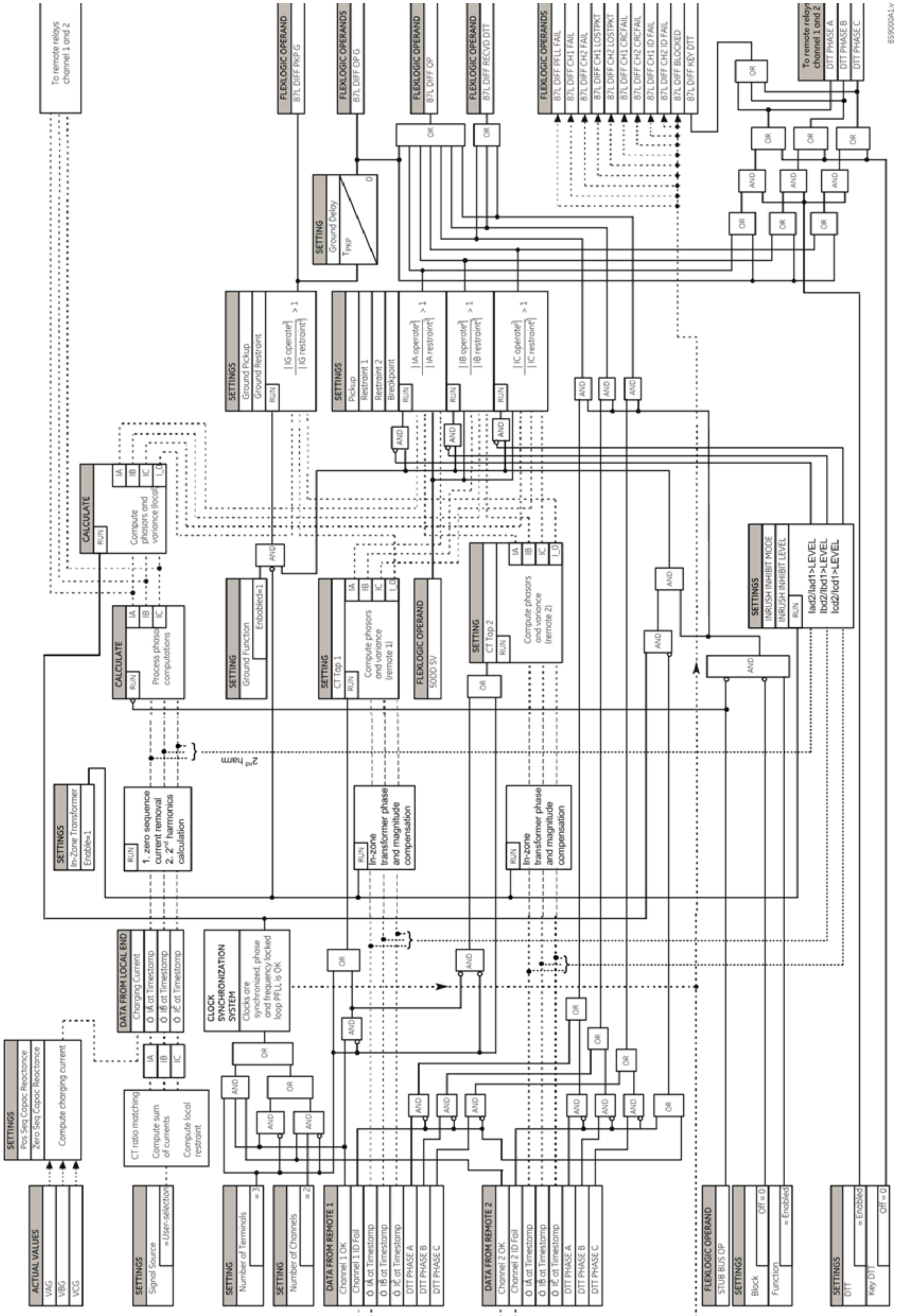

Figure 5–62: CURRENT DIFFERENTIAL SCHEME LOGIC

5

c) STUB BUS

PATH: SETTINGS ⇨ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ LINE DIFFERENTIAL ELEMENT ⇨⇩ STUB BUS

■ STUB BUS ■	STUB BUS FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	STUB BUS DISCONNECT: Off	Range: FlexLogic operand
MESSAGE	STUB BUS TRIGGER: Off	Range: FlexLogic operand
MESSAGE	STUB BUS TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	STUB BUS EVENTS: Disabled	Range: Disabled, Enabled

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 may 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) will trip on differential but local differential function and DTT signal (if enabled) to the local end, will be 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 as indicated below. There are two methods of setting the stub bus trigger and thus setting up stub bus operation:

  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 pick 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 method 1 should be used. 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 should be mapped to 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, the auxiliary contact of line disconnect switch (logic "1" when line switch is open) should be assigned 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 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 (see above). 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.

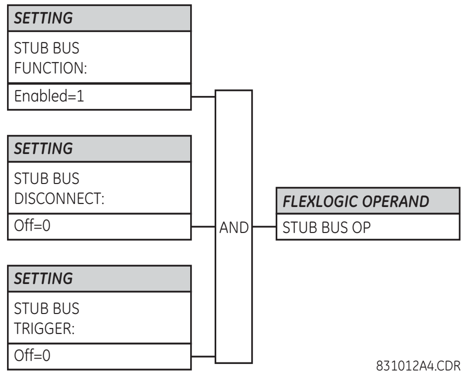

Figure 5–63: STUB BUS SCHEME LOGIC

5.6.4 PHASE CURRENT

a) MAIN MENU

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨⇩ SETTING GROUP 1(6) ⇨ PHASE CURRENT

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■ PHASE CURRENT
■
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	■ PHASE TOC1	See page 5-161.
MESSAGE	■ PHASE TOC2	See page 5-161.
MESSAGE	■ PHASE IOC1	See page 5-163.
MESSAGE	■ PHASE IOC2	See page 5-163.
MESSAGE	■ PHASE ■ DIRECTIONAL 1	See page 5-164.
MESSAGE	■ PHASE ■ DIRECTIONAL 2	See page 5-164.

b) INVERSE TIME OVERCURRENT 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 may be used to customize the inverse time curve characteristics. The definite time curve is also an option that may be appropriate if only simple protection is required.

Table 5–18: 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 will operate. 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.

5

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. The IEEE curves are derived from the formulae:

$$T = TDM \times \left[\frac{A}{\left(\frac{I}{I_{pickup}}\right)^p - 1} + B \right], \quad T_{RESET} = TDM \times \left[\frac{t_r}{1 - \left(\frac{I}{I_{pickup}}\right)^2} \right] \qquad \textbf{(EQ 5.10)}$$

where: T = operate time (in seconds), TDM = Multiplier setting, I = input current, I_{pickup} = Pickup Current setting
A, B, p = constants, T_{RESET} = reset time in seconds (assuming energy capacity is 100% and **RESET** is “Timed”),
t_r = characteristic constant

Table 5–19: 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 5–20: 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

Table 5–20: 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**
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
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 formulae for these curves are:

$$T = TDM \times \left[\frac{K}{(I/I_{pickup})^E - 1}\right], \quad T_{RESET} = TDM \times \left[\frac{t_r}{1 - (I/I_{pickup})^2}\right] \qquad \textbf{(EQ 5.11)}$$

where: T = operate time (in seconds), TDM = Multiplier setting, I = input current, I_{pickup} = Pickup Current setting, K, E = constants, t_r = characteristic constant, and T_{RESET} = reset time in seconds (assuming energy capacity is 100% and **RESET** is “Timed”)

Table 5–21: 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 5–22: 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
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 TIME										
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:

$$T = \text{TDM} \times \left(A + \frac{B}{(I/I_{pkp}) - C} + \frac{D}{((I/I_{pkp}) - C)^2} + \frac{E}{((I/I_{pkp}) - C)^3} \right),\ T_{RESET} = TDM \times \left[\frac{t_r}{1 - (I/I_{pkp})^2} \right] \quad \textbf{(EQ 5.12)}$$

where: T = operate time (in seconds), TDM = Multiplier setting, I = Input current, I_{pkp} = Pickup Current setting, A to E = constants, t_r = characteristic constant, and T_{RESET} = reset time in seconds (assuming energy capacity is 100% and **RESET** is "Timed")

Table 5–23: 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 Short Inverse	0.0428	0.0609	0.6200	–0.0010	0.0221	0.222

Table 5–24: 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

I2t CURVES:

The curves for the I^2t are derived from the formulae:

$$T = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{pickup}}\right)^2}\right],\ T_{RESET} = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{pickup}}\right)^{-2}}\right] \quad \textbf{(EQ 5.13)}$$

where: T = Operate Time (sec.); TDM = Multiplier Setting; I = Input Current; I_{pickup} = Pickup Current Setting;
T_{RESET} = Reset Time in sec. (assuming energy capacity is 100% and RESET: Timed)

Table 5–25: 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:

5

The custom FlexCurves are described in detail in the FlexCurves section of this chapter. The curve shapes for the Flex-Curves are derived from the formulae:

$$T = \text{TDM} \times \left[\text{FlexCurve Time at } \left(\frac{I}{I_{pickup}}\right)\right] \quad \text{when } \left(\frac{I}{I_{pickup}}\right) \geq 1.00 \quad \textbf{(EQ 5.14)}$$

$$T_{RESET} = \text{TDM} \times \left[\text{FlexCurve Time at } \left(\frac{I}{I_{pickup}}\right)\right] \quad \text{when } \left(\frac{I}{I_{pickup}}\right) \leq 0.98 \quad \textbf{(EQ 5.15)}$$

where: T = Operate Time (sec.), 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.

$$T = \text{TDM} \ \text{ in seconds, when } I > I_{pickup} \quad \textbf{(EQ 5.16)}$$

$$T_{RESET} = \text{TDM} \ \text{ in seconds} \quad \textbf{(EQ 5.17)}$$

where: T = Operate Time (sec.), 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. Please refer to the FlexCurve section in this chapter for additional details.

c) PHASE TIME OVERCURRENT (ANSI 51P, IEC PTOC)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ PHASE CURRENT ⇨ PHASE TOC1(2))

	Display	Range
■ PHASE TOC1 ■	PHASE TOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	PHASE TOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	PHASE TOC1 INPUT: Phasor	Range: Phasor, RMS
MESSAGE	PHASE TOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	PHASE TOC1 CURVE: IEEE Mod Inv	Range: See Overcurrent Curve Types table
MESSAGE	PHASE TOC1 TD MULTIPLIER: 1.00	Range: 0.00 to 600.00 in steps of 0.01
MESSAGE	PHASE TOC1 RESET: Instantaneous	Range: Instantaneous, Timed
MESSAGE	PHASE TOC1 VOLTAGE RESTRAINT: Disabled	Range: Disabled, Enabled
MESSAGE	PHASE TOC1 BLOCK A: Off	Range: FlexLogic operand
MESSAGE	PHASE TOC1 BLOCK B: Off	Range: FlexLogic operand
MESSAGE	PHASE TOC1 BLOCK C: Off	Range: FlexLogic operand
MESSAGE	PHASE TOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	PHASE TOC1 EVENTS: Disabled	Range: Disabled, Enabled

The phase 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 phase current input quantities may 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” (refer to the Inverse *Time overcurrent curves characteristic* sub-section earlier for details on curve setup, trip times, and reset operation). When the element is blocked, the time accumulator will reset according to the reset characteristic. For example, if the element reset characteristic is set to “Instantaneous” and the element is blocked, the time accumulator will be cleared immediately.

The **PHASE TOC1 PICKUP** setting can be dynamically reduced 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 below); 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.

5

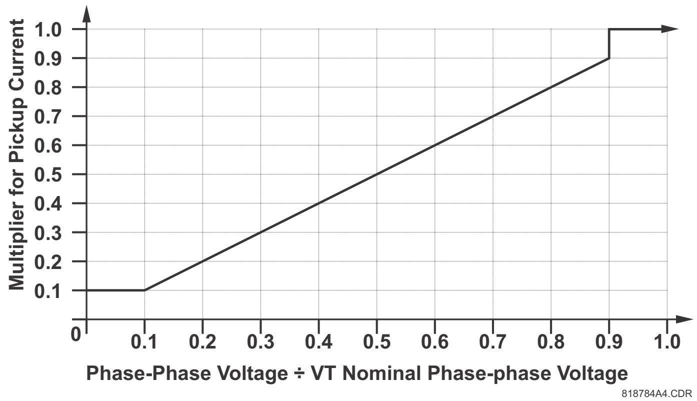

Figure 5–64: PHASE TIME OVERCURRENT VOLTAGE RESTRAINT CHARACTERISTIC

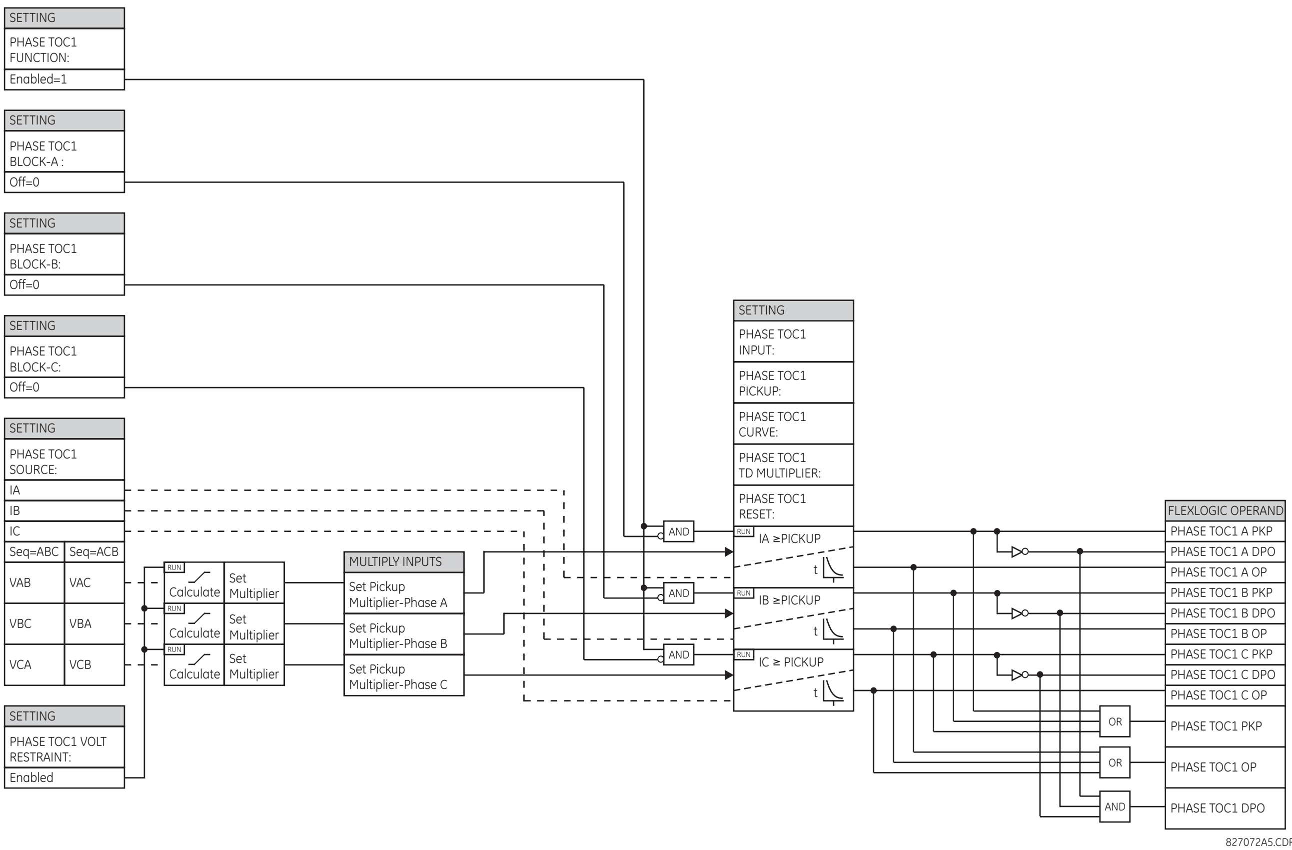

Figure 5–65: PHASE TIME OVERCURRENT 1 SCHEME LOGIC

d) PHASE INSTANTANEOUS OVERCURRENT (ANSI 50P, IEC PIOC)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ PHASE CURRENT ⇨ PHASE IOC 1(2)

		Display	Range
■ PHASE IOC1 ■	◀▶	PHASE IOC1 FUNCTION: Disabled	Range: *Disabled, Enabled*
MESSAGE	▲▼	PHASE IOC1 SIGNAL SOURCE: SRC 1	Range: *SRC 1, SRC 2*
MESSAGE	▲▼	PHASE IOC1 PICKUP: 1.000 pu	Range: *0.000 to 30.000 pu in steps of 0.001*
MESSAGE	▲▼	PHASE IOC1 PICKUP DELAY: 0.00 s	Range: *0.00 to 600.00 s in steps of 0.01*
MESSAGE	▲▼	PHASE IOC1 RESET DELAY: 0.00 s	Range: *0.00 to 600.00 s in steps of 0.01*
MESSAGE	▲▼	PHASE IOC1 BLOCK A: Off	Range: *FlexLogic operand*
MESSAGE	▲▼	PHASE IOC1 BLOCK B: Off	Range: *FlexLogic operand*
MESSAGE	▲▼	PHASE IOC1 BLOCK C: Off	Range: *FlexLogic operand*
MESSAGE	▲▼	PHASE IOC1 TARGET: Self-reset	Range: *Self-reset, Latched, Disabled*
MESSAGE	▲	PHASE IOC1 EVENTS: Disabled	Range: *Disabled, Enabled*

The phase instantaneous overcurrent element may 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 Element Response to Saturated Waveforms in UR-Series Relays (GET-8400A).

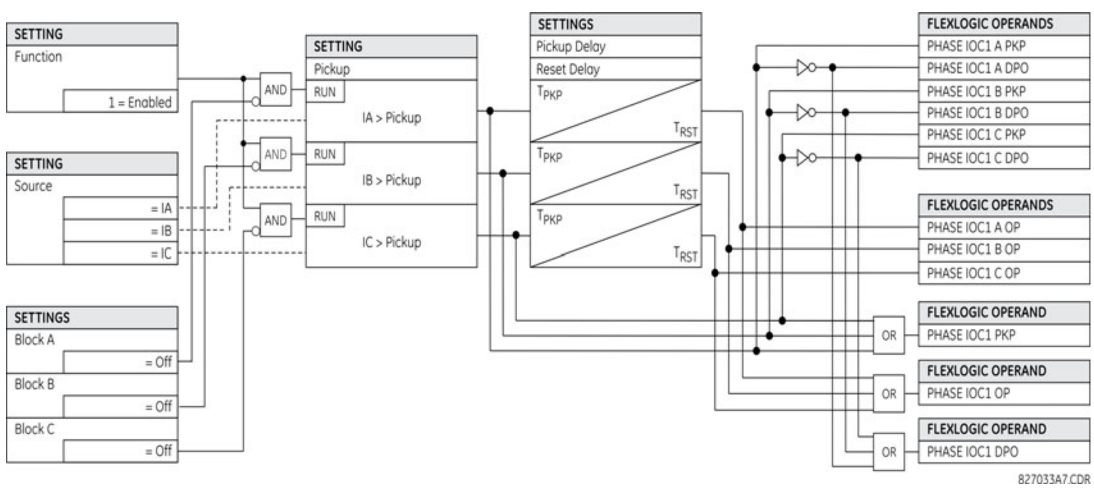

Figure 5–66: PHASE INSTANTANEOUS OVERCURRENT 1 SCHEME LOGIC

e) PHASE DIRECTIONAL OVERCURRENT (ANSI 67P, IEC PDOC/PTOC)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ PHASE CURRENT ⇨ PHASE DIRECTIONAL 1(2)

	Display	Range
■ PHASE ■ DIRECTIONAL 1	PHASE DIR 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	PHASE DIR 1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	PHASE DIR 1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	PHASE DIR 1 ECA: 30	Range: 0 to 359° in steps of 1
MESSAGE	PHASE DIR POL V1 THRESHOLD: 0.700 pu	Range: 0.000 to 3.000 pu in steps of 0.001
MESSAGE	PHASE DIR 1 BLOCK WHEN V MEM EXP: No	Range: No, Yes
MESSAGE	PHASE DIR 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	PHASE DIR 1 EVENTS: Disabled	Range: Disabled, Enabled

5

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.

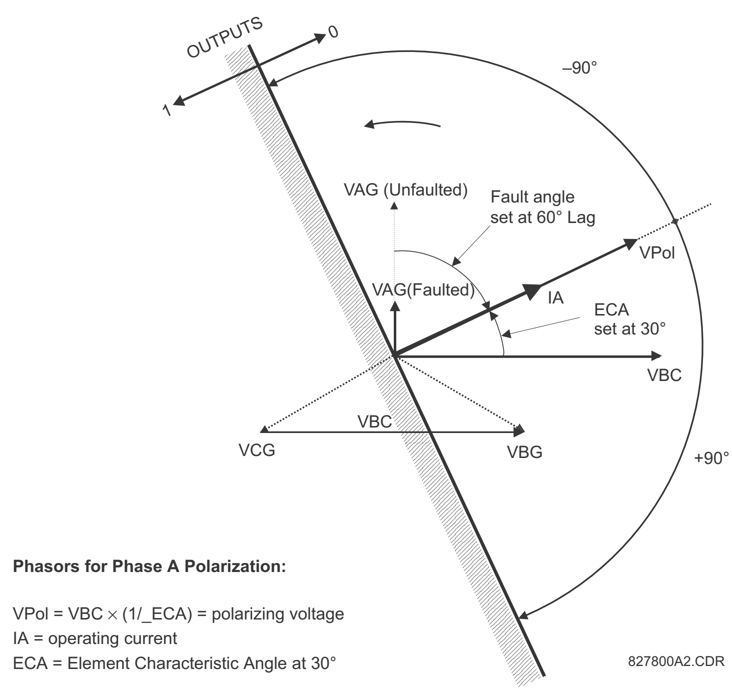

Figure 5–67: PHASE A DIRECTIONAL POLARIZATION

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 following table shows the operating and polarizing signals used for phase directional control:

PHASE	OPERATING SIGNAL	POLARIZING SIGNAL V_{pol}	
		ABC PHASE SEQUENCE	ACB PHASE SEQUENCE
A	angle of IA	angle of VBC × (1∠ECA)	angle of VCB × (1∠ECA)
B	angle of IB	angle of VCA × (1∠ECA)	angle of VAC × 1∠ECA)
C	angle of IC	angle of VAB × (1∠ECA)	angle of VBA × (1∠ECA)

MODE OF OPERATION:

- When the function is “Disabled”, or the operating current is below 5% × CT nominal, the element output is “0”.
- When the function is “Enabled”, the operating current is above 5% × CT nominal, and the polarizing voltage is above the **PRODUCT SETUP ⇨⇩ DISPLAY PROPERTIES ⇨⇩ 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 ±90°.
  – 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 will block 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 will be permitted to resume when the polarizing voltage becomes greater than the ‘polarizing voltage threshold’.

SETTINGS:

- **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 ECA:** This setting is used to select the element characteristic angle, i.e. 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. This element should be programmed via the ECA 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. The default value is “0.700 pu”.
- **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.

NOTE

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 may 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 a concern, a longer delay – in the order of 20 ms – may be needed.

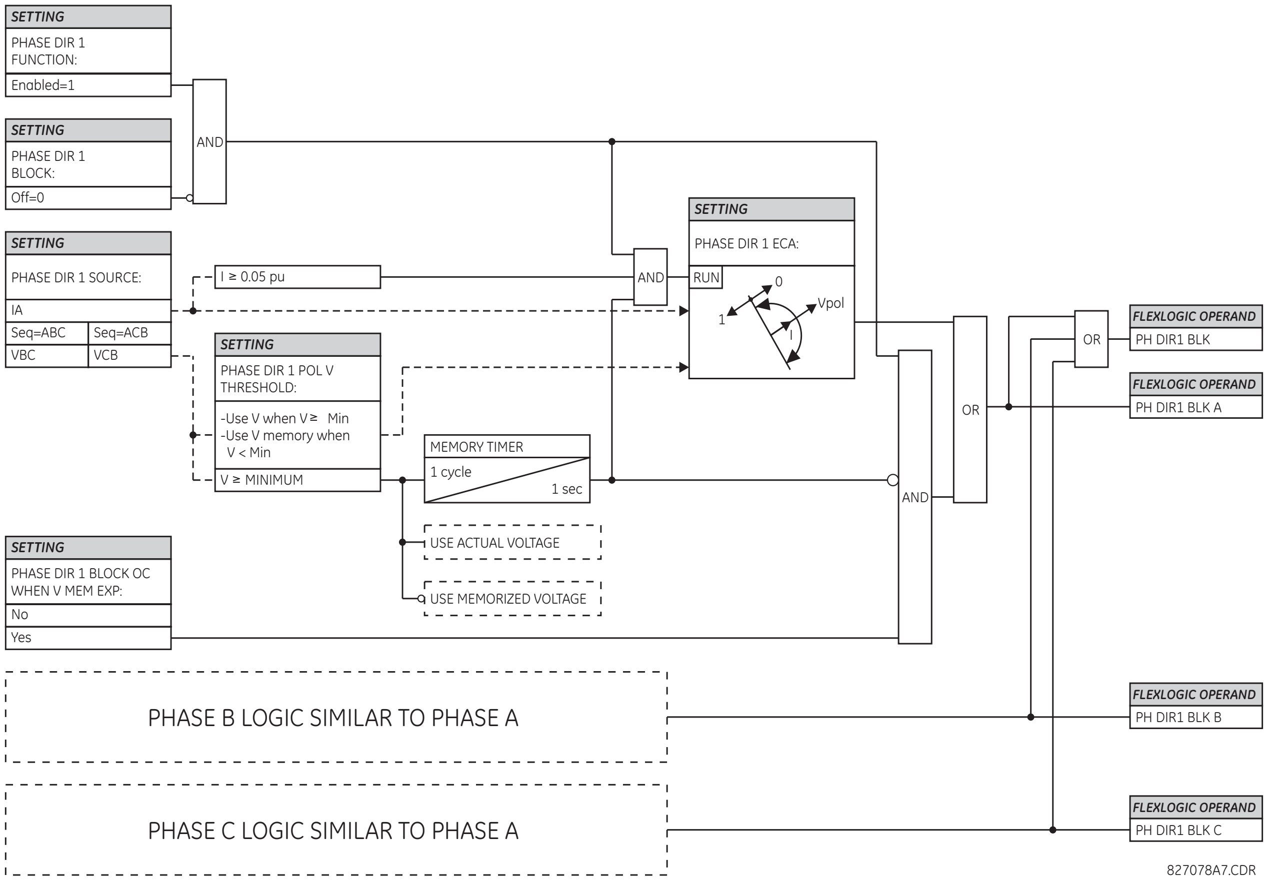

Figure 5–68: PHASE DIRECTIONAL SCHEME LOGIC

5.6.5 NEUTRAL CURRENT

a) MAIN MENU

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨⇩ SETTING GROUP 1(6) ⇨ NEUTRAL CURRENT

■ NEUTRAL CURRENT ■	◀▶	■ NEUTRAL TOC1 ■	See page 5-167.
MESSAGE	▲▼	■ NEUTRAL TOC2 ■	See page 5-167.
MESSAGE	▲▼	■ NEUTRAL IOC1 ■	See page 5-168.
MESSAGE	▲▼	■ NEUTRAL IOC2 ■	See page 5-168.
MESSAGE	▲▼	■ NEUTRAL ■ DIRECTIONAL 1	See page 5-169.
MESSAGE	▲	■ NEUTRAL ■ DIRECTIONAL 2	See page 5-169.

b) NEUTRAL TIME OVERCURRENT (ANSI 51N, IEC PTOC)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEUTRAL CURRENT ⇨ NEUTRAL TOC1(2)

Menu		Setting	Range
■ NEUTRAL TOC1 ■		NEUTRAL TOC1 FUNCTION: Disabled	Range: *Disabled, Enabled*
	MESSAGE	NEUTRAL TOC1 SIGNAL SOURCE: SRC 1	Range: *SRC 1, SRC 2*
	MESSAGE	NEUTRAL TOC1 INPUT: Phasor	Range: *Phasor, RMS*
	MESSAGE	NEUTRAL TOC1 PICKUP: 1.000 pu	Range: *0.000 to 30.000 pu in steps of 0.001*
	MESSAGE	NEUTRAL TOC1 CURVE: IEEE Mod Inv	Range: *See OVERCURRENT CURVE TYPES table*
	MESSAGE	NEUTRAL TOC1 TD MULTIPLIER: 1.00	Range: *0.00 to 600.00 in steps of 0.01*
	MESSAGE	NEUTRAL TOC1 RESET: Instantaneous	Range: *Instantaneous, Timed*
	MESSAGE	NEUTRAL TOC1 BLOCK: Off	Range: *FlexLogic operand*
	MESSAGE	NEUTRAL TOC1 TARGET: Self-reset	Range: *Self-reset, Latched, Disabled*
	MESSAGE	NEUTRAL TOC1 EVENTS: Disabled	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 3Io from the phase currents and may 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” (refer to the *Inverse time overcurrent curve characteristics* section for details on curve setup, trip times and reset operation). When the element is blocked, the time accumulator will reset according to the reset characteristic. For example, if the element reset characteristic is set to “Instantaneous” and the element is blocked, the time accumulator will be cleared immediately.

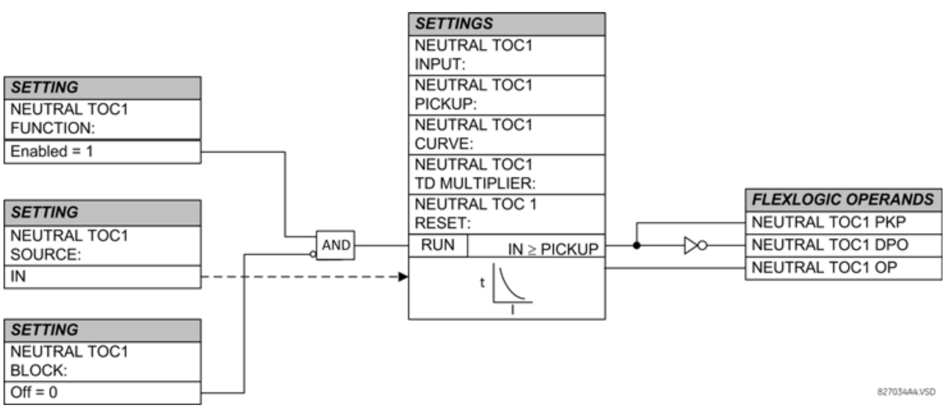

Figure 5–69: NEUTRAL TIME OVERCURRENT 1 SCHEME LOGIC

c) NEUTRAL INSTANTANEOUS OVERCURRENT (ANSI 50N, IEC PIOC)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEUTRAL CURRENT ⇨⇩ NEUTRAL IOC1(2)

■ NEUTRAL IOC1 ■	◀▶	NEUTRAL IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	NEUTRAL IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	▲▼	NEUTRAL IOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	▲▼	NEUTRAL IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	▲▼	NEUTRAL IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	▲▼	NEUTRAL IOC1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	▲▼	NEUTRAL IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	NEUTRAL IOC1 EVENTS: Disabled	Range: Disabled, Enabled

5

The neutral instantaneous overcurrent element may 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:

$$I_{op} = 3 \times (|I\_0| - K \cdot |I\_1|) \quad \text{where } K = 1/16 \qquad \textbf{(EQ 5.18)}$$

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: $I_{op} = 0.9375 \cdot I_{injected}$; three-phase pure zero-sequence injection: $I_{op} = 3 \times I_{injected}$).

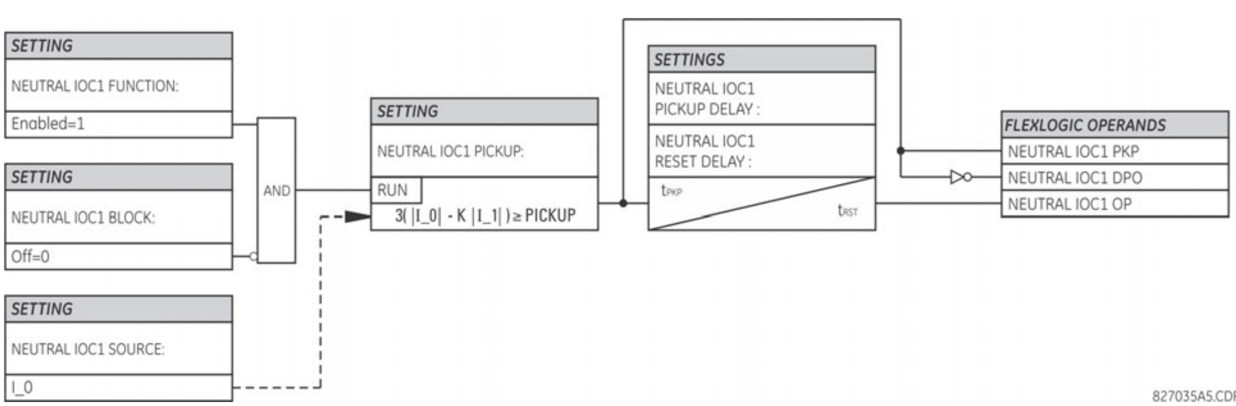

Figure 5–70: NEUTRAL IOC1 SCHEME LOGIC

d) NEUTRAL DIRECTIONAL OVERCURRENT (ANSI 67N, IEC PDEF/PTOC)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ NEUTRAL CURRENT ⇨⇩ NEUTRAL DIRECTIONAL OC1

	Setting	Range
■ NEUTRAL ■ DIRECTIONAL OC1	NEUTRAL DIR OC1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	NEUTRAL DIR OC1 SOURCE: SRC 1	*Range: SRC 1, SRC 2*
MESSAGE	NEUTRAL DIR OC1 POLARIZING: Voltage	*Range: Voltage, Current, Dual, Dual-V, Dual-I*
MESSAGE	NEUTRAL DIR OC1 POL VOLT: Calculated V0	*Range: Calculated V0, Measured VX*
MESSAGE	NEUTRAL DIR OC1 OP CURR: Calculated 3I0	*Range: Calculated 3I0, Measured IG*
MESSAGE	NEUTRAL DIR OC1 POS- SEQ RESTRAINT: 0.063	*Range: 0.000 to 0.500 in steps of 0.001*
MESSAGE	NEUTRAL DIR OC1 OFFSET: 0.00 Ω	*Range: 0.00 to 250.00 Ω in steps of 0.01*
MESSAGE	NEUTRAL DIR OC1 FWD ECA: 75° Lag	*Range: –90 to 90° in steps of 1*
MESSAGE	NEUTRAL DIR OC1 FWD LIMIT ANGLE: 90°	*Range: 40 to 90° in steps of 1*
MESSAGE	NEUTRAL DIR OC1 FWD PICKUP: 0.050 pu	*Range: 0.006 to 30.000 pu in steps of 0.001*
MESSAGE	NEUTRAL DIR OC1 REV LIMIT ANGLE: 90°	*Range: 40 to 90° in steps of 1*
MESSAGE	NEUTRAL DIR OC1 REV PICKUP: 0.050 pu	*Range: 0.006 to 30.000 pu in steps of 0.001*
MESSAGE	NEUTRAL DIR OC1 BLK: Off	*Range: FlexLogic operand*
MESSAGE	NEUTRAL DIR OC1 TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
MESSAGE	NEUTRAL DIR OC1 EVENTS: Disabled	*Range: Disabled, Enabled*

The neutral directional overcurrent element provides both forward and reverse fault direction indications 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 the 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.

$$I_{op} = 3 \times (|I\_0| - K \times |I\_1|) \quad \textbf{(EQ 5.19)}$$

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 may 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.

Table 5–26: QUANTITIES FOR "CALCULATED 3I0" CONFIGURATION

DIRECTIONAL UNIT				OVERCURRENT UNIT
POLARIZING MODE	DIRECTION	COMPARED PHASORS		
Voltage	Forward	–V_0 + Z_offset × I_0	I_0 × 1∠ECA	$I_{op} = 3 \times (\|I\_0\| – K \times \|I\_1\|)$ if $\|I_1\| > 0.8$ pu $I_{op} = 3 \times (\|I\_0\|)$ if $\|I_1\| \le 0.8$ pu
	Reverse	–V_0 + Z_offset × I_0	–I_0 × 1∠ECA	
Current	Forward	IG	I_0	
	Reverse	IG	–I_0	
Dual, Dual-V, Dual-I	Forward	–V_0 + Z_offset × I_0	I_0 × 1∠ECA	
		or		
		IG	I_0	
	Reverse	–V_0 + Z_offset × I_0	–I_0 × 1∠ECA	
		or		
		IG	–I_0	

Table 5–27: QUANTITIES FOR "MEASURED IG" CONFIGURATION

DIRECTIONAL UNIT				OVERCURRENT UNIT
POLARIZING MODE	DIRECTION	COMPARED PHASORS		
Voltage	Forward	–V_0 + Z_offset × IG/3	IG × 1∠ECA	$I_{op} = \|IG\|$
	Reverse	–V_0 + Z_offset × IG/3	–IG × 1∠ECA	

where: $V\_0 = \frac{1}{3}(VAG + VBG + VCG) = \text{zero sequence voltage}$,

$$I\_0 = \frac{1}{3}IN = \frac{1}{3}(IA + IB + IC) = \text{zero sequence current} ,$$

ECA = element characteristic angle and IG = ground current

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 below 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)

The above bias should be taken into account when using the neutral directional overcurrent element to directionalize other protection elements.

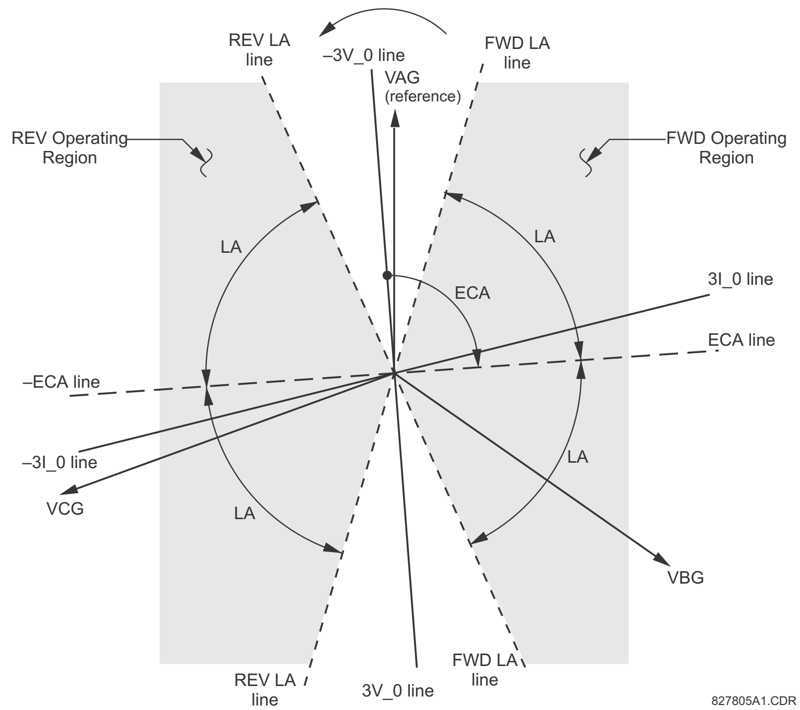

Figure 5–71: NEUTRAL DIRECTIONAL VOLTAGE-POLARIZED CHARACTERISTICS

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- **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 (V_0) or auxiliary voltage (V_X), accordingly, must be greater than the **VOLTAGE CUTOFF LEVEL** setting specified in the **PRODUCT SETUP ⇨⇩ DISPLAY PROPERTIES** menu to be validated for use as a 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, it should be ensured that a reversal of the ground current does not occur for a high-side fault. The low-side system impedance should be assumed minimal when checking for this condition. A similar situation arises for a wye/delta/wye transformer, where current in one transformer winding neutral may reverse when faults on both sides of the transformer are considered.
  - If “Dual” polarizing is selected, the element performs both directional comparisons as described above. 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.
- **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 3I_0 current calculated from the phase currents, or the ground current shall be used by this protection. This setting acts as a switch between the neutral and ground modes of operation (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 to 0.063 for backward compatibility with firmware revision 3.40 and older. Set to zero to remove the restraint. Set 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 shall not be larger than the zero-sequence impedance of the protected circuit. Practically, it shall be several times smaller. The offset impedance shall be entered 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 it must be kept 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 it must be kept in mind that the design uses a *positive-sequence restraint* technique for the “Calculated 3I0” mode of operation.

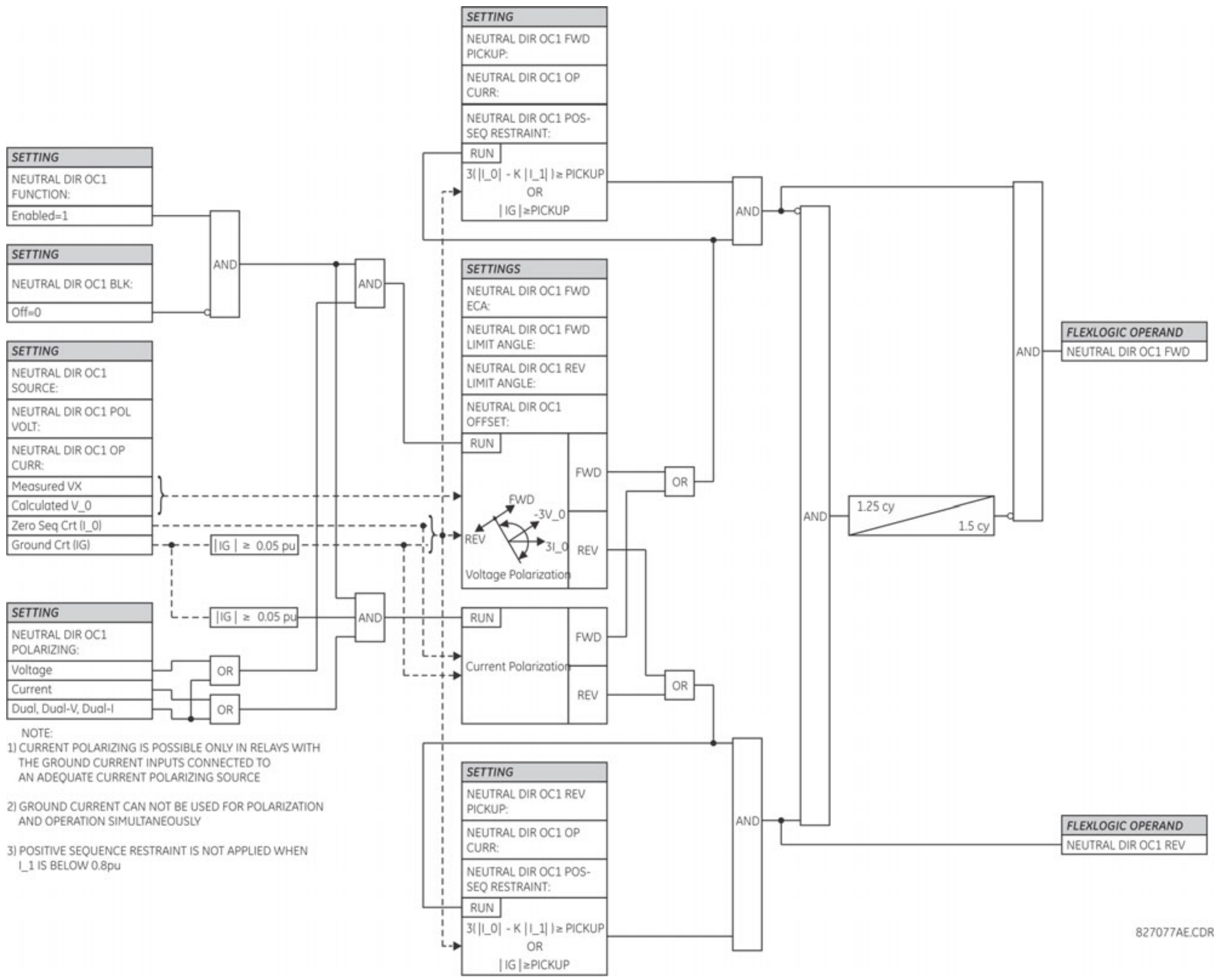

Figure 5–72: NEUTRAL DIRECTIONAL OVERCURRENT LOGIC

5.6.6 GROUND CURRENT

a) MAIN MENU

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨⇩ SETTING GROUP 1(6) ⇨⇩ GROUND CURRENT

■ GROUND CURRENT ■	◁▷	■ GROUND TOC1 ■	See page 5-174.
	MESSAGE △▽	■ GROUND TOC2 ■	See page 5-174.
	MESSAGE △▽	■ GROUND IOC1 ■	See page 5-175.
	MESSAGE △	■ GROUND IOC2 ■	See page 5-175.

b) GROUND TIME OVERCURRENT (ANSI 51G, IEC PTOC)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ GROUND CURRENT ⇨ GROUND TOC1(2)

		Display	Range
■ GROUND TOC1 ■	◀▶	GROUND TOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	GROUND TOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	▲▼	GROUND TOC1 INPUT: Phasor	Range: Phasor, RMS
MESSAGE	▲▼	GROUND TOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	▲▼	GROUND TOC1 CURVE: IEEE Mod Inv	Range: see the Overcurrent Curve Types table
MESSAGE	▲▼	GROUND TOC1 TD MULTIPLIER: 1.00	Range: 0.00 to 600.00 in steps of 0.01
MESSAGE	▲▼	GROUND TOC1 RESET: Instantaneous	Range: Instantaneous, Timed
MESSAGE	▲▼	GROUND TOC1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	▲▼	GROUND TOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	GROUND TOC1 EVENTS: Disabled	Range: Disabled, Enabled

5

This element can provide a desired 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” (refer to the *Inverse time overcurrent curve characteristics* section for details). When the element is blocked, the time accumulator will reset according to the reset characteristic. For example, if the element reset characteristic is set to “Instantaneous” and the element is blocked, the time accumulator will be cleared immediately.

NOTE

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.

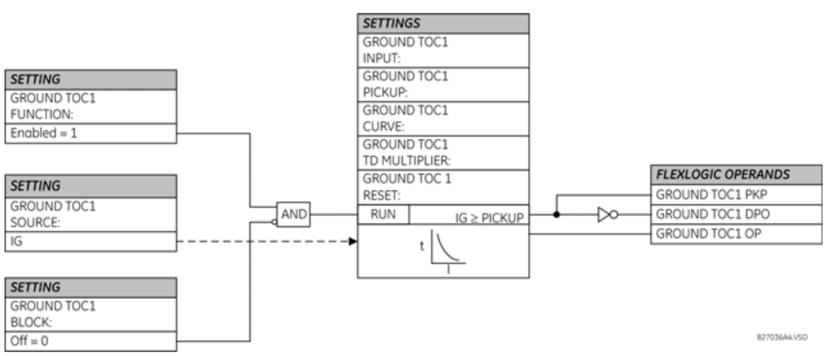

Figure 5–73: GROUND TOC1 SCHEME LOGIC

c) GROUND INSTANTANEOUS OVERCURRENT (ANSI 50G, IEC PIOC)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ GROUND CURRENT ⇨⇩ GROUND IOC1(2)

■ GROUND IOC1 ■	◀▶	GROUND IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	GROUND IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	▲▼	GROUND IOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	▲▼	GROUND IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	▲▼	GROUND IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	▲▼	GROUND IOC1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	▲▼	GROUND IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	GROUND IOC1 EVENTS: Disabled	Range: Disabled, Enabled

The ground instantaneous overcurrent element may 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.

NOTE

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.

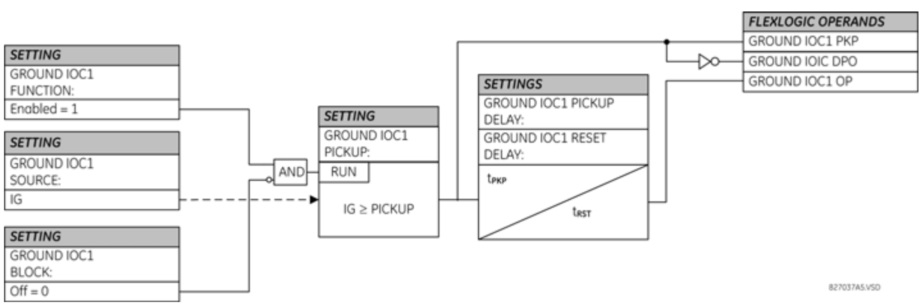

Figure 5–74: GROUND IOC1 SCHEME LOGIC

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5.6.7 NEGATIVE SEQUENCE CURRENT

a) NEGATIVE SEQUENCE TIME OVERCURRENT (ANSI 51Q, IEC PTOC)

PATH: SETTINGS ⇩ GROUPED ELEMENTS ⇨⇩ SETTING GROUP 1(6) ⇨⇩ NEGATIVE SEQUENCE CURRENT ⇨ NEG SEQ TOC1(2)

■ NEG SEQ TOC1 ■	NEG SEQ TOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	NEG SEQ TOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	NEG SEQ TOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	NEG SEQ TOC1 CURVE: IEEE Mod Inv	Range: see OVERCURRENT CURVE TYPES table
MESSAGE	NEG SEQ TOC1 TD MULTIPLIER: 1.00	Range: 0.00 to 600.00 in steps of 0.01
MESSAGE	NEG SEQ TOC1 RESET: Instantaneous	Range: Instantaneous, Timed
MESSAGE	NEG SEQ TOC1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	NEG SEQ TOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	NEG SEQ TOC1 EVENTS: Disabled	Range: Disabled, Enabled

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The negative-sequence time overcurrent element may 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” (refer to the *Inverse Time Overcurrent Characteristics* sub-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 is cleared immediately.

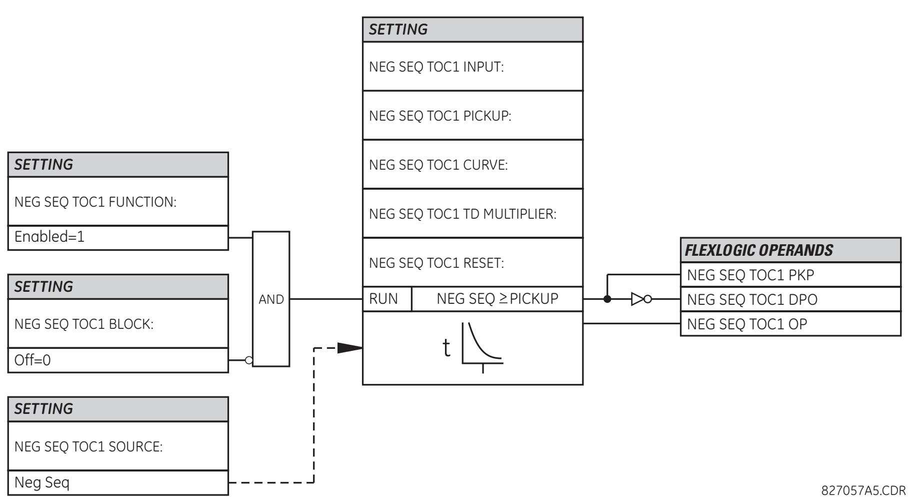

Figure 5–75: NEGATIVE SEQUENCE TOC1 SCHEME LOGIC

b) NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT (ANSI 50Q, IEC PIOC)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEGATIVE SEQUENCE CURRENT ⇨⇩ NEG SEQ OC1(2)

	Setting	Range
■ NEG SEQ IOC1 ■	NEG SEQ IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	NEG SEQ IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	NEG SEQ IOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	NEG SEQ IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NEG SEQ IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NEG SEQ IOC1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	NEG SEQ IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	NEG SEQ IOC1 EVENTS: Disabled	Range: Disabled, Enabled

The negative-sequence instantaneous overcurrent element may 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:

$$I_{op} = |I\_2| - K \cdot |I\_1| \quad \text{where } K = 1/8 \qquad \textbf{(EQ 5.20)}$$

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 the way the test currents are injected into the relay (single-phase injection: $I_{op} = 0.2917 \cdot I_{injected}$; three-phase injection, opposite rotation: $I_{op} = I_{injected}$).

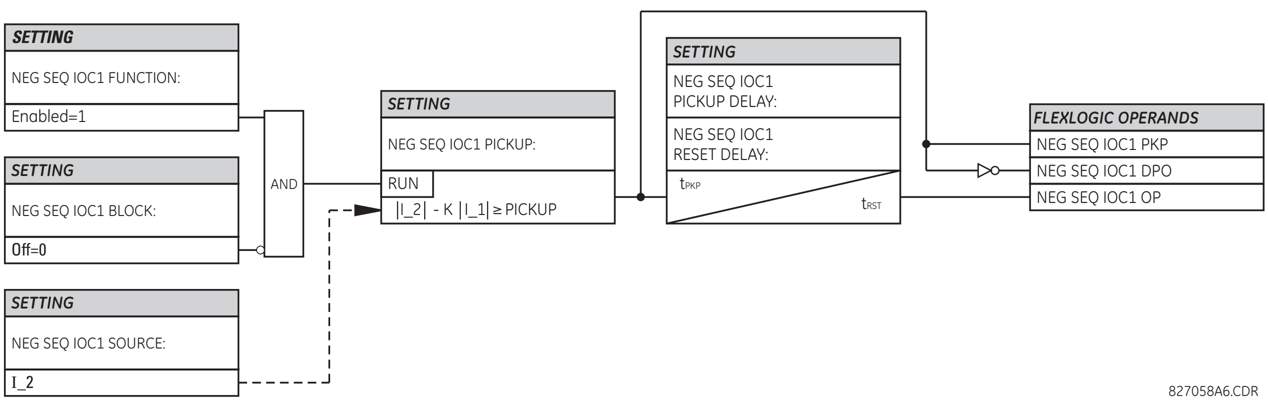

Figure 5–76: NEGATIVE SEQUENCE IOC1 SCHEME LOGIC

5.6.8 BREAKER FAILURE

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ BREAKER FAILURE ⇨ BREAKER FAILURE 1(2)

Menu	Key	Display	Range
■ BREAKER FAILURE 1 ■	◁▷	BF1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	BF1 MODE: 3-Pole	Range: 3-Pole, 1-Pole
MESSAGE	△▽	BF1 SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	△▽	BF1 USE AMP SUPV: Yes	Range: Yes, No
MESSAGE	△▽	BF1 USE SEAL-IN: Yes	Range: Yes, No
MESSAGE	△▽	BF1 3-POLE INITIATE: Off	Range: FlexLogic operand
MESSAGE	△▽	BF1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	△▽	BF1 PH AMP SUPV PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	△▽	BF1 N AMP SUPV PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	△▽	BF1 USE TIMER 1: Yes	Range: Yes, No
MESSAGE	△▽	BF1 TIMER 1 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	△▽	BF1 USE TIMER 2: Yes	Range: Yes, No
MESSAGE	△▽	BF1 TIMER 2 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	△▽	BF1 USE TIMER 3: Yes	Range: Yes, No
MESSAGE	△▽	BF1 TIMER 3 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	△▽	BF1 BKR POS1 ϕA/3P: Off	Range: FlexLogic operand
MESSAGE	△▽	BF1 BKR POS2 ϕA/3P: Off	Range: FlexLogic operand
MESSAGE	△▽	BF1 BREAKER TEST ON: Off	Range: FlexLogic operand
MESSAGE	△▽	BF1 PH AMP HISET PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	△▽	BF1 N AMP HISET PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	△▽	BF1 PH AMP LOSET PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001

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	Display	Range
MESSAGE	BF1 N AMP LOSET PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	BF1 LOSET TIME DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	BF1 TRIP DROPOUT DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	BF1 TARGET Self-Reset	Range: Self-reset, Latched, Disabled
MESSAGE	BF1 EVENTS Disabled	Range: Disabled, Enabled
MESSAGE	BF1 PH A INITIATE: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 PH B INITIATE: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 PH C INITIATE: Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 BKR POS1 φB Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 BKR POS1 φC Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 BKR POS2 φB Off	Range: FlexLogic operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	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 will cause 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 should be 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 may 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, a current supervised initiate should *not* be used. This feature should be utilized for those situations where coordinating margins may 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 immediately sends a trip signal 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 will enable 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.

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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 faceplate Trip LED (and the Phase A, B or C LED, if applicable)

MAIN PATH SEQUENCE:

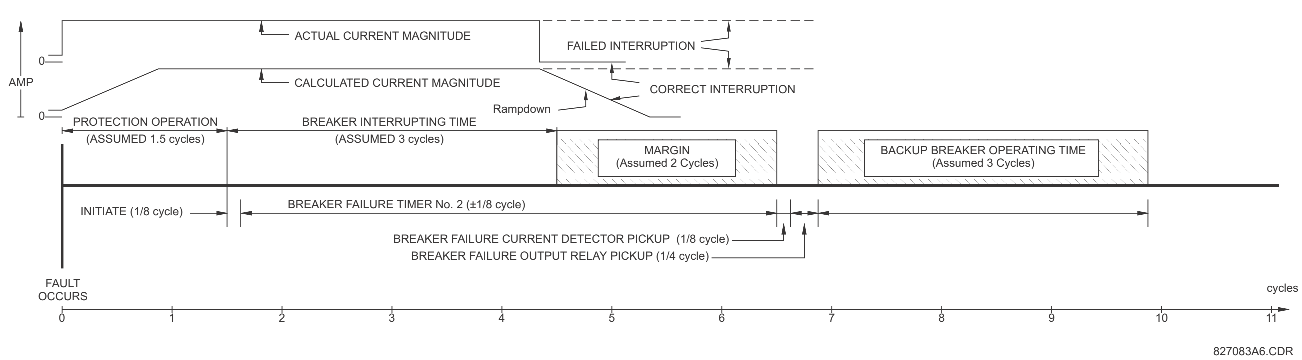

Figure 5–77: BREAKER FAILURE MAIN PATH SEQUENCE

The current supervision elements reset in less than 0.7 of a power cycle for any multiple of pickup current as shown below.

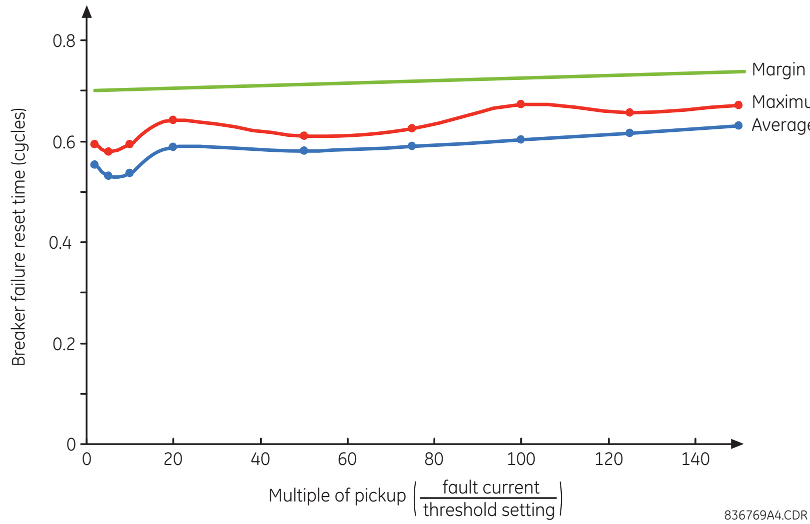

Figure 5–78: BREAKER FAILURE OVERCURRENT SUPERVISION RESET TIME

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 will only be initiated if current flowing through the breaker is above the supervision pickup level.
- **BF1 USE SEAL-IN:** If set to "Yes", the element will only be 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 will initiate three-pole tripping of the breaker.
- **BF1 PH AMP SUPV PICKUP:** This setting is used to set the phase current initiation and seal-in supervision level. Generally this setting should detect 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 will 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 should detect 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 will ramp-down to zero one power frequency cycle after the current is interrupted, and this lag should be included in the overall margin duration, as it occurs after current interruption. The *Breaker failure main path sequence* diagram below 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.

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- **BF1 BKR POS1 ϕA/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 may even be adjusted to have the shortest possible operating time.
- **BF1 BKR POS2 ϕA/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 may 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 should 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 should 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 should 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 should 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 ϕB / BF1 BKR POS 1 ϕC:** 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 may even be adjusted to have the shortest possible operating time. *This setting is valid only for single-pole breaker failure schemes*.
- **BF1 BKR POS2 ϕB:** Selects the FlexLogic operand that represents the protected breaker normal-type auxiliary switch contact on pole B (52/a). This may be a multiplied contact. *This setting is valid only for single-pole breaker failure schemes*.
- **BF1 BKR POS2 ϕC:** This setting selects the FlexLogic operand that represents the protected breaker normal-type auxiliary switch contact on pole C (52/a). This may 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 should be given via output operand BKR FAIL 1 TRIP OP.

SINGLE-POLE BREAKER FAILURE, INITIATE

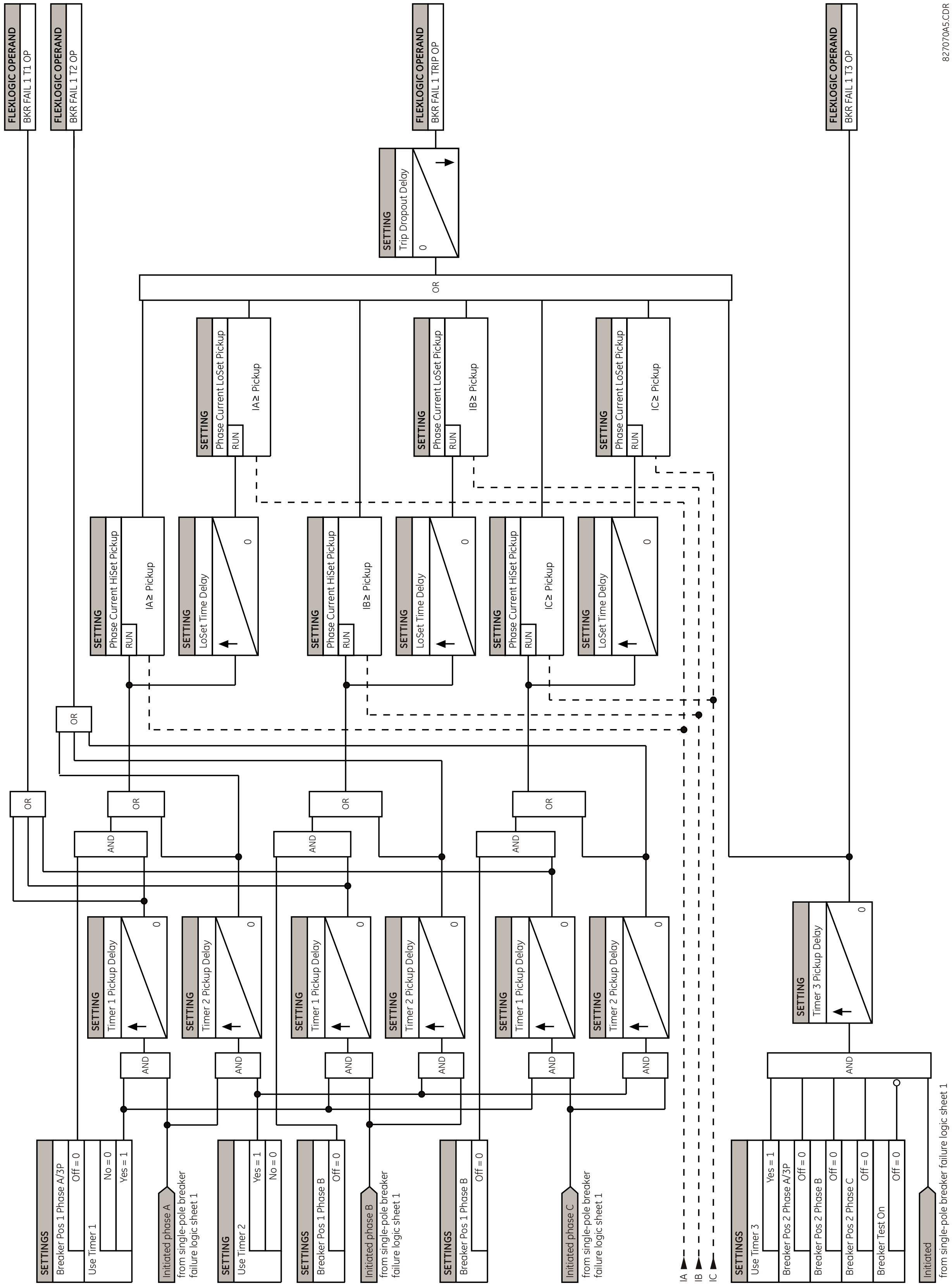

Figure 5–79: SINGLE-POLE BREAKER FAILURE, TIMERS

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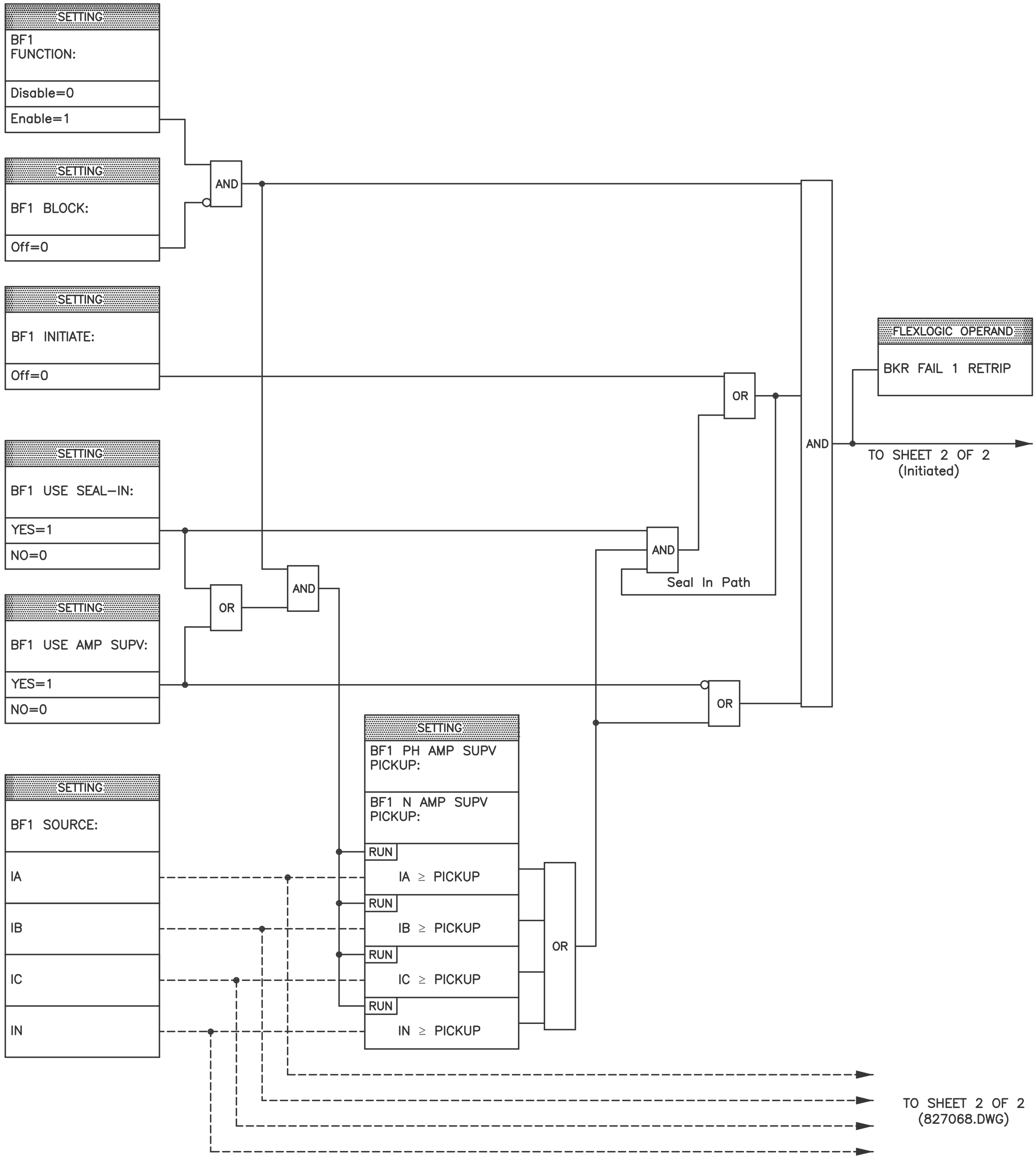


Figure 5–80: THREE-POLE BREAKER FAILURE, INITIATE

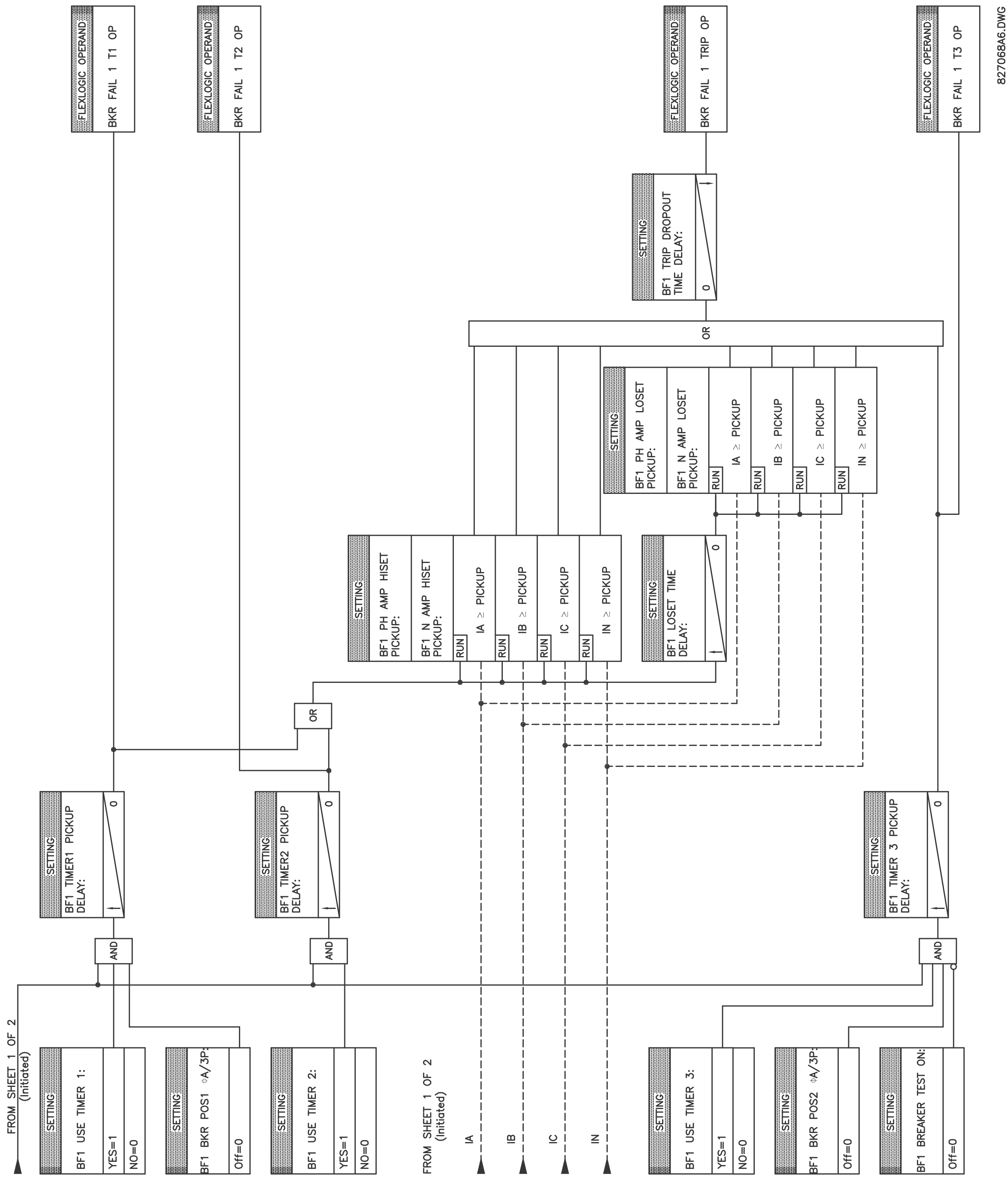


Figure 5–81: THREE-POLE BREAKER FAILURE, TIMERS

5.6.9 VOLTAGE ELEMENTS

a) MAIN MENU

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS

■ VOLTAGE ELEMENTS ■	■ PHASE ■ UNDERVOLTAGE1	See page 5-187.
MESSAGE	■ PHASE ■ UNDERVOLTAGE2	See page 5-187.
MESSAGE	■ PHASE ■ UNDERVOLTAGE3	See page 5-187.
MESSAGE	■ PHASE ■ OVERVOLTAGE1	See page 5-188.
MESSAGE	■ NEG SEQ OV 1 ■	See page 5-189.
MESSAGE	■ NEG SEQ OV 2 ■	See page 5-189.
MESSAGE	■ NEG SEQ OV 3 ■	See page 5-189.
MESSAGE	■ AUXILIARY UV1 ■	See page 5-190.
MESSAGE	■ AUXILIARY OV1 ■	See page 5-191.

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 may 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 may 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 may 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 may 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 below.

$$T = \frac{D}{\left(1 - \frac{V}{V_{pickup}}\right)} \quad \text{(EQ 5.21)}$$

where: T = operating time
D = undervoltage delay setting (D = 0.00 operates instantaneously)
V = secondary voltage applied to the relay
V_{pickup} = pickup level

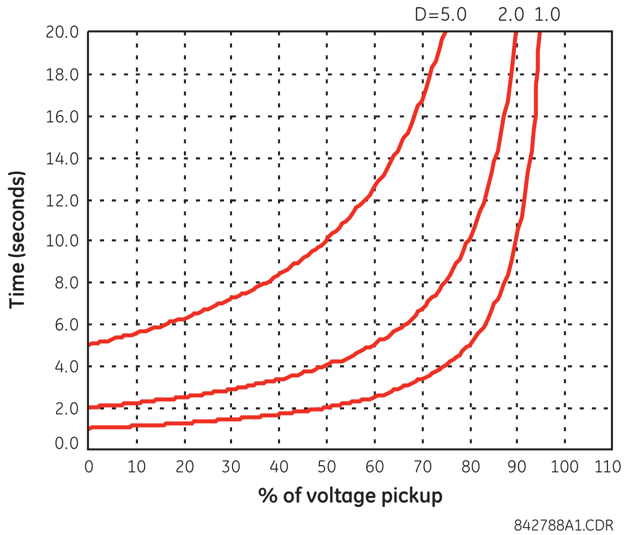


Figure 5–82: INVERSE TIME UNDERVOLTAGE CURVES

NOTE: At 0% of pickup, the operating time equals the UNDERVOLTAGE DELAY setting.

b) PHASE UNDERVOLTAGE (ANSI 27P, IEC PTUV)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨ PHASE UNDERVOLTAGE1(3)

		Setting	Range
■ PHASE ■ UNDERVOLTAGE1		PHASE UV1 FUNCTION: Disabled	Range: Disabled, Enabled
	MESSAGE	PHASE UV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	MESSAGE	PHASE UV1 MODE: Phase to Ground	Range: Phase to Ground, Phase to Phase
	MESSAGE	PHASE UV1 PICKUP: 1.000 pu	Range: 0.000 to 3.000 pu in steps of 0.001
	MESSAGE	PHASE UV1 CURVE: Definite Time	Range: Definite Time, Inverse Time
	MESSAGE	PHASE UV1 DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	MESSAGE	PHASE UV1 MINIMUM VOLTAGE: 0.100 pu	Range: 0.000 to 3.000 pu in steps of 0.001
	MESSAGE	PHASE UV1 BLOCK: Off	Range: FlexLogic operand
	MESSAGE	PHASE UV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	MESSAGE	PHASE UV1 EVENTS: Disabled	Range: Disabled, Enabled

This element may be used to give a desired 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” will allow a dead source to be considered a fault condition).

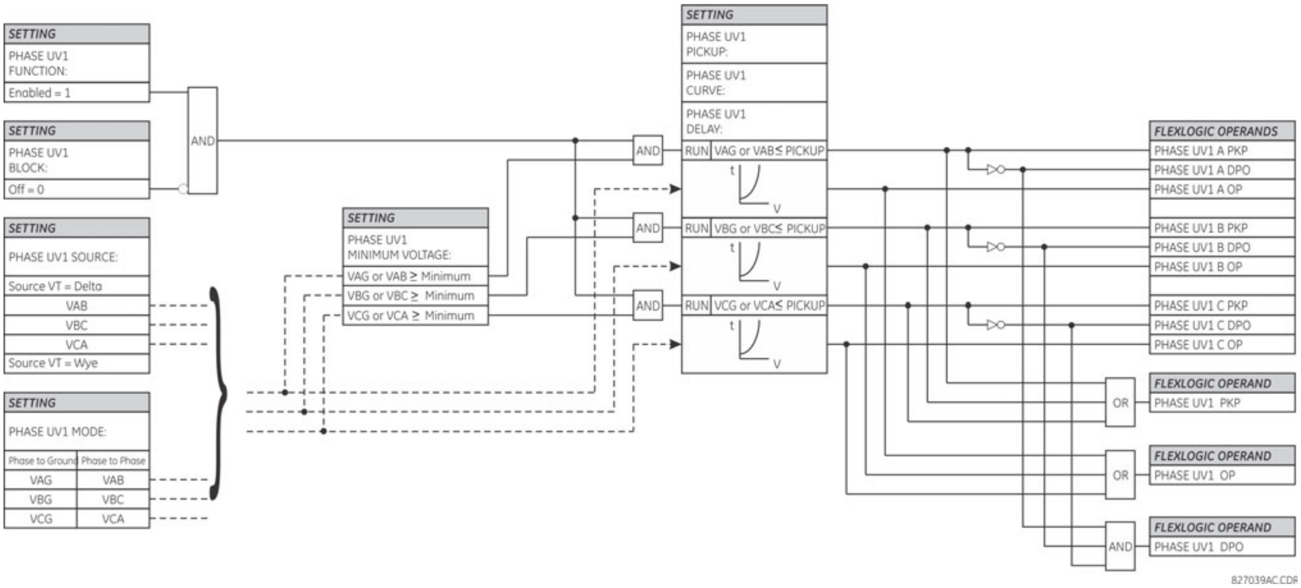


Figure 5–83: PHASE UNDERVOLTAGE1 SCHEME LOGIC

c) PHASE OVERVOLTAGE (ANSI 59P, IEC PTOV)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ PHASE OVERVOLTAGE1

■ PHASE ■ OVERVOLTAGE1		PHASE OV1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE		PHASE OV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE		PHASE OV1 PICKUP: 1.000 pu	Range: 0.000 to 3.000 pu in steps of 0.001
MESSAGE		PHASE OV1 PICKUP DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE		PHASE OV1 RESET DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE		PHASE OV1 BLOCK: Off	Range: FlexLogic Operand
MESSAGE		PHASE OV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE		PHASE OV1 EVENTS: Disabled	Range: Disabled, Enabled

The phase overvoltage element may be 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 specific voltages to be used for each phase are shown below.

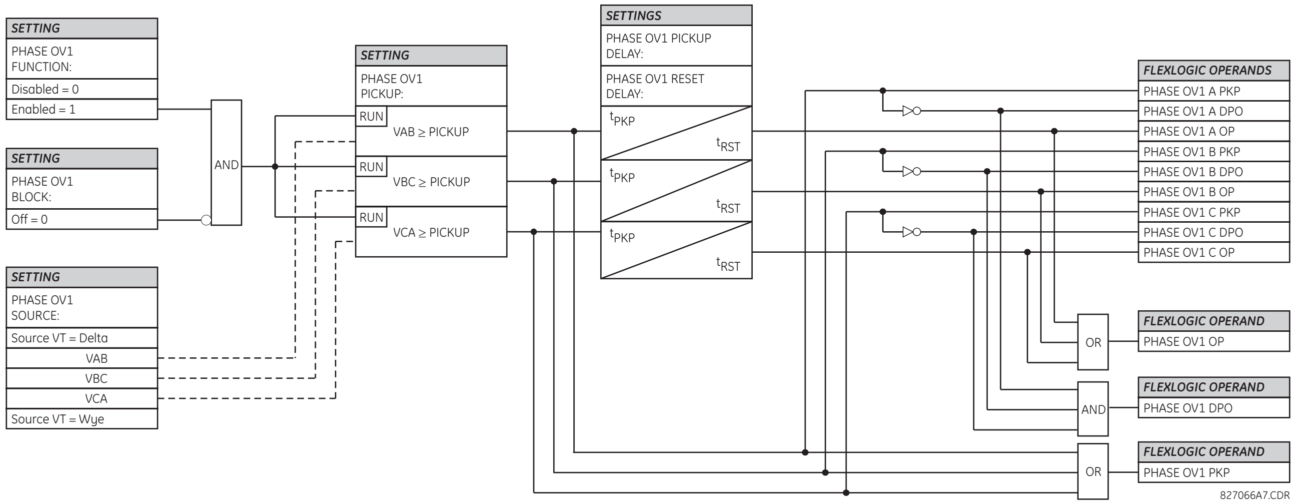


Figure 5–84: PHASE OVERVOLTAGE SCHEME LOGIC

NOTE

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}.

d) NEGATIVE SEQUENCE OVERVOLTAGE (ANSI 59Q, IEC PTOV)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ NEG SEQ OV1(3)

■ NEG SEQ OV1 ■	NEG SEQ OV1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	NEG SEQ OV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	NEG SEQ OV1 PICKUP: 0.300 pu	Range: 0.000 to 1.250 pu in steps of 0.001
MESSAGE	NEG SEQ OV1 PICKUP DELAY: 0.50 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NEG SEQ OV1 RESET DELAY: 0.50 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NEG SEQ OV1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	NEG SEQ OV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	NEG SEQ OV1 EVENTS: Disabled	Range: Disabled, Enabled

There are three negative-sequence overvoltage elements available.

The negative-sequence overvoltage element may be used to detect loss of one or two phases of the source, a reversed phase sequence of voltage, or a non-symmetrical system voltage condition.

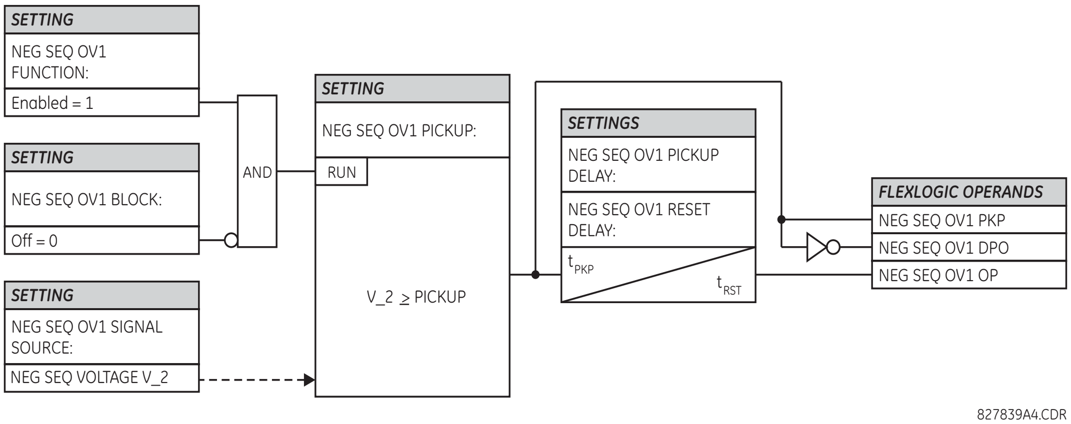


Figure 5–85: NEGATIVE-SEQUENCE OVERVOLTAGE SCHEME LOGIC

e) AUXILIARY UNDERVOLTAGE (ANSI 27X, IEC PTUV)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ AUXILIARY UV1

		Setting	Range
■ AUXILIARY UV1 ■		AUX UV1 FUNCTION: Disabled	Range: Disabled, Enabled
	MESSAGE	AUX UV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	MESSAGE	AUX UV1 PICKUP: 0.700 pu	Range: 0.000 to 3.000 pu in steps of 0.001
	MESSAGE	AUX UV1 CURVE: Definite Time	Range: Definite Time, Inverse Time
	MESSAGE	AUX UV1 DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	MESSAGE	AUX UV1 MINIMUM: VOLTAGE: 0.100 pu	Range: 0.000 to 3.000 pu in steps of 0.001
	MESSAGE	AUX UV1 BLOCK: Off	Range: FlexLogic operand
	MESSAGE	AUX UV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	MESSAGE	AUX UV1 EVENTS: Disabled	Range: Disabled, Enabled

The L30 contains one auxiliary undervoltage element for each VT bank. This element is intended for monitoring 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.

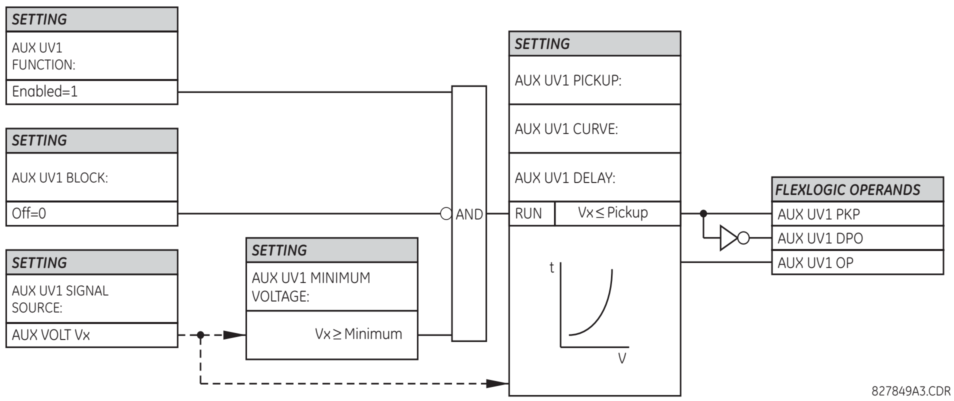


Figure 5–86: AUXILIARY UNDERVOLTAGE SCHEME LOGIC

f) AUXILIARY OVERVOLTAGE (ANSI 59X, IEC PTOV)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ AUXILIARY OV1

■ AUXILIARY OV1 ■	AUX OV1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	AUX OV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	AUX OV1 PICKUP: 0.300 pu	Range: 0.000 to 3.000 pu in steps of 0.001
MESSAGE	AUX OV1 PICKUP DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	AUX OV1 RESET DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	AUX OV1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	AUX OV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	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.

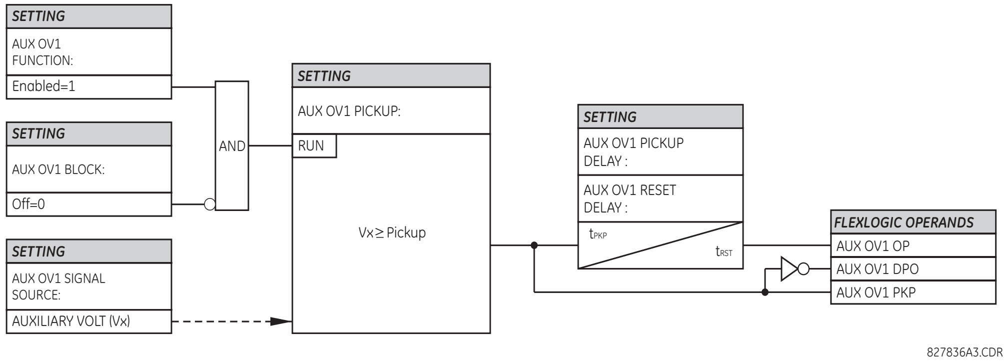


Figure 5–87: AUXILIARY OVERVOLTAGE SCHEME LOGIC

5

5.6.10 SUPERVISING ELEMENTS

a) MAIN MENU

PATH: SETTINGS ⇩ GROUPED ELEMENTS ⇨⇩ SETTING GROUP 1(6) ⇨⇩ SUPERVISING ELEMENTS

■ SUPERVISING ■ ELEMENTS	◀▶	■ DISTURBANCE ■ DETECTOR	See page 5-193.

b) DISTURBANCE DETECTOR

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨⇩ SETTING GROUP 1(6) ⇨⇩ SUPERVISING ELEMENTS ⇨ DISTURBANCE DETECTOR

■ DISTURBANCE ■ DETECTOR	◀▶	DD FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	DD NON-CURRENT SUPV: Off	Range: FlexLogic operand
MESSAGE	▲▼	DD CONTROL LOGIC: Off	Range: FlexLogic operand
MESSAGE	▲▼	DD LOGIC SEAL-IN: Off	Range: FlexLogic operand
MESSAGE	▲	DD EVENTS: Disabled	Range: Disabled, Enabled

The disturbance detector (50DD) element is an 87L-dedicated sensitive current disturbance detector that is used to detect any disturbance on the protected system. This detector 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.

If the disturbance detector is used to supervise the operation of the 87L function, it is recommended that the 87L trip element be used. The 50DD SV disturbance detector FlexLogic operand must then be assigned to an **87L TRIP SUPV** setting.

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 (ΔI_2), the change in zero-sequence current (ΔI_0), and the change in positive-sequence current (ΔI_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.

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 8 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 in range from 0.24 to 0.12 pu, the lower level is set every 8 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 delta level detectors (ΔI) detectors are designed to pickup for the 0.04 pu change in I_1, I_2, and I_0 currents. The ΔI value is measured by comparing the present value to the value calculated 4 cycles earlier.

- **DD FUNCTION:** This setting is used to enable/disable the operation of the disturbance detector.
- **DD NON-CURRENT SUPV**: This setting is used to select a FlexLogic operand which will activate the output of the disturbance detector upon events (such as frequency or voltage change) not accompanied by a current change.
- **DD CONTROL LOGIC**: This setting is used to prevent operation of I_0 and I_2 logic of disturbance detector during conditions such as single breaker pole being open which leads to unbalanced load current in single-pole tripping schemes. Breaker auxiliary contact can be used for such scheme.

- **DD LOGIC SEAL-IN**: This setting is used to maintain disturbance detector output for such conditions as balanced three-phase fault, low level time overcurrent fault, etc. whenever the disturbance detector might reset. Output of the disturbance detector will be maintained until the chosen FlexLogic operand resets.

NOTE

The user may disable the **DD EVENTS** setting as the disturbance detector element will respond to any current disturbance on the system which may result in filling the events buffer and possible loss of valuable data.

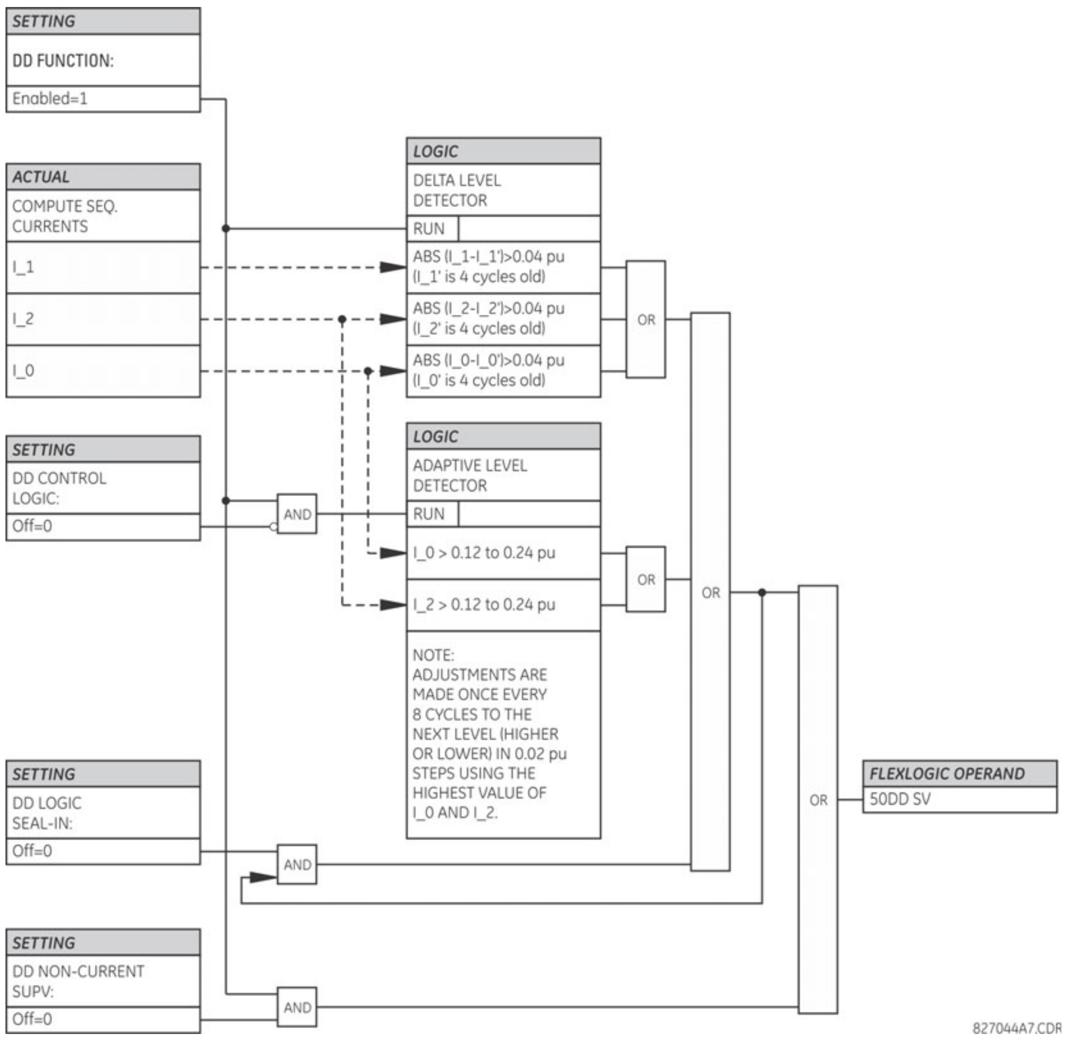


Figure 5–88: DISTURBANCE DETECTOR SCHEME LOGIC

5.7.1 OVERVIEW

Control elements are generally used for control rather than protection. See the *Introduction to Elements* section at the beginning of this chapter for further information.

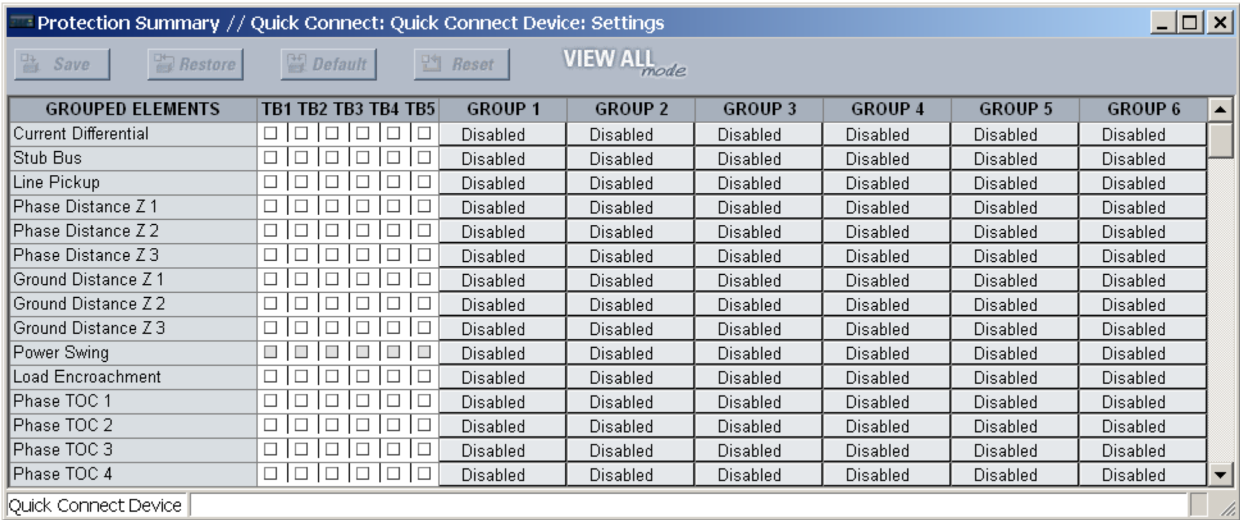
5.7.2 TRIP BUS

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ TRIP BUS ⇨⇩ TRIP BUS 1(6)

■ TRIP BUS 1 ■	TRIP BUS 1 FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE	TRIP BUS 1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	TRIP BUS 1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	TRIP BUS 1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	TRIP BUS 1 INPUT 1: Off	Range: FlexLogic operand
MESSAGE	TRIP BUS 1 INPUT 2: Off	Range: FlexLogic operand
	↓	
MESSAGE	TRIP BUS 1 INPUT 16: Off	Range: FlexLogic operand
MESSAGE	TRIP BUS 1 LATCHING: Disabled	Range: Enabled, Disabled
MESSAGE	TRIP BUS 1 RESET: Off	Range: FlexLogic operand
MESSAGE	TRIP BUS 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	TRIP BUS 1 EVENTS: Disabled	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 UR Setup software A protection summary is displayed by navigating to a specific protection or control protection element and checking the desired bus box. Once the desired 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 may be assigned directly from the trip bus menu.



GROUPED ELEMENTS	TB1	TB2	TB3	TB4	TB5	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6
Current Differential						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Stub Bus						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Line Pickup						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase Distance Z 1						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase Distance Z 2						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase Distance Z 3						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Ground Distance Z 1						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Ground Distance Z 2						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Ground Distance Z 3						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Power Swing						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Load Encroachment						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 1						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 2						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 3						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 4						Disabled	Disabled	Disabled	Disabled	Disabled	Disabled

Figure 5–89: TRIP BUS FIELDS IN THE PROTECTION SUMMARY

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. The time delay should be set 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 the front panel interface or via communications will reset the trip bus output.

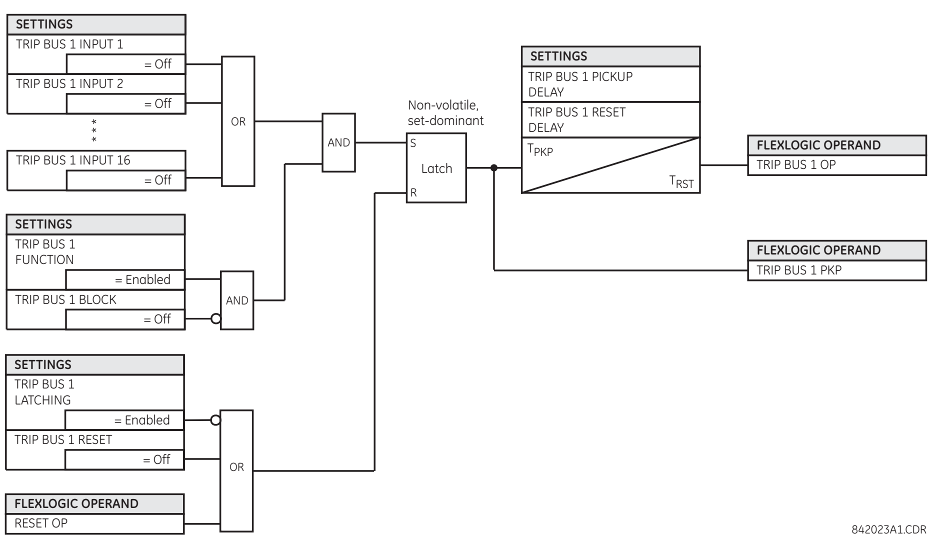


Figure 5–90: TRIP BUS LOGIC

5.7.3 SETTING GROUPS

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨ SETTINGS GROUPS

■ SETTING GROUPS ■	SETTING GROUPS FUNCTION: Enabled	*Range: Disabled, Enabled*
MESSAGE	SETTING GROUPS BLK: Off	*Range: FlexLogic operand*
MESSAGE	GROUP 2 ACTIVATE ON: Off	*Range: FlexLogic operand*
MESSAGE	GROUP 3 ACTIVATE ON: Off	*Range: FlexLogic operand*
	↓	
MESSAGE	GROUP 6 ACTIVATE ON: Off	*Range: FlexLogic operand*
MESSAGE	GROUP 1 NAME:	*Range: up to 16 alphanumeric characters*
MESSAGE	GROUP 2 NAME:	*Range: up to 16 alphanumeric characters*
	↓	
MESSAGE	GROUP 6 NAME:	*Range: up to 16 alphanumeric characters*
MESSAGE	SETTING GROUP EVENTS: Disabled	*Range: Disabled, Enabled*

The 61850 standard provides for the ability to monitor, edit, and change setting groups in a relay through a series of services operating on Setting Group Control Block values. There is one SGCB in LLN0 in LD1 in the UR as, at present, the other LDs do not support multiple setting groups The default value of **SETTING GROUPS** is Disabled. In order for 61850 and/or UR setting group control to function, the **SETTING GROUPS FUNCTION** must be set to Enabled.

The active setting group in the UR is settable from either the value set via a FlexLogic operand in the UR (present practice) or a SelectActiveSG command from a 61850 Client. For both the UR and IEC 61850, the default active setting group is "1".

A 61850 SelectActiveSG command sets one of the internal Non-Volatile flags (61850 SG Level x) that represents the requested Active Setting Group shown as follows:

Table 5–28: ACTIVE SETTING GROUP

SELECTACTIVESG VALUE	FLAG SET
1 (default)	SG Level 1
2	SG Level 2
3	SG Level 3
4	SG Level 4
5	SG Level 4
6	SG Level 6

On power-up or restart, the previously selected 61850 SG Level x is re-instated. Similarly, the input to the setting group control in the UR can be designed with Non-Volatile latches to achieve the same effect.

The setting groups menu controls the activation and deactivation of up to six possible groups of settings in the **GROUPED ELEMENTS** settings menu. The faceplate Settings In Use LEDs indicate which active group (with a non-flashing energized LED) is in service.

The **SETTING GROUPS BLK** setting prevents the active setting group from changing when the FlexLogic parameter is set to "On". This can be useful in applications where it is undesirable to change the settings under certain conditions, such as the breaker being open.

The **GROUP 2 ACTIVATE ON** to **GROUP 6 ACTIVATE ON** settings select 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.

The **SETTING GROUP 1 NAME** to **SETTING GROUP 6 NAME** settings 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.

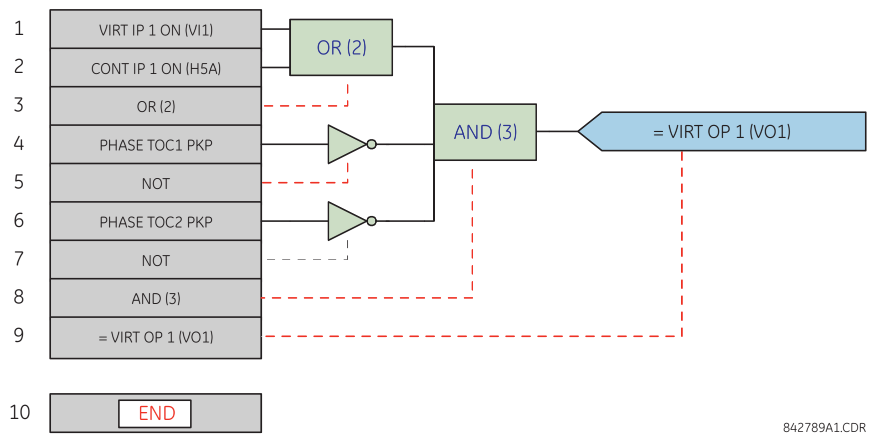


Figure 5–91: EXAMPLE FLEXLOGIC CONTROL OF A SETTINGS GROUP

5.7.4 SELECTOR SWITCH

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ SELECTOR SWITCH ⇨ SELECTOR SWITCH 1(2)

■ SELECTOR SWITCH 1 ■		SELECTOR 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE		SELECTOR 1 FULL RANGE: 7	Range: 1 to 7 in steps of 1
MESSAGE		SELECTOR 1 TIME-OUT: 5.0 s	Range: 3.0 to 60.0 s in steps of 0.1
MESSAGE		SELECTOR 1 STEP-UP: Off	Range: FlexLogic operand
MESSAGE		SELECTOR 1 STEP-UP MODE: Time-out	Range: Time-out, Acknowledge
MESSAGE		SELECTOR 1 ACK: Off	Range: FlexLogic operand
MESSAGE		SELECTOR 1 3BIT A0: Off	Range: FlexLogic operand
MESSAGE		SELECTOR 1 3BIT A1: Off	Range: FlexLogic operand
MESSAGE		SELECTOR 1 3BIT A2: Off	Range: FlexLogic operand
MESSAGE		SELECTOR 1 3BIT MODE: Time-out	Range: Time-out, Acknowledge
MESSAGE		SELECTOR 1 3BIT ACK: Off	Range: FlexLogic operand
MESSAGE		SELECTOR 1 POWER-UP MODE: Restore	Range: Restore, Synchronize, Sync/Restore
MESSAGE		SELECTOR 1 TARGETS: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE		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.

- **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 3 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 will not take place and an alarm will be 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 will change 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 will change 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 3 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 3 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" 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 will attempt 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.

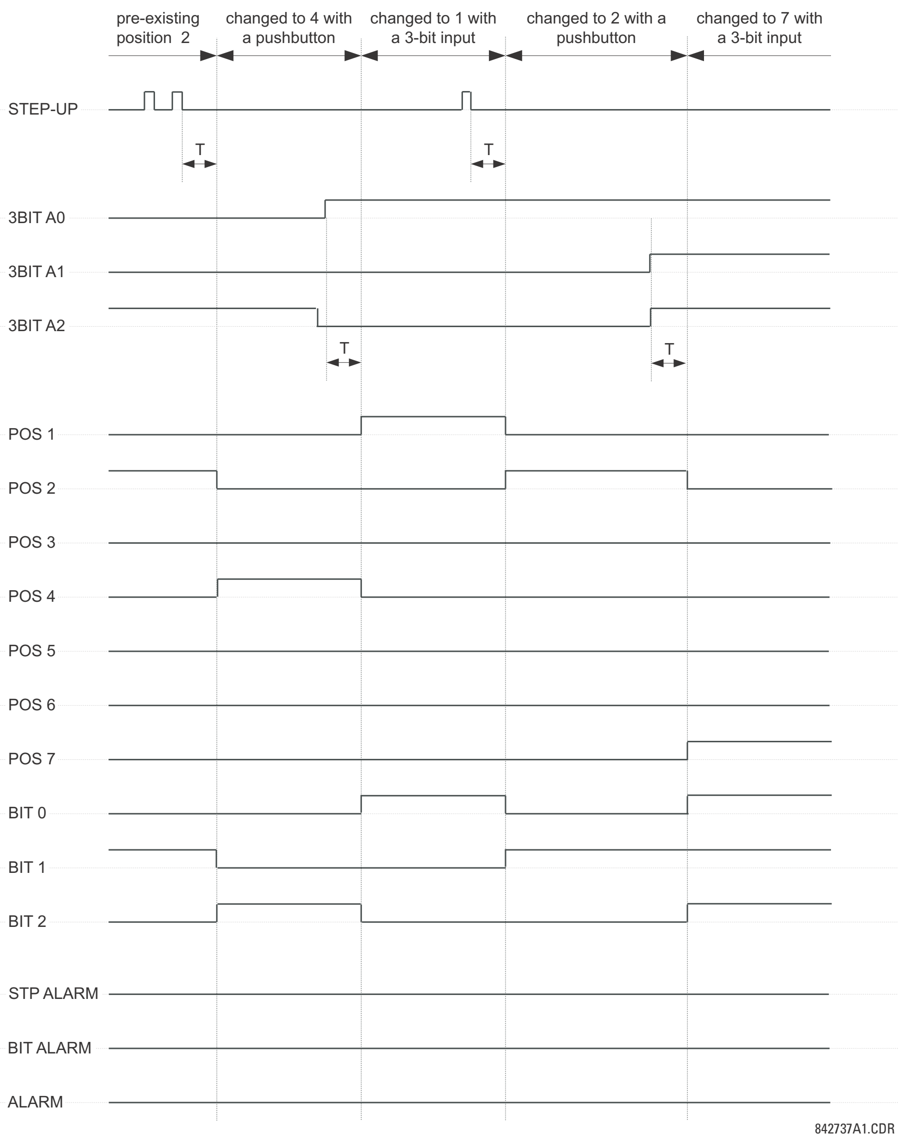


Figure 5–92: TIME-OUT MODE

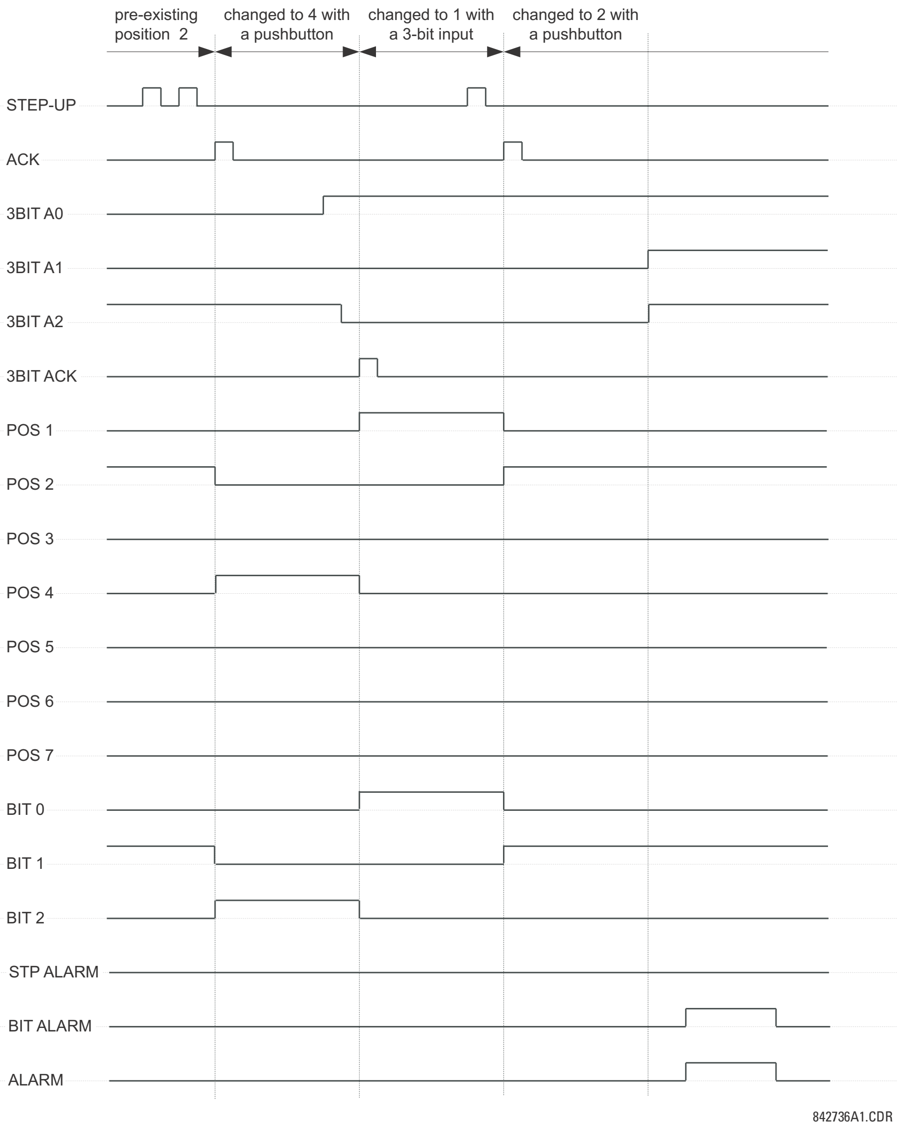


Figure 5–93: ACKNOWLEDGE MODE

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 shall 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 shall be applied automatically after 5 seconds of inactivity of the control inputs. When the relay powers up, it should 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 logic for the selector switch is shown below:

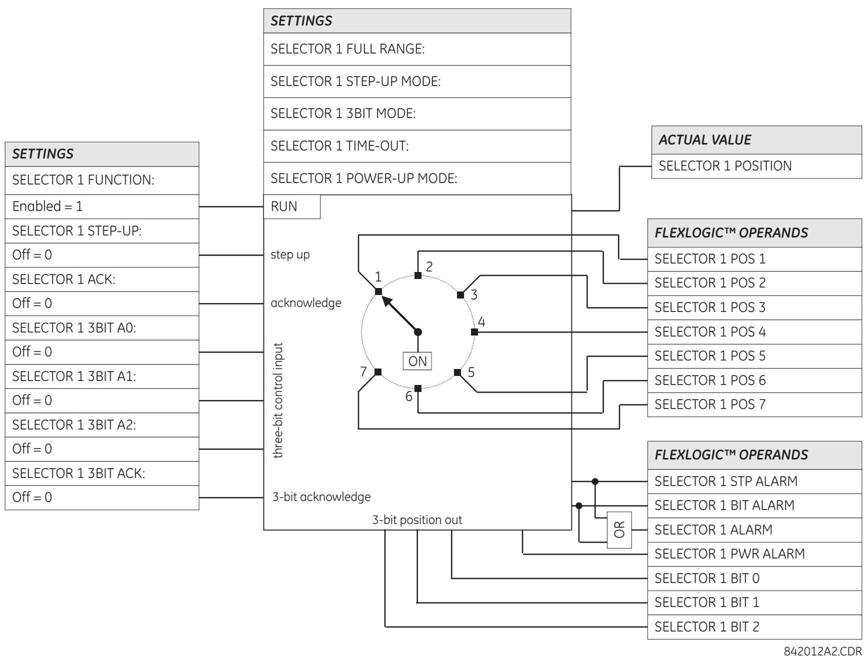


Figure 5–94: SELECTOR SWITCH LOGIC

5.7.5 UNDERFREQUENCY

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ UNDERFREQUENCY ⇨ UNDERFREQUENCY 1(6)

	Display	Range
■ UNDERFREQUENCY 1 ■	UNDFREQ 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	UNDERFREQ 1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	UNDERFREQ 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	UNDERFREQ 1 MIN VOLT/AMP: 0.10 pu	Range: 0.10 to 1.25 pu in steps of 0.01
MESSAGE	UNDERFREQ 1 PICKUP: 59.50 Hz	Range: 20.00 to 65.00 Hz in steps of 0.01
MESSAGE	UNDERFREQ 1 PICKUP DELAY: 2.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	UNDERFREQ 1 RESET DELAY : 2.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	UNDERFREQ 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	UNDERFREQ 1 EVENTS: Disabled	Range: Disabled, Enabled

There are six identical underfrequency elements, numbered from 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 will be a reduction in frequency. If the control systems of the system generators do not respond fast enough, the system may 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 may be automatically or manually restored.

The **UNDERFREQ 1 SOURCE** 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 will not operate, as it will not measure a parameter below the minimum voltage/current setting.

The **UNDERFREQ 1 MIN VOLT/AMP** setting 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.

This **UNDERFREQ 1 PICKUP** setting is used to select 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 will be 59.50 Hz.

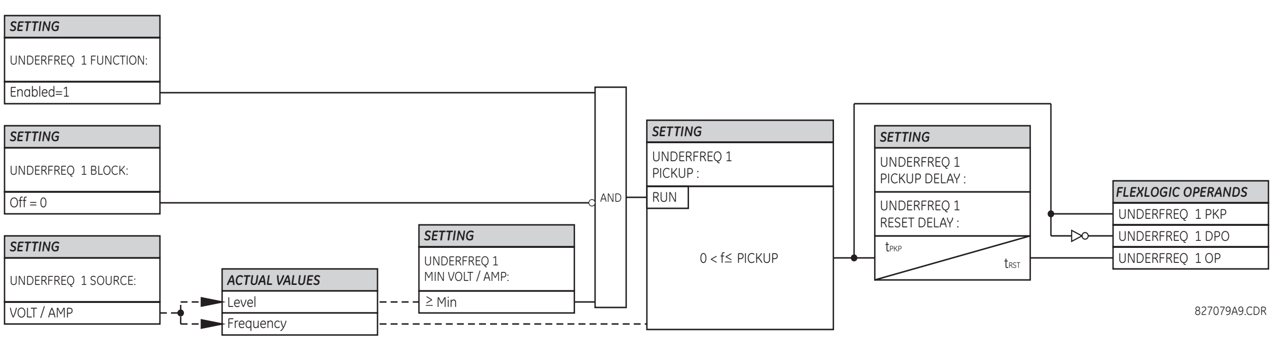


Figure 5–95: UNDERFREQUENCY SCHEME LOGIC

5.7.6 SYNCHROCHECK

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ SYNCHROCHECK ⇨ SYNCHROCHECK 1(4)

■ SYNCHROCHECK 1 ■		SYNCHK1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE		SYNCHK1 BLOCK: Off	Range: FlexLogic operand
MESSAGE		SYNCHK1 V1 SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE		SYNCHK1 V2 SOURCE: SRC 2	Range: SRC 1, SRC 2
MESSAGE		SYNCHK1 MAX VOLT DIFF: 10000 V	Range: 0 to 400000 V in steps of 1
MESSAGE		SYNCHK1 MAX ANGLE DIFF: 30°	Range: 0 to 100° in steps of 1
MESSAGE		SYNCHK1 MAX FREQ DIFF: 1.00 Hz	Range: 0.00 to 2.00 Hz in steps of 0.01
MESSAGE		SYNCHK1 MAX FREQ HYSTERESIS: 0.06 Hz	Range: 0.00 to 0.10 Hz in steps of 0.01
MESSAGE		SYNCHK1 DEAD SOURCE SELECT: LV1 and DV2	Range: None, LV1 and DV2, DV1 and LV2, DV1 or DV2, DV1 Xor DV2, DV1 and DV2
MESSAGE		SYNCHK1 DEAD V1 MAX VOLT: 0.30 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE		SYNCHK1 DEAD V2 MAX VOLT: 0.30 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE		SYNCHK1 LIVE V1 MIN VOLT: 0.70 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE		SYNCHK1 LIVE V2 MIN VOLT: 0.70 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE		SYNCHK1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE		SYNCHK1 EVENTS: Disabled	Range: Disabled, Enabled

There are four identical synchrocheck elements available, numbered 1 to 4.

The synchronism check function is intended for supervising the paralleling of two parts of a system which 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 would take 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 can be calculated by:

$$T = \frac{1}{\frac{360°}{2 \times \Delta\Phi} \times \Delta F} \qquad \textbf{(EQ 5.22)}$$

where: $\Delta\Phi$ = phase angle difference in degrees; ΔF = 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 by-pass the synchrocheck measurements (dead source function).

- **SYNCHK1 V1 SOURCE**: This setting selects the source for voltage V1 (see NOTES below).
- **SYNCHK1 V2 SOURCE**: This setting selects the source for voltage V2, which must not be the same as used for the V1 (see NOTES below).
- **SYNCHK1 MAX VOLT DIFF**: This setting 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:** This setting 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 DIFF:** This setting selects the maximum frequency difference in 'Hz' between the two sources. A frequency difference between the two input voltage systems below this value is within the permissible limit for synchronism.
- **SYNCHK1 MAX FREQ HYSTERESIS**: This setting 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 DEAD SOURCE SELECT:** This setting selects the combination of dead and live sources that will by-pass 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:** This setting establishes a maximum voltage magnitude for V1 in 1 'pu'. Below this magnitude, the V1 voltage input used for synchrocheck will be considered "Dead" or de-energized.
- **SYNCHK1 DEAD V2 MAX VOLT**: This setting establishes a maximum voltage magnitude for V2 in 'pu'. Below this magnitude, the V2 voltage input used for synchrocheck will be considered "Dead" or de-energized.
- **SYNCHK1 LIVE V1 MIN VOLT**: This setting establishes a minimum voltage magnitude for V1 in 'pu'. Above this magnitude, the V1 voltage input used for synchrocheck will be 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 will be 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) may include both a three-phase and an auxiliary voltage. The relay will automatically select the specific voltages to be used by the synchrocheck element in accordance with the following table.

NO.	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

NO.	V1 OR V2 (SOURCE Y)	V2 OR V1 (SOURCE Z)	AUTO-SELECTED COMBINATION		AUTO-SELECTED VOLTAGE
			SOURCE Y	SOURCE Z	
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 will be matched automatically so that the corresponding voltages from the two sources will be used to measure conditions. A phase to phase voltage will be used if available in both sources; if one or both of the Sources have only an auxiliary voltage, this voltage will be used. For example, if an auxiliary voltage is programmed to VAG, the synchrocheck element will automatically select 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.

NOTE

Exception: 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 will use the phase channel of a three-phase set of voltages if programmed as part of that source. The relay will use the auxiliary voltage channel only if that channel is programmed as part of the Source and a three-phase set is not.

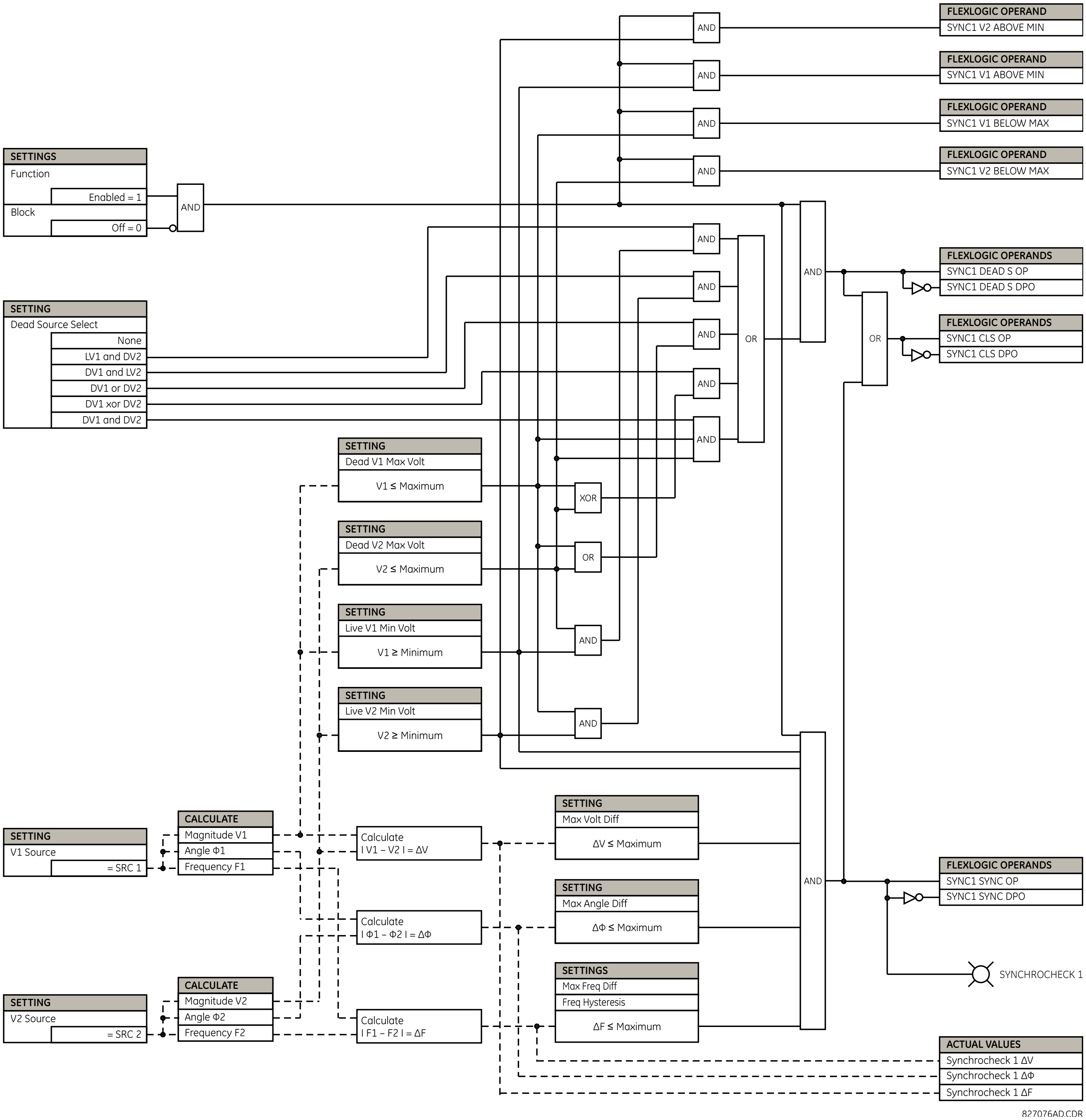


Figure 5–96: SYNCHROCHECK SCHEME LOGIC

5.7.7 AUTORECLOSE

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ AUTORECLOSE ⇨ AUTORECLOSE 1

	Display	Range
■ AUTORECLOSE 1 ■	AR1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	AR1 INITIATE: Off	Range: FlexLogic operand
MESSAGE	AR1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	AR1 MAX NUMBER OF SHOTS: 1	Range: 1, 2, 3, 4
MESSAGE	AR1 REDUCE MAX TO 1: Off	Range: FlexLogic operand
MESSAGE	AR1 REDUCE MAX TO 2: Off	Range: FlexLogic operand
MESSAGE	AR1 REDUCE MAX TO 3: Off	Range: FlexLogic operand
MESSAGE	AR1 MANUAL CLOSE: Off	Range: FlexLogic operand
MESSAGE	AR1 MNL RST FRM LO: Off	Range: FlexLogic operand
MESSAGE	AR1 RESET LOCKOUT IF BREAKER CLOSED: Off	Range: Off, On
MESSAGE	AR1 RESET LOCKOUT ON MANUAL CLOSE: Off	Range: Off, On
MESSAGE	AR1 BKR CLOSED: Off	Range: FlexLogic operand
MESSAGE	AR1 BKR OPEN: Off	Range: FlexLogic operand
MESSAGE	AR1 BLK TIME UPON MNL CLS: 10.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	AR1 DEAD TIME 1: 1.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	AR1 DEAD TIME 2: 2.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	AR1 DEAD TIME 3: 3.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	AR1 DEAD TIME 4: 4.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	AR1 ADD DELAY 1: Off	Range: FlexLogic operand
MESSAGE	AR1 DELAY 1: 0.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	AR1 ADD DELAY 2: Off	Range: FlexLogic operand

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MESSAGE	▲▼	AR1 DELAY 2: 0.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	▲▼	AR1 RESET LOCKOUT DELAY: 60.000	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	▲▼	AR1 RESET TIME: 60.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	▲▼	AR1 INCOMPLETE SEQ TIME: 5.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	▲	AR1 EVENTS: Disabled	Range: Disabled, Enabled

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 so desired, 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 may 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, will not close the breaker again; known as 'Lockout'. The scheme may 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.

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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 will seal-in and the scheme will continue 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 may possibly include AR1 SHOT CNT =n, SETTING GROUP ACT 1, etc. 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, bus differential protection operated, etc.).

- The ‘Incomplete Sequence’ timer times out.

The recloser will be 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.

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 could be from the breaker failure, bus differential protection, etc.).
- **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 autoreclose 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, the next setting (**AR1 RESET LOCKOUT ON MANUAL CLOSE**) should be disabled.
- **AR1 RESET LOCKOUT ON MANUAL CLOSE:** This setting allows the autoreclose 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 autoreclose 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 autoreclose 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, and should be set 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 should stay 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”.

NOTE

This timer must be set to a delay less than the reset timer.

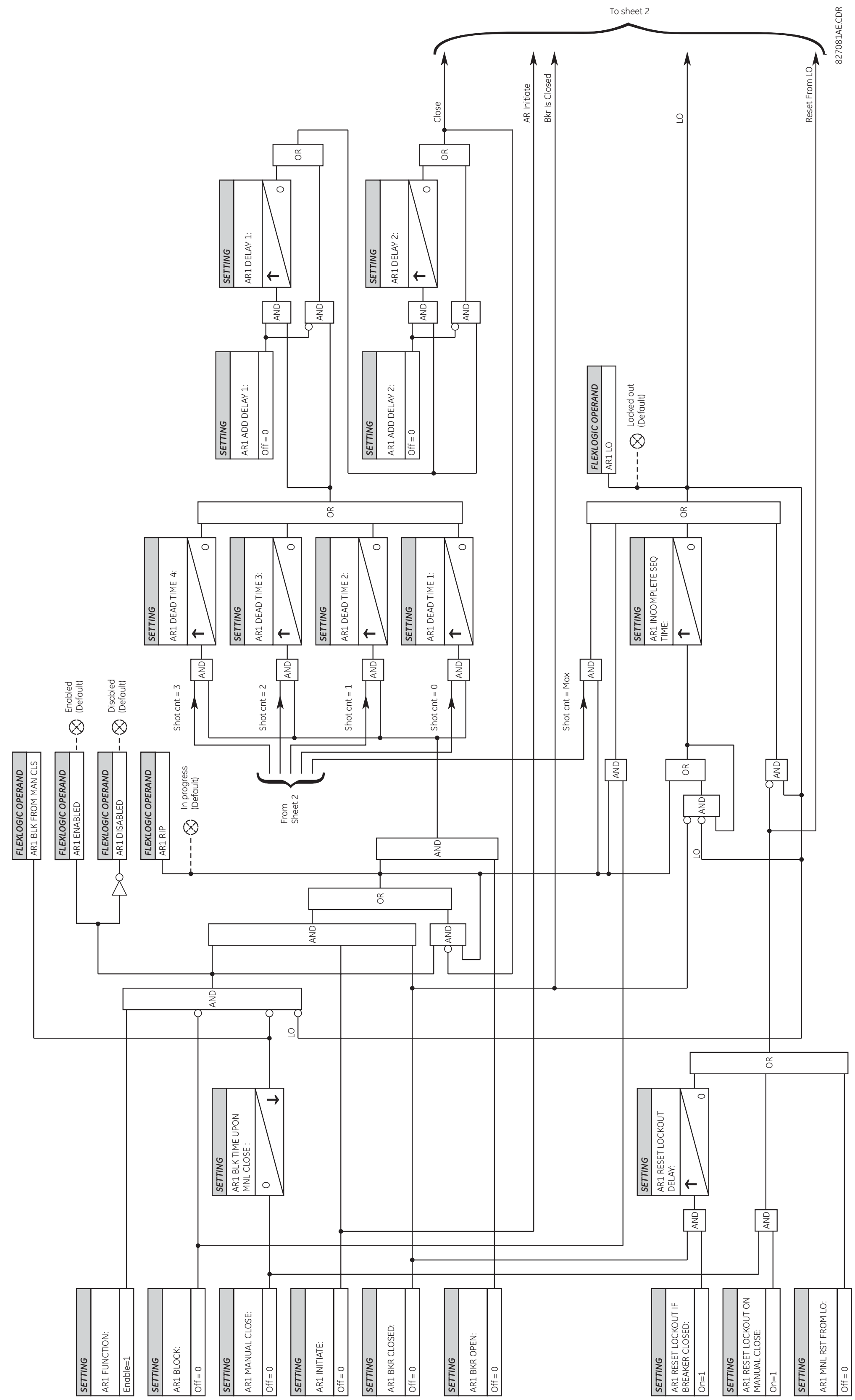

Figure 5–97: AUTORECLOSURE SCHEME LOGIC (Sheet 1 of 2)

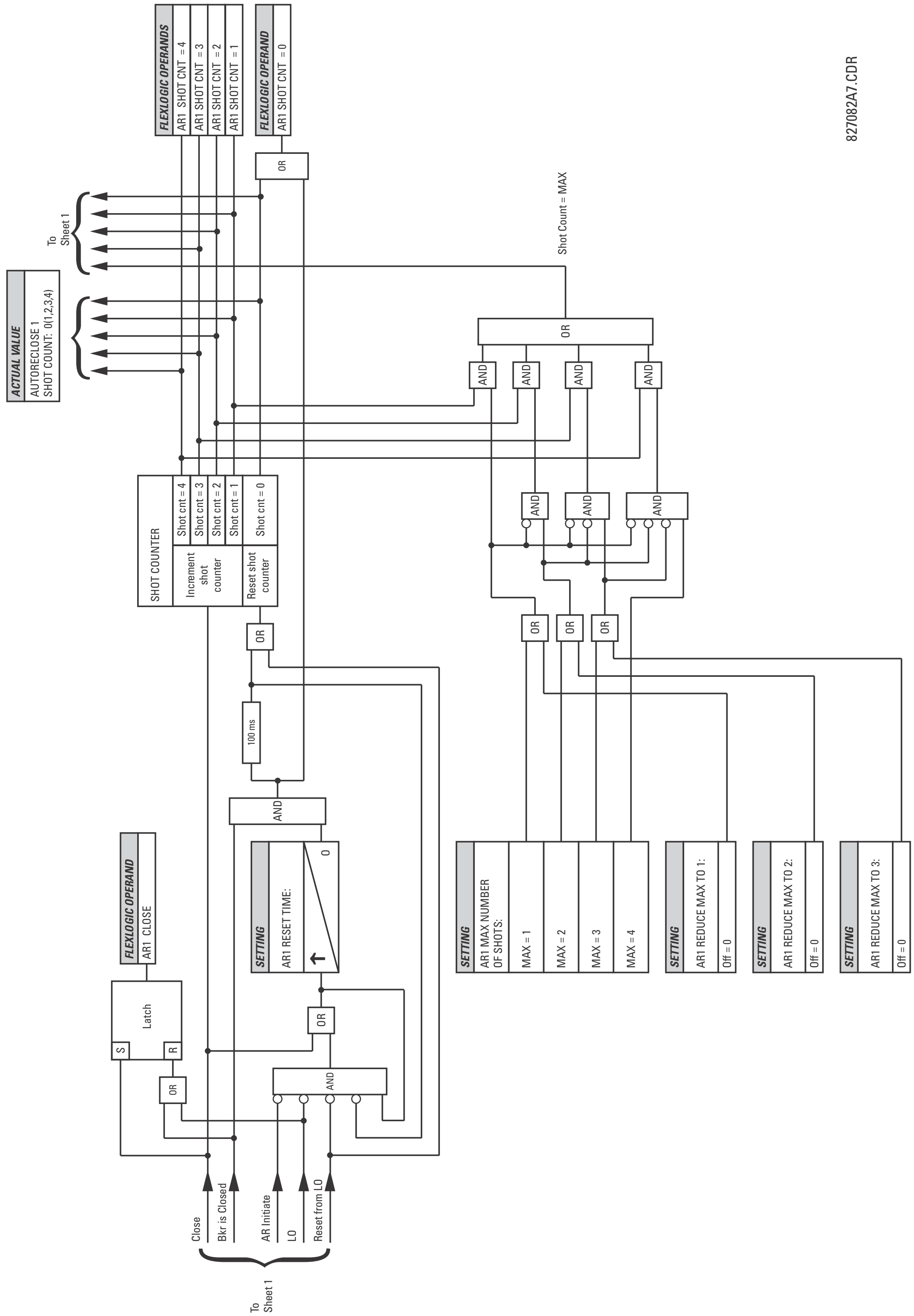

Figure 5–98: AUTORECLOSURE SCHEME LOGIC (Sheet 2 of 2)

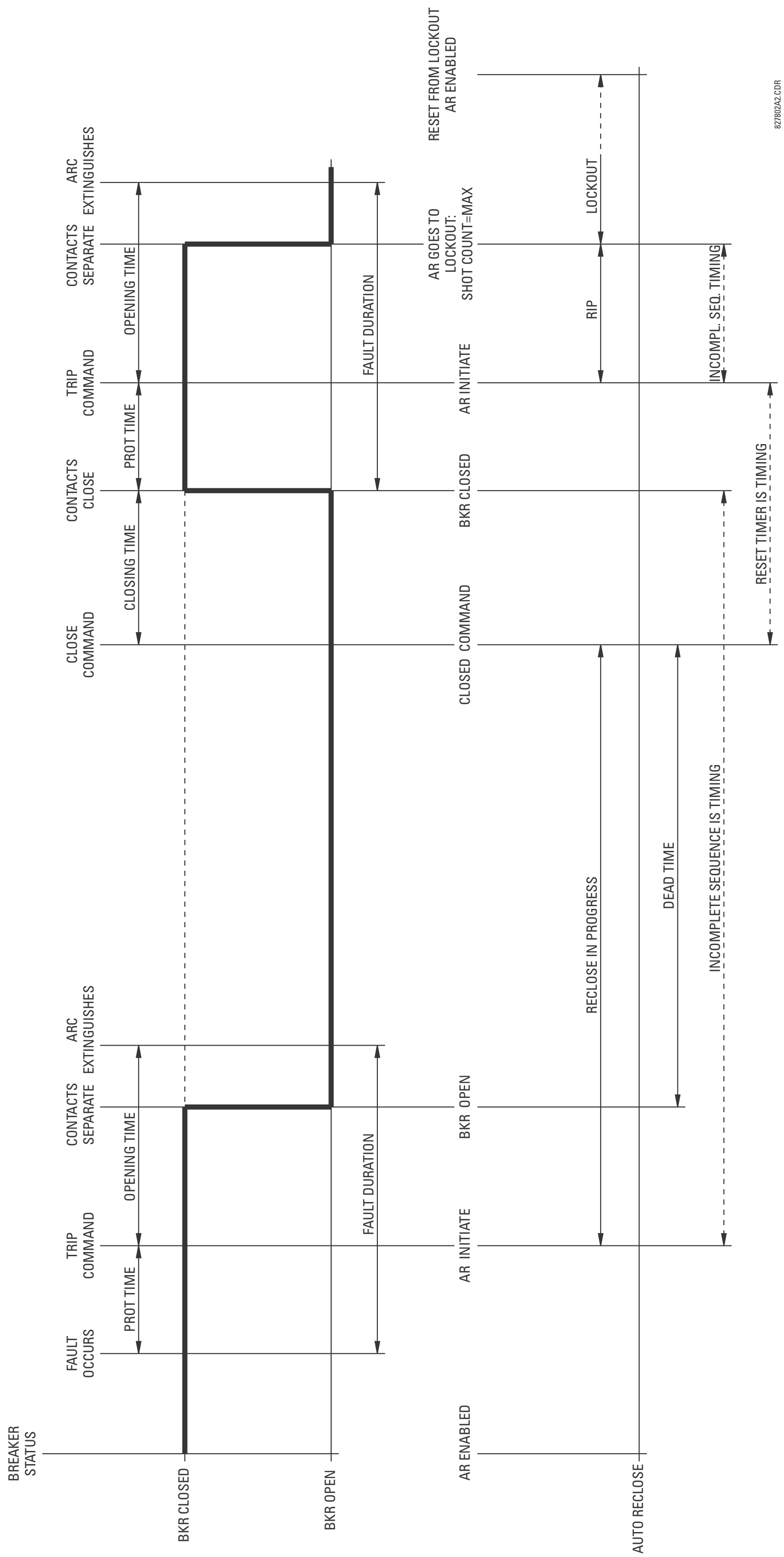

Figure 5–99: SINGLE SHOT AUTORECLOSING SEQUENCE - PERMANENT FAULT

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5.7.8 DIGITAL ELEMENTS

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ DIGITAL ELEMENTS ⇨ DIGITAL ELEMENT 1(48)

■ DIGITAL ELEMENT 1 ■	DIGITAL ELEMENT 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	DIG ELEM 1 NAME: Dig Element 1	Range: 16 alphanumeric characters
MESSAGE	DIG ELEM 1 INPUT: Off	Range: FlexLogic operand
MESSAGE	DIG ELEM 1 PICKUP DELAY: 0.000 s	Range: 0.000 to 999999.999 s in steps of 0.001
MESSAGE	DIG ELEM 1 RESET DELAY: 0.000 s	Range: 0.000 to 999999.999 s in steps of 0.001
MESSAGE	DIG ELEMENT 1 PICKUP LED: Enabled	Range: Disabled, Enabled
MESSAGE	DIG ELEM 1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	DIGITAL ELEMENT 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	DIGITAL ELEMENT 1 EVENTS: Disabled	Range: Disabled, Enabled

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 which will 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 time delay to pickup. If a pickup delay is not required, set to "0".
- **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.

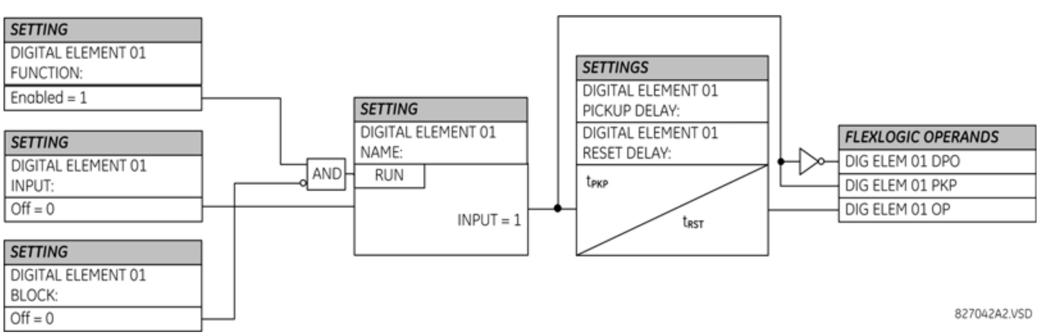


Figure 5–100: DIGITAL ELEMENT SCHEME LOGIC

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 will be 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 will drop below the threshold and the "Cont Op 1 VOff" FlexLogic operand will be 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 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 will fall below the monitor threshold and an alarm would be declared.

In most breaker control circuits, the trip coil is connected in series with a breaker auxiliary contact which is open when the breaker is open (see diagram below). To prevent unwanted alarms in this situation, the trip circuit monitoring logic must include the breaker position.

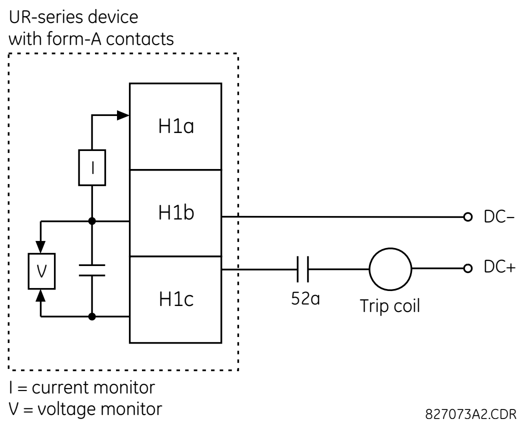
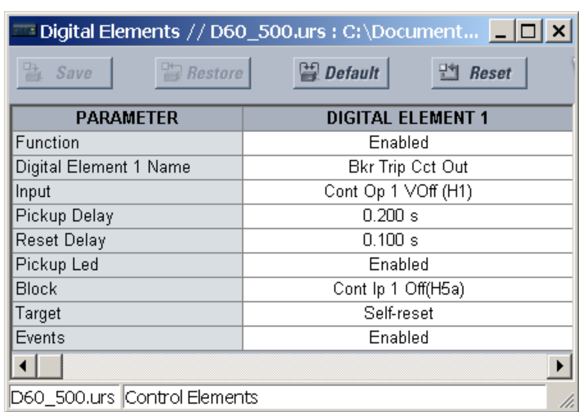


Figure 5–101: TRIP CIRCUIT EXAMPLE 1

Assume the output contact H1 is a trip contact. Using the contact output settings, this output will be 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 will be given an ID name, for example, "Cont Ip 1", and will be set "On" when the breaker is closed. The settings to use digital element 1 to monitor the breaker trip circuit are indicated below (EnerVista UR Setup example shown):



Digital Elements // D60_500.urs : C:\Document...

Save Restore Default Reset

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

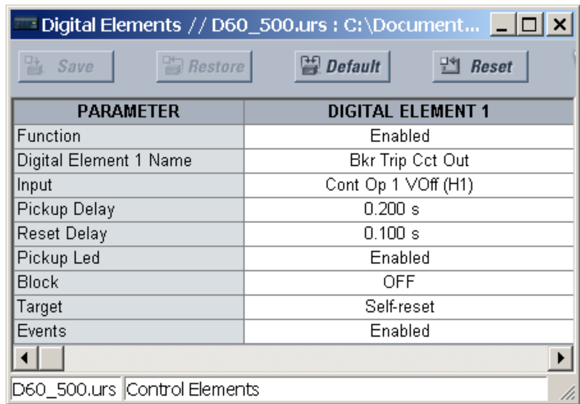
D60_500.urs Control Elements

NOTE

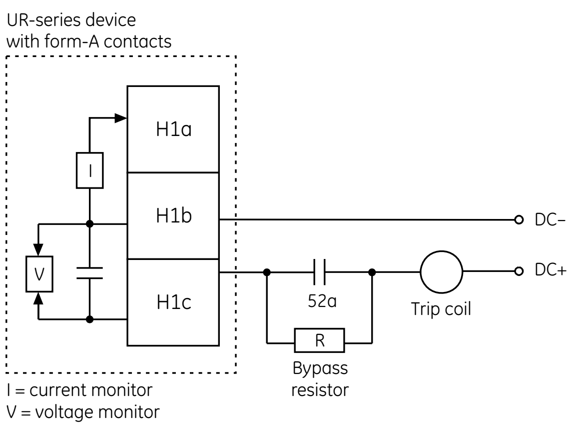
The PICKUP DELAY setting should be greater than the operating time of the breaker to avoid nuisance alarms.

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 figure below). This can be achieved by connecting a suitable resistor (see figure below) 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 UR Setup 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



Values for resistor “R”

Power supply	Resistance	Power
24 V DC	1000 Ω	2 W
30 V DC	5000 Ω	2 W
48 V DC	10000 Ω	2 W
110 V DC	25000 Ω	5 W
125 V DC	25000 Ω	5 W
250 V DC	50000 Ω	5 W

827074A3.CDR

Figure 5–102: TRIP CIRCUIT EXAMPLE 2

NOTE

The wiring connection for two examples above is applicable to both form-A contacts with voltage monitoring and solid-state contact with voltage monitoring.

5.7.9 DIGITAL COUNTERS

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ DIGITAL COUNTERS ⇨ COUNTER 1(8)

	Display	Range
■ COUNTER 1 ■	COUNTER 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	COUNTER 1 NAME: Counter 1	Range: 12 alphanumeric characters
MESSAGE	COUNTER 1 UNITS:	Range: 6 alphanumeric characters
MESSAGE	COUNTER 1 PRESET: 0	Range: –2,147,483,648 to +2,147,483,647
MESSAGE	COUNTER 1 COMPARE: 0	Range: –2,147,483,648 to +2,147,483,647
MESSAGE	COUNTER 1 UP: Off	Range: FlexLogic operand
MESSAGE	COUNTER 1 DOWN: Off	Range: FlexLogic operand
MESSAGE	COUNTER 1 BLOCK: Off	Range: FlexLogic operand
MESSAGE	CNT1 SET TO PRESET: Off	Range: FlexLogic operand
MESSAGE	COUNTER 1 RESET: Off	Range: FlexLogic operand
MESSAGE	COUNT1 FREEZE/RESET: Off	Range: FlexLogic operand
MESSAGE	COUNT1 FREEZE/COUNT: Off	Range: FlexLogic operand

There are 8 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 (e.g. 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 will appear 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 will rollover 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 will rollover to +2,147,483,647.
- **COUNTER 1 BLOCK:** Selects the FlexLogic operand for blocking the counting operation. All counter operands are blocked.

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- **CNT1 SET TO PRESET:** Selects the FlexLogic operand used to set the count to the preset value. The counter will be set to the preset value in the following situations:
  1. 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 will be set to 0).
  2. 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).
  3. 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 will be set 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.

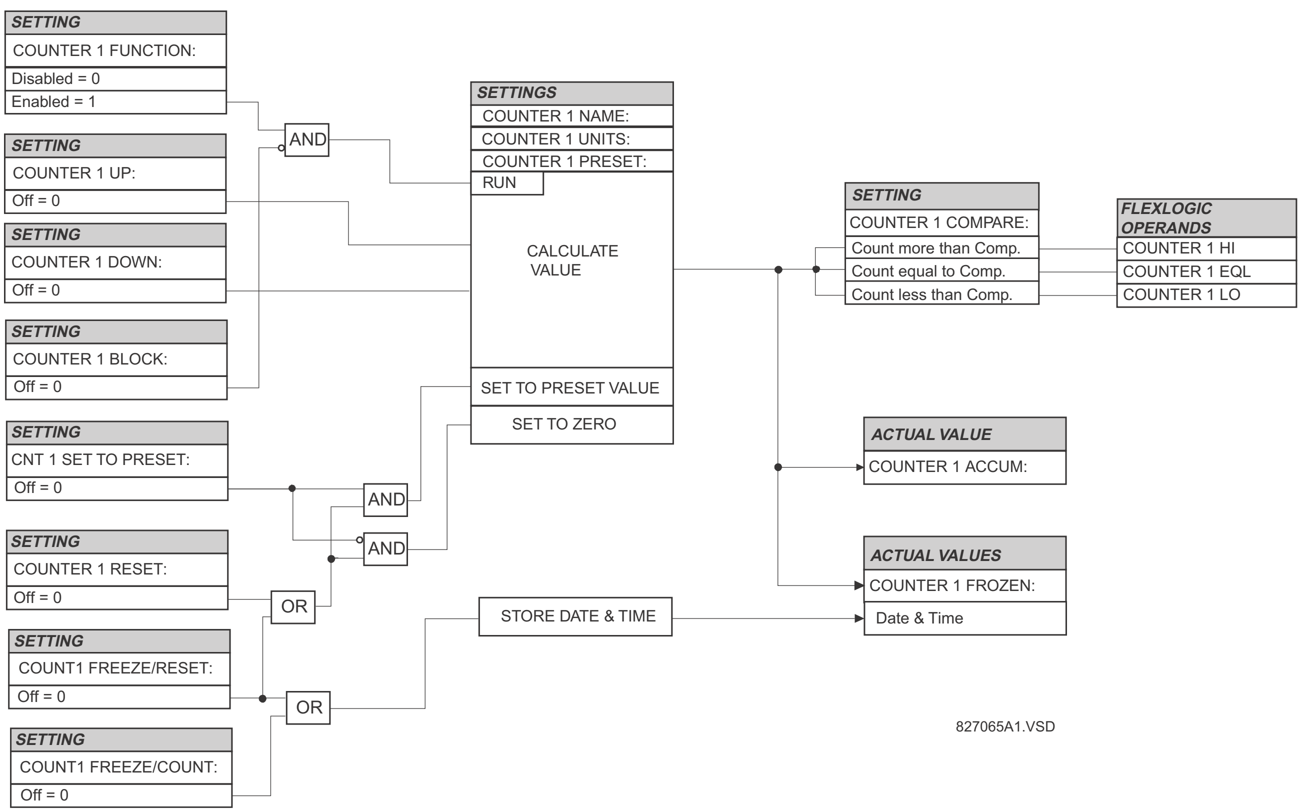

Figure 5–103: DIGITAL COUNTER SCHEME LOGIC

5.7.10 MONITORING ELEMENTS

a) MAIN MENU

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS

■ MONITORING ■ ELEMENTS	◁▷	■ BREAKER 1 ■ ARCING CURRENT	See page 5-221.
MESSAGE	△▽	■ BREAKER 2 ■ ARCING CURRENT	See page 5-221.
MESSAGE	△▽	■ CT FAILURE ■ DETECTOR	See page 5-224.
MESSAGE	△▽	■ VT FUSE FAILURE 1 ■	See page 5-225.
MESSAGE	△▽	■ VT FUSE FAILURE 2 ■	See page 5-225.
MESSAGE	△▽	■ BROKEN CONDUCTOR 1 ■	See page 5-227.
MESSAGE	△▽	■ BROKEN CONDUCTOR 2 ■	See page 5-227.
MESSAGE	△	■ THERMAL OVERLOAD ■ PROTECTION	See page 5-228.

b) BREAKER ARCING CURRENT

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨ BREAKER 1(2) ARCING CURRENT

■ BREAKER 1 ■ ARCING CURRENT	◁▷	BKR 1 ARC AMP FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	BKR 1 ARC AMP SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	△▽	BKR 1 ARC AMP INT-A: Off	Range: FlexLogic operand
MESSAGE	△▽	BKR 1 ARC AMP INT-B: Off	Range: FlexLogic operand
MESSAGE	△▽	BKR 1 ARC AMP INT-C: Off	Range: FlexLogic operand
MESSAGE	△▽	BKR 1 ARC AMP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	△▽	BKR 1 ARC AMP LIMIT: 1000 kA2-cyc	Range: 0 to 50000 kA^2-cycle in steps of 1
MESSAGE	△▽	BKR 1 ARC AMP BLOCK: Off	Range: FlexLogic operand
MESSAGE	△▽	BKR 1 ARC AMP TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	△	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, the interval between change-of-state of the operand (from 0 to 1) and contact separation should be measured 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(4)** 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, the same operand should be configured to initiate arcing current calculations for poles A, B and C of the breaker. In single-pole tripping applications, per-pole tripping operands should be configured 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.

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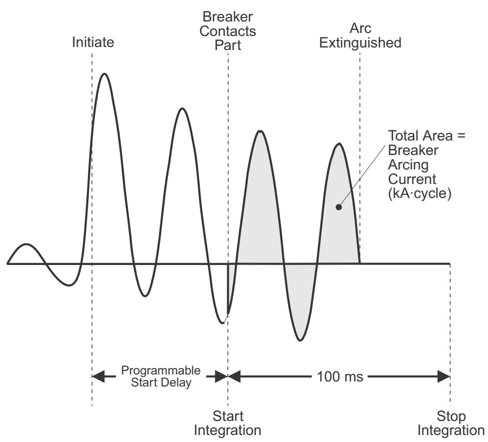

Figure 5–104: ARCING CURRENT MEASUREMENT

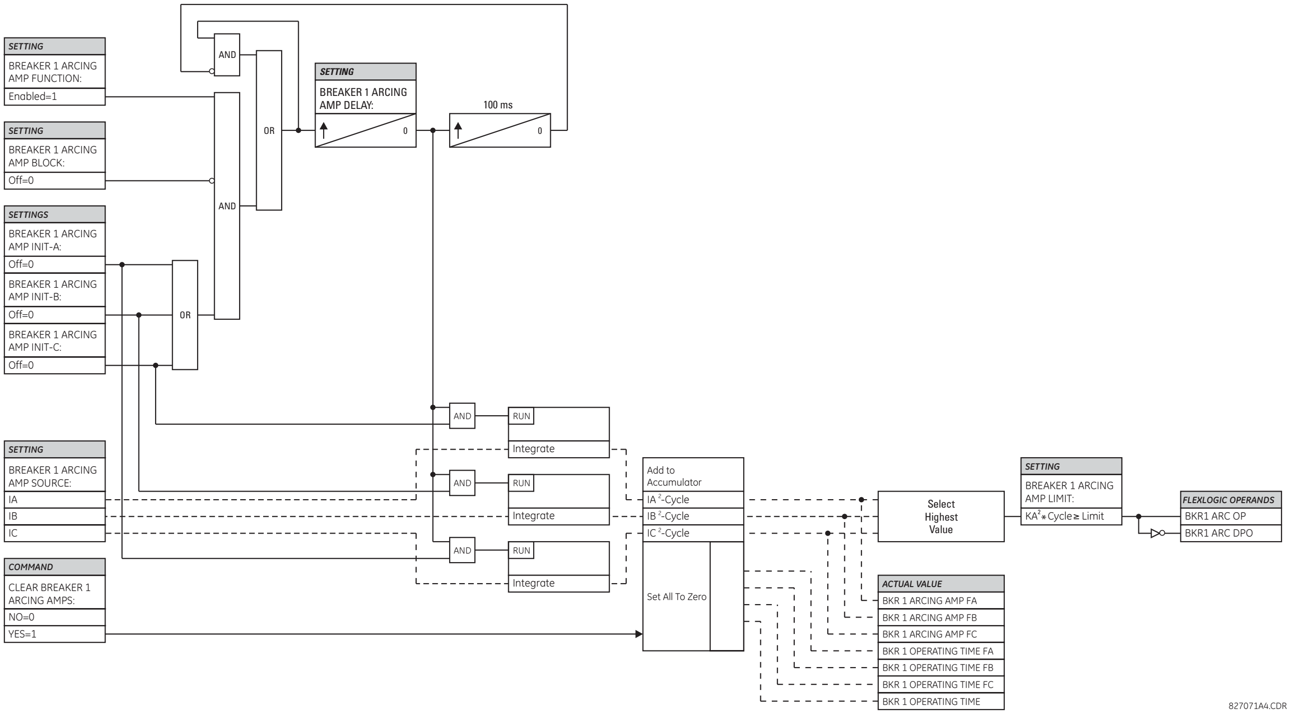

Figure 5–105: BREAKER ARCING CURRENT SCHEME LOGIC

c) CT FAILURE DETECTOR

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨⇩ CT FAILURE DETECTOR

■ CT FAILURE ■ DETECTOR		CT FAIL FUNCTION: Disabled	Range: Disabled, Enabled
	MESSAGE	CT FAIL BLOCK: Off	Range: FlexLogic operand
	MESSAGE	CT FAIL 3I0 INPUT 1: SRC 1	Range: SRC 1, SRC 2
	MESSAGE	CT FAIL 3I0 INPUT 1 PKP: 0.2 pu	Range: 0.0 to 2.0 pu in steps of 0.1
	MESSAGE	CT FAIL 3I0 INPUT 2: SRC 2	Range: SRC 1, SRC 2
	MESSAGE	CT FAIL 3I0 INPUT 2 PKP: 0.2 pu	Range: 0.0 to 2.0 pu in steps of 0.1
	MESSAGE	CT FAIL 3V0 INPUT: SRC 1	Range: SRC 1, SRC 2
	MESSAGE	CT FAIL 3V0 INPUT PKP: 0.20 pu	Range: 0.00 to 2.00 pu in steps of 0.01
	MESSAGE	CT FAIL PICKUP DELAY: 1.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	MESSAGE	CT FAIL TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	MESSAGE	CT FAIL EVENTS: Disabled	Range: Disabled, Enabled

The CT failure function is designed to detect 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 below) 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.

1. Zero-sequence current at different source current (may be different set of CTs or different CT core of the same CT).
2. Zero-sequence voltage at the assigned source.
3. Appropriate protection element or remote signal.

The CT failure settings are described below.

- **CT FAIL FUNCTION:** This setting enables or disables operation of the CT failure element.
- **CT FAIL BLOCK:** This setting 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) when CT fail should be blocked. Local signals or remote signals representing operation of some remote current protection elements via communication channels can also be chosen.
- **CT FAIL 3I0 INPUT 1:** This setting selects the current source for input 1. The most critical protection element should also be assigned to the same source.
- **CT FAIL 3I0 INPUT 1 PICKUP:** This setting selects the 3I_0 pickup value for input 1 (the main supervised CT source).
- **CT FAIL 3I0 INPUT 2**: This setting 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 3I0 INPUT 2 PICKUP**: This setting selects the 3I_0 pickup value for input 2 (different CT input) of the relay.
- **CT FAIL 3V0 INPUT:** This setting selects the voltage source.

- **CT FAIL 3V0 INPUT PICKUP:** This setting specifies the pickup value for the 3V_0 source.
- **CT FAIL PICKUP DELAY:** This setting specifies the pickup delay of the CT failure element.

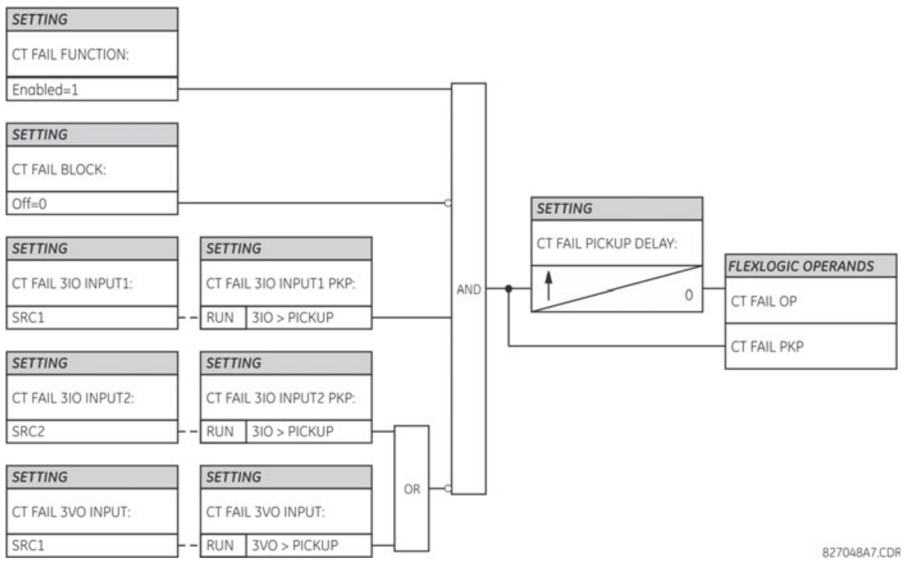

Figure 5–106: CT FAILURE DETECTOR SCHEME LOGIC

d) VT FUSE FAILURE

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨⇩ VT FUSE FAILURE 1(2)

■ VT FUSE FAILURE 1 ■		VT FUSE FAILURE 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
	MESSAGE	■ NEUTRAL WIRE OPEN 1 ■ DETECTION: Disabled	*Range: Disabled, Enabled*
	MESSAGE	■ NEUTRAL WIRE OPEN 1 ■ 3 HARM PKP: 0.100	*0.000 to 3.000 pu in steps of 0.001*

Every signal source includes a fuse failure scheme.

The VT fuse failure detector can be used to raise an alarm and/or block elements that may operate incorrectly for a full or partial loss of AC potential caused by one or more blown fuses. Some elements that might 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 rapid decrease in the phase voltages magnitude from a healthy voltage level without disturbance in current can indicate a 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.

The **VT FUSE FAILURE 1 FUNCTION** setting enables and disables the fuse failure feature for each source.

The VT NEU WIRE OPEN 1 FUNCTION setting enables and disables the VT neutral wire open detection function. When the VT is connected in Delta, do not enabled this function because there is no neutral wire for Delta connected VT.

The VT NEU WIRE OPEN 1 3 HRAM PKP setting specifies the pickup level of 3rd harmonic of 3V0 signal for the VT NEU WIRE OPEN detection logic to pick up.

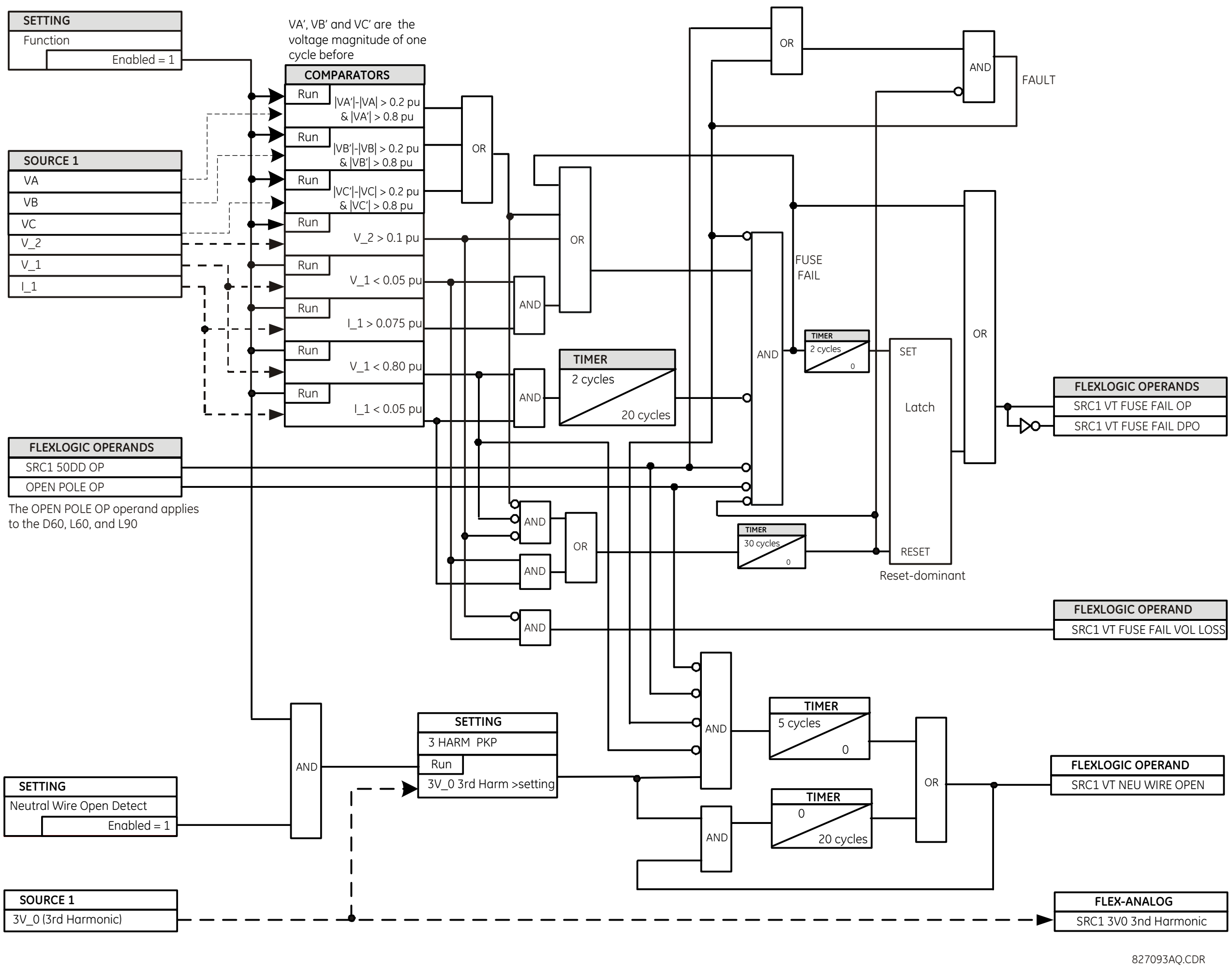

Figure 5–107: VT FUSE FAIL SCHEME LOGIC

Base voltage for this element is PHASE VT SECONDARY setting in the case of WYE VTs and (PHASE VT SECONDARY)/ $\sqrt{3}$ in case of DELTA VTs.

e) BROKEN CONDUCTOR DETECTION

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨⇩ BROKEN CONDUCTOR 1(2)

■ BROKEN CONDUCTOR 1 ■		BROKEN CONDUCTOR 1 FUNCTION: Disabled	Range: Disabled, Enabled
	MESSAGE	BROKEN CONDUCTOR 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
	MESSAGE	BROKEN CONDUCTOR 1 I2/I1 RATIO: 20%	Range: 20.0% to 100.0% in steps of 0.1%
	MESSAGE	BROKEN CONDUCTOR 1 I1 MIN: 0.10 pu	Range: 0.05 to 1.00 pu in steps of 0.01
	MESSAGE	BROKEN CONDUCTOR 1 I1 MAX: 1.50 pu	Range: 0.05 to 5.00 pu in steps of 0.01
	MESSAGE	BROKEN CONDUCTOR 1 PKP DELAY: 20.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	MESSAGE	BROKEN CONDCT 1 BLK: Off	Range: FlexLogic operand
	MESSAGE	BROKEN CONDUCT 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	MESSAGE	BROKEN CONDUCT 1 EVENTS: Disabled	Range: Disabled, Enabled

Two broken conductor detection elements are provided.

The broken conductor function will detect a transmission line broken conductor condition or a single-pole breaker malfunction condition through checking the phase current input signals and the I_2 / I_1 ratio. The intention of this function 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, switching, etc.), 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.

The broken conductor function should not be used to respond to fault transients and single-pole tripping/reclosing conditions. Therefore, the time delay should be programmed 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**: This setting 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 this setting should be set 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, this setting should not be set 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. This broken conductor function should not respond to any fault conditions, so normally this setting is programmed 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.

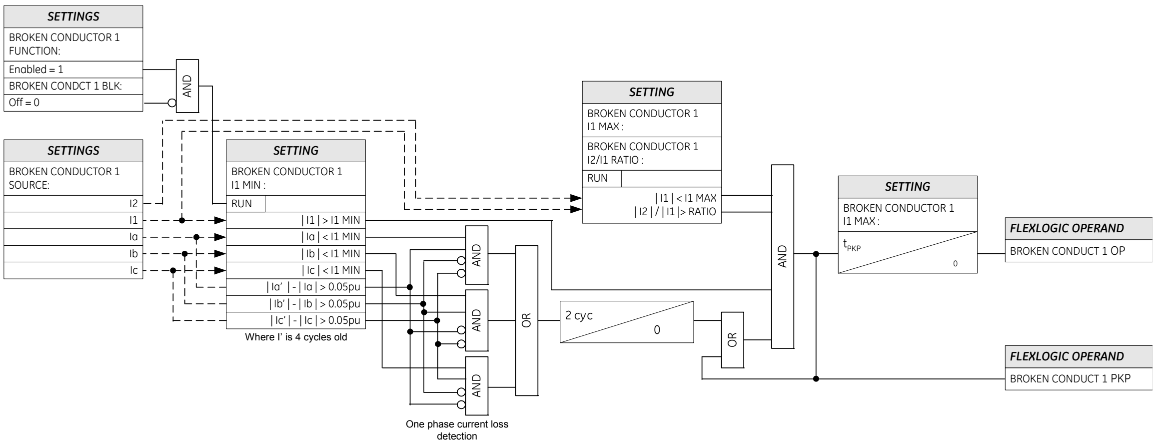

Figure 5–108: BROKEN CONDUCTOR DETECTION LOGIC

f) THERMAL OVERLOAD PROTECTION

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨⇩ THERMAL OVERLOAD PROTECTION ⇨⇩ THERMAL PROTECTION 1(2)

		Setting	Range
■ THERMAL ■ PROTECTION 1	◁▷	THERMAL PROTECTION 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	△▽	THERMAL PROTECTION 1 SOURCE: SRC1	*Range: SRC 1, SRC 2*
MESSAGE	△▽	THERMAL PROTECTION 1 BASE CURR: 0.80 pu	*Range: 0.20 to 3.00 pu in steps of 0.01*
MESSAGE	△▽	THERMAL PROTECTION 1 k FACTOR: 1.10	*Range: 1.00 to 1.20 in steps of 0.05*
MESSAGE	△▽	THERM PROT 1 TRIP TIME CONST: 45 min.	*Range: 0 to 1000 min. in steps of 1*
MESSAGE	△▽	THERM PROT 1 RESET TIME CONST: 45 min.	*Range: 0 to 1000 min. in steps of 1*
MESSAGE	△▽	THERM PROT 1 MINIM RESET TIME: 20 min.	*Range: 0 to 1000 min. in steps of 1*
MESSAGE	△▽	THERM PROT 1 RESET: Off	*Range: FlexLogic operand*
MESSAGE	△▽	THERM PROT 1 BLOCK: Off	*Range: FlexLogic operand*
MESSAGE	△▽	THERMAL PROTECTION 1 TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
MESSAGE	△	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 previous averaged load current over the last 5 cycles is less than 10% of the base current. If this current is greater or equal than 10% than the base current, then the hot curve characteristic is applied.

The IEC255-8 cold curve is defined as follows:

$$t_{op} = \tau_{op} \times \ln\left(\frac{I^2}{I^2 - (kI_B)^2}\right) \quad \text{(EQ 5.23)}$$

The IEC255-8 hot curve is defined as follows:

$$t_{op} = \tau_{op} \times \ln\left(\frac{I^2 - I_p^2}{I^2 - (kI_B)^2}\right) \quad \text{(EQ 5.24)}$$

In the above equations,

- 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.

The reset time of the thermal overload protection element is also time delayed using following formula:

$$t_{rst} = \tau_{rst} \times \ln\left(\frac{(kI_B)^2}{\left|I^2 - (kI_B)^2\right|}\right) + T_{min} \quad \text{(EQ 5.25)}$$

In the above equation,

- τ_{rst} = thermal protection trip time constant.
- T_{min} is a minimum reset time setting

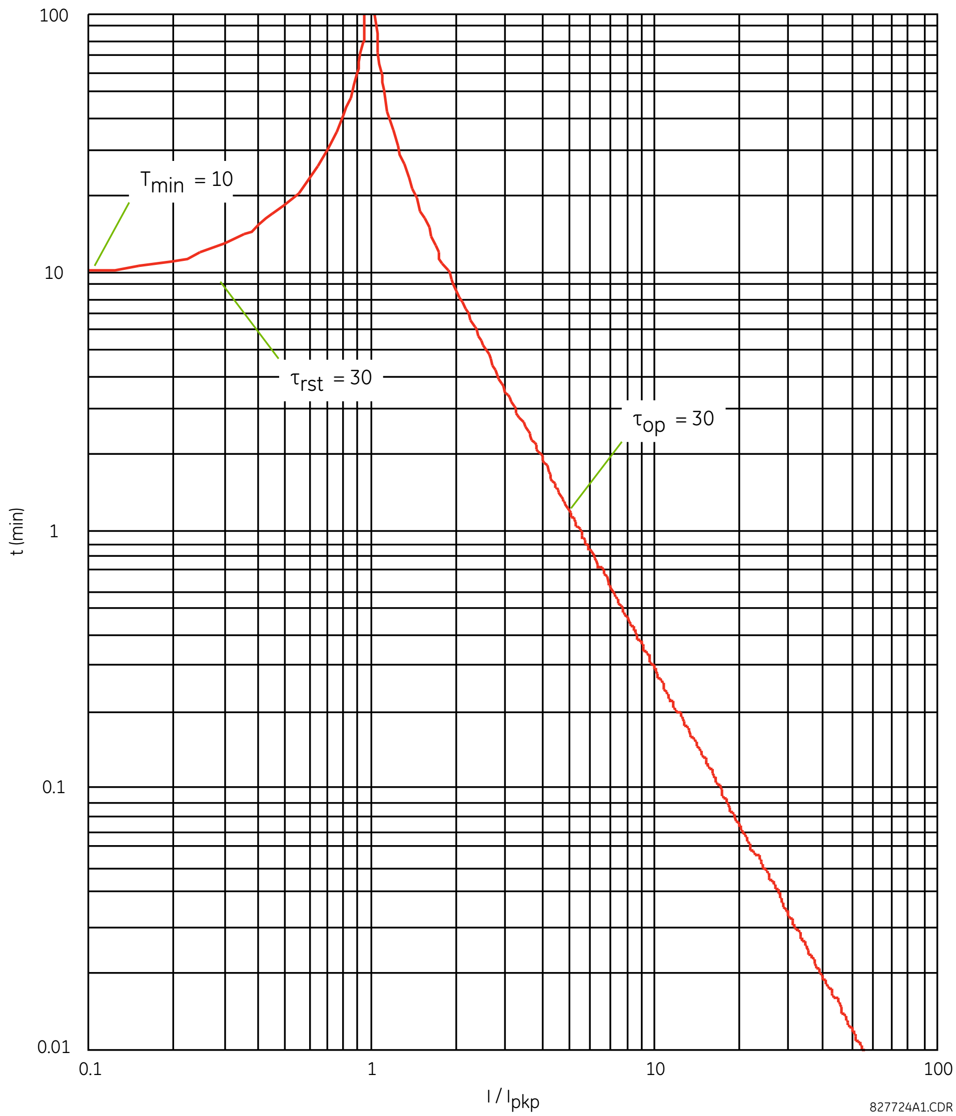

Figure 5–109: IEC 255-8 SAMPLE OPERATE AND RESET CURVES

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:

$$E_n = E_{n-1} + \frac{\Delta t}{t_{op(In)}} \qquad \text{(EQ 5.26)}$$

When current is less than the dropout level, $I_n > 0.97 \times k \times I_B$, the element starts decreasing the thermal energy:

$$E_n = E_{n-1} - \frac{\Delta t}{t_{rst(In)}} \qquad \text{(EQ 5.27)}$$

In the above equations,

- Δt is the power cycle duration.
- n is the power cycle index.
- $t_{op(In)}$ is the trip time calculated at index n as per the IEC255-8 cold curve or hot curve equations.
- $t_{rst(In)}$ 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.

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- 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 5–29: 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 logic for the thermal overload protection element is shown below.

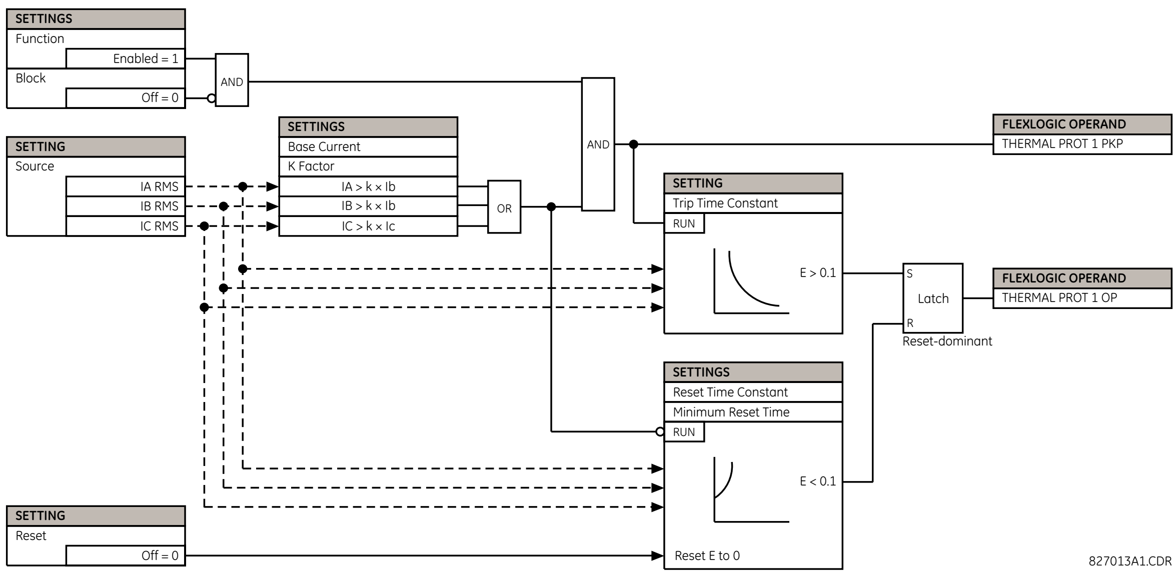


Figure 5–110: THERMAL OVERLOAD PROTECTION SCHEME LOGIC

5.8.1 CONTACT INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨ CONTACT INPUTS

```
■ CONTACT INPUTS
■

    ■ CONTACT INPUT H5a
    ■

MESSAGE   CONTACT INPUT H5a ID:     Range: up to 12 alphanumeric characters
          Cont Ip 1

MESSAGE   CONTACT INPUT H5a         Range: 0.0 to 16.0 ms in steps of 0.5
          DEBNCE TIME: 2.0 ms

MESSAGE   CONTACT INPUT H5a         Range: Disabled, Enabled
          EVENTS: Disabled
          ↓

    ■ CONTACT INPUT xxx
    ■

    ■ CONTACT INPUT
    ■ THRESHOLDS

MESSAGE   Ips H5a,H5c,H6a,H6c       Range: 17, 33, 84, 166 Vdc
          THRESHOLD: 33 Vdc

MESSAGE   Ips H7a,H7c,H8a,H8c       Range: 17, 33, 84, 166 Vdc
          THRESHOLD: 33 Vdc
          ↓

MESSAGE   Ips xxx,xxx,xxx,xxx       Range: 17, 33, 84, 166 Vdc
          THRESHOLD: 33 Vdc
```

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 may 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 will trigger an event.

A raw status is scanned for all Contact Inputs synchronously at the constant rate of 0.5 ms as shown in the figure below. 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 figure below, 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 (debounced), 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 diagram).

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 below). 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 1msec.

For example, 8 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 below). 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 below) and HIGH-LOW (marks no. 5, 6, 7, and 8 below) transitions.

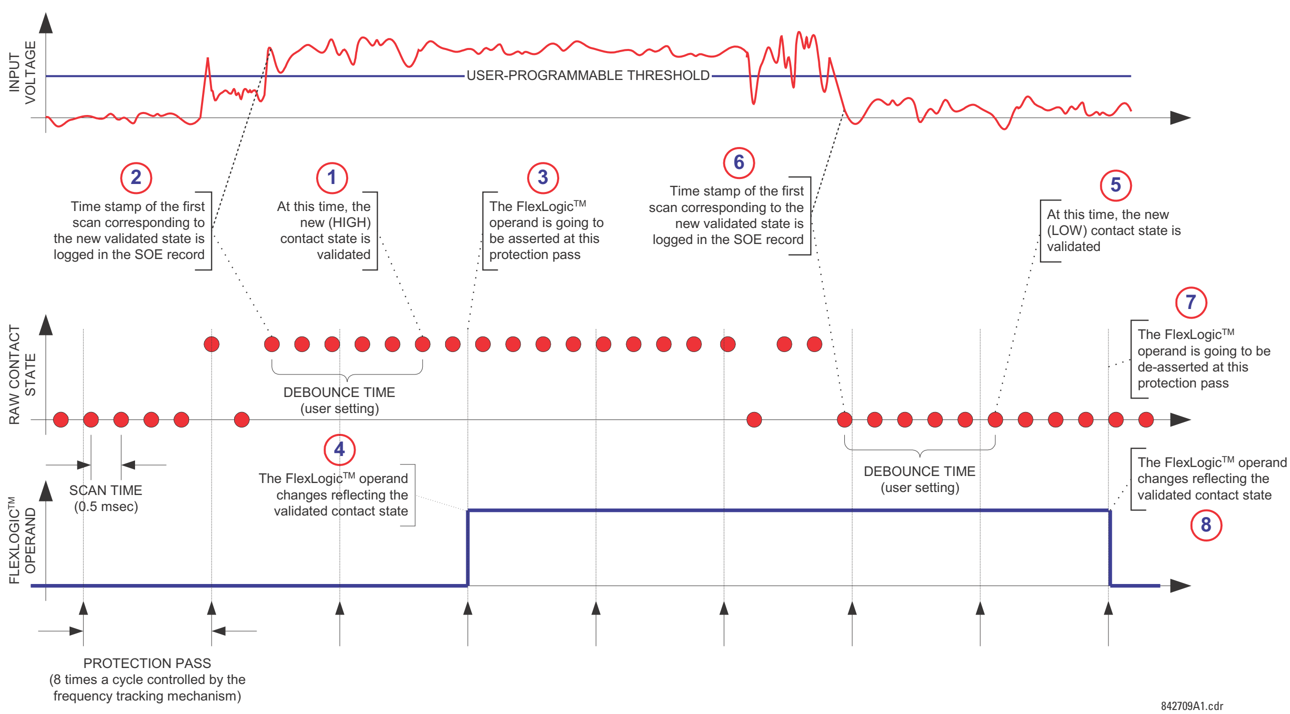


Figure 5–111: INPUT CONTACT DEBOUNCING MECHANISM AND TIME-STAMPING SAMPLE TIMING

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 should be 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.

5.8.2 VIRTUAL INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ VIRTUAL INPUTS ⇨ VIRTUAL INPUT 1(64)

Menu		Setting	Range
■ VIRTUAL INPUT 1 ■		VIRTUAL INPUT 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE		VIRTUAL INPUT 1 ID: Virt Ip 1	Range: Up to 12 alphanumeric characters
MESSAGE		VIRTUAL INPUT 1 TYPE: Latched	Range: Self-Reset, Latched
MESSAGE		VIRTUAL INPUT 1 EVENTS: Disabled	Range: Disabled, Enabled

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 will be 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 will be 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.

5

NOTE: 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 will likely have to be lengthened in time. A FlexLogic timer with a delayed reset can perform this function.

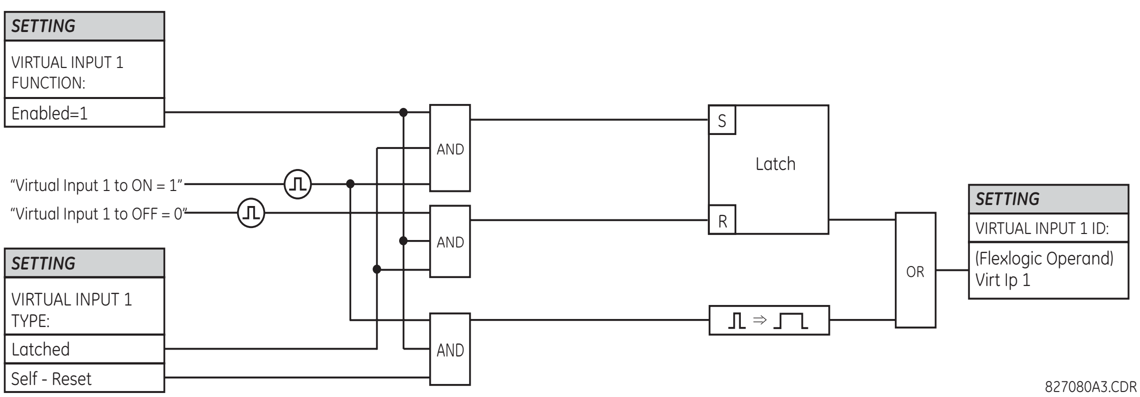


Figure 5–112: VIRTUAL INPUTS SCHEME LOGIC

5.8.3 CONTACT OUTPUTS

a) DIGITAL OUTPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS ⇨ CONTACT OUTPUT H1

```
■ CONTACT OUTPUT H1
■
```

Display		Range
	CONTACT OUTPUT H1 ID Cont Op 1	*Range: Up to 12 alphanumeric characters*
MESSAGE	OUTPUT H1 OPERATE: Off	*Range: FlexLogic operand*
MESSAGE	OUTPUT H1 SEAL-IN: Off	*Range: FlexLogic operand*
MESSAGE	CONTACT OUTPUT H1 EVENTS: Enabled	*Range: Disabled, Enabled*

Upon startup of the relay, the main processor will determine from an assessment of the modules installed in the chassis which contact outputs are available and present the settings for only these outputs.

An ID may be assigned to each contact output. The signal that can **OPERATE** a contact output may be any FlexLogic operand (virtual output, element state, contact input, or virtual input). An additional FlexLogic operand may 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 will set 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 ION.

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 in the L30 using the CONT OP 1 ION 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 IOn"
CONTACT OUTPUT H1 EVENTS: "Enabled"

b) LATCHING OUTPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS ⇨ CONTACT OUTPUT H1a

```
■ CONTACT OUTPUT H1a
■
```

Display		Range
	OUTPUT H1a ID L-Cont Op 1	*Range: Up to 12 alphanumeric characters*
MESSAGE	OUTPUT H1a OPERATE: Off	*Range: FlexLogic operand*
MESSAGE	OUTPUT H1a RESET: Off	*Range: FlexLogic operand*
MESSAGE	OUTPUT H1a TYPE: Operate-dominant	*Range: Operate-dominant, Reset-dominant*
MESSAGE	OUTPUT H1a EVENTS: Disabled	*Range: Disabled, Enabled*

The L30 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 a part of the relay or as individual modules, are shipped from the factory with all latching contacts opened. 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 will seal-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, will 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 will seal-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, will 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 will close if set to "Operate-dominant" and will open if set to "Reset-dominant".

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 should be 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"

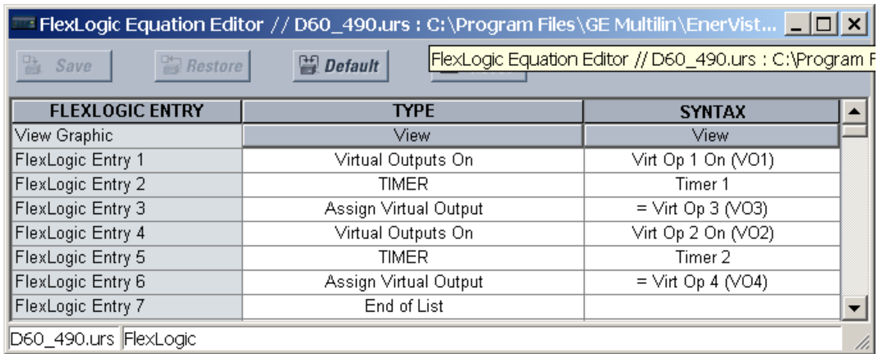
OUTPUT H1c OPERATE: "VO2"
OUTPUT H1c RESET: "VO1"

Since the two physical contacts in this example are mechanically separated and have individual control inputs, they will not operate at exactly the same time. A discrepancy in the range of a fraction of a maximum operating time may occur. Therefore, a pair of contacts programmed to be a multi-contact relay will 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 as described below:

Write the following FlexLogic equation (EnerVista UR Setup 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	

Both timers (Timer 1 and Timer 2) should be set 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):

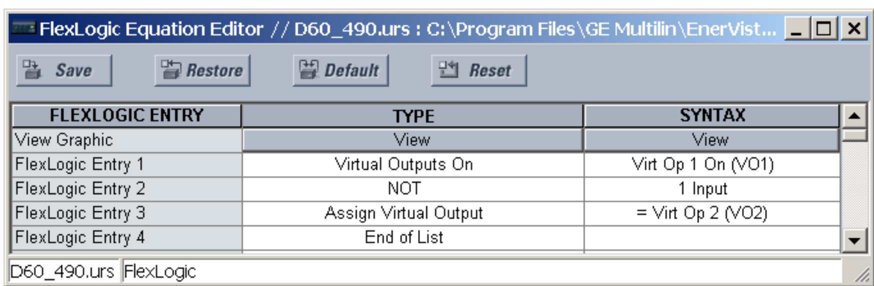
OUTPUT H1a OPERATE: "VO1"
OUTPUT H1a RESET: "VO4"

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 should stay closed as long as VO1 is high, and should stay opened when VO1 is low. Program the relay as follows.

Write the following FlexLogic equation (EnerVista UR Setup 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"

5.8.4 VIRTUAL OUTPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ VIRTUAL OUTPUTS ⇨ VIRTUAL OUTPUT 1(96)

■ VIRTUAL OUTPUT 1 ■		VIRTUAL OUTPUT 1 ID Virt Op 1	*Range: Up to 12 alphanumeric characters*
	MESSAGE	VIRTUAL OUTPUT 1 EVENTS: Disabled	*Range: Disabled, Enabled*

There are 96 virtual outputs that may be assigned via FlexLogic. If not assigned, the output will be forced to 'OFF' (Logic 0). An ID may 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 would be programmed as follows:

VIRTUAL OUTPUT 1 ID: "Trip"
VIRTUAL OUTPUT 1 EVENTS: "Disabled"

5.8.5 REMOTE DEVICES

a) REMOTE INPUTS AND OUTPUTS OVERVIEW

Remote inputs and outputs provide a means of exchanging digital state information between Ethernet-networked devices. The IEC 61850 GSSE (Generic Substation State Event) and GOOSE (Generic Object Oriented Substation Event) standards are used.

The sharing of digital point state information between GSSE/GOOSE equipped relays is essentially an extension to FlexLogic, allowing distributed FlexLogic by making operands available to/from devices on a common communications network. In addition to digital point states, GSSE/GOOSE messages identify the originator of the message and provide other information required by the communication specification. All devices listen to network messages and capture data only from messages that have originated in selected devices.

IEC 61850 GSSE messages are compatible with UCA GOOSE messages and contain a fixed set of digital points. IEC 61850 GOOSE messages can, in general, contain any configurable data items. When used by the remote input/output feature, IEC 61850 GOOSE messages contain the same data as GSSE messages.

Both GSSE and GOOSE messages are designed to be short, reliable, and high priority. GOOSE messages have additional advantages over GSSE messages due to their support of VLAN (virtual LAN) and Ethernet priority tagging functionality. The GSSE message structure contains space for 128 bit pairs representing digital point state information. The IEC 61850 specification provides 32 “DNA” bit pairs that represent the state of two pre-defined events and 30 user-defined events. All remaining bit pairs are “UserSt” bit pairs, which are status bits representing user-definable events. The L30 implementation provides 32 of the 96 available UserSt bit pairs.

The IEC 61850 specification includes features that are used to cope with the loss of communication between transmitting and receiving devices. Each transmitting device will send a GSSE/GOOSE message upon a successful power-up, when the state of any included point changes, or after a specified interval (the *default update* time) if a change-of-state has not occurred. The transmitting device also sends a ‘hold time’ which is set greater than four times the programmed default time required by the receiving device.

Receiving devices are constantly monitoring the communications network for messages they require, as recognized by the identification of the originating device carried in the message. Messages received from remote devices include the message *time allowed to live*. The receiving relay sets a timer assigned to the originating device to this time interval, and if it has not received another message from this device at time-out, the remote device is declared to be non-communicating, so it will use the programmed default state for all points from that specific remote device. If a message is received from a remote device before the *time allowed to live* expires, all points for that device are updated to the states contained in the message and the hold timer is restarted. The status of a remote device, where “Offline” indicates non-communicating, can be displayed.

The remote input/output facility provides for 32 remote inputs and 64 remote outputs.

The L90 provides an additional method of sharing digital point state information among different relays: direct messages. Direct messages are only used between UR-series relays inter-connected via dedicated type 7X communications modules, usually between substations. The digital state data conveyed by direct messages are direct inputs and direct outputs.

b) DIRECT MESSAGES

Direct messages are only used between UR-series relays containing the type 7X UR communications module. These messages are transmitted every one-half of the power frequency cycle (10 ms for 50 Hz and 8.33 ms for 60 Hz) This facility is of particular value for pilot schemes and transfer tripping. Direct messaging is available on both single channel and dual channel communications modules. The inputs and outputs on communications channel 1 are numbered 1-1 through 1-8, and the inputs and outputs on communications channel 2 are numbered 2-1 through 2-8.

NOTE

Settings associated with direct messages are automatically presented in accordance with the number of channels provided in the communications module in a specific relay.

c) LOCAL DEVICES: DEVICE ID FOR TRANSMITTING GSSE MESSAGES

In a L30 relay, the device ID that represents the IEC 61850 GOOSE application ID (GoID) name string sent as part of each GOOSE message is programmed in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ FIXED GOOSE ⇨⇩ GOOSE ID** setting.

Likewise, the device ID that represents the IEC 61850 GSSE application ID name string sent as part of each GSSE message is programmed in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ GSSE ⇨⇩ GSSE ID** setting.

In L30 releases previous to 5.0x, these name strings were represented by the **RELAY NAME** setting.

d) REMOTE DEVICES: ID OF DEVICE FOR RECEIVING GSSE/GOOSE MESSAGES

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ REMOTE DEVICES ⇨ REMOTE DEVICE 1(16)

■ REMOTE DEVICE 1 ■	◀▶	REMOTE DEVICE 1 ID: Remote Device 1	Range: up to 20 alphanumeric characters
MESSAGE	▲▼	REMOTE DEVICE 1 ETYPE APPID: 0	Range: 0 to 16383 in steps of 1
MESSAGE	▲	REMOTE DEVICE 1 DATASET: Fixed	Range: Fixed, GOOSE 1 through GOOSE 16

Remote devices are available for setting purposes. A receiving relay must be programmed to capture messages from only those originating remote devices of interest. This setting is used to select specific remote devices by entering (bottom row) the exact identification (ID) assigned to those devices.

The **REMOTE DEVICE 1 ETYPE APPID** setting is only used with GOOSE messages; they are not applicable to GSSE messages. This setting identifies the Ethernet application identification in the GOOSE message. It should match the corresponding settings on the sending device.

The **REMOTE DEVICE 1 DATASET** setting provides for the choice of the L30 fixed (DNA/UserSt) dataset (that is, containing DNA and UserSt bit pairs), or one of the configurable datasets.

Note that the dataset for the received data items must be made up of existing items in an existing logical node. For this reason, logical node GGIO3 is instantiated to hold the incoming data items. GGIO3 is not necessary to make use of the received data. The remote input data item mapping takes care of the mapping of the inputs to remote input FlexLogic operands. However, GGIO3 data can be read by IEC 61850 clients.

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5.8.6 REMOTE INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ REMOTE INPUTS ⇨ REMOTE INPUT 1(32)

■ REMOTE INPUT 1 ■	◀▶	REMOTE INPUT 1 ID: Remote Ip 1	Range: up to 12 alphanumeric characters
MESSAGE	▲▼	REMOTE IN 1 DEVICE: Remote Device 1	Range: Remote Device 1 to Remote device 16
MESSAGE	▲▼	REMOTE IN 1 ITEM: None	Range: None, DNA-1 to DNA-32, UserSt-1 to UserSt-32, Config Item 1 to Config Item 32
MESSAGE	▲▼	REMOTE IN 1 DEFAULT STATE: Off	Range: On, Off, Latest/On, Latest/Off
MESSAGE	▲	REMOTE IN 1 EVENTS: Disabled	Range: Disabled, Enabled

Remote Inputs that create FlexLogic operands at the receiving relay are extracted from GSSE/GOOSE messages originating in remote devices. Each remote input can be selected from a list consisting of: DNA-1 through DNA-32, UserSt-1 through UserSt-32, and Dataset Item 1 through Dataset Item 32. The function of DNA inputs is defined in the IEC 61850 specification and is presented in the IEC 61850 DNA Assignments table in the *Remote outputs* section. The function of UserSt inputs is defined by the user selection of the FlexLogic operand whose state is represented in the GSSE/GOOSE message. A user must program a DNA point from the appropriate FlexLogic operand.

Remote input 1 must be programmed to replicate the logic state of a specific signal from a specific remote device for local use. This programming is performed via the three settings shown above.

The **REMOTE INPUT 1 ID** setting allows the user to assign descriptive text to the remote input. The **REMOTE IN 1 DEVICE** setting selects the remote device which originates the required signal, as previously assigned to the remote device via the setting **REMOTE DEVICE (16) ID** (see the *Remote devices* section). The **REMOTE IN 1 ITEM** setting selects the specific bits of the GSSE/GOOSE message required.

The **REMOTE IN 1 DEFAULT STATE** setting selects the logic state for this point if the local relay has just completed startup or the remote device sending the point is declared to be non-communicating. The following choices are available:

- Setting **REMOTE IN 1 DEFAULT STATE** to "On" value defaults the input to logic 1.
- Setting **REMOTE IN 1 DEFAULT STATE** to "Off" value defaults the input to logic 0.
- Setting **REMOTE IN 1 DEFAULT STATE** to "Latest/On" freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to logic 1. When communication resumes, the input becomes fully operational.
- Setting **REMOTE IN 1 DEFAULT STATE** to "Latest/Off" freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to logic 0. When communication resumes, the input becomes fully operational.

NOTE

For additional information on GSSE/GOOOSE messaging, refer to the Remote Devices section in this chapter.

5.8.7 REMOTE DOUBLE-POINT STATUS INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ REMOTE DPS INPUTS ⇨ REMOTE DPS INPUT 1(5)

■ REMOTE DPS INPUT 1 ■		REM DPS IN 1 ID: RemDPS Ip 1	Range: up to 12 alphanumeric characters
	MESSAGE	REM DPS IN 1 DEV: Remote Device 1	Range: Remote Device 1 to Remote device 16
	MESSAGE	REM DPS IN 1 ITEM: None	Range: None, Dataset Item 1 to Dataset Item 32
	MESSAGE	REM DPS IN 1 EVENTS: Disabled	Range: Enabled, Disabled

Remote double-point status inputs are extracted from GOOSE messages originating in the remote device. Each remote double point status input must be programmed to replicate the logic state of a specific signal from a specific remote device for local use. This functionality is accomplished with the five remote double-point status input settings.

- **REM DPS IN 1 ID**: This setting assigns descriptive text to the remote double-point status input.
- **REM DPS IN 1 DEV**: This setting selects a remote device ID to indicate the origin of a GOOSE message. The range is selected from the remote device IDs specified in the *Remote devices* section.
- **REM DPS IN 1 ITEM**: This setting specifies the required bits of the GOOSE message.

The configurable GOOSE dataset items must be changed to accept a double-point status item from a GOOSE dataset (changes are made in the **SETTINGS ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ GSSE/GOOSE CONFIGURATION ⇨⇩ RECEPTION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1(16) ⇨ CONFIG GSE 1 DATASET ITEMS** menus). Dataset items configured to receive any of "GGIO3.ST.IndPos1.stV" to "GGIO3.ST.IndPos5.stV" will accept double-point status information that will be decoded by the remote double-point status inputs configured to this dataset item.

The remote double point status is recovered from the received IEC 61850 dataset and is available as through the RemDPS Ip 1 BAD, RemDPS Ip 1 INTERM, RemDPS Ip 1 OFF, and RemDPS Ip 1 ON FlexLogic operands. These operands can then be used in breaker or disconnect control schemes.

5.8.8 REMOTE OUTPUTS

a) DNA BIT PAIRS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ REMOTE OUTPUTS DNA BIT PAIRS ⇨ REMOTE OUTPUTS DNA- 1(32) BIT PAIR

■ REMOTE OUTPUTS ■ DNA- 1 BIT PAIR		DNA- 1 OPERAND: Off	Range: FlexLogic operand
	MESSAGE	DNA- 1 EVENTS: Disabled	Range: Disabled, Enabled

Remote outputs (1 to 32) are FlexLogic operands inserted into GSSE/GOOSE messages that are transmitted to remote devices on a LAN. Each digital point in the message must be programmed to carry the state of a specific FlexLogic operand. The above operand setting represents a specific DNA function (as shown in the following table) to be transmitted.

Table 5–30: IEC 61850 DNA ASSIGNMENTS

DNA	IEC 61850 DEFINITION	FLEXLOGIC OPERAND
1	Test	IEC 61850 TEST MODE
2	ConfRev	IEC 61850 CONF REV

b) USERST BIT PAIRS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ REMOTE OUTPUTS UserSt BIT PAIRS ⇨ REMOTE OUTPUTS UserSt- 1(32) BIT PAIR

```
■ REMOTE OUTPUTS
■ UserSt- 1 BIT PAIR        UserSt- 1 OPERAND:       Range: FlexLogic operand
                            Off

               MESSAGE      UserSt- 1 EVENTS:        Range: Disabled, Enabled
                            Disabled
```

Remote outputs 1 to 32 originate as GSSE/GOOSE messages to be transmitted to remote devices. Each digital point in the message must be programmed to carry the state of a specific FlexLogic operand. The setting above is used to select the operand which represents a specific UserSt function (as selected by the user) to be transmitted.

NOTE

For more information on GSSE/GOOSE messaging, refer to Remote Inputs/Outputs Overview in the Remote Devices section.

5.8.9 DIRECT INPUTS AND OUTPUTS

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a) DESCRIPTION

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. It should be noted that failures of communications channels will 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).

NOTE

On the two-terminal, two channel system (redundant channel), direct outputs 1-1 to 1-8 are send 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.

b) DIRECT INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ DIRECT ⇨ DIRECT INPUTS

```
■ DIRECT INPUTS
■                           DIRECT INPUT 1-1         Range: Off, On
                            DEFAULT: Off

               MESSAGE      DIRECT INPUT 1-2         Range: Off, On
                            DEFAULT: Off
                                   ↓
               MESSAGE      DIRECT INPUT 1-8         Range: Off, On
                            DEFAULT: Off
```

MESSAGE	▲▼	DIRECT INPUT 2-1 DEFAULT: Off	Range: Off, On
MESSAGE	▲▼	DIRECT INPUT 2-2 DEFAULT: Off	Range: Off, On
		↓	
MESSAGE	▲	DIRECT INPUT 2-8 DEFAULT: Off	Range: Off, On

The **DIRECT INPUT 1-1(8) DEFAULT** setting 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)) will have 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.

c) DIRECT OUTPUTS

PATH: SETTINGS ⇩ INPUTS/OUTPUTS ⇨⇩ DIRECT ⇨⇩ DIRECT OUTPUTS

■ DIRECT OUTPUTS ■	◀▶	DIRECT OUTPUT 1-1: Off	Range: FlexLogic operand
MESSAGE	▲▼	DIRECT OUTPUT 1-2: Off	Range: FlexLogic operand
		↓	
MESSAGE	▲▼	DIRECT OUTPUT 1-8: Off	Range: FlexLogic operand
MESSAGE	▲▼	DIRECT OUTPUT 2-1: Off	Range: FlexLogic operand
MESSAGE	▲▼	DIRECT OUTPUT 2-2: Off	Range: FlexLogic operand
		↓	
MESSAGE	▲	DIRECT OUTPUT 2-8: Off	Range: FlexLogic operand

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 setting above is used to select the operand which represents a specific function (as selected by the user) to be transmitted.

NOTE

Direct outputs 2-1 to 2-8 are only functional on three-terminal systems.

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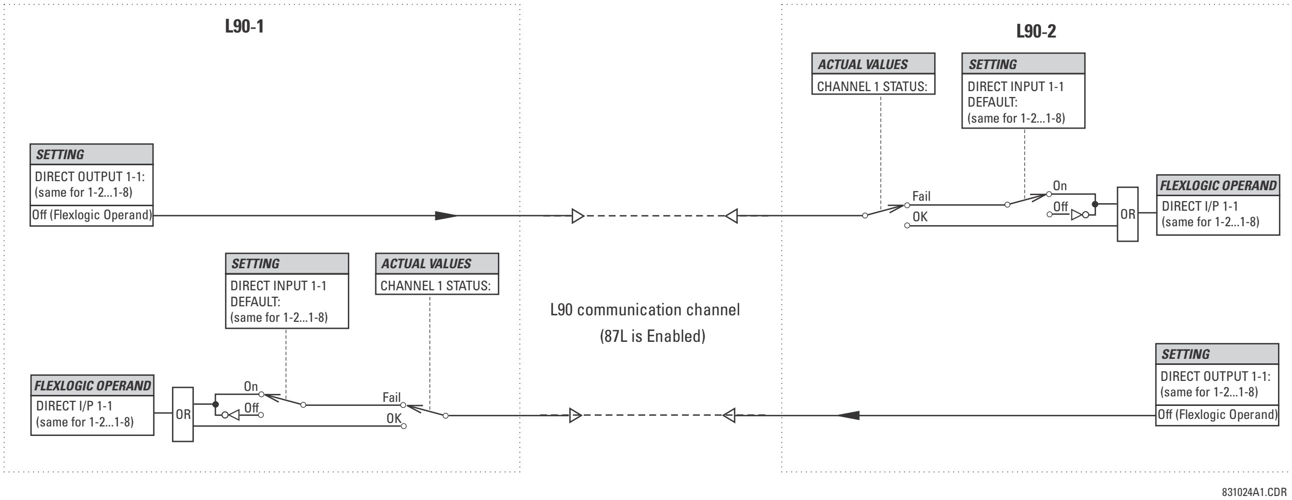

Figure 5–113: DIRECT INPUTS/OUTPUTS LOGIC

5.8.10 RESETTING

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ RESETTING

■ RESETTING ■	◁▷	RESET OPERAND: Off	Range: FlexLogic operand

Some events can be programmed to latch the faceplate LED event indicators and the target message on the display. Once set, the latching mechanism will hold all of the latched indicators or messages 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. The RESET command can be sent from the faceplate Reset button, a remote device via a communications channel, or any programmed operand.

When the RESET command is received by the relay, two FlexLogic operands are created. These operands, which are stored as events, reset the latches if the initiating condition has cleared. The three sources of RESET commands each create the RESET OP FlexLogic operand. Each individual source of a RESET command also creates its individual operand RESET OP (PUSHBUTTON), RESET OP (COMMS) or RESET OP (OPERAND) to identify the source of the command. The setting shown above selects the operand that will create the RESET OP (OPERAND) operand.

5.8.11 IEC 61850 GOOSE ANALOGS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ IEC 61850 GOOSE ANALOGS ⇨⇩ GOOSE ANALOG INPUT 1(32)

■ GOOSE ANALOG ■ INPUT 1	◁▷	ANALOG 1 DEFAULT: 1000.000	Range: –1000000.000 to 1000000.000 in steps of 0.001
MESSAGE	△▽	ANALOG 1 DEFAULT MODE: Default Value	Range: Default Value, Last Known
MESSAGE	△▽	GOOSE ANALOG 1 UNITS:	Range: up to 4 alphanumeric characters
MESSAGE	△	GOOSE ANALOG 1 PU: 1.000	Range: 0.000 to 1000000000.000 in steps of 0.001

The IEC 61850 GOOSE analog inputs feature allows the transmission of analog values between any two UR-series devices. The following settings are available for each GOOSE analog input.

- **ANALOG 1 DEFAULT**: This setting specifies the value of the GOOSE analog input when the sending device is offline and the **ANALOG 1 DEFAULT MODE** is set to “Default Value”.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 may be rounded to the closest possible floating point number.
- **ANALOG 1 DEFAULT MODE**: When the sending device is offline and this setting is “Last Known”, the value of the GOOSE analog input remains at the last received value. When the sending device is offline and this setting value is “Default Value”, then the value of the GOOSE analog input is defined by the **ANALOG 1 DEFAULT** setting.
- **GOOSE ANALOG 1 UNITS**: This setting specifies a four-character alphanumeric string that can is used in the actual values display of the corresponding GOOSE analog input value.
- **GOOSE ANALOG 1 PU**: This setting specifies the per-unit base factor when using the GOOSE analog input FlexAnalog values in other L30 features, such as FlexElements. The base factor is applied to the GOOSE analog input FlexAnalog quantity to normalize it to a per-unit quantity. The base units are described in the following table.

Table 5–31: GOOSE ANALOG INPUT BASE UNITS

ELEMENT	BASE UNITS
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
BREAKER ARCING AMPS (Brk X Arc Amp A, B, and C)	BASE = 2000 $kA^2 \times$ cycle
dcmA	BASE = maximum value of the **DCMA INPUT MAX** setting for the two transducers configured under the +IN and –IN inputs.
FREQUENCY	f_{BASE} = 1 Hz
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 $V_{BASE} \times I_{BASE}$ for the +IN and –IN inputs
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

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The GOOSE analog input FlexAnalog values are available for use in other L30 functions that use FlexAnalog values.

5.8.12 IEC 61850 GOOSE INTEGERS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ IEC 61850 GOOSE UINTEGERS ⇨⇩ GOOSE UINTEGER INPUT 1(16)

■ GOOSE UINTEGER ■ INPUT 1	◁▷	UINTEGER 1 DEFAULT: 1000	*Range: 0 to 429496295 in steps of 1*
MESSAGE	△	UINTEGER 1 DEFAULT MODE: Default Value	*Range: Default Value, Last Known*

The IEC 61850 GOOSE uinteger inputs feature allows the transmission of FlexInteger values between any two UR-series devices. The following settings are available for each GOOSE uinteger input.

- **UINTEGER 1 DEFAULT**: This setting specifies the value of the GOOSE uinteger input when the sending device is offline and the **UINTEGER 1 DEFAULT MODE** is set to “Default Value”.This setting is stored as a 32-bit unsigned integer number.
- **UINTEGER 1 DEFAULT MODE**: When the sending device is offline and this setting is “Last Known”, the value of the GOOSE uinteger input remains at the last received value. When the sending device is offline and this setting value is “Default Value”, then the value of the GOOSE uinteger input is defined by the **UINTEGER 1 DEFAULT** setting.

The GOOSE integer input FlexInteger values are available for use in other L30 functions that use FlexInteger values.

5.9.1 DCMA INPUTS

PATH: SETTINGS ⇨⇩ TRANSDUCER I/O ⇨⇩ DCMA INPUTS ⇨ DCMA INPUT H1(U8)

■ DCMA INPUT H1 ■	DCMA INPUT H1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	DCMA INPUT H1 ID: DCMA Ip 1	Range: up to 20 alphanumeric characters
MESSAGE	DCMA INPUT H1 UNITS: μA	Range: 6 alphanumeric characters
MESSAGE	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 mA
MESSAGE	DCMA INPUT H1 MIN VALUE: 0.000	Range: –9999.999 to +9999.999 in steps of 0.001
MESSAGE	DCMA INPUT H1 MAX VALUE: 0.000	Range: –9999.999 to +9999.999 in steps of 0.001

Hardware and software is provided to receive signals from external transducers and convert these signals into a digital format for use as required. The relay will accept 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. Specific 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. 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 will automatically generate 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 5F transducer module installed in slot H.

The function of the channel may be either "Enabled" or "Disabled". If "Disabled", no actual values are created for the channel. An alphanumeric "ID" is assigned to each channel; this ID will be included in the channel actual value, along with the programmed units associated with the parameter measured by the transducer, such as volts, °C, megawatts, etc. 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 would be a watts transducer with a span from –20 to +180 MW; in this case the **DCMA INPUT H1 MIN VALUE** value would be "–20" and the **DCMA INPUT H1 MAX VALUE** value "180". Intermediate values between the min and max values are scaled linearly.

5.9.2 RTD INPUTS

PATH: SETTINGS ⇨⇩ TRANSDUCER I/O ⇨⇩ RTD INPUTS ⇨ RTD INPUT H1(U8)

■ RTD INPUT H1 ■	◀▶	RTD INPUT H1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	RTD INPUT H1 ID: RTD Ip 1	Range: Up to 20 alphanumeric characters
MESSAGE	▲	RTD INPUT H1 TYPE: 100Ω Nickel	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 will automatically generate 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.

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The function of the channel may be either "Enabled" or "Disabled". If "Disabled", there will not be an actual value created for the channel. An alphanumeric ID is assigned to the channel; this ID will be 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.

Refer to the following table for reference temperature values for each RTD type.

Table 5–32: 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

5.9.3 DCMA OUTPUTS

PATH: SETTINGS ⇨⇩ TRANSDUCER I/O ⇨⇩ DCMA OUTPUTS ⇨ DCMA OUTPUT H1(U8)

■ DCMA OUTPUT H1 ■	◄►	DCMA OUTPUT H1 SOURCE: Off	Range: Off, any analog actual value parameter
MESSAGE	▲▼	DCMA OUTPUT H1 RANGE: –1 to 1 mA	Range: –1 to 1 mA, 0 to 1 mA, 4 to 20 mA
MESSAGE	▲▼	DCMA OUTPUT H1 MIN VAL: 0.000 pu	Range: –90.000 to 90.000 pu in steps of 0.001
MESSAGE	▲	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. Specific 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 shown below.

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).

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The relay checks the driving signal (x in equations below) for the minimum and maximum limits, and subsequently rescales 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:

$$I_{out} = \begin{cases} I_{min} & \text{if } x < \textbf{MIN VAL} \\ I_{max} & \text{if } x > \textbf{MAX VAL} \\ k(x - \textbf{MIN VAL}) + I_{min} & \text{otherwise} \end{cases} \qquad \text{(EQ 5.28)}$$

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:

$$k = \frac{I_{max} - I_{min}}{\textbf{MAX VAL} - \textbf{MIN VAL}} \qquad \text{(EQ 5.29)}$$

The feature is intentionally inhibited if the **MAX VAL** and **MIN VAL** settings are entered incorrectly, e.g. when **MAX VAL** – **MIN VAL** < 0.1 pu. The resulting characteristic is illustrated in the following figure.

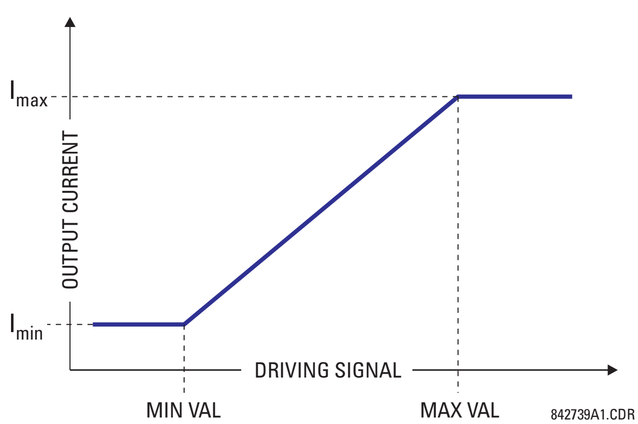

Figure 5–114: DCMA OUTPUT CHARACTERISTIC

The dcmA output settings are described below.

- **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. Refer to Appendix A for a complete list of FlexAnalog parameters.
- **DCMA OUTPUT H1 RANGE**: This setting allows selection of the output range. Each dcmA channel may 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.

NOTE

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 are described below.

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:

$$P = \sqrt{3} \times 13.8\text{ kV} \times 0.8\text{ kA} \times 0.9 = 17.21\text{ MW} \quad \textbf{(EQ 5.30)}$$

The three-phase power with 20% overload margin is:

$$P_{max} = 1.2 \times 17.21\text{ MW} = 20.65\text{ MW} \quad \textbf{(EQ 5.31)}$$

The base unit for power (refer to the FlexElements section in this chapter for additional details) is:

$$P_{BASE} = 115\text{ V} \times 120 \times 1.2\text{ kA} = 16.56\text{ MW} \quad \textbf{(EQ 5.32)}$$

The minimum and maximum power values to be monitored (in pu) are:

$$\text{minimum power} = \frac{-20.65\text{ MW}}{16.56\text{ MW}} = -1.247\text{ pu}, \quad \text{maximum power} = \frac{20.65\text{ MW}}{16.56\text{ MW}} = 1.247\text{ pu} \quad \textbf{(EQ 5.33)}$$

The following settings should be 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 $\pm 0.005 \times (1 - (-1)) \times 20.65\text{ MW} = \pm 0.207\text{ MW}$
- ±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 should be monitored from 0 A upwards, allowing for 50% overload.

The phase current with the 50% overload margin is:

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$$I_{max} = 1.5 \times 4.2\text{ kA} = 6.3\text{ kA} \quad \textbf{(EQ 5.34)}$$

The base unit for current (refer to the *FlexElements* section in this chapter for additional details) is:

$$I_{BASE} = 5\text{ kA} \quad \textbf{(EQ 5.35)}$$

The minimum and maximum power values to be monitored (in pu) are:

$$\text{minimum current} = \frac{0\text{ kA}}{5\text{ kA}} = 0\text{ pu},\quad \text{maximum current} = \frac{6.3\text{ kA}}{5\text{ kA}} = 1.26\text{ pu} \quad \textbf{(EQ 5.36)}$$

The following settings should be 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 could be calculated by superimposing the following two sources of error:

- ±0.5% of the full scale for the analog output module, or $\pm 0.005 \times (20 - 4) \times 6.3\text{ kA} = \pm 0.504\text{ kA}$
- ±0.25% of reading or ±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 × 4.2 kA, 0.001 × 5 kA) + 0.504 kA = 0.515 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 should be monitored in the range from 70% to 110% of nominal.

5

The minimum and maximum positive-sequence voltages to be monitored are:

$$V_{min} = 0.7 \times \frac{400\text{ kV}}{\sqrt{3}} = 161.66\text{ kV},\quad V_{max} = 1.1 \times \frac{400\text{ kV}}{\sqrt{3}} = 254.03\text{ kV} \quad \textbf{(EQ 5.37)}$$

The base unit for voltage (refer to the *FlexElements* section in this chapter for additional details) is:

$$V_{BASE} = 0.0664\text{ kV} \times 6024 = 400\text{ kV} \quad \textbf{(EQ 5.38)}$$

The minimum and maximum voltage values to be monitored (in pu) are:

$$\text{minimum voltage} = \frac{161.66\text{ kV}}{400\text{ kV}} = 0.404\text{ pu},\quad \text{maximum voltage} = \frac{254.03\text{ kV}}{400\text{ kV}} = 0.635\text{ pu} \quad \textbf{(EQ 5.39)}$$

The following settings should be 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" (refer to 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:

- ±0.5% of the full scale for the analog output module, or $\pm 0.005 \times (1 - 0) \times 254.03\text{ kV} = \pm 1.27\text{ kV}$
- ±0.5% of reading

For example, under nominal conditions, the positive-sequence reads 230.94 kV and the worst-case error is 0.005 x 230.94 kV + 1.27 kV = 2.42 kV.

5.10.1 TEST MODE

PATH: SETTINGS ⇨⇩ TESTING ⇨ TEST MODE

■■ SETTINGS ■■ TESTING	◁▷	TEST MODE FUNCTION: Disabled	*Range: Disabled, Isolated, Forcible*
MESSAGE	△	TEST MODE FORCING: On	*Range: FlexLogic operand*

The L30 provides a test facility to verify the functionality of contact inputs and outputs, some communication channels and the phasor measurement unit (where applicable), using simulated conditions. The test mode is indicated on the relay faceplate by a Test Mode LED indicator.

The test mode may be in any of three states: disabled, isolated, or forcible.

In the “Disabled” mode, L30 operation is normal and all test features are disabled.

In the “Isolated” mode, the L30 is prevented from performing certain control actions, including tripping via contact outputs. All relay contact outputs, including latching outputs, are disabled. Channel tests and phasor measurement unit tests remain usable on applicable UR-series models.

In the “Forcible” mode, the operand selected by the **TEST MODE FORCING** setting controls the relay inputs and outputs. If the test mode is forcible, and the operand assigned to the **TEST MODE FORCING** setting is “Off”, the L30 inputs and outputs operate normally. If the test mode is forcible, and the operand assigned to the **TEST MODE FORCING** setting is “On”, the L30 contact inputs and outputs are forced to the values specified in the following sections. Forcing may be controlled by manually changing the operand selected by the **TEST MODE FORCING** setting between on and off, or by selecting a user-programmable pushbutton, contact input, or communication-based input operand. Channel tests and phasor measurement unit tests remain usable on applicable UR-series models.

NOTE

Communications based inputs and outputs remain fully operational in test mode. If a control action is programmed using direct inputs and outputs or remote inputs and outputs, then the test procedure must take this into account.

When in “Forcible” mode, the operand selected by the **TEST MODE FORCING** setting dictates further response of the L30 to testing conditions. To force contact inputs and outputs through relay settings, set **TEST MODE FORCING** to “On”. To force contact inputs and outputs through a user-programmable condition, such as FlexLogic operand (pushbutton, digital input, communication-based input, or a combination of these), set **TEST MODE FORCING** to the desired operand. The contact input or output is forced when the selected operand assumes a logic 1 state.

The L30 remains fully operational in test mode, allowing for various testing procedures. In particular, the protection and control elements, FlexLogic, and communication-based inputs and outputs function normally.

The only difference between the normal operation and the test mode is the behavior of the input and output contacts. The contact inputs can be forced to report as open or closed or remain fully operational, whereas the contact outputs can be forced to open, close, freeze, or remain fully operational. The response of the digital input and output contacts to the test mode is programmed individually for each input and output using the force contact inputs and force contact outputs test functions described in the following sections.

The test mode state is indicated on the relay faceplate 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 5–33: TEST MODE OPERATION

TEST MODE FUNCTION	TEST MODE FORCING OPERAND	IN-SERVICE LED	TEST MODE LED	CRITICAL FAIL RELAY	INPUT AND OUTPUT BEHAVIOR
Disabled	No effect	Unaffected	Off	Unaffected	Contact outputs and inputs are under normal operation. Channel tests and PMU tests not operational (where applicable).
Isolated	No effect	Off	On	De-energized	Contact outputs are disabled and contact inputs are operational. Channel tests and PMU tests are also operational (where applicable).
Forcible	On (logic 1)	Off	Flashing	De-energized	Contact inputs and outputs are controlled by the force contact input and force contact output functions. Channel tests and PMU tests are operational (where applicable).
	Off (logic 0)	Off	Flashing	De-energized	Contact outputs and inputs are under normal operation. Channel tests and PMU tests are also operational (where applicable).

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 will remain at the last programmed value. This allows a L30 that has been placed in isolated mode to remain isolated during testing and maintenance activities. On restart, the **TEST MODE FORCING** setting and the force contact input and force contact output settings all revert to their default states.

5.10.2 FORCE CONTACT INPUTS

PATH: SETTINGS ⇨⇩ TESTING ⇨⇩ FORCE CONTACT INPUTS

```
■ FORCE CONTACT        FORCE Cont Ip 1        Range: Disabled, Open, Closed
■ INPUTS               :Disabled

              MESSAGE  FORCE Cont Ip 2        Range: Disabled, Open, Closed
                       :Disabled
                           ↓
              MESSAGE  FORCE Cont Ip xx       Range: Disabled, Open, Closed
                       :Disabled
```

The relay digital inputs (contact inputs) could be pre-programmed to respond to the test mode in the following ways:

- If set to “Disabled”, 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. This value should be selected 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) for the entire duration of the test mode regardless of the voltage across the input terminals.
- If set to “Closed”, the input is forced to report as closed (Logic 1) for the entire duration of the test mode regardless of the voltage across the input terminals.

The force contact inputs feature provides a method of performing checks on the function of all contact inputs. Once enabled, the relay is placed into test mode, allowing this feature to override the normal function of contact inputs. The Test Mode LED will be on, indicating that the relay is in test mode. The state of each contact input may be programmed as “Disabled”, “Open”, or “Closed”. All contact input operations return to normal when all settings for this feature are disabled.

5.10.3 FORCE CONTACT OUTPUTS

PATH: SETTINGS ⇨⇩ TESTING ⇨⇩ FORCE CONTACT OUTPUTS

■ FORCE CONTACT ■ OUTPUTS	◀▶	FORCE Cont Op 1 :Disabled	*Range: Disabled, Energized, De-energized, Freeze*
MESSAGE	▲▼	FORCE Cont Op 2 :Disabled	*Range: Disabled, Energized, De-energized, Freeze*
		↓	
MESSAGE	▲	FORCE Cont Op xx :Disabled	*Range: Disabled, Energized, De-energized, Freeze*

The relay contact outputs can be pre-programmed to respond to the test mode.

If set to “Disabled”, the contact output remains fully operational. If operates when its control operand is logic 1 and will resets when its control operand is logic 0. If set to “Energized”, the output will close and remain closed for the entire duration of the test mode, regardless of the status of the operand configured to control the output contact. If set to “De-energized”, the output will open and remain opened for the entire duration of the test mode regardless of the status of the operand configured to control the output contact. If set to “Freeze”, the output retains its position from before entering the test mode, regardless of the status of the operand configured to control the output contact.

These settings are applied two ways. First, external circuits may be tested by energizing or de-energizing contacts. Second, by controlling the output contact state, relay logic may be tested and undesirable effects on external circuits avoided.

Example 1: Initiating test mode through user-programmable pushbutton 1

For example, the test mode can be initiated from user-programmable pushbutton 1. The pushbutton will be programmed as “Latched” (pushbutton pressed to initiate the test, and pressed again to terminate the test). During the test, digital input 1 should remain operational, digital inputs 2 and 3 should open, and digital input 4 should close. Also, contact output 1 should freeze, contact output 2 should open, contact output 3 should close, and contact output 4 should remain fully operational. The required settings are shown below.

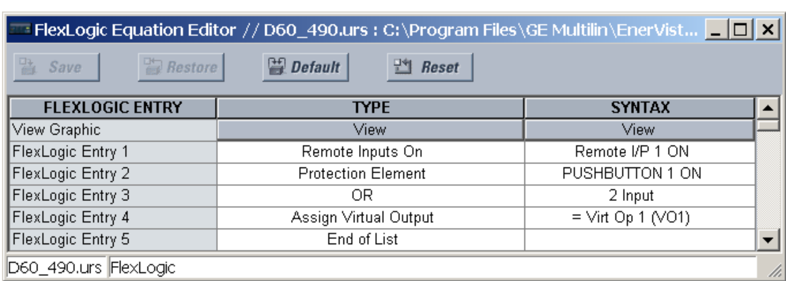
To enable user-programmable pushbutton 1 to initiate the test mode, make the following changes in the **SETTINGS ⇨⇩ TESTING ⇨ TEST MODE** menu: **TEST MODE FUNCTION:** “Enabled” and **TEST MODE INITIATE:** “PUSHBUTTON 1 ON”

Make the following changes to configure the contact inputs and outputs. In the **SETTINGS ⇨⇩ TESTING ⇨⇩ FORCE CONTACT INPUTS** and **FORCE CONTACT OUTPUTS** menus, set:

FORCE Cont Ip 1: “Disabled”, **FORCE Cont Ip 2:** “Open”, **FORCE Cont Ip 3:** “Open”, and **FORCE Cont Ip 4:** “Closed”
FORCE Cont Op 1: “Freeze”, **FORCE Cont Op 2:** “De-energized”, **FORCE Cont Op 3:** “Energized”,
and **FORCE Cont Op 4:** “Disabled”

Example 2: Initiating a test from user-programmable pushbutton 1 or through remote input 1

In this example, the test can be initiated locally from user-programmable pushbutton 1 or remotely through remote input 1. Both the pushbutton and the remote input will be programmed as “Latched”. Write the following FlexLogic equation:


FlexLogic Equation Editor // D60_490.urs : C:\Program Files\GE Multilin\EnerVist...

Save | Restore | Default | Reset

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Remote Inputs On	Remote I/P 1 ON
FlexLogic Entry 2	Protection Element	PUSHBUTTON 1 ON
FlexLogic Entry 3	OR	2 Input
FlexLogic Entry 4	Assign Virtual Output	= Virt Op 1 (VO1)
FlexLogic Entry 5	End of List	

D60_490.urs | FlexLogic

Set the user-programmable pushbutton as latching by changing **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE PUSHBUTTONS ⇨ USER PUSHBUTTON 1 ⇨ PUSHBUTTON 1 FUNCTION** to “Latched”. To enable either pushbutton 1 or remote input 1 to initiate the Test mode, make the following changes in the **SETTINGS ⇨⇩ TESTING ⇨ TEST MODE** menu:

TEST MODE FUNCTION: “Enabled” and **TEST MODE INITIATE:** “VO1”

5.10.4 CHANNEL TESTS

PATH: SETTINGS ⇨⇩ TESTING ⇨⇩ CHANNEL TESTS

■ CHANNEL TESTS ■		■ LOCAL LOOPBACK ■
MESSAGE		■ REMOTE LOOPBACK ■

This function performs checking of the communications established by both relays.

■ LOCAL LOOPBACK ■		LOCAL LOOPBACK FUNCTION: No	Range: Yes, No
MESSAGE		LOCAL LOOPBACK CHANNEL NUMBER: 1	Range: 1, 2

■ REMOTE LOOPBACK ■		REMOTE LOOPBACK FUNCTION: No	Range: Yes, No
MESSAGE		REMOTE LOOPBACK CHANNEL NUMBER: 1	Range: 1, 2

Refer to the *Commissioning* chapter for a detailed description of using the channel tests.

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5.10.5 PHASOR MEASUREMENT UNIT TEST VALUES

PATH: SETTINGS ⇨⇩ TESTING ⇨⇩ PMU TEST VALUES ⇨ PMU 1 TEST VALUES

■ PMU 1 ■ TEST VALUES		PMU 1 TEST FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE		PMU 1 VA TEST MAGNITUDE: 500.00 kV	Range: 0.00 to 700.00 kV in steps of 0.01
MESSAGE		PMU 1 VA TEST ANGLE: 0.00°	Range: –180.00 to 180.00° in steps of 0.05
MESSAGE		PMU 1 VB TEST MAGNITUDE: 500.00 kV	Range: 0.00 to 700.00 kV in steps of 0.01
MESSAGE		PMU 1 VB TEST ANGLE: –120.00°	Range: –180.00 to 180.00° in steps of 0.05
MESSAGE		PMU 1 VC TEST MAGNITUDE: 500.00 kV	Range: 0.00 to 700.00 kV in steps of 0.01
MESSAGE		PMU 1 VC TEST ANGLE: 120.00°	Range: –180.00 to 180.00° in steps of 0.05
MESSAGE		PMU 1 VX TEST MAGNITUDE: 500.00 kV	Range: 0.00 to 700.00 kV in steps of 0.01
MESSAGE		PMU 1 VX TEST ANGLE: 0.00°	Range: –180.00 to 180.00° in steps of 0.05
MESSAGE		PMU 1 IA TEST MAGNITUDE: 1.000 kA	Range: 0.000 to 9.999 kA in steps of 0.001
MESSAGE		PMU 1 IA TEST ANGLE: –10.00°	Range: –180.00 to 180.00° in steps of 0.05

MESSAGE	▲▼	PMU 1 IB TEST MAGNITUDE: 1.000 kA	Range: 0.000 to 9.999 kA in steps of 0.001
MESSAGE	▲▼	PMU 1 IB TEST ANGLE: –130.00°	Range: –180.00 to 180.00° in steps of 0.05
MESSAGE	▲▼	PMU 1 IC TEST MAGNITUDE: 1.000 kA	Range: 0.000 to 9.999 kA in steps of 0.001
MESSAGE	▲▼	PMU 1 IC TEST ANGLE: 110.00°	Range: –180.00 to 180.00° in steps of 0.05
MESSAGE	▲▼	PMU 1 IG TEST MAGNITUDE: 0.000 kA	Range: 0.000 to 9.999 kA in steps of 0.001
MESSAGE	▲▼	PMU 1 IG TEST ANGLE: 0.00°	Range: –180.00 to 180.00° in steps of 0.05
MESSAGE	▲▼	PMU 1 TEST FREQUENCY: 60.000 Hz	Range: 20.000 to 60.000 Hz in steps of 0.001
MESSAGE	▲	PMU 1 TEST df/dt: 0.000 Hz/s	Range: –10.000 to 10.000 Hz/s 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 C37.118 client that test values are being sent in place of the real measurements.

The UR Synchrophasor Implementation defines a test mode which 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:

a. The Data Invalid / Test Mode bit (bit 15 in the STAT word) is set.

b. The Sim bit in all output datasets is set.

6.1.1 ACTUAL VALUES MENU

Menu	Item	Reference
ACTUAL VALUES STATUS	CONTACT INPUTS	See page 6-3.
	VIRTUAL INPUTS	See page 6-3.
	REMOTE INPUTS	See page 6-3.
	REMOTE DPS INPUTS	See page 6-4.
	DIRECT INPUTS	See page 6-4.
	CONTACT OUTPUTS	See page 6-4.
	VIRTUAL OUTPUTS	See page 6-5.
	AUTORECLOSE	See page 6-5.
	REMOTE DEVICES STATUS	See page 6-5.
	REMOTE DEVICES STATISTICS	See page 6-6.
	CHANNEL TESTS	See page 6-6.
	DIGITAL COUNTERS	See page 6-7.
	SELECTOR SWITCHES	See page 6-7.
	FLEX STATES	See page 6-8.
	IEC 61850 GOOSE UINTEGERS	See page 6-8.
	ETHERNET	See page 6-8.
	REAL TIME CLOCK SYNCHRONIZING	See page 6-9.
	COMM STATUS REMAINING CONNECT	See page 6-10.
	PRP	See page 6-10.
ACTUAL VALUES METERING	87L DIFFERENTIAL CURRENT	See page 6-14.
	SOURCE SRC 1	See page 6-15.

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Menu	Submenu	Reference
	SOURCE SRC 2	
	SYNCHROCHECK	See page 6-18.
	TRACKING FREQUENCY	See page 6-18.
	FLEXELEMENTS	See page 6-19.
	IEC 61850 GOOSE ANALOGS	See page 6-19.
	PHASOR MEASUREMENT UNIT	See page 6-20.
	PMU AGGREGATOR	See page 6-21.
	TRANSDUCER I/O DCMA INPUTS	See page 6-21.
	TRANSDUCER I/O RTD INPUTS	See page 6-21.
ACTUAL VALUES RECORDS	FAULT REPORTS	See page 6-22.
	EVENT RECORDS	See page 6-22.
	OSCILLOGRAPHY	See page 6-23.
	DATA LOGGER	See page 6-23.
	PMU RECORDS	See page 6-23.
	MAINTENANCE	See page 6-24.
ACTUAL VALUES PRODUCT INFO	MODEL INFORMATION	See page 6-25.
	FIRMWARE REVISIONS	See page 6-25.

NOTE

For status reporting, ‘On’ represents Logic 1 and ‘Off’ represents Logic 0.

6.2.1 CONTACT INPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨ CONTACT INPUTS

■ CONTACT INPUTS ■		Cont Ip 1 Off	Range: On, Off
	MESSAGE	Cont Ip 2 Off	Range: On, Off
		↓	
	MESSAGE	Cont Ip xx Off	Range: On, Off

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.

6.2.2 VIRTUAL INPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ VIRTUAL INPUTS

■ VIRTUAL INPUTS ■		Virt Ip 1 Off	Range: On, Off
	MESSAGE	Virt Ip 2 Off	Range: On, Off
		↓	
	MESSAGE	Virt Ip 64 Off	Range: On, Off

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.

6.2.3 REMOTE INPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE INPUTS

■ REMOTE INPUTS ■		REMOTE INPUT 1 STATUS: Off	Range: On, Off
	MESSAGE	REMOTE INPUT 2 STATUS: Off	Range: On, Off
		↓	
	MESSAGE	REMOTE INPUT 32 STATUS: Off	Range: On, Off

The present state of the 32 remote inputs is shown here.

The state displayed will be that of the remote point unless the remote device has been established to be “Offline” in which case the value shown is the programmed default state for the remote input.

6.2.4 REMOTE DOUBLE-POINT STATUS INPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE DPS INPUTS

■ REMOTE DPS INPUTS ■	◁▷	REMOTE DPS INPUT 1 STATUS: Bad	Range: On, Off, Intermediate, Bad
MESSAGE	△▽	REMOTE DPS INPUT 2 STATUS: Bad	Range: On, Off, Intermediate, Bad
		↓	
MESSAGE	△	REMOTE DPS INPUT 5 STATUS: Bad	Range: On, Off, Intermediate, Bad

The present state of the remote double-point status inputs is shown here. The actual values indicate if the remote double-point status inputs are in the on (close), off (open), intermediate, or bad state.

6.2.5 DIRECT INPUTS

PATH: ACTUAL VALUES ⇩ STATUS ⇨⇩ DIRECT INPUTS

■ DIRECT INPUTS ■	◁▷	DIRECT INPUT 1-1: Off	Range: On, Off
MESSAGE	△▽	DIRECT INPUT 1-2: Off	Range: On, Off
		↓	
MESSAGE	△▽	DIRECT INPUT 1-8: Off	Range: On, Off
MESSAGE	△▽	DIRECT INPUT 2-1: Off	Range: On, Off
MESSAGE	△▽	DIRECT INPUT 2-2: Off	Range: On, Off
		↓	
MESSAGE	△	DIRECT INPUT 2-8: Off	Range: On, Off

The present state of the direct inputs from communications channels 1 and 2 are shown here. The state displayed will be 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.

6.2.6 CONTACT OUTPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ CONTACT OUTPUTS

■ CONTACT OUTPUTS ■	◁▷	Cont Op 1 Off	Range: On, Off, VOff, VOn, IOn, IOff
MESSAGE	△▽	Cont Op 2 Off	Range: On, Off, VOff, VOn, IOn, IOff
		↓	
MESSAGE	△	Cont Op xx Off	Range: On, Off, VOff, VOn, IOn, IOff

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.

NOTE

For form-A contact outputs, the state of the voltage and current detectors is displayed as Off, VOff, IOff, On, IOn, and VOn. For form-C contact outputs, the state is displayed as Off or On.

6.2.7 VIRTUAL OUTPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ VIRTUAL OUTPUTS

■ VIRTUAL OUTPUTS ■		Virt Op 1 Off	*Range: On, Off*
	MESSAGE	Virt Op 2 Off	*Range: On, Off*
		↓	
	MESSAGE	Virt Op 96 Off	*Range: On, Off*

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.

6.2.8 AUTORECLOSE

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ AUTORECLOSE ⇨ AUTORECLOSE 1

■ AUTORECLOSE 1 ■		AUTORECLOSE 1 SHOT COUNT: 0	*Range: 0, 1, 2, 3, 4*

The automatic reclosure shot count is shown here.

6.2.9 REMOTE DEVICES

a) STATUS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE DEVICES STATUS

■ REMOTE DEVICES ■ STATUS		All REMOTE DEVICES ONLINE: No	*Range: Yes, No*
	MESSAGE	REMOTE DEVICE 1 STATUS: Offline	*Range: Online, Offline*
	MESSAGE	REMOTE DEVICE 2 STATUS: Offline	*Range: Online, Offline*
		↓	
	MESSAGE	REMOTE DEVICE 16 STATUS: Offline	*Range: Online, Offline*

The present state of the programmed remote devices is shown here. The **ALL REMOTE DEVICES ONLINE** message indicates whether or not all programmed remote devices are online. If the corresponding state is "No", then at least one required remote device is not online.

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b) STATISTICS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE DEVICES STATISTICS ⇨ REMOTE DEVICE 1(16)

Menu		Display	Range
■ REMOTE DEVICE 1 ■	◀▶	REMOTE DEVICE 1 StNum: 0	
	MESSAGE	REMOTE DEVICE 1 SqNum: 0	

Statistical data (two types) for up to 16 programmed remote devices is shown here.

The **STNUM** number is obtained from the indicated remote device and increments whenever a change of state of at least one item occurs in the GSSE/GOOSE message. The **SQNUM** number is obtained from the indicated remote device and increments whenever a GSSE/GOOSE message, without a state change, is sent. When the GSSE/GOOSE message trasmits a state change, the **SQNUM** resets to 0. This number rolls over to zero when a count of 4,294,967,295 is incremented.

6.2.10 CHANNEL TESTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ CHANNEL TESTS

Menu		Display	Range
■ CHANNEL TESTS ■	◀▶	CHANNEL 1 STATUS: n/a	*Range: n/a, FAIL, OK*
	MESSAGE	CHANNEL 1 LOST PACKETS: 0	*Range: 0 to 65535 in steps of 1. Reset count to 0 through the* **COMMANDS ⇨⇩ CLEAR RECORDS** *menu.*
	MESSAGE	CHANNEL 1 LOCAL LOOPBCK STATUS: n/a	*Range: n/a, FAIL, OK*
	MESSAGE	CHANNEL 1 REMOTE LOOPBCK STATUS: n/a	*Range: n/a, FAIL, OK*
	MESSAGE	CHANNEL 1 LOOP DELAY: 0.0 ms	
	MESSAGE	CHANNEL 1 ASYMMETRY: +0.0 ms	*Range: –10 to 10 ms in steps of 0.1*
	MESSAGE	CHANNEL 2 STATUS: n/a	*Range: n/a, FAIL, OK*
	MESSAGE	CHANNEL 2 LOST PACKETS: 0	*Range: 0 to 65535 in steps of 1. Reset count to 0 through the* **COMMANDS ⇨⇩ CLEAR RECORDS** *menu.*
	MESSAGE	CHANNEL 2 LOCAL LOOPBCK STATUS: n/a	*Range: n/a, FAIL, OK*
	MESSAGE	CHANNEL 2 REMOTE LOOPBCK STATUS: n/a	*Range: n/a, FAIL, OK*
	MESSAGE	CHANNEL 2 LOOP DELAY: 0.0 ms	
	MESSAGE	CHANNEL 2 ASYMMETRY: +0.0 ms	*Range: –10 to 10 ms in steps of 0.1*
	MESSAGE	VALIDITY OF CHANNEL CONFIGURATION: n/a	*Range: n/a, FAIL, OK*
	MESSAGE	PFLL STATUS: n/a	*Range: n/a, FAIL, OK*

The status information for two channels is shown here. A brief description of each actual value is below:

- **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 ⇨⇩ CLEAR RECORDS menu.
- **CHANNEL 1(2) LOCAL LOOPBACK STATUS:** The result of the local loopback test is displayed here.
- **CHANNEL 1(2) REMOTE LOOPBACK STATUS**: The result of the remote loopback test is displayed 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).
- **CHANNEL 1(2) ASYMMETRY**: The result of channel asymmetry calculations derived from GPS signal is being displayed here for both channels if CHANNEL ASYMMETRY is "Enabled". A positive "+" sign indicates the transit delay in the transmitting direction is less than the delay in the receiving direction; a negative "–" sign indicates 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 can not 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, is displayed here. If a remote relay ID number does not match the programmed number at the local relay, the "FAIL" value is displayed. 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. Refer to SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ L90 POWER SYSTEM section for more information
- **PFLL STATUS**: This value represents the status of the phase and frequency locked loop (PFLL) filter which 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. If "n/a", then PFLL is disabled.

NOTE

At startup, the clocks of all terminals are not synchronized and the PFLL status displayed is "FAIL". It takes up to 8 seconds after startup for the value displayed to change from "FAIL" to "OK".

6.2.11 DIGITAL COUNTERS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ DIGITAL COUNTERS ⇨ DIGITAL COUNTERS Counter 1(8)

■ DIGITAL COUNTERS ■ Counter 1	◁▷	Counter 1 ACCUM: 0
MESSAGE	△▽	Counter 1 FROZEN: 0
MESSAGE	△▽	Counter 1 FROZEN: YYYY/MM/DD HH:MM:SS
MESSAGE	△	Counter 1 MICROS: 0

The present status of the eight digital counters is shown here. The status of each counter, with the user-defined counter name, includes the accumulated and frozen counts (the count units label will also appear). 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.

6.2.12 SELECTOR SWITCHES

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ SELECTOR SWITCHES

■ SELECTOR SWITCHES ■	◁▷	SELECTOR SWITCH 1 POSITION: 0/7	*Range: Current Position / 7*
MESSAGE	△	SELECTOR SWITCH 2 POSITION: 0/7	*Range: Current Position / 7*

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.

6.2.13 FLEX STATES

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ FLEX STATES

Menu		Display	Range
■ FLEX STATES ■	◀▶	PARAM 1: Off Off	Range: Off, On
MESSAGE	▲▼	PARAM 2: Off Off	Range: Off, On
		↓	
MESSAGE	▲	PARAM 256: Off Off	Range: Off, On

There are 256 FlexState™ bits available. The second line value indicates the state of the given FlexState bit.

6.2.14 IEC 61850 GOOSE INTEGERS

PATH: ACTUAL VALUES ⇨⇩ STATUS ⇨⇩ IEC 61850 GOOSE UINTEGERS

Menu		Display
■ IEC 61850 ■ GOOSE UINTEGERS	◀▶	UINT INPUT 1 0
MESSAGE	▲▼	UINT INPUT 2 0
		↓
MESSAGE	▲	UINT INPUT 16 0

SOFTWARE OPTION

The L30 Line Current Differential System is provided with optional IEC 61850 communications capability. This feature is specified as a software option at the time of ordering. Refer to the *Ordering* section of chapter 2 for additional details.

The IEC 61850 GGIO5 integer input data points are displayed in this menu. The GGIO5 integer data values are received via IEC 61850 GOOSE messages sent from other devices.

6.2.15 ETHERNET

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ ETHERNET

Menu		Display	Range
■ ETHERNET ■	◀▶	ETHERNET PRI LINK STATUS: Fail	Range: Fail, OK
MESSAGE	▲	ETHERNET SEC LINK STATUS: Fail	Range: Fail, OK
MESSAGE	▲	ETHERNET TRD LINK STATUS: Fail	Range: Fail, OK

These values indicate the status of the first, second, and third Ethernet links.

6.2.16 REAL TIME CLOCK SYNCHRONIZING

PATH: ACTUAL VALUES ⇨⇩ STATUS ⇨⇩ REAL TIME CLOCK SYNCHRONIZING

Menu		Display	Range
■ REAL TIME CLOCK ■ SYNCHRONIZING	◁▷	RTC Sync Source: None	Range: See text below
MESSAGE	△▽	GrandMaster ID: 0X0000000000000000	Range: Any 8 octet value
MESSAGE	△▽	Accuracy: 999,999,999 ns	Range: 0 to 999, 999, 999 ns
MESSAGE	△▽	Port 1 PTP State: NO SIGNAL	Range: Disabled, No Signal, Calibrating, Synch'd (No Pdelay), Synchronized
MESSAGE	△▽	Port 2 PTP State: NO SIGNAL	Range: Disabled, No Signal, Calibrating, Synch'd (No Pdelay), Synchronized
MESSAGE	△▽	Port 3 PTP State: NO SIGNAL	Range: Disabled, No Signal, Calibrating, Synch'd (No Pdelay), Synchronized
MESSAGE	△	PTP - IRIG-B Delta: 500,000,000 ns	Range: -500,000,000 to +500,000,000 ns

The 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, SNTP, and None.

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, and
- **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.

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6.2.17 REMAINING CONNECTION STATUS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ COMM STATUS REMAINING CONNECT

■ COMM STATUS ■ REMAINING CONNECT	◁▷	MMS (max 5) 5	Range: 0 to 5
MESSAGE	△▽	MODBUS TCP (max 4) 4	Range: 0 to 4
MESSAGE	△▽	DNP (max 2) 2	Range: 0 to 2
MESSAGE	△▽	IEC-104 (max 2) 2	Range: 0 to 2
MESSAGE	△	PMU TCP (max 4) 4	Range: 0 to 4

These values specify the remaining number of TCP connections still available for each protocol. Every 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.

Note that the maximum number of PMU TCP connections matches the number of aggregators.

6.2.18 PARALLEL REDUNDANCY PROTOCOL (PRP)

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The Parallel Redundancy Protocol (PRP) defines a redundancy protocol for high availability in substation automation networks.

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ PRP

■ PRP ■	◁▷	Total Rx Port A:	Range: 0 to 4G, blank if PRP disabled
MESSAGE	△▽	Total Rx Port B:	Range: 0 to 4G, blank if PRP disabled
MESSAGE	△▽	Total Errors:	Range: 0 to 4G, blank if PRP disabled
MESSAGE	△▽	Mismatches Port A:	Range: 0 to 4G, blank if PRP disabled
MESSAGE	△	Mismatches Port B:	Range: 0 to 4G, blank if PRP disabled

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).

6.3.1 METERING CONVENTIONS

a) UR CONVENTION FOR MEASURING POWER AND ENERGY

The following figure illustrates the conventions established for use in UR-series relays.

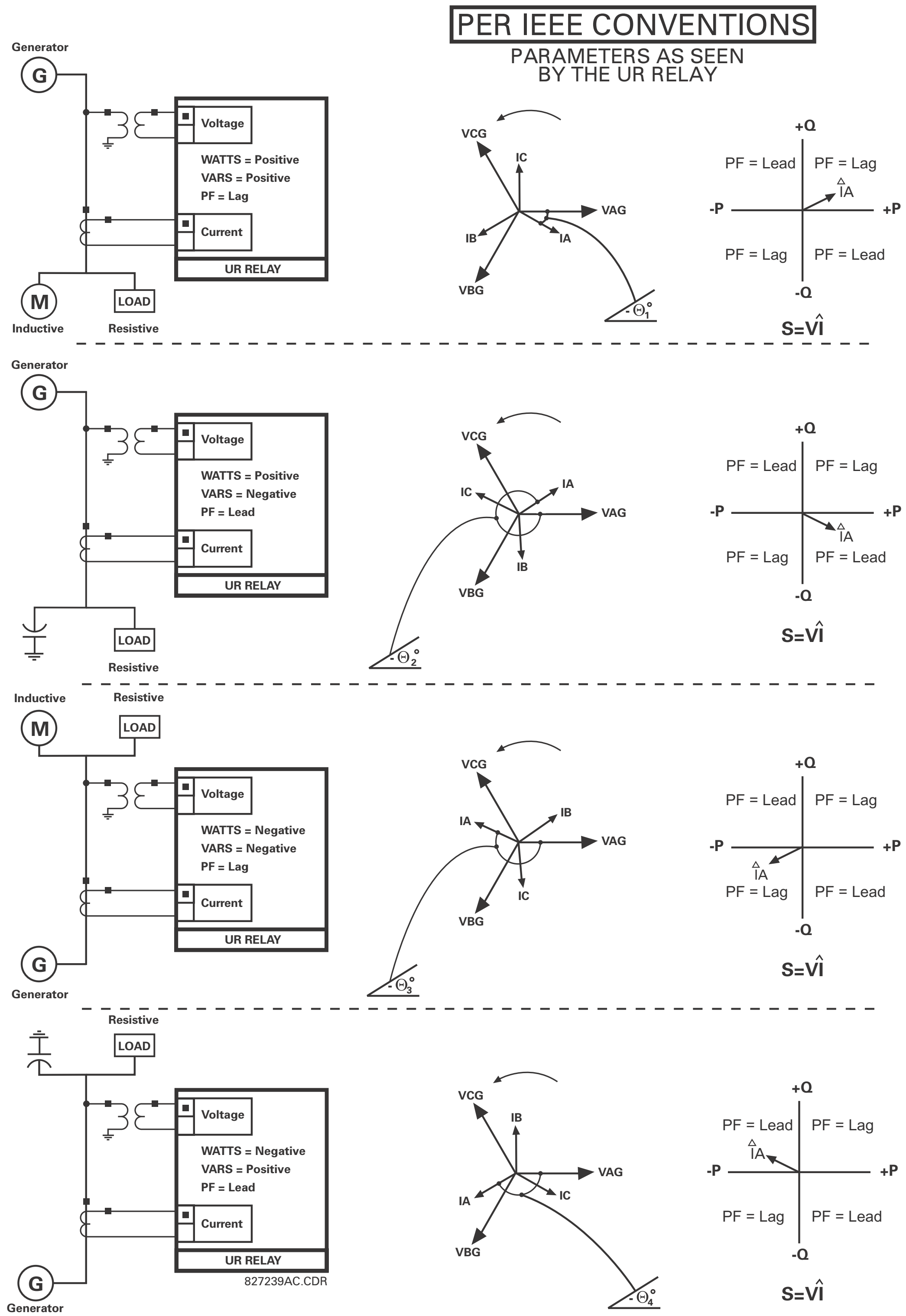

Figure 6–1: FLOW DIRECTION OF SIGNED VALUES FOR WATTS AND VARS

b) UR CONVENTION FOR MEASURING PHASE ANGLES

All phasors calculated by UR-series relays 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 will first determine 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. This is illustrated below.

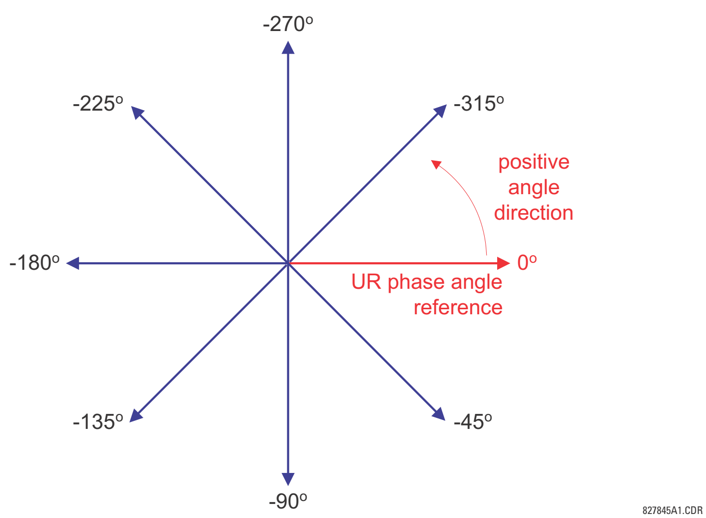

Figure 6–2: UR PHASE ANGLE MEASUREMENT CONVENTION

c) UR CONVENTION FOR MEASURING SYMMETRICAL COMPONENTS

The UR-series of relays 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:

$$V\_0 = N/A$$
$$V\_1 = \frac{1\angle -30°}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$
$$V\_2 = \frac{1\angle 30°}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$

- ACB phase rotation:

$$V\_0 = N/A$$
$$V\_1 = \frac{1\angle 30°}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$
$$V\_2 = \frac{1\angle -30°}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$

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 *VAG* and *VAB*, 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.

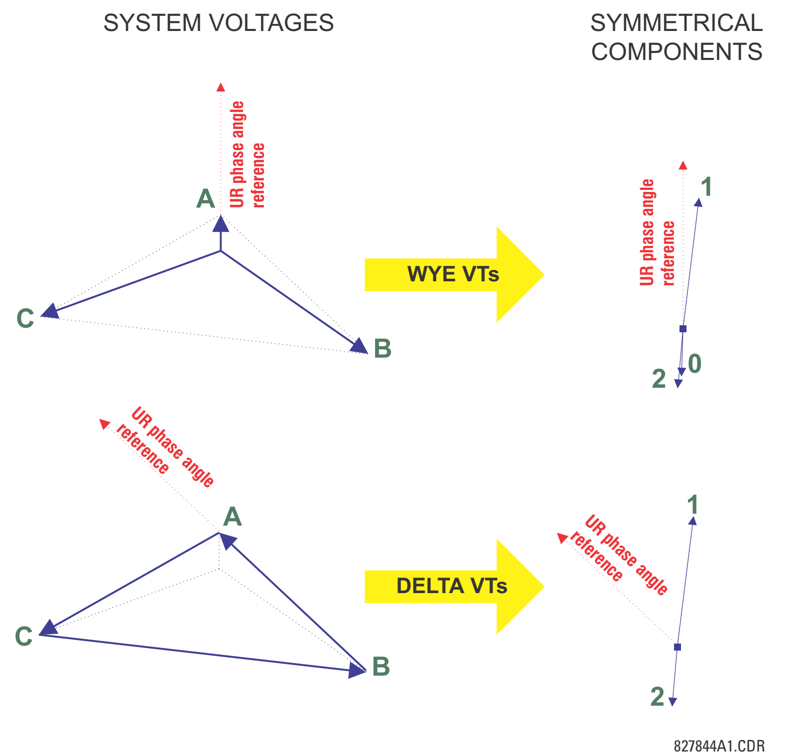

Figure 6–3: MEASUREMENT CONVENTION FOR SYMMETRICAL COMPONENTS

6.3.2 DIFFERENTIAL CURRENT

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ 87L DIFFERENTIAL CURRENT

■ 87L DIFFERENTIAL ■ CURRENT	◁▷	LOCAL IA: 0.000 A 0.0°
MESSAGE	▲▼	LOCAL IB: 0.000 A 0.0°
MESSAGE	▲▼	LOCAL IC: 0.000 A 0.0°
MESSAGE	▲▼	TERMINAL 1 IA: 0.000 A 0.0°
MESSAGE	▲▼	TERMINAL 1 IB: 0.000 A 0.0°
MESSAGE	▲▼	TERMINAL 1 IC: 0.000 A 0.0°
MESSAGE	▲▼	TERMINAL 2 IA: 0.000 A 0.0°
MESSAGE	▲▼	TERMINAL 2 IB: 0.000 A 0.0°
MESSAGE	▲▼	TERMINAL 2 IC: 0.000 A 0.0°
MESSAGE	▲▼	IA DIFF. CURRENT: 0.000 A 0.0°
MESSAGE	▲▼	IA RESTR. CURRENT: 0.000 A
MESSAGE	▲▼	IB DIFF. CURRENT: 0.000 A 0.0°
MESSAGE	▲▼	IB RESTR. CURRENT: 0.000 A
MESSAGE	▲▼	IC DIFF. CURRENT: 0.000 A 0.0°
MESSAGE	▲▼	IC RESTR. CURRENT: 0.000 A
MESSAGE	▲▼	IG DIFF. CURRENT: 0.000 A 0.0°
MESSAGE	▲	IG RESTR. CURRENT: 0.000 A

The metered current values are displayed 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 are displayed for the local relay.

NOTE

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.

6.3.3 SOURCES

a) MAIN MENU

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ SOURCE SRC1

Menu	Key	Display	Reference
■ SOURCE SRC 1 ■	◁▷	■ PHASE CURRENT ■ SRC 1	See page 6-15.
MESSAGE	△▽	■ GROUND CURRENT ■ SRC 1	See page 6-16.
MESSAGE	△▽	■ PHASE VOLTAGE ■ SRC 1	See page 6-16.
MESSAGE	△▽	■ AUXILIARY VOLTAGE ■ SRC 1	See page 6-17.
MESSAGE	△▽	■ POWER ■ SRC 1	See page 6-17.
MESSAGE	△	■ FREQUENCY ■ SRC 1	See page 6-18.

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 will be unavailable.

b) PHASE CURRENT METERING

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ SOURCE SRC 1 ⇨ PHASE CURRENT

Menu	Key	Display
■ PHASE CURRENT ■ SRC 1	◁▷	SRC 1 RMS Ia: 0.000 b: 0.000 c: 0.000 A
MESSAGE	△▽	SRC 1 RMS Ia: 0.000 A
MESSAGE	△▽	SRC 1 RMS Ib: 0.000 A
MESSAGE	△▽	SRC 1 RMS Ic: 0.000 A
MESSAGE	△▽	SRC 1 RMS In: 0.000 A
MESSAGE	△▽	SRC 1 PHASOR Ia: 0.000 A 0.0°
MESSAGE	△▽	SRC 1 PHASOR Ib: 0.000 A 0.0°
MESSAGE	△▽	SRC 1 PHASOR Ic: 0.000 A 0.0°
MESSAGE	△▽	SRC 1 PHASOR In: 0.000 A 0.0°
MESSAGE	△▽	SRC 1 ZERO SEQ I0: 0.000 A 0.0°
MESSAGE	△▽	SRC 1 POS SEQ I1: 0.000 A 0.0°

MESSAGE	SRC 1 NEG SEQ I2: 0.000 A 0.0°

The metered phase current values are displayed in this menu. The "SRC 1" text will be replaced by whatever name was programmed by the user for the associated source (see **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES**).

c) GROUND CURRENT METERING

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ SOURCE SRC 1 ⇨⇩ GROUND CURRENT

■ GROUND CURRENT ■ SRC 1	SRC 1 RMS Ig: 0.000 A
MESSAGE	SRC 1 PHASOR Ig: 0.000 A 0.0°
MESSAGE	SRC 1 PHASOR Igd: 0.000 A 0.0°

The metered ground current values are displayed in this menu. The "SRC 1" text will be replaced by whatever name was programmed by the user for the associated source (see **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES**).

d) PHASE VOLTAGE METERING

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ SOURCE SRC 1 ⇨ PHASE VOLTAGE

■ PHASE VOLTAGE ■ SRC 1	SRC 1 RMS Vag: 0.00 V
MESSAGE	SRC 1 RMS Vbg: 0.00 V
MESSAGE	SRC 1 RMS Vcg: 0.00 V
MESSAGE	SRC 1 PHASOR Vag: 0.000 V 0.0°
MESSAGE	SRC 1 PHASOR Vbg: 0.000 V 0.0°
MESSAGE	SRC 1 PHASOR Vcg: 0.000 V 0.0°
MESSAGE	SRC 1 RMS Vab: 0.00 V
MESSAGE	SRC 1 RMS Vbc: 0.00 V
MESSAGE	SRC 1 RMS Vca: 0.00 V
MESSAGE	SRC 1 PHASOR Vab: 0.000 V 0.0°
MESSAGE	SRC 1 PHASOR Vbc: 0.000 V 0.0°
MESSAGE	SRC 1 PHASOR Vca: 0.000 V 0.0°
MESSAGE	SRC 1 ZERO SEQ V0: 0.000 V 0.0°

```
MESSAGE   SRC 1   POS SEQ V1:
           0.000  V        0.0°

MESSAGE   SRC 1   NEG SEQ V2:
           0.000  V        0.0°
```

The metered phase voltage values are displayed in this menu. The "SRC 1" text will be replaced by whatever name was programmed by the user for the associated source (see **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES**).

e) AUXILIARY VOLTAGE METERING

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ SOURCE SRC 1 ⇨⇩ AUXILIARY VOLTAGE

```
■ AUXILIARY VOLTAGE          SRC 1   RMS Vx:
■ SRC 1                       0.00  V

MESSAGE                      SRC 1   PHASOR Vx:
                              0.000  V        0.0°
```

The metered auxiliary voltage values are displayed in this menu. The "SRC 1" text will be replaced by whatever name was programmed by the user for the associated source (see **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES**).

f) POWER METERING

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ SOURCE SRC 1 ⇨⇩ POWER

```
■ POWER                      SRC 1   REAL POWER
■ SRC 1                      3ϕ:   0.000  W

MESSAGE                      SRC 1   REAL POWER
                             ϕa:   0.000  W

MESSAGE                      SRC 1   REAL POWER
                             ϕb:   0.000  W

MESSAGE                      SRC 1   REAL POWER
                             ϕc:   0.000  W

MESSAGE                      SRC 1   REACTIVE PWR
                             3ϕ:   0.000  var

MESSAGE                      SRC 1   REACTIVE PWR
                             ϕa:   0.000  var

MESSAGE                      SRC 1   REACTIVE PWR
                             ϕb:   0.000  var

MESSAGE                      SRC 1   REACTIVE PWR
                             ϕc:   0.000  var

MESSAGE                      SRC 1   APPARENT PWR
                             3ϕ:   0.000  VA

MESSAGE                      SRC 1   APPARENT PWR
                             ϕa:   0.000  VA

MESSAGE                      SRC 1   APPARENT PWR
                             ϕb:   0.000  VA

MESSAGE                      SRC 1   APPARENT PWR
                             ϕc:   0.000  VA

MESSAGE                      SRC 1   POWER FACTOR
                             3ϕ:       1.000
```

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```
MESSAGE   SRC 1  POWER FACTOR
          φa:       1.000

MESSAGE   SRC 1  POWER FACTOR
          φb:       1.000

MESSAGE   SRC 1  POWER FACTOR
          φc:       1.000
```

The metered values for real, reactive, and apparent power, as well as power factor, are displayed in this menu. The "SRC 1" text will be replaced by whatever name was programmed by the user for the associated source (see **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES**).

g) FREQUENCY METERING

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ SOURCE SRC 1 ⇨⇩ FREQUENCY

```
■ FREQUENCY           SRC 1  FREQUENCY:
■ SRC 1                0.00 Hz
```

The metered frequency values are displayed in this menu. The "SRC 1" text will be replaced by whatever name was 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.

6.3.4 SYNCHROCHECK

6

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ SYNCHROCHECK ⇨ SYNCHROCHECK 1(2)

```
■ SYNCHROCHECK 1      SYNCHROCHECK 1 DELTA
■                     VOLT:   0.000 V

MESSAGE               SYNCHROCHECK 1 DELTA
                      PHASE:      0.0°

MESSAGE               SYNCHROCHECK 1 DELTA
                      FREQ:   0.00 Hz
```

The actual values menu for synchrocheck 2 is identical to that of synchrocheck 1. If a synchrocheck function setting is "Disabled", the corresponding actual values menu item will not be displayed.

6.3.5 TRACKING FREQUENCY

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ TRACKING FREQUENCY

```
■ TRACKING FREQUENCY  TRACKING FREQUENCY:
■                     60.00 Hz
```

The tracking frequency is displayed here. The frequency is tracked based on configuration of the reference source. The **TRACKING FREQUENCY** is based upon 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.

6.3.6 FLEXELEMENTS™

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ FLEXELEMENTS ⇨ FLEXELEMENT 1(8)

```
■ FLEXELEMENT 1          ◀▶   FLEXELEMENT 1
■                             OpSig: 0.000 pu
```

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

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
BREAKER ARCING AMPS (Brk X Arc Amp A, B, and C)	BASE = 2000 $kA^2 \times$ cycle
dcmA	BASE = maximum value of the **DCMA INPUT MAX** setting for the two transducers configured under the +IN and –IN inputs.
FREQUENCY	f_{BASE} = 1 Hz
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 $V_{BASE} \times I_{BASE}$ for the +IN and –IN inputs
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

6.3.7 IEC 61580 GOOSE ANALOG VALUES

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ IEC 61850 GOOSE ANALOGS

```
■ IEC 61850              ◀▶   ANALOG INPUT  1
■ GOOSE ANALOGS               0.000

              MESSAGE    ▲▼   ANALOG INPUT  2
                              0.000

              MESSAGE    ▲▼   ANALOG INPUT  3
                              0.000
                                    ↓
              MESSAGE    ▲    ANALOG INPUT 32
                              0.000
```

The L30 Line Current Differential System is provided with optional IEC 61850 communications capability. This feature is specified as a software option at the time of ordering. Refer to the *Ordering* section of chapter 2 for additional details.

The IEC 61850 GGIO3 analog input data points are displayed in this menu. The GGIO3 analog data values are received via IEC 61850 GOOSE messages sent from other devices.

6.3.8 PHASOR MEASUREMENT UNIT

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ PHASOR MEASUREMENT UNIT ⇨ PMU 1(4)

■ PMU 1 ■		PMU 1 VA: 0.0000 kV, 0.00°	Range: Va or Vab per VT bank connection
MESSAGE		PMU 1 VB: 0.0000 kV, 0.00°	Range: Va or Vab per VT bank connection
MESSAGE		PMU 1 VC: 0.0000 kV, 0.00°	Range: Va or Vab per VT bank connection
MESSAGE		PMU 1 VX: 0.0000 kV, 0.00°	
MESSAGE		PMU 1 V1: 0.0000 kV, 0.00°	
MESSAGE		PMU 1 V2: 0.0000 kV, 0.00°	
MESSAGE		PMU 1 V0: 0.0000 kV, 0.00°	Range: Substituted with zero if delta-connected VTs.
MESSAGE		PMU 1 IA: 0.0000 kA, 0.00°	
MESSAGE		PMU 1 IB: 0.0000 kA, 0.00°	
MESSAGE		PMU 1 IC: 0.0000 kA, 0.00°	
MESSAGE		PMU 1 IG: 0.0000 kA, 0.00°	
MESSAGE		PMU 1 I1: 0.0000 kA, 0.00°	
MESSAGE		PMU 1 I2: 0.0000 kA, 0.00°	
MESSAGE		PMU 1 I0: 0.0000 kA, 0.00°	
MESSAGE		PMU 1 FREQUENCY: 0.0000 Hz	
MESSAGE		PMU 1 df/dt: 0.0000 Hz/s	
MESSAGE		PMU 1 CONFIG CHANGE COUNTER: 0	Range: 0 to 65535

The above actual values are displayed 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.

6.3.9 PMU AGGREGATOR

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ PHASOR MEASUREMENT UNIT ⇨ PMU AGGREGATOR 1

```
■ PMU AGGREGATOR 1        PMU AGGREGATOR 1
■                    ◄►   PDU SIZE: 0
```

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.

6.3.10 TRANSDUCER INPUTS AND OUTPUTS

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ TRANSDUCER I/O DCMA INPUTS ⇨ DCMA INPUT xx

```
■ DCMA INPUT xx           DCMA INPUT xx
■                    ◄►   0.000 mA
```

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.

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ TRANSDUCER I/O RTD INPUTS ⇨ RTD INPUT xx

```
■ RTD INPUT xx            RTD INPUT xx
■                    ◄►   -50 °C
```

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

6.4.1 FAULT REPORTS

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨ FAULT REPORTS ⇨ FAULT REPORT 1(15)

NO FAULTS TO REPORT			
or			
■ FAULT REPORT 1 ■	◁▷	FAULT 1 LINE ID: SRC 1	*Range: SRC 1, SRC 2*
MESSAGE	△▽	FAULT 1 DATE: 2000/08/11	*Range: YYYY/MM/DD*
MESSAGE	△▽	FAULT 1 TIME: 00:00:00.000000	*Range: HH:MM:SS.ssssss*
MESSAGE	△▽	FAULT 1 TYPE: ABG	*Range: not available if the source VTs are in the "Delta" configuration*
MESSAGE	△▽	FAULT 1 LOCATION 00.0 km	*Range: not available if the source VTs are in the "Delta" configuration*
MESSAGE	△	FAULT 1 RECLOSE SHOT: 0	*Range: where applicable*

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. Refer to 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.

6.4.2 EVENT RECORDS

6

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨ EVENT RECORDS

■ EVENT RECORDS ■	◁▷	EVENT: XXXX RESET OP(PUSHBUTTON)		
		↓		
MESSAGE	△▽	EVENT: 3 POWER ON	◁▷	▽ EVENT 3 DATE: 2000/07/14
MESSAGE	△▽	EVENT: 2 POWER OFF		△ EVENT 3 TIME: 14:53:00.03405
MESSAGE	△	EVENT: 1 EVENTS CLEARED		*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. If all 1024 event records have been filled, the oldest record will be 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. Refer to the **COMMANDS ⇩ CLEAR RECORDS** menu for clearing event records.

6.4.3 OSCILLOGRAPHY

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨⇩ OSCILLOGRAPHY

Menu		Display	Range
■ OSCILLOGRAPHY ■	◀▶	FORCE TRIGGER? No	Range: No, Yes
	MESSAGE ▲▼	NUMBER OF TRIGGERS: 0	
	MESSAGE ▲▼	AVAILABLE RECORDS: 0	
	MESSAGE ▲▼	CYCLES PER RECORD: 0.0	
	MESSAGE ▲	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 additional details.

A trigger can be forced here at any time by setting "Yes" to the **FORCE TRIGGER?** command. Refer to the **COMMANDS ⇨⇩ CLEAR RECORDS** menu for information on clearing the oscillography records.

6.4.4 DATA LOGGER

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨⇩ DATA LOGGER

Menu		Display
■ DATA LOGGER ■	◀▶	OLDEST SAMPLE TIME: 2000/01/14 13:45:51
	MESSAGE ▲	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 will be static until the log gets full, at which time it will start 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.

Refer to the **COMMANDS ⇨⇩ CLEAR RECORDS** menu for clearing data logger records.

6.4.5 PHASOR MEASUREMENT UNIT RECORDS

PATH: ACTUAL VALUES ⇨ RECORDS ⇨⇩ PMU RECORDS

Menu		Display	Range
■ PMU ■ RECORDS	◀▶	NUMBER OF TRIGGERS: 0	Range: 0 to 65535 in steps of 1
	MESSAGE ▲	■ PMU 1 ■ 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:

PATH: ACTUAL VALUES ⇨ RECORDS ⇨⇩ PMU RECORDS ⇨ PMU 1 RECORDING

■ PMU 1 ■ RECORDING	◁▷	PMU 1 FORCE TRIGGER: Yes	Range: No, Yes
MESSAGE	△▽	PUM 1 AVAILABLE RECORDS: 0	Range: 0 to 65535 in steps of 1
MESSAGE	△▽	PUM 1 SECONDS PER RECORD: 0.0	Range: 0 to 6553.5 in steps of 0.1
MESSAGE	△	PUM 1 LAST CLEARED: 2005/07/14 015:40:16	Range: date and time in format shown

6.4.6 BREAKER MAINTENANCE

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨⇩ MAINTENANCE ⇨ BREAKER 1(2)

■ BREAKER 1 ■	◁▷	BKR 1 ARCING AMP ϕA: 0.00 kA2-cyc
MESSAGE	△▽	BKR 1 ARCING AMP ϕB: 0.00 kA2-cyc
MESSAGE	△▽	BKR 1 ARCING AMP ϕC: 0.00 kA2-cyc
MESSAGE	△▽	BKR 1 OPERATING TIME ϕA: 0 ms
MESSAGE	△▽	BKR 1 OPERATING TIME ϕB: 0 ms
MESSAGE	△▽	BKR 1 OPERATING TIME ϕC: 0 ms
MESSAGE	△	BKR 1 OPERATING TIME: 0 ms

There is an identical menu for each of the breakers. The **BKR 1 ARCING AMP** values are in units of kA^2-cycles. Refer to 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.

6.5.1 MODEL INFORMATION

PATH: ACTUAL VALUES ⇨⇩ PRODUCT INFO ⇨ MODEL INFORMATION

Menu		Display	Range
■ MODEL INFORMATION ■	◁▷	ORDER CODE LINE 1: L30-E00-HCH-F8F-H6A	Range: standard GE Multilin order code format; example order code shown
MESSAGE	△▽	ORDER CODE LINE 2:	Range: standard GE Multilin order code format
MESSAGE	△▽	ORDER CODE LINE 3:	Range: standard GE Multilin order code format
MESSAGE	△▽	ORDER CODE LINE 4:	Range: standard GE Multilin order code format
MESSAGE	△▽	SERIAL NUMBER:	Range: standard GE Multilin serial number format
MESSAGE	△▽	ETHERNET MAC ADDRESS 000000000000	Range: standard Ethernet MAC address format
MESSAGE	△▽	MANUFACTURING DATE: 0	Range: YYYY/MM/DD HH:MM:SS
MESSAGE	△▽	PMU FEATURE ACTIVE: No	Range: Yes, No
MESSAGE	△▽	CT/ VT ADVANCED DIAG ACTIVE: No	Range: Yes, No
MESSAGE	△▽	OPERATING TIME: 0:00:00	Range: operating time in HH:MM:SS
MESSAGE	△	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.

6.5.2 FIRMWARE REVISIONS

PATH: ACTUAL VALUES ⇨⇩ PRODUCT INFO ⇨⇩ FIRMWARE REVISIONS

Menu		Display	Range
■ FIRMWARE REVISIONS ■	◁▷	L30 Relay REVISION: 7.1x	Range: 0.00 to 655.35 Revision number of the application firmware.
MESSAGE	△▽	MODIFICATION FILE NUMBER: 0	Range: 0 to 65535 (ID of the MOD FILE) Value is 0 for each standard firmware release.
MESSAGE	△▽	BOOT PROGRAM REVISION: 3.01	Range: 0.00 to 655.35 Revision number of the boot program firmware.
MESSAGE	△▽	FRONT PANEL PROGRAM REVISION: 0.08	Range: 0.00 to 655.35 Revision number of faceplate program firmware.
MESSAGE	△▽	COMPILE DATE: 2004/09/15 04:55:16	Range: Any valid date and time. Date and time when product firmware was built.
MESSAGE	△	BOOT DATE: 2004/09/15 16:41:32	Range: Any valid date and time. Date and time when the boot program was built.

The shown data is illustrative only. A modification file number of 0 indicates that, currently, no modifications have been installed.

7.1.1 COMMANDS MENU

```
COMMANDS

        ⇩
MESSAGE    ■■ COMMANDS
           ■■ VIRTUAL INPUTS

MESSAGE    ■■ COMMANDS
           ■■ CLEAR RECORDS

MESSAGE    ■■ COMMANDS
           ■■ SET DATE AND TIME

MESSAGE    ■■ COMMANDS
           ■■ RELAY MAINTENANCE

MESSAGE    ■■ COMMANDS
           ■■ PMU ONE-SHOT

MESSAGE    ■■ COMMANDS
           ■■ SECURITY
```

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
```

7.1.2 VIRTUAL INPUTS

PATH: COMMANDS ⇨ VIRTUAL INPUTS

```
■■ COMMANDS            Virt Ip  1      Range: Off, On
■■ VIRTUAL INPUTS      Off

                       Virt Ip  2      Range: Off, On
                       Off
                          ↓
MESSAGE                Virt Ip 64      Range: Off, On
                       Off
```

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 will be a state off (logic 0) or on (logic 1).

7

7.1.3 CLEAR RECORDS

PATH: COMMANDS ⇨⇩ CLEAR RECORDS

■■ COMMANDS ■■ CLEAR RECORDS	CLEAR FAULT REPORTS? No	*Range: No, Yes*
	CLEAR EVENT RECORDS? No	*Range: No, Yes*
	CLEAR OSCILLOGRAPHY? No	*Range: No, Yes*
	CLEAR DATA LOGGER? No	*Range: No, Yes*
	CLEAR BREAKER 1 ARCING AMPS? No	*Range: No, Yes*
	CLEAR BREAKER 2 ARCING AMPS? No	*Range: No, Yes*
	CLEAR CHANNEL TEST RECORDS? No	*Range: No, Yes*
	CLEAR UNAUTHORIZED ACCESS? No	*Range: No, Yes*
	CLEAR PMU 1 RECORDS? No	*Range: No, Yes*
	CLEAR PMU 1 CONFIG CHANGE COUNTER? No	*Range: No, Yes*
	CLEAR ALL RELAY RECORDS? No	*Range: No, Yes*

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”.

7

7.1.4 SET DATE AND TIME

PATH: COMMANDS ⇨⇩ SET DATE AND TIME

■■ COMMANDS ■■ SET DATE AND TIME	SET DATE AND TIME: 2000/01/14 13:47:03	*(YYYY/MM/DD HH:MM:SS)*

The date and time can be entered here via the faceplate keypad, but if the relay is synchronizing to an external time source such as PTP, IRIGB or SNTP, the manually entered time will be quickly over-written. 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 (if entered) and date will take effect at the moment the ENTER key is clicked.

The timescale of the entered time should be **local time**, including daylight time where and when applicable.

7.1.5 RELAY MAINTENANCE

PATH: COMMANDS ⇨⇩ RELAY MAINTENANCE

■■ COMMANDS ■■ RELAY MAINTENANCE	PERFORM LAMPTEST? No	*Range: No, Yes*
	UPDATE ORDER CODE? No	*Range: No, Yes*
	REBOOT RELAY? No	*Range: No, Yes*
	SERVICE COMMAND: 0	*Range: 0, 101*

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 will then automatically revert to "No". The service command is activated by entering a numerical code and pressing the ENTER key.

The **PERFORM LAMPTEST** command turns on all faceplate LEDs and display pixels for a short duration. The **UPDATE ORDER CODE** 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 is shown.

```
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 will be shown.

The **SERVICE COMMAND** is used to perform specific L30 service actions. Presently, there is only one service action available. Code "101" is used to clear factory diagnostic information stored in the non-volatile memory. If a code other than "101" is entered, the command will be ignored and no actions will be 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 may want to clear the diagnostic information for themselves under certain circumstances. For example, it may be desirable to 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 will restart from scratch.

The **REBOOT RELAY COMMAND** reboots 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.

NOTE: With the CyberSentry option, the Administrator or Operator role can initiate the Reboot Relay command.

7.1.6 PHASOR MEASUREMENT UNIT ONE-SHOT

PATH: COMMANDS ⇨⇩ PMU ONE-SHOT

■■ COMMANDS ■■ PMU ONE-SHOT	PMU ONE-SHOT FUNCTION: Disabled	*Range: Enabled, Disabled*
	PMU ONE-SHOT SEQUENCE NUMBER: 0	*Range: 0 to nominal frequency – 1 in steps of 1*
	PMU ONE-SHOT TIME: 2005/06/14 7:58:35	*Range: 24h time format*

This feature allows pre-scheduling a PMU measurement at a specific point in time. This functionality can be used to test for accuracy of the PMU, and for manual collection of synchronized measurements through the system, as explained below.

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 SEQUENCE NUMBER**. 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 may 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 figure below, 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.

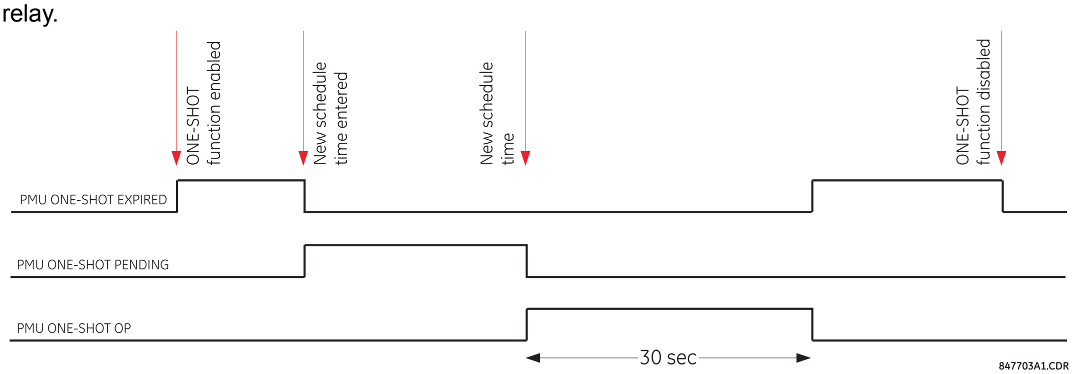

Figure 7–1: PMU ONE-SHOT FLEXLOGIC OPERANDS

TESTING ACCURACY OF THE PMU:

The one-shot feature can be used to test accuracy of the synchrophasor measurement. GPS-synchronized tests 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 figure below, the one-shot feature could 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 should be retained as a part of the testing documentation.

Note that the PMU under such test does not have to be connected to a real GPS receiver as the accuracy is measured with respect to the timing reference provided to the PMU and not to the absolute UTC time. Therefore a simple IRIG-B generator could be used instead. Also, the test set does not have to support GPS synchronization. Any stable signal source can be used. If both the PMU under test and the test set use the timing reference, they should be driven from the same IRIG-B signal: either the same GPS receiver or IRIG-B generator. Otherwise, the setpoints of the test set and the PMU measurements should not be compared as they are referenced to different time scales.

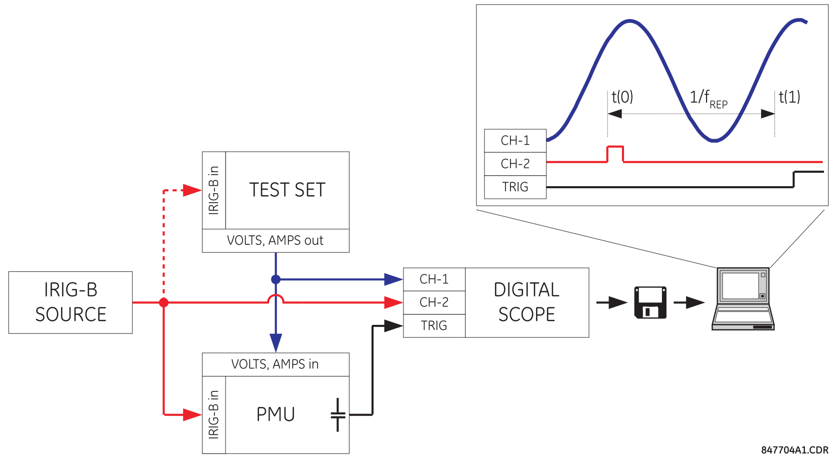

Figure 7–2: USING THE PMU ONE-SHOT FEATURE TO TEST SYNCHROPHASOR MEASUREMENT ACCURACY

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 PMU can be pre-scheduled to freeze their measurements at the same time. When frozen the measurements could be collected using EnerVista UR Setup or a protocol client.

7.1.7 SECURITY

PATH: COMMANDS ⇨⇩ SECURITY

Menu	Setting	Range / Default
■■ SECURITY ■■	ADMINISTRATOR LOGOFF: No	*Range: Yes, No* *Default: No*
	ENGINEER LOGOFF: No	*Range: Yes, No* *Default: No*
	OPERATOR LOGOFF: No	*Range: Yes, No* *Default: No*
	CLEAR SECURITY DATA:	*Range: Yes, No* *Default: 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.

7.2.1 TARGETS MENU

		TARGETS	
		⇩	
MESSAGE	▼	DIGITAL ELEMENT 1: LATCHED	*Displayed only if targets for this element are active. Example shown.*
MESSAGE	▲▼	DIGITAL ELEMENT 48: LATCHED	*Displayed only if targets for this element are active. Example shown.*
MESSAGE	▲	↓ ↓	

The status of any active targets will be displayed in the targets menu. If no targets are active, the display will read **NO ACTIVE TARGETS**:

7.2.2 TARGET MESSAGES

When there are no active targets, the first target to become active will cause 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 will again default back to the target message.

The range of variables for the target messages is described below. Phase information will be included if applicable. If a target message status changes, the status with the highest priority will be displayed.

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.

7.2.3 RELAY SELF-TESTS

a) 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 tables below. When either type of self-test error occurs, the Trouble LED Indicator will turn on and a target message displayed. 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 is de-energized.
- All other output relays are de-energized and are prevented from further operation.
- The faceplate In Service LED indicator is turned off.
- A RELAY OUT OF SERVICE event is recorded.

b) MAJOR SELF-TEST ERROR MESSAGES

The major self-test errors are outlined in this section.

```
MODULE FAILURE___:
Contact Factory (xxx)
```

- *Latched target message*: Yes.
- *Description of problem*: Module hardware failure detected.
- *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).

```
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 configuration of 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 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”.

c) MINOR SELF-TEST ERROR MESSAGES

Most of the minor self-test errors can be disabled. Refer to the settings in the *User-programmable self-tests* section in the *Settings* chapter for additional details.

```
IEC 61850 DATA SET:
LLN0 GOOSE# Error
```

- *Latched target message*: No.
- *Description of problem*: A data item in a configurable GOOSE data set is not supported by the L30 order code.
- *How often the test is performed*: On power up.
- *What to do*: Verify that all the items in the GOOSE data set are supported by the L30. The EnerVista UR Setup software will list the valid items. An IEC61850 client will also show which nodes are available for the L30.

```
IEC 61850 DATA SET:
LLN0 BR# Error
```

- *Latched target message*: No.
- *Description of problem*: A data item in a configurable report data set is not supported by the L30 order code.
- *How often the test is performed*: On power up.
- *What to do*: Verify that all the items in the configurable report data set are supported by the L30. The EnerVista UR Setup software will list the valid items. An IEC61850 client will also show which nodes are available for the L30.

```
MAINTENANCE ALERT:
Replace Battery
```

- *Latched target message*: Yes.
- *Description of problem*: The battery is not functioning.
- *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.

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```
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:
ENET PORT # OFFLINE
```

- *Latched target message*: No.
- *Description of problem*: The Ethernet connection has failed for the specified port.
- *How often the test is performed*: Every five seconds.
- *What to do*: Check the Ethernet port connection on the switch.

```
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 may 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:
Port ## Failure
```

- *Latched target message*: No.
- *Description of problem*: An Ethernet connection has failed.
- *How often the test is performed*: Monitored every five seconds.
- *What to do*: Check Ethernet connections. Port 1 is the primary port and port 2 is the secondary port.

```
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 SNTP configuration and network connections.

```
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.

```
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.

```
REMOTE DEVICE FAIL:
COMM Path Incomplete
```

- *Latched target message*: No.
- *Description of problem*: One or more GOOSE devices are not responding.
- *How often the test is performed*: Event driven. The test is performed when a device programmed to receive GOOSE messages stops receiving. This can be from 1 to 60 seconds, depending on GOOSE packets.
- *What to do*: Check GOOSE setup.

```
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.

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```
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.

d) WRONG TRANSCEIVER MESSAGES

Description: The type of SFP does not match the CPU type.

T-type CPU = All ports support fiber SFPs only

Type: minor

Target: latched

Message: "WRONG TRANSCEIVER"

A webpage "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.

e) SFP X MODULE FAIL MESSAGES

Description: A faulty SFP or unplugging the SFP would generate this self test.

Type: minor

Target: self reset

Message: SFP MODULE x FAIL

The webpage "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.

HARDFIBER SELF-TEST ERROR MESSAGES

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In addition to those provided by the standard UR-series devices, the UR devices implement HardFiber self-tests. These are listed below. 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 at the B95^{Plus}, see that product's instruction manual.

Equipment Mismatch Major Self-Test

Description: 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.

If this message appears, 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 Major Self-Test

Description: UR-series device module hardware failure detected.

Severity: Protection is not available and all contact outputs and shared outputs are de-asserted.

If this message appears, 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 Major Self-test

Description: 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 of the crosschecking setting in this 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.

If this message appears, 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.

Should the problem persist 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 annunciated 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.

Process Bus Trouble Minor Self-Test

Description: 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-series device.

If this message appears, 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 Minor Self-Test

Description: Brick internal self-testing has detected a 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-series device.

If this message appears, 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 faceplate reset key if the command has ended, however the output may still be non-functional.

8.1.1 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 it is desired to detect which phase is faulted. The L30 relay transmits data for all three phases.

Time consolidation reduces communications bandwidth requirements. Time consolidation 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 for details). 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 2 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 on-line 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 will be synchronized.

8.1.2 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 in a distributed fashion. The peer to peer architecture is based on two main 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.

8.1.3 REMOVAL OF DECAYING OFFSET

The inductive behavior of power system transmission lines gives rise to decaying exponential offsets during transient conditions, which could 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 effectively 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 was possible without introducing any significant phase delay thanks 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.

8.1.4 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:

$$I_{1\_Re\_A(k)} = \frac{4}{N}\sum_{p=0}^{N/2-1} i_{1\_f\_A(k-p)} \cdot \cos\left(\frac{2\pi(p+1/2)}{N}\right) \quad \textbf{(EQ 8.1)}$$

For the imaginary part, we have:

$$I_{1\_Im\_A(k)} = -\frac{4}{N}\sum_{p=0}^{N/2-1} i_{1\_f\_A(k-p)} \cdot \sin\left(\frac{2\pi(p+1/2)}{N}\right) \quad \textbf{(EQ 8.2)}$$

where: *k* is the present phaselet index,
N is the number of samples per cycle, and
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.

8.1.5 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 may 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.

8.1.6 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:

$$I_{DIFF\_RE\_A} = I_{LOC\_PHASOR\_RE\_A} + I_{REM1\_PHASOR\_RE\_A} + I_{REM2\_PHASOR\_RE\_A} \quad \textbf{(EQ 8.3)}$$

The imaginary part is expressed as:

$$I_{DIFF\_IM\_A} = I_{LOC\_PHASOR\_IM\_A} + I_{REM1\_PHASOR\_IM\_A} + I_{REM2\_PHASOR\_IM\_A} \quad \textbf{(EQ 8.4)}$$

The differential current is squared for the severity equation:

$$(I_{DIFF\_A})^2 = (I_{DIFF\_RE\_A})^2 + (I_{DIFF\_IM\_A})^2 \quad \textbf{(EQ 8.5)}$$

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 are connected to the relay (breaker-and-the half applications), then a maximum of all (up to 4) currents is chosen to be processed for traditional restraint:

The current chosen is expressed as:

$$(I_{LOC\_TRAD\_A})^2 = \max((I_{1\_MAG\_A})^2, (I_{2\_MAG\_A})^2, (I_{3\_MAG\_A})^2, (I_{4\_MAG\_A})^2, (I_{q\_MAG\_A})^2) \quad \textbf{(EQ 8.6)}$$

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:

$$\begin{aligned} &\text{If } (I_{LOC\_TRAD\_A})^2 < BP^2 \\ &\text{then } (I_{LOC\_REST\_TRAD\_A})^2 = 2(S_1 \cdot I_{LOC\_TRAD\_A})^2 \\ &\text{else } (I_{LOC\_REST\_TRAD\_A})^2 = 2((S_2 \cdot I_{LOC\_TRAD\_A})^2 - (S_2 \cdot BP)^2) + 2(S_1 \cdot BP)^2 \end{aligned} \quad \textbf{(EQ 8.7)}$$

For three-terminal systems we have

$$\begin{aligned} &\text{If } (I_{LOC\_TRAD\_A})^2 < BP^2 \\ &\text{then } (I_{LOC\_REST\_TRAD\_A})^2 = \frac{4}{3}(S_1 \cdot I_{LOC\_TRAD\_A})^2 \\ &\text{else } (I_{LOC\_REST\_TRAD\_A})^2 = \frac{4}{3}((S_2 \cdot I_{LOC\_TRAD\_A})^2 - (S_2 \cdot BP)^2) + \frac{4}{3}(S_1 \cdot BP)^2 \end{aligned} \quad \textbf{(EQ 8.8)}$$

The final restraint current sent to peers and used locally in differential calculations is as follows:

$$I_{LOC\_RESTRAINT\_A} = \sqrt{(I_{LOC\_REST\_TRAD\_A})^2 + MULT_A \cdot (I_{LOC\_ADA\_A})^2} \quad \textbf{(EQ 8.9)}$$

where: $MULT_A$ is a multiplier that increases restraint if CT saturation is detected (see *CT Saturation Detection* for details);
$I_{LOC\_ADA\_A}$ 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:

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$$(I_{REST\_A})^2 = (I_{LOC\_PHASOR\_RESTRAINT\_A})^2 + (I_{REM1\_PHASOR\_RESTRAINT\_A})^2 + (I_{REM2\_PHASOR\_RESTRAINT\_A})^2 \quad \textbf{(EQ 8.10)}$$

The fault severity for each phase is determined by following equation:

$$S_A = (I_{DIFF\_A})^2 - (2P^2 + (I_{REST\_A})^2) \quad \textbf{(EQ 8.11)}$$

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 is equivalent to relaxing the confidence interval and increases sensitivity. Thus, the restraint multiplier is an application adjustment that is used to achieve the desired 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.

8.1.7 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 may 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:

$$\begin{aligned} I_{OP\_87G\_RE} = {} & I_{LOC\_PHASOR\_RE\_A} + I_{LOC\_PHASOR\_RE\_B} + I_{LOC\_PHASOR\_RE\_C} + I_{REM1\_PHASOR\_RE\_A} + I_{REM1\_PHASOR\_RE\_B} \\ & + I_{REM1\_PHASOR\_RE\_C} + I_{REM2\_PHASOR\_RE\_A} + I_{REM2\_PHASOR\_RE\_B} + I_{REM2\_PHASOR\_RE\_C} \end{aligned} \quad \textbf{(EQ 8.12)}$$

$$\begin{aligned} I_{OP\_87G\_IM} = {} & I_{LOC\_PHASOR\_IM\_A} + I_{LOC\_PHASOR\_IM\_B} + I_{LOC\_PHASOR\_IM\_C} + I_{REM1\_PHASOR\_IM\_A} + I_{REM1\_PHASOR\_IM\_B} \\ & + I_{REM1\_PHASOR\_IM\_C} + I_{REM2\_PHASOR\_IM\_A} + I_{REM2\_PHASOR\_IM\_B} + I_{REM2\_PHASOR\_IM\_C} \end{aligned} \quad \textbf{(EQ 8.13)}$$

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 below.

For two-terminal applications:

$$\text{If } (I_{REM\_REST\_A})^2 < \text{BP}^2, \text{ then } (I_{REM\_REST\_A})^2 = \frac{(I_{REM\_RESTRAINT\_A})^2}{2S_1^2}$$

$$\text{else } (I_{REM\_REST\_A})^2 = \frac{(I_{REM\_RESTRAINT\_A})^2 - 2(S_1 \times \text{BP})^2}{2S_2^2} + \text{BP}^2 \quad \textbf{(EQ 8.14)}$$

For three-terminal applications:

$$\text{If } (I_{\text{REM\_REST\_A}})^2 < \text{BP}^2, \text{ then } (I_{\text{REM\_REST\_A}})^2 = \frac{(I_{\text{REM\_RESTRAINT\_A}})^2}{\frac{4}{3} \times S_1^2}$$

$$\text{else } (I_{\text{REM\_REST\_A}})^2 = \frac{(I_{\text{REM\_RESTRAINT\_A}})^2 - \frac{4}{3}(S_1 \times \text{BP})^2}{\frac{4}{3} \times S_2^2} + \text{BP}^2 \quad \textbf{(EQ 8.15)}$$

The 87G restraining signal is calculated as follows:

$$(I_{\text{RES\_87G}})^2 = \max((I_{\text{LOC\_REST\_A}})^2, (I_{\text{LOC\_REST\_B}})^2, (I_{\text{LOC\_REST\_C}})^2, (I_{\text{REM1\_REST\_A}})^2, (I_{\text{REM1\_REST\_B}})^2, (I_{\text{REM1\_REST\_C}})^2, (I_{\text{REM2\_REST\_A}})^2, (I_{\text{REM2\_REST\_B}})^2, (I_{\text{REM2\_REST\_C}})^2) \quad \textbf{(EQ 8.16)}$$

The terms for the second remote terminal are omitted in two-terminal applications.

The operate signal for the ground differential function, $(I_{\text{OP\_87G}})^2$, is then calculated as:

$$(I_{\text{OP\_87G}})^2 = (I_{\text{OP\_87G\_RE}})^2 + (I_{\text{OP\_87G\_IM}})^2 \quad \textbf{(EQ 8.17)}$$

The restraint signal, $(I_{87G})^2$**,** is calculated as follows for two-terminal applications:

$$(I_{87G})^2 = 2S_{87G}^{\ 2} \times (I_{\text{RES\_87G}})^2 \quad \textbf{(EQ 8.18)}$$

The restraint signal, $(I_{87G})^2$**,** is calculated as follows for three-terminal applications:

$$(I_{87G})^2 = \frac{4}{3} \times S_{87G}^{\ 2} \times (I_{\text{RES\_87G}})^2 \quad \textbf{(EQ 8.19)}$$

where S_{87G} is the slope setting for the ground differential function.

The ground differential element picks up if the following condition holds.

$$((I_{\text{OP\_87G}})^2 - (2P_{87G}^{\ 2} + (I_{87G})^2) > 0) \text{ and } ((I_{\text{RES\_87G}})^2 < (3\text{ pu})^2) \quad \textbf{(EQ 8.20)}$$

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 the 87LG function is not required to clear high-current faults, allowing for more sensitive settings to be used for the 87LG function.

8.1.8 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, samples should be taken 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 2 or 3 terminal system. For 4 or more terminals the error may be somewhat higher, depending on the quality of the communications channels. The algorithm is unconditionally stable. In the case of 2 and 3 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 will accommodate any frequency shift normally encountered in power systems.

8.1.9 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, and is needed to control the uncertainty in the phase angle of phasor measurements, which will be 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 block diagram for clock control for a two terminal system is shown in the following figure. 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.

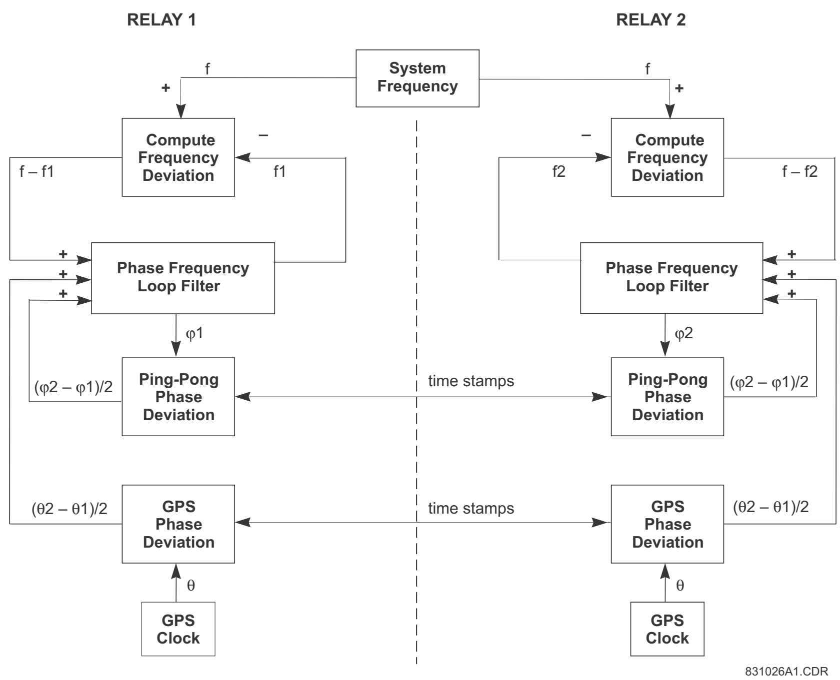

Figure 8–1: BLOCK DIAGRAM FOR CLOCK SYNCHRONIZATION IN A TWO-TERMINAL SYSTEM

The L30 provides sensitive digital current differential protection by computing differential current from current phasors. To improve sensitivity, the clocks are controlling current sampling are closely synchronized via the ping-pong algorithm. However, this algorithm assumes 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 GPS (Global Positioning System) 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 as 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

(PFLL) as shown on the diagram above. If GPS time reference is lost, the channel asymmetry compensation is not enabled, and the relay clock may start to drift and accumulate differential error. In this case, the 87L function has to be blocked. Refer to Chapter 10: Application of Settings for samples of how to program the relay.

8.1.10 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 will detect frequency deviation, but if there is no current flowing nor voltage measurement available at a particular relay, it will 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 will resume 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:

$$\begin{aligned} \overline{\boldsymbol{I}(n)} &= \mathrm{Re}(\mathrm{Phasor}_n) + j \cdot \mathrm{Im}(\mathrm{Phasor}_n) \\ \overline{\boldsymbol{I}_{a,k}(n)} &= \overline{\boldsymbol{I}(n)} \quad \text{for phase } a \text{ from the } k\text{th terminal at time step } n \\ \overline{\boldsymbol{I}_{b,k}(n)} &= \overline{\boldsymbol{I}(n)} \quad \text{for phase } b \text{ from the } k\text{th terminal at time step } n \\ \overline{\boldsymbol{I}_{c,k}(n)} &= \overline{\boldsymbol{I}(n)} \quad \text{for phase } c \text{ from the } k\text{th terminal at time step } n \end{aligned} \tag{EQ 8.21}$$

Each terminal computes positive sequence current:

$$\overline{\boldsymbol{I}_{pos,k}(n)} = \frac{1}{3}\left(\overline{\boldsymbol{I}_{a,k}(n)} + \overline{\boldsymbol{I}_{b,k}(n)} \cdot e^{j2\pi/3} + \overline{\boldsymbol{I}_{c,k}(n)} \cdot e^{j2\pi/3}\right) \tag{EQ 8.22}$$

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:

$$\overline{\mathrm{Deviation}_k(n)} = \overline{\boldsymbol{I}_{pos,k}(n)} \times \overline{\boldsymbol{I}_{pos,k}(n-N)}^{*} \tag{EQ 8.23}$$

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:

$$\mathrm{FrequencyDeviation} = \frac{\Delta f}{f} = \frac{\tan^{-1}(\mathrm{Im}(\overline{\mathrm{Deviation}})/\mathrm{Re}(\overline{\mathrm{Deviation}}))}{2\pi} \tag{EQ 8.24}$$

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:

$$\Delta\omega = \Delta f \cdot \tan^{-1}(\mathrm{Im}(\overline{\mathrm{Deviation}})/\mathrm{Re}(\overline{\mathrm{Deviation}})) \tag{EQ 8.25}$$

8.1.11 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 are not always available and may 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 may be switched to a different physical path, leading to gross phase error.

The primary source of phase information are CPU time-tagged messages. If GPS compensation is enabled, GPS time stamps are used to compensate for asymmetry. In all cases, frequency deviation information is also 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 3 messages. In the case of systems with 4 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 1 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 could 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 8 bit time stamp with 1 bit corresponding to 1/64 of a cycle will accommodate a round trip delay of up to 4 cycles, which should be more than adequate.

The computation of round trip delay and phase offset from four time stamps is as follows:

$$\begin{aligned} a &= T_{i-2} - T_{i-3} \\ b &= T_i - T_{i-1} \\ \delta_i &= a + b \\ \theta_i &= \frac{a-b}{2} \end{aligned} \qquad \text{(EQ 8.26)}$$

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 could be done either in software or hardware, provided the jitter is limited to less than plus or minus 130 μs. A fixed bias in the time stamp is acceptable, provided it is the same for all terminals.

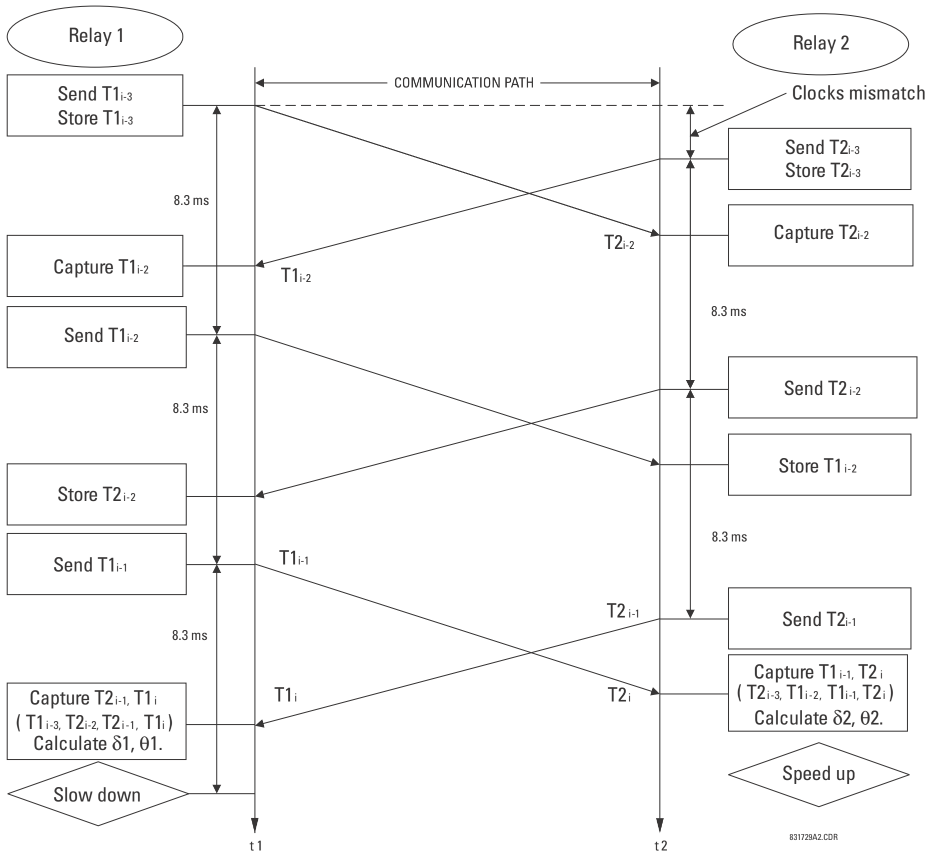

Figure 8–2: ROUND TRIP DELAY AND CLOCK OFFSET COMPUTATION FROM TIME STAMPS

8

8.1.12 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 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 will measure approximately the same frequency deviation. However, if there is not enough current at a terminal to compute frequency deviation, 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.

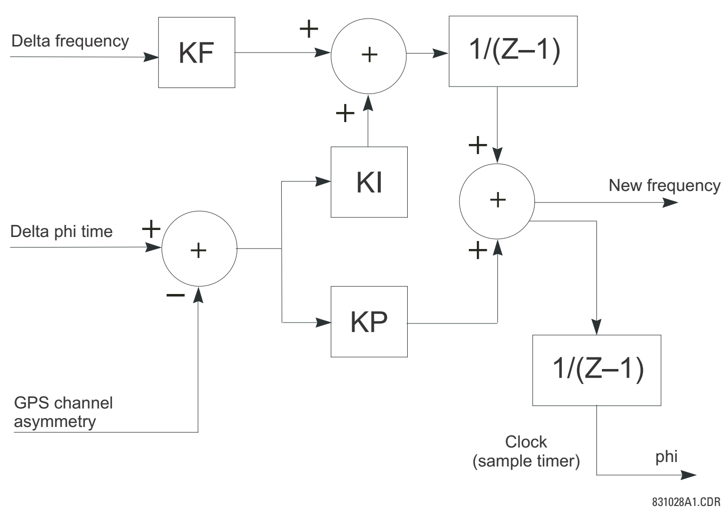

Figure 8–3: BLOCK DIAGRAM OF LOOP FILTER

There are 4 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 desired time constants of the system as follows:

$$KI \quad \frac{T_{repeat}}{T^2_{phase}}, \quad KP \quad \frac{2}{T_{phase}}, \quad KF \quad \frac{T_{repeat}}{T_{frequency}} \qquad \text{(EQ 8.27)}$$

where: T_{repeat} = the time between execution of the filter algorithm
T_{phase} = time constant for the primary phase locked loop
$T_{frequency}$ = time constant for the frequency locked loop

8.1.13 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 should be no longer than the maximum sequence number (4 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 will show 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.

8.1.14 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.

8.1.15 HARDWARE AND COMMUNICATION REQUIREMENTS

The average total channel delay in each direction is not critical, provided the total round trip delay is less than 4 power system cycles. The jitter is important, and should be less than ±130 μs 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 2 or 3 terminal system, the difference is not critical, and can even vary with time. In the case of a 4 or more terminal system, variation in the difference limits the sensitivity of the system.

- The allowable margin of 130 μs 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 should be less than 100 parts per million per minute.
- A 6 Mhz clock with a 16-bit hardware counter is adequate, provided the method is used for achieving the 32-bit resolution that is described in this document.
- An 8-bit time stamp is adequate provided time stamp messages are exchanged once per cycle.
- A 4-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.

8.1.16 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:

$$\text{SumSquares}_{1\_A(k)} = \frac{4}{N}\sum_{p=0}^{N/2-1}(i_{1\_f\_A(k-p)})^2 \qquad \textbf{(EQ 8.28)}$$

Then fundamental magnitude is computed as follows for the same phaselet:

$$I_{1\_MAG\_A} = \sqrt{(I_{1\_RE\_A})^2 + (I_{1\_IM\_A})^2} \qquad \textbf{(EQ 8.29)}$$

Finally, the local adaptive restraint term is computed as follows, for each local current:

$$(I_{1\_ADA\_A})^2 = \frac{4}{N}(\text{SumSquares}_{1\_A(k)} - (I_{1\_MAG\_A})^2) \qquad \textbf{(EQ 8.30)}$$

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 8.15 as θ_i. If 2 channels are used, clock deviation is computed for both channels and then 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 PFLLs. During startup conditions, a decaying exponential is computed to simulate envelope of the error during startup

The clock uncertainty is expressed as:

$$\text{clock\_unc} = \text{clock\_dev} + \text{start\_up\_error} \qquad \textbf{(EQ 8.31)}$$

Eventually, the local clock error is computed as:

$$\text{CLOCK}_A = \frac{(\text{clock\_unc})^2}{9}\cdot((I_{LOC\_RE\_A})^2 + (I_{LOC\_IM\_A})^2) \qquad \textbf{(EQ 8.32)}$$

The local squared adaptive restraint is computed from all local current sources (1 to 4) and is obtained as follows:

$$(I_{LOC\_ADA\_A})^2 = 18\cdot((I_{1\_ADA\_A})^2 + (I_{2\_ADA\_A})^2 + (I_{3\_ADA\_A})^2 + (I_{4\_ADA\_A})^2 + (I_{q\_ADA\_A})^2 + \text{CLOCK}_A) \qquad \textbf{(EQ 8.33)}$$

8.1.17 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 may 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 may be caused by a fault and may 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 below. As seen from the figure, 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 simultaneously sensitive 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.

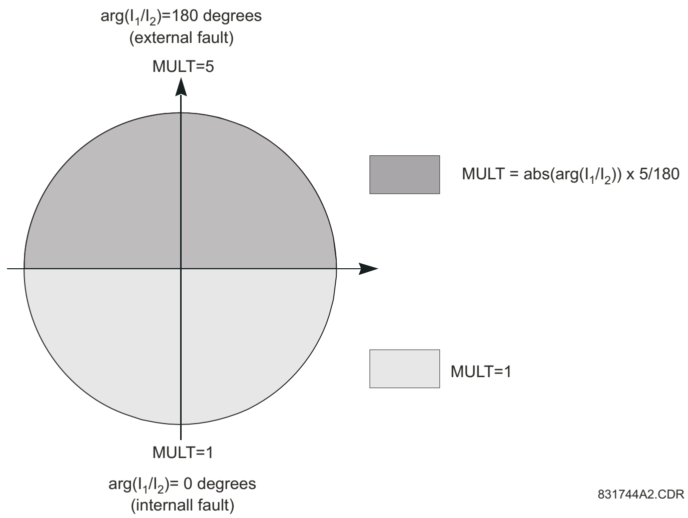

Figure 8–4: CT SATURATION ADAPTIVE RESTRAINT MULTIPLIER

8.1.18 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 should 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 $C \times dv/dt$ 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 underlying single phase model for compensation for a two and three terminal system are shown below.

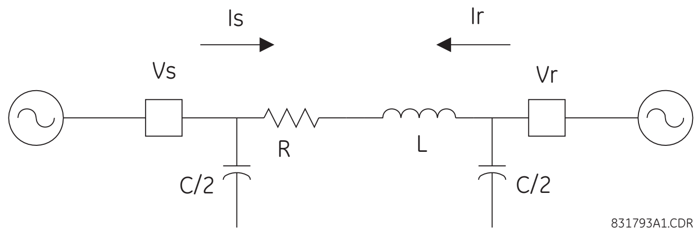

Figure 8–5: 2-TERMINAL TRANSMISSION LINE SINGLE PHASE MODEL FOR COMPENSATION

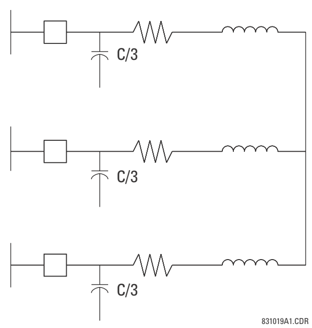

Figure 8–6: 3-TERMINAL TRANSMISSION LINE SINGLE PHASE MODEL FOR COMPENSATION

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 will be approximate.

If the VTs are connected in wye, the compensation is accurate for both balanced conditions (i.e. 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 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 which 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 may 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 should be the residual capacitance remaining after subtracting the shunt inductive reactance from the total capacitive reactance at the power system frequency.

8.1.19 DIFFERENTIAL ELEMENT CHARACTERISTICS

The differential element is completely dependent 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. Should the communications channel delay time increase, such as caused by path switching in a SONET system or failure of the communications power supply, the relay will act 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 will operate. 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 may be high and/or CT saturation may 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.

8.1.20 RELAY SYNCHRONIZATION

On startup of the relays, the channel status will be checked first. If channel status is OK, all relays will send a special "startup" message and the synchronization process will be initiated. It will take about 5 to 7 seconds to declare 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 will restart 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:

1. With second redundant channel, relays will not lose functionality at all if second channel is live.
2. 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 5 seconds, PFLL at both relays will be declared as failed and the re-synchronization process will be initiated (about 5 to 7 seconds) after channel status becomes OK.

In three-terminal mode:

1. 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 will be suspended (that is, the 87L function will not be 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 will be declared as OK and the configuration will revert back to master-master.
2. If 2 channels fail, PFLL at all relays will be declared as failed and when the channels are back into service, the re-synchronization process will be initiated (about 5 to 7 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 to 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 outlined above. 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:

1. 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.
2. PFFL has failed or is suspended,
3. 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, PFLL 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.

8.2.1 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:

1. Difference in angles (+ real represents pure internal fault when currents are essentially in phase, – real represents external fault when currents are 180° apart).
2. The magnitude of remote current.
3. The magnitude of the local current.
4. Dynamically estimated errors in calculations.
5. Settings.

The following figure also shows the relay's capability to handle week-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 is also dependant 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 3 terminal mode is similar where both remote currents are combined together.

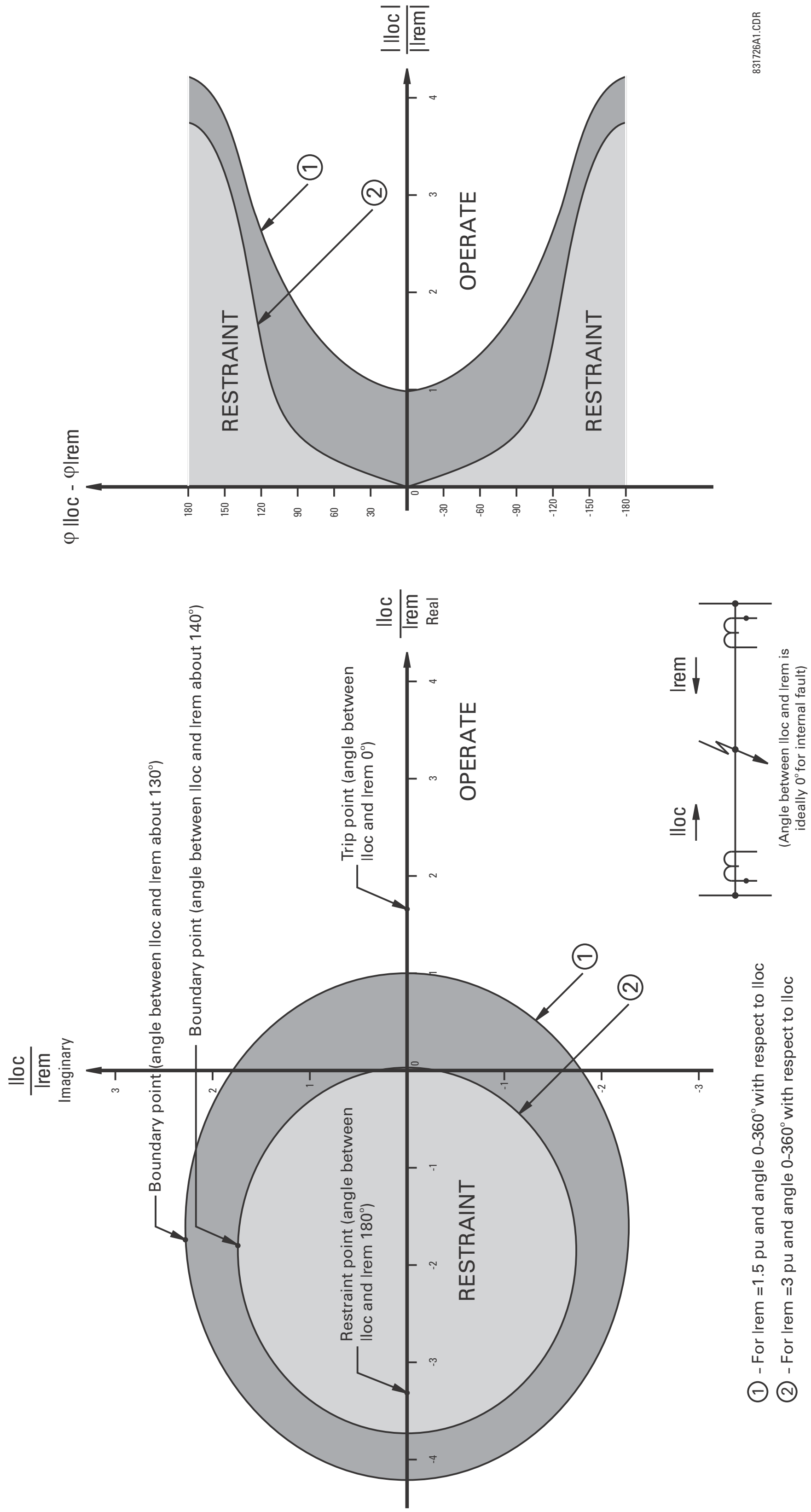

Figure 8–7: RESTRAINT CHARACTERISTICS

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8.2.2 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 ∠0°
- Remote current: I_{remote}= 0.8 pu ∠180°

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:

$$I_{op}^2 \quad |I\_L \quad I\_R|^2 \quad |4.0\angle 0° \quad 0.8\angle 180°|^2 \quad 10.24 \qquad \textbf{(EQ 8.34)}$$

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.

$$\begin{aligned} I_{Rest}^2 \quad & (2 \cdot S_1^2 \cdot |I\_L|^2) \quad (2 \cdot S_1^2 \cdot |I\_R|^2) \quad 2P^2 \quad \sigma \\ & (2 \cdot (0.1)^2 \cdot |4|^2) \quad (2 \cdot (0.1)^2 \cdot |0.8|^2) \quad 2 \cdot (0.5)^2 \quad 0 \\ & 0.8328 \end{aligned} \qquad \textbf{(EQ 8.35)}$$

where σ = 0, assuming a pure sine wave.

8.2.3 TRIP DECISION TEST

The trip condition is shown below.

$$\frac{I_{Op}^2}{I_{Rest}^2} > 1 \quad \Rightarrow \quad \frac{10.24}{0.8328} \quad 12.3 > 1 \quad \Rightarrow \quad \text{Trip} \qquad \textbf{(EQ 8.36)}$$

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 chapter 5.

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, etc. Increasing the slope percentage increases the width of the restraint area.

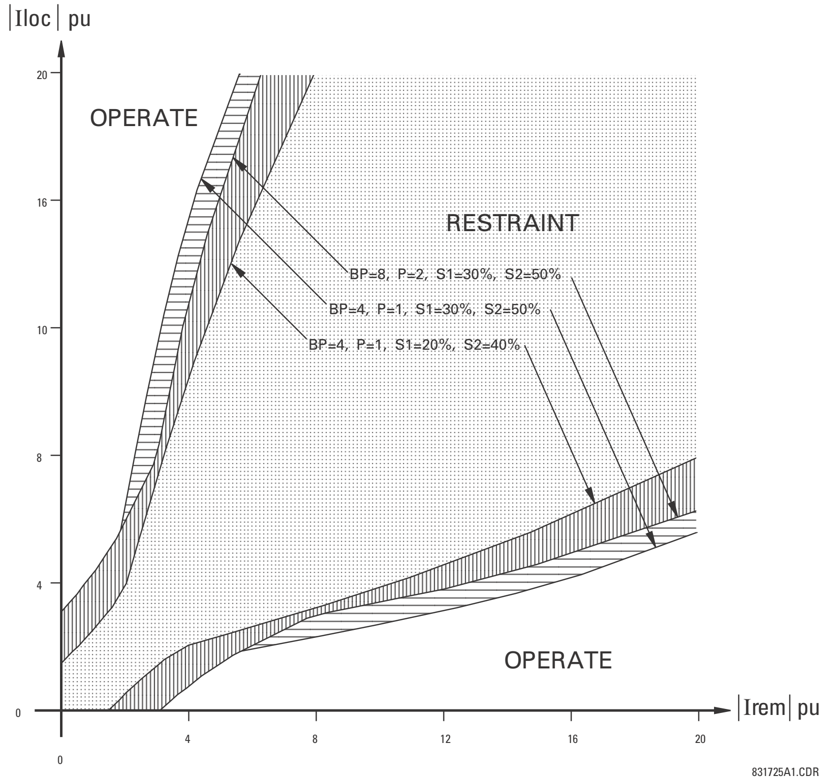

Figure 8–8: SETTINGS IMPACT ON RESTRAINT CHARACTERISTIC

8.3.1 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 below shows an equivalent system for fault location.

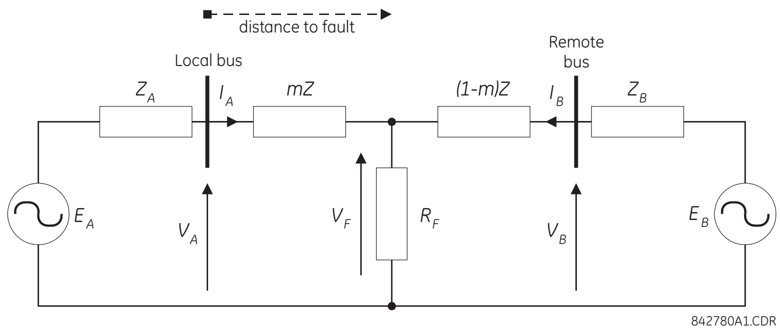

Figure 8–9: EQUIVALENT SYSTEM FOR FAULT LOCATION

The following equations hold true for this equivalent system.

$$V_A \quad m \cdot Z \cdot I_A \quad R_F \cdot (I_A \quad I_B) \qquad \textbf{(EQ 8.37)}$$

where: m = sought pu distance to fault, Z = positive sequence impedance of the line.

The currents from the local and remote systems can be parted between their fault (F) and pre-fault load (pre) components:

$$I_A \quad I_{AF} \quad I_{Apre} \qquad \textbf{(EQ 8.38)}$$

and neglecting shunt parameters of the line:

$$I_B \quad I_{BF} \quad I_{Apre} \qquad \textbf{(EQ 8.39)}$$

Inserting the I_A and I_B equations into the V_A equation and solving for the fault resistance yields:

$$R_F \quad \frac{V_A \quad m \cdot Z \cdot I_A}{I_{AF} \cdot \left(1 \quad \frac{I_{BF}}{I_{AF}}\right)} \qquad \textbf{(EQ 8.40)}$$

Assuming the fault components of the currents, I_{AF} and I_{BF} are in phase, and observing that the fault resistance, as impedance, does not have any imaginary part gives:

$$\mathrm{Im}\left(\frac{V_A \quad m \cdot Z \cdot I_A}{I_{AF}}\right) \quad 0 \qquad \textbf{(EQ 8.41)}$$

where: Im() represents the imaginary part of a complex number. Solving the above equation for the unknown m creates the following fault location algorithm:

$$m \quad \frac{\mathrm{Im}(V_A \cdot I_{AF}^*)}{\mathrm{Im}(Z \cdot I_A \cdot I_{AF}^*)} \qquad \textbf{(EQ 8.42)}$$

where * denotes the complex conjugate and $I_{AF} \quad I_A \quad I_{Apre}$.

Depending on the fault type, appropriate voltage and current signals are selected from the phase quantities before applying the two equations above (the superscripts denote phases, the subscripts denote stations).

For AG faults:

$$V_A \quad V_A^A, \quad I_A \quad I_A^A \quad K_0 \cdot I_{0A} \qquad \textbf{(EQ 8.43)}$$

For BG faults:

$$V_A \quad V_A^B, \quad I_A \quad I_A^B \quad K_0 \cdot I_{0A} \qquad \textbf{(EQ 8.44)}$$

For CG faults:

$$V_A \quad V_A^C, \quad I_A \quad I_A^{BC} \quad K_0 \cdot I_{0A} \qquad \textbf{(EQ 8.45)}$$

For AB and ABG faults:

$$V_A \quad V_A^A \quad V_A^B, \quad I_A \quad I_A^A \quad I_A^B \qquad \textbf{(EQ 8.46)}$$

For BC and BCG faults:

$$V_A \quad V_A^B \quad V_A^C, \quad I_A \quad I_A^B \quad I_A^C \qquad \textbf{(EQ 8.47)}$$

For CA and CAG faults:

$$V_A \quad V_A^C \quad V_A^A, \quad I_A \quad I_A^C \quad I_A^A \qquad \textbf{(EQ 8.48)}$$

where K_0 is the zero sequence compensation factor (for the first six equations above)

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:

$$\begin{aligned} V_A \quad & \frac{1}{3}(V_N \quad V_{AB} \quad V_{CA}) \\ V_B \quad & \frac{1}{3}(V_N \quad V_{BC} \quad V_{AB}) \\ V_B \quad & \frac{1}{3}(V_N \quad V_{CA} \quad V_{BC}) \end{aligned} \qquad \textbf{(EQ 8.49)}$$

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:

$$\begin{aligned} V_A \quad & \frac{1}{3}(V_{AB} \quad V_{CA}) \quad Z_{SYS0} I_0 \\ V_B \quad & \frac{1}{3}(V_{BC} \quad V_{AB}) \quad Z_{SYS0} I_0 \\ V_B \quad & \frac{1}{3}(V_{CA} \quad V_{BC}) \quad Z_{SYS0} I_0 \end{aligned} \qquad \textbf{(EQ 8.50)}$$

where Z_{SYS0} is the equivalent zero-sequence impedance behind the relay as entered under the fault report setting menu.

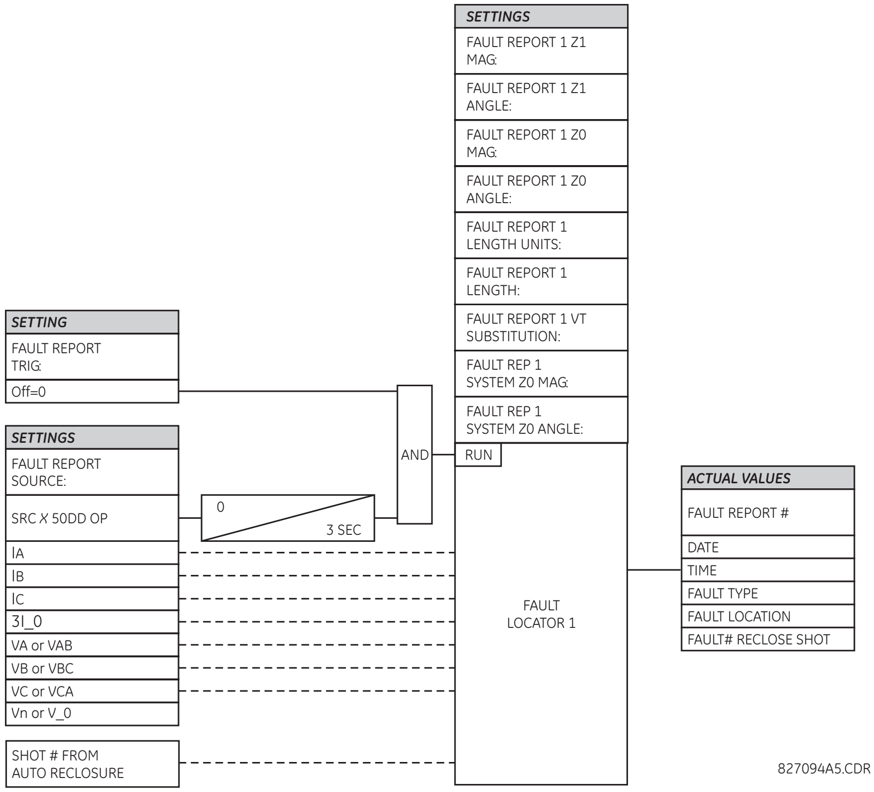

Figure 8–10: FAULT LOCATOR SCHEME

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9.1.1 INTRODUCTION

In general, proper CT selection is required to provide both adequate fault sensitivity and prevention of operation on high-current external faults that could 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 should be based on the criteria described below. If the available CTs do not meet the described criteria, the L30 will still provide good security for CT saturation for external faults. The L30 adaptive restraint characteristics, based on estimates of measurement errors and CT saturation detection, allow the relay to be secure on external faults while maintaining excellent performance for severe internal faults. Where CT characteristics do not meet criteria or where CTs at both ends may have different characteristics, the differential settings should be adjusted as per section 9.2.1.

The capability of the CTs, and the connected burden, should be checked as follows:

1. The CTs should be class TPX or TPY (class TPZ should only be used after discussion with both the manufacturer of the CT and GE Multilin) or IEC class 5P20 or better.
2. The CT primary current rating should be somewhat higher than the maximum continuous current, but not extremely high relative to maximum load because the differential element minimum sensitivity setting is approximately 0.2 × CT rating (the L30 relay allows for different CT ratings at each of the terminals).
3. The VA rating of the CTs should be above the Secondary Burden × CT Rated Secondary Current. The maximum secondary burden for acceptable performance is:

$$R_b \quad R_r < \frac{\text{CT Rated VA}}{(\text{CT Secondary } I_{rated})^2} \qquad \textbf{(EQ 9.1)}$$

where: R_b = total (two-way) wiring resistance plus any other load
R_r = relay burden at rated secondary current

4. The CT kneepoint voltage (per the V_k curves from the manufacturer) should be higher than the maximum secondary voltage during a fault. This can be estimated by:

$$V_k > I_{fp} \times \left(\frac{X}{R} \quad 1\right) \times (R_{CT} \quad R_L \quad R_r) \quad \text{for phase-phase faults}$$
$$V_k > I_{fg} \times \left(\frac{X}{R} \quad 1\right) \times (R_{CT} \quad 2R_L \quad R_r) \quad \text{for phase-ground faults} \qquad \textbf{(EQ 9.2)}$$

where: I_{fp} = maximum secondary phase-phase fault current
I_{fg} = maximum secondary phase-ground fault current
X / R = primary system reactance / resistance ratio
R_{CT} = CT secondary winding resistance
R_L = AC secondary wiring resistance (one-way)

9.1.2 CALCULATION EXAMPLE 1

This example illustrates how to check the performance of a class C400 ANSI/IEEE CT, ratios 2000/1800/1600/1500 : 5 A connected at 1500:5. The burden and kneepoints are verified in this example.

Given the following values:

- maximum I_{fp} = 14 000 A
- maximum I_{fg} = 12 000 A
- impedance angle of source and line = 78°
- CT secondary leads are 75 m of AWG 10.

The following procedure verifies the burden. ANSI/IEEE class C400 requires that the CT can deliver 1 to 20 times the rated secondary current to a standard B-4 burden (4 ohms or lower) without exceeding a maximum ratio error of 10%.

1. The maximum allowed burden at the 1500/5 tap is $(1500/2000) \times 4 \quad 3\ \Omega$.
2. The R_{CT}, R_r, and R_L values are calculated as:

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$$R_{CT} = 0.75\ \Omega$$
$$R_r = \frac{0.2\text{ VA}}{(5\text{ A})^2} = 0.008\ \Omega \quad \textbf{(EQ 9.3)}$$
$$R_L = 2 \times 75\text{ m} \times \frac{3.75\ \Omega}{1000\text{ m}} = 2 \times 0.26\ \Omega = 0.528\ \Omega$$

3. This gives a total burden of:

$$\text{Total Burden} = R_{CT} + R_r + R_L = 0.75\ \Omega + 0.008\ \Omega + 0.52\ \Omega = 1.28\ \Omega. \quad \textbf{(EQ 9.4)}$$

4. This is less than the allowed 3 Ω, which is OK.

The following procedure verifies the kneepoint voltage.

1. The maximum voltage available from the $\text{CT} = (1500/2000) \times 400 = 300\text{ V}$.
2. The system X/R ratio $= \tan 78° = 4.71$.
3. The CT voltage for maximum phase fault is:

$$V = \frac{14000\text{ A}}{\text{ratio of }300{:}1} \times (4.71 + 1) \times (0.75 + 0.26 + 0.008\ \Omega) = 271.26\text{ V (< 300 V, which is OK)} \quad \textbf{(EQ 9.5)}$$

4. The CT voltage for maximum ground fault is:

$$V = \frac{12000\text{ A}}{\text{ratio of }300{:}1} \times (4.71 + 1) \times (0.75 + 0.52 + 0.008\ \Omega) = 291.89\text{ V (< 300 V, which is OK)} \quad \textbf{(EQ 9.6)}$$

5. The CT will provide acceptable performance in this application.

9.1.3 CALCULATION EXAMPLE 2

To check the performance of an IEC CT of class 5P20, 15 VA, ratio 1500:5 A, assume the following values:

- maximum I_{fp} = 14 000 A
- maximum I_{fg} = 12 000 A
- impedance angle of source and line = 78°
- CT secondary leads are 75 m of AWG 10.

The IEC rating requires the CT deliver up to 20 times the rated secondary current without exceeding a maximum ratio error of 5%, to a burden of:

$$\text{Burden} = \frac{15\text{ VA}}{(5\text{ A})^2} = 0.6\ \Omega\text{ at the 5 A rated current} \quad \textbf{(EQ 9.7)}$$

The total Burden = R_r + R_l = 0.008 + 0.52 = 0.528 Ω, which is less than the allowed 0.6 Ω, which is OK.

The following procedure verifies the kneepoint voltage.

1. The maximum voltage available from the $\text{CT} = (1500/2000) \times 400 = 300\text{ V}$.
2. The system X/R ratio $= \tan 78° = 4.71$.
3. The CT voltage for maximum phase fault is:

$$V = \frac{14000\text{ A}}{\text{ratio of }300{:}1} \times (4.71 + 1) \times (0.75 + 0.26 + 0.008\ \Omega) = 271.26\text{ V (< 300 V, which is OK)} \quad \textbf{(EQ 9.8)}$$

4. The CT voltage for maximum ground fault is:

$$V = \frac{12000\text{ A}}{\text{ratio of }300{:}1} \times (4.71 + 1) \times (0.75 + 0.52 + 0.008\ \Omega) = 291.89\text{ V (< 300 V, which is OK)} \quad \textbf{(EQ 9.9)}$$

5. The CT will provide acceptable performance in this application.

9.2.1 INTRODUCTION

NOTE

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.

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.

9.2.2 CURRENT DIFFERENTIAL PICKUP

This setting established the sensitivity of the element to high impedance faults, and it is therefore desirable to choose a low level, but this can cause a 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, pickup should be set 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, pickup should be set 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, this setting should be increased 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.

9.2.3 CURRENT DIFF RESTRAINT 1

This 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 this should be raised to 30% if the CTs can perform quite differently during faults.

9.2.4 CURRENT DIFF RESTRAINT 2

This 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 this should be raised to 70% if the CTs can perform quite differently during faults.

NOTE

Assigning the **CURRENT DIFF RESTRAINT 1(2)** settings to the same value reverts dual slope bias characteristics into single slope bias characteristics.

9.2.5 CURRENT DIFF BREAK POINT

This setting controls the threshold where the relay changes from using the restraint 1 to the restraint 2 characteristics. Two approaches can be considered.

1. 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.
2. 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.

9.2.6 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, a user should 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:

1. Set **CURRENT DIFF RESTRAINT 1** and **CURRENT DIFF RESTRAINT 2** to the same value (e.g. 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 desired 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.

$$\begin{aligned} CT_{ratio}(\text{relay } 1) &\quad 1000/5 \\ CT_{ratio}(\text{relay } 2) &\quad 2000/5 \end{aligned} \qquad \textbf{(EQ 9.10)}$$

Consequently, we have the following CT tap value for relays 1 and 2.

$$\begin{aligned} CT_{tap}(\text{relay } 1) &\quad 2.0 \\ CT_{tap}(\text{relay } 2) &\quad 0.5 \end{aligned} \qquad \textbf{(EQ 9.11)}$$

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:

$$\begin{aligned} \text{Pickup}(\text{relay } 1) &\quad 0.4 \\ \text{Pickup}(\text{relay } 2) &\quad 0.2 \end{aligned} \qquad \textbf{(EQ 9.12)}$$

Choosing relay 1 as a reference with a breakpoint of 5.0, the break point at relay 2 is chosen as follows:

$$\begin{aligned} \text{Breakpoint}(\text{relay } 2) &\quad \text{Breakpoint}(\text{relay } 1) \times \frac{CT_{ratio}(\text{relay } 1)}{CT_{ratio}(\text{relay } 2)} \\ &\quad 5.0 \times \frac{1000/5}{2000/5} \quad 2.5 \end{aligned} \qquad \textbf{(EQ 9.13)}$$

Use the following equality the verify the calculated breakpoint:

$$\text{Breakpoint}(\text{relay } 1) \times CT_{ratio}(\text{relay } 1) \quad \text{Breakpoint}(\text{relay } 2) \times CT_{ratio}(\text{relay } 2) \qquad \textbf{(EQ 9.14)}$$

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.

$$\begin{aligned} CT_{ratio}(\text{relay } 1) &\quad 1000/5 \\ CT_{ratio}(\text{relay } 2) &\quad 2000/5 \\ CT_{ratio}(\text{relay } 3) &\quad 500/5 \end{aligned} \qquad \textbf{(EQ 9.15)}$$

Consequently, we have the following CT tap value for relays 1, 2, and 3.

$$\begin{aligned} CT_{tap1}(\text{relay } 1) &\quad 2.00 \qquad CT_{tap2}(\text{relay } 1) \quad 0.50 \\ CT_{tap1}(\text{relay } 2) &\quad 0.50 \qquad CT_{tap2}(\text{relay } 2) \quad 0.25 \\ CT_{tap1}(\text{relay } 3) &\quad 2.00 \qquad CT_{tap2}(\text{relay } 3) \quad 4.00 \end{aligned} \qquad \textbf{(EQ 9.16)}$$

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:

$$\begin{aligned} &\text{Pickup}(\text{relay } 1) \quad 0.4 \\ &\text{Pickup}(\text{relay } 2) \quad 0.2 \\ &\text{Pickup}(\text{relay } 3) \quad 0.8 \end{aligned} \qquad \textbf{(EQ 9.17)}$$

Choosing relay as a reference with a breakpoint value of 5.0 pu, breakpoints for relays 2 and 3 are calculated as follows:

$$\begin{aligned} \text{Breakpoint}(\text{relay } 2) \quad & \text{Breakpoint}(\text{relay } 1) \times \frac{CT_{\text{ratio}}(\text{relay } 1)}{CT_{\text{ratio}}(\text{relay } 2)} \\ & 5.0 \times \frac{1000/5}{2000/5} \quad 2.5 \end{aligned} \qquad \textbf{(EQ 9.18)}$$

$$\begin{aligned} \text{Breakpoint}(\text{relay } 3) \quad & \text{Breakpoint}(\text{relay } 1) \times \frac{CT_{\text{ratio}}(\text{relay } 1)}{CT_{\text{ratio}}(\text{relay } 3)} \\ & 5.0 \times \frac{1000/5}{500/5} \quad 10.0 \end{aligned} \qquad \textbf{(EQ 9.19)}$$

To verify the calculated values, we have:

$$\begin{aligned} &\text{Breakpoint}(\text{relay } 1) \times CT_{\text{ratio}}(\text{relay } 1) \quad 5.0 \times 1000/5 \quad 1000 \\ &\text{Breakpoint}(\text{relay } 2) \times CT_{\text{ratio}}(\text{relay } 2) \quad 2.5 \times 2000/5 \quad 1000 \\ &\text{Breakpoint}(\text{relay } 3) \times CT_{\text{ratio}}(\text{relay } 3) \quad 10.0 \times 5000/5 \quad 1000 \end{aligned} \qquad \textbf{(EQ 9.20)}$$

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.

9.3.1 DESCRIPTION

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:

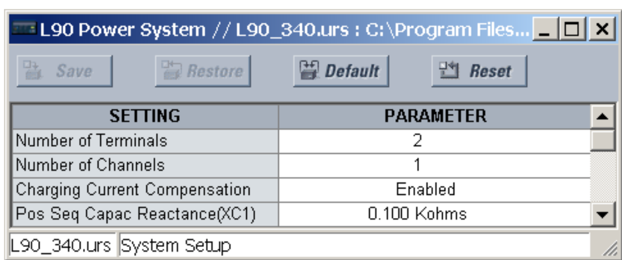
1. Enable GPS compensation on the loss of the GPS signal at any terminal and continue to operate the 87L element (using the memorized value of the last asymmetry) until a change in the channel round-trip delay is detected.
2. Enable GPS compensation on the loss of the GPS signal at any terminal and block the 87L element after a specified time.
3. 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.

9.3.2 COMPENSATION METHOD 1

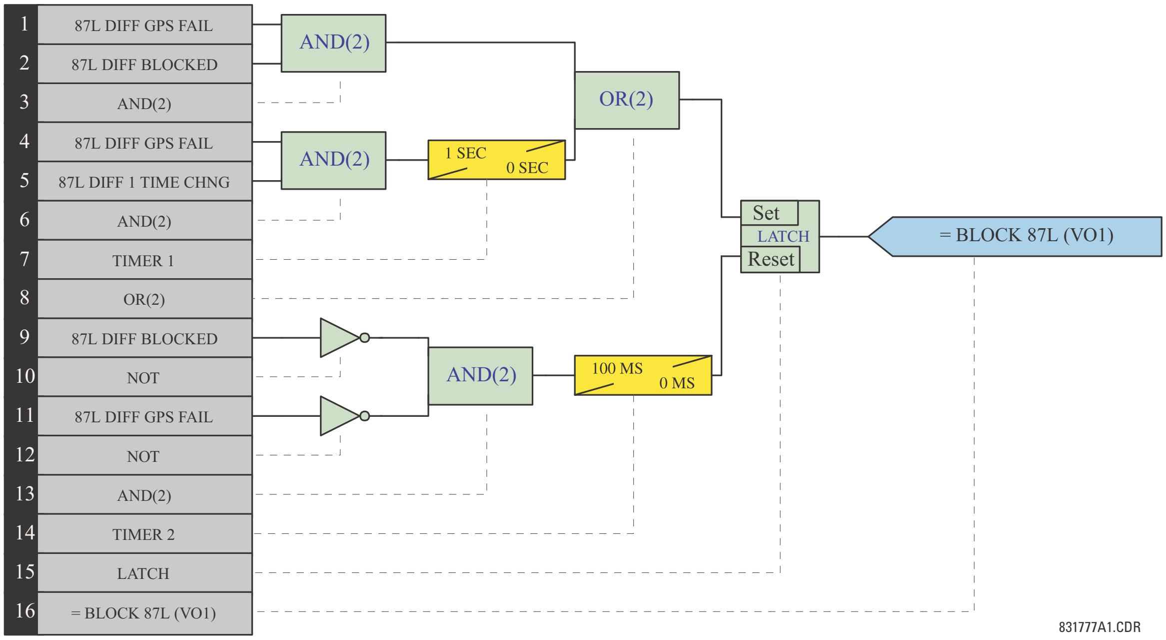
Enable GPS compensation on the loss of the GPS signal at any terminal and continue to operate the 87L element until a change in the channel round-trip delay is detected.

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 **L30 POWER SYSTEM** settings menu and signaled by the 87L DIFF 1(2) TIME CHNG FlexLogic™ operand. To implement this method, follow the steps below:

1. Enable Channel Asymmetry compensation by setting it to ON. Assign the GPS receiver failsafe alarm contact with the setting Block GPS Time Ref.



2. Create FlexLogic™ similar to that shown below 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.



3. Assign virtual output BLOCK 87L (VO1) to the 87L Current Differential Block setting. It can be used to enable backup protection, raise an alarm, and perform other functions as per the given protection philosophy.

9.3.3 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.

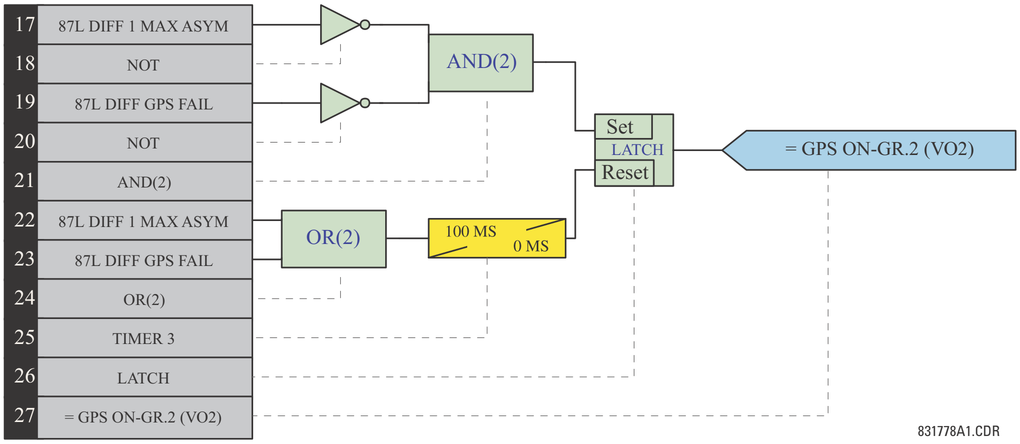
9.3.4 COMPENSATION METHOD 3

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 doesn't 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 below 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 will switch back to Settings Group 1 with less sensitive settings.

9



2. Set the 87L element with different differential settings for Settings Groups 1 and 2 as shown below

Current Differential // L90_340.urs : C:\Program...

Save | Restore | Default | Reset

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

Current Differential // L90_340.urs : C:\Program...

Save | Restore | Default | Reset

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) as shown below.

Setting Groups // L90_340.urs : C:\Program File...

Save | Restore | Default | Reset

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

L90 Power System // L90_340.urs : C:\Program Files...

Save | Restore | Default | Reset

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

9.4.1 INSTANTANEOUS ELEMENT ERROR DURING L30 SYNCHRONIZATION

As explained in the *Theory of Operation* chapter, two or three L30 relays are synchronized to each other and to system frequency to provide digital differential protection and accurate measurements for other protection and control functions. When an L30 system is starting up, the relays adjust their frequency aggressively to bring all relays into synchronization with the system quickly. The tracking frequency can differ from nominal (or system frequency) by a few Hertz, especially during the first second of synchronization. The 87L function is blocked during synchronization; therefore, the difference between system frequency and relay sampling frequency does not affect 87L function. However, instantaneous elements have additional error caused by the sensitivity of Fourier phasor estimation to the difference between signal frequency and tracking frequency.

To secure instantaneous element operation, it is recommended either to use FlexLogic as shown below to block the instantaneous elements during synchronization, or to use a different setting group with more conservative pickup for this brief interval.

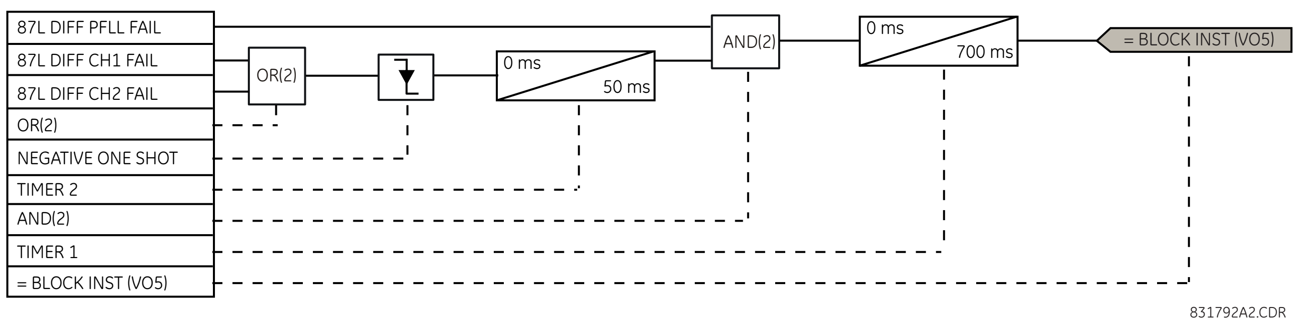


Figure 9–1: FLEXLOGIC TO BLOCK INSTANTANEOUS ELEMENT DURING 87L STARTUP

The elements must be treated selectively. If, for example, the phase undervoltage setting includes margin sufficient to accommodate the maximum additional error on startup, blocking or delay are not needed for phase undervoltage. 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 will not appear during L30 startup, therefore all elements using these quantities are safe.

The table below indicates the maximum error and recommended block durations for different elements.

ELEMENT	MAXIMUM ERROR ON STARTUP, (OPERATE SIGNAL VS. SETTING)	RECOMMENDED BLOCK DURATION
Phase undervoltage	18%	0.7 seconds
Phase instantaneous overcurrent	9%	0.5 seconds

9

10.1.1 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 (e.g. W7J).
2. Interconnect the two relays using the proper media (e.g. 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” should change to “Local Loopback Test PASSED” and then to “No”, signifying the test was successfully completed and the communication modules operated properly.
11. 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"
12. 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"
13. Make the following setting change in one of the relays:

    TESTING ⇨⇩ CHANNEL TESTS ⇨⇩ REMOTE LOOPBACK TEST ⇨⇩ REMOTE LOOPBACK CHANNEL NUMBER: "1"
14. 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 sec. the “Remote Loopback Test PASSED” message appears for a few seconds and then changes to “No”, signifying 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.
15. 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"
16. 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"

17. Verify and record that Remote Loopback Test fails during communications failures as follows: start test as per Steps 13 to 14 and in 2 to 5 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 is displayed. The status check should read as follows: **ACTUAL VALUES ⇩ STATUS ⇩ CHANNEL TESTS ⇨ CHANNEL 1(2) LOCAL LOOPBACK STATUS:** "Fail"

18. Re-connect the fiber Rx cable. Repeat Steps 13 to 14 and verify that Remote Loopback Test performs properly again.

19. 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 should be constantly on the display.

20. Repeat Steps 13 to 14 and verify that Remote Loopback Test is correct.

21. Make the following setting change in both relays: **TESTING ⇨ TEST MODE**: "Disabled"

NOTE

During channel tests, verify in the ACTUAL VALUES ⇨⇩ STATUS ⇨⇩ CHANNEL TESTS ⇨ CHANNEL 1(2) LOST PACKETS display that the values are very low – even 0. If values are comparatively high, settings of communications equipment (if applicable) should be checked.

10.1.2 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 PFLL status displays. All PFLL status displays must be either OK or Fail.

1. Ensure that Steps 1 through 7 inclusive of the previous section are completed.

2. 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 ⇨⇩ PFLL 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 ⇨⇩ PFLL 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 ⇨⇩ PFLL 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 PFLL after such interruption.

5. Disconnect the fiber Channel 1(2) Tx cable for more 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 ⇨⇩ PFLL STATUS: "Fail"

6. Reconnect the fiber Channel 1(2) Tx cable and in 6 to 8 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 ⇨⇩ PFLL 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 will not affect PFLL 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 ⇨ PFLL STATUS: "OK"
   ACTUAL VALUES ⇨⇩ METERING ⇨⇩ TRACKING FREQUENCY ⇨ TRACKING FREQUENCY: actual frequency at both relays

NOTE

For 3-terminal configuration, the above-indicated tests should be carried out accordingly.

10.1.3 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 which helps with start-up activities. When a differential condition is detected, the output operands from the element will be 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 PFLL STATUS displays indicate OK.
3. Minimum pickup test with local current only:
   - 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.
   - 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):

$$I_{op} \quad \sqrt{2 \times \frac{P^2}{1 \quad 2S_1^2}} \qquad \textbf{(EQ 10.1)}$$

   - Repeat the above test for different slope and pickup settings, if desired.
   - Repeat the above tests for Phases B and C.
4. Minimum pickup test with local current and simulated remote current (pure internal fault simulation):
   - Disconnect the local relay from the communications channel.
   - Loop back the transmit signal to the receive input on the back of the relay.
   - Wait until the CHANNEL and PFLL status displays indicate OK.
   - 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:

$$I_{op} \quad \sqrt{\frac{2P^2}{(1 \quad \mathrm{TAP})^2 \quad 2S_1^2(1 \quad \mathrm{TAP}^2)}} \qquad \textbf{(EQ 10.2)}$$

     where TAP represents the CT Tap setting for the corresponding channel.
   - Repeat the above test for different slope and pickup settings, if desired.
   - 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**.
   - Repeat the above tests for Phases B and C.
   - Restore the communication circuits to normal.

NOTE

Download the UR Test software from the GE Multilin website (http://www.gedigitalenergy.com/multilin) or contact GE Multilin for information about the UR current differential test program which allows the user to simulate different operating conditions for verifying correct responses of the relays during commissioning activities.

10.1.4 LOCAL-REMOTE RELAY TESTS

a) 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 will close 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 thorough 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.

b) 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.

11.1.1 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. Modules must only be replaced with like modules in their original factory configured slots.

The enhanced faceplate can be opened to the left, once the thumb screw has been removed, as shown below. This allows for easy accessibility 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.

842812A1.CDR

Figure 11–1: UR MODULE WITHDRAWAL AND INSERTION (ENHANCED FACEPLATE)

The standard faceplate can be opened to the left, once the sliding latch on the right side has been pushed up, as shown below. This allows for easy accessibility of the modules for withdrawal.

842760A1.CDR

Figure 11–2: UR MODULE WITHDRAWAL AND INSERTION (STANDARD FACEPLATE)

To properly remove a module, the ejector/inserter clips, located at the top and bottom of each module, must be pulled simultaneously. Before performing this action, **control power must be removed from the relay**. Record the original location of the module to ensure that the same or replacement module is inserted into the correct slot. Modules with current input provide automatic shorting of external CT circuits.

To properly insert a module, ensure that the **correct** module type is inserted into the **correct** slot position. The ejector/inserter 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 will be fully inserted.

NOTE

CPU connections must be individually disconnected from the module before the module can be removed from the chassis.

11.2.1 REPLACE BATTERY

When required, the battery can be replaced. The power supply module contains the battery.

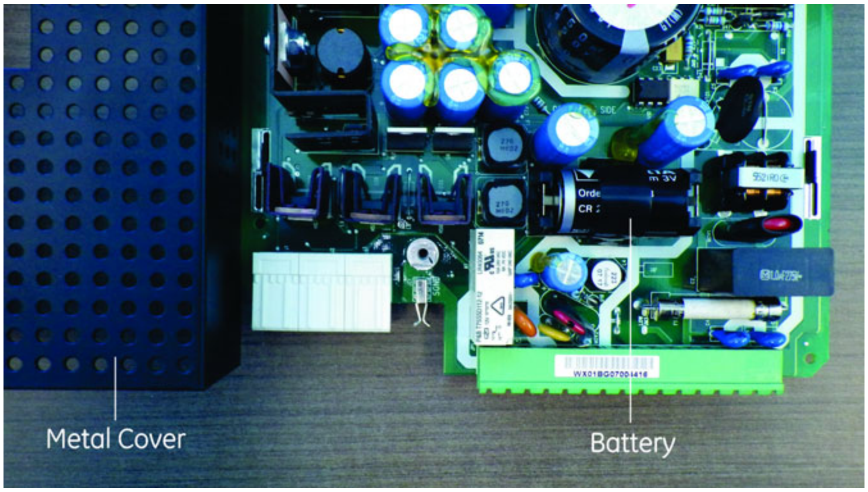
⚠CAUTION **To avoid injury, ensure that the unit has been powered off for a minimum of three minutes before replacing the battery.**

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 latch on the right side of the front panel and opening the panel to the left.
4. Unscrew the bracket on the front left of the unit so that you can open fully the front panel to access the power supply module, which is typically in the first slot on the left side.
5. Simultaneously pull the ejector clips at the top and bottom of the power supply module and remove the module.
6. Unscrew the screw that attaches the metal cover to the module.
7. Slide the metal cover away from the clips about 1 cm (1/4 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. Use a flat-head screwdriver if you cannot unclip the plastic with your fingers.
9. Observe the + and - polarity of the battery and replace it with the same polarity as marked on the battery holder. Replace the battery with the identical make and model. For example, do not use a rechargeable battery.

Figure 11–3: BATTERY LOCATION ON POWER SUPPLY MODULE



10. Reinstall the battery clip 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

11.2.2 DISPOSE OF BATTERY

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.

CS Nakládání s bateriemi
Tento produkt obsahuje baterie, které nemohou být zneškodněny v Evropské unii jako netříděný komunální odpadu. 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.

DA Batteri affald
Dette 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.

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.

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.

ES Eliminacion de baterias
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 : wwwrecyclethis.info.

ET Patareide kõrvaldamine
Käesolev toode sisaldab patareisid, mida Euroopa Liidus ei tohi kõrvaldada sorteerimata olmejäätmetena. Andmeid patareide kohta vaadake toote dokumentatsioonist. Patareid on märgistatud 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.

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 cadmiumia (Cd), lyijyä (Pb) tai elohopeaa (Hg). Oikean kierrätystavan varmistamiseksi palauta tuote paikalliselle jälleenmyyjälle tai palauta se paristojen keräyspisteeseen. Lisätietoja sivuilla www.recyclethis.info.

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.

HU Akkumulátor hulladék kezelése

Ezen termék akkumulátort tartalmaz, amely az Európai Unión belül csak a kijelölt módon és helyen dobható ki. A terméken 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 hulladékudvarokban. További információ a www.recyclethis.info oldalon.

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: ww.recyclethis.info.

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.

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), svinu (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.

NL Verwijderen van baterijen

Dit product bevat een batterij welke niet kan verwijdert 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.

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.

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.

PT Eliminação de Baterias

Este produto contêm 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 rotulação 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.

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 собержит кадмий (Cd), свинец (Pb) или ртуть (Hg). Для надлежащей утилизации по окончании срока эксплуатации пользователь должен возвратить батареи локальному поставщику или сдать в специальный пункт приема. Подробности можно найти на веб-сайте: www.recyclethis.info.

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 informácii pozrite: www.recyclethis.info.

SL Odlaganje baterij

Ta izdelek vsebuje baterijo, ki je v Evropski uniji ni dovoljeno odstranjevati kot nesortiran komunalni odpadek. 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.

SV Kassering av batteri

Denna produkt innehåller ett batteri som inte får kastas i allmänna sophanteringssytem 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.

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 noktlarına atınız. Daha fazla bilgi için: www.recyclethis.info.

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

A.1.1 FLEXANALOG ITEMS

FlexAnalog items are also viewable in a web browser. In the browser, enter the IP address of the UR, access the **Device Information Menu** option, then the **FlexAnalog Parameter Listing** option.

Table A–1: FLEXANALOG DATA ITEMS (Sheet 1 of 9)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
5688	Channel 1 Asymmetry	---	Channel 1 asymmetry
5690	Channel 2 Asymmetry	---	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
6144	SRC 1 Ia RMS	Amps	Source 1 phase A current RMS
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	Degrees	Source 1 ground current magnitude
6168	SRC 1 Ig Angle	Amps	Source 1 ground current angle
6169	SRC 1 I_0 Mag	Degrees	Source 1 zero-sequence current magnitude
6171	SRC 1 I_0 Angle	Amps	Source 1 zero-sequence current angle
6172	SRC 1 I_1 Mag	Degrees	Source 1 positive-sequence current magnitude
6174	SRC 1 I_1 Angle	Amps	Source 1 positive-sequence current angle
6175	SRC 1 I_2 Mag	Degrees	Source 1 negative-sequence current magnitude
6177	SRC 1 I_2 Angle	Amps	Source 1 negative-sequence current angle
6178	SRC 1 Igd Mag	Degrees	Source 1 differential ground current magnitude
6180	SRC 1 Igd Angle	Amps	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

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 2 of 9)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
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	Degrees	Source 2 ground current magnitude
6232	SRC 2 Ig Angle	Amps	Source 2 ground current angle
6233	SRC 2 I_0 Mag	Degrees	Source 2 zero-sequence current magnitude
6235	SRC 2 I_0 Angle	Amps	Source 2 zero-sequence current angle
6236	SRC 2 I_1 Mag	Degrees	Source 2 positive-sequence current magnitude
6238	SRC 2 I_1 Angle	Amps	Source 2 positive-sequence current angle
6239	SRC 2 I_2 Mag	Degrees	Source 2 negative-sequence current magnitude
6241	SRC 2 I_2 Angle	Amps	Source 2 negative-sequence current angle
6242	SRC 2 Igd Mag	Degrees	Source 2 differential ground current magnitude
6244	SRC 2 Igd Angle	Amps	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
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

Table A–1: FLEXANALOG DATA ITEMS (Sheet 3 of 9)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
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
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

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 4 of 9)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
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
9024	Prefault Ia Mag [0]	Amps	Fault 1 pre-fault phase A current magnitude
9026	Prefault Ia Ang [0]	Degrees	Fault 1 pre-fault phase A current angle
9027	Prefault Ib Mag [0]	Amps	Fault 1 pre-fault phase B current magnitude
9029	Prefault Ib Ang [0]	Degrees	Fault 1 pre-fault phase B current angle
9030	Prefault Ic Mag [0]	Amps	Fault 1 pre-fault phase C current magnitude
9032	Prefault Ic Ang [0]	Degrees	Fault 1 pre-fault phase C current angle
9033	Prefault Va Mag [0]	Volts	Fault 1 pre-fault phase A voltage magnitude
9035	Prefault Va Ang [0]	Degrees	Fault 1 pre-fault phase A voltage angle
9036	Prefault Vb Mag [0]	Volts	Fault 1 pre-fault phase B voltage magnitude
9038	Prefault Vb Ang [0]	Degrees	Fault 1 pre-fault phase B voltage angle
9039	Prefault Vc Mag [0]	Volts	Fault 1 pre-fault phase C voltage magnitude
9041	Prefault Vc Ang [0]	Degrees	Fault 1 pre-fault phase C voltage angle
9042	Postfault Ia Mag [0]	Amps	Fault 1 post-fault phase A current magnitude
9044	Postfault Ia Ang [0]	Degrees	Fault 1 post-fault phase A current angle
9045	Postfault Ib Mag [0]	Amps	Fault 1 post-fault phase B current magnitude
9047	Postfault Ib Ang [0]	Degrees	Fault 1 post-fault phase B current angle
9048	Postfault Ic Mag [0]	Amps	Fault 1 post-fault phase C current magnitude
9050	Postfault Ic Ang [0]	Degrees	Fault 1 post-fault phase C current angle
9051	Postfault Va Mag [0]	Volts	Fault 1 post-fault phase A voltage magnitude
9053	Postfault Va Ang [0]	Degrees	Fault 1 post-fault phase A voltage angle
9054	Postfault Vb Mag [0]	Volts	Fault 1 post-fault phase B voltage magnitude
9056	Postfault Vb Ang [0]	Degrees	Fault 1 post-fault phase B voltage angle
9057	Postfault Vc Mag [0]	Volts	Fault 1 post-fault phase C voltage magnitude
9059	Postfault Vc Ang [0]	Degrees	Fault 1 post-fault phase C voltage angle
9060	Fault Type [0]	---	Fault 1 type
9061	Fault Location [0]	---	Fault 1 location
9216	Synchchk 1 Delta V	Volts	Synchrocheck 1 delta voltage
9218	Synchchk 1 Delta F	Hz	Synchrocheck 1 delta frequency
9219	Synchchk 1 Delta Phs	Degrees	Synchrocheck 1 delta phase
9220	Synchchk 2 Delta V	Volts	Synchrocheck 2 delta voltage
9222	Synchchk 2 Delta F	Hz	Synchrocheck 2 delta frequency
9223	Synchchk 2 Delta Phs	Degrees	Synchrocheck 2 delta phase

Table A–1: FLEXANALOG DATA ITEMS (Sheet 5 of 9)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
9224	Synchchk 3 Delta V	Volts	Synchrocheck 3 delta voltage
9226	Synchchk 3 Delta F	Hz	Synchrocheck 3 delta frequency
9227	Synchchk 3 Delta Phs	Degrees	Synchrocheck 3 delta phase
9228	Synchchk 4 Delta V	Volts	Synchrocheck 4 delta voltage
9230	Synchchk 4 Delta F	Hz	Synchrocheck 4 delta frequency
9231	Synchchk 4 Delta Phs	Degrees	Synchrocheck 4 delta phase
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
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

A

Table A–1: FLEXANALOG DATA ITEMS (Sheet 6 of 9)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
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
9536	PMU 1 Va Mag	Volts	Phasor measurement unit 1 phase A voltage magnitude
9538	PMU 1 Va Angle	Degrees	Phasor measurement unit 1 phase A voltage angle
9539	PMU 1 Vb Mag	Volts	Phasor measurement unit 1 phase B voltage magnitude
9541	PMU 1 Vb Angle	Degrees	Phasor measurement unit 1 phase B voltage angle
9542	PMU 1 Vc Mag	Volts	Phasor measurement unit 1 phase C voltage magnitude
9544	PMU 1 Vc Angle	Degrees	Phasor measurement unit 1 phase C voltage angle
9545	PMU 1 Vx Mag	Volts	Phasor measurement unit 1 auxiliary voltage magnitude
9547	PMU 1 Vx Angle	Degrees	Phasor measurement unit 1 auxiliary voltage angle
9548	PMU 1 V1 Mag	Volts	Phasor measurement unit 1 positive-sequence voltage magnitude
9550	PMU 1 V1 Angle	Degrees	Phasor measurement unit 1 positive-sequence voltage angle
9551	PMU 1 V2 Mag	Volts	Phasor measurement unit 1 negative-sequence voltage magnitude
9553	PMU 1 V2 Angle	Degrees	Phasor measurement unit 1 negative-sequence voltage angle
9554	PMU 1 V0 Mag	Volts	Phasor measurement unit 1 zero-sequence voltage magnitude
9556	PMU 1 V0 Angle	Degrees	Phasor measurement unit 1 zero-sequence voltage angle
9557	PMU 1 Ia Mag	Amps	Phasor measurement unit 1 phase A current magnitude
9559	PMU 1 Ia Angle	Degrees	Phasor measurement unit 1 phase A current angle
9560	PMU 1 Ib Mag	Amps	Phasor measurement unit 1 phase B current magnitude
9562	PMU 1 Ib Angle	Degrees	Phasor measurement unit 1 phase B current angle
9563	PMU 1 Ic Mag	Amps	Phasor measurement unit 1 phase C current magnitude
9565	PMU 1 Ic Angle	Degrees	Phasor measurement unit 1 phase C current angle
9566	PMU 1 Ig Mag	Amps	Phasor measurement unit 1 ground current magnitude
9568	PMU 1 Ig Angle	Degrees	Phasor measurement unit 1 ground current angle
9569	PMU 1 I1 Mag	Amps	Phasor measurement unit 1 positive-sequence current magnitude
9571	PMU 1 I1 Angle	Degrees	Phasor measurement unit 1 positive-sequence current angle
9572	PMU 1 I2 Mag	Amps	Phasor measurement unit 1 negative-sequence current magnitude
9574	PMU 1 I2 Angle	Degrees	Phasor measurement unit 1 negative-sequence current angle
9575	PMU 1 I0 Mag	Amps	Phasor measurement unit 1 zero-sequence current magnitude
9577	PMU 1 I0 Angle	Degrees	Phasor measurement unit 1 zero-sequence current angle
9578	PMU 1 Freq	Hz	Phasor measurement unit 1 frequency
9580	PMU 1 df dt	Hz/s	Phasor measurement unit 1 rate of change of frequency
9581	PMU 1 Conf Ch	---	Phasor measurement unit 1 configuration change counter
12306	Oscill Num Triggers	---	Oscillography number of triggers
13504	DCMA Inputs 1 Value	mA	dcmA input 1 actual value
13506	DCMA Inputs 2 Value	mA	dcmA input 2 actual value
13508	DCMA Inputs 3 Value	mA	dcmA input 3 actual value
13510	DCMA Inputs 4 Value	mA	dcmA input 4 actual value
13512	DCMA Inputs 5 Value	mA	dcmA input 5 actual value
13514	DCMA Inputs 6 Value	mA	dcmA input 6 actual value
13516	DCMA Inputs 7 Value	mA	dcmA input 7 actual value
13518	DCMA Inputs 8 Value	mA	dcmA input 8 actual value
13520	DCMA Inputs 9 Value	mA	dcmA input 9 actual value
13522	DCMA Inputs 10 Value	mA	dcmA input 10 actual value
13524	DCMA Inputs 11 Value	mA	dcmA input 11 actual value

Table A–1: FLEXANALOG DATA ITEMS (Sheet 7 of 9)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
13526	DCMA Inputs 12 Value	mA	dcmA input 12 actual value
13528	DCMA Inputs 13 Value	mA	dcmA input 13 actual value
13530	DCMA Inputs 14 Value	mA	dcmA input 14 actual value
13532	DCMA Inputs 15 Value	mA	dcmA input 15 actual value
13534	DCMA Inputs 16 Value	mA	dcmA input 16 actual value
13536	DCMA Inputs 17 Value	mA	dcmA input 17 actual value
13538	DCMA Inputs 18 Value	mA	dcmA input 18 actual value
13540	DCMA Inputs 19 Value	mA	dcmA input 19 actual value
13542	DCMA Inputs 20 Value	mA	dcmA input 20 actual value
13544	DCMA Inputs 21 Value	mA	dcmA input 21 actual value
13546	DCMA Inputs 22 Value	mA	dcmA input 22 actual value
13548	DCMA Inputs 23 Value	mA	dcmA input 23 actual value
13550	DCMA Inputs 24 Value	mA	dcmA input 24 actual value
13552	RTD Inputs 1 Value	---	RTD input 1 actual value
13553	RTD Inputs 2 Value	---	RTD input 2 actual value
13554	RTD Inputs 3 Value	---	RTD input 3 actual value
13555	RTD Inputs 4 Value	---	RTD input 4 actual value
13556	RTD Inputs 5 Value	---	RTD input 5 actual value
13557	RTD Inputs 6 Value	---	RTD input 6 actual value
13558	RTD Inputs 7 Value	---	RTD input 7 actual value
13559	RTD Inputs 8 Value	---	RTD input 8 actual value
13560	RTD Inputs 9 Value	---	RTD input 9 actual value
13561	RTD Inputs 10 Value	---	RTD input 10 actual value
13562	RTD Inputs 11 Value	---	RTD input 11 actual value
13563	RTD Inputs 12 Value	---	RTD input 12 actual value
13564	RTD Inputs 13 Value	---	RTD input 13 actual value
13565	RTD Inputs 14 Value	---	RTD input 14 actual value
13566	RTD Inputs 15 Value	---	RTD input 15 actual value
13567	RTD Inputs 16 Value	---	RTD input 16 actual value
13568	RTD Inputs 17 Value	---	RTD input 17 actual value
13569	RTD Inputs 18 Value	---	RTD input 18 actual value
13570	RTD Inputs 19 Value	---	RTD input 19 actual value
13571	RTD Inputs 20 Value	---	RTD input 20 actual value
13572	RTD Inputs 21 Value	---	RTD input 21 actual value
13573	RTD Inputs 22 Value	---	RTD input 22 actual value
13574	RTD Inputs 23 Value	---	RTD input 23 actual value
13575	RTD Inputs 24 Value	---	RTD input 24 actual value
13576	RTD Inputs 25 Value	---	RTD input 25 actual value
13577	RTD Inputs 26 Value	---	RTD input 26 actual value
13578	RTD Inputs 27 Value	---	RTD input 27 actual value
13579	RTD Inputs 28 Value	---	RTD input 28 actual value
13580	RTD Inputs 29 Value	---	RTD input 29 actual value
13581	RTD Inputs 30 Value	---	RTD input 30 actual value
13582	RTD Inputs 31 Value	---	RTD input 31 actual value
13583	RTD Inputs 32 Value	---	RTD input 32 actual value
13584	RTD Inputs 33 Value	---	RTD input 33 actual value
13585	RTD Inputs 34 Value	---	RTD input 34 actual value

Table A–1: FLEXANALOG DATA ITEMS (Sheet 8 of 9)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
13586	RTD Inputs 35 Value	---	RTD input 35 actual value
13587	RTD Inputs 36 Value	---	RTD input 36 actual value
13588	RTD Inputs 37 Value	---	RTD input 37 actual value
13589	RTD Inputs 38 Value	---	RTD input 38 actual value
13590	RTD Inputs 39 Value	---	RTD input 39 actual value
13591	RTD Inputs 40 Value	---	RTD input 40 actual value
13592	RTD Inputs 41 Value	---	RTD input 41 actual value
13593	RTD Inputs 42 Value	---	RTD input 42 actual value
13594	RTD Inputs 43 Value	---	RTD input 43 actual value
13595	RTD Inputs 44 Value	---	RTD input 44 actual value
13596	RTD Inputs 45 Value	---	RTD input 45 actual value
13597	RTD Inputs 46 Value	---	RTD input 46 actual value
13598	RTD Inputs 47 Value	---	RTD input 47 actual value
13599	RTD Inputs 48 Value	---	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
24447	Active Setting Group	---	Current setting group
32768	Tracking Frequency	Hz	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
39184	FlexElement 9 Value	---	FlexElement 9 actual value
39186	FlexElement 10 Value	---	FlexElement 10 actual value
39188	FlexElement 11 Value	---	FlexElemen 11 actual value
39190	FlexElement 12 Value	---	FlexElement 12 actual value
39192	FlexElement 13 Value	---	FlexElement 13 actual value
39194	FlexElement 14 Value	---	FlexElement 14 actual value
39196	FlexElement 15 Value	---	FlexElement 15 actual value
39198	FlexElement 16 Value	---	FlexElement 16 actual value
41132	VTFF 1 V0 3rd Harmonic	---	V0 3rd Harmonic 1
41134	VTFF 2 V0 3rd Harmonic	---	V0 3rd Harmonic 2
41136	VTFF 3 V0 3rd Harmonic	---	V0 3rd Harmonic 3
41138	VTFF 4 V0 3rd Harmonic	---	V0 3rd Harmonic 4
41140	VTFF 5 V0 3rd Harmonic	---	V0 3rd Harmonic 5
41142	VTFF 6 V0 3rd Harmonic	---	V0 3rd Harmonic 6
45584	GOOSE Analog In 1	---	IEC 61850 GOOSE analog input 1
45586	GOOSE Analog In 2	---	IEC 61850 GOOSE analog input 2
45588	GOOSE Analog In 3	---	IEC 61850 GOOSE analog input 3
45590	GOOSE Analog In 4	---	IEC 61850 GOOSE analog input 4
45592	GOOSE Analog In 5	---	IEC 61850 GOOSE analog input 5
45594	GOOSE Analog In 6	---	IEC 61850 GOOSE analog input 6

Table A–1: FLEXANALOG DATA ITEMS (Sheet 9 of 9)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
45596	GOOSE Analog In 7	---	IEC 61850 GOOSE analog input 7
45598	GOOSE Analog In 8	---	IEC 61850 GOOSE analog input 8
45600	GOOSE Analog In 9	---	IEC 61850 GOOSE analog input 9
45602	GOOSE Analog In 10	---	IEC 61850 GOOSE analog input 10
45604	GOOSE Analog In 11	---	IEC 61850 GOOSE analog input 11
45606	GOOSE Analog In 12	---	IEC 61850 GOOSE analog input 12
45608	GOOSE Analog In 13	---	IEC 61850 GOOSE analog input 13
45610	GOOSE Analog In 14	---	IEC 61850 GOOSE analog input 14
45612	GOOSE Analog In 15	---	IEC 61850 GOOSE analog input 15
45614	GOOSE Analog In 16	---	IEC 61850 GOOSE analog input 16
61439	PMU Num Triggers	---	Phasor measurement unit recording number of triggers

A.1.2 FLEXINTEGER ITEMS

FlexInteger items are also viewable in a web browser. In the browser, enter the IP address of the UR, access the **Device Information Menu** option, then the **FlexInteger Parameter Listing** option.

Table A–2: FLEXINTEGER DATA ITEMS

ADDRESS	FLEXINTEGER NAME	UNITS	DESCRIPTION
9736	PMU 1 SOC	seconds	PMU 1 SOC timestamps
9738	PMU 1 FRACSEC	seconds	PMU 1 FRACSEC timestamps
9740	PMU 1 STAT	---	PMU 1 STAT flags
9968	GOOSE UInt Input 1	---	IEC61850 GOOSE UInteger input 1
9970	GOOSE UInt Input 2	---	IEC61850 GOOSE UInteger input 2
9972	GOOSE UInt Input 3	---	IEC61850 GOOSE UInteger input 3
9974	GOOSE UInt Input 4	---	IEC61850 GOOSE UInteger input 4
9976	GOOSE UInt Input 5	---	IEC61850 GOOSE UInteger input 5
9978	GOOSE UInt Input 6	---	IEC61850 GOOSE UInteger input 6
9980	GOOSE UInt Input 7	---	IEC61850 GOOSE UInteger input 7
9982	GOOSE UInt Input 8	---	IEC61850 GOOSE UInteger input 8
9984	GOOSE UInt Input 9	---	IEC61850 GOOSE UInteger input 9
9986	GOOSE UInt Input 10	---	IEC61850 GOOSE UInteger input 10
9988	GOOSE UInt Input 11	---	IEC61850 GOOSE UInteger input 11
9990	GOOSE UInt Input 12	---	IEC61850 GOOSE UInteger input 12
9992	GOOSE UInt Input 13	---	IEC61850 GOOSE UInteger input 13
9994	GOOSE UInt Input 14	---	IEC61850 GOOSE UInteger input 14
9996	GOOSE UInt Input 15	---	IEC61850 GOOSE UInteger input 15
9998	GOOSE UInt Input 16	---	IEC61850 GOOSE UInteger input 16

B.1.1 INTRODUCTION

The UR-series relays support a number of communications protocols to allow connection to equipment such as personal computers, RTUs, SCADA masters, and programmable logic controllers. The Modicon Modbus RTU protocol is the most basic protocol supported by the UR. Modbus is available via RS232 or RS485 serial links or via ethernet (using the Modbus/TCP specification). The following description is intended primarily for users who wish to develop their own master communication drivers and applies to the serial Modbus RTU protocol. Note that:

- The UR always acts as a slave device, meaning that it never initiates communications; it only listens and responds to requests issued by a master computer.
- For Modbus, a subset of the Remote Terminal Unit (RTU) protocol format is supported that allows extensive monitoring, programming, and control functions using read and write register commands.

B.1.2 PHYSICAL LAYER

The Modbus RTU protocol is hardware-independent so that the physical layer can be any of a variety of standard hardware configurations including RS232 and RS485. The relay includes a faceplate (front panel) RS232 port and two rear terminal communications ports that may be configured as RS485, fiber optic, 10Base-T, or 10Base-F. Data flow is half-duplex in all configurations. See chapter 3 for details on communications wiring.

Each data byte is transmitted in an asynchronous format consisting of 1 start bit, 8 data bits, 1 stop bit, and possibly 1 parity bit. This produces a 10 or 11 bit data frame. This can be important for transmission through modems at high bit rates (11 bit data frames are not supported by many modems at baud rates greater than 300).

The baud rate and parity are independently programmable for each communications port. Baud rates of 300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 57600, or 115200 bps are available. Even, odd, and no parity are available. Refer to the *Communications* section of chapter 5 for further details.

The master device in any system must know the address of the slave device with which it is to communicate. The relay will not act on a request from a master if the address in the request does not match the relay's slave address (unless the address is the broadcast address – see below).

A single setting selects the slave address used for all ports, with the exception that for the faceplate port, the relay will accept any address when the Modbus RTU protocol is used.

B.1.3 DATA LINK LAYER

Communications takes place in packets which are groups of asynchronously framed byte data. The master transmits a packet to the slave and the slave responds with a packet. The end of a packet is marked by *dead-time* on the communications line. The following describes general format for both transmit and receive packets. For exact details on packet formatting, refer to subsequent sections describing each function code.

Table B–1: MODBUS PACKET FORMAT

DESCRIPTION	SIZE
SLAVE ADDRESS	1 byte
FUNCTION CODE	1 byte
DATA	*N* bytes
CRC	2 bytes
DEAD TIME	3.5 bytes transmission time

- **SLAVE ADDRESS:** This is the address of the slave device that is intended to receive the packet sent by the master and to perform the desired action. Each slave device on a communications bus must have a unique address to prevent bus contention. All of the relay's ports have the same address which is programmable from 1 to 254; see chapter 5 for details. Only the addressed slave will respond to a packet that starts with its address. Note that the faceplate port is an exception to this rule; it will act on a message containing any slave address.

  A master transmit packet with slave address 0 indicates a broadcast command. All slaves on the communication link take action based on the packet, but none respond to the master. Broadcast mode is only recognized when associated with function code 05h. For any other function code, a packet with broadcast mode slave address 0 will be ignored.

- **FUNCTION CODE:** This is one of the supported functions codes of the unit which tells the slave what action to perform. See the *Supported Function Codes* section for complete details. An exception response from the slave is indicated by setting the high order bit of the function code in the response packet. See the *Exception Responses* section for further details.
- **DATA:** This will be a variable number of bytes depending on the function code. This may include actual values, settings, or addresses sent by the master to the slave or by the slave to the master.
- **CRC:** This is a two byte error checking code. The RTU version of Modbus includes a 16-bit cyclic redundancy check (CRC-16) with every packet which is an industry standard method used for error detection. If a Modbus slave device receives a packet in which an error is indicated by the CRC, the slave device will not act upon or respond to the packet thus preventing any erroneous operations. See the *CRC-16 Algorithm* section for details on calculating the CRC.
- **DEAD TIME:** A packet is terminated when no data is received for a period of 3.5 byte transmission times (about 15 ms at 2400 bps, 2 ms at 19200 bps, and 300 µs at 115200 bps). Consequently, the transmitting device must not allow gaps between bytes longer than this interval. Once the dead time has expired without a new byte transmission, all slaves start listening for a new packet from the master except for the addressed slave.

B.1.4 CRC-16 ALGORITHM

The CRC-16 algorithm essentially treats the entire data stream (data bits only; start, stop and parity ignored) as one continuous binary number. This number is first shifted left 16 bits and then divided by a characteristic polynomial (11000000000000101B). The 16-bit remainder of the division is appended to the end of the packet, MSByte first. The resulting packet including CRC, when divided by the same polynomial at the receiver will give a zero remainder if no transmission errors have occurred. This algorithm requires the characteristic polynomial to be reverse bit ordered. The most significant bit of the characteristic polynomial is dropped, since it does not affect the value of the remainder.

A C programming language implementation of the CRC algorithm will be provided upon request.

Table B–2: CRC-16 ALGORITHM

SYMBOLS:	-->	data transfer	
	A	16 bit working register	
	Alow	low order byte of A	
	Ahigh	high order byte of A	
	CRC	16 bit CRC-16 result	
	i,j	loop counters	
	(+)	logical EXCLUSIVE-OR operator	
	N	total number of data bytes	
	Di	i-th data byte (i = 0 to N-1)	
	G	16 bit characteristic polynomial = 1010000000000001 (binary) with MSbit dropped and bit order reversed	
	shr (x)	right shift operator (th LSbit of x is shifted into a carry flag, a '0' is shifted into the MSbit of x, all other bits are shifted right one location)	
ALGORITHM:	1.	FFFF (hex) --> A	
	2.	0 --> i	
	3.	0 --> j	
	4.	Di (+) Alow --> Alow	
	5.	j + 1 --> j	
	6.	shr (A)	
	7.	Is there a carry?	No: go to 8; Yes: G (+) A --> A and continue.
	8.	Is j = 8?	No: go to 5; Yes: continue
	9.	i + 1 --> i	
	10.	Is i = N?	No: go to 3; Yes: continue
	11.	A --> CRC	

B.2.1 SUPPORTED FUNCTION CODES

Modbus officially defines function codes from 1 to 127 though only a small subset is generally needed. The relay supports some of these functions, as summarized in the following table. Subsequent sections describe each function code in detail.

FUNCTION CODE		MODBUS DEFINITION	GE MULTILIN DEFINITION
HEX	DEC		
03	3	Read holding registers	Read actual values or settings
04	4	Read holding registers	Read actual values or settings
05	5	Force single coil	Execute operation
06	6	Preset single register	Store single setting
10	16	Preset multiple registers	Store multiple settings

B.2.2 READ ACTUAL VALUES OR SETTINGS (FUNCTION CODE 03/04H)

This function code allows the master to read one or more consecutive data registers (actual values or settings) from a relay. Data registers are always 16-bit (two-byte) values transmitted with high order byte first. The maximum number of registers that can be read in a single packet is 125. See the *Modbus memory map* table for exact details on the data registers.

Since some PLC implementations of Modbus only support one of function codes 03h and 04h. The L30 interpretation allows either function code to be used for reading one or more consecutive data registers. The data starting address will determine the type of data being read. Function codes 03h and 04h are therefore identical.

The following table shows the format of the master and slave packets. The example shows a master device requesting three register values starting at address 4050h from slave device 11h (17 decimal); the slave device responds with the values 40, 300, and 0 from registers 4050h, 4051h, and 4052h, respectively.

Table B–3: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION	
PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11
FUNCTION CODE	04
DATA STARTING ADDRESS - high	40
DATA STARTING ADDRESS - low	50
NUMBER OF REGISTERS - high	00
NUMBER OF REGISTERS - low	03
CRC - low	A7
CRC - high	4A

SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11
FUNCTION CODE	04
BYTE COUNT	06
DATA #1 - high	00
DATA #1 - low	28
DATA #2 - high	01
DATA #2 - low	2C
DATA #3 - high	00
DATA #3 - low	00
CRC - low	0D
CRC - high	60

B.2.3 EXECUTE OPERATION (FUNCTION CODE 05H)

This function code allows the master to perform various operations in the relay. Available operations are shown in the *Summary of operation codes* table below.

The following table shows the format of the master and slave packets. The example shows a master device requesting the slave device 11h (17 decimal) to perform a reset. The high and low code value bytes always have the values "FF" and "00" respectively and are a remnant of the original Modbus definition of this function code.

B

Table B–4: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	**EXAMPLE (HEX)**	**PACKET FORMAT**	**EXAMPLE (HEX)**
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	05	FUNCTION CODE	05
OPERATION CODE - high	00	OPERATION CODE - high	00
OPERATION CODE - low	01	OPERATION CODE - low	01
CODE VALUE - high	FF	CODE VALUE - high	FF
CODE VALUE - low	00	CODE VALUE - low	00
CRC - low	DF	CRC - low	DF
CRC - high	6A	CRC - high	6A

Table B–5: SUMMARY OF OPERATION CODES FOR FUNCTION 05H

OPERATION CODE (HEX)	DEFINITION	DESCRIPTION
0000	NO OPERATION	Does not do anything.
0001	RESET	Performs the same function as the faceplate RESET key.
0005	CLEAR EVENT RECORDS	Performs the same function as the faceplate **CLEAR EVENT RECORDS** menu command.
0006	CLEAR OSCILLOGRAPHY	Clears all oscillography records.
1000 to 103F	VIRTUAL IN 1 to 64 ON/OFF	Sets the states of Virtual Inputs 1 to 64 either "ON" or "OFF".

B.2.4 STORE SINGLE SETTING (FUNCTION CODE 06H)

This function code allows the master to modify the contents of a single setting register in an relay. Setting registers are always 16 bit (two byte) values transmitted high order byte first. The following table shows the format of the master and slave packets. The example shows a master device storing the value 200 at memory map address 4051h to slave device 11h (17 dec).

Table B–6: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	**EXAMPLE (HEX)**	**PACKET FORMAT**	**EXAMPLE (HEX)**
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	06	FUNCTION CODE	06
DATA STARTING ADDRESS - high	40	DATA STARTING ADDRESS - high	40
DATA STARTING ADDRESS - low	51	DATA STARTING ADDRESS - low	51
DATA - high	00	DATA - high	00
DATA - low	C8	DATA - low	C8
CRC - low	CE	CRC - low	CE
CRC - high	DD	CRC - high	DD

B.2.5 STORE MULTIPLE SETTINGS (FUNCTION CODE 10H)

This function code allows the master to modify the contents of a one or more consecutive setting registers in a relay. Setting registers are 16-bit (two byte) values transmitted high order byte first. The maximum number of setting registers that can be stored in a single packet is 60. The following table shows the format of the master and slave packets. The example shows a master device storing the value 200 at memory map address 4051h, and the value 1 at memory map address 4052h to slave device 11h (17 decimal).

Table B–7: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION	
PACKET FORMAT	**EXAMPLE (HEX)**
SLAVE ADDRESS	11
FUNCTION CODE	10
DATA STARTING ADDRESS - hi	40
DATA STARTING ADDRESS - lo	51
NUMBER OF SETTINGS - hi	00
NUMBER OF SETTINGS - lo	02
BYTE COUNT	04
DATA #1 - high order byte	00
DATA #1 - low order byte	C8
DATA #2 - high order byte	00
DATA #2 - low order byte	01
CRC - low order byte	12
CRC - high order byte	62

SLAVE RESPONSE	
PACKET FORMAT	**EXAMPLE (HEX)**
SLAVE ADDRESS	11
FUNCTION CODE	10
DATA STARTING ADDRESS - hi	40
DATA STARTING ADDRESS - lo	51
NUMBER OF SETTINGS - hi	00
NUMBER OF SETTINGS - lo	02
CRC - lo	07
CRC - hi	64

B.2.6 EXCEPTION RESPONSES

Programming or operation errors usually happen because of illegal data in a packet. These errors result in an exception response from the slave. The slave detecting one of these errors sends a response packet to the master with the high order bit of the function code set to 1.

The following table shows the format of the master and slave packets. The example shows a master device sending the unsupported function code 39h to slave device 11.

Table B–8: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION	
PACKET FORMAT	**EXAMPLE (HEX)**
SLAVE ADDRESS	11
FUNCTION CODE	39
CRC - low order byte	CD
CRC - high order byte	F2

SLAVE RESPONSE	
PACKET FORMAT	**EXAMPLE (HEX)**
SLAVE ADDRESS	11
FUNCTION CODE	B9
ERROR CODE	01
CRC - low order byte	93
CRC - high order byte	95

B.3.1 OBTAINING RELAY FILES VIA MODBUS

a) DESCRIPTION

The UR relay has a generic file transfer facility, meaning that you use the same method to obtain all of the different types of files from the unit. The Modbus registers that implement file transfer are found in the "Modbus File Transfer (Read/Write)" and "Modbus File Transfer (Read Only)" modules, starting at address 3100 in the Modbus Memory Map. To read a file from the UR relay, use the following steps:

1. Write the filename to the "Name of file to read" register using a write multiple registers command. If the name is shorter than 80 characters, you may write only enough registers to include all the text of the filename. Filenames are not case sensitive.
2. Repeatedly read all the registers in "Modbus File Transfer (Read Only)" using a read multiple registers command. It is not necessary to read the entire data block, since the UR relay will remember which was the last register you read. The "position" register is initially zero and thereafter indicates how many bytes (2 times the number of registers) you have read so far. The "size of..." register indicates the number of bytes of data remaining to read, to a maximum of 244.
3. Keep reading until the "size of..." register is smaller than the number of bytes you are transferring. This condition indicates end of file. Discard any bytes you have read beyond the indicated block size.
4. If you need to re-try a block, read only the "size of.." and "block of data", without reading the position. The file pointer is only incremented when you read the position register, so the same data block will be returned as was read in the previous operation. On the next read, check to see if the position is where you expect it to be, and discard the previous block if it is not (this condition would indicate that the UR relay did not process your original read request).

The UR relay retains connection-specific file transfer information, so files may be read simultaneously on multiple Modbus connections.

b) OTHER PROTOCOLS

All the files available via Modbus may also be retrieved using the standard file transfer mechanisms in other protocols (for example, TFTP or MMS).

c) COMTRADE, OSCILLOGRAPHY, AND DATA LOGGER FILES

Oscillography and data logger files are formatted using the COMTRADE file format per IEEE C37.111-1999 Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems. The files can be obtained in either text or binary COMTRADE format.

d) READING OSCILLOGRAPHY FILES

Familiarity with the oscillography feature is required to understand the following description. Refer to the Oscillography section in Chapter 5 for additional details.

The Oscillography Number of Triggers register is incremented by one every time a new oscillography file is triggered (captured) and cleared to zero when oscillography data is cleared. When a new trigger occurs, the associated oscillography file is assigned a file identifier number equal to the incremented value of this register; the newest file number is equal to the Oscillography_Number_of_Triggers register. This register can be used to determine if any new data has been captured by periodically reading it to see if the value has changed; if the number has increased then new data is available.

The Oscillography Number of Records register specifies the maximum number of files (and the number of cycles of data per file) that can be stored in memory of the relay. The Oscillography Available Records register specifies the actual number of files that are stored and still available to be read out of the relay.

Writing “Yes” (i.e. the value 1) to the Oscillography Clear Data register clears oscillography data files, clears both the Oscillography Number of Triggers and Oscillography Available Records registers to zero, and sets the Oscillography Last Cleared Date to the present date and time.

To read binary COMTRADE oscillography files, read the following filenames:

`OSCnnnn.CFG` and `OSCnnn.DAT`

e) READING DATA LOGGER FILES

Familiarity with the data logger feature is required to understand this description. Refer to the Data Logger section of Chapter 5 for details. To read the entire data logger in binary COMTRADE format, read the following files.

`datalog.cfg` and `datalog.dat`

To read the entire data logger in ASCII COMTRADE format, read the following files.

`dataloga.cfg` and `dataloga.dat`

To limit the range of records to be returned in the COMTRADE files, append the following to the filename before writing it:

- To read from a specific time to the end of the log: <space> startTime
- To read a specific range of records: <space> startTime <space> endTime
- Replace <startTime> and <endTime> with Julian dates (seconds since Jan. 1 1970) as numeric text.

f) READING EVENT RECORDER FILES

To read the entire event recorder contents in ASCII format (the only available format), use the following filename:

`EVT.TXT`

To read from a specific record to the end of the log, use the following filename:

`EVTnnn.TXT` (replace `nnn` with the desired starting record number)

To read from a specific record to another specific record, use the following filename:

`EVT.TXT xxxxx yyyyy` (replace `xxxxx` with the starting record number and `yyyyy` with the ending record number)

g) READING FAULT REPORT FILES

Fault report data has been available via the L30 file retrieval mechanism since UR firmware version 2.00. The file name is **`faultReport#####.htm`**. The ##### refers to the fault report record number. The fault report number is a counter that indicates how many fault reports have ever occurred. The counter rolls over at a value of 65535. Only the last ten fault reports are available for retrieval; a request for a non-existent fault report file will yield a null file. The current value fault report counter is available in “Number of Fault Reports” Modbus register at location 0x3020.

For example, if 14 fault reports have occurred then the files `faultReport5.htm`, `faultReport6.htm`, up to `faultReport14.htm` are available to be read. The expected use of this feature has an external master periodically polling the “Number of Fault Reports' register. If the value changes, then the master reads all the new files.

The contents of the file is in standard HTML notation and can be viewed via any commercial browser.

B.3.2 MODBUS PASSWORD OPERATION

The L30 supports password entry from a local or remote connection.

Local access is defined as any access to settings or commands via the faceplate interface. This includes both keypad entry and the faceplate RS232 connection. Remote access is defined as any access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. Any changes to the local or remote passwords 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 faceplate, the local password must be used.

The command password is set up at memory location 4000. Command security is required to change the command password. Similarly, the setting password is set up at memory location 4002. These are the same settings found in the **SETTINGS ⇨ PRODUCT SETUP ⇨ PASSWORD SECURITY** menu via the keypad. Enabling password security for the faceplate display will also enable it for Modbus, and *vice-versa*.

To gain command level security access, the command password must be entered at memory location 4008. To gain setting level security access, the setting password must be entered at memory location 400A. The entered setting password must match the current setting password setting, or must be zero, to change settings or download firmware.

Command and setting passwords each have a 30 minute timer. Each timer starts when you enter the particular password, and is re-started whenever you *use* it. For example, writing a setting re-starts the setting password timer and writing a command register or forcing a coil re-starts the command password timer. The value read at memory location 4010 can be used to confirm whether a command password is enabled or disabled (a value of 0 represents disabled). The value read at memory location 4011 can be used to confirm whether a setting password is enabled or disabled.

Command or setting password security access is restricted to the particular port or particular TCP/IP connection on which the entry was made. Passwords must be entered when accessing the relay through other ports or connections, and the passwords must be re-entered after disconnecting and re-connecting on TCP/IP.

B.4.1 MODBUS MEMORY MAP

The map is also viewable in a web browser. In the browser, enter the IP address of the UR and click the option.

Table B–9: MODBUS MEMORY MAP (Sheet 1 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Product Information (Read Only)						
0000	UR Product Type	0 to 65535	---	1	F001	0
0002	Product Version	0 to 655.35	---	0.01	F001	1
0003	Boot Configuration Register	0 to 65535	---	1	F001	0
Product Information (Read Only -- Written by Factory)						
0010	Serial Number	---	---	---	F203	“0”
0020	Manufacturing Date	0 to 4294967295	---	1	F050	0
0022	Modification Number	0 to 65535	---	1	F001	0
0040	Order Code	---	---	---	F204	“Order Code x”
0090	Ethernet MAC Address	---	---	---	F072	0
0093	Reserved (13 items)	---	---	---	F001	0
00A0	CPU Module Serial Number	---	---	---	F203	(none)
00B0	CPU Supplier Serial Number	---	---	---	F203	(none)
00C0	Ethernet Sub Module Serial Number (8 items)	---	---	---	F203	(none)
Product Information (Read Only -- Written by Factory)						
0110	FPGA Version	---	---	---	F206	(none)
0113	FPGA Date	0 to 4294967295	--	1	F050	0
Self Test Targets (Read Only)						
0200	Self Test States (4 items)	0 to 4294967295	0	1	F143	0
Front Panel (Read Only)						
0208	LED Column *n* State, *n* = 1 to 10 (10 items)	0 to 65535	---	1	F501	0
0220	Display Message	---	---	---	F204	(none)
0248	Last Key Pressed	0 to 47	---	1	F530	0 (None)
Keypress Emulation (Read/Write)						
0280	Simulated keypress -- write zero before each keystroke	0 to 46	---	1	F190	0 (No key -- use between real keys)
Virtual Input Commands (Read/Write Command) (64 modules)						
0400	Virtual Input 1 State	0 to 1	---	1	F108	0 (Off)
0401	Virtual Input 2 State	0 to 1	---	1	F108	0 (Off)
0402	Virtual Input 3 State	0 to 1	---	1	F108	0 (Off)
0403	Virtual Input 4 State	0 to 1	---	1	F108	0 (Off)
0404	Virtual Input 5 State	0 to 1	---	1	F108	0 (Off)
0405	Virtual Input 6 State	0 to 1	---	1	F108	0 (Off)
0406	Virtual Input 7 State	0 to 1	---	1	F108	0 (Off)
0407	Virtual Input 8 State	0 to 1	---	1	F108	0 (Off)
0408	Virtual Input 9 State	0 to 1	---	1	F108	0 (Off)
0409	Virtual Input 10 State	0 to 1	---	1	F108	0 (Off)
040A	Virtual Input 11 State	0 to 1	---	1	F108	0 (Off)
040B	Virtual Input 12 State	0 to 1	---	1	F108	0 (Off)
040C	Virtual Input 13 State	0 to 1	---	1	F108	0 (Off)
040D	Virtual Input 14 State	0 to 1	---	1	F108	0 (Off)
040E	Virtual Input 15 State	0 to 1	---	1	F108	0 (Off)
040F	Virtual Input 16 State	0 to 1	---	1	F108	0 (Off)
0410	Virtual Input 17 State	0 to 1	---	1	F108	0 (Off)
0411	Virtual Input 18 State	0 to 1	---	1	F108	0 (Off)
0412	Virtual Input 19 State	0 to 1	---	1	F108	0 (Off)
0413	Virtual Input 20 State	0 to 1	---	1	F108	0 (Off)
0414	Virtual Input 21 State	0 to 1	---	1	F108	0 (Off)
0415	Virtual Input 22 State	0 to 1	---	1	F108	0 (Off)

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Table B–9: MODBUS MEMORY MAP (Sheet 2 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
0416	Virtual Input 23 State	0 to 1	---	1	F108	0 (Off)
0417	Virtual Input 24 State	0 to 1	---	1	F108	0 (Off)
0418	Virtual Input 25 State	0 to 1	---	1	F108	0 (Off)
0419	Virtual Input 26 State	0 to 1	---	1	F108	0 (Off)
041A	Virtual Input 27 State	0 to 1	---	1	F108	0 (Off)
041B	Virtual Input 28 State	0 to 1	---	1	F108	0 (Off)
041C	Virtual Input 29 State	0 to 1	---	1	F108	0 (Off)
041D	Virtual Input 30 State	0 to 1	---	1	F108	0 (Off)
041E	Virtual Input 31 State	0 to 1	---	1	F108	0 (Off)
041F	Virtual Input 32 State	0 to 1	---	1	F108	0 (Off)
0420	Virtual Input 33 State	0 to 1	---	1	F108	0 (Off)
0421	Virtual Input 34 State	0 to 1	---	1	F108	0 (Off)
0422	Virtual Input 35 State	0 to 1	---	1	F108	0 (Off)
0423	Virtual Input 36 State	0 to 1	---	1	F108	0 (Off)
0424	Virtual Input 37 State	0 to 1	---	1	F108	0 (Off)
0425	Virtual Input 38 State	0 to 1	---	1	F108	0 (Off)
0426	Virtual Input 39 State	0 to 1	---	1	F108	0 (Off)
0427	Virtual Input 40 State	0 to 1	---	1	F108	0 (Off)
0428	Virtual Input 41 State	0 to 1	---	1	F108	0 (Off)
0429	Virtual Input 42 State	0 to 1	---	1	F108	0 (Off)
042A	Virtual Input 43 State	0 to 1	---	1	F108	0 (Off)
042B	Virtual Input 44 State	0 to 1	---	1	F108	0 (Off)
042C	Virtual Input 45 State	0 to 1	---	1	F108	0 (Off)
042D	Virtual Input 46 State	0 to 1	---	1	F108	0 (Off)
042E	Virtual Input 47 State	0 to 1	---	1	F108	0 (Off)
042F	Virtual Input 48 State	0 to 1	---	1	F108	0 (Off)
0430	Virtual Input 49 State	0 to 1	---	1	F108	0 (Off)
0431	Virtual Input 50 State	0 to 1	---	1	F108	0 (Off)
0432	Virtual Input 51 State	0 to 1	---	1	F108	0 (Off)
0433	Virtual Input 52 State	0 to 1	---	1	F108	0 (Off)
0434	Virtual Input 53 State	0 to 1	---	1	F108	0 (Off)
0435	Virtual Input 54 State	0 to 1	---	1	F108	0 (Off)
0436	Virtual Input 55 State	0 to 1	---	1	F108	0 (Off)
0437	Virtual Input 56 State	0 to 1	---	1	F108	0 (Off)
0438	Virtual Input 57 State	0 to 1	---	1	F108	0 (Off)
0439	Virtual Input 58 State	0 to 1	---	1	F108	0 (Off)
043A	Virtual Input 59 State	0 to 1	---	1	F108	0 (Off)
043B	Virtual Input 60 State	0 to 1	---	1	F108	0 (Off)
043C	Virtual Input 61 State	0 to 1	---	1	F108	0 (Off)
043D	Virtual Input 62 State	0 to 1	---	1	F108	0 (Off)
043E	Virtual Input 63 State	0 to 1	---	1	F108	0 (Off)
043F	Virtual Input 64 State	0 to 1	---	1	F108	0 (Off)
Digital Counter States (Read Only Non-Volatile) (8 modules)						
0800	Digital Counter 1 Value	-2147483647 to 2147483647	---	1	F004	0
0802	Digital Counter 1 Frozen	-2147483647 to 2147483647	---	1	F004	0
0804	Digital Counter 1 Frozen Time Stamp	0 to 4294967295	---	1	F050	0
0806	Digital Counter 1 Frozen Time Stamp us	0 to 4294967295	---	1	F003	0
0808	...Repeated for Digital Counter 2					
0810	...Repeated for Digital Counter 3					
0818	...Repeated for Digital Counter 4					
0820	...Repeated for Digital Counter 5					
0828	...Repeated for Digital Counter 6					
0830	...Repeated for Digital Counter 7					

Table B–9: MODBUS MEMORY MAP (Sheet 3 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
0838	...Repeated for Digital Counter 8					
FlexStates (Read Only)						
0900	FlexState Bits (16 items)	0 to 65535	---	1	F001	0
Element States (Read Only)						
1000	Element Operate States (64 items)	0 to 65535	---	1	F502	0
User Displays Actuals (Read Only)						
1080	Formatted user-definable displays (16 items)	---	---	---	F200	(none)
Modbus User Map Actuals (Read Only)						
1200	User Map Values (256 items)	0 to 65535	---	1	F001	0
Element Targets (Read Only)						
14E0	Target Sequence	0 to 65535	---	1	F001	0
14E1	Number of Targets	0 to 65535	---	1	F001	0
Element Targets (Read/Write)						
14E2	Target to Read	0 to 65535	---	1	F001	0
Element Targets (Read Only)						
14E3	Target Message	---	---	---	F200	“.”
Digital Input/Output States (Read Only)						
1500	Contact Input States (6 items)	0 to 65535	---	1	F500	0
1508	Virtual Input States (8 items)	0 to 65535	---	1	F500	0
1510	Contact Output States (4 items)	0 to 65535	---	1	F500	0
1518	Contact Output Current States (4 items)	0 to 65535	---	1	F500	0
1520	Contact Output Voltage States (4 items)	0 to 65535	---	1	F500	0
1528	Virtual Output States (6 items)	0 to 65535	---	1	F500	0
1530	Contact Output Detectors (4 items)	0 to 65535	---	1	F500	0
Input/Output States (Read Only)						
1540	Remote Device States (2 items)	0 to 65535	---	1	F500	0
1542	Remote Input States (4 items)	0 to 65535	---	1	F500	0
1550	Remote Devices Online	0 to 1	---	1	F126	0 (No)
1551	Remote Double-Point Status Input 1 State	0 to 3	---	1	F605	3 (Bad)
1552	Remote Double-Point Status Input 2 State	0 to 3	---	1	F605	3 (Bad)
1553	Remote Double-Point Status Input 3 State	0 to 3	---	1	F605	3 (Bad)
1554	Remote Double-Point Status Input 4 State	0 to 3	---	1	F605	3 (Bad)
1555	Remote Double-Point Status Input 5 State	0 to 3	---	1	F605	3 (Bad)
Direct Input/Output States (Read Only)						
15A0	Direct Input 1-1 State (8 items)	0 to 1	---	1	F108	0 (Off)
15A8	Direct Input 1-2 State (8 items)	0 to 1	---	1	F108	0 (Off)
15B0	Direct Input 1 State	0 to 65535	---	1	F500	0
15B1	Direct Input 2 State	0 to 65535	---	1	F500	0
Field Unit Input/Output States (Read Only)						
15E0	Field unit contact input states (3 items)	0 to 65535	---	1	F500	0
15E3	Field unit contact input output operand states (8 items)	0 to 65535	---	1	F500	0
15EB	Field contact output physical states (8 items)	0 to 65535	---	1	F500	0
15F3	Field contact output current states (8 items)	0 to 65535	---	1	F500	0
15FB	Field contact output physical states (8 items)	0 to 65535	---	1	F500	0
1603	Field shared input states	0 to 65535	---	1	F500	0
1604	Field shared input channel states	0 to 65535	---	1	F500	0
1605	Field shared input test states	0 to 65535	---	1	F500	0
1606	Field shared output operand states	0 to 65535	---	1	F500	0
1607	Field latching output open operand states	0 to 65535	---	1	F500	0
1608	Field latching output close operand states	0 to 65535	---	1	F500	0
1609	Field latching output open driver states	0 to 65535	---	1	F500	0
160A	Field latching output close driver states	0 to 65535	---	1	F500	0
160B	Field latching output physical states	0 to 65535	---	1	F500	0
160C	Field unit online/offline states	0 to 65535	---	1	F500	0

Table B–9: MODBUS MEMORY MAP (Sheet 4 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
160D	Fiedl RTD input trouble states	0 to 65535	---	1	F500	0
160E	Field transducer input trouble states	0 to 65535	---	1	F500	0
Ethernet Fibre Channel Status (Read/Write)						
1610	Ethernet primary fibre channel status	0 to 2	---	1	F134	0 (Fail)
1611	Ethernet secondary fibre channel status	0 to 2	---	1	F134	0 (Fail)
1612	Ethernet tertiary fibre channel status	0 to 2	---	1	F134	0 (Fail)
Data Logger Actuals (Read Only)						
1618	Data logger channel count	0 to 16	channel	1	F001	0
1619	Time of oldest available samples	0 to 4294967295	seconds	1	F050	0
161B	Time of newest available samples	0 to 4294967295	seconds	1	F050	0
161D	Data logger duration	0 to 999.9	days	0.1	F001	0
87L Channel Status Actuals (Read Only)						
1638	Channel 1 Asymmetry	-65.535 to 65.535	ms	0.001	F004	0
163A	Channel 2 Asymmetry	-99.999 to 99.999	ms	0.001	F004	0
Field Unit RTD Actuals (Read Only) (8 modules)						
16C0	Field RTD x Value	-32768 to 32767	°C	1	F002	0
16C1	...Repeated for module number 2					
16C2	...Repeated for module number 3					
16C3	...Repeated for module number 4					
16C4	...Repeated for module number 5					
16C5	...Repeated for module number 6					
16C6	...Repeated for module number 7					
16C7	...Repeated for module number 8					
Field Unit Transducer Actuals (Read Only) (8 modules)						
16C8	Field Transducer x Value	-32.768 to 32.767	---	0.001	F004	0
16CA	...Repeated for module number 2					
16CC	...Repeated for module number 3					
16CE	...Repeated for module number 4					
16D0	...Repeated for module number 5					
16D2	...Repeated for module number 6					
16D4	...Repeated for module number 7					
16D6	...Repeated for module number 8					
Source Current (Read Only) (6 modules)						
1800	Source 1 Phase A Current RMS	0 to 999999.999	A	0.001	F060	0
1802	Source 1 Phase B Current RMS	0 to 999999.999	A	0.001	F060	0
1804	Source 1 Phase C Current RMS	0 to 999999.999	A	0.001	F060	0
1806	Source 1 Neutral Current RMS	0 to 999999.999	A	0.001	F060	0
1808	Source 1 Phase A Current Magnitude	0 to 999999.999	A	0.001	F060	0
180A	Source 1 Phase A Current Angle	-359.9 to 0	degrees	0.1	F002	0
180B	Source 1 Phase B Current Magnitude	0 to 999999.999	A	0.001	F060	0
180D	Source 1 Phase B Current Angle	-359.9 to 0	degrees	0.1	F002	0
180E	Source 1 Phase C Current Magnitude	0 to 999999.999	A	0.001	F060	0
1810	Source 1 Phase C Current Angle	-359.9 to 0	degrees	0.1	F002	0
1811	Source 1 Neutral Current Magnitude	0 to 999999.999	A	0.001	F060	0
1813	Source 1 Neutral Current Angle	-359.9 to 0	degrees	0.1	F002	0
1814	Source 1 Ground Current RMS	0 to 999999.999	A	0.001	F060	0
1816	Source 1 Ground Current Magnitude	0 to 999999.999	A	0.001	F060	0
1818	Source 1 Ground Current Angle	-359.9 to 0	degrees	0.1	F002	0
1819	Source 1 Zero Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
181B	Source 1 Zero Sequence Current Angle	-359.9 to 0	degrees	0.1	F002	0
181C	Source 1 Positive Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
181E	Source 1 Positive Sequence Current Angle	-359.9 to 0	degrees	0.1	F002	0
181F	Source 1 Negative Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
1821	Source 1 Negative Sequence Current Angle	-359.9 to 0	degrees	0.1	F002	0

Table B–9: MODBUS MEMORY MAP (Sheet 5 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
1822	Source 1 Differential Ground Current Magnitude	0 to 999999.999	A	0.001	F060	0
1824	Source 1 Differential Ground Current Angle	-359.9 to 0	degrees	0.1	F002	0
1825	Reserved (27 items)	---	---	---	F001	0
1840	...Repeated for Source 2					
1880	...Repeated for Source 3					
18C0	...Repeated for Source 4					
1900	...Repeated for Source 5					
1940	...Repeated for Source 6					
Source Voltage (Read Only) (6 modules)						
1A00	Source 1 Phase AG Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A02	Source 1 Phase BG Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A04	Source 1 Phase CG Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A06	Source 1 Phase AG Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A08	Source 1 Phase AG Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A09	Source 1 Phase BG Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A0B	Source 1 Phase BG Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A0C	Source 1 Phase CG Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A0E	Source 1 Phase CG Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A0F	Source 1 Phase AB or AC Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A11	Source 1 Phase BC or BA Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A13	Source 1 Phase CA or CB Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A15	Source 1 Phase AB or AC Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A17	Source 1 Phase AB or AC Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A18	Source 1 Phase BC or BA Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A1A	Source 1 Phase BC or BA Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A1B	Source 1 Phase CA or CB Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A1D	Source 1 Phase CA or CB Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A1E	Source 1 Auxiliary Voltage RMS		V		F060	0
1A20	Source 1 Auxiliary Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A22	Source 1 Auxiliary Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A23	Source 1 Zero Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A25	Source 1 Zero Sequence Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A26	Source 1 Positive Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A28	Source 1 Positive Sequence Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A29	Source 1 Negative Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A2B	Source 1 Negative Sequence Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A2C	Reserved (20 items)	---	---	---	F001	0
1A40	...Repeated for Source 2					
1A80	...Repeated for Source 3					
1AC0	...Repeated for Source 4					
1B00	...Repeated for Source 5					
1B40	...Repeated for Source 6					
Source Power (Read Only) (6 modules)						
1C00	Source 1 Three Phase Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C02	Source 1 Phase A Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C04	Source 1 Phase B Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C06	Source 1 Phase C Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C08	Source 1 Three Phase Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C0A	Source 1 Phase A Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0

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Table B–9: MODBUS MEMORY MAP (Sheet 6 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
1C0C	Source 1 Phase B Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C0E	Source 1 Phase C Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C10	Source 1 Three Phase Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C12	Source 1 Phase A Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C14	Source 1 Phase B Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C16	Source 1 Phase C Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C18	Source 1 Three Phase Power Factor	-0.999 to 1	---	0.001	F013	0
1C19	Source 1 Phase A Power Factor	-0.999 to 1	---	0.001	F013	0
1C1A	Source 1 Phase B Power Factor	-0.999 to 1	---	0.001	F013	0
1C1B	Source 1 Phase C Power Factor	-0.999 to 1	---	0.001	F013	0
1C1C	Reserved (4 items)	---	---	---	F001	0
1C20	...Repeated for Source 2					
1C40	...Repeated for Source 3					
1C60	...Repeated for Source 4					
1C80	...Repeated for Source 5					
1CA0	...Repeated for Source 6					
Source Frequency (Read Only) (6 modules)						
1D80	Frequency for Source 1	2 to 90	Hz	0.001	F003	0
1D82	Frequency for Source 2	2 to 90	Hz	0.001	F003	0
1D84	Frequency for Source 3	2 to 90	Hz	0.001	F003	0
1D86	Frequency for Source 4	2 to 90	Hz	0.001	F003	0
1D88	Frequency for Source 5	2 to 90	Hz	0.001	F003	0
1D8A	Frequency for Source 6	2 to 90	Hz	0.001	F003	0
Breaker Arcing Current Actuals (Read Only Non-Volatile) (6 modules)						
21E0	Breaker 1 Arcing Current Phase A	0 to 99999999	kA^2-cyc	1	F060	0
21E2	Breaker 1 Arcing Current Phase B	0 to 99999999	kA^2-cyc	1	F060	0
Breaker Arcing Current Actuals (Read Only Non-Volatile) (6 modules)						
21E4	Breaker 1 Arcing Current Phase C	0 to 99999999	kA^2-cyc	1	F060	0
Breaker Arcing Current Actuals (Read Only Non-Volatile) (6 modules)						
21E6	Breaker 1 Operating Time Phase A	0 to 65535	ms	1	F001	0
21E7	Breaker 1 Operating Time Phase B	0 to 65535	ms	1	F001	0
Breaker Arcing Current Actuals (Read Only Non-Volatile) (6 modules)						
21E8	Breaker 1 Operating Time Phase C	0 to 65535	ms	1	F001	0
21E9	Breaker 1 Operating Time	0 to 65535	ms	1	F001	0
21EA	...Repeated for module number 2					
Breaker Arcing Current Actuals (Read Only Non-Volatile) (6 modules)						
21EE	...Repeated for module number 2					
Breaker Arcing Current Actuals (Read Only Non-Volatile) (6 modules)						
21F0	...Repeated for module number 2					
Breaker Arcing Current Actuals (Read Only Non-Volatile) (6 modules)						
21F2	...Repeated for module number 2					
Breaker Arcing Current Actuals (Read Only Non-Volatile) (6 modules)						
21FA	...Repeated for module number 3					
21FE	...Repeated for module number 4					
2208	...Repeated for module number 5					
2212	...Repeated for module number 6					
Breaker Arcing Current Commands (Read/Write Command) (6 modules)						
2224	Breaker 1 Arcing Current Clear Command	0 to 1	---	1	F126	0 (No)
2225	Breaker 2 Arcing Current Clear Command	0 to 1	---	1	F126	0 (No)
2226	Breaker 3 Arcing Current Clear Command	0 to 1	---	1	F126	0 (No)

Table B–9: MODBUS MEMORY MAP (Sheet 7 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
2227	Breaker 4 Arcing Current Clear Command	0 to 1	---	1	F126	0 (No)
2228	Breaker 5 Arcing Current Clear Command	0 to 1	---	1	F126	0 (No)
2229	Breaker 6 Arcing Current Clear Command	0 to 1	---	1	F126	0 (No)
Passwords Unauthorized Access (Read/Write Command)						
2230	Reset Unauthorized Access	0 to 1	---	1	F126	0 (No)
Fault Location (Read Only) (5 modules)						
2340	Fault 1 Prefault Phase A Current Magnitude	0 to 999999.999	A	0.001	F060	0
2342	Fault 1 Prefault Phase A Current Angle	-359.9 to 0	degrees	0.1	F002	0
2343	Fault 1 Prefault Phase B Current Magnitude	0 to 999999.999	A	0.001	F060	0
2345	Fault 1 Prefault Phase B Current Angle	-359.9 to 0	degrees	0.1	F002	0
2346	Fault 1 Prefault Phase C Current Magnitude	0 to 999999.999	A	0.001	F060	0
2348	Fault 1 Prefault Phase C Current Angle	-359.9 to 0	degrees	0.1	F002	0
2349	Fault 1 Prefault Phase A Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
234B	Fault 1 Prefault Phase A Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
234C	Fault 1 Prefault Phase B Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
234E	Fault 1 Prefault Phase B Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
234F	Fault 1 Prefault Phase C Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2351	Fault 1 Prefault Phase C Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
2352	Fault 1 Phase A Current Magnitude	0 to 999999.999	A	0.001	F060	0
2354	Fault 1 Phase A Current Angle	-359.9 to 0	degrees	0.1	F002	0
2355	Fault 1 Phase B Current Magnitude	0 to 999999.999	A	0.001	F060	0
2357	Fault 1 Phase B Current Angle	-359.9 to 0	degrees	0.1	F002	0
2358	Fault 1 Phase C Current Magnitude	0 to 999999.999	A	0.001	F060	0
235A	Fault 1 Phase C Current Angle	-359.9 to 0	degrees	0.1	F002	0
235B	Fault 1 Phase A Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
235D	Fault 1 Phase A Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
235E	Fault 1 Phase B Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2360	Fault 1 Phase B Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
2361	Fault 1 Phase C Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2363	Fault 1 Phase C Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
2364	Fault 1 Type	0 to 11	---	1	F148	0 (NA)
2365	Fault 1 Location based on Line length units (km or miles)	-3276.7 to 3276.7	---	0.1	F002	0
2366	...Repeated for Fault 2					
238C	...Repeated for Fault 3					
23B2	...Repeated for Fault 4					
23D8	...Repeated for Fault 5					
Synchrocheck Actuals (Read Only) (4 modules)						
2400	Synchrocheck 1 Delta Voltage	-1000000000000 to 1000000000000	V	1	F060	0
2402	Synchrocheck 1 Delta Frequency	0 to 655.35	Hz	0.01	F001	0
2403	Synchrocheck 1 Delta Phase	0 to 359.9	degrees	0.1	F001	0
2404	...Repeated for Synchrocheck 2					
2408	...Repeated for Synchrocheck 3					
240C	...Repeated for Synchrocheck 4					
Autoreclose Status (Read Only) (6 modules)						
2410	Autoreclose 1 Count	0 to 65535	---	1	F001	0
2411	Autoreclose 2 Count	0 to 65535	---	1	F001	0
2412	Autoreclose 3 Count	0 to 65535	---	1	F001	0
2413	Autoreclose 4 Count	0 to 65535	---	1	F001	0
2414	Autoreclose 5 Count	0 to 65535	---	1	F001	0
2415	Autoreclose 6 Count	0 to 65535	---	1	F001	0
Field Unit Raw Data Settings (Read/Write Setting)						
2460	Field Raw Data Port	0 to 7	---	1	F244	6 (H1a)
2461	Field Raw Data Freeze	0 to 1	---	1	F102	0 (Disabled)

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Table B–9: MODBUS MEMORY MAP (Sheet 8 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
87L Current differential actual values (Read Only)						
2480	Local IA Magnitude	0 to 999999.999	A	0.001	F060	0
2482	Local IB Magnitude	0 to 999999.999	A	0.001	F060	0
2484	Local IC Magnitude	0 to 999999.999	A	0.001	F060	0
2486	Terminal 1 IA Magnitude	0 to 999999.999	A	0.001	F060	0
2488	Terminal 1 IB Magnitude	0 to 999999.999	A	0.001	F060	0
248A	Terminal 1 IC Magnitude	0 to 999999.999	A	0.001	F060	0
248C	Terminal 2 IA Magnitude	0 to 999999.999	A	0.001	F060	0
248E	Terminal 2 IB Magnitude	0 to 999999.999	A	0.001	F060	0
2490	Terminal 2 IC Magnitude	0 to 999999.999	A	0.001	F060	0
2492	Differential Current IA Magnitude	0 to 999999.999	A	0.001	F060	0
2494	Differential Current IB Magnitude	0 to 999999.999	A	0.001	F060	0
2496	Differential Current IC Magnitude	0 to 999999.999	A	0.001	F060	0
2498	Local IA Angle	-359.9 to 0	degrees	0.1	F002	0
2499	Local IB Angle	-359.9 to 0	degrees	0.1	F002	0
249A	Local IC Angle	-359.9 to 0	degrees	0.1	F002	0
249B	Terminal 1 IA Angle	-359.9 to 0	degrees	0.1	F002	0
249C	Terminal 1 IB Angle	-359.9 to 0	degrees	0.1	F002	0
249D	Terminal 1 IC Angle	-359.9 to 0	degrees	0.1	F002	0
249E	Terminal 2 IA Angle	-359.9 to 0	degrees	0.1	F002	0
249F	Terminal 2 IB Angle	-359.9 to 0	degrees	0.1	F002	0
24A0	Terminal 2 IC Angle	-359.9 to 0	degrees	0.1	F002	0
24A1	Differential Current IA Angle	-359.9 to 0	degrees	0.1	F002	0
24A2	Differential Current IB Angle	-359.9 to 0	degrees	0.1	F002	0
24A3	Differential Current IC Angle	-359.9 to 0	degrees	0.1	F002	0
24A4	Op Square Current IA	0 to 999999.999	A	0.001	F060	0
24A6	Op Square Current IB	0 to 999999.999	A	0.001	F060	0
24A8	Op Square Current IC	0 to 999999.999	A	0.001	F060	0
24AA	Restraint Square Current IA	0 to 999999.999	A	0.001	F060	0
24AC	Restraint Square Current IB	0 to 999999.999	A	0.001	F060	0
24AE	Restraint Square Current IC	0 to 999999.999	A	0.001	F060	0
24B0	Restraint Current IA	0 to 999999.999	A	0.001	F060	0
24B2	Restraint Current IB	0 to 999999.999	A	0.001	F060	0
24B4	Restraint Current IC	0 to 999999.999	A	0.001	F060	0
24B6	Differential Current IG Magnitude	0 to 999999.999	A	0.001	F060	0
24B8	Differential Current IG Angle	-359.9 to 0	degrees	0.1	F002	0
24B9	Restraint Current IG	0 to 999999.999	A	0.001	F060	0
24BB	Local IG Magnitude	0 to 999999.999	A	0.001	F060	0
24BD	Local IG Angle	-359.9 to 0	degrees	0.1	F002	0
24BE	Terminal 1 IG Magnitude	0 to 999999.999	A	0.001	F060	0
24C0	Terminal 1 IG Angle	-359.9 to 0	degrees	0.1	F002	0
24C1	Terminal 2 IG Magnitude	0 to 999999.999	A	0.001	F060	0
24C3	Terminal 2 IG Angle	-359.9 to 0	degrees	0.1	F002	0
Current differential second harmonics actual values (Read Only)						
24CD	Line current differential (87L) second harmonic Iad magnitude	0 to 999999.999	A	0.001	F060	0
24CF	Line current differential (87L) second harmonic Ibd magnitude	0 to 999999.999	A	0.001	F060	0
24D1	Line current differential (87L) second harmonic Icd magnitude	0 to 999999.999	A	0.001	F060	0
Phasor Measurement Unit actual values (Read Only) (4 modules)						
2540	PMU 1 Phase A Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2542	PMU Unit 1 Phase A Voltage Angle	-359.9 to 0	°	0.1	F002	0
2543	PMU 1 Phase B Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2545	PMU 1 Phase B Voltage Angle	-359.9 to 0	°	0.1	F002	0

Table B–9: MODBUS MEMORY MAP (Sheet 9 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
2546	PMU 1 Phase C Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2548	PMU 1 Phase C Voltage Angle	-359.9 to 0	°	0.1	F002	0
2549	PMU 1 Auxiliary Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
254B	PMU 1 Auxiliary Voltage Angle	-359.9 to 0	°	0.1	F002	0
254C	PMU 1 Positive Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
254E	PMU 1 Positive Sequence Voltage Angle	-359.9 to 0	°	0.1	F002	0
254F	PMU 1 Negative Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2551	PMU 1 Negative Sequence Voltage Angle	-359.9 to 0	°	0.1	F002	0
2552	PMU 1 Zero Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2554	PMU 1 Zero Sequence Voltage Angle	-359.9 to 0	°	0.1	F002	0
2555	PMU 1 Phase A Current Magnitude	0 to 999999.999	A	0.001	F060	0
2557	PMU 1 Phase A Current Angle	-359.9 to 0	°	0.1	F002	0
2558	PMU 1 Phase B Current Magnitude	0 to 999999.999	A	0.001	F060	0
255A	PMU 1 Phase B Current Angle	-359.9 to 0	°	0.1	F002	0
255B	PMU 1 Phase C Current Magnitude	0 to 999999.999	A	0.001	F060	0
255D	PMU 1 Phase C Current Angle	-359.9 to 0	°	0.1	F002	0
255E	PMU 1 Ground Current Magnitude	0 to 999999.999	A	0.001	F060	0
2560	PMU 1 Ground Current Angle	-359.9 to 0	°	0.1	F002	0
2561	PMU 1 Positive Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
2563	PMU 1 Positive Sequence Current Angle	-359.9 to 0	°	0.1	F002	0
2564	PMU 1 Negative Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
2566	PMU 1 Negative Sequence Current Angle	-359.9 to 0	°	0.1	F002	0
2567	PMU 1 Zero Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
2569	PMU 1 Zero Sequence Current Angle	-359.9 to 0	°	0.1	F002	0
256A	PMU 1 Frequency	2 to 90	Hz	0.001	F003	0
256C	PMU 1 df/dt	-327.67 to 327.67	Hz/s	0.01	F002	0
256D	PMU 1 Configuration Change Counter	0 to 655.35		0.01	F001	0
256E	Reserved (4 items)	0 to 1	---	1	F001	0
2572	...Repeated for PMU 2					
25A4	...Repeated for PMU 3					
25D6	...Repeated for PMU 4					
Phasor measurement unit integer values (read only actual value registers) (4 modules)						
2608	PMU 1 SOC timestamp	0 to 4294967295	seconds	1	F003	0
260A	PMU 1 FRAMESEC timestamp	0 to 4294967295	seconds	1	F003	0
260C	PMU 1 STAT flags	0 to 4294967295	---	1	F003	0
260E	...Repeated for PMU 2					
2614	...Repeated for PMU 3					
261A	...Repeated for PMU 4					
Remote double-point status inputs (read/write setting registers) (5 modules)						
2620	Remote double-point status input 1 device	1 to 32	---	1	F001	1
2621	Remote double-point status input 1 item	0 to 128	---	1	F156	0 (None)
2622	Remote double-point status input 1 name	1 to 64	---	1	F205	"Rem Ip 1"
2628	Remote double-point status input 1 events	0 to 1	---	1	F102	0 (Disabled)
2629	... Repeated for double-point status input 2					
2632	... Repeated for double-point status input 3					
263B	... Repeated for double-point status input 4					
2644	... Repeated for double-point status input 5					
Phasor measurement unit actuals (read only) (4 modules)						
2650	PMU 1 Aggregator PDU Size	---	---	---	F001	0
2651	...Repeated for PMU 2					
2652	...Repeated for PMU 3					
2653	...Repeated for PMU 4					
IEC 61850 GGIO5 configuration (read/write setting registers) (16 modules)						
26B0	IEC 61850 GGIO5 uinteger input 1 operand	---	---	---	F612	0

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Table B–9: MODBUS MEMORY MAP (Sheet 10 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
26B1	IEC 61850 GGIO5 uinteger input 2 operand	---	---	---	F612	0
26B2	IEC 61850 GGIO5 uinteger input 3 operand	---	---	---	F612	0
26B3	IEC 61850 GGIO5 uinteger input 4 operand	---	---	---	F612	0
26B4	IEC 61850 GGIO5 uinteger input 5 operand	---	---	---	F612	0
26B5	IEC 61850 GGIO5 uinteger input 6 operand	---	---	---	F612	0
26B6	IEC 61850 GGIO5 uinteger input 7 operand	---	---	---	F612	0
26B7	IEC 61850 GGIO5 uinteger input 8 operand	---	---	---	F612	0
26B8	IEC 61850 GGIO5 uinteger input 9 operand	---	---	---	F612	0
26B9	IEC 61850 GGIO5 uinteger input 10 operand	---	---	---	F612	0
26BA	IEC 61850 GGIO5 uinteger input 11 operand	---	---	---	F612	0
26BB	IEC 61850 GGIO5 uinteger input 12 operand	---	---	---	F612	0
26BC	IEC 61850 GGIO5 uinteger input 13 operand	---	---	---	F612	0
26BD	IEC 61850 GGIO5 uinteger input 14 operand	---	---	---	F612	0
26BE	IEC 61850 GGIO5 uinteger input 15 operand	---	---	---	F612	0
26BF	IEC 61850 GGIO5 uinteger input 16 operand	---	---	---	F612	0
IEC 61850 received integers (read only actual values)						
26F0	IEC 61850 received uinteger 1	0 to 4294967295	---	1	F003	0
26F2	IEC 61850 received uinteger 2	0 to 4294967295	---	1	F003	0
26F4	IEC 61850 received uinteger 3	0 to 4294967295	---	1	F003	0
26F6	IEC 61850 received uinteger 4	0 to 4294967295	---	1	F003	0
26F8	IEC 61850 received uinteger 5	0 to 4294967295	---	1	F003	0
26FA	IEC 61850 received uinteger 6	0 to 4294967295	---	1	F003	0
26FC	IEC 61850 received uinteger 7	0 to 4294967295	---	1	F003	0
26FE	IEC 61850 received uinteger 8	0 to 4294967295	---	1	F003	0
2700	IEC 61850 received uinteger 9	0 to 4294967295	---	1	F003	0
2702	IEC 61850 received uinteger 10	0 to 4294967295	---	1	F003	0
2704	IEC 61850 received uinteger 11	0 to 4294967295	---	1	F003	0
2706	IEC 61850 received uinteger 12	0 to 4294967295	---	1	F003	0
2708	IEC 61850 received uinteger 13	0 to 4294967295	---	1	F003	0
270A	IEC 61850 received uinteger 14	0 to 4294967295	---	1	F003	0
270C	IEC 61850 received uinteger 15	0 to 4294967295	---	1	F003	0
270E	IEC 61850 received uinteger 16	0 to 4294967295	---	1	F003	0
Expanded FlexStates (Read Only)						
2B00	FlexStates, one per register (256 items)	0 to 1	---	1	F108	0 (Off)
Expanded Digital Input/Output states (Read Only)						
2D00	Contact Input States, one per register (96 items)	0 to 1	---	1	F108	0 (Off)
2D80	Contact Output States, one per register (64 items)	0 to 1	---	1	F108	0 (Off)
2E00	Virtual Output States, one per register (96 items)	0 to 1	---	1	F108	0 (Off)
Expanded Remote Input/Output Status (Read Only)						
2F00	Remote Device States, one per register (16 items)	0 to 1	---	1	F155	0 (Offline)
2F80	Remote Input States, one per register (64 items)	0 to 1	---	1	F108	0 (Off)
Oscillography Values (Read Only)						
3000	Oscillography Number of Triggers	0 to 65535	---	1	F001	0
3001	Oscillography Available Records	0 to 65535	---	1	F001	0
3002	Oscillography Last Cleared Date	0 to 400000000	---	1	F050	0
3004	Oscillography Number Of Cycles Per Record	0 to 65535	---	1	F001	0
Oscillography Commands (Read/Write Command)						
3005	Oscillography Force Trigger	0 to 1	---	1	F126	0 (No)
3011	Oscillography Clear Data	0 to 1	---	1	F126	0 (No)
3012	Oscillography Number of Triggers	0 to 32767	---	1	F001	0
Fault Report Indexing (Read Only Non-Volatile)						
3020	Number of Fault Reports	0 to 65535	---	1	F001	0
Fault Report Actuals (Read Only Non-Volatile) (15 modules)						
3030	Fault Report 1 Time	0 to 4294967295	---	1	F050	0

Table B–9: MODBUS MEMORY MAP (Sheet 11 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
3032	Fault Report 2 Time	0 to 4294967295	---	1	F050	0
3034	Fault Report 3 Time	0 to 4294967295	---	1	F050	0
3036	Fault Report 4 Time	0 to 4294967295	---	1	F050	0
3038	Fault Report 5 Time	0 to 4294967295	---	1	F050	0
303A	Fault Report 6 Time	0 to 4294967295	---	1	F050	0
303C	Fault Report 7 Time	0 to 4294967295	---	1	F050	0
303E	Fault Report 8 Time	0 to 4294967295	---	1	F050	0
3040	Fault Report 9 Time	0 to 4294967295	---	1	F050	0
3042	Fault Report 10 Time	0 to 4294967295	---	1	F050	0
3044	Fault Report 11 Time	0 to 4294967295	---	1	F050	0
3046	Fault Report 12 Time	0 to 4294967295	---	1	F050	0
3048	Fault Report 13 Time	0 to 4294967295	---	1	F050	0
304A	Fault Report 14 Time	0 to 4294967295	---	1	F050	0
304C	Fault Report 15 Time	0 to 4294967295	---	1	F050	0
Modbus file transfer (read/write)						
3100	Name of file to read	---	---	---	F204	(none)
Modbus file transfer values (read only)						
3200	Character position of current block within file	0 to 4294967295	---	1	F003	0
3202	Size of currently-available data block	0 to 65535	---	1	F001	0
3203	Block of data from requested file (122 items)	0 to 65535	---	1	F001	0
Security (Read Only)						
328A	Administrator alphanumeric password status	0 to 1	---	1	F102	0 (Disabled)
Security (Read Only)						
329F	Supervisor alphanumeric password status	0 to 1	---	1	F102	0 (Disabled)
Security (Read Only)						
32B4	Engineer alphanumeric password status	0 to 1	---	1	F102	0 (Disabled)
Security (Read Only)						
32C9	Operator alphanumeric password status	0 to 1	---	1	F102	0 (Disabled)
Security (Read Only)						
32DE	Observer alphanumeric password status	0 to 1	---	1	F102	0 (Disabled)
Security (Read Only)						
32E9	Reserved for password settings of future roles (63 items)	0 to 65535	---	1	F001	0
3328	Security status indicator	0 to 65535	---	1	F618	0
Security (Read/Write Setting)						
3329	Session Lockout	0 to 99	---	1	F001	3
332A	Session Lockout Period	0 to 9999	min	1	F001	3
332B	Load Factory Defaults	0 to 1	---	1	F126	0 (No)
332C	Syslog Serve IP Address	0 to 4294967295	---	1	F003	0
332E	Syslog Server Port Number	0 to 65535	---	1	F001	514
Security Supervisory (Read/Write Setting)						
3331	Device Authentication Enable	0 to 1	---	1	F126	1 (Yes)
3332	Supervisor Role Enable	0 to 1	---	1	F102	0 (Disabled)
3333	Lock Relay	0 to 1	---	1	F102	0 (Disabled)
3334	Factory Service Mode Enable	0 to 1	---	1	F102	0 (Disabled)
3335	Failed Authentication Alarm Enable	0 to 1	---	1	F102	1 (Enabled)
3336	Firmware Lock Alarm	0 to 1	---	1	F102	1 (Enabled)
3337	Settings Lock Alarm	0 to 1	---	1	F102	1 (Enabled)
3338	Bypass Access	0 to 1	---	1	F628	0 (Disabled)
3339	Encryption	0 to 1	---	1	F102	1 (Enabled)
333A	Serial Inactivity Timeout	1 to 9999	---	1	F001	1
Security Command (Read/Write Command)						
3350	Operator Logoff	0 to 1	---	1	F126	0 (No)
3351	Engineer Logoff	0 to 1	---	1	F126	0 (No)
3352	Administrator Logoff	0 to 1	---	1	F126	0 (No)

Table B–9: MODBUS MEMORY MAP (Sheet 12 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
3353	Clear Security Data	0 to 1	---	1	F126	0 (No)
Security Reserved Modbus Registers (Read/Write)						
3360	Address 0x3360 reserved for serial login (20 items)	0 to 9999	---	1	F001	3
3374	Address 0x3374 reserved for serial logout	0 to 9999	---	1	F001	3
Security Reserved Modbus Registers (Read Only)						
3375	Address 0x3374 reserved for serial logout	0 to 5	---	1	F617	3 (Engineer)
Event recorder actual values (read only)						
3400	Events Since Last Clear	0 to 4294967295	---	1	F003	0
3402	Number of Available Events	0 to 4294967295	---	1	F003	0
3404	Event Recorder Last Cleared Date	0 to 4294967295	---	1	F050	0
Event recorder commands (read/write)						
3406	Event Recorder Clear Command	0 to 1	---	1	F126	0 (No)
DCMA Input Values (Read Only) (24 modules)						
34C0	DCMA Inputs 1 Value	-9999999 to 9999999	---	1	F004	0
34C2	DCMA Inputs 2 Value	-9999999 to 9999999	---	1	F004	0
34C4	DCMA Inputs 3 Value	-9999999 to 9999999	---	1	F004	0
34C6	DCMA Inputs 4 Value	-9999999 to 9999999	---	1	F004	0
34C8	DCMA Inputs 5 Value	-9999999 to 9999999	---	1	F004	0
34CA	DCMA Inputs 6 Value	-9999999 to 9999999	---	1	F004	0
34CC	DCMA Inputs 7 Value	-9999999 to 9999999	---	1	F004	0
34CE	DCMA Inputs 8 Value	-9999999 to 9999999	---	1	F004	0
34D0	DCMA Inputs 9 Value	-9999999 to 9999999	---	1	F004	0
34D2	DCMA Inputs 10 Value	-9999999 to 9999999	---	1	F004	0
34D4	DCMA Inputs 11 Value	-9999999 to 9999999	---	1	F004	0
34D6	DCMA Inputs 12 Value	-9999999 to 9999999	---	1	F004	0
34D8	DCMA Inputs 13 Value	-9999999 to 9999999	---	1	F004	0
34DA	DCMA Inputs 14 Value	-9999999 to 9999999	---	1	F004	0
34DC	DCMA Inputs 15 Value	-9999999 to 9999999	---	1	F004	0
34DE	DCMA Inputs 16 Value	-9999999 to 9999999	---	1	F004	0
34E0	DCMA Inputs 17 Value	-9999999 to 9999999	---	1	F004	0
34E2	DCMA Inputs 18 Value	-9999999 to 9999999	---	1	F004	0
34E4	DCMA Inputs 19 Value	-9999999 to 9999999	---	1	F004	0
34E6	DCMA Inputs 20 Value	-9999999 to 9999999	---	1	F004	0
34E8	DCMA Inputs 21 Value	-9999999 to 9999999	---	1	F004	0
34EA	DCMA Inputs 22 Value	-9999999 to 9999999	---	1	F004	0
34EC	DCMA Inputs 23 Value	-9999999 to 9999999	---	1	F004	0
34EE	DCMA Inputs 24 Value	-9999999 to 9999999	---	1	F004	0
RTD Input Values (Read Only) (48 modules)						
34F0	RTD Input 1 Value	-32768 to 32767	°C	1	F002	0
34F1	RTD Input 2 Value	-32768 to 32767	°C	1	F002	0
34F2	RTD Input 3 Value	-32768 to 32767	°C	1	F002	0
34F3	RTD Input 4 Value	-32768 to 32767	°C	1	F002	0
34F4	RTD Input 5 Value	-32768 to 32767	°C	1	F002	0
34F5	RTD Input 6 Value	-32768 to 32767	°C	1	F002	0
34F6	RTD Input 7 Value	-32768 to 32767	°C	1	F002	0
34F7	RTD Input 8 Value	-32768 to 32767	°C	1	F002	0
34F8	RTD Input 9 Value	-32768 to 32767	°C	1	F002	0
34F9	RTD Input 10 Value	-32768 to 32767	°C	1	F002	0
34FA	RTD Input 11 Value	-32768 to 32767	°C	1	F002	0
34FB	RTD Input 12 Value	-32768 to 32767	°C	1	F002	0
34FC	RTD Input 13 Value	-32768 to 32767	°C	1	F002	0
34FD	RTD Input 14 Value	-32768 to 32767	°C	1	F002	0
34FE	RTD Input 15 Value	-32768 to 32767	°C	1	F002	0
34FF	RTD Input 16 Value	-32768 to 32767	°C	1	F002	0

Table B–9: MODBUS MEMORY MAP (Sheet 13 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
3500	RTD Input 17 Value	-32768 to 32767	°C	1	F002	0
3501	RTD Input 18 Value	-32768 to 32767	°C	1	F002	0
3502	RTD Input 19 Value	-32768 to 32767	°C	1	F002	0
3503	RTD Input 20 Value	-32768 to 32767	°C	1	F002	0
3504	RTD Input 21 Value	-32768 to 32767	°C	1	F002	0
3505	RTD Input 22 Value	-32768 to 32767	°C	1	F002	0
3506	RTD Input 23 Value	-32768 to 32767	°C	1	F002	0
3507	RTD Input 24 Value	-32768 to 32767	°C	1	F002	0
3508	RTD Input 25 Value	-32768 to 32767	°C	1	F002	0
3509	RTD Input 26 Value	-32768 to 32767	°C	1	F002	0
350A	RTD Input 27 Value	-32768 to 32767	°C	1	F002	0
350B	RTD Input 28 Value	-32768 to 32767	°C	1	F002	0
350C	RTD Input 29 Value	-32768 to 32767	°C	1	F002	0
350D	RTD Input 30 Value	-32768 to 32767	°C	1	F002	0
350E	RTD Input 31 Value	-32768 to 32767	°C	1	F002	0
350F	RTD Input 32 Value	-32768 to 32767	°C	1	F002	0
3510	RTD Input 33 Value	-32768 to 32767	°C	1	F002	0
3511	RTD Input 34 Value	-32768 to 32767	°C	1	F002	0
3512	RTD Input 35 Value	-32768 to 32767	°C	1	F002	0
3513	RTD Input 36 Value	-32768 to 32767	°C	1	F002	0
3514	RTD Input 37 Value	-32768 to 32767	°C	1	F002	0
3515	RTD Input 38 Value	-32768 to 32767	°C	1	F002	0
3516	RTD Input 39 Value	-32768 to 32767	°C	1	F002	0
3517	RTD Input 40 Value	-32768 to 32767	°C	1	F002	0
3518	RTD Input 41 Value	-32768 to 32767	°C	1	F002	0
3519	RTD Input 42 Value	-32768 to 32767	°C	1	F002	0
351A	RTD Input 43 Value	-32768 to 32767	°C	1	F002	0
351B	RTD Input 44 Value	-32768 to 32767	°C	1	F002	0
351C	RTD Input 45 Value	-32768 to 32767	°C	1	F002	0
351D	RTD Input 46 Value	-32768 to 32767	°C	1	F002	0
351E	RTD Input 47 Value	-32768 to 32767	°C	1	F002	0
351F	RTD Input 48 Value	-32768 to 32767	°C	1	F002	0
Ohm Input Values (Read Only) (2 modules)						
3520	Ohm Inputs 1 Value	0 to 65535	Þ	1	F001	0
3521	Ohm Inputs 2 Value	0 to 65535	Þ	1	F001	0
Radius Configuration (Read/Write Setting)						
3735	Undefined	0 to 4294967295	---	1	F003	56554706
3737	Undefined	1 to 65535	---	1	F001	1812
3738	Undefined	1 to 65535	---	1	F001	1813
3739	Undefined	0 to 4294967295	---	1	F003	56554706
373B	Undefined	0 to 65535	---	1	F001	1812
373D	Undefined	0 to 65535	---	1	F001	1813
373F	Undefined	---	---	1	F619	0 (EAP-TTLS)
3740	Undefined	1 to 65535	---	1	F001	2910
3741	Undefined	0 to 9999	sec	1	F001	10
3742	Undefined	0 to 9999	---	1	F001	3
3743	Undefined	---	---	---	F002	(none)
PTP Basic Configuration (Read/Write Setting)						
3750	PTP Strict Power Profile	0 to 1	---	1	F102	1 (Enabled)
3751	PTP Domain Number	0 to 255	---	1	F001	0
3752	PTP VLAN Priority	0 to 7	---	1	F001	4
3753	PTP VLAN ID	0 to 4095	---	1	F001	0
3754	Undefined (2 items)	0 to 1	---	1	F001	0

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Table B–9: MODBUS MEMORY MAP (Sheet 14 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
PTP Port Configuration (Read/Write Setting) (3 modules)						
3756	PTP Port x Function	0 to 1	---	1	F102	0 (Disabled)
3757	Port x Path Delay Adder	0 to 60000	ns	1	F001	0
3758	Port x Path Delay Asymmetry	-1000 to 1000	ns	1	F002	0
3759	...Repeated for module number 2					
375C	...Repeated for module number 3					
Real Time Clock Synchronizing Actuals (Read Only)						
375F	RTC Sync Source	0 to 5	---	1	F624	0 (none)
3760	PTP GrandMaster ID	0 to 100	--	1	F073	0
3764	Real Time Clock Accuracy	0 to 999999999	ns	1	F003	0
3766	PTP Port 1 State (3 items)	0 to 4	--	1	F625	0 (Disabled)
3769	RTC Offset	0 to 999999999	ns	1	F004	0
376B	PTP - IRIG-B Delta	-500000000 to 500000000	ns	1	F004	0
Real Time Clock Synchronizing FlexAnalogs (Read Only)						
376D	PTP - IRIG-B Delta FlexAnalog	-262143 to 262143	---	1	F004	0
Field Units (Read/Write Setting) (8 modules)						
3800	Field Unit 1 ID	0 to 1	---	1	F205	"U1"
3806	Field Unit 1 Function	0 to 1	---	1	F102	0 (Disabled)
3807	Field Unit 1 Type	0 to 3	---	1	F243	0 (CC-05)
3808	Field Unit 1 Serial Number	0 to1	---	1	F205	"000000000000"
380E	Field Unit 1 Port	1 to 4	---	1	F001	1
380F	...Repeated for Field Unit 2					
381E	...Repeated for Filed Unit 3					
382D	...Repeated for Filed Unit 4					
383C	...Repeated for Filed Unit 5					
384B	...Repeated for Filed Unit 6					
385A	...Repeated for Filed Unit 7					
3869	...Repeated for Filed Unit 8					
Field Unit Process Card Ports (Read/Write Setting)						
3878	Field Unit 1 Process Card Port	0 to 7	---	1	F244	6 (H1a)
3879	Field Unit 2 Process Card Port	0 to 7	---	1	F244	4 (H2a)
387A	Field Unit3 Process Card Port	0 to 7	---	1	F244	2 (H3a)
387B	Field Unit 4 Process Card Port	0 to 7	---	1	F244	0 (H4a)
387C	Field Unit 5 Process Card Port	0 to 7	---	1	F244	7 (H1b)
387D	Field Unit 6 Process Card Port	0 to 7	---	1	F244	5 (H2b)
387E	Field Unit 7 Process Card Port	0 to 7	---	1	F244	3 (H3b)
387F	Field Unit 8 Process Card Port	0 to 7	---	1	F244	1 (H4b)
Field Unit CT VT Settings (Read/Write Setting) (6 modules)						
3890	Remote Phase CT x Origin 1	0 to 16	---	1	F247	0 (none)
3891	Remote Phase CT x Origin 2	0 to 16	---	1	F247	0 (none)
3892	Remote Ground CT x Origin 1	0 to 16	---	1	F248	0 (none))
3893	Remote Ground CT x Origin 2	0 to 16	---	1	F248	0 (none)
3894	AC Bank Redundancy Type	0 to 2	---	1	F261	1 (Dependability Biased)
3895	Remote Phase CT 1 Primary	1 to 65000	---	1	F001	1
3896	Remote Phase CT 1 Secondary	0 to 1	---	1	F123	0 (1 A)
3897	Remote Ground CT 1 Primary	1 to 65000	---	1	F001	1
3898	Remote Ground CT 1 Secondary	0 to 1	---	1	F123	0 (1 A)
3899	Remote Phase VT 1 Connection	0 to 1	---	1	F100	0 (Wye)
389A	Remote Phase VT 1 Secondary	25 to 240	---	0.1	F001	664
389B	Remote Phase VT 1 Ratio	1 to 24000	---	1	F060	1
389D	Remote Auxiliary VT 1 Connection	0 to 6	---	1	F166	1 (Vag)
389E	Remote Auxiliary VT 1 Secondary	25 to 240	---	0.1	F001	664
389F	Remote Auxiliary VT 1 Ratio	1 to 24000	---	1	F060	1

Table B–9: MODBUS MEMORY MAP (Sheet 15 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
38A1	...Repeated for module number 2					
38B2	...Repeated for module number 3					
38C3	...Repeated for module number 4					
38D4	...Repeated for module number 5					
38E5	...Repeated for module number 6					
Field Unit Contact Inputs (Read/Write Setting) (40 modules)						
3900	Field Contact Input 1 ID	---	---	1	F205	"FCI 1"
3906	Field Contact Input 1 Origin	0 to 8	---	1	F256	0 (none)
3907	Field Contact Input 1 Input	1 to 18	---	1	F001	1
3908	Field Contact Input 1 Failsafe Value	0 to 1	---	1	F108	0 (Off)
3909	Field Contact Input 1 Debounce Time	0 to 16	ms	0.5	F001	20
390A	Field Contact Input 1 Events	0 to 1	---	1	F102	1 (Enabled)
390B	...Repeated for Field Contact Input 2					
3916	...Repeated for Field Contact Input 3					
3921	...Repeated for Field Contact Input 4					
392C	...Repeated for Field Contact Input 5					
3937	...Repeated for Field Contact Input 6					
3942	...Repeated for Field Contact Input 7					
394D	...Repeated for Field Contact Input 8					
3958	...Repeated for Field Contact Input9					
3963	...Repeated for Field Contact Input 10					
396E	...Repeated for Field Contact Input 11					
3979	...Repeated for Field Contact Input 12					
3984	...Repeated for Field Contact Input 13					
398F	...Repeated for Field Contact Input 14					
399A	...Repeated for Field Contact Input 15					
39A5	...Repeated for Field Contact Input 16					
39B0	...Repeated for Field Contact Input 17					
39BB	...Repeated for Field Contact Input 18					
39C6	...Repeated for Field Contact Input 19					
39D1	...Repeated for Field Contact Input 20					
39DC	...Repeated for Field Contact Input 21					
39E7	...Repeated for Field Contact Input 22					
39F2	...Repeated for Field Contact Input 23					
39FD	...Repeated for Field Contact Input 24					
3A08	...Repeated for Field Contact Input 25					
3A13	...Repeated for Field Contact Input 26					
3A1E	...Repeated for Field Contact Input 27					
3A29	...Repeated for Field Contact Input 28					
3A34	...Repeated for Field Contact Input 29					
3A3F	...Repeated for Field Contact Input 30					
3A4A	...Repeated for Field Contact Input 31					
3A55	...Repeated for Field Contact Input 32					
3A60	...Repeated for Field Contact Input 33					
3A6B	...Repeated for Field Contact Input 34					
3A76	...Repeated for Field Contact Input 35					
3A81	...Repeated for Field Contact Input 36					
3A8C	...Repeated for Field Contact Input 37					
3A97	...Repeated for Field Contact Input 38					
3AA2	...Repeated for Field Contact Input 39					
3AAD	...Repeated for Field Contact Input 40					
Field Unit Shared Inputs (Read/Write Setting) (16 modules)						
3B00	Field Shared Input 1 ID	0 to 65535	---	1	F205	"SI 1"
3B06	Field Shared Input 1 Unit Origin 1	0 to 8	---	1	F256	0 (none)

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Table B–9: MODBUS MEMORY MAP (Sheet 16 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
3B07	Field Shared Input 1Channel Origin 1	1 to 15	---	1	F001	1
3B08	Field Shared Input 1 Events	0 to 1	---	1	F102	1 (Enabled)
3B09	...Repeated for Field Shared Input 2					
3B12	...Repeated for Field Shared Input 3					
3B1B	...Repeated for Field Shared Input 4					
3B24	...Repeated for Field Shared Input 5					
3B2D	...Repeated for Field Shared Input 6					
3B36	...Repeated for Field Shared Input 7					
3B3F	...Repeated for Field Shared Input 8					
3B48	...Repeated for Field Shared Input 9					
3B51	...Repeated for Field Shared Input 10					
3B5A	...Repeated for Field Shared Input 11					
3B63	...Repeated for Field Shared Input 12					
3B6C	...Repeated for Field Shared Input 13					
3B75	...Repeated for Field Shared Input 14					
3B7E	...Repeated for Field Shared Input 15					
3B87	...Repeated for Field Shared Input 16					
Field Unit Contact Outputs (Read/Write Setting) (8 modules)						
3B90	Field Contact Output 1 ID (6 items)	---	---	---	F205	"FCO U /OUT"
3BB4	Field Output 1 Operate (6 items)	0 to 4294967295	---	1	F300	0
3BC0	Field Output 1 Seal In (6 items)	0 to 4294967295	---	1	F300	0
3BCC	Field Output 1 Events (6 items)	0 to 1	---	1	F102	1 (Enabled)
3BD2	...Repeated for Field Contact Output 2					
3C14	...Repeated for Field Contact Output 3					
3C56	...Repeated for Field Contact Output 4					
3C98	...Repeated for Field Contact Output 5					
3CDA	...Repeated for Field Contact Output 6					
3D1C	...Repeated for Field Contact Output 7					
3D5E	...Repeated for Field Contact Output 8					
Field Unit Latching Outputs (Read/Write Setting) (8 modules)						
3DC7	Field Latching Output 1 ID	0 to 1	---	---	F205	"FLO Ux /LO"
3DCD	Field Latching Output 1 Open	0 to 4294967295	---	1	F300	0
3DCF	Field Latching Output 1 Close	0 to 4294967295	---	1	F300	0
3DD1	Field Latching Output 1 Events	0 to 1	---	1	F102	1 (Enabled)
3DD2	Field Latching Output 1 Reserved (2 items)	0 to 1	---	1	F001	0
3DD4	...Repeated for Fielding Latching Output 2					
3DE1	...Repeated for Field Contact Output 3					
3DEE	...Repeated for Field Contact Output 4					
3DFB	...Repeated for Field Contact Output 5					
3E08	...Repeated for Field Contact Output 6					
3E15	...Repeated for Field Contact Output 7					
3E22	...Repeated for Field Contact Output 8					
Field Unit Shared Outputs (Read/Write Setting) (16 modules)						
3E30	Field Shared Output 1 ID	0 to 65535	---	---	F205	"SO 1"
3E36	Field Shared Output 1 Operate	0 to 4294967295	---	1	F300	0
3E38	Field Shared Output 1 Unit Dest 1	0 to 8	---	1	F256	0 (none)
3E39	Field Shared Output 1 Channel Dest 1	0 to 15	---	1	F001	1
3E3A	Field Shared Output 1 Unit Dest 2	0 to 8	---	1	F256	0 (none)
3E3B	Field Shared Output 1 Channel Dest 2	1 to 15	---	1	F001	1
3E3C	Field Shared Output 1 Events	0 to 1	---	1	F102	1 (Enabled)
3E3D	...Repeated for Field Shared Output 2					
3E4A	...Repeated for Field Shared Output 3					
3E57	...Repeated for Field Shared Output 4					
3E64	...Repeated for Field Shared Output 5					

Table B–9: MODBUS MEMORY MAP (Sheet 17 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
3E71	...Repeated for Field Shared Output 6					
3E7E	...Repeated for Field Shared Output 7					
3E8B	...Repeated for Field Shared Output 8					
3E98	...Repeated for Field Shared Output 9					
3EA5	...Repeated for Field Shared Output 10					
3EB2	...Repeated for Field Shared Output 11					
3EBF	...Repeated for Field Shared Output 12					
3ECC	...Repeated for Field Shared Output 13					
3ED9	...Repeated for Field Shared Output 14					
3EE6	...Repeated for Field Shared Output 15					
3EF3	...Repeated for Field Shared Output 16					
Field Unit RTDs (Read/Write Setting) (8 modules)						
3F00	Field Unit RTD 1Name	0 to 1	---	1	F205	"RTD 1"
3F06	Field Unit RTD 1 Origin	0 to 1	---	1	F205	"RTD 1"
3F07	Field Unit RTD 1 Type	0 to 2	---	1	F259	0 (100 Ohm Nickel)
3F08	...Repeated for Field Unit RTD 2					
3F10	...Repeated for Field Unit RTD 3					
3F18	...Repeated for Field Unit RTD 4					
3F20	...Repeated for Field Unit RTD 5					
3F28	...Repeated for Field Unit RTD 6					
3F30	...Repeated for Field Unit RTD 7					
3F38	...Repeated for Field Unit RTD 8					
Field Unit Transducers (Read/Write Setting) (8 modules)						
3F40	Field Unit Transducer 1 Name	0 to 1	---	1	F205	"TRD 1"
3F46	Field Unit Transducer 1 Origin	0 to 24	---	1	F53	0 (none)
3F47	Field Unit Transducer 1 Range	0 to 9	---	1	F246	6 (0...20mA)
3F48	Field Unit Transducer 1 Min Value	-9999.999 to 9999.999	---	0.01	F004	0
3F4A	Field Unit Transducer 1 Max Value	-9999.999 to 9999.999	---	0.001	F004	100000
3F4C	Field Unit Transducer 1 Units	---	---	---	F206	(none)
3F4F	...Repeated for Field Unit Transducer 2					
3F5E	...Repeated for Field Unit Transducer 3					
3F6D	...Repeated for Field Unit Transducer 4					
3F7C	...Repeated for Field Unit Transducer 5					
3F8B	...Repeated for Field Unit Transducer 6					
3F9A	...Repeated for Field Unit Transducer 7					
3FA9	...Repeated for Field Unit Transducer 8					
Field Unit Identifiers (Read Only) (8 modules)						
3FB8	Attached Field Unit 1 Serial Number	---	---	1	F205	(none)
3FBE	Attached Filed Unit 1 Port Number	---	---	1	F001	0
3FBF	Attached Field Unit 1 Type	0 to 3	---	1	F243	0 (CC-05)
3FC0	Field Unit 1 Status	0 to 4	---	1	F262	0 (Disabled)
3FC1	...Repeated for Field Unit 2					
3FCA	...Repeated for Field Unit 3					
3FD3	...Repeated for Field Unit 4					
3FDC	...Repeated for Field Unit 5					
3FE5	...Repeated for Field Unit 6					
3FEE	...Repeated for Field Unit 7					
3FF7	...Repeated for Field Unit 8					
Passwords (Read/Write Command)						
4000	Command Password Setting	0 to 4294967295	---	1	F202	0
Passwords (Read/Write Setting)						
400A	Setting Password Setting	0 to 4294967295	---	1	F202	0

Table B–9: MODBUS MEMORY MAP (Sheet 18 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Passwords (Read/Write)						
4014	Command Password Entry	0 to 4294967295	---	1	F202	(none)
401E	Setting Password Entry	0 to 4294967295	---	1	F202	(none)
Passwords (Read Only)						
4028	Command Password Status	0 to 1	---	1	F102	0 (Disabled)
4029	Setting Password Status	0 to 1	---	1	F102	0 (Disabled)
Passwords (Read/Write Setting)						
402A	Command Password Access Timeout	5 to 480	min	1	F001	5
402B	Setting Password Access Timeout	5 to 480	min	1	F001	30
402C	Invalid Password Attempts	2 to 5	---	1	F001	3
402D	Password Lockout Duration	5 to 60	min	1	F001	5
Passwords (Read/Write)						
402E	Password Access Events	0 to 1	---	1	F102	0 (Disabled)
Passwords (Read/Write Setting)						
402F	Local Setting Auth	1 to 4294967295	---	1	F300	1
4031	Remote Setting Auth	0 to 4294967295	---	1	F300	1
4033	Access Auth Timeout	5 to 480	min	1	F001	30
User Display Invoke (Read/Write Setting)						
4040	Invoke and Scroll Through User Display Menu Operand	0 to 4294967295	---	1	F300	0
LED Test (Read/Write Setting)						
4048	LED Test Function	0 to 1	---	1	F102	0 (Disabled)
4049	LED Test Control	0 to 4294967295	---	1	F300	0
Preferences (Read/Write Setting)						
404F	Language	0 to 3	---	1	F531	0 (English)
4050	Flash Message Time	0.5 to 10	s	0.1	F001	10
4051	Default Message Timeout	10 to 900	s	1	F001	300
4052	Default Message Intensity	0 to 3	---	1	F101	0 (25%)
4053	Screen Saver Feature	0 to 1	---	1	F102	0 (Disabled)
4054	Screen Saver Wait Time	1 to 65535	min	1	F001	30
4055	Current Cutoff Level	0.002 to 0.02	pu	0.001	F001	20
4056	Voltage Cutoff Level	0.1 to 1	V	0.1	F001	10
87L Channel Status (Read Only)						
4059	Channel 1 Local Loopback Status	0 to 2	---	1	F134	2 (n/a)
405A	Channel 1 Loop Delay	0 to 200	ms	0.1	F001	0
405B	Channel 1 Number of Lost Packets	0 to 65535	---	1	F001	0
405C	Channel 1 Remote Loopback Status	0 to 2	---	1	F134	2 (n/a)
405D	Channel 1 Status	0 to 2	---	1	F134	1 (OK)
405E	Channel 2 Local Loopback Status	0 to 2	---	1	F134	2 (n/a)
405F	Channel 2 Loop Delay	0 to 200	ms	0.1	F001	0
4060	Channel 2 Number of Lost Packets	0 to 65535	---	1	F001	0
4061	Channel 2 Remote Loopback Status	0 to 2	---	1	F134	2 (n/a)
4062	Channel 2 Status	0 to 2	---	1	F134	1 (OK)
4063	Channel PFLL Status	0 to 2	---	1	F134	1 (OK)
4064	87L Network Status	0 to 2	---	1	F134	2 (n/a)
87L Channel Status (Read/Write Command)						
4065	Channel Status Clear	0 to 1	---	1	F126	0 (No)
87L Power System (Read/Write Setting)						
4068	Block GPS Time Reference	0 to 4294967295	---	1	F300	0
406A	Channel Asymmetry Compensation	0 to 4294967295	---	1	F300	0
406C	Charging Current Compensation	0 to 1	---	1	F102	0 (Disabled)
406D	Local Relay ID	0 to 255	---	1	F001	0
406E	Maximum Channel Asymmetry	0 to 10	ms	0.1	F001	15
406F	Number of Channels	1 to 2	---	1	F001	1
4070	Number of Terminals	2 to 3	---	1	F001	2

Table B–9: MODBUS MEMORY MAP (Sheet 19 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
4071	Positive Sequence Reactance	0.1 to 65.535	kohms	0.001	F001	100
4072	Round Trip Time	0 to 10	ms	0.1	F001	15
4073	Terminal 1 ID	0 to 255	---	1	F001	0
4074	Terminal 2 ID	0 to 255	---	1	F001	0
4075	Zero-Sequence Current Removal	0 to 1	---	1	F102	0 (Disabled)
4076	Zero Sequence Reactance	0.1 to 65.535	kohms	0.001	F001	100
Communications (Read/Write Setting)						
407D	COM2 Selection	0 to 3	---	1	F601	0 (RS485)
407F	COM2 Minimum Response Time	0 to 1000	ms	10	F001	0
4080	Modbus Slave Address	1 to 254	---	1	F001	254
4085	RS485 Com2 Baud Rate	0 to 11	---	1	F112	8 (115200)
4086	RS485 Com2 Parity	0 to 2	---	1	F113	0 (None)
4087	IP Address	0 to 4294967295	---	1	F003	56554706
4089	IP Subnet Mask	0 to 4294967295	---	1	F003	4294966272
408B	Port 1 Gateway IP Address	0 to 4294967295	---	1	F003	56554497
4097	Port 1 Link Loss Alert	0 to 1	---	1	F102	0 (Disabled)
4098	Port 2 Link Loss Alert	0 to 1	---	1	F102	0 (Disabled)
4099	Port 3 Link Loss Alert	0 to 1	---	1	F102	0 (Disabled)
409A	DNP Channel 1 Port	0 to 5	---	1	F177	0 (None)
409B	DNP Channel 2 Port	0 to 5	---	1	F177	0 (None)
409C	DNP Address	0 to 65519	---	1	F001	1
409E	DNP Client Addresses (2 items)	0 to 4294967295	---	1	F003	0
40A3	TCP Port Number for the Modbus protocol	0 to 65535	---	1	F001	502
40A4	TCP/UDP Port Number for the DNP Protocol	0 to 65535	---	1	F001	20000
40A5	TCP Port Number for the HTTP (Web Server) Protocol	0 to 65535	---	1	F001	80
40A6	Main UDP Port Number for the TFTP Protocol	0 to 65535	---	1	F001	69
40A7	Data Transfer UDP Port Numbers for the TFTP Protocol (zero means “automatic”) (2 items)	0 to 65535	---	1	F001	0
40A9	DNP Unsolicited Responses Function	0 to 1	---	1	F102	0 (Disabled)
40AA	DNP Unsolicited Responses Timeout	0 to 60	s	1	F001	5
40AB	DNP unsolicited responses maximum retries	1 to 255	---	1	F001	10
40AC	DNP unsolicited responses destination address	0 to 65519	---	1	F001	1
40AD	Ethernet operation mode	0 to 1	---	1	F192	1 (Half-Duplex)
40AE	DNP current scale factor	0 to 8	---	1	F194	2 (1)
40AF	DNP voltage scale factor	0 to 8	---	1	F194	2 (1)
40B0	DNP power scale factor	0 to 8	---	1	F194	2 (1)
40B1	DNP energy scale factor	0 to 8	---	1	F194	2 (1)
40B2	DNP power scale factor	0 to 8	---	1	F194	2 (1)
40B3	DNP other scale factor	0 to 8	---	1	F194	2 (1)
40B4	DNP current default deadband	0 to 100000000	---	1	F003	30000
40B6	DNP voltage default deadband	0 to 100000000	---	1	F003	30000
40B8	DNP power default deadband	0 to 100000000	---	1	F003	30000
40BA	DNP energy default deadband	0 to 100000000	---	1	F003	30000
40BC	DNP power factor default deadband	0 to 100000000	--	1	F003	30000
40BE	DNP other default deadband	0 to 100000000	---	1	F003	30000
40C0	DNP IIN time synchronization bit period	1 to 10080	min	1	F001	1440
40C1	DNP message fragment size	30 to 2048	---	1	F001	240
40C2	DNP client address 3	0 to 4294967295	---	1	F003	0
40C4	DNP client address 4	0 to 4294967295	---	1	F003	0
40C6	DNP client address 5	0 to 4294967295	---	1	F003	0
40C8	DNP number of paired binary output control points	0 to 32	---	1	F001	0
40C9	DNP TCP connection timeout	10 to 65535	---	1	F001	120
40CA	DNP communications reserved (22 items)	0 to 1	---	1	F001	0
40E0	TCP port number for the IEC 60870-5-104 protocol	0 to 65535	---	1	F001	2404

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Table B–9: MODBUS MEMORY MAP (Sheet 20 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
40E1	IEC 60870-5-104 protocol function	0 to 1	---	1	F102	0 (Disabled)
40E2	IEC 60870-5-104 protocol common address of ASDU	0 to 65535	---	1	F001	0
40E3	IEC 60870-5-104 protocol cyclic data transmit period	1 to 65535	s	1	F001	60
40E4	IEC 60870-5-104 current default threshold	0 to 100000000	---	1	F003	30000
40E6	IEC 60870-5-104 voltage default threshold	0 to 100000000	---	1	F003	30000
40E8	IEC 60870-5-104 power default threshold	0 to 100000000	---	1	F003	30000
40EA	IEC 60870-5-104 energy default threshold	0 to 100000000	---	1	F003	30000
40EC	IEC 60870-5-104 power default threshold	0 to1	---	0.01	F001	100
40EE	IEC 60870-5-104 other default threshold	0 to 100000000	---	1	F003	30000
40F0	IEC 60870-5-104 client address (5 items)	0 to 4294967295	---	1	F003	0
4104	IEC 60870-5-104 redundancy port	0 to 1	---	1	F126	0 (No)
4105	Port 2 IP Address	0 to 4294967295	---	1	F003	56554706
4107	Port 2 IP Subnet Mask	0 to 4294967295	---	1	F003	4294966272
4109	Port 2 Gateway IP Address	0 to 4294967295	---	1	F003	56554497
410B	PRT2 Ethernet Operation Mode	0 to 1	---	1	F192	1 (Full-Duplex)
410C	PRT2 Redundancy Enabled	0 to 2	---	1	F627	0 (None)
410D	Port 3 IP Address	0 to 4294967295	---	1	F003	56554706
410F	Port 3 IP Subnet Mask	0 to 4294967295	---	1	F003	4294966272
4111	Port 3 Gateway IP Address	0 to 4294967295	---	1	F003	56554497
4113	Port 3 Ethernet Operation Mode	0 to 1	---	1	F192	1 (Full-Duplex)
4114	PRT1 GOOSE Enabled	0 to 1	---	1	F102	1 (Enabled)
4115	PRT2 GOOSE Enabled	0 to 1	---	1	F102	1 (Enabled)
4116	PRT3 GOOSE Enabled	0 to 1	---	1	F102	1 (Enabled)
4119	PRT2 PRP Mcst Addr	---	---	---	F072	0
411C	IEC Communications Reserved (33 items)	0 to 1	---	1	F001	0
413E	High Enet Traffic Function	0 to 1	---	1	F102	0 (Disabled)
413F	High Enet Traffic Events	0 to 1	---	1	F102	0 (Disabled)
4140	DNP object 1 default variation	1 to 2	---	1	F001	2
4141	DNP object 2 default variation	1 to 3	---	1	F001	2
4142	DNP object 20 default variation	0 to 3	---	1	F523	0 (1)
4143	DNP object 21 default variation	0 to 3	---	1	F524	0 (1)
4144	DNP object 22 default variation	0 to 3	---	1	F523	0 (1)
4145	DNP object 23 default variation	0 to 3	---	1	F523	0 (1)
4146	DNP object 30 default variation	1 to 5	---	1	F001	1
4147	DNP object 32 default variation	0 to 5	---	1	F525	0 (1)
Communications Actuals (Read Only)						
4160	Modbus Available TCP/IP Connections	0 to 4	---	1	F001	4
4161	DNP Available TCP/IP Connections	0 to 2	---	1	F001	2
4162	IEC Available TCP/IP Connections	0 to 2	---	1	F001	2
4163	MMS Available TCP/IP Connections	0 to 5	---	1	F001	5
4164	PMU Available TCP/IP Connections	0 to 4	---	1	F001	4
Simple Network Time Protocol (Read/Write Setting)						
4168	Simple Network Time Protocol (SNTP) function	0 to 1	---	1	F102	0 (Disabled)
4169	Simple Network Time Protocol (SNTP) server IP address	0 to 4294967295	---	1	F003	0
416B	Simple Network Time Protocol (SNTP) UDP port number	1 to 65535	---	1	F001	123
Data Logger Commands (Read/Write Command)						
4170	Data Logger Clear	0 to 1	---	1	F126	0 (No)
Data Logger (Read/Write Setting)						
4181	Data Logger Channel Settings (16 items)	---	---	---	F600	0
4191	Data Logger Mode	0 to 1	---	1	F260	0 (continuous)
4192	Data Logger Trigger	0 to 4294967295	---	1	F300	0
4194	Data Logger Rate	15 to 3600000	ms	1	F003	60000
Clock (Read/Write Setting)						
419F	Synchronizing Source	0 to 3	---	1	F623	0 (none)

Table B–9: MODBUS MEMORY MAP (Sheet 21 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Clock (Read/Write Command)						
41A0	Real Time Clock Set Time	0 to 235959	---	1	F050	0
Clock (Read/Write Setting)						
41A2	SR Date Format	0 to 4294967295	---	1	F051	0
41A4	SR Time Format	0 to 4294967295	---	1	F052	0
41A6	IRIG-B Signal Type	0 to 2	---	1	F114	0 (None)
41A7	Clock Events Enable / Disable	0 to 1	---	1	F102	0 (Disabled)
41A8	Time Zone Offset from UTC	–24 to 24	hours	0.5	F002	0
41A9	Daylight Savings Time (DST) Function	0 to 1	---	1	F102	0 (Disabled)
41AA	Daylight Savings Time (DST) Start Month	0 to 11	---	1	F237	0 (January)
41AB	Daylight Savings Time (DST) Start Day	0 to 6	---	1	F238	0 (Sunday)
41AC	Daylight Savings Time (DST) Start Day Instance	0 to 4	---	1	F239	0 (First)
41AD	Daylight Savings Time (DST) Start Hour	0 to 23	---	1	F001	2
41AE	Daylight Savings Time (DST) Stop Month	0 to 11	---	1	F237	0 (January)
41AF	Daylight Savings Time (DST) Stop Day	0 to 6	---	1	F238	0 (Sunday)
41B0	Daylight Savings Time (DST) Stop Day Instance	0 to 4	---	1	F239	0 (First)
41B1	Daylight Savings Time (DST) Stop Hour	0 to 23	---	1	F001	2
Fault Report Commands (Read/Write Command)						
41B2	Fault Reports Clear Data Command	0 to 1	---	1	F126	0 (No)
Oscillography (Read/Write Setting)						
41C0	Oscillography Number of Records	3 to 64	---	1	F001	15
41C1	Oscillography Trigger Mode	0 to 1	---	1	F118	0 (Auto. Overwrite)
41C2	Oscillography Trigger Position	0 to 100	%	1	F001	50
41C3	Oscillography Trigger Source	0 to 4294967295	---	1	F300	0
41C5	Oscillography AC Input Waveforms	0 to 4	---	1	F183	2 (16 samples/ cycle)
41D0	Oscillography Analog Channel *n* (16 items)	0 to 65535	---	1	F600	0
4200	Oscillography Digital Channel *n* (63 items)	0 to 4294967295	---	1	F300	0
Trip and Alarm LEDs (Read/Write Setting)						
42B0	Trip LED Input FlexLogic Operand	0 to 4294967295	---	1	F300	0
42B2	Alarm LED Input FlexLogic Operand	0 to 4294967295	---	1	F300	0
User Programmable LEDs (Read/Write Setting) (48 modules)						
42C0	FlexLogic Operand to Activate LED	0 to 4294967295	---	1	F300	0
42C2	User LED type (latched or self-resetting)	0 to 1	---	1	F127	1 (Self-Reset)
42C3	...Repeated for User-Programmable LED 2					
42C6	...Repeated for User-Programmable LED 3					
42C9	...Repeated for User-Programmable LED 4					
42CC	...Repeated for User-Programmable LED 5					
42CF	...Repeated for User-Programmable LED 6					
42D2	...Repeated for User-Programmable LED 7					
42D5	...Repeated for User-Programmable LED 8					
42D8	...Repeated for User-Programmable LED 9					
42DB	...Repeated for User-Programmable LED 10					
42DE	...Repeated for User-Programmable LED 11					
42E1	...Repeated for User-Programmable LED 12					
42E4	...Repeated for User-Programmable LED 13					
42E7	...Repeated for User-Programmable LED 14					
42EA	...Repeated for User-Programmable LED 15					
42ED	...Repeated for User-Programmable LED 16					
42F0	...Repeated for User-Programmable LED 17					
42F3	...Repeated for User-Programmable LED 18					
42F6	...Repeated for User-Programmable LED 19					
42F9	...Repeated for User-Programmable LED 20					
42FC	...Repeated for User-Programmable LED 21					

Table B–9: MODBUS MEMORY MAP (Sheet 22 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
42FF	...Repeated for User-Programmable LED 22					
4302	...Repeated for User-Programmable LED 23					
4305	...Repeated for User-Programmable LED 24					
4308	...Repeated for User-Programmable LED 25					
430B	...Repeated for User-Programmable LED 26					
430E	...Repeated for User-Programmable LED 27					
4311	...Repeated for User-Programmable LED 28					
4314	...Repeated for User-Programmable LED 29					
4317	...Repeated for User-Programmable LED 30					
431A	...Repeated for User-Programmable LED 31					
431D	...Repeated for User-Programmable LED 32					
4320	...Repeated for User-Programmable LED 33					
4323	...Repeated for User-Programmable LED 34					
4326	...Repeated for User-Programmable LED 35					
4329	...Repeated for User-Programmable LED 36					
432C	...Repeated for User-Programmable LED 37					
432F	...Repeated for User-Programmable LED 38					
4332	...Repeated for User-Programmable LED 39					
4335	...Repeated for User-Programmable LED 40					
4338	...Repeated for User-Programmable LED 41					
433B	...Repeated for User-Programmable LED 42					
433E	...Repeated for User-Programmable LED 43					
4341	...Repeated for User-Programmable LED 44					
4344	...Repeated for User-Programmable LED 45					
4347	...Repeated for User-Programmable LED 46					
434A	...Repeated for User-Programmable LED 47					
434D	...Repeated for User-Programmable LED 48					
PRP Status (Read Only)						
4363	Total Received Port A	0 to 4294967295	---	1	F003	0
4365	Total Received Port B	0 to 4294967295	---	1	F003	0
4367	Total Mismatches Port A	0 to 4294967295	---	1	F003	0
4369	Total Mismatches Port B	0 to 4294967295	---	1	F003	0
436B	Total Errors	0 to 4294967295	---	1	F003	0
IPv4 Route Table (Read/Write Setting) (6 Modules)						
4370	IPv4 Network Route 1 Destination	0 to 4294967295	---	1	F003	2130706433
4372	IPv4 Network Route 1 Netmask	0 to 4294967295	---	1	F003	4294966272
4374	IPv4 Network Route 1 Gateway	0 to 4294967295	---	1	F003	2130706433
4376	...Repeated for Route 2					
437C	...Repeated for Route 3					
4382	...Repeated for Route 4					
4388	...Repeated for Route 5					
438E	...Repeated for Route 6					
Installation (Read/Write Setting)						
43E0	Relay Programmed State	0 to 1	---	1	F133	0 (Not Programmed)
43E1	Relay Name	---	---	---	F202	“Relay-1”
User Programmable Self Tests (Read/Write Setting)						
4441	User Programmable Detect Ring Break Function	0 to 1	---	1	F102	1 (Enabled)
4442	User Programmable Direct Device Off Function	0 to 1	---	1	F102	1 (Enabled)
4443	User Programmable Remote Device Off Function	0 to 1	---	1	F102	1 (Enabled)
4444	User Programmable First Ethernet Fail Function	0 to 1	---	1	F102	0 (Disabled)
4445	User Programmable Secondary Ethernet Fail Function	0 to 1	---	1	F102	0 (Disabled)
4446	User Programmable Battery Fail Function	0 to 1	---	1	F102	1 (Enabled)
4447	User Programmable SNTP Fail Function	0 to 1	---	1	F102	1 (Enabled)

Table B–9: MODBUS MEMORY MAP (Sheet 23 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
4448	User Programmable IRIG-B Fail Function	0 to 1	---	1	F102	1 (Enabled)
444A	Process Bus Failure Operand	0 to 4294967295	---	1	F300	0
444C	PTP Fail Function	0 to 1	---	1	F102	1 (Enabled)
444D	User Programmable Third Ethernet Fail Function	0 to 1	---	1	F102	0 (Disabled)
444E	User Programmable SFP Fail Function	0 to 1	---	1	F102	0 (Disabled)
CT Settings (Read/Write Setting) (6 modules)						
4480	Phase CT 1 Primary	1 to 65000	A	1	F001	1
4481	Phase CT 1 Secondary	0 to 1	---	1	F123	0 (1 A)
4482	Ground CT 1 Primary	1 to 65000	A	1	F001	1
4483	Ground CT 1 Secondary	0 to 1	---	1	F123	0 (1 A)
4484	...Repeated for CT Bank 2					
4488	...Repeated for CT Bank 3					
448C	...Repeated for CT Bank 4					
4490	...Repeated for CT Bank 5					
4494	...Repeated for CT Bank 6					
VT Settings (Read/Write Setting) (3 modules)						
4500	Phase VT 1 Connection	0 to 1	---	1	F100	0 (Wye)
4501	Phase VT 1 Secondary	25 to 240	V	0.1	F001	664
4502	Phase VT 1 Ratio	1 to 24000	:1	1	F060	1
4504	Auxiliary VT 1 Connection	0 to 6	---	1	F166	1 (Vag)
4505	Auxiliary VT 1 Secondary	25 to 240	V	0.1	F001	664
4506	Auxiliary VT 1 Ratio	1 to 24000	:1	1	F060	1
4508	...Repeated for VT Bank 2					
4510	...Repeated for VT Bank 3					
4518	...Repeated for VT Bank 4					
4520	...Repeated for VT Bank 5					
4528	...Repeated for VT Bank 6					
Source Settings (Read/Write Setting) (6 modules)						
4580	Source 1 Name	0 to 1	---	---	F206	“SRC 1"
4583	Source 1 Phase CT	0 to 63	---	1	F400	0
4584	Source 1 Ground CT	0 to 63	---	1	F400	0
4585	Source 1 Phase VT	0 to 63	---	1	F400	0
4586	Source 1 Auxiliary VT	0 to 63	---	1	F400	0
4587	...Repeated for Source 2					
458E	...Repeated for Source 3					
4595	...Repeated for Source 4					
459C	...Repeated for Source 5					
45A3	...Repeated for Source 6					
Power System (Read/Write Setting)						
4600	Nominal Frequency	25 to 60	Hz	1	F001	60
4601	Phase Rotation	0 to 1	---	1	F106	0 (ABC)
4602	Frequency And Phase Reference	0 to 5	---	1	F167	0 (SRC 1)
4603	Frequency Tracking Function	0 to 1	---	1	F102	1 (Enabled)
87L Power System In-Zone Transformer (Read/Write Setting)						
4606	In-Zone Transformer Connection	0 to 12	---	1	F560	0 (None)
4607	87L In-Zone Transformer Location	0 to 2	---	1	F562	0 (Local-Tap)
Breaker control (read/write settings)						
47D0	Breaker 1 function	0 to 1	---	1	F102	0 (Disabled)
47D1	Breaker 1 name	---	---	---	F206	“Bkr 1"
47D4	Breaker 1 mode	0 to 1	---	1	F157	0 (3-Pole)
47D5	Breaker 1 open	0 to 4294967295	---	1	F300	0
47D7	Breaker 1 close	0 to 4294967295	---	1	F300	0
47D9	Breaker 1 phase A / three-pole closed	0 to 4294967295	---	1	F300	0
47DB	Breaker 1 phase B closed	0 to 4294967295	---	1	F300	0

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Table B–9: MODBUS MEMORY MAP (Sheet 24 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
47DD	Breaker 1 phase C closed	0 to 4294967295	---	1	F300	0
47DF	Breaker 1 external alarm	0 to 4294967295	---	1	F300	0
47E1	Breaker 1 alarm delay	0 to 65.535	s	0.001	F003	0
47E3	Breaker 1 pushbutton control	0 to 1	---	1	F102	0 (Disabled)
47E4	Breaker 1 manual close recall time	0 to 4294967295	s	0.001	F003	0
47E6	Breaker 1 out of service	0 to 4294967295	---	1	F300	0
47E8	Breaker 1 block open	0 to 4294967295	---	1	F300	0
47EA	Breaker 1 block close	0 to 4294967295	---	1	F300	0
47EC	Breaker 1 phase A / three-pole opened	0 to 4294967295	---	1	F300	0
47EE	Breaker 1 phase B opened	0 to 4294967295	---	1	F300	0
47F0	Breaker 1 phase C opened	0 to 4294967295	---	1	F300	0
47F2	Breaker 1 operate time	0 to 65.535	s	0.001	F001	70
47F3	Breaker 1 events	0 to 1	---	1	F102	0 (Disabled)
47F4	Reserved	0 to 65535	s	1	F001	0
47F5	...Repeated for breaker 2					
481A	...Repeated for breaker 3					
483F	...Repeated for breaker 4					
FlexCurve A (Read/Write Setting)						
4910	FlexCurve A (120 items)	0 to 655535	ms	1	F011	0
FlexCurve B (Read/Write Setting)						
4988	FlexCurve B (120 items)	0 to 655535	ms	1	F011	0
Modbus User Map (Read/Write Setting)						
4A00	Modbus Address Settings for User Map (256 items)	0 to 65535	---	1	F001	0
User Displays Settings (Read/Write Setting) (16 modules)						
4C00	User-Definable Display 1 Top Line Text	---	---	---	F202	" "
4C0A	User-Definable Display 1 Bottom Line Text	---	---	---	F202	""
4C14	Modbus Addresses of Display 1 Items (5 items)	0 to 65535	---	1	F001	0
4C19	Reserved (7 items)	---	---	---	F001	0
4C20	...Repeated for User-Definable Display 2					
4C40	...Repeated for User-Definable Display 3					
4C60	...Repeated for User-Definable Display 4					
4C80	...Repeated for User-Definable Display 5					
4CA0	...Repeated for User-Definable Display 6					
4CC0	...Repeated for User-Definable Display 7					
4CE0	...Repeated for User-Definable Display 8					
4D00	...Repeated for User-Definable Display 9					
4D20	...Repeated for User-Definable Display 10					
4D40	...Repeated for User-Definable Display 11					
4D60	...Repeated for User-Definable Display 12					
4D80	...Repeated for User-Definable Display 13					
4DA0	...Repeated for User-Definable Display 14					
4DC0	...Repeated for User-Definable Display 15					
4DE0	...Repeated for User-Definable Display 16					
Field Unit Raw Data Actuals (Read Only) (8 modules)						
4E00	Raw Field Data AC1 Mag	0 to 0.001	A	0.001	F003	0
4E02	Raw Field Data AC1 Angle	0 to 0.1	degree	0.1	F002	0
4E03	Raw Field Data AC2 Mag	0 to 0.001	A	0.001	F003	0
4E05	Raw Field Data AC2 Angle	0 to 0.1	degree	0.1	F002	0
4E06	Raw Field Data AC3 Mag	0 to 0.001	A	0.001	F003	0
4E08	Raw Field Data AC3 Angle	0 to 0.01	degree	0.1	F002	0
4E09	Raw Field Data AC4 Mag	0 to 0.001	A	0.001	F003	0
4E0B	Raw Field Data AC4 Angle	0 to 0.01	degree	0.1	F002	0
4E0C	Raw Field Data AC5 Mag	0 to 0.001	A/V	0.001	F003	0
4E0E	Raw Field Data AC5 Angle	0 to 0.01	degree	0.1	F002	0

Table B–9: MODBUS MEMORY MAP (Sheet 25 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
4E0F	Raw Field Data AC6 Mag	0 to 0.001	A/V	0.001	F003	0
4E11	Raw Field Data AC6 Angle	0 to 0.01	degree	0.1	F002	0
4E12	Raw Field Data AC7 Mag	0 to 0.001	A/V	0.001	F003	0
4E14	Raw Field Data AC7 Angle	0 to 0.01	degree	0.1	F002	0
4E15	Raw Field Data AC8 Mag	0 to 0.001	A/V	0.001	F003	0
4E17	Raw Field Data AC8 Angle	0 to 0.01	degree	0.1	F002	0
4E18	Raw Field Data DC1	0 to 0.001	V	0.001	F002	0
4E19	Raw Field Data DC2	0 to 0.001	V	0.001	F002	0
4E1A	Raw Field Data DC3	0 to 0.001	V	0.001	F002	0
4E1B	Raw Field Data FCI States (2 items)	0 to 1	---	1	F500	0
4E1D	Raw Field Data SI States	0 to 1	---	1	F500	0
4E1E	Raw Field Data SI Test States	0 to 1	---	1	F500	0
4E1F	Raw Field Data Brick ADC Temperature	0 to 1	degree	1	F002	0
4E20	Raw Field Data Brick Transceiver Temperature	0 to 1	degree	1	F002	0
4E21	Raw Field Data Brick Transceiver Voltage	0 to 0.01	V	0.01	F001	0
4E22	Raw Field Data Brick Transceiver Current	0 to 1	mA	1	F001	0
4E23	Raw Field Data Brick Tx Power	0 to 0.01	dBm	0.1	F002	0
4E24	Raw Field Data Brick Rx Power	0 to 0.1	dBm	0.1	F002	0
4E25	Raw Field Data Brick Diagnostics (2 items)	0 to 65535	---	1	F500	0
4E27	Raw Field Data Local Transceiver Temperature	0 to 1	degree	1	F002	0
4E28	Raw Field Data Local Transceiver Voltage	0 to 0.01	V	0.01	F001	0
4E29	Raw Field Data Local Transceiver Current	0 to 1	mA	1	F001	0
4E2A	Raw Field Data Local Tx Power	0 to 0.1	dBm	0.1	F002	0
4E2B	Raw Field Data Local Rx Power	0 to 0.1	dBm	0.1	F002	0
4E2C	Repeated for module number 2					
4E58	Repeated for module number 3					
4E84	Repeated for module number 4					
4E80	Repeated for module number 5					
4EDC	Repeated for module number 6					
4F08	Repeated for module number 7					
4F34	Repeated for module number 8					
Flexlogic (Read/Write Setting)						
5000	FlexLogic Entry (512 items)	0 to 4294967295	---	1	F300	2097152
RTD Inputs (Read/Write Setting) (48 modules)						
5400	RTD Input 1 Function	0 to 1	---	1	F102	0 (Disabled)
5401	RTD Input 1 ID	---	---	---	F205	“RTD Ip 1“
5407	RTD Input 1 Type	0 to 3	---	1	F174	0 (100 ohm Platinum)
5414	...Repeated for RTD Input 2					
5428	...Repeated for RTD Input 3					
543C	...Repeated for RTD Input 4					
5450	...Repeated for RTD Input 5					
5464	...Repeated for RTD Input 6					
5478	...Repeated for RTD Input 7					
548C	...Repeated for RTD Input 8					
54A0	...Repeated for RTD Input 9					
54B4	...Repeated for RTD Input 10					
54C8	...Repeated for RTD Input 11					
54DC	...Repeated for RTD Input 12					
54F0	...Repeated for RTD Input 13					
5404	...Repeated for RTD Input 14					
5518	...Repeated for RTD Input 15					
552C	...Repeated for RTD Input 16					
5540	...Repeated for RTD Input 17					

Table B–9: MODBUS MEMORY MAP (Sheet 26 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5554	...Repeated for RTD Input 18					
5568	...Repeated for RTD Input 19					
557C	...Repeated for RTD Input 20					
5590	...Repeated for RTD Input 21					
55A4	...Repeated for RTD Input 22					
55B8	...Repeated for RTD Input 23					
55CC	...Repeated for RTD Input 24					
55E0	...Repeated for RTD Input 25					
55F4	...Repeated for RTD Input 26					
5508	...Repeated for RTD Input 27					
561C	...Repeated for RTD Input 28					
5630	...Repeated for RTD Input 29					
5644	...Repeated for RTD Input 30					
5658	...Repeated for RTD Input 31					
566C	...Repeated for RTD Input 32					
5680	...Repeated for RTD Input 33					
5694	...Repeated for RTD Input 34					
56A8	...Repeated for RTD Input 35					
56BC	...Repeated for RTD Input 36					
56D0	...Repeated for RTD Input 37					
56E4	...Repeated for RTD Input 38					
56F8	...Repeated for RTD Input 39					
560C	...Repeated for RTD Input 40					
5620	...Repeated for RTD Input 41					
5734	...Repeated for RTD Input 42					
5748	...Repeated for RTD Input 43					
575C	...Repeated for RTD Input 44					
5770	...Repeated for RTD Input 45					
5784	...Repeated for RTD Input 46					
5798	...Repeated for RTD Input 47					
57AC	...Repeated for RTD Input 48					
Flexlogic Timers (Read/Write Setting) (32 modules)						
5800	FlexLogic Timer 1 Type	0 to 2	---	1	F129	0 (millisecond)
5801	FlexLogic Timer 1 Pickup Delay	0 to 60000	---	1	F001	0
5802	FlexLogic Timer 1 Dropout Delay	0 to 60000	---	1	F001	0
5803	Reserved (5 items)	0 to 65535	---	1	F001	0
5808	...Repeated for FlexLogic Timer 2					
5810	...Repeated for FlexLogic Timer 3					
5818	...Repeated for FlexLogic Timer 4					
5820	...Repeated for FlexLogic Timer 5					
5828	...Repeated for FlexLogic Timer 6					
5830	...Repeated for FlexLogic Timer 7					
5838	...Repeated for FlexLogic Timer 8					
5840	...Repeated for FlexLogic Timer 9					
5848	...Repeated for FlexLogic Timer 10					
5850	...Repeated for FlexLogic Timer 11					
5858	...Repeated for FlexLogic Timer 12					
5860	...Repeated for FlexLogic Timer 13					
5868	...Repeated for FlexLogic Timer 14					
5870	...Repeated for FlexLogic Timer 15					
5878	...Repeated for FlexLogic Timer 16					
5880	...Repeated for FlexLogic Timer 17					
5888	...Repeated for FlexLogic Timer 18					
5890	...Repeated for FlexLogic Timer 19					

Table B–9: MODBUS MEMORY MAP (Sheet 27 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5898	...Repeated for FlexLogic Timer 20					
58A0	...Repeated for FlexLogic Timer 21					
58A8	...Repeated for FlexLogic Timer 22					
58B0	...Repeated for FlexLogic Timer 23					
58B8	...Repeated for FlexLogic Timer 24					
58C0	...Repeated for FlexLogic Timer 25					
58C8	...Repeated for FlexLogic Timer 26					
58D0	...Repeated for FlexLogic Timer 27					
58D8	...Repeated for FlexLogic Timer 28					
58E0	...Repeated for FlexLogic Timer 29					
58E8	...Repeated for FlexLogic Timer 30					
58F0	...Repeated for FlexLogic Timer 31					
58F8	...Repeated for FlexLogic Timer 32					
Phase Time Overcurrent (Read/Write Grouped Setting) (6 modules)						
5900	Phase Time Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5901	Phase Time Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5902	Phase Time Overcurrent 1 Input	0 to 1	---	1	F122	0 (Phasor)
5903	Phase Time Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5904	Phase Time Overcurrent 1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
5905	Phase Time Overcurrent 1 Multiplier	0 to 600	---	0.01	F001	100
5906	Phase Time Overcurrent 1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
5907	Phase Time Overcurrent 1 Voltage Restraint	0 to 1	---	1	F102	0 (Disabled)
5908	Phase TOC 1 Block For Each Phase (3 items)	0 to 4294967295	---	1	F300	0
590F	Phase Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5910	Phase Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5911	Reserved (3 items)	0 to 1	---	1	F001	0
5914	...Repeated for Phase Time Overcurrent 2					
5928	...Repeated for Phase Time Overcurrent 3					
593C	...Repeated for Phase Time Overcurrent 4					
5950	...Repeated for Phase Time Overcurrent 5					
5964	...Repeated for Phase Time Overcurrent 6					
Phase Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)						
5A00	Phase Instantaneous Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5A01	Phase Instantaneous Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5A02	Phase Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5A03	Phase Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
5A04	Phase Instantaneous Overcurrent 1 Reset Delay	0 to 600	s	0.01	F001	0
5A05	Phase IOC1 Block For Each Phase (3 items)	0 to 4294967295	---	1	F300	0
5A0B	Phase Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5A0C	Phase Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5A0D	Reserved (6 items)	0 to 1	---	1	F001	0
5A13	...Repeated for Phase Instantaneous Overcurrent 2					
5A26	...Repeated for Phase Instantaneous Overcurrent 3					
5A39	...Repeated for Phase Instantaneous Overcurrent 4					
5A4C	...Repeated for Phase Instantaneous Overcurrent 5					
5A5F	...Repeated for Phase Instantaneous Overcurrent 6					
5A72	...Repeated for Phase Instantaneous Overcurrent 7					
5A85	...Repeated for Phase Instantaneous Overcurrent 8					
5A98	...Repeated for Phase Instantaneous Overcurrent 9					
5AAB	...Repeated for Phase Instantaneous Overcurrent 10					
5ABE	...Repeated for Phase Instantaneous Overcurrent 11					
5AD1	...Repeated for Phase Instantaneous Overcurrent 12					
Neutral Time Overcurrent (Read/Write Grouped Setting) (6 modules)						
5B00	Neutral Time Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)

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Table B–9: MODBUS MEMORY MAP (Sheet 28 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5B01	Neutral Time Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5B02	Neutral Time Overcurrent 1 Input	0 to 1	---	1	F122	0 (Phasor)
5B03	Neutral Time Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5B04	Neutral Time Overcurrent 1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
5B05	Neutral Time Overcurrent 1 Multiplier	0 to 600	---	0.01	F001	100
5B06	Neutral Time Overcurrent 1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
5B07	Neutral Time Overcurrent 1 Block	0 to 4294967295	---	1	F300	0
5B09	Neutral Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5B0A	Neutral Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5B0B	Reserved (6 items)	0 to 1	---	1	F001	0
5B11	...Repeated for Neutral Time Overcurrent 2					
5B22	...Repeated for Neutral Time Overcurrent 3					
5B33	...Repeated for Neutral Time Overcurrent 4					
5B44	...Repeated for Neutral Time Overcurrent 5					
5B55	...Repeated for Neutral Time Overcurrent 6					
Neutral Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)						
5C00	Neutral Instantaneous Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5C01	Neutral Instantaneous Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5C02	Neutral Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5C03	Neutral Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
5C04	Neutral Instantaneous Overcurrent 1 Reset Delay	0 to 600	s	0.01	F001	0
5C05	Neutral Instantaneous Overcurrent 1 Block	0 to 4294967295	---	1	F300	0
5C07	Neutral Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5C08	Neutral Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5C09	Reserved (8 items)	0 to 1	---	1	F001	0
5C11	...Repeated for Neutral Instantaneous Overcurrent 2					
5C22	...Repeated for Neutral Instantaneous Overcurrent 3					
5C33	...Repeated for Neutral Instantaneous Overcurrent 4					
5C44	...Repeated for Neutral Instantaneous Overcurrent 5					
5C55	...Repeated for Neutral Instantaneous Overcurrent 6					
5C66	...Repeated for Neutral Instantaneous Overcurrent 7					
5C77	...Repeated for Neutral Instantaneous Overcurrent 8					
5C88	...Repeated for Neutral Instantaneous Overcurrent 9					
5C99	...Repeated for Neutral Instantaneous Overcurrent 10					
5CAA	...Repeated for Neutral Instantaneous Overcurrent 11					
5CBB	...Repeated for Neutral Instantaneous Overcurrent 12					
Ground Time Overcurrent (Read/Write Grouped Setting) (6 modules)						
5D00	Ground Time Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5D01	Ground Time Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5D02	Ground Time Overcurrent 1 Input	0 to 1	---	1	F122	0 (Phasor)
5D03	Ground Time Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5D04	Ground Time Overcurrent 1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
5D05	Ground Time Overcurrent 1 Multiplier	0 to 600	---	0.01	F001	100
5D06	Ground Time Overcurrent 1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
5D07	Ground Time Overcurrent 1 Block	0 to 4294967295	---	1	F300	0
5D09	Ground Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5D0A	Ground Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5D0B	Reserved (6 items)	0 to 1	---	1	F001	0
5D11	...Repeated for Ground Time Overcurrent 2					
5D22	...Repeated for Ground Time Overcurrent 3					
5D33	...Repeated for Ground Time Overcurrent 4					
5D44	...Repeated for Ground Time Overcurrent 5					
5D55	...Repeated for Ground Time Overcurrent 6					

Table B–9: MODBUS MEMORY MAP (Sheet 29 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Ground Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)						
5DA0	Ground Instantaneous Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5DA1	Ground Instantaneous Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5DA2	Ground Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5DA3	Ground Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
5DA4	Ground Instantaneous Overcurrent 1 Reset Delay	0 to 600	s	0.01	F001	0
5DA5	Ground Instantaneous Overcurrent 1 Block	0 to 4294967295	---	1	F300	0
5DA7	Ground Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5DA8	Ground Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5DA9	Reserved (8 items)	0 to 1	---	1	F001	0
5DB1	...Repeated for Ground Instantaneous Overcurrent 2					
5DC2	...Repeated for Ground Instantaneous Overcurrent 3					
5DD3	...Repeated for Ground Instantaneous Overcurrent 4					
5DE4	...Repeated for Ground Instantaneous Overcurrent 5					
5DF5	...Repeated for Ground Instantaneous Overcurrent 6					
5E06	...Repeated for Ground Instantaneous Overcurrent 7					
5E17	...Repeated for Ground Instantaneous Overcurrent 8					
5E28	...Repeated for Ground Instantaneous Overcurrent 9					
5E39	...Repeated for Ground Instantaneous Overcurrent 10					
5E4A	...Repeated for Ground Instantaneous Overcurrent 11					
5E5B	...Repeated for Ground Instantaneous Overcurrent 12					
CT Fail (Read/Write Setting) (6 modules)						
5E6C	CT Fail 1 Function	0 to 1	---	1	F102	0 (Disabled)
5E6D	CT Fail 1 Block	0 to 4294967295	---	1	F300	0
5E6F	CT Fail 1 Current Source 1	0 to 5	---	1	F167	0 (SRC 1)
5E70	CT Fail 1 Current Pickup 1	0 to 2	pu	0.1	F001	2
5E71	CT Fail 1 Current Source 2	0 to 5	---	1	F167	1 (SRC 2)
5E72	CT Fail 1 Current Pickup 2	0 to 2	pu	0.1	F001	2
5E73	CT Fail 1 Voltage Source	0 to 5	---	1	F167	0 (SRC 1)
5E74	CT Fail 1 Voltage Pickup	0 to 2	pu	0.01	F001	20
5E75	CT Fail 1 Pickup Delay	0 to 65.535	s	0.001	F001	1000
5E76	CT Fail 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5E77	CT Fail 1 Events	0 to 1	---	1	F102	0 (Disabled)
5E78	...Repeated for CT Fail 2					
5E84	...Repeated for CT Fail 3					
5E90	...Repeated for CT Fail 4					
5E9C	...Repeated for CT Fail 5					
5EA8	...Repeated for CT Fail 6					
Stub Bus (Read/Write Grouped Setting)						
5F10	Stub Bus Function	0 to 1	---	1	F102	0 (Disabled)
5F11	Stub Bus Disconnect	0 to 4294967295	---	1	F300	0
5F13	Stub Bus Trigger	0 to 4294967295	---	1	F300	0
5F15	Stub Bus Target	0 to 2	---	1	F109	0 (Self-reset)
5F17	Stub Bus Events	0 to 1	---	1	F102	0 (Disabled)
50DD Disturbance Detection (Read/Write Grouped Setting)						
5F20	50DD Function	0 to 1	---	1	F102	0 (Disabled)
5F21	50DD Non Current Supervision	0 to 4294967295	---	1	F300	0
5F23	50DD Control Logic	0 to 4294967295	---	1	F300	0
5F25	50DD Logic Seal In	0 to 4294967295	---	1	F300	0
5F27	50DD Events	0 to 1	---	1	F102	0 (Disabled)
Setting Groups (Read/Write Setting)						
5F70	Setting Group for Modbus Comms (0 means group 1)	0 to 5	---	1	F001	0
5F71	Setting Groups Block	0 to 4294967295	---	1	F300	0
5F73	FlexLogic to Activate Groups 2 through 6 (5 items)	0 to 4294967295	---	1	F300	0

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Table B–9: MODBUS MEMORY MAP (Sheet 30 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5F7D	Setting Group Function	0 to 1	---	1	F102	0 (Disabled)
5F7E	Setting Group Events	0 to 1	---	1	F102	0 (Disabled)
Setting Groups (Read Only)						
5F7F	Current Setting Group	0 to 5	---	1	F001	0
Setting Group Names (Read/Write Setting)						
5F8C	Setting Group 1 Name	---	---	---	F203	(none)
5F94	Setting Group 2 Name	---	---	---	F203	(none)
5F9C	Setting Group 3 Name	---	---	---	F203	(none)
5FA4	Setting Group 4 Name	---	---	---	F203	(none)
5FAC	Setting Group 5 Name	---	---	---	F203	(none)
5FB4	Setting Group 6 Name	---	---	---	F203	(none)
Current Differential 87L (Read/Write Grouped Setting)						
6000	87L Current Differential Function	0 to 1	---	1	F102	0 (Disabled)
6001	87L Current Differential Block	0 to 4294967295	---	1	F300	0
6003	87L Current Differential Signal Source 1	0 to 5	---	1	F167	0 (SRC 1)
6004	87L Minimum Phase Current Sensitivity	0.1 to 4	pu	0.01	F001	20
6005	87L Current Differential Tap Setting	0.2 to 5	---	0.01	F001	100
6006	87L Current Differential Phase Percent Restraint 1	1 to 50	%	1	F001	30
6007	87L Current Differential Phase Percent Restraint 2	1 to 70	%	1	F001	50
6008	87L Current Differential Phase Dual Slope Breakpoint	0 to 20	pu	0.1	F001	10
6009	87L Current Differential Ground Function	0 to 1	---	1	F102	0 (Disabled)
600A	87L Current Differential Ground Pickup	0.05 to 1	pu	0.01	F001	10
600B	87L Current Differential Ground Restraint	1 to 50	%	1	F001	25
600C	87L Current Differential Ground Delay	0 to 5	seconds	0.01	F001	10
600D	87L Current Differential Key DTT	0 to 1	---	1	F102	1 (Enabled)
600E	87L Current Differential External Key DTT	0 to 4294967295	---	1	F300	0
6010	87L Current Differential Target	0 to 2	---	1	F109	0 (Self-reset)
6011	87L Current Differential Event	0 to 1	---	1	F102	0 (Disabled)
6012	87L Current Differential Tap 2 Setting	0.2 to 5	---	0.01	F001	100
Current Differential 87L In-Zone Transformer (Read/Write Grouped Setting)						
601E	87L Inrush Inhibit Mode	0 to 3	---	1	F561	0 (Disabled)
601F	87L Inrush Inhibit Level	1 to 40	$\%f_0$	0.1	F001	200
Autoreclose (Read/Write Setting) (6 modules)						
6200	Autoreclose 1 Function	0 to 1	---	1	F102	0 (Disabled)
6201	Autoreclose 1 Initiate	0 to 4294967295	---	1	F300	0
6203	Autoreclose 1 Block	0 to 4294967295	---	1	F300	0
6205	Autoreclose 1 Max Number of Shots	1 to 4	---	1	F001	1
6206	Autoreclose 1 Manual Close	0 to 4294967295	---	1	F300	0
6208	Autoreclose 1 Manual Reset from LO	0 to 4294967295	---	1	F300	0
620A	Autoreclose 1 Reset Lockout if Breaker Closed	0 to 1	---	1	F108	0 (Off)
620B	Autoreclose 1 Reset Lockout On Manual Close	0 to 1	---	1	F108	0 (Off)
620C	Autoreclose 1 Breaker Closed	0 to 4294967295	---	1	F300	0
620E	Autoreclose 1 Breaker Open	0 to 4294967295	---	1	F300	0
6210	Autoreclose 1 Block Time Upon Manual Close	0 to 655.35	s	0.01	F001	1000
6211	Autoreclose 1 Dead Time Shot 1	0 to 655.35	s	0.01	F001	100
6212	Autoreclose 1 Dead Time Shot 2	0 to 655.35	s	0.01	F001	200
6213	Autoreclose 1 Dead Time Shot 3	0 to 655.35	s	0.01	F001	300
6214	Autoreclose 1 Dead Time Shot 4	0 to 655.35	s	0.01	F001	400
6215	Autoreclose 1 Reset Lockout Delay	0 to 655.35	s	0.01	F001	6000
6216	Autoreclose 1 Reset Time	0 to 655.35	s	0.01	F001	6000
6217	Autoreclose 1 Incomplete Sequence Time	0 to 655.35	s	0.01	F001	500
6218	Autoreclose 1 Events	0 to 1	---	1	F102	0 (Disabled)
6219	Autoreclose 1 Reduce Max 1	0 to 4294967295	---	1	F300	0
621B	Autoreclose 1 Reduce Max 2	0 to 4294967295	---	1	F300	0

Table B–9: MODBUS MEMORY MAP (Sheet 31 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
621D	Autoreclose 1 Reduce Max 3	0 to 4294967295	---	1	F300	0
621F	Autoreclose 1 Add Delay 1	0 to 4294967295	---	1	F300	0
6221	Autoreclose 1 Delay 1	0 to 655.35	s	0.01	F001	0
6222	Autoreclose 1 Add Delay 2	0 to 4294967295	---	1	F300	0
6224	Autoreclose 1 Delay 2	0 to 655.35	s	0.01	F001	0
6225	Reserved (4 items)	0 to 0.001	---	0.001	F001	0
6229	...Repeated for Autoreclose 2					
6252	...Repeated for Autoreclose 3					
627B	...Repeated for Autoreclose 4					
62A4	...Repeated for Autoreclose 5					
62CD	...Repeated for Autoreclose 6					
Negative Sequence Time Overcurrent (Read/Write Grouped Setting) (2 modules)						
6300	Negative Sequence Time Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
6301	Negative Sequence Time Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
6302	Negative Sequence Time Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
6303	Negative Sequence Time Overcurrent 1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
6304	Negative Sequence Time Overcurrent 1 Multiplier	0 to 600	---	0.01	F001	100
6305	Negative Sequence Time Overcurrent 1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
6306	Negative Sequence Time Overcurrent 1 Block	0 to 4294967295	---	1	F300	0
6308	Negative Sequence Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
6309	Negative Sequence Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
630A	Reserved (7 items)	0 to 1	---	1	F001	0
6311	...Repeated for Negative Sequence Time Overcurrent 2					
Negative Sequence Instantaneous Overcurrent (Read/Write Grouped Setting) (2 modules)						
63C0	Negative Sequence Instantaneous OC 1 Function	0 to 1	---	1	F102	0 (Disabled)
63C1	Negative Sequence Instantaneous OC 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
63C2	Negative Sequence Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
63C3	Negative Sequence Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
63C4	Negative Sequence Instantaneous OC 1 Reset Delay	0 to 600	s	0.01	F001	0
63C5	Negative Sequence Instantaneous Overcurrent 1 Block	0 to 4294967295	---	1	F300	0
63C7	Negative Sequence Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
63C8	Negative Sequence Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
63C9	Reserved (8 items)	0 to 1	---	1	F001	0
63D1	...Repeated for Negative Sequence Instantaneous OC 2					
Negative Sequence Overvoltage (Read/Write Grouped Setting)						
6440	Negative Sequence Overvoltage Function	0 to 1	---	1	F102	0 (Disabled)
6441	Negative Sequence Overvoltage Source	0 to 5	---	1	F167	0 (SRC 1)
64A42	Negative Sequence Overvoltage Pickup	0 to 1.25	pu	0.001	F001	300
6443	Negative Sequence Overvoltage Pickup Delay	0 to 600	s	0.01	F001	50
6444	Negative Sequence Overvoltage Reset Delay	0 to 600	s	0.01	F001	50
6445	Negative Sequence Overvoltage Block	0 to 4294967295	---	1	F300	0
6447	Negative Sequence Overvoltage Target	0 to 2	---	1	F109	0 (Self-reset)
6448	Negative Sequence Overvoltage Events	0 to 1	---	1	F102	0 (Disabled)
6449	...Repeated for module number 2					
6452	...Repeated for module number 3					
Phase Undervoltage (Read/Write Grouped Setting) (2 modules)						
7000	Phase Undervoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7001	Phase Undervoltage 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7002	Phase Undervoltage 1 Pickup	0 to 3	pu	0.001	F001	1000
7003	Phase Undervoltage 1 Curve	0 to 1	---	1	F111	0 (Definite Time)
7004	Phase Undervoltage 1 Delay	0 to 600	s	0.01	F001	100
7005	Phase Undervoltage 1 Minimum Voltage	0 to 3	pu	0.001	F001	100
7006	Phase Undervoltage 1 Block	0 to 4294967295	---	1	F300	0
7008	Phase Undervoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)

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Table B–9: MODBUS MEMORY MAP (Sheet 32 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7009	Phase Undervoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
700A	Phase Undervoltage 1 Measurement Mode	0 to 1	---	1	F186	0 (Phase to Ground)
700A	Reserved (6 items)	0 to 1	---	1	F001	0
7013	...Repeated for Phase Undervoltage 2					
7015	...Repeated for Phase Undervoltage 2					
7017	...Repeated for Phase Undervoltage 2					
701B	...Repeated for Phase Undervoltage 2					
701C	...Repeated for Phase Undervoltage 2					
7022	...Repeated for Phase Undervoltage 3					
7025	...Repeated for Phase Undervoltage 3					
7027	...Repeated for Phase Undervoltage 3					
7028	...Repeated for Phase Undervoltage 3					
702A	...Repeated for Phase Undervoltage 3					
Phase Overvoltage (Read/Write Grouped Setting)						
7040	Phase Overvoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7041	Phase Overvoltage 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7042	Phase Overvoltage 1 Pickup	0 to 3	pu	0.001	F001	1000
7043	Phase Overvoltage 1 Delay	0 to 600	s	0.01	F001	100
7044	Phase Overvoltage 1 Reset Delay	0 to 600	s	0.01	F001	100
7045	Phase Overvoltage 1 Block	0 to 4294967295	---	1	F300	0
7047	Phase Overvoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7048	Phase Overvoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7049	Reserved (8 items)	0 to 1	---	1	F001	0
Phase Directional Overcurrent (Read/Write Grouped Setting) (2 modules)						
7200	Phase Directional Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
7201	Phase Directional Overcurrent 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7202	Phase Directional Overcurrent 1 Block	0 to 4294967295	---	1	F300	0
7204	Phase Directional Overcurrent 1 ECA	0 to 359	---	1	F001	30
7205	Phase Directional Overcurrent 1 Pol V Threshold	0 to 3	pu	0.001	F001	700
7206	Phase Directional Overcurrent 1 Block Overcurrent	0 to 1	---	1	F126	0 (No)
7207	Phase Directional Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7208	Phase Directional Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
7209	Reserved (8 items)	0 to 1	---	1	F001	0
7211	...Repeated for Phase Directional Overcurrent 2					
...	...Repeated for Phase Directional Overcurrent...					
Neutral Directional Overcurrent (Read/Write Grouped Setting) (2 modules)						
7230	Neutral Directional Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
7231	Neutral Directional Overcurrent 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7232	Neutral Directional Overcurrent 1 Polarizing	0 to 4	---	1	F230	0 (Voltage)
7233	Neutral Directional Overcurrent 1 Forward ECA	-90 to 90	° Lag	1	F002	75
7234	Neutral Directional Overcurrent 1 Forward Limit Angle	40 to 90	degrees	1	F001	90
7235	Neutral Directional Overcurrent 1 Forward Pickup	0.006 to 30	pu	0.001	F001	50
7236	Neutral Directional Overcurrent 1 Reverse Limit Angle	40 to 90	degrees	1	F001	90
7237	Neutral Directional Overcurrent 1 Reverse Pickup	0.002 to 30	pu	0.001	F001	50
7238	Neutral Directional Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7239	Neutral Directional Overcurrent 1 Block	0 to 65535	---	1	F300	0
723B	Neutral Directional Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
723C	Neutral Directional Overcurrent 1 Polarizing Voltage	0 to 1	---	1	F231	0 (Calculated V0)
723D	Neutral Directional Overcurrent 1 Op Current	0 to 1	---	1	F196	0 (Calculated 3I0)
723E	Neutral Directional Overcurrent 1 Offset	0 to 250	ohms	0.01	F001	0
723F	Neutral Directional Overcurrent 1 Pos Seq Restraint	0 to 0.5	---	0.001	F001	63
7240	Reserved	0 to 1	---	1	F001	0

Table B–9: MODBUS MEMORY MAP (Sheet 33 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7241	...Repeated for Neutral Directional Overcurrent 2					
Disconnect Switch (Read/Write setting) (24 modules)						
74A0	Disconnect switch 1 function	0 to 1	---	1	F102	0 (Disabled)
74A1	Disconnect switch 1 name	---	---	---	F206	“SW 1"
74A4	Disconnect switch 1 mode	0 to 1	---	1	F157	0 (3-Pole)
74A5	Disconnect switch 1 open	0 to 4294967295	---	1	F300	0
74A7	Disconnect switch 1 block open	0 to 4294967295	---	1	F300	0
74A9	Disconnect switch 1 close	0 to 4294967295	---	1	F300	0
74AB	Disconnect switch 1 block close	0 to 4294967295	---	1	F300	0
74AD	Disconnect switch 1 phase A / three-pole closed	0 to 4294967295	---	1	F300	0
74AF	Disconnect switch 1 phase A / three-pole opened	0 to 4294967295	---	1	F300	0
74B1	Disconnect switch 1 phase B closed	0 to 4294967295	---	1	F300	0
74B3	Disconnect switch 1 phase B opened	0 to 4294967295	---	1	F300	0
74B5	Disconnect switch 1 phase C closed	0 to 4294967295	---	1	F300	0
74B7	Disconnect switch 1 phase C opened	0 to 4294967295	---	1	F300	0
74B9	Disconnect switch 1 operate time	0 to 65.535	s	0.001	F001	70
74BA	Disconnect switch 1 alarm delay	0 to 65.535	s	0.001	F003	0
74BC	Disconnect switch 1 events	0 to 1	---	1	F102	0 (Disabled)
74BD	Reserved (2 items)	---	---	---	---	---
74BF	...Repeated for module number 2					
Thermal Overload Protection (Read/Write Settings) (2 modules)						
7788	Thermal Protection 1 Function	0 to 1	---	1	F102	0 (Disabled)
7789	Thermal Protection 1 Source	0 to 5	---	1	F167	0 (SRC 1)
778A	Thermal Protection 1 Base Current	0.2 to 3	pu	0.01	F001	80
778B	Thermal Protection 1 K Factor	1 to 1.2	---	0.05	F001	110
778C	Thermal Protection 1 Trip Time Constant	0 to 1000	min.	1	F001	45
778D	Thermal Protection 1 Reset Time Constant	0 to 1000	min.	1	F001	45
778E	Thermal Protection 1 Minimum Reset Time	0 to 1000	min.	1	F001	20
778F	Thermal Protection 1 Reset	0 to 4294967295	---	1	F300	0
7791	Thermal Protection 1 Block	0 to 4294967295	---	1	F300	0
7793	Thermal Protection 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7794	Thermal Protection 1 Events	0 to 1	---	1	F102	0 (Disabled)
7795	Reserved (2 items)	---	---	---	F001	0
7797	Repeated for Thermal Protection 2					
Broken conductor detection (Read/Write Settings) (6 modules)						
77AA	Broken Conductor 1 Function	0 to 1	---	1	F102	0 (Disabled)
77AB	Broken Conductor 1 Source	0 to 5	---	1	F167	0 (SRC 1)
77AC	Broken Conductor 1 I2/I1 Ratio	20 to 100	%	0.1	F001	200
77AD	Broken Conductor 1 I1 Minimum	0.05 to 1	pu	0.01	F001	10
77AE	Broken Conductor 1 I1 Maximum	0.05 to 5	pu	0.01	F001	150
77AF	Broken Conductor 1 Pickup Delay	0 to 65.535	s	0.001	F001	20000
77B0	Broken Conductor 1 Block	0 to 4294967295	---	1	F300	0
77B2	Broken Conductor 1 Target	0 to 2	---	1	F109	0 (Self-reset)
77B3	Broken Conductor 1 Events	0 to 1	---	1	F102	0 (Disabled)
77B4	Reserved (2 items)	---	---	---	F001	0
77B6	...Repeated for Broken Conductor 2					
Ohm Inputs (Read/Write Setting) (2 modules)						
77F8	Ohm Inputs 1 Function	0 to 1	---	1	F102	0 (Disabled)
77F9	Ohm Inputs 1 ID	---	---	---	F205	"Ohm Ip 1 "
77FF	Ohm Inputs 1 Reserved (9 items)	0 to 65535	---	1	F001	0
7808	...Repeated for Ohm Inputs 2					
Phasor Measurement Unit Recorder Config Counter Command (Read/Write Command) (4 modules)						
781A	PMU 1 Recorder Clear Config Counter	0 to 1	---	1	F126	0 (No)

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Table B–9: MODBUS MEMORY MAP (Sheet 34 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Phasor Measurement Unit Power Trigger (Read/Write Setting) (4 modules)						
7820	PMU 1 Power Trigger Function	0 to 1	---	1	F102	0 (Disabled)
7821	PMU 1 Power Trigger Active	0.25 to 3	pu	0.001	F001	1250
7822	PMU 1 Power Trigger Reactive	0.25 to 3	pu	0.001	F001	1250
7823	PMU 1 Power Trigger Apparent	0.25 to 3	pu	0.001	F001	1250
7824	PMU 1 Power Trigger Pickup Time	0 to 600	s	0.01	F001	10
7825	PMU 1 Power Trigger Dropout Time	0 to 600	s	0.01	F001	100
7826	PMU 1 Power Trigger Block (3 items)	0 to 4294967295	---	1	F300	0
782C	PMU 1 Power Trigger Target	0 to 2	---	1	F109	0 (Self-reset)
782D	PMU 1 Power Trigger Events	0 to 1	---	1	F102	0 (Disabled)
Phasor Measurement Unit Voltage Trigger (Read/Write Setting) (4 modules)						
7858	PMU 1 Voltage Trigger Function	0 to 1	---	1	F102	0 (Disabled)
7859	PMU 1 Voltage Trigger Low Voltage	0.25 to 1.25	pu	0.001	F001	800
785A	PMU 1 Voltage Trigger High Voltage	0.75 to 1.75	pu	0.001	F001	1200
785B	PMU 1 Voltage Trigger Pickup Time	0 to 600	s	0.01	F001	10
785C	PMU 1 Voltage Trigger Dropout Time	0 to 600	s	0.01	F001	100
785D	PMU 1 Voltage Trigger Block (3 items)	0 to 4294967295	---	1	F300	0
7863	PMU 1 Voltage Trigger Target	0 to 2	---	1	F109	0 (Self-reset)
7864	PMU 1 Voltage Trigger Events	0 to 1	---	1	F102	0 (Disabled)
Phasor Measurement Unit One-shot Command (Read/Write Setting)						
78BC	PMU One-shot Function	0 to 1	---	1	F102	0 (Disabled)
78BD	PMU One-shot Sequence Number	0 to 99	---	1	F001	1
788E	PMU One-shot Time	0 to 235959	---	1	F050	0
Phasor Measurement Unit Test Values (Read/Write Setting)						
7890	PMU 1 Test Function	0 to 1	---	1	F102	0 (Disabled)
7891	PMU 1 Phase A Voltage Test Magnitude	0 to 700	kV	0.01	F003	50000
7893	PMU 1 Phase A Voltage Test Angle	-180 to 180	°	0.05	F002	0
7894	PMU 1 Phase B Voltage Test Magnitude	0 to 700	kV	0.01	F003	50000
7896	PMU 1 Phase B Voltage Test Angle	-180 to 180	°	0.05	F002	-12000
7897	PMU 1 Phase C Voltage Test Magnitude	0 to 700	kV	0.01	F003	50000
7899	PMU 1 Phase C Voltage Test Angle	-180 to 180	°	0.05	F002	120
789A	PMU 1 Auxiliary Voltage Test Magnitude	0 to 700	kV	0.01	F003	50000
789C	PMU 1 Auxiliary Voltage Test Angle	-180 to 180	°	0.05	F002	0
789D	PMU 1 Phase A Current Test Magnitude	0 to 9.999	kA	0.001	F004	1000
789F	PMU 1 Phase A Current Test Angle	-180 to 180	°	0.05	F002	-1000
78A0	PMU 1 Phase B Current Test Magnitude	0 to 9.999	kA	0.001	F004	1000
78A2	PMU 1 Phase B Current Test Angle	-180 to 180	°	0.05	F002	-13000
78A3	PMU 1 Phase C Current Test Magnitude	0 to 9.999	kA	0.001	F003	1000
78A5	PMU 1 Phase C Current Test Angle	-180 to 180	°	0.05	F002	11000
78A6	PMU 1 Ground Current Test Magnitude	0 to 9.999	kA	0.001	F004	0
78A8	PMU 1 Ground Current Test Angle	-180 to 180	°	0.05	F002	0
78A9	PMU 1 Test Frequency	20 to 70	Hz	0.001	F003	60000
78AB	PMU 1 Test df/dt	-10 to 10	Hz/s	0.01	F002	0
Phasor Measurement Unit Recording Values (Read Only) (4 modules)						
7900	PMU 1 Available Records	0 to 65535	---	1	F001	0
7901	PMU 1 Second Per Record	0 to 6553.5	---	0.1	F001	0
7903	PMU 1 Last Cleared Date	0 to 400000000	---	1	F050	0
Phasor Measurement Unit Network Reporting Configuration (Read/Write Setting)						
7914	PMU Network Reporting Function	0 to 1	---	1	F102	0 (Disabled)
7915	PMU Network Reporting ID Code	1 to 65534	---	1	F001	1
7916	PMU TCP port number	1 to 65535	---	1	F001	4712
7917	PMU UDP port number 1	1 to 65535	---	1	F001	4713
7918	PMU UDP port number 2	1 to 65535	---	1	F001	4714

Table B–9: MODBUS MEMORY MAP (Sheet 35 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Phasor Measurement Unit Calibration (Read/Write Setting) (4 modules)						
7919	PMU Va Calibration Angle	-5 to 5	°	0.05	F002	0
791A	PMU Va Calibration Magnitude	95 to 105	%	0.1	F002	1000
791B	PMU Vb Calibration Angle	-5 to 5	°	0.05	F002	0
791C	PMU Vb Calibration Magnitude	95 to 105	%	0.1	F002	1000
791D	PMU Vc Calibration Angle	-5 to 5	°	0.05	F002	0
791E	PMU Vc Calibration Magnitude	95 to 105	%	0.1	F002	1000
791F	PMU Vx Calibration Angle	-5 to 5	°	0.05	F002	0
7920	PMU Vx Calibration Magnitude	95 to 105	%	0.1	F002	1000
7921	PMU Ia Calibration Angle	-5 to 5	°	0.05	F002	0
7922	PMU Ia Calibration Magnitude	95 to 105	%	0.1	F002	1000
7923	PMU Ib Calibration Angle	-5 to 5	°	0.05	F002	0
7924	PMU Ib Calibration Magnitude	95 to 105	%	0.1	F002	1000
7925	PMU Ic Calibration Angle	-5 to 5	°	0.05	F002	0
7926	PMU Ic Calibration Magnitude	95 to 105	%	0.1	F002	1000
7927	PMU Ig Calibration Angle	-5 to 5	°	0.05	F002	0
7928	PMU Ig Calibration Magnitude	95 to 105	%	0.1	F002	1000
7929	PMU Sequence Voltage Shift Angle	-180 to 180	°	30	F002	0
792A	PMU Sequence Current Shift Angle	-180 to 180	°	30	F002	0
Phasor Measurement Unit Triggering (Read/Write Setting) (4 modules)						
7970	PMU 1 User Trigger	0 to 4294967295	---	1	F300	0
Phasor Measurement Unit Current Trigger (Read/Write Setting) (4 modules)						
7980	PMU 1 Current Trigger Function	0 to 1	---	1	F102	0 (Disabled)
7981	PMU 1 Current Trigger Pickup	0.1 to 30	pu	0.001	F001	1800
7982	PMU 1 Current Trigger Pickup Time	0 to 600	s	0.01	F001	10
7983	PMU 1 Current Trigger Dropout Time	0 to 600	s	0.01	F001	100
7984	PMU 1 Current Trigger Block (3 items)	0 to 4294967295	---	1	F300	0
798A	PMU 1 Current Trigger Target	0 to 2	---	1	F109	0 (Self-reset)
798B	PMU 1 Current Trigger Events	0 to 1	---	1	F102	0 (Disabled)
Phasor Measurement Unit df/dt Trigger (Read/Write Setting)						
79B0	PMU 1 df/dt Trigger Function	0 to 1	---	1	F102	0 (Disabled)
79B1	PMU 1 df/dt Trigger Raise	0.1 to 15	Hz/s	0.01	F001	25
79B2	PMU 1 df/dt Trigger Fall	0.1 to 15	Hz/s	0.01	F001	25
79B3	PMU 1 df/dt Trigger Pickup Time	0 to 600	s	0.01	F001	10
79B4	PMU 1 df/dt Trigger Dropout Time	0 to 600	s	0.01	F001	100
79B5	PMU 1 df/dt Trigger Block (3 items)	0 to 4294967295	---	1	F300	0
79BB	PMU 1 df/dt Trigger Target	0 to 2	---	1	F109	0 (Self-reset)
79BC	PMU 1 df/dt Trigger Events	0 to 1	---	1	F102	0 (Disabled)
Underfrequency (Read/Write Setting) (6 modules)						
7A80	Underfreqency Function	0 to 1	---	1	F102	0 (Disabled)
7A81	Underfrequency Block	0 to 4294967295	---	1	F300	0
7A83	Min Current	0.1 to 1.25	pu	0.01	F001	10
7A84	Underfrequency Pickup	20 to 65	Hz	0.01	F001	5950
7A85	Pickup Delay	0 to 65.535	s	0.001	F001	2000
7A86	Reset Delay	0 to 65.535	s	0.001	F001	2000
7A87	Underfrequency Source	0 to 5	---	1	F167	0 (SRC 1)
7A88	Underfrequency Events	0 to 1	---	1	F102	0 (Disabled)
7A89	Underfrequency Target	0 to 2	---	1	F109	0 (Self-reset)
7A8A	Underfreqency 1 Reserved (5 items)	0 to 1	---	1	F001	0
7A8F	...Repeated for Underfrequency 2					
7A9E	...Repeated for Underfrequency 3					
7AAD	...Repeated for Underfrequency 4					
7ABC	...Repeated for Underfrequency 5					
7ACB	...Repeated for Underfrequency 6					

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Table B–9: MODBUS MEMORY MAP (Sheet 36 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
User Programmable Pushbuttons (Read/Write Setting) (16 modules)						
7B60	User Programmable Pushbutton 1 Function	0 to 2	---	1	F109	2 (Disabled)
7B61	User Programmable Pushbutton 1 Top Line	---	---	---	F202	(none)
7B6B	User Programmable Pushbutton 1 On Text	---	---	---	F202	(none)
7B75	User Programmable Pushbutton 1 Off Text	---	---	---	F202	(none)
7B7F	User Programmable Pushbutton 1 Drop-Out Time	0 to 60	s	0.05	F001	0
7B80	User Programmable Pushbutton 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7B81	User Programmable Pushbutton 1 Events	0 to 1	---	1	F102	0 (Disabled)
7B82	User Programmable Pushbutton 1 LED Operand	0 to 4294967295	---	1	F300	0
7B84	User Programmable Pushbutton 1 Autoreset Delay	0 to 600	s	0.05	F001	0
7B85	User Programmable Pushbutton 1 Autoreset Function	0 to 1	---	1	F102	0 (Disabled)
7B86	User Programmable Pushbutton 1 Local Lock	0 to 4294967295	---	1	F300	0
7B88	User Programmable Pushbutton 1 Message Priority	0 to 2	---	1	F220	0 (Disabled)
7B89	User Programmable Pushbutton 1 Remote Lock	0 to 4294967295	---	1	F300	0
7B8B	User Programmable Pushbutton 1 Reset	0 to 4294967295	---	1	F300	0
7B8D	User Programmable Pushbutton 1 Set	0 to 4294967295	---	1	F300	0
7B8F	User Programmable Pushbutton 1 Hold	0 to 10	s	0.1	F001	1
7B90	...Repeated for User Programmable Pushbutton 2					
7BC0	...Repeated for User Programmable Pushbutton 3					
7BF0	...Repeated for User Programmable Pushbutton 4					
7C20	...Repeated for User Programmable Pushbutton 5					
7C50	...Repeated for User Programmable Pushbutton 6					
7C80	...Repeated for User Programmable Pushbutton 7					
7CB0	...Repeated for User Programmable Pushbutton 8					
7DE0	...Repeated for User Programmable Pushbutton 9					
7D10	...Repeated for User Programmable Pushbutton 10					
7D40	...Repeated for User Programmable Pushbutton 11					
7D70	...Repeated for User Programmable Pushbutton 12					
7DA0	...Repeated for User Programmable Pushbutton 13					
7DD0	...Repeated for User Programmable Pushbutton 14					
7E00	...Repeated for User Programmable Pushbutton 15					
7E30	...Repeated for User Programmable Pushbutton 16					
Auxiliary Undervoltage (Read/Write Grouped Setting) (3 modules)						
7F60	Auxiliary Undervoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7F61	Auxiliary Undervoltage 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7F62	Auxiliary Undervoltage 1 Pickup	0 to 3	pu	0.001	F001	700
7F63	Auxiliary Undervoltage 1 Delay	0 to 600	s	0.01	F001	100
7F64	Auxiliary Undervoltage 1 Curve	0 to 1	---	1	F111	0 (Definite Time)
7F65	Auxiliary Undervoltage 1 Minimum Voltage	0 to 3	pu	0.001	F001	100
7F66	Auxiliary Undervoltage 1 Block	0 to 4294967295	---	1	F300	0
7F68	Auxiliary Undervoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7F69	Auxiliary Undervoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7F6A	Reserved (7 items)	0 to 65535	---	1	F001	0
7F71	...Repeated for Auxiliary Undervoltage 2					
7F82	...Repeated for Auxiliary Undervoltage 3					
Auxiliary Overvoltage (Read/Write Grouped Setting) (3 modules)						
7FA0	Auxiliary Overvoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7FA1	Auxiliary Overvoltage 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7FA2	Auxiliary Overvoltage 1 Pickup	0 to 3	pu	0.001	F001	300
7FA3	Auxiliary Overvoltage 1 Pickup Delay	0 to 600	s	0.01	F001	100
7FA4	Auxiliary Overvoltage 1 Reset Delay	0 to 600	s	0.01	F001	100
7FA5	Auxiliary Overvoltage 1 Block	0 to 4294967295	---	1	F300	0
7FA7	Auxiliary Overvoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7FA8	Auxiliary Overvoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)

Table B–9: MODBUS MEMORY MAP (Sheet 37 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7FA9	Reserved (8 items)	0 to 65535	---	1	F001	0
7FB1	...Repeated for Auxiliary Overvoltage 2					
7FC2	...Repeated for Auxiliary Overvoltage 3					
Frequency (Read Only)						
8000	Tracking Frequency	---	Hz	---	F001	0
Temp Monitor Actual Values (Read Only Non-Volatile)						
81C0	Reserved Register T1	-55 to 125	C	1	F002	-55
81C1	Reserved Register T2	-55 to 125	C	1	F002	125
81C2	Reserved Register T3	-2147483647 to 2147483647	---	1	F004	0
81C4	Reserved Register T4	0 to 4294967295	---	1	F003	0
81C6	Reserved Register T5	0 to 4294967295	---	1	F003	0
81C8	Reserved Register T6	0 to 4294967295	---	1	F003	0
81CA	Reserved Register T7	0 to 4294967295	---	1	F003	0
81CC	Reserved Register T8	0 to 4294967295	---	1	F003	0
Breaker Failure (Read/Write Grouped Setting) (4 or 6 modules)						
8600	Breaker Failure 1 Function	0 to 1	---	1	F102	0 (Disabled)
8601	Breaker Failure 1 Mode	0 to 1	---	1	F157	0 (3-Pole)
8602	Breaker Failure 1 Source	0 to 5	---	1	F167	0 (SRC 1)
8603	Breaker Failure 1 Amp Supervision	0 to 1	---	1	F126	1 (Yes)
8604	Breaker Failure 1 Use Seal-In	0 to 1	---	1	F126	1 (Yes)
8605	Breaker Failure 1 Three Pole Initiate	0 to 4294967295	---	1	F300	0
8607	Breaker Failure 1 Block	0 to 4294967295	---	1	F300	0
8609	Breaker Failure 1 Phase Amp Supv Pickup	0.001 to 30	pu	0.001	F001	1050
860A	Breaker Failure 1 Neutral Amp Supv Pickup	0.001 to 30	pu	0.001	F001	1050
860B	Breaker Failure 1 Use Timer 1	0 to 1	---	1	F126	1 (Yes)
860C	Breaker Failure 1 Timer 1 Pickup	0 to 65.535	s	0.001	F001	0
860D	Breaker Failure 1 Use Timer 2	0 to 1	---	1	F126	1 (Yes)
860E	Breaker Failure 1 Timer 2 Pickup	0 to 65.535	s	0.001	F001	0
860F	Breaker Failure 1 Use Timer 3	0 to 1	---	1	F126	1 (Yes)
8610	Breaker Failure 1 Timer 3 Pickup	0 to 65.535	s	0.001	F001	0
8611	Breaker Failure 1 Breaker Status 1 Phase A/3P	0 to 4294967295	---	1	F300	0
8613	Breaker Failure 1 Breaker Status 2 Phase A/3P	0 to 4294967295	---	1	F300	0
8615	Breaker Failure 1 Breaker Test On	0 to 4294967295	---	1	F300	0
8617	Breaker Failure 1 Phase Amp Hiset Pickup	0.001 to 30	pu	0.001	F001	1050
8618	Breaker Failure 1 Neutral Amp Hiset Pickup	0.001 to 30	pu	0.001	F001	1050
8619	Breaker Failure 1 Phase Amp Loset Pickup	0.001 to 30	pu	0.001	F001	1050
861A	Breaker Failure 1 Neutral Amp Loset Pickup	0.001 to 30	pu	0.001	F001	1050
861B	Breaker Failure 1 Loset Time	0 to 65.535	s	0.001	F001	0
861C	Breaker Failure 1 Trip Dropout Delay	0 to 65.535	s	0.001	F001	0
861D	Breaker Failure 1 Target	0 to 2	---	1	F109	0 (Self-reset)
861E	Breaker Failure 1 Events	0 to 1	---	1	F102	0 (Disabled)
861F	Breaker Failure 1 Phase A Initiate	0 to 4294967295	---	1	F300	0
8621	Breaker Failure 1 Phase B Initiate	0 to 4294967295	---	1	F300	0
8623	Breaker Failure 1 Phase C Initiate	0 to 4294967295	---	1	F300	0
8625	Breaker Failure 1 Breaker Status 1 Phase B	0 to 4294967295	---	1	F300	0
8627	Breaker Failure 1 Breaker Status 1 Phase C	0 to 4294967295	---	1	F300	0
8629	Breaker Failure 1 Breaker Status 2 Phase B	0 to 4294967295	---	1	F300	0
862B	Breaker Failure 1 Breaker Status 2 Phase C	0 to 4294967295	---	1	F300	0
862D	...Repeated for Breaker Failure 2					
865A	...Repeated for Breaker Failure 3					
8687	...Repeated for Breaker Failure 4					
86B4	...Repeated for Breaker Failure 5					
86E1	...Repeated for Breaker Failure 6					

Table B–9: MODBUS MEMORY MAP (Sheet 38 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
FlexState Settings (Read/Write Setting)						
8800	FlexState Parameters (256 items)	0 to 4294967295	---	---	F300	0
Digital Elements (Read/Write Setting) (48 modules)						
8A00	Digital Element 1 Function	0 to 1	---	1	F102	0 (Disabled)
8A01	Digital Element 1 Name	---	---	---	F203	“Dig Element 1“
8A09	Digital Element 1 Input	0 to 4294967295	---	1	F300	0
8A0B	Digital Element 1 Pickup Delay	0 to 999999.999	s	0.001	F003	0
8A0D	Digital Element 1 Reset Delay	0 to 999999.999	s	0.001	F003	0
8A0F	Digital Element 1 Block	0 to 4294967295	---	1	F300	0
8A11	Digital Element 1 Target	0 to 2	---	1	F109	0 (Self-reset)
8A12	Digital Element 1 Events	0 to 1	---	1	F102	0 (Disabled)
8A13	Digital Element 1 Pickup LED	0 to 1	---	1	F102	1 (Enabled)
8A14	Reserved (2 items)	---	---	---	F001	0
8A16	...Repeated for Digital Element 2					
8A2C	...Repeated for Digital Element 3					
8A42	...Repeated for Digital Element 4					
8A58	...Repeated for Digital Element 5					
8A6E	...Repeated for Digital Element 6					
8A84	...Repeated for Digital Element 7					
8A9A	...Repeated for Digital Element 8					
8AB0	...Repeated for Digital Element 9					
8AC6	...Repeated for Digital Element 10					
8ADC	...Repeated for Digital Element 11					
8AF2	...Repeated for Digital Element 12					
8B08	...Repeated for Digital Element 13					
8B1E	...Repeated for Digital Element 14					
8B34	...Repeated for Digital Element 15					
8B4A	...Repeated for Digital Element 16					
8B60	...Repeated for Digital Element 17					
8B76	...Repeated for Digital Element 18					
8B8C	...Repeated for Digital Element 19					
8BA2	...Repeated for Digital Element 20					
8BB8	...Repeated for Digital Element 21					
8BCE	...Repeated for Digital Element 22					
8BE4	...Repeated for Digital Element 23					
8BFA	...Repeated for Digital Element 24					
8C10	...Repeated for Digital Element 25					
8C26	...Repeated for Digital Element 26					
8C3C	...Repeated for Digital Element 27					
8C52	...Repeated for Digital Element 28					
8C68	...Repeated for Digital Element 29					
8C7E	...Repeated for Digital Element 30					
8C94	...Repeated for Digital Element 31					
8CAA	...Repeated for Digital Element 32					
8CC0	...Repeated for Digital Element 33					
8CD6	...Repeated for Digital Element 34					
8CEC	...Repeated for Digital Element 35					
8D02	...Repeated for Digital Element 36					
8D18	...Repeated for Digital Element 37					
8D2E	...Repeated for Digital Element 38					
8D44	...Repeated for Digital Element 39					
8D5A	...Repeated for Digital Element 40					
8D70	...Repeated for Digital Element 41					
8D86	...Repeated for Digital Element 42					

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Table B–9: MODBUS MEMORY MAP (Sheet 39 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
8D9C	...Repeated for Digital Element 43					
8DB2	...Repeated for Digital Element 44					
8DC8	...Repeated for Digital Element 45					
8DDE	...Repeated for Digital Element 46					
8DF4	...Repeated for Digital Element 47					
8E0A	...Repeated for Digital Element 48					
Trip Bus (Read/Write Setting) (6 modules)						
8E00	Trip Bus 1 Function	0 to 1	---	1	F102	0 (Disabled)
8ED1	Trip Bus 1 Block	0 to 4294967295	---	---	F300	0
8ED3	Trip Bus 1 Pickup Delay	0 to 600	s	0.01	F001	0
8ED4	Trip Bus 1 Reset Delay	0 to 600	s	0.01	F001	0
8ED5	Trip Bus 1 Input (16 items)	0 to 4294967295	---	1	F300	0
8EF5	Trip Bus 1 Latching	0 to 1	---	1	F102	0 (Disabled)
8EF6	Trip Bus 1 Reset	0 to 65535	---	1	F300	0
8EF8	Trip Bus 1 Target	0 to 2	---	1	F109	0 (Self-reset)
8EF9	Trip Bus 1 Events	0 to 1	---	1	F102	0 (Disabled)
8EFA	Reserved (8 items)	---	---	---	F001	0
8F02	...Repeated for Trip Bus 2					
8F34	...Repeated for Trip Bus 3					
8F66	...Repeated for Trip Bus 4					
8F98	...Repeated for Trip Bus 5					
8FCA	...Repeated for Trip Bus 6					
FlexElement (Read/Write Setting) (16 modules)						
9000	FlexElement 1 Function	0 to 1	---	1	F102	0 (Disabled)
9001	FlexElement 1 Name	---	---	---	F206	"FxE 1"
9004	FlexElement 1 InputP	0 to 65535	---	1	F600	0
9005	FlexElement 1 InputM	0 to 65535	---	1	F600	0
9006	FlexElement 1 Compare	0 to 1	---	1	F516	0 (LEVEL)
9007	FlexElement 1 Input	0 to 1	---	1	F515	0 (SIGNED)
9008	FlexElement 1 Direction	0 to 1	---	1	F517	0 (OVER)
9009	FlexElement 1 Hysteresis	0.1 to 50	%	0.1	F001	30
900A	FlexElement 1 Pickup	-90 to 90	pu	0.001	F004	1000
900C	FlexElement 1 DeltaT Units	0 to 2	---	1	F518	0 (Milliseconds)
900D	FlexElement 1 DeltaT	20 to 86400	---	1	F003	20
900F	FlexElement 1 Pickup Delay	0 to 65.535	s	0.001	F001	0
9010	FlexElement 1 Reset Delay	0 to 65.535	s	0.001	F001	0
9011	FlexElement 1 Block	0 to 65535	---	1	F300	0
9013	FlexElement 1 Target	0 to 2	---	1	F109	0 (Self-reset)
9014	FlexElement 1 Events	0 to 1	---	1	F102	0 (Disabled)
9015	...Repeated for FlexElement 2					
902A	...Repeated for FlexElement 3					
903F	...Repeated for FlexElement 4					
9054	...Repeated for FlexElement 5					
9069	...Repeated for FlexElement 6					
907E	...Repeated for FlexElement 7					
9093	...Repeated for FlexElement 8					
Fault Report Settings (Read/Write Setting) (up to 5 modules)						
9200	Fault Report 1 Source	0 to 5	---	1	F167	0 (SRC 1)
9201	Fault Report 1 Trigger	0 to 4294967295	---	1	F300	0
9203	Fault Report 1 Z1 Magnitude	0.01 to 250	ohms	0.01	F001	300
9204	Fault Report 1 Z1 Angle	25 to 90	degrees	1	F001	75
9205	Fault Report 1 Z0 Magnitude	0.01 to 650	ohms	0.01	F001	900
9206	Fault Report 1 Z0 Angle	25 to 90	degrees	1	F001	75
9207	Fault Report 1 Line Length Units	0 to 1	---	1	F147	0 (km)

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Table B–9: MODBUS MEMORY MAP (Sheet 40 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
9208	Fault Report 1 Line Length	0 to 2000		0.1	F001	1000
9209	Fault Report 1 VT Substitution	0 to 2	---	1	F270	0 (None)
920A	Fault Report 1 System Z0 Magnitude	0.01 to 650.00	ohms	0.01	F001	900
9208	Fault Report 1 System Z0 Angle	25 to 90	degrees	1	F001	75
920C	Fault REM1-TAP Z1 Magnitude	0.01 to 250	ohms	0.01	F001	300
920D	Fault REM1-TAP Z1 Angle	25 to 90	degrees	1	F001	75
920E	Fault REM1-TAP Length	0 to 2000	---	0.1	F001	1000
920F	Fault REM2-TAP Z1 Magnitude	0.01 to 250	ohms	0.01	F001	300
9210	Fault REM2-TAP Z1 Angle	25 to 90	degrees	1	F001	75
9511	Fault REM2-TAP Length	0 to 2000	---	0.1	F001	1000
9212	...Repeated for Fault Report 2					
9224	...Repeated for Fault Report 3					
9236	...Repeated for Fault Report 4					
9248	...Repeated for Fault Report 5					
dcmA Outputs (Read/Write Setting) (24 modules)						
9360	dcmA Output 1 Source	0 to 65535	---	1	F600	0
9361	dcmA Output 1 Range	0 to 2	---	1	F522	0 (–1 to 1 mA)
9362	dcmA Output 1 Minimum	–90 to 90	pu	0.001	F004	0
9364	dcmA Output 1 Maximum	–90 to 90	pu	0.001	F004	1000
9366	...Repeated for dcmA Output 2					
936C	...Repeated for dcmA Output 3					
9372	...Repeated for dcmA Output 4					
9378	...Repeated for dcmA Output 5					
937E	...Repeated for dcmA Output 6					
9384	...Repeated for dcmA Output 7					
938A	...Repeated for dcmA Output 8					
9390	...Repeated for dcmA Output 9					
9396	...Repeated for dcmA Output 10					
939C	...Repeated for dcmA Output 11					
93A2	...Repeated for dcmA Output 12					
93A8	...Repeated for dcmA Output 13					
93AE	...Repeated for dcmA Output 14					
93B4	...Repeated for dcmA Output 15					
93BA	...Repeated for dcmA Output 16					
93C0	...Repeated for dcmA Output 17					
93C6	...Repeated for dcmA Output 18					
93CC	...Repeated for dcmA Output 19					
93D2	...Repeated for dcmA Output 20					
93D8	...Repeated for dcmA Output 21					
93DE	...Repeated for dcmA Output 22					
93E4	...Repeated for dcmA Output 23					
93EA	...Repeated for dcmA Output 24					
IEC 61850 Received Integers (Read/Write Setting) (16 modules)						
98A0	IEC61850 GOOSE UInteger 1 default value	0 to 429496295	---	1	F003	1000
98A2	IEC61850 GOOSE UInteger input 1 mode	0 to 1	---	1	F491	0 (Default Value)
98A3	...Repeated for IEC61850 GOOSE UInteger 2					
98A6	...Repeated for IEC61850 GOOSE UInteger 3					
98A9	...Repeated for IEC61850 GOOSE UInteger 4					
98AC	...Repeated for IEC61850 GOOSE UInteger 5					
98AF	...Repeated for IEC61850 GOOSE UInteger 6					
98B2	...Repeated for IEC61850 GOOSE UInteger 7					
98B5	...Repeated for IEC61850 GOOSE UInteger 8					
98B8	...Repeated for IEC61850 GOOSE UInteger 9					

Table B–9: MODBUS MEMORY MAP (Sheet 41 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
98BB	...Repeated for IEC61850 GOOSE UInteger 10					
98BE	...Repeated for IEC61850 GOOSE UInteger 11					
98C1	...Repeated for IEC61850 GOOSE UInteger 12					
98C4	...Repeated for IEC61850 GOOSE UInteger 13					
98C7	...Repeated for IEC61850 GOOSE UInteger 14					
98CA	...Repeated for IEC61850 GOOSE UInteger 15					
98CD	...Repeated for IEC61850 GOOSE UInteger 16					
FlexElement Actuals (Read Only) (16 modules)						
9000	FlexElement 1 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9902	FlexElement 2 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9904	FlexElement 3 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9906	FlexElement 4 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9908	FlexElement 5 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
990A	FlexElement 6 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
990C	FlexElement 7 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
990E	FlexElement 8 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
VT Fuse Failure (Read/Write Setting) (6 modules)						
A09A	VT Fuse Failure Function	0 to 1	---	1	F102	0 (Disabled)
A09B	VT Fuse Failure Neutral Wire Open Function	0 to 1	---	1	F102	0 (Disabled)
A09C	VT Fuse Failure Neutral Wire Open 3rd Harmonic Pickup	0 to 3	pu	0.001	F001	100
A09D	...Repeated for module number 2					
A0A0	...Repeated for module number 3					
A0A3	...Repeated for module number 4					
A0A6	...Repeated for module number 5					
A0A9	...Repeated for module number 6					
A0AC	VTFF x V0 3rd harmonic	0 to 999999.999	V	0.001	F060	0
Selector switch actual values (read only)						
A210	Selector switch 1 position	1 to 7	---	1	F001	0
A211	Selector switch 2 position	1 to 7	---	1	F001	1
Selector switch settings (read/write, 2 modules)						
A280	Selector 1 Function	0 to 1	---	1	F102	0 (Disabled)
A281	Selector 1 Range	1 to 7	---	1	F001	7
A282	Selector 1 Timeout	3 to 60	s	0.1	F001	50
A283	Selector 1 Step Up	0 to 4294967295	---	1	F300	0
A285	Selector 1 Step Mode	0 to 1	---	1	F083	0 (Time-out)
A286	Selector 1 Acknowledge	0 to 4294967295	---	1	F300	0
A288	Selector 1 Bit0	0 to 4294967295	---	1	F300	0
A28A	Selector 1 Bit1	0 to 4294967295	---	1	F300	0
A28C	Selector 1 Bit2	0 to 4294967295	---	1	F300	0
A28E	Selector 1 Bit Mode	0 to 1	---	1	F083	0 (Time-out)
A28F	Selector 1 Bit Acknowledge	0 to 4294967295	---	1	F300	0
A291	Selector 1 Power Up Mode	0 to 2	---	1	F084	0 (Restore)
A292	Selector 1 Target	0 to 2	---	1	F109	0 (Self-reset)
A293	Selector 1 Events	0 to 1	---	1	F102	0 (Disabled)
A294	Reserved (10 items)	---	---	1	F001	0
A29E	...Repeated for Selector 2					
Digital Counter (Read/Write Setting) (8 modules)						
A300	Digital Counter 1 Function	0 to 1	---	1	F102	0 (Disabled)
A301	Digital Counter 1 Name	---	---	---	F205	“Counter 1"
A307	Digital Counter 1 Units	---	---	---	F206	(none)
A30A	Digital Counter 1 Block	0 to 4294967295	---	1	F300	0
A30C	Digital Counter 1 Up	0 to 4294967295	---	1	F300	0
A30E	Digital Counter 1 Down	0 to 4294967295	---	1	F300	0

Table B–9: MODBUS MEMORY MAP (Sheet 42 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
A311	Digital Counter 1 Preset	–2147483647 to 2147483647	---	1	F004	0
A313	Digital Counter 1 Compare	–2147483647 to 2147483647	---	1	F004	0
A315	Digital Counter 1 Reset	0 to 4294967295	---	1	F300	0
A317	Digital Counter 1 Freeze/Reset	0 to 4294967295	---	1	F300	0
A319	Digital Counter 1 Freeze/Count	0 to 4294967295	---	1	F300	0
A31B	Digital Counter 1 Set To Preset	0 to 4294967295	---	1	F300	0
A31D	Reserved (11 items)	---	---	---	F001	0
A328	...Repeated for Digital Counter 2					
A350	...Repeated for Digital Counter 3					
A378	...Repeated for Digital Counter 4					
A3A0	...Repeated for Digital Counter 5					
A3C8	...Repeated for Digital Counter 6					
A3F0	...Repeated for Digital Counter 7					
A418	...Repeated for Digital Counter 8					
Flexcurves C and D (Read/Write Setting)						
A600	FlexCurve C (120 items)	0 to 65535	ms	1	F011	0
A680	FlexCurve D (120 items)	0 to 65535	ms	1	F011	0
Non Volatile Latches (Read/Write Setting) (16 modules)						
A700	Non-Volatile Latch 1 Function	0 to 1	---	1	F102	0 (Disabled)
A701	Non-Volatile Latch 1 Type	0 to 1	---	1	F519	0 (Reset Dominant)
A702	Non-Volatile Latch 1 Set	0 to 4294967295	---	1	F300	0
A704	Non-Volatile Latch 1 Reset	0 to 4294967295	---	1	F300	0
A706	Non-Volatile Latch 1 Target	0 to 2	---	1	F109	0 (Self-reset)
A707	Non-Volatile Latch 1 Events	0 to 1	---	1	F102	0 (Disabled)
A708	Reserved (4 items)	---	---	---	F001	0
A70C	...Repeated for Non-Volatile Latch 2					
A718	...Repeated for Non-Volatile Latch 3					
A724	...Repeated for Non-Volatile Latch 4					
A730	...Repeated for Non-Volatile Latch 5					
A73C	...Repeated for Non-Volatile Latch 6					
A748	...Repeated for Non-Volatile Latch 7					
A754	...Repeated for Non-Volatile Latch 8					
A760	...Repeated for Non-Volatile Latch 9					
A76C	...Repeated for Non-Volatile Latch 10					
A778	...Repeated for Non-Volatile Latch 11					
A784	...Repeated for Non-Volatile Latch 12					
A790	...Repeated for Non-Volatile Latch 13					
A79C	...Repeated for Non-Volatile Latch 14					
A7A8	...Repeated for Non-Volatile Latch 15					
A7B4	...Repeated for Non-Volatile Latch 16					
IEC 61850 received analog settings (read/write) (32 modules)						
AA00	IEC 61850 GOOSE analog 1 default value	–1000000 to 1000000	---	0.001	F060	1000
AA02	IEC 61850 GOOSE analog input 1 mode	0 to 1	---	1	F491	0 (Default Value)
AA03	IEC 61850 GOOSE analog input 1 units	---	---	---	F207	(none)
AA05	IEC 61850 GOOSE analog input 1 per-unit base	0 to 999999999.999	---	0.001	F060	1
AA07	...Repeated for IEC 61850 GOOSE analog input 2					
AA0E	...Repeated for IEC 61850 GOOSE analog input 3					
AA15	...Repeated for IEC 61850 GOOSE analog input 4					
AA1C	...Repeated for IEC 61850 GOOSE analog input 5					
AA23	...Repeated for IEC 61850 GOOSE analog input 6					
AA2A	...Repeated for IEC 61850 GOOSE analog input 7					
AA31	...Repeated for IEC 61850 GOOSE analog input 8					

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Table B–9: MODBUS MEMORY MAP (Sheet 43 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
AA38	...Repeated for IEC 61850 GOOSE analog input 9					
AA3F	...Repeated for IEC 61850 GOOSE analog input 10					
AA46	...Repeated for IEC 61850 GOOSE analog input 11					
AA4D	...Repeated for IEC 61850 GOOSE analog input 12					
AA54	...Repeated for IEC 61850 GOOSE analog input 13					
AA5B	...Repeated for IEC 61850 GOOSE analog input 14					
AA62	...Repeated for IEC 61850 GOOSE analog input 15					
AA69	...Repeated for IEC 61850 GOOSE analog input 16					
AA70	...Repeated for IEC 61850 GOOSE analog input 17					
AA77	...Repeated for IEC 61850 GOOSE analog input 18					
AA7E	...Repeated for IEC 61850 GOOSE analog input 19					
AA85	...Repeated for IEC 61850 GOOSE analog input 20					
AA8C	...Repeated for IEC 61850 GOOSE analog input 21					
AA93	...Repeated for IEC 61850 GOOSE analog input 22					
AA9A	...Repeated for IEC 61850 GOOSE analog input 23					
AAA1	...Repeated for IEC 61850 GOOSE analog input 24					
AAA8	...Repeated for IEC 61850 GOOSE analog input 25					
AAAF	...Repeated for IEC 61850 GOOSE analog input 26					
AAB6	...Repeated for IEC 61850 GOOSE analog input 27					
AABD	...Repeated for IEC 61850 GOOSE analog input 28					
AAC4	...Repeated for IEC 61850 GOOSE analog input 29					
AACB	...Repeated for IEC 61850 GOOSE analog input 30					
AAD2	...Repeated for IEC 61850 GOOSE analog input 31					
AAD9	...Repeated for IEC 61850 GOOSE analog input 32					
IEC 61850 XCBR configuration (read/write settings) (6 modules)						
AB00	Operand for IEC 61850 XCBR1.ST.Loc status	0 to 4294967295	---	1	F300	0
AB02	Command to clear XCBR1 OpCnt (operation counter)	0 to 1	---	1	F126	0 (No)
AB03	Operand for IEC 61850 XCBR Check Sync Release	0 to 4294967295	---	1	F300	0
AB05	Operand for IEC 6185 XCBR Open Interlock	0 to 4294967295	---	1	F300	0
AB06	Operand for IEC 61850 XCBR3.ST.Loc status	0 to 4294967295	---	1	F300	0
AB07	Operand for IEC 61850 XCBR Close Interlock	0 to 4294967295	---	1	F300	0
AB09	Operand for IEC 61850 XCBR Pos ct1Model	0 to 4	---	1	F001	2
AB0A	Operand for IEC 61850 XCBR Pos sboTimeout	2 to 60	s	1	F001	30
AB0B	...Repeated for Module 2					
AB16	...Repeated for Module 3					
AB21	...Repeated for Module 4					
AB2C	...Repeated for Module 5					
AB37	...Repeated for Module 6					
IEC 61850 LN name prefixes (read/write settings)						
AB48	IEC 61850 logical node LPHD1 name prefix	0 to 65534	---	1	F206	(none)
AB4B	IEC 61850 logical node PIOCx name prefix (72 items)	0 to 65534	---	1	F206	(none)
AC23	IEC 61850 logical node PTOCx name prefix (24 items)	0 to 65534	---	1	F206	(none)
AC6B	IEC 61850 logical node PTUVx name prefix (13 items)	0 to 65534	---	1	F206	(none)
AC92	IEC 61850 logical node PTOVx name prefix (10 items)	0 to 65534	---	1	F206	(none)
ACB0	IEC 61850 logical node PDISx name prefix (10 items)	0 to 65534	---	1	F206	(none)
ACCE	IEC 61850 logical node RBRFx name prefix (24 items)	0 to 65534	---	1	F206	(none)
AD16	IEC 61850 logical node RPSBx name prefix	0 to 65534	---	1	F206	(none)
AD19	IEC 61850 logical node RRECx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AD2B	IEC 61850 logical node MMXUx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AD3D	IEC 61850 logical node GGIOx name prefix (5 items)	0 to 65534	---	1	F206	(none)
AD4C	IEC 61850 logical node RFLOx name prefix (5 items)	0 to 65534	---	1	F206	(none)
AD5B	IEC 61850 logical node XCBRx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AD6D	IEC 61850 logical node PTRCx name prefix (6 items)	0 to 65534	---	1	F206	(none)

Table B–9: MODBUS MEMORY MAP (Sheet 44 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
AD7F	IEC 61850 logical node PDIFx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AD8B	IEC 61850 logical node MMXNx name prefix (6 items)	0 to 65534	---	1	F206	(none)
ADFA	IEC 61850 logical node CSWIx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AE54	IEC 61850 logical node XSWIx name prefix (6 items)	0 to 65534	---	1	F206	(none)
IEC 61850 GGIO4 general analog configuration settings (read/write)						
AF00	Number of analog points in GGIO4	4 to 32	---	4	F001	4
AF01	GOOSE analog scan period	100 to 5000	---	10	F001	1000
IEC 61850 GGIO4 analog input points configuration settings (read/write)						
AF10	IEC 61850 GGIO4 analog input 1 value	---	---	---	F600	0
AF11	IEC 61850 GGIO4 analog input 1 deadband	0.001 to 100	%	0.001	F003	100000
AF13	IEC 61850 GGIO4 analog input 1 minimum	–1000000000000 to 1000000000000	---	0.001	F060	0
AF15	IEC 61850 GGIO4 analog input 1 maximum	–1000000000000 to 1000000000000	---	0.001	F060	1000000
AF17	...Repeated for IEC 61850 GGIO4 analog input 2					
AF1E	...Repeated for IEC 61850 GGIO4 analog input 3					
AF25	...Repeated for IEC 61850 GGIO4 analog input 4					
AF2C	...Repeated for IEC 61850 GGIO4 analog input 5					
AF33	...Repeated for IEC 61850 GGIO4 analog input 6					
AF3A	...Repeated for IEC 61850 GGIO4 analog input 7					
AF41	...Repeated for IEC 61850 GGIO4 analog input 8					
AF48	...Repeated for IEC 61850 GGIO4 analog input 9					
AF4F	...Repeated for IEC 61850 GGIO4 analog input 10					
AF56	...Repeated for IEC 61850 GGIO4 analog input 11					
AF5D	...Repeated for IEC 61850 GGIO4 analog input 12					
AF64	...Repeated for IEC 61850 GGIO4 analog input 13					
AF6B	...Repeated for IEC 61850 GGIO4 analog input 14					
AF72	...Repeated for IEC 61850 GGIO4 analog input 15					
AF79	...Repeated for IEC 61850 GGIO4 analog input 16					
AF80	...Repeated for IEC 61850 GGIO4 analog input 17					
AF87	...Repeated for IEC 61850 GGIO4 analog input 18					
AF8E	...Repeated for IEC 61850 GGIO4 analog input 19					
AF95	...Repeated for IEC 61850 GGIO4 analog input 20					
AF9C	...Repeated for IEC 61850 GGIO4 analog input 21					
AFA3	...Repeated for IEC 61850 GGIO4 analog input 22					
AFAA	...Repeated for IEC 61850 GGIO4 analog input 23					
AFB1	...Repeated for IEC 61850 GGIO4 analog input 24					
AFB8	...Repeated for IEC 61850 GGIO4 analog input 25					
AFBF	...Repeated for IEC 61850 GGIO4 analog input 26					
AFC6	...Repeated for IEC 61850 GGIO4 analog input 27					
AFCD	...Repeated for IEC 61850 GGIO4 analog input 28					
AFD4	...Repeated for IEC 61850 GGIO4 analog input 29					
AFDB	...Repeated for IEC 61850 GGIO4 analog input 30					
AFE2	...Repeated for IEC 61850 GGIO4 analog input 31					
AFE9	...Repeated for IEC 61850 GGIO4 analog input 32					
IEC 61850 GOOSE/GSSE Configuration (Read/Write Setting)						
B01C	Default GOOSE/GSSE Update Time	1 to 60	s	1	F001	60
B01D	IEC 61850 GSSE Function (GsEna)	0 to 1	---	1	F102	1 (Enabled)
B013	IEC 61850 GSSE ID	---	---	---	F209	“GSSEOut”
B03F	IEC 61850 GOOSE Function (GoEna)	0 to 1	---	1	F102	0 (Disabled)
B040	IEC 61850 GSSE Destination MAC Address	---	---	---	F072	0
B043	IEC 61850 Standard GOOSE ID	---	---	---	F209	“GOOSEOut”
B064	IEC 61850 Standard GOOSE Destination MAC Address	---	---	---	F072	0
B067	IEC 61850 GOOSE VLAN Transmit Priority	0 to 7	---	1	F001	4
B068	IEC 61850 GOOSE VLAN ID	0 to 4095	---	1	F001	0

Table B–9: MODBUS MEMORY MAP (Sheet 45 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
B069	IEC 61850 GOOSE ETYPE APPID	0 to 16383	---	1	F001	0
B06A	Reserved (2 items)	0 to 1	---	1	F001	0
IEC 61850 Server Configuration (Read/Write Settings/Commands)						
B06C	TCP Port Number for the IEC 61850 / MMS Protocol	0 to 65535	---	1	F001	102
B06D	IEC 61850 Logical Device Name	---	---	---	F213	“IECName”
B07D	IEC 61850 Logical Device Instance	---	---	---	F213	“LDInst”
B08D	IEC 61850 LPHD Location	---	---	---	F204	“Location”
B0B5	Include non-IEC 61850 Data	0 to 1	---	1	F102	0 (Disabled)
B0B6	IEC 61850 Server Data Scanning Function	0 to 1	---	1	F102	0 (Disabled)
B0B7	IEC 61850 LPHD Latitude	-90000 to 90000	degree	1	F004	0
B0B9	IEC 61850 LPHD DC PhyNam Longitude	-180000 to 180000	degree	1	F004	0
B9BB	IEC 61850 LPHD DC PhyNam Altitude	0 to 10000	m	1	F003	0
B0BD	Reserved (3 items)	0 to 1	---	1	F001	0
IEC 61850 MMXU Deadbands (Read/Write Setting) (6 modules)						
B0C0	IEC 61850 MMXU TotW Deadband 1	0.001 to 100	%	0.001	F003	10000
B0C2	IEC 61850 MMXU TotVAr Deadband 1	0.001 to 100	%	0.001	F003	10000
B0C4	IEC 61850 MMXU TotVA Deadband 1	0.001 to 100	%	0.001	F003	10000
B0C6	IEC 61850 MMXU TotPF Deadband 1	0.001 to 100	%	0.001	F003	10000
B0C8	IEC 61850 MMXU Hz Deadband 1	0.001 to 100	%	0.001	F003	10000
B0CA	IEC 61850 MMXU PPV.phsAB Deadband 1	0.001 to 100	%	0.001	F003	10000
B0CC	IEC 61850 MMXU PPV.phsBC Deadband 1	0.001 to 100	%	0.001	F003	10000
B0CE	IEC 61850 MMXU PPV.phsCA Deadband 1	0.001 to 100	%	0.001	F003	10000
B0D0	IEC 61850 MMXU PhV.phsADeadband 1	0.001 to 100	%	0.001	F003	10000
B0D2	IEC 61850 MMXU PhV.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B0D4	IEC 61850 MMXU PhV.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B0D6	IEC 61850 MMXU A.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B0D8	IEC 61850 MMXU A.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B0DA	IEC 61850 MMXU A.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B0DC	IEC 61850 MMXU A.neut Deadband 1	0.001 to 100	%	0.001	F003	10000
B0DE	IEC 61850 MMXU W.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B0E0	IEC 61850 MMXU W.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B0E2	IEC 61850 MMXU W.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B0E4	IEC 61850 MMXU VAr.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B0E6	IEC 61850 MMXU VAr.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B0E8	IEC 61850 MMXU VAr.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B0EA	IEC 61850 MMXU VA.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B0EC	IEC 61850 MMXU VA.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B0EE	IEC 61850 MMXU VA.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B0F0	IEC 61850 MMXU PF.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B0F2	IEC 61850 MMXU PF.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B0F4	IEC 61850 MMXU PF.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B0F6	...Repeated for Deadband 2					
B12C	...Repeated for Deadband 3					
B162	...Repeated for Deadband 4					
B198	...Repeated for Deadband 5					
B1CE	...Repeated for Deadband 6					
IEC 61850 Received Analogs (Read Only) (32 modules)						
B210	IEC 61850 Received Analog 1	-1000000000000 to 1000000000000	---	0.001	F060	0
B212	...Repeated for Received Analog 2					
B214	...Repeated for Received Analog 3					
B216	...Repeated for Received Analog 4					
B218	...Repeated for Received Analog 5					
B21A	...Repeated for Received Analog 6					

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Table B–9: MODBUS MEMORY MAP (Sheet 46 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
B21C	...Repeated for Received Analog 7					
B21E	...Repeated for Received Analog 8					
B220	...Repeated for Received Analog 9					
B222	...Repeated for Received Analog 10					
B224	...Repeated for Received Analog 11					
B226	...Repeated for Received Analog 12					
B228	...Repeated for Received Analog 13					
B22A	...Repeated for Received Analog 14					
B22C	...Repeated for Received Analog 15					
B22E	...Repeated for Received Analog 16					
B230	...Repeated for Received Analog 17					
B232	...Repeated for Received Analog 18					
B234	...Repeated for Received Analog 19					
B236	...Repeated for Received Analog 20					
B238	...Repeated for Received Analog 21					
B23A	...Repeated for Received Analog 22					
B23C	...Repeated for Received Analog 23					
B23E	...Repeated for Received Analog 24					
B240	...Repeated for Received Analog 25					
B242	...Repeated for Received Analog 26					
B244	...Repeated for Received Analog 27					
B246	...Repeated for Received Analog 28					
B248	...Repeated for Received Analog 29					
B24A	...Repeated for Received Analog 30					
B24C	...Repeated for Received Analog 31					
B24E	...Repeated for Received Analog 32					
IEC 61850 Configurable Report Settings (Read/Write Setting)						
B290	IEC 61850 configurable reports dataset items (64 items)	0 to 848	---	1	F615	0 (None)
IEC 61850 XSWI Configuration (Read/Write Setting) (24 modules)						
B370	Flexlogic Operand for IEC 61850 XSWI.ST.Loc Status	0 to 4294967295	---	1	F300	0
IEC 61850 XSWI Configuration (Read/Write Command) (24 modules)						
B372	Command to Clear XSWI OpCnt (Operation Counter)	0 to 1	---	1	F126	0 (No)
IEC 61850 GGIO1 Configuration Settings (Read/Write Setting)						
B400	Number of Status Indications in GGIO1	8 to 128	---	8	F001	8
B402	IEC 61850 GGIO1 Indication FlexLogic operands (128 items)	0 to 4294967295	---	1	F300	0
IEC 61850 Configurable GOOSE Transmission (Read/Write Setting) (8 modules)						
B5A0	IEC 61850 Configurable GOOSE Function	0 to 1	---	1	F102	0 (None)
B5A1	IEC 61850 Configurable GOOSE ID	---	---	---	F209	“GOOSEOut_x_”
B5C2	Configurable GOOSE Destination MAC Address	---	---	---	F072	0
B5C5	IEC 61850 Configurable GOOSE VLAN Transmit Priority	0 to 7	---	1	F001	4
B5C6	IEC 61850 Configurable GOOSE VLAN ID	0 to 4095	---	1	F001	0
B5C7	IEC 61850 Configurable GOOSE ETYPE APPID	0 to 16383	---	1	F001	0
B5C8	IEC 61850 Configurable GOOSE ConfRev	1 to 4294967295	---	1	F003	1
B5CA	IEC 61850 Configurable GOOSE Retransmission Curve	0 to 3	---	1	F611	3 (Relaxed)
B5CB	Configurable GOOSE dataset items for transmission (64 items)	0 to 542	---	1	F616	0 (None)
B60B	...Repeated for Module 2					
B676	...Repeated for Module 3					
B6E1	...Repeated for Module 4					
B74C	...Repeated for Module 5					
B7B7	...Repeated for Module 6					
B822	...Repeated for Module 7					
B88D	...Repeated for Module 8					

Table B–9: MODBUS MEMORY MAP (Sheet 47 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
IEC 61850 Configurable GOOSE Reception (Read/Write Setting) (16 modules)						
B900	Configurable GOOSE dataset items for reception (32 items)	0 to 197	---	1	F233	0 (None)
B920	...Repeated for Module 2					
B940	...Repeated for Module 3					
B960	...Repeated for Module 4					
B980	...Repeated for Module 5					
B9A0	...Repeated for Module 6					
B9C0	...Repeated for Module 7					
B9E0	...Repeated for Module 8					
BA00	...Repeated for Module 9					
BA20	...Repeated for Module 10					
BA40	...Repeated for Module 11					
BA60	...Repeated for Module 12					
BA80	...Repeated for Module 13					
BAA0	...Repeated for Module 14					
BAC0	...Repeated for Module 15					
BAE0	...Repeated for Module 16					
Contact Inputs (Read/Write Setting) (96 modules)						
BB00	Contact Input 1 Name	---	---	---	F205	"Cont Ip 1"
BB06	Contact Input 1 Events	0 to 1	---	1	F102	0 (Disabled)
BB07	Contact Input 1 Debounce Time	0 to 16	ms	0.5	F001	20
BB08	...Repeated for Contact Input 2					
BB10	...Repeated for Contact Input 3					
BB18	...Repeated for Contact Input 4					
BB20	...Repeated for Contact Input 5					
BB28	...Repeated for Contact Input 6					
BB30	...Repeated for Contact Input 7					
BB38	...Repeated for Contact Input 8					
BB40	...Repeated for Contact Input 9					
BB48	...Repeated for Contact Input 10					
BB50	...Repeated for Contact Input 11					
BB58	...Repeated for Contact Input 12					
BB60	...Repeated for Contact Input 13					
BB68	...Repeated for Contact Input 14					
BB70	...Repeated for Contact Input 15					
BB78	...Repeated for Contact Input 16					
BB80	...Repeated for Contact Input 17					
BB88	...Repeated for Contact Input 18					
BB90	...Repeated for Contact Input 19					
BB98	...Repeated for Contact Input 20					
BBA0	...Repeated for Contact Input 21					
BBA8	...Repeated for Contact Input 22					
BBB0	...Repeated for Contact Input 23					
BBB8	...Repeated for Contact Input 24					
BBC0	...Repeated for Contact Input 25					
BBC8	...Repeated for Contact Input 26					
BBD0	...Repeated for Contact Input 27					
BBD8	...Repeated for Contact Input 28					
BBE0	...Repeated for Contact Input 29					
BBE8	...Repeated for Contact Input 30					
BBF0	...Repeated for Contact Input 31					
BBF8	...Repeated for Contact Input 32					
BC00	...Repeated for Contact Input 33					

Table B–9: MODBUS MEMORY MAP (Sheet 48 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
BC08	...Repeated for Contact Input 34					
BC10	...Repeated for Contact Input 35					
BC18	...Repeated for Contact Input 36					
BC20	...Repeated for Contact Input 37					
BC28	...Repeated for Contact Input 38					
BC30	...Repeated for Contact Input 39					
BC38	...Repeated for Contact Input 40					
BC40	...Repeated for Contact Input 41					
BC48	...Repeated for Contact Input 42					
BC50	...Repeated for Contact Input 43					
BC58	...Repeated for Contact Input 44					
BC60	...Repeated for Contact Input 45					
BC68	...Repeated for Contact Input 46					
BC70	...Repeated for Contact Input 47					
BC78	...Repeated for Contact Input 48					
BC80	...Repeated for Contact Input 49					
BC88	...Repeated for Contact Input 50					
BC90	...Repeated for Contact Input 51					
BC98	...Repeated for Contact Input 52					
BCA0	...Repeated for Contact Input 53					
BCA8	...Repeated for Contact Input 54					
BCB0	...Repeated for Contact Input 55					
BCB8	...Repeated for Contact Input 56					
BCC0	...Repeated for Contact Input 57					
BCC8	...Repeated for Contact Input 58					
BCD0	...Repeated for Contact Input 59					
BCD8	...Repeated for Contact Input 60					
BCE0	...Repeated for Contact Input 61					
BCE8	...Repeated for Contact Input 62					
BCF0	...Repeated for Contact Input 63					
BCF8	...Repeated for Contact Input 64					
BD00	...Repeated for Contact Input 65					
BD08	...Repeated for Contact Input 66					
BD10	...Repeated for Contact Input 67					
BD18	...Repeated for Contact Input 68					
BD20	...Repeated for Contact Input 69					
BD28	...Repeated for Contact Input 70					
BD30	...Repeated for Contact Input 71					
BD38	...Repeated for Contact Input 72					
BD40	...Repeated for Contact Input 73					
BD48	...Repeated for Contact Input 74					
BD50	...Repeated for Contact Input 75					
BD58	...Repeated for Contact Input 76					
BD60	...Repeated for Contact Input 77					
BD68	...Repeated for Contact Input 78					
BD70	...Repeated for Contact Input 79					
BD78	...Repeated for Contact Input 80					
BD80	...Repeated for Contact Input 81					
BD88	...Repeated for Contact Input 82					
BD90	...Repeated for Contact Input 83					
BD98	...Repeated for Contact Input 84					
BDA0	...Repeated for Contact Input 85					
BDA8	...Repeated for Contact Input 86					
BDB0	...Repeated for Contact Input 87					

Table B–9: MODBUS MEMORY MAP (Sheet 49 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
BDB8	...Repeated for Contact Input 88					
BDC0	...Repeated for Contact Input 89					
BDC8	...Repeated for Contact Input 90					
BDD0	...Repeated for Contact Input 91					
BDD8	...Repeated for Contact Input 92					
BDE0	...Repeated for Contact Input 93					
BDE8	...Repeated for Contact Input 94					
BDF0	...Repeated for Contact Input 95					
BDF8	...Repeated for Contact Input 96					
Contact Input Thresholds (Read/Write Setting)						
BE00	Contact Input *n* Threshold, *n* = 1 to 48 (48 items)	0 to 3	---	1	F128	1 (33 Vdc)
Virtual Inputs (Read/Write Setting) (64 modules)						
BE30	Virtual Input 1 Function	0 to 1	---	1	F102	0 (Disabled)
BE31	Virtual Input 1 Name	---	---	---	F205	“Virt Ip 1“
BE37	Virtual Input 1 Programmed Type	0 to 1	---	1	F127	0 (Latched)
BE38	Virtual Input 1 Events	0 to 1	---	1	F102	0 (Disabled)
BE39	Reserved (3 items)	---	---	---	F001	0
BE3C	...Repeated for Virtual Input 2					
BE48	...Repeated for Virtual Input 3					
BE54	...Repeated for Virtual Input 4					
BE60	...Repeated for Virtual Input 5					
BE6C	...Repeated for Virtual Input 6					
BE78	...Repeated for Virtual Input 7					
BE84	...Repeated for Virtual Input 8					
BE90	...Repeated for Virtual Input 9					
BE9C	...Repeated for Virtual Input 10					
BEA8	...Repeated for Virtual Input 11					
BEB4	...Repeated for Virtual Input 12					
BEC0	...Repeated for Virtual Input 13					
BECC	...Repeated for Virtual Input 14					
BED8	...Repeated for Virtual Input 15					
BEE4	...Repeated for Virtual Input 16					
BEF0	...Repeated for Virtual Input 17					
BEFC	...Repeated for Virtual Input 18					
BF08	...Repeated for Virtual Input 19					
BF14	...Repeated for Virtual Input 20					
BF20	...Repeated for Virtual Input 21					
BF2C	...Repeated for Virtual Input 22					
BF38	...Repeated for Virtual Input 23					
BF44	...Repeated for Virtual Input 24					
BF50	...Repeated for Virtual Input 25					
BF5C	...Repeated for Virtual Input 26					
BF68	...Repeated for Virtual Input 27					
BF74	...Repeated for Virtual Input 28					
BF80	...Repeated for Virtual Input 29					
BF8C	...Repeated for Virtual Input 30					
BF98	...Repeated for Virtual Input 31					
BFA4	...Repeated for Virtual Input 32					
BFB0	...Repeated for Virtual Input 33					
BFBC	...Repeated for Virtual Input 34					
BFC8	...Repeated for Virtual Input 35					
BFD4	...Repeated for Virtual Input 36					
BFE0	...Repeated for Virtual Input 37					
BFEC	...Repeated for Virtual Input 38					

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Table B–9: MODBUS MEMORY MAP (Sheet 50 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
BFF8	...Repeated for Virtual Input 39					
C004	...Repeated for Virtual Input 40					
C010	...Repeated for Virtual Input 41					
C01C	...Repeated for Virtual Input 42					
C028	...Repeated for Virtual Input 43					
C034	...Repeated for Virtual Input 44					
C040	...Repeated for Virtual Input 45					
C04C	...Repeated for Virtual Input 46					
C058	...Repeated for Virtual Input 47					
C064	...Repeated for Virtual Input 48					
C070	...Repeated for Virtual Input 49					
C07C	...Repeated for Virtual Input 50					
C088	...Repeated for Virtual Input 51					
C094	...Repeated for Virtual Input 52					
C0A0	...Repeated for Virtual Input 53					
C0AC	...Repeated for Virtual Input 54					
C0B8	...Repeated for Virtual Input 55					
C0C4	...Repeated for Virtual Input 56					
C0D0	...Repeated for Virtual Input 57					
C0DC	...Repeated for Virtual Input 58					
C0E8	...Repeated for Virtual Input 59					
C0F4	...Repeated for Virtual Input 60					
C100	...Repeated for Virtual Input 61					
C10C	...Repeated for Virtual Input 62					
C118	...Repeated for Virtual Input 63					
C124	...Repeated for Virtual Input 64					
Virtual Outputs (Read/Write Setting) (96 modules)						
C130	Virtual Output 1 Name	---	---	---	F205	“Virt Op 1 “
C136	Virtual Output 1 Events	0 to 1	---	1	F102	0 (Disabled)
C137	Reserved	---	---	---	F001	0
C138	...Repeated for Virtual Output 2					
C140	...Repeated for Virtual Output 3					
C148	...Repeated for Virtual Output 4					
C150	...Repeated for Virtual Output 5					
C158	...Repeated for Virtual Output 6					
C160	...Repeated for Virtual Output 7					
C168	...Repeated for Virtual Output 8					
C170	...Repeated for Virtual Output 9					
C178	...Repeated for Virtual Output 10					
C180	...Repeated for Virtual Output 11					
C188	...Repeated for Virtual Output 12					
C190	...Repeated for Virtual Output 13					
C198	...Repeated for Virtual Output 14					
C1A0	...Repeated for Virtual Output 15					
C1A8	...Repeated for Virtual Output 16					
C1B0	...Repeated for Virtual Output 17					
C1B8	...Repeated for Virtual Output 18					
C1C0	...Repeated for Virtual Output 19					
C1C8	...Repeated for Virtual Output 20					
C1D0	...Repeated for Virtual Output 21					
C1D8	...Repeated for Virtual Output 22					
C1E0	...Repeated for Virtual Output 23					
C1E8	...Repeated for Virtual Output 24					
C1F0	...Repeated for Virtual Output 25					

Table B–9: MODBUS MEMORY MAP (Sheet 51 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C1F8	...Repeated for Virtual Output 26					
C200	...Repeated for Virtual Output 27					
C208	...Repeated for Virtual Output 28					
C210	...Repeated for Virtual Output 29					
C218	...Repeated for Virtual Output 30					
C220	...Repeated for Virtual Output 31					
C228	...Repeated for Virtual Output 32					
C230	...Repeated for Virtual Output 33					
C238	...Repeated for Virtual Output 34					
C240	...Repeated for Virtual Output 35					
C248	...Repeated for Virtual Output 36					
C250	...Repeated for Virtual Output 37					
C258	...Repeated for Virtual Output 38					
C260	...Repeated for Virtual Output 39					
C268	...Repeated for Virtual Output 40					
C270	...Repeated for Virtual Output 41					
C278	...Repeated for Virtual Output 42					
C280	...Repeated for Virtual Output 43					
C288	...Repeated for Virtual Output 44					
C290	...Repeated for Virtual Output 45					
C298	...Repeated for Virtual Output 46					
C2A0	...Repeated for Virtual Output 47					
C2A8	...Repeated for Virtual Output 48					
C2B0	...Repeated for Virtual Output 49					
C2B8	...Repeated for Virtual Output 50					
C2C0	...Repeated for Virtual Output 51					
C2C8	...Repeated for Virtual Output 52					
C2D0	...Repeated for Virtual Output 53					
C2D8	...Repeated for Virtual Output 54					
C2E0	...Repeated for Virtual Output 55					
C2E8	...Repeated for Virtual Output 56					
C2F0	...Repeated for Virtual Output 57					
C2F8	...Repeated for Virtual Output 58					
C300	...Repeated for Virtual Output 59					
C308	...Repeated for Virtual Output 60					
C310	...Repeated for Virtual Output 61					
C318	...Repeated for Virtual Output 62					
C320	...Repeated for Virtual Output 63					
C328	...Repeated for Virtual Output 64					
C330	...Repeated for Virtual Output 65					
C338	...Repeated for Virtual Output 66					
C340	...Repeated for Virtual Output 67					
C348	...Repeated for Virtual Output 68					
C350	...Repeated for Virtual Output 69					
C358	...Repeated for Virtual Output 70					
C360	...Repeated for Virtual Output 71					
C368	...Repeated for Virtual Output 72					
C370	...Repeated for Virtual Output 73					
C378	...Repeated for Virtual Output 74					
C380	...Repeated for Virtual Output 75					
C388	...Repeated for Virtual Output 76					
C390	...Repeated for Virtual Output 77					
C398	...Repeated for Virtual Output 78					
C3A0	...Repeated for Virtual Output 79					

Table B–9: MODBUS MEMORY MAP (Sheet 52 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C3A8	...Repeated for Virtual Output 80					
C3B0	...Repeated for Virtual Output 81					
C3B8	...Repeated for Virtual Output 82					
C3C0	...Repeated for Virtual Output 83					
C3C8	...Repeated for Virtual Output 84					
C3D0	...Repeated for Virtual Output 85					
C3D8	...Repeated for Virtual Output 86					
C3E0	...Repeated for Virtual Output 87					
C3E8	...Repeated for Virtual Output 88					
C3F0	...Repeated for Virtual Output 89					
C3F8	...Repeated for Virtual Output 90					
C400	...Repeated for Virtual Output 91					
C408	...Repeated for Virtual Output 92					
C410	...Repeated for Virtual Output 93					
C418	...Repeated for Virtual Output 94					
C420	...Repeated for Virtual Output 95					
C428	...Repeated for Virtual Output 96					
Mandatory (Read/Write Setting)						
C430	Test Mode Function	0 to 2	---	1	F245	0 (Disabled)
C431	Force VFD and LED	0 to 1	---	1	F126	0 (No)
C432	Test Mode Initiate	0 to 4294967295	---	1	F300	1
Clear commands (read/write)						
C434	Clear All Relay Records Command	0 to 1	---	1	F126	0 (No)
Mandatory (Read Only)						
C435	DSP Advanced Diagnostics Active	0 to 1	--	1	F126	0 (No)
C436	Synchrophasor Feature Active	0 to 1	--	1	F126	0 (No)
Mandatory (Read/Write Command)						
C434	Relay Reboot Command	0 to 1	---	1	F126	0 (No)
C438	Save Volatile Data	0 to 1	---	1	F126	0 (No)
Clear Records (Read/Write Setting)						
C450	Clear Fault Reports operand	0 to 4294967295	---	1	F300	0
C454	Clear Event Records operand	0 to 4294967295	---	1	F300	0
C456	Clear Oscillography operand	0 to 4294967295	---	1	F300	0
C458	Clear Data Logger operand	0 to 4294967295	---	1	F300	0
C45A	Clear Breaker 1 Arcing Current operand	0 to 4294967295	---	1	F300	0
C45C	Clear Breaker 2 Arcing Current operand	0 to 4294967295	---	1	F300	0
C45E	Clear Breaker 3 Arcing Current operand	0 to 4294967295	---	1	F300	0
C460	Clear Breaker 4 Arcing Current operand	0 to 4294967295	---	1	F300	0
C466	Clear Channel Status operand	0 to 4294967295	---	1	F300	0
C46C	Clear Unauthorized Access operand	0 to 4294967295	---	1	F300	0
C472	Reserved (13 items)	---	---	---	F001	0
Direct Input/Output Settings (Read/Write Setting)						
C500	Direct Input Default States (8 items)	0 to 1	---	1	F108	0 (Off)
C508	Direct Input Default States (8 items)	0 to 1	---	1	F108	0 (Off)
C510	Direct Output x 1 Operand (8 items)	0 to 4294967295	---	1	F300	0
C520	Direct Output x 2 Operand (8 items)	0 to 4294967295	---	1	F300	0
Reset (Read/Write Setting)						
C750	FlexLogic operand which initiates a reset	0 to 4294967295	---	1	F300	0
Control Pushbuttons (Read/Write Setting) (7 modules)						
C760	Control Pushbutton 1 Function	0 to 1	---	1	F102	0 (Disabled)
C761	Control Pushbutton 1 Events	0 to 1	---	1	F102	0 (Disabled)
C762	...Repeated for Control Pushbutton 2					
C764	...Repeated for Control Pushbutton 3					
C766	...Repeated for Control Pushbutton 4					

Table B–9: MODBUS MEMORY MAP (Sheet 53 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C768	...Repeated for Control Pushbutton 5					
C76A	...Repeated for Control Pushbutton 6					
C76C	...Repeated for Control Pushbutton 7					
Force Contact Inputs/Outputs (Read/Write Settings)						
C7A0	Force Contact Input *x* State (96 items)	0 to 2	---	1	F144	0 (Disabled)
C800	Force Contact Output *x* State (64 items)	0 to 3	---	1	F131	0 (Disabled)
87L Channel Tests (Read/Write)						
C840	Local Loopback Function	0 to 1	---	1	F126	0 (No)
C841	Local Loopback Channel	1 to 2	---	1	F001	1
C842	Remote Loopback Function	0 to 1	---	1	F126	0 (No)
C843	Remote Loopback Channel	1 to 2	---	1	F001	1
C844	Remote Diagnostics Transmit	0 to 2	---	1	F223	0 (NO TEST)
Remote Devices (Read/Write Setting) (32 modules)						
CB00	Remote Device 1 GSSE/GOOSE Application ID	---	---	---	F209	“Remote Device 1“
CB21	Remote Device 1 GOOSE Ethernet APPID	0 to 16383	---	1	F001	0
CB22	Remote Device 1 GOOSE Dataset	0 to 16	---	1	F184	0 (Fixed)
CB24	Undefined	0 to 3	---	1	F626	0 (None)
CB25	...Repeated for Device 2					
CB4A	...Repeated for Device 3					
CB6F	...Repeated for Device 4					
CB94	...Repeated for Device 5					
CBB9	...Repeated for Device 6					
CBDE	...Repeated for Device 7					
CC03	...Repeated for Device 8					
CC28	...Repeated for Device 9					
CC4D	...Repeated for Device 10					
CC72	...Repeated for Device 11					
CC97	...Repeated for Device 12					
CCBC	...Repeated for Device 13					
CCE1	...Repeated for Device 14					
CD06	...Repeated for Device 15					
CD2B	...Repeated for Device 16					
CD50	...Repeated for Device 17					
CD75	...Repeated for Device 18					
CD9A	...Repeated for Device 19					
CDBF	...Repeated for Device 20					
CDE4	...Repeated for Device 21					
CE09	...Repeated for Device 22					
CE2E	...Repeated for Device 23					
CE53	...Repeated for Device 24					
CE78	...Repeated for Device 25					
CE9D	...Repeated for Device 26					
CEC2	...Repeated for Device 27					
CEE7	...Repeated for Device 28					
CF0C	...Repeated for Device 29					
CF31	...Repeated for Device 30					
CF56	...Repeated for Device 31					
CF7B	...Repeated for Device 32					
Remote Inputs (Read/Write Setting) (64 modules)						
CFA0	Remote Input 1 Device	1 to 16	---	1	F001	1
CFA1	Remote Input 1 Item	0 to 64	---	1	F156	0 (None)
CFA2	Remote Input 1 Default State	0 to 3	---	1	F086	0 (Off)
CFA3	Remote Input 1 Events	0 to 1	---	1	F102	0 (Disabled)

Table B–9: MODBUS MEMORY MAP (Sheet 54 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
CFA4	Remote Input 1 Name	1 to 64	---	1	F205	“Rem Ip 1”
CFAA	...Repeated for Remote Input 2					
CFB4	...Repeated for Remote Input 3					
CFBE	...Repeated for Remote Input 4					
CFC8	...Repeated for Remote Input 5					
CFD2	...Repeated for Remote Input 6					
CFDC	...Repeated for Remote Input 7					
CFE6	...Repeated for Remote Input 8					
CFF0	...Repeated for Remote Input 9					
CFFA	...Repeated for Remote Input 10					
D004	...Repeated for Remote Input 11					
D00E	...Repeated for Remote Input 12					
D018	...Repeated for Remote Input 13					
D022	...Repeated for Remote Input 14					
D02C	...Repeated for Remote Input 15					
D036	...Repeated for Remote Input 16					
D040	...Repeated for Remote Input 17					
D04A	...Repeated for Remote Input 18					
D054	...Repeated for Remote Input 19					
D05E	...Repeated for Remote Input 20					
D068	...Repeated for Remote Input 21					
D072	...Repeated for Remote Input 22					
D07C	...Repeated for Remote Input 23					
D086	...Repeated for Remote Input 24					
D090	...Repeated for Remote Input 25					
D09A	...Repeated for Remote Input 26					
D0A4	...Repeated for Remote Input 27					
D0AE	...Repeated for Remote Input 28					
D0B8	...Repeated for Remote Input 29					
D0C2	...Repeated for Remote Input 30					
D0CC	...Repeated for Remote Input 31					
D0D6	...Repeated for Remote Input 32					
D0E0	...Repeated for Remote Input 33					
D0EA	...Repeated for Remote Input 34					
D0F4	...Repeated for Remote Input 35					
D0FE	...Repeated for Remote Input 36					
D108	...Repeated for Remote Input 37					
D112	...Repeated for Remote Input 38					
D11C	...Repeated for Remote Input 39					
D126	...Repeated for Remote Input 40					
D130	...Repeated for Remote Input 41					
D13A	...Repeated for Remote Input 42					
D144	...Repeated for Remote Input 43					
D14E	...Repeated for Remote Input 44					
D158	...Repeated for Remote Input 45					
D162	...Repeated for Remote Input 46					
D16C	...Repeated for Remote Input 47					
D176	...Repeated for Remote Input 48					
D180	...Repeated for Remote Input 49					
D18A	...Repeated for Remote Input 50					
D194	...Repeated for Remote Input 51					
D19E	...Repeated for Remote Input 52					
D1A8	...Repeated for Remote Input 53					
D1B2	...Repeated for Remote Input 54					

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Table B–9: MODBUS MEMORY MAP (Sheet 55 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
D1BC	...Repeated for Remote Input 55					
D1C6	...Repeated for Remote Input 56					
D1D0	...Repeated for Remote Input 57					
D1DA	...Repeated for Remote Input 58					
D1E4	...Repeated for Remote Input 59					
D1EE	...Repeated for Remote Input 60					
D1F8	...Repeated for Remote Input 61					
D202	...Repeated for Remote Input 62					
D20C	...Repeated for Remote Input 63					
D216	...Repeated for Remote Input 64					
Remote Output DNA Pairs (Read/Write Setting) (32 modules)						
D220	Remote Output DNA 1 Operand	0 to 4294967295	---	1	F300	0
D221	Remote Output DNA 1 Events	0 to 1	---	1	F102	0 (Disabled)
D222	Reserved (2 items)	0 to 1	---	1	F001	0
D224	...Repeated for Remote Output 2					
D228	...Repeated for Remote Output 3					
D22C	...Repeated for Remote Output 4					
D230	...Repeated for Remote Output 5					
D234	...Repeated for Remote Output 6					
D238	...Repeated for Remote Output 7					
D23C	...Repeated for Remote Output 8					
D240	...Repeated for Remote Output 9					
D244	...Repeated for Remote Output 10					
D248	...Repeated for Remote Output 11					
D24C	...Repeated for Remote Output 12					
D250	...Repeated for Remote Output 13					
D254	...Repeated for Remote Output 14					
D258	...Repeated for Remote Output 15					
D25C	...Repeated for Remote Output 16					
D260	...Repeated for Remote Output 17					
D264	...Repeated for Remote Output 18					
D268	...Repeated for Remote Output 19					
D26C	...Repeated for Remote Output 20					
D270	...Repeated for Remote Output 21					
D274	...Repeated for Remote Output 22					
D278	...Repeated for Remote Output 23					
D27C	...Repeated for Remote Output 24					
D280	...Repeated for Remote Output 25					
D284	...Repeated for Remote Output 26					
D288	...Repeated for Remote Output 27					
D28C	...Repeated for Remote Output 28					
D290	...Repeated for Remote Output 29					
D294	...Repeated for Remote Output 30					
D298	...Repeated for Remote Output 31					
D29C	...Repeated for Remote Output 32					
Remote Output UserSt Pairs (Read/Write Setting) (32 modules)						
D2A0	Remote Output UserSt 1 Operand	0 to 4294967295	---	1	F300	0
D2A1	Remote Output UserSt 1 Events	0 to 1	---	1	F102	0 (Disabled)
D2A2	Reserved (2 items)	0 to 1	---	1	F001	0
D2A4	...Repeated for Remote Output 2					
D2A8	...Repeated for Remote Output 3					
D2AC	...Repeated for Remote Output 4					
D2B0	...Repeated for Remote Output 5					
D2B4	...Repeated for Remote Output 6					

Table B–9: MODBUS MEMORY MAP (Sheet 56 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
D2B8	...Repeated for Remote Output 7					
D2BC	...Repeated for Remote Output 8					
D2C0	...Repeated for Remote Output 9					
D2C4	...Repeated for Remote Output 10					
D2C8	...Repeated for Remote Output 11					
D2CC	...Repeated for Remote Output 12					
D2D0	...Repeated for Remote Output 13					
D2D4	...Repeated for Remote Output 14					
D2D8	...Repeated for Remote Output 15					
D2DC	...Repeated for Remote Output 16					
D2E0	...Repeated for Remote Output 17					
D2E4	...Repeated for Remote Output 18					
D2E8	...Repeated for Remote Output 19					
D2EC	...Repeated for Remote Output 20					
D2F0	...Repeated for Remote Output 21					
D2F4	...Repeated for Remote Output 22					
D2F8	...Repeated for Remote Output 23					
D2FC	...Repeated for Remote Output 24					
D300	...Repeated for Remote Output 25					
D304	...Repeated for Remote Output 26					
D308	...Repeated for Remote Output 27					
D30C	...Repeated for Remote Output 28					
D310	...Repeated for Remote Output 29					
D314	...Repeated for Remote Output 30					
D318	...Repeated for Remote Output 31					
D31C	...Repeated for Remote Output 32					
IEC 61850 GGIO2 Control Configuration (Read/Write Setting) (64 modules)						
D320	IEC 61850 GGIO2.CF.SPCSO1.ctlModel Value	0 to 2	---	1	F001	2
D321	IEC 61850 GGIO2.CF.SPCSO2.ctlModel Value	0 to 2	---	1	F001	2
D322	IEC 61850 GGIO2.CF.SPCSO3.ctlModel Value	0 to 2	---	1	F001	2
D323	IEC 61850 GGIO2.CF.SPCSO4.ctlModel Value	0 to 2	---	1	F001	2
D324	IEC 61850 GGIO2.CF.SPCSO5.ctlModel Value	0 to 2	---	1	F001	2
D325	IEC 61850 GGIO2.CF.SPCSO6.ctlModel Value	0 to 2	---	1	F001	2
D326	IEC 61850 GGIO2.CF.SPCSO7.ctlModel Value	0 to 2	---	1	F001	2
D327	IEC 61850 GGIO2.CF.SPCSO8.ctlModel Value	0 to 2	---	1	F001	2
D328	IEC 61850 GGIO2.CF.SPCSO9.ctlModel Value	0 to 2	---	1	F001	2
D329	IEC 61850 GGIO2.CF.SPCSO10.ctlModel Value	0 to 2	---	1	F001	2
D32A	IEC 61850 GGIO2.CF.SPCSO11.ctlModel Value	0 to 2	---	1	F001	2
D32B	IEC 61850 GGIO2.CF.SPCSO12.ctlModel Value	0 to 2	---	1	F001	2
D32C	IEC 61850 GGIO2.CF.SPCSO13.ctlModel Value	0 to 2	---	1	F001	2
D32D	IEC 61850 GGIO2.CF.SPCSO14.ctlModel Value	0 to 2	---	1	F001	2
D32E	IEC 61850 GGIO2.CF.SPCSO15.ctlModel Value	0 to 2	---	1	F001	2
D32F	IEC 61850 GGIO2.CF.SPCSO16.ctlModel Value	0 to 2	---	1	F001	2
D330	IEC 61850 GGIO2.CF.SPCSO17.ctlModel Value	0 to 2	---	1	F001	2
D331	IEC 61850 GGIO2.CF.SPCSO18.ctlModel Value	0 to 2	---	1	F001	2
D332	IEC 61850 GGIO2.CF.SPCSO19.ctlModel Value	0 to 2	---	1	F001	2
D333	IEC 61850 GGIO2.CF.SPCSO20.ctlModel Value	0 to 2	---	1	F001	2
D334	IEC 61850 GGIO2.CF.SPCSO21.ctlModel Value	0 to 2	---	1	F001	2
D335	IEC 61850 GGIO2.CF.SPCSO22.ctlModel Value	0 to 2	---	1	F001	2
D336	IEC 61850 GGIO2.CF.SPCSO23.ctlModel Value	0 to 2	---	1	F001	2
D337	IEC 61850 GGIO2.CF.SPCSO24.ctlModel Value	0 to 2	---	1	F001	2
D338	IEC 61850 GGIO2.CF.SPCSO25.ctlModel Value	0 to 2	---	1	F001	2
D339	IEC 61850 GGIO2.CF.SPCSO26.ctlModel Value	0 to 2	---	1	F001	2
D33A	IEC 61850 GGIO2.CF.SPCSO27.ctlModel Value	0 to 2	---	1	F001	2

Table B–9: MODBUS MEMORY MAP (Sheet 57 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
D33B	IEC 61850 GGIO2.CF.SPCSO28.ctlModel Value	0 to 2	---	1	F001	2
D33C	IEC 61850 GGIO2.CF.SPCSO29.ctlModel Value	0 to 2	---	1	F001	2
D33D	IEC 61850 GGIO2.CF.SPCSO30.ctlModel Value	0 to 2	---	1	F001	2
D33E	IEC 61850 GGIO2.CF.SPCSO31.ctlModel Value	0 to 2	---	1	F001	2
D33F	IEC 61850 GGIO2.CF.SPCSO32.ctlModel Value	0 to 2	---	1	F001	2
D340	IEC 61850 GGIO2.CF.SPCSO33.ctlModel Value	0 to 2	---	1	F001	2
D341	IEC 61850 GGIO2.CF.SPCSO34.ctlModel Value	0 to 2	---	1	F001	2
D342	IEC 61850 GGIO2.CF.SPCSO35.ctlModel Value	0 to 2	---	1	F001	2
D343	IEC 61850 GGIO2.CF.SPCSO36.ctlModel Value	0 to 2	---	1	F001	2
D344	IEC 61850 GGIO2.CF.SPCSO37.ctlModel Value	0 to 2	---	1	F001	2
D345	IEC 61850 GGIO2.CF.SPCSO38.ctlModel Value	0 to 2	---	1	F001	2
D346	IEC 61850 GGIO2.CF.SPCSO39.ctlModel Value	0 to 2	---	1	F001	2
D347	IEC 61850 GGIO2.CF.SPCSO40.ctlModel Value	0 to 2	---	1	F001	2
D348	IEC 61850 GGIO2.CF.SPCSO41.ctlModel Value	0 to 2	---	1	F001	2
D349	IEC 61850 GGIO2.CF.SPCSO42.ctlModel Value	0 to 2	---	1	F001	2
D34A	IEC 61850 GGIO2.CF.SPCSO43.ctlModel Value	0 to 2	---	1	F001	2
D34B	IEC 61850 GGIO2.CF.SPCSO44.ctlModel Value	0 to 2	---	1	F001	2
D34C	IEC 61850 GGIO2.CF.SPCSO45.ctlModel Value	0 to 2	---	1	F001	2
D34D	IEC 61850 GGIO2.CF.SPCSO46.ctlModel Value	0 to 2	---	1	F001	2
D34E	IEC 61850 GGIO2.CF.SPCSO47.ctlModel Value	0 to 2	---	1	F001	2
D34F	IEC 61850 GGIO2.CF.SPCSO48.ctlModel Value	0 to 2	---	1	F001	2
D350	IEC 61850 GGIO2.CF.SPCSO49.ctlModel Value	0 to 2	---	1	F001	2
D351	IEC 61850 GGIO2.CF.SPCSO50.ctlModel Value	0 to 2	---	1	F001	2
D352	IEC 61850 GGIO2.CF.SPCSO51.ctlModel Value	0 to 2	---	1	F001	2
D353	IEC 61850 GGIO2.CF.SPCSO52.ctlModel Value	0 to 2	---	1	F001	2
D354	IEC 61850 GGIO2.CF.SPCSO53.ctlModel Value	0 to 2	---	1	F001	2
D355	IEC 61850 GGIO2.CF.SPCSO54.ctlModel Value	0 to 2	---	1	F001	2
D356	IEC 61850 GGIO2.CF.SPCSO55.ctlModel Value	0 to 2	---	1	F001	2
D357	IEC 61850 GGIO2.CF.SPCSO56.ctlModel Value	0 to 2	---	1	F001	2
D358	IEC 61850 GGIO2.CF.SPCSO57.ctlModel Value	0 to 2	---	1	F001	2
D359	IEC 61850 GGIO2.CF.SPCSO58.ctlModel Value	0 to 2	---	1	F001	2
D35A	IEC 61850 GGIO2.CF.SPCSO59.ctlModel Value	0 to 2	---	1	F001	2
D35B	IEC 61850 GGIO2.CF.SPCSO60.ctlModel Value	0 to 2	---	1	F001	2
D35C	IEC 61850 GGIO2.CF.SPCSO61.ctlModel Value	0 to 2	---	1	F001	2
D35D	IEC 61850 GGIO2.CF.SPCSO62.ctlModel Value	0 to 2	---	1	F001	2
D35E	IEC 61850 GGIO2.CF.SPCSO63.ctlModel Value	0 to 2	---	1	F001	2
D35F	IEC 61850 GGIO2.CF.SPCSO64.ctlModel Value	0 to 2	---	1	F001	2
Remote Device Status (Read Only) (32 modules)						
D380	Remote Device 1 StNum	0 to 4294967295	---	1	F003	0
D382	Remote Device 1 SqNum	0 to 4294967295	---	1	F003	0
D384	...Repeated for Remote Device 2					
D388	...Repeated for Remote Device 3					
D38C	...Repeated for Remote Device 4					
D390	...Repeated for Remote Device 5					
D394	...Repeated for Remote Device 6					
D398	...Repeated for Remote Device 7					
D39C	...Repeated for Remote Device 8					
D3A0	...Repeated for Remote Device 9					
D3A4	...Repeated for Remote Device 10					
D3A8	...Repeated for Remote Device 11					
D3AC	...Repeated for Remote Device 12					
D3B0	...Repeated for Remote Device 13					
D3B4	...Repeated for Remote Device 14					
D3B8	...Repeated for Remote Device 15					

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Table B–9: MODBUS MEMORY MAP (Sheet 58 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
D3BC	...Repeated for Remote Device 16					
D3C0	...Repeated for Remote Device 17					
D3C4	...Repeated for Remote Device 18					
D3C8	...Repeated for Remote Device 19					
D3CC	...Repeated for Remote Device 20					
D3D0	...Repeated for Remote Device 21					
D3D4	...Repeated for Remote Device 22					
D3D8	...Repeated for Remote Device 23					
D3DC	...Repeated for Remote Device 24					
D3E0	...Repeated for Remote Device 25					
D3E4	...Repeated for Remote Device 26					
D3E8	...Repeated for Remote Device 27					
D3EC	...Repeated for Remote Device 28					
D3F0	...Repeated for Remote Device 29					
D3F4	...Repeated for Remote Device 30					
D3F8	...Repeated for Remote Device 31					
D3FC	...Repeated for Remote Device 32					
Phasor Measurement Unit Basic Configuration (Read/Write Setting) (4 modules)						
D400	PMU x Function	0 to 1	---	1	F102	0 (Disabled)
D401	PMU x LDInst	---	---	1	F214	"PMUx \040"
D422	PMU x IDcode	1 to 65534	---	1	F001	1
D423	PMU x STN	---	---	---	F203	"GE-UR-PMU"
D42B	PMU x Source	0 to 5	---	1	F167	0 (SRC 1)
D42C	PMU x Class	0 to 2	---	1	F549	1 (Class M)
D42D	PMU x Format	0 to 1	---	1	F547	0 (Integer)
D42E	PMU x Style	0 to 1	---	1	F546	0 (Polar)
D42F	PMU x Rate	0 to 13	---	1	F544	4 (10/sec)
D430	PMU x PHS-x (14 items)	0 to 14	---	1	F543	1 (Va)
D43E	PMU x PHS-x Name (14 items)	---	---	---	F203	"GE-UR-PMU-PHS 1 "
D4AE	PMU x A-CH-x (16 items)	0 to 65535	---	1	F600	0
D4BE	PMU x A-CH-x (16 items)	---	---	---	F203	"AnalogChannel 1 "
D53E	PMU x D-CH-x (16 items)	0 to 4294967295	---	1	F300	0
D55E	PMU x D-CH-x Name (16 items)	---	---	---	F203	"Dig Channel 1 "
D5DE	PMU x D-CH-x Normal State (16 items)	0 to 1	---	1	F108	0 (Off)
D5EE	PMU x Reserved (16 items)	0 to 1	---	1	F001	0
Contact Outputs (Read/Write Setting) (64 modules)						
DC90	Contact Output 1 Name	---	---	---	F205	“Cont Op 1"
DC96	Contact Output 1 Operation	0 to 4294967295	---	1	F300	0
DC98	Contact Output 1 Seal In	0 to 4294967295	---	1	F300	0
DC9A	Latching Output 1 Reset	0 to 4294967295	---	1	F300	0
DC9C	Contact Output 1 Events	0 to 1	---	1	F102	1 (Enabled)
DC9D	Latching Output 1 Type	0 to 1	---	1	F090	0 (Operate-dominant)
DC9E	Reserved	---	---	---	F001	0
DC9F	...Repeated for Contact Output 2					
DCAE	...Repeated for Contact Output 3					
DCBD	...Repeated for Contact Output 4					
DCCC	...Repeated for Contact Output 5					
DCDB	...Repeated for Contact Output 6					
DCEA	...Repeated for Contact Output 7					
DCF9	...Repeated for Contact Output 8					
DD08	...Repeated for Contact Output 9					
DD17	...Repeated for Contact Output 10					

Table B–9: MODBUS MEMORY MAP (Sheet 59 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
DD26	...Repeated for Contact Output 11					
DD35	...Repeated for Contact Output 12					
DD44	...Repeated for Contact Output 13					
DD53	...Repeated for Contact Output 14					
DD62	...Repeated for Contact Output 15					
DD71	...Repeated for Contact Output 16					
DD80	...Repeated for Contact Output 17					
DD8F	...Repeated for Contact Output 18					
DD9E	...Repeated for Contact Output 19					
DDAD	...Repeated for Contact Output 20					
DDBC	...Repeated for Contact Output 21					
DDCB	...Repeated for Contact Output 22					
DDDA	...Repeated for Contact Output 23					
DDE9	...Repeated for Contact Output 24					
DDF8	...Repeated for Contact Output 25					
DE07	...Repeated for Contact Output 26					
DE16	...Repeated for Contact Output 27					
DE25	...Repeated for Contact Output 28					
DE34	...Repeated for Contact Output 29					
DE43	...Repeated for Contact Output 30					
DE52	...Repeated for Contact Output 31					
DE61	...Repeated for Contact Output 32					
DE70	...Repeated for Contact Output 33					
DE7F	...Repeated for Contact Output 34					
DE8E	...Repeated for Contact Output 35					
DE9D	...Repeated for Contact Output 36					
DEAC	...Repeated for Contact Output 37					
DEBB	...Repeated for Contact Output 38					
DECA	...Repeated for Contact Output 39					
DED9	...Repeated for Contact Output 40					
DEE8	...Repeated for Contact Output 41					
DEF7	...Repeated for Contact Output 42					
DF06	...Repeated for Contact Output 43					
DF15	...Repeated for Contact Output 44					
DF24	...Repeated for Contact Output 45					
DF33	...Repeated for Contact Output 46					
DF42	...Repeated for Contact Output 47					
DF51	...Repeated for Contact Output 48					
DF60	...Repeated for Contact Output 49					
DF6F	...Repeated for Contact Output 50					
DF7E	...Repeated for Contact Output 51					
DF8D	...Repeated for Contact Output 52					
DF9C	...Repeated for Contact Output 53					
DFAB	...Repeated for Contact Output 54					
DFBA	...Repeated for Contact Output 55					
DFC9	...Repeated for Contact Output 56					
DFD8	...Repeated for Contact Output 57					
DFE7	...Repeated for Contact Output 58					
DFF6	...Repeated for Contact Output 59					
E005	...Repeated for Contact Output 60					
E014	...Repeated for Contact Output 61					
E023	...Repeated for Contact Output 62					
E032	...Repeated for Contact Output 63					
E041	...Repeated for Contact Output 64					

Table B–9: MODBUS MEMORY MAP (Sheet 60 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
dcmA Inputs (Read/Write Setting) (24 modules)						
E050	dcmA Inputs 1 Function	0 to 1	---	1	F102	0 (Disabled)
E051	dcmA Inputs 1 ID	---	---	---	F205	“DCMA I 1"
E057	Reserved 1 (4 items)	0 to 65535	---	1	F001	0
E05B	dcmA Inputs 1 Units	---	---	---	F206	“mA”
E05E	dcmA Inputs 1 Range	0 to 6	---	1	F173	6 (4 to 20 mA)
E05F	dcmA Inputs 1 Minimum Value	-9999.999 to 9999.999	---	0.001	F004	4000
E061	dcmA Inputs 1 Maximum Value	-9999.999 to 9999.999	---	0.001	F004	20000
E063	...Repeated for dcmA Inputs 2					
E076	...Repeated for dcmA Inputs 3					
E089	...Repeated for dcmA Inputs 4					
E09C	...Repeated for dcmA Inputs 5					
E0AF	...Repeated for dcmA Inputs 6					
E0C2	...Repeated for dcmA Inputs 7					
E0D5	...Repeated for dcmA Inputs 8					
E0E8	...Repeated for dcmA Inputs 9					
E0FB	...Repeated for dcmA Inputs 10					
E10E	...Repeated for dcmA Inputs 11					
E121	...Repeated for dcmA Inputs 12					
E134	...Repeated for dcmA Inputs 13					
E147	...Repeated for dcmA Inputs 14					
E15A	...Repeated for dcmA Inputs 15					
E16D	...Repeated for dcmA Inputs 16					
E180	...Repeated for dcmA Inputs 17					
E193	...Repeated for dcmA Inputs 18					
E1A6	...Repeated for dcmA Inputs 19					
E1B9	...Repeated for dcmA Inputs 20					
E1CC	...Repeated for dcmA Inputs 21					
E1DF	...Repeated for dcmA Inputs 22					
E1F2	...Repeated for dcmA Inputs 23					
E205	...Repeated for dcmA Inputs 24					
Phasor Measurement Unit Aggregator (Read/Write Setting) (4 modules)						
E220	PMU Aggregator 1 Name	---	---	1	F209	"MSVID 1 "
E241	Aggregator 1 IDcode	1 to 65534	---	1	F001	1
E242	Aggregator 1 Protocol	0 to 2	---	1	F001	0 (NONE)
E243	Aggregator 1 TCP Port	0 to 65534	---	1	F001	4712
E244	Aggregator 1 UDP Port	0 to 65534	---	1	F001	4713
E245	PMU Aggregator 1 90-5 UDP Port	0 to 65534	---	1	F001	102
E246	PMU Aggregator 1 PDC Network Control	0 to 1	---	1	F102	0 (Disabled)
E247	Aggregator 1 Include PMU1	0 to 1	---	1	F126	0 (No)
E248	Aggregator 1 Include PMU2	0 to 1	---	1	F126	0 (No)
E249	Aggregator 1 Include PMU3	0 to 1	---	1	F126	0 (No)
E24A	Aggregator 1 Include PMU4	0 to 1	---	1	F126	0 (No)
E24B	PMU Aggregator 1 ASDUS	1 to 4	---	1	F001	1
E24C	PMU Aggregator 1 Port	1 to 3	---	1	F001	1
E24D	PMU Aggregator 1 Reserved (3 items)	1 to 3	---	1	F001	0
E250	...Repeated for PMU Aggregator 2					
E280	...Repeated for PMU Aggregator 3					
E2B0	...Repeated for PMU Aggregator 4					
Phasor Measurement Unit Recording Command (Read/Write Command)						
E4D4	PMU 1 Recording Clear Command	0 to 1	---	1	F126	0 (No)
E4D5	PMU 1 Recording Force Trigger	0 to 1	---	1	F126	0 (No)
Phasor Measurement Unit Recording (Read/Write Setting)						
E4DC	PMU 1 Record Function	0 to 1	---	1	F102	0 (Disabled)

Table B–9: MODBUS MEMORY MAP (Sheet 61 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
E4DD	PMU 1 No Of Timed Records	2 to 128	---	1	F001	3
E4DE	PMU 1 Trigger Mode	0 to 1	---	1	F542	0 (Auto Overwrite)
E4DF	PMU 1 Timed Trigger Position	1 to 50	%	1	F001	10
Phasor Measurement Unit Control Block (Read/Write Setting) (4 modules)						
E650	PMU Aggregator 1 Control Block SvEna	0 to 4294967295	---	1	F300	0
E652	PMU Aggregator 1 Control Block Client Control	0 to 4294967295	---	1	F300	0
E654	PMU Aggregator 1 CB SvEna Default	0 to 4294967295	---	1	F300	0
E656	PMU Aggregator 1 Control Block ConfRev	1 to 4294967295	---	1	F003	1
E658	PMU Aggregator 1 Control Block Priority	0 to 7	---	1	F001	4
E659	PMU Aggregator 1 Control Block IPClass	0 to 1	---	1	F563	1 (Expedited Forwarding)
E65A	PMU Aggregator 1 Control Block VID	0 to 4095	---	1	F001	0
E65B	PMU Aggregator 1 Control Block APPID	0 to 16383	---	1	F001	0
E65C	PMU Aggregator 1 Control Block IP Address	0 to 4294967295	---	1	F003	0
E65E	PMU Aggregator 1 Control Block Security	0 to 2	---	1	F001	0
E65F	...Repeated for PMU Aggregator 2					
E66E	...Repeated for PMU Aggregator 3					
E67D	...Repeated for PMU Aggregator 4					
DNP/IEC Points (Read/Write Setting)						
E700	DNP/IEC 60870-5-104 Binary Input Points (256 items)	0 to 4294967295	---	1	F300	0
E900	DNP/IEC 60870-5-104 Analog Input Points (256 items)	0 to 65535	---	1	F300	0
Synchrocheck (Read/Write Setting) (4 modules)						
EC00	Synchrocheck 1 Function	0 to 1	---	1	F102	0 (Disabled)
EC01	Synchrocheck 1 V1 Source	0 to 5	---	1	F167	0 (SRC 1)
EC02	Synchrocheck 1 V2 Source	0 to 5	---	1	F167	1 (SRC 2)
EC03	Synchrocheck 1 Maximum Voltage Difference	0 to 400000	V	1	F060	10000
EC05	Synchrocheck 1 Maximum Angle Difference	0 to 100	degrees	1	F001	30
EC06	Synchrocheck 1 Maximum Frequency Difference	0 to 2	Hz	0.01	F001	100
EC07	Synchrocheck 1 Dead Source Select	0 to 5	---	1	F176	1 (LV1 and DV2)
EC08	Synchrocheck 1 Dead V1 Maximum Voltage	0 to 1.25	pu	0.01	F001	30
EC09	Synchrocheck 1 Dead V2 Maximum Voltage	0 to 1.25	pu	0.01	F001	30
EC0A	Synchrocheck 1 Live V1 Minimum Voltage	0 to 1.25	pu	0.01	F001	70
EC0B	Synchrocheck 1 Live V2 Minimum Voltage	0 to 1.25	pu	0.01	F001	70
EC0C	Synchrocheck 1 Target	0 to 2	---	1	F109	0 (Self-reset)
EC0D	Synchrocheck 1 Events	0 to 1	---	1	F102	0 (Disabled)
EC0E	Synchrocheck 1 Block	0 to 4294967295	---	1	F300	0
EC10	Synchrocheck 1 Frequency Hysteresis	0 to 0.1	Hz	0.01	F001	6
EC11	...Repeated for Synchrocheck 2					
EC22	...Repeated for Synchrocheck 3					
EC33	...Repeated for Synchrocheck 4					
Phasor Measurement Unit Frequency Trigger (Read/Write Setting) (4 modules)						
ECCC	PMU 1 Frequency Trigger Function	0 to 1	---	1	F102	0 (Disabled)
ECCD	PMU 1 Frequency Trigger Low Frequency	20 to 70	Hz	0.01	F001	4900
ECCE	PMU 1 Frequency Trigger High Frequency	20 to 70	Hz	0.01	F001	6100
ECCF	PMU 1 Frequency Trigger Pickup Time	0 to 600	s	0.01	F001	10
ECD0	PMU 1 Frequency Trigger Dropout Time	0 to 600	s	0.01	F001	100
ECD1	PMU 1 Frequency Trigger Block (3 items)	0 to 4294967295	---	1	F300	0
ECD7	PMU 1 Frequency Trigger Target	0 to 2	---	1	F109	0 (Self-reset)
ECD8	PMU 1 Frequency Trigger Events	0 to 1	---	1	F102	0 (Disabled)
Setting file template values (read only)						
ED00	FlexLogic displays active	0 to 1	---	1	F102	1 (Enabled)
ED01	Undefined	---	---	---	F205	(none)
ED07	Last settings change date	0 to 4294967295	---	1	F050	0
ED09	Template bitmask (750 items)	0 to 65535	---	1	F001	0

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Table B–9: MODBUS MEMORY MAP (Sheet 62 of 62)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Phasor Measurement Unit Records (Read Only)						
EFFF	PMU Recording Number of Triggers	0 to 65535	samples	1	F001	0

B.4.2 DATA FORMATS

F001
UR_UINT16 UNSIGNED 16 BIT INTEGER

F002
UR_SINT16 SIGNED 16 BIT INTEGER

F003
UR_UINT32 UNSIGNED 32 BIT INTEGER (2 registers)

High order word is stored in the first register.
Low order word is stored in the second register.

F004
UR_SINT32 SIGNED 32 BIT INTEGER (2 registers)

High order word is stored in the first register/
Low order word is stored in the second register.

F005
UR_UINT8 UNSIGNED 8 BIT INTEGER

F006
UR_SINT8 SIGNED 8 BIT INTEGER

F011
UR_UINT16 FLEXCURVE DATA (120 points)

A FlexCurve is an array of 120 consecutive data points (x, y) which are interpolated to generate a smooth curve. The y-axis is the user defined trip or operation time setting; the x-axis is the pickup ratio and is pre-defined. Refer to format F119 for a listing of the pickup ratios; the enumeration value for the pickup ratio indicates the offset into the FlexCurve base address where the corresponding time value is stored.

F012
DISPLAY_SCALE DISPLAY SCALING
(unsigned 16-bit integer)

MSB indicates the SI units as a power of ten. LSB indicates the number of decimal points to display.

Example: Current values are stored as 32 bit numbers with three decimal places and base units in Amps. If the retrieved value is 12345.678 A and the display scale equals 0x0302 then the displayed value on the unit is 12.35 kA.

F013
POWER_FACTOR (SIGNED 16 BIT INTEGER)

Positive values indicate lagging power factor; negative values indicate leading.

F040
UR_UINT48 48-BIT UNSIGNED INTEGER

F050
UR_UINT32 TIME and DATE (UNSIGNED 32 BIT INTEGER)

Gives the current time in seconds elapsed since 00:00:00 January 1, 1970.

F051
UR_UINT32 DATE in SR format (alternate format for F050)

First 16 bits are Month/Day (MM/DD/xxxx). Month: 1=January, 2=February,...,12=December; Day: 1 to 31 in steps of 1
Last 16 bits are Year (xx/xx/YYYY): 1970 to 2106 in steps of 1

F052
UR_UINT32 TIME in SR format (alternate format for F050)

First 16 bits are Hours/Minutes (HH:MM:xx.xxx).
Hours: 0=12am, 1=1am,...,12=12pm,...23=11pm;
Minutes: 0 to 59 in steps of 1

Last 16 bits are Seconds (xx:xx:.SS.SSS): 0=00.000s, 1=00.001,...,59999=59.999s)

F060
FLOATING_POINT IEEE FLOATING POINT (32 bits)

F070
HEX2 2 BYTES - 4 ASCII DIGITS

F071
HEX4 4 BYTES - 8 ASCII DIGITS

F072
HEX6 6 BYTES - 12 ASCII DIGITS

F073
HEX8 8 BYTES - 16 ASCII DIGITS

F074
HEX20 20 BYTES - 40 ASCII DIGITS

F080
ENUMERATION: AUTORECLOSE MODE

0 = 1 & 3 Pole, 1 = 1 Pole, 2 = 3 Pole-A, 3 = 3 Pole-B

F083
ENUMERATION: SELECTOR MODES

0 = Time-Out, 1 = Acknowledge

F084
ENUMERATION: SELECTOR POWER UP

0 = Restore, 1 = Synchronize, 2 = Sync/Restore

F086
ENUMERATION: DIGITAL INPUT DEFAULT STATE

0 = Off, 1 = On, 2= Latest/Off, 3 = Latest/On

F090
ENUMERATION: LATCHING OUTPUT TYPE

0 = Operate-dominant, 1 = Reset-dominant

F100
ENUMERATION: VT CONNECTION TYPE

0 = Wye; 1 = Delta

F101
ENUMERATION: MESSAGE DISPLAY INTENSITY

0 = 25%, 1 = 50%, 2 = 75%, 3 = 100%

F102
ENUMERATION: DISABLED/ENABLED

0 = Disabled; 1 = Enabled

F103
ENUMERATION: CURVE SHAPES

bitmask	curve shape
0	IEEE Mod Inv
1	IEEE Very Inv
2	IEEE Ext Inv
3	IEC Curve A
4	IEC Curve B
5	IEC Curve C
6	IEC Short Inv
7	IAC Ext Inv
8	IAC Very Inv

bitmask	curve shape
9	IAC Inverse
10	IAC Short Inv
11	I2t
12	Definite Time
13	FlexCurve A
14	FlexCurve B
15	FlexCurve C
16	FlexCurve D

F104
ENUMERATION: RESET TYPE

0 = Instantaneous, 1 = Timed, 2 = Linear

F105
ENUMERATION: LOGIC INPUT

0 = Disabled, 1 = Input 1, 2 = Input 2

F106
ENUMERATION: PHASE ROTATION

0 = ABC, 1 = ACB

F108
ENUMERATION: OFF/ON

0 = Off, 1 = On

F109
ENUMERATION: CONTACT OUTPUT OPERATION

0 = Self-reset, 1 = Latched, 2 = Disabled

F110
ENUMERATION: CONTACT OUTPUT LED CONTROL

0 = Trip, 1 = Alarm, 2 = None

F111
ENUMERATION: UNDERVOLTAGE CURVE SHAPES

0 = Definite Time, 1 = Inverse Time

B

F112
ENUMERATION: RS485 BAUD RATES

bitmask	value	bitmask	value	bitmask	value
0	300	4	9600	8	115200
1	1200	5	19200	9	14400
2	2400	6	38400	10	28800
3	4800	7	57600	11	33600

F113
ENUMERATION: PARITY

0 = None, 1 = Odd, 2 = Even

F114
ENUMERATION: IRIG-B SIGNAL TYPE

0 = None, 1 = DC Shift, 2 = Amplitude Modulated

F115
ENUMERATION: BREAKER STATUS

0 = Auxiliary A, 1 = Auxiliary B

F116
ENUMERATION: NEUTRAL OVERVOLTAGE CURVES

0 = Definite Time, 1 = FlexCurve A, 2 = FlexCurve B, 3 = FlexCurve C

F117
ENUMERATION: NUMBER OF OSCILLOGRAPHY RECORDS

0 = 1×72 cycles, 1 = 3×36 cycles, 2 = 7×18 cycles, 3 = 15×9 cycles

F118
ENUMERATION: OSCILLOGRAPHY MODE

0 = Automatic Overwrite, 1 = Protected

F119
ENUMERATION: FLEXCURVE PICKUP RATIOS

mask	value	mask	value	mask	value	mask	value
0	0.00	30	0.88	60	2.90	90	5.90
1	0.05	31	0.90	61	3.00	91	6.00
2	0.10	32	0.91	62	3.10	92	6.50
3	0.15	33	0.92	63	3.20	93	7.00
4	0.20	34	0.93	64	3.30	94	7.50
5	0.25	35	0.94	65	3.40	95	8.00
6	0.30	36	0.95	66	3.50	96	8.50
7	0.35	37	0.96	67	3.60	97	9.00
8	0.40	38	0.97	68	3.70	98	9.50
9	0.45	39	0.98	69	3.80	99	10.00
10	0.48	40	1.03	70	3.90	100	10.50
11	0.50	41	1.05	71	4.00	101	11.00
12	0.52	42	1.10	72	4.10	102	11.50
13	0.54	43	1.20	73	4.20	103	12.00
14	0.56	44	1.30	74	4.30	104	12.50
15	0.58	45	1.40	75	4.40	105	13.00
16	0.60	46	1.50	76	4.50	106	13.50
17	0.62	47	1.60	77	4.60	107	14.00
18	0.64	48	1.70	78	4.70	108	14.50
19	0.66	49	1.80	79	4.80	109	15.00
20	0.68	50	1.90	80	4.90	110	15.50
21	0.70	51	2.00	81	5.00	111	16.00
22	0.72	52	2.10	82	5.10	112	16.50
23	0.74	53	2.20	83	5.20	113	17.00
24	0.76	54	2.30	84	5.30	114	17.50
25	0.78	55	2.40	85	5.40	115	18.00
26	0.80	56	2.50	86	5.50	116	18.50
27	0.82	57	2.60	87	5.60	117	19.00
28	0.84	58	2.70	88	5.70	118	19.50
29	0.86	59	2.80	89	5.80	119	20.00

F122
ENUMERATION: ELEMENT INPUT SIGNAL TYPE

0 = Phasor, 1 = RMS

F123
ENUMERATION: CT SECONDARY

0 = 1 A, 1 = 5 A

F124
ENUMERATION: LIST OF ELEMENTS

bitmask	element
0	Phase Instantaneous Overcurrent 1
1	Phase Instantaneous Overcurrent 2
2	Phase Instantaneous Overcurrent 3
3	Phase Instantaneous Overcurrent 4
4	Phase Instantaneous Overcurrent 5

bitmask	element
5	Phase Instantaneous Overcurrent 6
6	Phase Instantaneous Overcurrent 7
7	Phase Instantaneous Overcurrent 8
16	Phase Time Overcurrent 1
17	Phase Time Overcurrent 2
18	Phase Time Overcurrent 3
19	Phase Time Overcurrent 4
24	Phase Directional Overcurrent 1
25	Phase Directional Overcurrent 2
32	Neutral Instantaneous Overcurrent 1
33	Neutral Instantaneous Overcurrent 2
34	Neutral Instantaneous Overcurrent 3
35	Neutral Instantaneous Overcurrent 4
36	Neutral Instantaneous Overcurrent 5
37	Neutral Instantaneous Overcurrent 6
38	Neutral Instantaneous Overcurrent 7
39	Neutral Instantaneous Overcurrent 8
48	Neutral Time Overcurrent 1
49	Neutral Time Overcurrent 2
50	Neutral Time Overcurrent 3
51	Neutral Time Overcurrent 4
56	Neutral Directional Overcurrent 1
57	Neutral Directional Overcurrent 2
64	Ground Instantaneous Overcurrent 1
65	Ground Instantaneous Overcurrent 2
66	Ground Instantaneous Overcurrent 3
67	Ground Instantaneous Overcurrent 4
68	Ground Instantaneous Overcurrent 5
69	Ground Instantaneous Overcurrent 6
70	Ground Instantaneous Overcurrent 7
71	Ground Instantaneous Overcurrent 8
80	Ground Time Overcurrent 1
81	Ground Time Overcurrent 2
82	Ground Time Overcurrent 3
83	Ground Time Overcurrent 4
96	Negative Sequence Instantaneous Overcurrent 1
97	Negative Sequence Instantaneous Overcurrent 2
112	Negative Sequence Time Overcurrent 1
113	Negative Sequence Time Overcurrent 2
120	Negative Sequence Overvoltage
140	Auxiliary Undervoltage 1
144	Phase Undervoltage 1
145	Phase Undervoltage 2
148	Auxiliary Overvoltage 1
152	Phase Overvoltage 1
154	Compensated Overvoltage 1
224	SRC1 VT Fuse Failure
225	SRC2 VT Fuse Failure
232	SRC1 50DD (Disturbance Detection)
233	SRC2 50DD (Disturbance Detection)
240	87L Current Differential
246	CT Failure
255	Stub Bus

bitmask	element
280	Breaker Failure 1
281	Breaker Failure 2
288	Breaker Arcing Current 1
289	Breaker Arcing Current 2
304	Autoreclose (three-pole) 1
311	Phasor measurement unit one-shot
312	Synchrocheck 1
313	Synchrocheck 2
336	Setting Group
337	Reset
388	Selector 1
389	Selector 2
390	Control pushbutton 1
391	Control pushbutton 2
392	Control pushbutton 3
393	Control pushbutton 4
394	Control pushbutton 5
395	Control pushbutton 6
396	Control pushbutton 7
400	FlexElement 1
401	FlexElement 2
402	FlexElement 3
403	FlexElement 4
404	FlexElement 5
405	FlexElement 6
406	FlexElemen 7
407	FlexElement 8
420	Non-volatile Latch 1
421	Non-volatile Latch 2
422	Non-volatile Latch 3
423	Non-volatile Latch 4
424	Non-volatile Latch 5
425	Non-volatile Latch 6
426	Non-volatile Latch 7
427	Non-volatile Latch 8
428	Non-volatile Latch 9
429	Non-volatile Latch 10
430	Non-volatile Latch 11
431	Non-volatile Latch 12
432	Non-volatile Latch 13
433	Non-volatile Latch 14
434	Non-volatile Latch 15
435	Non-volatile Latch 16
544	Digital Counter 1
545	Digital Counter 2
546	Digital Counter 3
547	Digital Counter 4
548	Digital Counter 5
549	Digital Counter 6
550	Digital Counter 7
551	Digital Counter 8
692	Digital Element 1
693	Digital Element 2

B

bitmask	element
694	Digital Element 3
695	Digital Element 4
696	Digital Element 5
697	Digital Element 6
698	Digital Element 7
699	Digital Element 8
700	Digital Element 9
701	Digital Element 10
702	Digital Element 11
703	Digital Element 12
704	Digital Element 13
705	Digital Element 14
706	Digital Element 15
707	Digital Element 16
708	Digital Element 17
709	Digital Element 18
710	Digital Element 19
711	Digital Element 20
712	Digital Element 21
713	Digital Element 22
714	Digital Element 23
715	Digital Element 24
716	Digital Element 25
717	Digital Element 26
718	Digital Element 27
719	Digital Element 28
720	Digital Element 29
721	Digital Element 30
722	Digital Element 31
723	Digital Element 32
724	Digital Element 33
725	Digital Element 34
726	Digital Element 35
727	Digital Element 36
728	Digital Element 37
729	Digital Element 38
730	Digital Element 39
731	Digital Element 40
732	Digital Element 41
733	Digital Element 42
734	Digital Element 43
735	Digital Element 44
736	Digital Element 45
737	Digital Element 46
738	Digital Element 47
739	Digital Element 48
740	Phasor Measurement Unit 1 Frequency
746	Phasor Measurement Unit 1 Voltage
752	Phasor Measurement Unit 1 Current
758	Phasor Measurement Unit 1 Power
764	PMU 1 Rate of Change of Frequency
770	Phasor Measurement Unit 1
842	Trip Bus 1

bitmask	element
843	Trip Bus 2
844	Trip Bus 3
845	Trip Bus 4
846	Trip Bus 5
847	Trip Bus 6
849	RTD Input 1
850	RTD Input 2
851	RTD Input 3
852	RTD Input 4
853	RTD Input 5
854	RTD Input 6
855	RTD Input 7
856	RTD Input 8
857	RTD Input 9
858	RTD Input 10
859	RTD Input 11
860	RTD Input 12
861	RTD Input 13
862	RTD Input 14
863	RTD Input 15
864	RTD Input 16
865	RTD Input 17
866	RTD Input 18
867	RTD Input 19
868	RTD Input 20
869	RTD Input 21
870	RTD Input 22
871	RTD Input 23
872	RTD Input 24
873	RTD Input 25
874	RTD Input 26
875	RTD Input 27
876	RTD Input 28
877	RTD Input 29
878	RTD Input 30
879	RTD Input 31
880	RTD Input 32
881	RTD Input 33
882	RTD Input 34
883	RTD Input 35
884	RTD Input 36
885	RTD Input 37
886	RTD Input 38
887	RTD Input 39
888	RTD Input 40
889	RTD Input 41
890	RTD Input 42
891	RTD Input 43
892	RTD Input 44
893	RTD Input 45
894	RTD Input 46
895	RTD Input 47
896	RTD Input 48

bitmask	element
900	User-Programmable Pushbutton 1
901	User-Programmable Pushbutton 2
902	User-Programmable Pushbutton 3
903	User-Programmable Pushbutton 4
904	User-Programmable Pushbutton 5
905	User-Programmable Pushbutton 6
906	User-Programmable Pushbutton 7
907	User-Programmable Pushbutton 8
908	User-Programmable Pushbutton 9
909	User-Programmable Pushbutton 10
910	User-Programmable Pushbutton 11
911	User-Programmable Pushbutton 12
912	User-Programmable Pushbutton 13
913	User-Programmable Pushbutton 14
914	User-Programmable Pushbutton 15
915	User-Programmable Pushbutton 16
920	Disconnect switch 1
921	Disconnect switch 2
922	Disconnect switch 3
923	Disconnect switch 4
924	Disconnect switch 5
925	Disconnect switch 6
926	Disconnect switch 7
927	Disconnect switch 8
928	Disconnect switch 9
929	Disconnect switch 10
930	Disconnect switch 11
931	Disconnect switch 12
932	Disconnect switch 13
933	Disconnect switch 14
934	Disconnect switch 15
935	Disconnect switch 16
968	Breaker 1
969	Breaker 2
970	Breaker 3
971	Breaker 4
1012	Thermal overload protection 1
1013	Thermal overload protection 2
1014	Broken conductor detection 1
1015	Broken conductor detection 2

F125
ENUMERATION: ACCESS LEVEL

0 = Restricted; 1 = Command, 2 = Setting, 3 = Factory Service

F126
ENUMERATION: NO/YES CHOICE

0 = No, 1 = Yes

F127
ENUMERATION: LATCHED OR SELF-RESETTING

0 = Latched, 1 = Self-Reset

F128
ENUMERATION: CONTACT INPUT THRESHOLD

0 = 17 V DC, 1 = 33 V DC, 2 = 84 V DC, 3 = 166 V DC

F129
ENUMERATION: FLEXLOGIC TIMER TYPE

0 = millisecond, 1 = second, 2 = minute

F130
ENUMERATION: SIMULATION MODE

0 = Off. 1 = Pre-Fault, 2 = Fault, 3 = Post-Fault

F131
ENUMERATION: FORCED CONTACT OUTPUT STATE

0 = Disabled, 1 = Energized, 2 = De-energized, 3 = Freeze

F133
ENUMERATION: PROGRAM STATE

0 = Not Programmed, 1 = Programmed

F134
ENUMERATION: PASS/FAIL

0 = Fail, 1 = OK, 2 = n/a

F135
ENUMERATION: GAIN CALIBRATION

0 = 0x1, 1 = 1x16

F136
ENUMERATION: NUMBER OF OSCILLOGRAPHY RECORDS

0 = 31 x 8 cycles, 1 = 15 x 16 cycles, 2 = 7 x 32 cycles
3 = 3 x 64 cycles, 4 = 1 x 128 cycles

F137
ENUMERATION: USER-PROGRAMMABLE PUSHBUTTON FUNCTION

0 = Disabled, 1 = Self-Reset, 2 = Latched

F138
ENUMERATION: OSCILLOGRAPHY FILE TYPE

0 = Data File, 1 = Configuration File, 2 = Header File

F140
ENUMERATION: CURRENT, SENS CURRENT, VOLTAGE, DISABLED

0 = Disabled, 1 = Current 46 A, 2 = Voltage 280 V,
3 = Current 4.6 A, 4 = Current 2 A, 5 = Notched 4.6 A,
6 = Notched 2 A

F141
ENUMERATION: SELF TEST ERRORS

Bitmask	Error
0	Any Self Tests
1	IRIG-B Failure
2	Port 1 Offline
3	Port 2 Offline
4	Port 3 Offline
5	Port 4 Offline
6	Port 5 Offline
7	Port 6 Offline
8	RRTD Communications Failure
9	Voltage Monitor
10	FlexLogic Error Token
11	Equipment Mismatch
12	Process Bus Failure
13	Unit Not Programmed
14	System Exception
15	Latching Output Discrepancy
17	Maintenance Alert 01
18	SNTP Failure
19	Maintenance Alert
20	Maintenance Alert
21	Maintenance Alert
22	Temperature Monitor
23	Process Bus Trouble
24	Brick Trouble
25	Field RTD Trouble
26	Field TDR Trouble
27	Remote Device Offline
28	Direct Device Offline
29	Maintenance Alert
30	Any Minor Error
31	Any Major Error
33	Maintenance Alert
64	Maintenance Alert
65	IEC 61850 Data Set
66	Aggregator Error
67	Unit Not Calibrated
68	Settings Save Error
69	SRAM Data Error
70	Program Memory
71	Watchdog Error
72	Low On Memory
73	Prototype Firmware
74	Module Failure 01
75	Module Failure 02
76	Module Failure 03
77	Module Failure 04
78	Module Failure 05
79	Module Failure 06
80	Module Failure 07
81	Module Failure 08
82	Module Failure 09
83	Incompatible H/W
84	Module Failure 10
85	Module Failure 11
86	Module Failure 12
87	High ENET Traffic
89	Relay Restart
90	FGM Failure
91	FGM Failure
92	FGM Failure
93	FGM Failure
94	FGM Failure
95	FGM Error
96	Maintenance Alert
97	PHY Monitor
98	Storage Media Alarm
99	Wrong Transceiver

F142
ENUMERATION: EVENT RECORDER ACCESS FILE TYPE

0 = All Record Data, 1 = Headers Only, 2 = Numeric Event Cause

F143
UR_UINT32: 32 BIT ERROR CODE (F141 specifies bit number)

A bit value of 0 = no error, 1 = error

F144
ENUMERATION: FORCED CONTACT INPUT STATE

0 = Disabled, 1 = Open, 2 = Closed

F146
ENUMERATION: MISCELLANEOUS EVENT CAUSES

bitmask	definition
0	Events Cleared
1	Oscillography Triggered
2	Date/time Changed
3	Default Settings Loaded
4	Test Mode Forcing On
5	Test Mode Forcing Off
6	Power On
7	Power Off
8	Relay In Service
9	Relay Out Of Service
10	Watchdog Reset
11	Oscillography Clear
12	Reboot Command
13	Led Test Initiated
14	Flash Programming
15	Fault Report Trigger
16	User Programmable Fault Report Trigger
17	---
18	Reload CT/VT module Settings
19	---
20	Ethernet Port 1 Offline
21	Ethernet Port 2 Offline
22	Ethernet Port 3 Offline
23	Ethernet Port 4 Offline
24	Ethernet Port 5 Offline
25	Ethernet Port 6 Offline
26	Test Mode Isolated
27	Test Mode Forcible
28	Test Mode Disabled
29	Temperature Warning On
30	Temperature Warning Off
31	Unauthorized Access
32	System Integrity Recovery
33	System Integrity Recovery 06
34	System Integrity Recovery 07

F148
ENUMERATION: FAULT TYPE

bitmask	fault type	bitmask	fault type
0	NA	6	AC
1	AG	7	ABG
2	BG	8	BCG
3	CG	9	ACG
4	AB	10	ABC
5	BC	11	ABCG

B

F151
ENUMERATION: RTD SELECTION

bitmask	RTD#	bitmask	RTD#	bitmask	RTD#
0	NONE	17	RTD 17	33	RTD 33
1	RTD 1	18	RTD 18	34	RTD 34
2	RTD 2	19	RTD 19	35	RTD 35
3	RTD 3	20	RTD 20	36	RTD 36
4	RTD 4	21	RTD 21	37	RTD 37
5	RTD 5	22	RTD 22	38	RTD 38
6	RTD 6	23	RTD 23	39	RTD 39
7	RTD 7	24	RTD 24	40	RTD 40
8	RTD 8	25	RTD 25	41	RTD 41
9	RTD 9	26	RTD 26	42	RTD 42
10	RTD 10	27	RTD 27	43	RTD 43
11	RTD 11	28	RTD 28	44	RTD 44
12	RTD 12	29	RTD 29	45	RTD 45
13	RTD 13	30	RTD 30	46	RTD 46
14	RTD 14	31	RTD 31	47	RTD 47
15	RTD 15	32	RTD 32	48	RTD 48
16	RTD 16				

F152
ENUMERATION: SETTING GROUP

0 = Active Group, 1 = Group 1, 2 = Group 2, 3 = Group 3
4 = Group 4, 5 = Group 5, 6 = Group 6

F155
ENUMERATION: REMOTE DEVICE STATE

0 = Offline, 1 = Online

B

F156
ENUMERATION: REMOTE INPUT BIT PAIRS

bitmask	value	bitmask	value
0	NONE	35	UserSt-3
1	DNA-1	36	UserSt-4
2	DNA-2	37	UserSt-5
3	DNA-3	38	UserSt-6
4	DNA-4	39	UserSt-7
5	DNA-5	40	UserSt-8
6	DNA-6	41	UserSt-9
7	DNA-7	42	UserSt-10
8	DNA-8	43	UserSt-11
9	DNA-9	44	UserSt-12
10	DNA-10	45	UserSt-13
11	DNA-11	46	UserSt-14
12	DNA-12	47	UserSt-15
13	DNA-13	48	UserSt-16
14	DNA-14	49	UserSt-17
15	DNA-15	50	UserSt-18
16	DNA-16	51	UserSt-19
17	DNA-17	52	UserSt-20
18	DNA-18	53	UserSt-21
19	DNA-19	54	UserSt-22
20	DNA-20	55	UserSt-23
21	DNA-21	56	UserSt-24
22	DNA-22	57	UserSt-25
23	DNA-23	58	UserSt-26
24	DNA-24	59	UserSt-27
25	DNA-25	60	UserSt-28
26	DNA-26	61	UserSt-29
27	DNA-27	62	UserSt-30
28	DNA-28	63	UserSt-31
29	DNA-29	64	UserSt-32
30	DNA-30	65	Dataset Item 1
31	DNA-31	66	Dataset Item 2
32	DNA-32	67	Dataset Item 3
33	UserSt-1	↓	↓
34	UserSt-2	96	Dataset Item 32

F157
ENUMERATION: BREAKER MODE

0 = 3-Pole, 1 = 1-Pole

F158
ENUMERATION: SCHEME CALIBRATION TEST

0 = Normal, 1 = Symmetry 1, 2 = Symmetry 2, 3 = Delay 1
4 = Delay 2

F159
ENUMERATION: BREAKER AUX CONTACT KEYING

0 = 52a, 1 = 52b, 2 = None

F166
ENUMERATION: AUXILIARY VT CONNECTION TYPE

0 = Vn, 1 = Vag, 2 = Vbg, 3 = Vcg, 4 = Vab, 5 = Vbc, 6 = Vca

F167
ENUMERATION: SIGNAL SOURCE

0 = SRC 1, 1 = SRC 2, 2 = SRC 3, 3 = SRC 4,
4 = SRC 5, 5 = SRC 6

F168
ENUMERATION: INRUSH INHIBIT FUNCTION

0 = Disabled, 1 = Adapt. 2nd, 2 = Trad. 2nd

F170
ENUMERATION: LOW/HIGH OFFSET and GAIN TRANSDUCER INPUT/OUTPUT SELECTION

0 = LOW, 1 = HIGH

F171
ENUMERATION: TRANSDUCER CHANNEL INPUT TYPE

0 = dcmA IN, 1 = Ohms IN, 2 = RTD IN, 3 = dcmA OUT,
4 = RRTD IN

F172
ENUMERATION: SLOT LETTERS

bitmask	slot	bitmask	slot	bitmask	slot	bitmask	slot
0	F	4	K	8	P	12	U
1	G	5	L	9	R	13	V
2	H	6	M	10	S	14	W
3	J	7	N	11	T	15	X

F173
ENUMERATION: DCMA INPUT/OUTPUT RANGE

bitmask	dcmA input/output range
0	0 to –1 mA
1	0 to 1 mA
2	–1 to 1 mA
3	0 to 5 mA
4	0 to 10 mA
5	0 to 20 mA
6	4 to 20 mA

F174
ENUMERATION: TRANSDUCER RTD INPUT TYPE

0 = 100 Ohm Platinum, 1 = 120 Ohm Nickel,
2 = 100 Ohm Nickel, 3 = 10 Ohm Copper

F175
ENUMERATION: PHASE LETTERS

0 = A, 1 = B, 2 = C

F176
ENUMERATION: SYNCHROCHECK DEAD SOURCE SELECT

bitmask	synchrocheck dead source
0	None
1	LV1 and DV2
2	DV1 and LV2
3	DV1 or DV2
4	DV1 Xor DV2
5	DV1 and DV2

F177
ENUMERATION: COMMUNICATION PORT

0 = None, 1 = COM1-RS485 (not applicable to UR firmware 7.00), 2 = COM2-RS485, 3 = Front Panel-RS232, 4 = Network - TCP, 5 = Network - UDP

F178
ENUMERATION: DATA LOGGER RATES

0 = 1 sec, 1 = 1 min, 2 = 5 min, 3 = 10 min, 4 = 15 min, 5 = 20 min, 6 = 30 min, 7 = 60 min, 8 = 15 ms, 9 = 30 ms, 10 = 100 ms, 11 = 500 ms

F180
ENUMERATION: PHASE/GROUND

0 = PHASE, 1 = GROUND

F181
ENUMERATION: ODD/EVEN/NONE

0 = ODD, 1 = EVEN, 2 = NONE

F183
ENUMERATION: AC INPUT WAVEFORMS

bitmask	definition
0	Off
1	8 samples/cycle
2	16 samples/cycle
3	32 samples/cycle
4	64 samples/cycle

F184
ENUMERATION: REMOTE DEVICE GOOSE DATASET

value	GOOSE dataset
0	Off
1	GooseIn 1
2	GooseIn 2
3	GooseIn 3
4	GooseIn 4
5	GooseIn 5
6	GooseIn 6
7	GooseIn 7
8	GooseIn 8
9	GooseIn 9
10	GooseIn 10
11	GooseIn 11
12	GooseIn 12
13	GooseIn 13
14	GooseIn 14
15	GooseIn 15
16	GooseIn 16

F185
ENUMERATION: PHASE A,B,C, GROUND SELECTOR

0 = A, 1 = B, 2 = C, 3 = G

F186
ENUMERATION: MEASUREMENT MODE

0 = Phase to Ground, 1 = Phase to Phase

F190
ENUMERATION: SIMULATED KEYPRESS

bitmsk	keypress	bitmsk	keypress
0	--- use between real keys	23	Reset
		24	User 1
1	1	25	User 2
2	2	26	User 3
3	3	27	User-programmable key 1
4	4	28	User-programmable key 2
5	5	29	User-programmable key 3
6	6	30	User-programmable key 4
7	7	31	User-programmable key 5
8	8	32	User-programmable key 6
9	9	33	User-programmable key 7
10	0	34	User-programmable key 8
11	Decimal Point	35	User-programmable key 9
12	Plus/Minus	36	User-programmable key 10
13	Value Up	37	User-programmable key 11
14	Value Down	38	User-programmable key 12
15	Message Up	43	User-programmable key 13
16	Message Down	44	User-programmable key 14

bitmsk	keypress
17	Message Left
18	Message Right
19	Menu
20	Help
21	Escape
22	---

bitmsk	keypress
45	User-programmable key 15
46	User-programmable key 16
47	User 4 (control pushbutton)
48	User 5 (control pushbutton)
49	User 6 (control pushbutton)
50	User 7 (control pushbutton)

F192
ENUMERATION: ETHERNET OPERATION MODE

0 = Half-Duplex, 1 = Full-Duplex

F194
ENUMERATION: DNP SCALE

0 = 0.01, 1 = 0.1, 2 = 1, 3 = 10, 4 = 100, 5 = 1000, 6 = 10000, 7 = 100000, 8 = 0.001

F196
ENUMERATION: NEUTRAL DIRECTIONAL OVERCURRENT OPERATING CURRENT

0 = Calculated 3I0, 1 = Measured IG

F199
ENUMERATION: DISABLED/ENABLED/CUSTOM

0 = Disabled, 1 = Enabled, 2 = Custom

F200
TEXT40: 40-CHARACTER ASCII TEXT

20 registers, 16 Bits: 1st Char MSB, 2nd Char. LSB

F201
TEXT8: 8-CHARACTER ASCII PASSCODE

4 registers, 16 Bits: 1st Char MSB, 2nd Char. LSB

F202
TEXT20: 20-CHARACTER ASCII TEXT

10 registers, 16 Bits: 1st Char MSB, 2nd Char. LSB

F203
TEXT16: 16-CHARACTER ASCII TEXT

F204
TEXT80: 80-CHARACTER ASCII TEXT

F205
TEXT12: 12-CHARACTER ASCII TEXT

F206
TEXT6: 6-CHARACTER ASCII TEXT

F207
TEXT4: 4-CHARACTER ASCII TEXT

F208
TEXT2: 2-CHARACTER ASCII TEXT

F211
ENUMERATION: SOURCE SELECTION

0 = None, 1 = SRC 1, 2 = SRC 2, 3 = SRC 3, 4 = SRC 4, 5 = SRC 5, 6 = SRC 6

F213
TEXT32: 32-CHARACTER ASCII TEXT

F220
ENUMERATION: PUSHBUTTON MESSAGE PRIORITY

value	priority
0	Disabled
1	Normal
2	High Priority

F222
ENUMERATION: TEST ENUMERATION

0 = Test Enumeration 0, 1 = Test Enumeration 1

F223
ENUMERATION: DIAGNOSTIC TEST

0 = No Test, 1 = Run Test, 2 = End Test

F226
ENUMERATION: REMOTE INPUT/OUTPUT TRANSFER METHOD

0 = None, 1 = GSSE, 2 = GOOSE

F227
ENUMERATION: RELAY SERVICE STATUS

0 = Unknown, 1 = Relay In Service, 2 = Relay Out Of Service

F228
ENUMERATION: SETTINGS CONTROL EVENT TYPE

0 = Unknown, 1 = Setting Change, 2 = Firmware Upgrade, 3 = Hardware Change

F229
ENUMERATION: SETTINGS CONTROL CHANGE METHOD

0 = None, 1 = Keypad, 2 = Front Port, 3 = COM1, 4 = COM2, 5 = Ethernet

F230
ENUMERATION: DIRECTIONAL POLARIZING

0 = Voltage, 1 = Current, 2 = Dual, 3 = Dual-V, 4 = Dual-I

F232
ENUMERATION: CONFIGURABLE GOOSE DATASET ITEMS FOR TRANSMISSION

value	GOOSE dataset item
0	None
1	GGIO1.ST.Ind1.q
2	GGIO1.ST.Ind1.stVal
3	GGIO1.ST.Ind2.q
4	GGIO1.ST.Ind2.stVal
↓	↓
255	GGIO1.ST.Ind128.q
256	GGIO1.ST.Ind128.stVal
257	MMXU1.MX.TotW.mag.f
258	MMXU1.MX.TotVAr.mag.f
259	MMXU1.MX.TotVA.mag.f
260	MMXU1.MX.TotPF.mag.f
261	MMXU1.MX.Hz.mag.f
262	MMXU1.MX.PPV.phsAB.cVal.mag.f
263	MMXU1.MX.PPV.phsAB.cVal.ang.f
264	MMXU1.MX.PPV.phsBC.cVal.mag.f
265	MMXU1.MX.PPV.phsBC.cVal.ang.f
266	MMXU1.MX.PPV.phsCA.cVal.mag.f
267	MMXU1.MX.PPV.phsCA.cVal.ang.f
268	MMXU1.MX.PhV.phsA.cVal.mag.f
269	MMXU1.MX.PhV.phsA.cVal.ang.f
270	MMXU1.MX.PhV.phsB.cVal.mag.f
271	MMXU1.MX.PhV.phsB.cVal.ang.f
272	MMXU1.MX.PhV.phsC.cVal.mag.f
273	MMXU1.MX.PhV.phsC.cVal.ang.f
274	MMXU1.MX.A.phsA.cVal.mag.f
275	MMXU1.MX.A.phsA.cVal.ang.f
276	MMXU1.MX.A.phsB.cVal.mag.f
277	MMXU1.MX.A.phsB.cVal.ang.f
278	MMXU1.MX.A.phsC.cVal.mag.f
279	MMXU1.MX.A.phsC.cVal.ang.f
280	MMXU1.MX.A.neut.cVal.mag.f
281	MMXU1.MX.A.neut.cVal.ang.f
282	MMXU1.MX.W.phsA.cVal.mag.f
283	MMXU1.MX.W.phsB.cVal.mag.f
284	MMXU1.MX.W.phsC.cVal.mag.f
285	MMXU1.MX.VAr.phsA.cVal.mag.f
286	MMXU1.MX.VAr.phsB.cVal.mag.f
287	MMXU1.MX.VAr.phsC.cVal.mag.f
288	MMXU1.MX.VA.phsA.cVal.mag.f
289	MMXU1.MX.VA.phsB.cVal.mag.f
290	MMXU1.MX.VA.phsC.cVal.mag.f
291	MMXU1.MX.PF.phsA.cVal.mag.f
292	MMXU1.MX.PF.phsB.cVal.mag.f
293	MMXU1.MX.PF.phsC.cVal.mag.f
294	MMXU2.MX.TotW.mag.f
295	MMXU2.MX.TotVAr.mag.f
296	MMXU2.MX.TotVA.mag.f
297	MMXU2.MX.TotPF.mag.f
298	MMXU2.MX.Hz.mag.f
299	MMXU2.MX.PPV.phsAB.cVal.mag.f
300	MMXU2.MX.PPV.phsAB.cVal.ang.f
301	MMXU2.MX.PPV.phsBC.cVal.mag.f
302	MMXU2.MX.PPV.phsBC.cVal.ang.f
303	MMXU2.MX.PPV.phsCA.cVal.mag.f
304	MMXU2.MX.PPV.phsCA.cVal.ang.f
305	MMXU2.MX.PhV.phsA.cVal.mag.f
306	MMXU2.MX.PhV.phsA.cVal.ang.f
307	MMXU2.MX.PhV.phsB.cVal.mag.f
308	MMXU2.MX.PhV.phsB.cVal.ang.f
309	MMXU2.MX.PhV.phsC.cVal.mag.f
310	MMXU2.MX.PhV.phsC.cVal.ang.f
311	MMXU2.MX.A.phsA.cVal.mag.f
312	MMXU2.MX.A.phsA.cVal.ang.f
313	MMXU2.MX.A.phsB.cVal.mag.f
314	MMXU2.MX.A.phsB.cVal.ang.f
315	MMXU2.MX.A.phsC.cVal.mag.f
316	MMXU2.MX.A.phsC.cVal.ang.f
317	MMXU2.MX.A.neut.cVal.mag.f
318	MMXU2.MX.A.neut.cVal.ang.f
319	MMXU2.MX.W.phsA.cVal.mag.f
320	MMXU2.MX.W.phsB.cVal.mag.f
321	MMXU2.MX.W.phsC.cVal.mag.f
322	MMXU2.MX.VAr.phsA.cVal.mag.f
323	MMXU2.MX.VAr.phsB.cVal.mag.f
324	MMXU2.MX.VAr.phsC.cVal.mag.f
325	MMXU2.MX.VA.phsA.cVal.mag.f
326	MMXU2.MX.VA.phsB.cVal.mag.f
327	MMXU2.MX.VA.phsC.cVal.mag.f
328	MMXU2.MX.PF.phsA.cVal.mag.f
329	MMXU2.MX.PF.phsB.cVal.mag.f
330	MMXU2.MX.PF.phsC.cVal.mag.f
331	MMXU3.MX.TotW.mag.f
332	MMXU3.MX.TotVAr.mag.f
333	MMXU3.MX.TotVA.mag.f
334	MMXU3.MX.TotPF.mag.f
335	MMXU3.MX.Hz.mag.f
336	MMXU3.MX.PPV.phsAB.cVal.mag.f
337	MMXU3.MX.PPV.phsAB.cVal.ang.f
338	MMXU3.MX.PPV.phsBC.cVal.mag.f
339	MMXU3.MX.PPV.phsBC.cVal.ang.f
340	MMXU3.MX.PPV.phsCA.cVal.mag.f
341	MMXU3.MX.PPV.phsCA.cVal.ang.f
342	MMXU3.MX.PhV.phsA.cVal.mag.f
343	MMXU3.MX.PhV.phsA.cVal.ang.f
344	MMXU3.MX.PhV.phsB.cVal.mag.f
345	MMXU3.MX.PhV.phsB.cVal.ang.f

B

value	GOOSE dataset item
346	MMXU3.MX.PhV.phsC.cVal.mag.f
347	MMXU3.MX.PhV.phsC.cVal.ang.f
348	MMXU3.MX.A.phsA.cVal.mag.f
349	MMXU3.MX.A.phsA.cVal.ang.f
350	MMXU3.MX.A.phsB.cVal.mag.f
351	MMXU3.MX.A.phsB.cVal.ang.f
352	MMXU3.MX.A.phsC.cVal.mag.f
353	MMXU3.MX.A.phsC.cVal.ang.f
354	MMXU3.MX.A.neut.cVal.mag.f
355	MMXU3.MX.A.neut.cVal.ang.f
356	MMXU3.MX.W.phsA.cVal.mag.f
357	MMXU3.MX.W.phsB.cVal.mag.f
358	MMXU3.MX.W.phsC.cVal.mag.f
359	MMXU3.MX.VAr.phsA.cVal.mag.f
360	MMXU3.MX.VAr.phsB.cVal.mag.f
361	MMXU3.MX.VAr.phsC.cVal.mag.f
362	MMXU3.MX.VA.phsA.cVal.mag.f
363	MMXU3.MX.VA.phsB.cVal.mag.f
364	MMXU3.MX.VA.phsC.cVal.mag.f
365	MMXU3.MX.PF.phsA.cVal.mag.f
366	MMXU3.MX.PF.phsB.cVal.mag.f
367	MMXU3.MX.PF.phsC.cVal.mag.f
368	MMXU4.MX.TotW.mag.f
369	MMXU4.MX.TotVAr.mag.f
370	MMXU4.MX.TotVA.mag.f
371	MMXU4.MX.TotPF.mag.f
372	MMXU4.MX.Hz.mag.f
373	MMXU4.MX.PPV.phsAB.cVal.mag.f
374	MMXU4.MX.PPV.phsAB.cVal.ang.f
375	MMXU4.MX.PPV.phsBC.cVal.mag.f
376	MMXU4.MX.PPV.phsBC.cVal.ang.f
377	MMXU4.MX.PPV.phsCA.cVal.mag.f
378	MMXU4.MX.PPV.phsCA.cVal.ang.f
379	MMXU4.MX.PhV.phsA.cVal.mag.f
380	MMXU4.MX.PhV.phsA.cVal.ang.f
381	MMXU4.MX.PhV.phsB.cVal.mag.f
382	MMXU4.MX.PhV.phsB.cVal.ang.f
383	MMXU4.MX.PhV.phsC.cVal.mag.f
384	MMXU4.MX.PhV.phsC.cVal.ang.f
385	MMXU4.MX.A.phsA.cVal.mag.f
386	MMXU4.MX.A.phsA.cVal.ang.f
387	MMXU4.MX.A.phsB.cVal.mag.f
388	MMXU4.MX.A.phsB.cVal.ang.f
389	MMXU4.MX.A.phsC.cVal.mag.f
390	MMXU4.MX.A.phsC.cVal.ang.f
391	MMXU4.MX.A.neut.cVal.mag.f
392	MMXU4.MX.A.neut.cVal.ang.f
393	MMXU4.MX.W.phsA.cVal.mag.f
394	MMXU4.MX.W.phsB.cVal.mag.f
395	MMXU4.MX.W.phsC.cVal.mag.f
396	MMXU4.MX.VAr.phsA.cVal.mag.f
397	MMXU4.MX.VAr.phsB.cVal.mag.f
398	MMXU4.MX.VAr.phsC.cVal.mag.f

value	GOOSE dataset item
399	MMXU4.MX.VA.phsA.cVal.mag.f
400	MMXU4.MX.VA.phsB.cVal.mag.f
401	MMXU4.MX.VA.phsC.cVal.mag.f
402	MMXU4.MX.PF.phsA.cVal.mag.f
403	MMXU4.MX.PF.phsB.cVal.mag.f
404	MMXU4.MX.PF.phsC.cVal.mag.f
405	MMXU5.MX.TotW.mag.f
406	MMXU5.MX.TotVAr.mag.f
407	MMXU5.MX.TotVA.mag.f
408	MMXU5.MX.TotPF.mag.f
409	MMXU5.MX.Hz.mag.f
410	MMXU5.MX.PPV.phsAB.cVal.mag.f
411	MMXU5.MX.PPV.phsAB.cVal.ang.f
412	MMXU5.MX.PPV.phsBC.cVal.mag.f
413	MMXU5.MX.PPV.phsBC.cVal.ang.f
414	MMXU5.MX.PPV.phsCA.cVal.mag.f
415	MMXU5.MX.PPV.phsCA.cVal.ang.f
416	MMXU5.MX.PhV.phsA.cVal.mag.f
417	MMXU5.MX.PhV.phsA.cVal.ang.f
418	MMXU5.MX.PhV.phsB.cVal.mag.f
419	MMXU5.MX.PhV.phsB.cVal.ang.f
420	MMXU5.MX.PhV.phsC.cVal.mag.f
421	MMXU5.MX.PhV.phsC.cVal.ang.f
422	MMXU5.MX.A.phsA.cVal.mag.f
423	MMXU5.MX.A.phsA.cVal.ang.f
424	MMXU5.MX.A.phsB.cVal.mag.f
425	MMXU5.MX.A.phsB.cVal.ang.f
426	MMXU5.MX.A.phsC.cVal.mag.f
427	MMXU5.MX.A.phsC.cVal.ang.f
428	MMXU5.MX.A.neut.cVal.mag.f
429	MMXU5.MX.A.neut.cVal.ang.f
430	MMXU5.MX.W.phsA.cVal.mag.f
431	MMXU5.MX.W.phsB.cVal.mag.f
432	MMXU5.MX.W.phsC.cVal.mag.f
433	MMXU5.MX.VAr.phsA.cVal.mag.f
434	MMXU5.MX.VAr.phsB.cVal.mag.f
435	MMXU5.MX.VAr.phsC.cVal.mag.f
436	MMXU5.MX.VA.phsA.cVal.mag.f
437	MMXU5.MX.VA.phsB.cVal.mag.f
438	MMXU5.MX.VA.phsC.cVal.mag.f
439	MMXU5.MX.PF.phsA.cVal.mag.f
440	MMXU5.MX.PF.phsB.cVal.mag.f
441	MMXU5.MX.PF.phsC.cVal.mag.f
442	MMXU6.MX.TotW.mag.f
443	MMXU6.MX.TotVAr.mag.f
444	MMXU6.MX.TotVA.mag.f
445	MMXU6.MX.TotPF.mag.f
446	MMXU6.MX.Hz.mag.f
447	MMXU6.MX.PPV.phsAB.cVal.mag.f
448	MMXU6.MX.PPV.phsAB.cVal.ang.f
449	MMXU6.MX.PPV.phsBC.cVal.mag.f
450	MMXU6.MX.PPV.phsBC.cVal.ang.f
451	MMXU6.MX.PPV.phsCA.cVal.mag.f

value	GOOSE dataset item
452	MMXU6.MX.PPV.phsCA.cVal.ang.f
453	MMXU6.MX.PhV.phsA.cVal.mag.f
454	MMXU6.MX.PhV.phsA.cVal.ang.f
455	MMXU6.MX.PhV.phsB.cVal.mag.f
456	MMXU6.MX.PhV.phsB.cVal.ang.f
457	MMXU6.MX.PhV.phsC.cVal.mag.f
458	MMXU6.MX.PhV.phsC.cVal.ang.f
459	MMXU6.MX.A.phsA.cVal.mag.f
460	MMXU6.MX.A.phsA.cVal.ang.f
461	MMXU6.MX.A.phsB.cVal.mag.f
462	MMXU6.MX.A.phsB.cVal.ang.f
463	MMXU6.MX.A.phsC.cVal.mag.f
464	MMXU6.MX.A.phsC.cVal.ang.f
465	MMXU6.MX.A.neut.cVal.mag.f
466	MMXU6.MX.A.neut.cVal.ang.f
467	MMXU6.MX.W.phsA.cVal.mag.f
468	MMXU6.MX.W.phsB.cVal.mag.f
469	MMXU6.MX.W.phsC.cVal.mag.f
470	MMXU6.MX.VAr.phsA.cVal.mag.f
471	MMXU6.MX.VAr.phsB.cVal.mag.f
472	MMXU6.MX.VAr.phsC.cVal.mag.f
473	MMXU6.MX.VA.phsA.cVal.mag.f
474	MMXU6.MX.VA.phsB.cVal.mag.f
475	MMXU6.MX.VA.phsC.cVal.mag.f
476	MMXU6.MX.PF.phsA.cVal.mag.f
477	MMXU6.MX.PF.phsB.cVal.mag.f
478	MMXU6.MX.PF.phsC.cVal.mag.f
479	GGIO4.MX.AnIn1.mag.f
480	GGIO4.MX.AnIn2.mag.f
481	GGIO4.MX.AnIn3.mag.f
482	GGIO4.MX.AnIn4.mag.f
483	GGIO4.MX.AnIn5.mag.f
484	GGIO4.MX.AnIn6.mag.f
485	GGIO4.MX.AnIn7.mag.f
486	GGIO4.MX.AnIn8.mag.f
487	GGIO4.MX.AnIn9.mag.f
488	GGIO4.MX.AnIn10.mag.f
489	GGIO4.MX.AnIn11.mag.f
490	GGIO4.MX.AnIn12.mag.f
491	GGIO4.MX.AnIn13.mag.f
492	GGIO4.MX.AnIn14.mag.f
493	GGIO4.MX.AnIn15.mag.f
494	GGIO4.MX.AnIn16.mag.f
495	GGIO4.MX.AnIn17.mag.f
496	GGIO4.MX.AnIn18.mag.f
497	GGIO4.MX.AnIn19.mag.f
498	GGIO4.MX.AnIn20.mag.f
499	GGIO4.MX.AnIn21.mag.f
500	GGIO4.MX.AnIn22.mag.f
501	GGIO4.MX.AnIn23.mag.f
502	GGIO4.MX.AnIn24.mag.f
503	GGIO4.MX.AnIn25.mag.f
504	GGIO4.MX.AnIn26.mag.f
505	GGIO4.MX.AnIn27.mag.f
506	GGIO4.MX.AnIn28.mag.f
507	GGIO4.MX.AnIn29.mag.f
508	GGIO4.MX.AnIn30.mag.f
509	GGIO4.MX.AnIn31.mag.f
510	GGIO4.MX.AnIn32.mag.f
511	GGIO5.ST.UIntIn1.q
512	GGIO5.ST.UIntIn1.stVal
513	GGIO5.ST.UIntIn2.q
514	GGIO5.ST.UIntIn2.stVal
515	GGIO5.ST.UIntIn3.q
516	GGIO5.ST.UIntIn3.stVal
517	GGIO5.ST.UIntIn4.q
518	GGIO5.ST.UIntIn4.stVal
519	GGIO5.ST.UIntIn5.q
520	GGIO5.ST.UIntIn5.stVal
521	GGIO5.ST.UIntIn6.q
522	GGIO5.ST.UIntIn6.stVal
523	GGIO5.ST.UIntIn7.q
524	GGIO5.ST.UIntIn7.stVal
525	GGIO5.ST.UIntIn8.q
526	GGIO5.ST.UIntIn8.stVal
527	GGIO5.ST.UIntIn9.q
528	GGIO5.ST.UIntIn9.stVal
529	GGIO5.ST.UIntIn10.q
530	GGIO5.ST.UIntIn10.stVal
531	GGIO5.ST.UIntIn11.q
532	GGIO5.ST.UIntIn11.stVal
533	GGIO5.ST.UIntIn12.q
534	GGIO5.ST.UIntIn12.stVal
535	GGIO5.ST.UIntIn13.q
536	GGIO5.ST.UIntIn13.stVal
537	GGIO5.ST.UIntIn14.q
538	GGIO5.ST.UIntIn14.stVal
539	GGIO5.ST.UIntIn15.q
540	GGIO5.ST.UIntIn15.stVal
541	GGIO5.ST.UIntIn16.q
542	GGIO5.ST.UIntIn16.stVal

F233
ENUMERATION: CONFIGURABLE GOOSE DATASET ITEMS FOR RECEPTION

value	GOOSE dataset item
0	None
1	GGIO3.ST.Ind1.q
2	GGIO3.ST.Ind1.stVal
3	GGIO3.ST.Ind2.q
4	GGIO3.ST.Ind2.stVal
↓	↓
127	GGIO1.ST.Ind64q
128	GGIO1.ST.Ind64.stVal
129	GGIO3.MX.AnIn1.mag.f

B

B

value	GOOSE dataset item
130	GGIO3.MX.AnIn2.mag.f
131	GGIO3.MX.AnIn3.mag.f
132	GGIO3.MX.AnIn4.mag.f
133	GGIO3.MX.AnIn5.mag.f
134	GGIO3.MX.AnIn6.mag.f
135	GGIO3.MX.AnIn7.mag.f
136	GGIO3.MX.AnIn8.mag.f
137	GGIO3.MX.AnIn9.mag.f
138	GGIO3.MX.AnIn10.mag.f
139	GGIO3.MX.AnIn11.mag.f
140	GGIO3.MX.AnIn12.mag.f
141	GGIO3.MX.AnIn13.mag.f
142	GGIO3.MX.AnIn14.mag.f
143	GGIO3.MX.AnIn15.mag.f
144	GGIO3.MX.AnIn16.mag.f
145	GGIO3.MX.AnIn17.mag.f
146	GGIO3.MX.AnIn18.mag.f
147	GGIO3.MX.AnIn19.mag.f
148	GGIO3.MX.AnIn20.mag.f
149	GGIO3.MX.AnIn21.mag.f
150	GGIO3.MX.AnIn22.mag.f
151	GGIO3.MX.AnIn23.mag.f
152	GGIO3.MX.AnIn24.mag.f
153	GGIO3.MX.AnIn25.mag.f
154	GGIO3.MX.AnIn26.mag.f
155	GGIO3.MX.AnIn27.mag.f
156	GGIO3.MX.AnIn28.mag.f
157	GGIO3.MX.AnIn29.mag.f
158	GGIO3.MX.AnIn30.mag.f
159	GGIO3.MX.AnIn31.mag.f
160	GGIO3.MX.AnIn32.mag.f
161	GGIO3.ST.IndPos1.stVal
162	GGIO3.ST.IndPos2.stVal
163	GGIO3.ST.IndPos3.stVal
164	GGIO3.ST.IndPos4.stVal
165	GGIO3.ST.IndPos5.stVal
166	GGIO3.ST.UIntIn1.q
167	GGIO3.ST.UIntIn1.stVal
168	GGIO3.ST.UIntIn2.q
169	GGIO3.ST.UIntIn2.stVal
170	GGIO3.ST.UIntIn3.q
171	GGIO3.ST.UIntIn3.stVal
172	GGIO3.ST.UIntIn4.q
173	GGIO3.ST.UIntIn4.stVal
174	GGIO3.ST.UIntIn5.q
175	GGIO3.ST.UIntIn5.stVal
176	GGIO3.ST.UIntIn6.q
177	GGIO3.ST.UIntIn6.stVal
178	GGIO3.ST.UIntIn7.q
179	GGIO3.ST.UIntIn7.stVal
180	GGIO3.ST.UIntIn8.q
181	GGIO3.ST.UIntIn8.stVal
182	GGIO3.ST.UIntIn9.q
183	GGIO3.ST.UIntIn9.stVal
184	GGIO3.ST.UIntIn10.q
185	GGIO3.ST.UIntIn10.stVal
186	GGIO3.ST.UIntIn11.q
187	GGIO3.ST.UIntIn11.stVal
188	GGIO3.ST.UIntIn12.q
189	GGIO3.ST.UIntIn12.stVal
190	GGIO3.ST.UIntIn13.q
191	GGIO3.ST.UIntIn13.stVal
192	GGIO3.ST.UIntIn14.q
193	GGIO3.ST.UIntIn14.stVal
194	GGIO3.ST.UIntIn15.q
195	GGIO3.ST.UIntIn15.stVal
196	GGIO3.ST.UIntIn16.q
197	GGIO3.ST.UIntIn16.stVal

F236
ENUMERATION: WATTMETRIC GRN FLT CURVE

0 = Definite Time, 1 = Inverse, 2 = FlexCurve A, 3 = FlexCurve B, 4 = FlexCurve C, 5 = FlexCurve D

F237
ENUMERATION: REAL TIME CLOCK MONTH

value	month
0	January
1	February
2	March
3	April
4	May
5	June
6	July
7	August
8	September
9	October
10	November
11	December

F238
ENUMERATION: REAL TIME CLOCK DAY

value	day
0	Sunday
1	Monday
2	Tuesday
3	Wednesday
4	Thursday
5	Friday
6	Saturday

F239
ENUMERATION: REAL TIME CLOCK DAYLIGHT SAVINGS TIME START DAY INSTANCE

value	instance
0	First
1	Second
2	Third
3	Fourth
4	Last

F243
ENUMERATION: FIELD UNIT TYPE

0 = CC-05, 1 = CV-05, 2 = CC-01, 3 = CV-01

F244
ENUMERATION: PROCESS CARD PORT

0 = H4a, 1 = H4b 2 = H3a, 3 = H3b, 4 = H2a, 5 = H2b, 6 = H1a, 7 = H1b

F245
ENUMERATION: TEST MODE FUNCTION

Value	Function
0	Disabled
1	Isolated
2	Forcible

F257
ENUMERATION: PROCESS CARD DSP CONFIGURATION

value	instance
0	CC
1	CV
2	CD
3	VC
4	VV
5	VD
6	DC
7	DV
8	DD

F260
ENUMERATION: DATA LOGGER MODE

0 = Continuous, 1 = Trigger

F261
ENUMERATION: BANK REDUNDANCY TYPE

0 = None, 1 = Dependability Biased, 2 = Security Biased

F263
ENUMERATION: PROCESS BUS SYSTEM STATUS

0 = N/A, 1 = OK, 2 = Fail

F270
ENUMERATION: FAULT REPORT VT SUBSTITUTION

Value	Description
0	None
1	I_0
2	V_0

F300
UR_UINT32: FLEXLOGIC BASE TYPE (15-bit type)

The FlexLogic BASE type is 7 bits and is combined with an 8-bit descriptor and 1 bit for protection element to form a 16-bit value. The combined bits are of the form: PTTTTTTTDDDDDDDD, where P bit if set, indicates that the FlexLogic type is associated with a protection element state and T represents bits for the BASE type, and D represents bits for the descriptor.

The values in square brackets indicate the base type with P prefix [PTTTTTTT] and the values in round brackets indicate the descriptor range. The right most T bit indicates whether the type is an ON or OFF type. There can be a total of 64 types (plus protection elements). There can be a total of 256 descriptors of each type.

[0] Off (0) – this is boolean FALSE value
[1] On (1) – this is boolean TRUE value
[2] CONTACT INPUTS (1 to 96)
[3] CONTACT INPUTS OFF (1 to 96)
[4] VIRTUAL INPUTS (1 to 32)
[6] VIRTUAL OUTPUTS (1 to 64
[8] CONTACT OUTPUTS
[10] CONTACT OUTPUTS VOLTAGE DETECTED (1 to 64)
[11] CONTACT OUTPUTS VOLTAGE OFF DETECTED (1 to 64)
[12] CONTACT OUTPUTS CURRENT DETECTED (1 to 64)
[13] CONTACT OUTPUTS CURRENT OFF DETECTED (1 to 64)
[14] REMOTE INPUTS (1 to 32)
[16] DIRECT INPUTS (1 to 96)
[18] REMOTE OUTPUT DNA BIT PAIRS (1 to 32)
[20] REMOTE OUTPUT UserSt BIT PAIRS (1 to 32)
[22] REMOTE DEVICE ONLINE (1 to 16)
[24] MISCELLANEOUS EQUATION
[26] TELEPROTECTION INPUTS
[28] INSERT (via keypad only)
[30] DELETE (via keypad only)
[32] END
[34] NOT (1 INPUT)
[36] 2 INPUT XOR (0)
[38] LATCH SET/RESET (2 inputs)
[40] OR (2 to 16 inputs)
[42] AND (2 to 16 inputs)
[44] NOR (2 to 16 inputs)
[46] NAND (2 to 16 inputs)
[48] TIMER (1 to 32)

[50] ASSIGN VIRTUAL OUTPUT (1 to 64)
[52] ONE SHOT
[54] SELF-TEST ERROR (see F141 for range)
[56] PLATFORM DIRECT INPUT (1 to 96)
[58] PLATFORM DIRECT OUTPUT (1 to 96)
[60] PLATFORM DIRECT DEVICE (1 to 8)
[62] MISCELLANEOUS EVENTS (see F146 for range)
[64] PDC NETWORK CONTROL
[66] PMU RECORDERE OUT OF MEMORY
[68] PMU RECORDER STOPPED
[128 to 255] ELEMENT STATES (see memory map element states section)

F400
UR_UINT16: CT/VT BANK SELECTION

bitmask	bank selection
0	Card 1 Contact 1 to 4
1	Card 1 Contact 5 to 8
2	Card 2 Contact 1 to 4
3	Card 2 Contact 5 to 8
4	Card 3 Contact 1 to 4
5	Card 3 Contact 5 to 8

F491
ENUMERATION: ANALOG INPUT MODE

0 = Default Value, 1 = Last Known

F500
UR_UINT16: PACKED BITFIELD

First register indicates input/output state with bits 0 (MSB) to 15 (LSB) corresponding to input/output state 1 to 16. The second register indicates input/output state with bits 0 to 15 corresponding to input/output state 17 to 32 (if required) The third register indicates input/output state with bits 0 to 15 corresponding to input/output state 33 to 48 (if required). The fourth register indicates input/output state with bits 0 to 15 corresponding to input/output state 49 to 64 (if required).

The number of registers required is determined by the specific data item. A bit value of 0 = Off and 1 = On.

F501
UR_UINT16: LED STATUS

Low byte of register indicates LED status with bit 0 representing the top LED and bit 7 the bottom LED. A bit value of 1 indicates the LED is on, 0 indicates the LED is off.

F502
BITFIELD: ELEMENT OPERATE STATES

Each bit contains the operate state for an element. See the F124 format code for a list of element IDs. The operate bit for element ID X is bit [X mod 16] in register [X/16].

F504
BITFIELD: 3-PHASE ELEMENT STATE

bitmask	element state
0	Pickup
1	Operate
2	Pickup Phase A
3	Pickup Phase B
4	Pickup Phase C
5	Operate Phase A
6	Operate Phase B
7	Operate Phase C

F505
BITFIELD: CONTACT OUTPUT STATE

0 = Contact State, 1 = Voltage Detected, 2 = Current Detected

F507
BITFIELD: COUNTER ELEMENT STATE

0 = Count Greater Than, 1 = Count Equal To, 2 = Count Less Than

F509
BITFIELD: SIMPLE ELEMENT STATE

0 = Operate

F510
BITFIELD: 87L ELEMENT STATE

bitmask	87L Element State
0	Operate A
1	Operate B
2	Operate C
3	Received DTT
4	Operate
5	Key DTT
6	PFLL FAIL
7	PFLL OK
8	Channel 1 FAIL
9	Channel 2 FAIL
10	Channel 1 Lost Packet
11	Channel 2 Lost Packet
12	Channel 1 CRC Fail
13	Channel 2 CRC Fail

F511
BITFIELD: 3-PHASE SIMPLE ELEMENT STATE

0 = Operate, 1 = Operate A, 2 = Operate B, 3 = Operate C

F515
ENUMERATION ELEMENT INPUT MODE

0 = Signed, 1 = Absolute

F516
ENUMERATION ELEMENT COMPARE MODE

0 = Level, 1 = Delta

F518
ENUMERATION: FLEXELEMENT UNITS

0 = Milliseconds, 1 = Seconds, 2 = Minutes

F519
ENUMERATION: NON-VOLATILE LATCH

0 = Reset-Dominant, 1 = Set-Dominant

F522
ENUMERATION: TRANSDUCER DCMA OUTPUT RANGE

0 = –1 to 1 mA; 1 = 0 to 1 mA; 2 = 4 to 20 mA

F523
ENUMERATION: DNP OBJECTS 20, 22, AND 23 DEFAULT VARIATION

bitmask	default variation
0	1
1	2
2	5
3	6

F524
ENUMERATION: DNP OBJECT 21 DEFAULT VARIATION

bitmask	Default Variation
0	1
1	2
2	9
3	10

F525
ENUMERATION: DNP OBJECT 32 DEFAULT VARIATION

bitmask	default variation
0	1
1	2
2	3
3	4
4	5
5	7

F530
ENUMERATION: FRONT PANEL INTERFACE KEYPRESS

value	keypress
0	None
1	Menu
2	Message Up
3	7
4	8
5	9
6	Help
7	Message Left
8	4
9	5
10	6
11	Escape
12	Message Right
13	1
14	2

value	keypress
15	3
16	Enter
17	Message Down
18	0
19	Decimal
20	+/–
21	Value Up
22	Value Down
23	Reset
24	User 1
25	User 2
26	User 3
31	User PB 1
32	User PB 2

value	keypress
33	User PB 3
34	User PB 4
35	User PB 5
36	User PB 6
37	User PB 7
38	User PB 8
39	User PB 9
40	User PB 10
41	User PB 11
42	User PB 12
44	User 4
45	User 5
46	User 6
47	User 7

F531
ENUMERATION: LANGUAGE

0 = English, 1 = French, 2 = Chinese, 3 = Russian, 4 = Turkish

F540
ENUMERATION: PMU POST-FILTER

0 = None, 1 = Symm-3-Point, 2 = Symm-5-Point,
3 = Symm-7-Point, 4 = Class M, 5 = Class P

F542
ENUMERATION: PMU TRIGGERING MODE

0 = Automatic Overwrite, 1 = Protected

F543
ENUMERATION: PMU PHASORS

value	phasor
0	Off
1	Va
2	Vb
3	Vc
4	Vx
5	Ia
6	Ib
7	Ic

value	phasor
8	Ig
9	V_1
10	V_2
11	V_0
12	I_1
13	I_2
14	I_0

B

B

F544
ENUMERATION: PMU RECORDING/REPORTING RATE

value	rate
0	1/second
1	2/second
2	4/second
3	5/second
4	10/second
5	12/second
6	15/second

value	rate
7	20second
8	25/second
9	30/second
10	50/second
11	60/second
12	100/second
13	120/second

F545
ENUMERATION: PMU COM PORT TYPE

0 = Network, 1 = RS485, 2 = Dir Comm Ch1, 3 = Dir Comm Ch2, 4 = GOOSE, 5 = None

F546
ENUMERATION: PMU REPORTING STYLE

0 = Polar, 1 = Rectangular

F547
ENUMERATION: PMU REPORTING FORMAT

0 = Integer, 1 = Floating

F560
ENUMERATION: IN-ZONE TRANSFORMER CONNECTION

Enumeration	In-zone transformer connnection
0	None
1	0° lag
2	30° lag
3	60° lag
4	90° lag
5	120° lag
6	150° lag
7	180° lag
8	210° lag
9	240° lag
10	270° lag
11	300° lag
12	330° lag

F561
ENUMERATION: 87L INRUSH INHIBIT MODE

Enumeration	Inrush inhibit mode
0	Disabled
1	Per phase
2	Two out of three
3	Average

F562
ENUMERATION: 87L IN-ZONE TRANSFORMER LOCATION

Enumeration	In-zone transformer location
0	Local-tap
1	Remote 1-tap
2	Remote 2-tap

F600
UR_UINT16: FLEXANALOG PARAMETER

Corresponds to the Modbus address of the value used when this parameter is selected. Only certain values may be used as FlexAnalogs (basically all metering quantities used in protection).

F605
ENUMERATION: REMOTE DOUBLE-POINT STATUS INPUT STATUS

Enumeration	Remote DPS input status
0	Intermediate
1	Off
2	On
3	Bad

F606
ENUMERATION: REMOTE DOUBLE-POINT STATUS INPUT

Enumeration	Remote double-point status input
0	None
1	Remote input 1
2	Remote input 2
3	Remote input 3
↓	↓
64	Remote input 64

F611
ENUMERATION: GOOSE RETRANSMISSION SCHEME

Enumeration	Configurable GOOSE retransmission scheme
0	Heartbeat
1	Aggressive
2	Medium
3	Relaxed

F612
UR_UINT16: FLEXINTEGER PARAMETER

This 16-bit value corresponds to the Modbus address of the selected FlexInteger parameter. Only certain values may be used as FlexIntegers.

F615
ENUMERATION: IEC 61850 REPORT DATASET ITEMS

Enumeration	IEC 61850 report dataset items
0	None
1	PDIF1.ST.Str.general
2	PDIF1.ST.Op.general
3	PDIF2.ST.Str.general
4	PDIF2.ST.Op.general
5	PDIF3.ST.Str.general
6	PDIF3.ST.Op.general
7	PDIF4.ST.Str.general
8	PDIF4.ST.Op.general
9	PDIS1.ST.Str.general
10	PDIS1.ST.Op.general
11	PDIS2.ST.Str.general
12	PDIS2.ST.Op.general
13	PDIS3.ST.Str.general
14	PDIS3.ST.Op.general
15	PDIS4.ST.Str.general
16	PDIS4.ST.Op.general
17	PDIS5.ST.Str.general
18	PDIS5.ST.Op.general
19	PDIS6.ST.Str.general
20	PDIS6.ST.Op.general
21	PDIS7.ST.Str.general
22	PDIS7.ST.Op.general
23	PDIS8.ST.Str.general
24	PDIS8.ST.Op.general
25	PDIS9.ST.Str.general
26	PDIS9.ST.Op.general
27	PDIS10.ST.Str.general
28	PDIS10.ST.Op.general
29	PIOC1.ST.Str.general
30	PIOC1.ST.Op.general
31	PIOC2.ST.Str.general
32	PIOC2.ST.Op.general
33	PIOC3.ST.Str.general
34	PIOC3.ST.Op.general
35	PIOC4.ST.Str.general
36	PIOC4.ST.Op.general
37	PIOC5.ST.Str.general
38	PIOC5.ST.Op.general
39	PIOC6.ST.Str.general
40	PIOC6.ST.Op.general
41	PIOC7.ST.Str.general
42	PIOC7.ST.Op.general
43	PIOC8.ST.Str.general
44	PIOC8.ST.Op.general
45	PIOC9.ST.Str.general
46	PIOC9.ST.Op.general
47	PIOC10.ST.Str.general
48	PIOC10.ST.Op.general
49	PIOC11.ST.Str.general
50	PIOC11.ST.Op.general
51	PIOC12.ST.Str.general
52	PIOC12.ST.Op.general
53	PIOC13.ST.Str.general
54	PIOC13.ST.Op.general
55	PIOC14.ST.Str.general
56	PIOC14.ST.Op.general
57	PIOC15.ST.Str.general
58	PIOC15.ST.Op.general
59	PIOC16.ST.Str.general
60	PIOC16.ST.Op.general
61	PIOC17.ST.Str.general
62	PIOC17.ST.Op.general
63	PIOC18.ST.Str.general
64	PIOC18.ST.Op.general
65	PIOC19.ST.Str.general
66	PIOC19.ST.Op.general
67	PIOC20.ST.Str.general
68	PIOC20.ST.Op.general
69	PIOC21.ST.Str.general
70	PIOC21.ST.Op.general
71	PIOC22.ST.Str.general
72	PIOC22.ST.Op.general
73	PIOC23.ST.Str.general
74	PIOC23.ST.Op.general
75	PIOC24.ST.Str.general
76	PIOC24.ST.Op.general
77	PIOC25.ST.Str.general
78	PIOC25.ST.Op.general
79	PIOC26.ST.Str.general
80	PIOC26.ST.Op.general
81	PIOC27.ST.Str.general
82	PIOC27.ST.Op.general
83	PIOC28.ST.Str.general
84	PIOC28.ST.Op.general
85	PIOC29.ST.Str.general
86	PIOC29.ST.Op.general
87	PIOC30.ST.Str.general
88	PIOC30.ST.Op.general
89	PIOC31.ST.Str.general
90	PIOC31.ST.Op.general
91	PIOC32.ST.Str.general
92	PIOC32.ST.Op.general
93	PIOC33.ST.Str.general
94	PIOC33.ST.Op.general
95	PIOC34.ST.Str.general
96	PIOC34.ST.Op.general
97	PIOC35.ST.Str.general
98	PIOC35.ST.Op.general
99	PIOC36.ST.Str.general
100	PIOC36.ST.Op.general
101	PIOC37.ST.Str.general

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Enumeration	IEC 61850 report dataset items
102	PIOC37.ST.Op.general
103	PIOC38.ST.Str.general
104	PIOC38.ST.Op.general
105	PIOC39.ST.Str.general
106	PIOC39.ST.Op.general
107	PIOC40.ST.Str.general
108	PIOC40.ST.Op.general
109	PIOC41.ST.Str.general
110	PIOC41.ST.Op.general
111	PIOC42.ST.Str.general
112	PIOC42.ST.Op.general
113	PIOC43.ST.Str.general
114	PIOC43.ST.Op.general
115	PIOC44.ST.Str.general
116	PIOC44.ST.Op.general
117	PIOC45.ST.Str.general
118	PIOC45.ST.Op.general
119	PIOC46.ST.Str.general
120	PIOC46.ST.Op.general
121	PIOC47.ST.Str.general
122	PIOC47.ST.Op.general
123	PIOC48.ST.Str.general
124	PIOC48.ST.Op.general
125	PIOC49.ST.Str.general
126	PIOC49.ST.Op.general
127	PIOC50.ST.Str.general
128	PIOC50.ST.Op.general
129	PIOC51.ST.Str.general
130	PIOC51.ST.Op.general
131	PIOC52.ST.Str.general
132	PIOC52.ST.Op.general
133	PIOC53.ST.Str.general
134	PIOC53.ST.Op.general
135	PIOC54.ST.Str.general
136	PIOC54.ST.Op.general
137	PIOC55.ST.Str.general
138	PIOC55.ST.Op.general
139	PIOC56.ST.Str.general
140	PIOC56.ST.Op.general
141	PIOC57.ST.Str.general
142	PIOC57.ST.Op.general
143	PIOC58.ST.Str.general
144	PIOC58.ST.Op.general
145	PIOC59.ST.Str.general
146	PIOC59.ST.Op.general
147	PIOC60.ST.Str.general
148	PIOC60.ST.Op.general
149	PIOC61.ST.Str.general
150	PIOC61.ST.Op.general
151	PIOC62.ST.Str.general
152	PIOC62.ST.Op.general
153	PIOC63.ST.Str.general
154	PIOC63.ST.Op.general

Enumeration	IEC 61850 report dataset items
155	PIOC64.ST.Str.general
156	PIOC64.ST.Op.general
157	PIOC65.ST.Str.general
158	PIOC65.ST.Op.general
159	PIOC66.ST.Str.general
160	PIOC66.ST.Op.general
161	PIOC67.ST.Str.general
162	PIOC67.ST.Op.general
163	PIOC68.ST.Str.general
164	PIOC68.ST.Op.general
165	PIOC69.ST.Str.general
166	PIOC69.ST.Op.general
167	PIOC70.ST.Str.general
168	PIOC70.ST.Op.general
169	PIOC71.ST.Str.general
170	PIOC71.ST.Op.general
171	PIOC72.ST.Str.general
172	PIOC72.ST.Op.general
173	PTOC1.ST.Str.general
174	PTOC1.ST.Op.general
175	PTOC2.ST.Str.general
176	PTOC2.ST.Op.general
177	PTOC3.ST.Str.general
178	PTOC3.ST.Op.general
179	PTOC4.ST.Str.general
180	PTOC4.ST.Op.general
181	PTOC5.ST.Str.general
182	PTOC5.ST.Op.general
183	PTOC6.ST.Str.general
184	PTOC6.ST.Op.general
185	PTOC7.ST.Str.general
186	PTOC7.ST.Op.general
187	PTOC8.ST.Str.general
188	PTOC8.ST.Op.general
189	PTOC9.ST.Str.general
190	PTOC9.ST.Op.general
191	PTOC10.ST.Str.general
192	PTOC10.ST.Op.general
193	PTOC11.ST.Str.general
194	PTOC11.ST.Op.general
195	PTOC12.ST.Str.general
196	PTOC12.ST.Op.general
197	PTOC13.ST.Str.general
198	PTOC13.ST.Op.general
199	PTOC14.ST.Str.general
200	PTOC14.ST.Op.general
201	PTOC15.ST.Str.general
202	PTOC15.ST.Op.general
203	PTOC16.ST.Str.general
204	PTOC16.ST.Op.general
205	PTOC17.ST.Str.general
206	PTOC17.ST.Op.general
207	PTOC18.ST.Str.general

Enumeration	IEC 61850 report dataset items
208	PTOC18.ST.Op.general
209	PTOC19.ST.Str.general
210	PTOC19.ST.Op.general
211	PTOC20.ST.Str.general
212	PTOC20.ST.Op.general
213	PTOC21.ST.Str.general
214	PTOC21.ST.Op.general
215	PTOC22.ST.Str.general
216	PTOC22.ST.Op.general
217	PTOC23.ST.Str.general
218	PTOC23.ST.Op.general
219	PTOC24.ST.Str.general
220	PTOC24.ST.Op.general
221	PTOV1.ST.Str.general
222	PTOV1.ST.Op.general
223	PTOV2.ST.Str.general
224	PTOV2.ST.Op.general
225	PTOV3.ST.Str.general
226	PTOV3.ST.Op.general
227	PTOV4.ST.Str.general
228	PTOV4.ST.Op.general
229	PTOV5.ST.Str.general
230	PTOV5.ST.Op.general
231	PTOV6.ST.Str.general
232	PTOV6.ST.Op.general
233	PTOV7.ST.Str.general
234	PTOV7.ST.Op.general
235	PTOV8.ST.Str.general
236	PTOV8.ST.Op.general
237	PTOV9.ST.Str.general
238	PTOV9.ST.Op.general
239	PTOV10.ST.Str.general
240	PTOV10.ST.Op.general
241	PTRC1.ST.Tr.general
242	PTRC1.ST.Op.general
243	PTRC2.ST.Tr.general
244	PTRC2.ST.Op.general
245	PTRC3.ST.Tr.general
246	PTRC3.ST.Op.general
247	PTRC4.ST.Tr.general
248	PTRC4.ST.Op.general
249	PTRC5.ST.Tr.general
250	PTRC5.ST.Op.general
251	PTRC6.ST.Tr.general
252	PTRC6.ST.Op.general
253	PTUV1.ST.Str.general
254	PTUV1.ST.Op.general
255	PTUV2.ST.Str.general
256	PTUV2.ST.Op.general
257	PTUV3.ST.Str.general
258	PTUV3.ST.Op.general
259	PTUV4.ST.Str.general
260	PTUV4.ST.Op.general

Enumeration	IEC 61850 report dataset items
261	PTUV5.ST.Str.general
262	PTUV5.ST.Op.general
263	PTUV6.ST.Str.general
264	PTUV6.ST.Op.general
265	PTUV7.ST.Str.general
266	PTUV7.ST.Op.general
267	PTUV8.ST.Str.general
268	PTUV8.ST.Op.general
269	PTUV9.ST.Str.general
270	PTUV9.ST.Op.general
271	PTUV10.ST.Str.general
272	PTUV10.ST.Op.general
273	PTUV11.ST.Str.general
274	PTUV11.ST.Op.general
275	PTUV12.ST.Str.general
276	PTUV12.ST.Op.general
277	PTUV13.ST.Str.general
278	PTUV13.ST.Op.general
279	RBRF1.ST.OpEx.general
280	RBRF1.ST.OpIn.general
281	RBRF2.ST.OpEx.general
282	RBRF2.ST.OpIn.general
283	RBRF3.ST.OpEx.general
284	RBRF3.ST.OpIn.general
285	RBRF4.ST.OpEx.general
286	RBRF4.ST.OpIn.general
287	RBRF5.ST.OpEx.general
288	RBRF5.ST.OpIn.general
289	RBRF6.ST.OpEx.general
290	RBRF6.ST.OpIn.general
291	RBRF7.ST.OpEx.general
292	RBRF7.ST.OpIn.general
293	RBRF8.ST.OpEx.general
294	RBRF8.ST.OpIn.general
295	RBRF9.ST.OpEx.general
296	RBRF9.ST.OpIn.general
297	RBRF10.ST.OpEx.general
298	RBRF10.ST.OpIn.general
299	RBRF11.ST.OpEx.general
300	RBRF11.ST.OpIn.general
301	RBRF12.ST.OpEx.general
302	RBRF12.ST.OpIn.general
303	RBRF13.ST.OpEx.general
304	RBRF13.ST.OpIn.general
305	RBRF14.ST.OpEx.general
306	RBRF14.ST.OpIn.general
307	RBRF15.ST.OpEx.general
308	RBRF15.ST.OpIn.general
309	RBRF16.ST.OpEx.general
310	RBRF16.ST.OpIn.general
311	RBRF17.ST.OpEx.general
312	RBRF17.ST.OpIn.general
313	RBRF18.ST.OpEx.general

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Enumeration	IEC 61850 report dataset items
314	RBRF18.ST.OpIn.general
315	RBRF19.ST.OpEx.general
316	RBRF19.ST.OpIn.general
317	RBRF20.ST.OpEx.general
318	RBRF20.ST.OpIn.general
319	RBRF21.ST.OpEx.general
320	RBRF21.ST.OpIn.general
321	RBRF22.ST.OpEx.general
322	RBRF22.ST.OpIn.general
323	RBRF23.ST.OpEx.general
324	RBRF23.ST.OpIn.general
325	RBRF24.ST.OpEx.general
326	RBRF24.ST.OpIn.general
327	RFLO1.MX.FltDiskm.mag.f
328	RFLO2.MX.FltDiskm.mag.f
329	RFLO3.MX.FltDiskm.mag.f
330	RFLO4.MX.FltDiskm.mag.f
331	RFLO5.MX.FltDiskm.mag.f
332	RPSB1.ST.Str.general
333	RPSB1.ST.Op.general
334	RPSB1.ST.BlkZn.stVal
335	RREC1.ST.Op.general
336	RREC1.ST.AutoRecSt.stVal
337	RREC2.ST.Op.general
338	RREC2.ST.AutoRecSt.stVal
339	RREC3.ST.Op.general
340	RREC3.ST.AutoRecSt.stVal
341	RREC4.ST.Op.general
342	RREC4.ST.AutoRecSt.stVal
343	RREC5.ST.Op.general
344	RREC5.ST.AutoRecSt.stVal
345	RREC6.ST.Op.general
346	RREC6.ST.AutoRecSt.stVal
347	CSWI1.ST.Loc.stVal
348	CSWI1.ST.Pos.stVal
349	CSWI2.ST.Loc.stVal
350	CSWI2.ST.Pos.stVal
351	CSWI3.ST.Loc.stVal
352	CSWI3.ST.Pos.stVal
353	CSWI4.ST.Loc.stVal
354	CSWI4.ST.Pos.stVal
355	CSWI5.ST.Loc.stVal
356	CSWI5.ST.Pos.stVal
357	CSWI6.ST.Loc.stVal
358	CSWI6.ST.Pos.stVal
359	CSWI7.ST.Loc.stVal
360	CSWI7.ST.Pos.stVal
361	CSWI8.ST.Loc.stVal
362	CSWI8.ST.Pos.stVal
363	CSWI9.ST.Loc.stVal
364	CSWI9.ST.Pos.stVal
365	CSWI10.ST.Loc.stVal
366	CSWI10.ST.Pos.stVal

Enumeration	IEC 61850 report dataset items
367	CSWI11.ST.Loc.stVal
368	CSWI11.ST.Pos.stVal
369	CSWI12.ST.Loc.stVal
370	CSWI12.ST.Pos.stVal
371	CSWI13.ST.Loc.stVal
372	CSWI13.ST.Pos.stVal
373	CSWI14.ST.Loc.stVal
374	CSWI14.ST.Pos.stVal
375	CSWI15.ST.Loc.stVal
376	CSWI15.ST.Pos.stVal
377	CSWI16.ST.Loc.stVal
378	CSWI16.ST.Pos.stVal
379	CSWI17.ST.Loc.stVal
380	CSWI17.ST.Pos.stVal
381	CSWI18.ST.Loc.stVal
382	CSWI18.ST.Pos.stVal
383	CSWI19.ST.Loc.stVal
384	CSWI19.ST.Pos.stVal
385	CSWI20.ST.Loc.stVal
386	CSWI20.ST.Pos.stVal
387	CSWI21.ST.Loc.stVal
388	CSWI21.ST.Pos.stVal
389	CSWI22.ST.Loc.stVal
390	CSWI22.ST.Pos.stVal
391	CSWI23.ST.Loc.stVal
392	CSWI23.ST.Pos.stVal
393	CSWI24.ST.Loc.stVal
394	CSWI24.ST.Pos.stVal
395	CSWI25.ST.Loc.stVal
396	CSWI25.ST.Pos.stVal
397	CSWI26.ST.Loc.stVal
398	CSWI26.ST.Pos.stVal
399	CSWI27.ST.Loc.stVal
400	CSWI27.ST.Pos.stVal
401	CSWI28.ST.Loc.stVal
402	CSWI28.ST.Pos.stVal
403	CSWI29.ST.Loc.stVal
404	CSWI29.ST.Pos.stVal
405	CSWI30.ST.Loc.stVal
406	CSWI30.ST.Pos.stVal
407	GGIO1.ST.Ind1.stVal
408	GGIO1.ST.Ind2.stVal
409	GGIO1.ST.Ind3.stVal
410	GGIO1.ST.Ind4.stVal
411	GGIO1.ST.Ind5.stVal
412	GGIO1.ST.Ind6.stVal
413	GGIO1.ST.Ind7.stVal
414	GGIO1.ST.Ind8.stVal
415	GGIO1.ST.Ind9.stVal
416	GGIO1.ST.Ind10.stVal
417	GGIO1.ST.Ind11.stVal
418	GGIO1.ST.Ind12.stVal
419	GGIO1.ST.Ind13.stVal

Enumeration	IEC 61850 report dataset items
420	GGIO1.ST.Ind14.stVal
421	GGIO1.ST.Ind15.stVal
422	GGIO1.ST.Ind16.stVal
423	GGIO1.ST.Ind17.stVal
424	GGIO1.ST.Ind18.stVal
425	GGIO1.ST.Ind19.stVal
426	GGIO1.ST.Ind20.stVal
427	GGIO1.ST.Ind21.stVal
428	GGIO1.ST.Ind22.stVal
429	GGIO1.ST.Ind23.stVal
430	GGIO1.ST.Ind24.stVal
431	GGIO1.ST.Ind25.stVal
432	GGIO1.ST.Ind26.stVal
433	GGIO1.ST.Ind27.stVal
434	GGIO1.ST.Ind28.stVal
435	GGIO1.ST.Ind29.stVal
436	GGIO1.ST.Ind30.stVal
437	GGIO1.ST.Ind31.stVal
438	GGIO1.ST.Ind32.stVal
439	GGIO1.ST.Ind33.stVal
440	GGIO1.ST.Ind34.stVal
441	GGIO1.ST.Ind35.stVal
442	GGIO1.ST.Ind36.stVal
443	GGIO1.ST.Ind37.stVal
444	GGIO1.ST.Ind38.stVal
445	GGIO1.ST.Ind39.stVal
446	GGIO1.ST.Ind40.stVal
447	GGIO1.ST.Ind41.stVal
448	GGIO1.ST.Ind42.stVal
449	GGIO1.ST.Ind43.stVal
450	GGIO1.ST.Ind44.stVal
451	GGIO1.ST.Ind45.stVal
452	GGIO1.ST.Ind46.stVal
453	GGIO1.ST.Ind47.stVal
454	GGIO1.ST.Ind48.stVal
455	GGIO1.ST.Ind49.stVal
456	GGIO1.ST.Ind50.stVal
457	GGIO1.ST.Ind51.stVal
458	GGIO1.ST.Ind52.stVal
459	GGIO1.ST.Ind53.stVal
460	GGIO1.ST.Ind54.stVal
461	GGIO1.ST.Ind55.stVal
462	GGIO1.ST.Ind56.stVal
463	GGIO1.ST.Ind57.stVal
464	GGIO1.ST.Ind58.stVal
465	GGIO1.ST.Ind59.stVal
466	GGIO1.ST.Ind60.stVal
467	GGIO1.ST.Ind61.stVal
468	GGIO1.ST.Ind62.stVal
469	GGIO1.ST.Ind63.stVal
470	GGIO1.ST.Ind64.stVal
471	GGIO1.ST.Ind65.stVal
472	GGIO1.ST.Ind66.stVal

Enumeration	IEC 61850 report dataset items
473	GGIO1.ST.Ind67.stVal
474	GGIO1.ST.Ind68.stVal
475	GGIO1.ST.Ind69.stVal
476	GGIO1.ST.Ind70.stVal
477	GGIO1.ST.Ind71.stVal
478	GGIO1.ST.Ind72.stVal
479	GGIO1.ST.Ind73.stVal
480	GGIO1.ST.Ind74.stVal
481	GGIO1.ST.Ind75.stVal
482	GGIO1.ST.Ind76.stVal
483	GGIO1.ST.Ind77.stVal
484	GGIO1.ST.Ind78.stVal
485	GGIO1.ST.Ind79.stVal
486	GGIO1.ST.Ind80.stVal
487	GGIO1.ST.Ind81.stVal
488	GGIO1.ST.Ind82.stVal
489	GGIO1.ST.Ind83.stVal
490	GGIO1.ST.Ind84.stVal
491	GGIO1.ST.Ind85.stVal
492	GGIO1.ST.Ind86.stVal
493	GGIO1.ST.Ind87.stVal
494	GGIO1.ST.Ind88.stVal
495	GGIO1.ST.Ind89.stVal
496	GGIO1.ST.Ind90.stVal
497	GGIO1.ST.Ind91.stVal
498	GGIO1.ST.Ind92.stVal
499	GGIO1.ST.Ind93.stVal
500	GGIO1.ST.Ind94.stVal
501	GGIO1.ST.Ind95.stVal
502	GGIO1.ST.Ind96.stVal
503	GGIO1.ST.Ind97.stVal
504	GGIO1.ST.Ind98.stVal
505	GGIO1.ST.Ind99.stVal
506	GGIO1.ST.Ind100.stVal
507	GGIO1.ST.Ind101.stVal
508	GGIO1.ST.Ind102.stVal
509	GGIO1.ST.Ind103.stVal
510	GGIO1.ST.Ind104.stVal
511	GGIO1.ST.Ind105.stVal
512	GGIO1.ST.Ind106.stVal
513	GGIO1.ST.Ind107.stVal
514	GGIO1.ST.Ind108.stVal
515	GGIO1.ST.Ind109.stVal
516	GGIO1.ST.Ind110.stVal
517	GGIO1.ST.Ind111.stVal
518	GGIO1.ST.Ind112.stVal
519	GGIO1.ST.Ind113.stVal
520	GGIO1.ST.Ind114.stVal
521	GGIO1.ST.Ind115.stVal
522	GGIO1.ST.Ind116.stVal
523	GGIO1.ST.Ind117.stVal
524	GGIO1.ST.Ind118.stVal
525	GGIO1.ST.Ind119.stVal

B

Enumeration	IEC 61850 report dataset items
526	GGIO1.ST.Ind120.stVal
527	GGIO1.ST.Ind121.stVal
528	GGIO1.ST.Ind122.stVal
529	GGIO1.ST.Ind123.stVal
530	GGIO1.ST.Ind124.stVal
531	GGIO1.ST.Ind125.stVal
532	GGIO1.ST.Ind126.stVal
533	GGIO1.ST.Ind127.stVal
534	GGIO1.ST.Ind128.stVal
535	MMXU1.MX.TotW.mag.f
536	MMXU1.MX.TotVAr.mag.f
537	MMXU1.MX.TotVA.mag.f
538	MMXU1.MX.TotPF.mag.f
539	MMXU1.MX.Hz.mag.f
540	MMXU1.MX.PPV.phsAB.cVal.mag.f
541	MMXU1.MX.PPV.phsAB.cVal.ang.f
542	MMXU1.MX.PPV.phsBC.cVal.mag.f
543	MMXU1.MX.PPV.phsBC.cVal.ang.f
544	MMXU1.MX.PPV.phsCA.cVal.mag.f
545	MMXU1.MX.PPV.phsCA.cVal.ang.f
546	MMXU1.MX.PhV.phsA.cVal.mag.f
547	MMXU1.MX.PhV.phsA.cVal.ang.f
548	MMXU1.MX.PhV.phsB.cVal.mag.f
549	MMXU1.MX.PhV.phsB.cVal.ang.f
550	MMXU1.MX.PhV.phsC.cVal.mag.f
551	MMXU1.MX.PhV.phsC.cVal.ang.f
552	MMXU1.MX.A.phsA.cVal.mag.f
553	MMXU1.MX.A.phsA.cVal.ang.f
554	MMXU1.MX.A.phsB.cVal.mag.f
555	MMXU1.MX.A.phsB.cVal.ang.f
556	MMXU1.MX.A.phsC.cVal.mag.f
557	MMXU1.MX.A.phsC.cVal.ang.f
558	MMXU1.MX.A.neut.cVal.mag.f
559	MMXU1.MX.A.neut.cVal.ang.f
560	MMXU1.MX.W.phsA.cVal.mag.f
561	MMXU1.MX.W.phsB.cVal.mag.f
562	MMXU1.MX.W.phsC.cVal.mag.f
563	MMXU1.MX.VAr.phsA.cVal.mag.f
564	MMXU1.MX.VAr.phsB.cVal.mag.f
565	MMXU1.MX.VAr.phsC.cVal.mag.f
566	MMXU1.MX.VA.phsA.cVal.mag.f
567	MMXU1.MX.VA.phsB.cVal.mag.f
568	MMXU1.MX.VA.phsC.cVal.mag.f
569	MMXU1.MX.PF.phsA.cVal.mag.f
570	MMXU1.MX.PF.phsB.cVal.mag.f
571	MMXU1.MX.PF.phsC.cVal.mag.f
572	MMXU2.MX.TotW.mag.f
573	MMXU2.MX.TotVAr.mag.f
574	MMXU2.MX.TotVA.mag.f
575	MMXU2.MX.TotPF.mag.f
576	MMXU2.MX.Hz.mag.f
577	MMXU2.MX.PPV.phsAB.cVal.mag.f
578	MMXU2.MX.PPV.phsAB.cVal.ang.f

Enumeration	IEC 61850 report dataset items
579	MMXU2.MX.PPV.phsBC.cVal.mag.f
580	MMXU2.MX.PPV.phsBC.cVal.ang.f
581	MMXU2.MX.PPV.phsCA.cVal.mag.f
582	MMXU2.MX.PPV.phsCA.cVal.ang.f
583	MMXU2.MX.PhV.phsA.cVal.mag.f
584	MMXU2.MX.PhV.phsA.cVal.ang.f
585	MMXU2.MX.PhV.phsB.cVal.mag.f
586	MMXU2.MX.PhV.phsB.cVal.ang.f
587	MMXU2.MX.PhV.phsC.cVal.mag.f
588	MMXU2.MX.PhV.phsC.cVal.ang.f
589	MMXU2.MX.A.phsA.cVal.mag.f
590	MMXU2.MX.A.phsA.cVal.ang.f
591	MMXU2.MX.A.phsB.cVal.mag.f
592	MMXU2.MX.A.phsB.cVal.ang.f
593	MMXU2.MX.A.phsC.cVal.mag.f
594	MMXU2.MX.A.phsC.cVal.ang.f
595	MMXU2.MX.A.neut.cVal.mag.f
596	MMXU2.MX.A.neut.cVal.ang.f
597	MMXU2.MX.W.phsA.cVal.mag.f
598	MMXU2.MX.W.phsB.cVal.mag.f
599	MMXU2.MX.W.phsC.cVal.mag.f
600	MMXU2.MX.VAr.phsA.cVal.mag.f
601	MMXU2.MX.VAr.phsB.cVal.mag.f
602	MMXU2.MX.VAr.phsC.cVal.mag.f
603	MMXU2.MX.VA.phsA.cVal.mag.f
604	MMXU2.MX.VA.phsB.cVal.mag.f
605	MMXU2.MX.VA.phsC.cVal.mag.f
606	MMXU2.MX.PF.phsA.cVal.mag.f
607	MMXU2.MX.PF.phsB.cVal.mag.f
608	MMXU2.MX.PF.phsC.cVal.mag.f
609	MMXU3.MX.TotW.mag.f
610	MMXU3.MX.TotVAr.mag.f
611	MMXU3.MX.TotVA.mag.f
612	MMXU3.MX.TotPF.mag.f
613	MMXU3.MX.Hz.mag.f
614	MMXU3.MX.PPV.phsAB.cVal.mag.f
615	MMXU3.MX.PPV.phsAB.cVal.ang.f
616	MMXU3.MX.PPV.phsBC.cVal.mag.f
617	MMXU3.MX.PPV.phsBC.cVal.ang.f
618	MMXU3.MX.PPV.phsCA.cVal.mag.f
619	MMXU3.MX.PPV.phsCA.cVal.ang.f
620	MMXU3.MX.PhV.phsA.cVal.mag.f
621	MMXU3.MX.PhV.phsA.cVal.ang.f
622	MMXU3.MX.PhV.phsB.cVal.mag.f
623	MMXU3.MX.PhV.phsB.cVal.ang.f
624	MMXU3.MX.PhV.phsC.cVal.mag.f
625	MMXU3.MX.PhV.phsC.cVal.ang.f
626	MMXU3.MX.A.phsA.cVal.mag.f
627	MMXU3.MX.A.phsA.cVal.ang.f
628	MMXU3.MX.A.phsB.cVal.mag.f
629	MMXU3.MX.A.phsB.cVal.ang.f
630	MMXU3.MX.A.phsC.cVal.mag.f
631	MMXU3.MX.A.phsC.cVal.ang.f

Enumeration	IEC 61850 report dataset items
632	MMXU3.MX.A.neut.cVal.mag.f
633	MMXU3.MX.A.neut.cVal.ang.f
634	MMXU3.MX.W.phsA.cVal.mag.f
635	MMXU3.MX.W.phsB.cVal.mag.f
636	MMXU3.MX.W.phsC.cVal.mag.f
637	MMXU3.MX.VAr.phsA.cVal.mag.f
638	MMXU3.MX.VAr.phsB.cVal.mag.f
639	MMXU3.MX.VAr.phsC.cVal.mag.f
640	MMXU3.MX.VA.phsA.cVal.mag.f
641	MMXU3.MX.VA.phsB.cVal.mag.f
642	MMXU3.MX.VA.phsC.cVal.mag.f
643	MMXU3.MX.PF.phsA.cVal.mag.f
644	MMXU3.MX.PF.phsB.cVal.mag.f
645	MMXU3.MX.PF.phsC.cVal.mag.f
646	MMXU4.MX.TotW.mag.f
647	MMXU4.MX.TotVAr.mag.f
648	MMXU4.MX.TotVA.mag.f
649	MMXU4.MX.TotPF.mag.f
650	MMXU4.MX.Hz.mag.f
651	MMXU4.MX.PPV.phsAB.cVal.mag.f
652	MMXU4.MX.PPV.phsAB.cVal.ang.f
653	MMXU4.MX.PPV.phsBC.cVal.mag.f
654	MMXU4.MX.PPV.phsBC.cVal.ang.f
655	MMXU4.MX.PPV.phsCA.cVal.mag.f
656	MMXU4.MX.PPV.phsCA.cVal.ang.f
657	MMXU4.MX.PhV.phsA.cVal.mag.f
658	MMXU4.MX.PhV.phsA.cVal.ang.f
659	MMXU4.MX.PhV.phsB.cVal.mag.f
660	MMXU4.MX.PhV.phsB.cVal.ang.f
661	MMXU4.MX.PhV.phsC.cVal.mag.f
662	MMXU4.MX.PhV.phsC.cVal.ang.f
663	MMXU4.MX.A.phsA.cVal.mag.f
664	MMXU4.MX.A.phsA.cVal.ang.f
665	MMXU4.MX.A.phsB.cVal.mag.f
666	MMXU4.MX.A.phsB.cVal.ang.f
667	MMXU4.MX.A.phsC.cVal.mag.f
668	MMXU4.MX.A.phsC.cVal.ang.f
669	MMXU4.MX.A.neut.cVal.mag.f
670	MMXU4.MX.A.neut.cVal.ang.f
671	MMXU4.MX.W.phsA.cVal.mag.f
672	MMXU4.MX.W.phsB.cVal.mag.f
673	MMXU4.MX.W.phsC.cVal.mag.f
674	MMXU4.MX.VAr.phsA.cVal.mag.f
675	MMXU4.MX.VAr.phsB.cVal.mag.f
676	MMXU4.MX.VAr.phsC.cVal.mag.f
677	MMXU4.MX.VA.phsA.cVal.mag.f
678	MMXU4.MX.VA.phsB.cVal.mag.f
679	MMXU4.MX.VA.phsC.cVal.mag.f
680	MMXU4.MX.PF.phsA.cVal.mag.f
681	MMXU4.MX.PF.phsB.cVal.mag.f
682	MMXU4.MX.PF.phsC.cVal.mag.f
683	MMXU5.MX.TotW.mag.f
684	MMXU5.MX.TotVAr.mag.f

Enumeration	IEC 61850 report dataset items
685	MMXU5.MX.TotVA.mag.f
686	MMXU5.MX.TotPF.mag.f
687	MMXU5.MX.Hz.mag.f
688	MMXU5.MX.PPV.phsAB.cVal.mag.f
689	MMXU5.MX.PPV.phsAB.cVal.ang.f
690	MMXU5.MX.PPV.phsBC.cVal.mag.f
691	MMXU5.MX.PPV.phsBC.cVal.ang.f
692	MMXU5.MX.PPV.phsCA.cVal.mag.f
693	MMXU5.MX.PPV.phsCA.cVal.ang.f
694	MMXU5.MX.PhV.phsA.cVal.mag.f
695	MMXU5.MX.PhV.phsA.cVal.ang.f
696	MMXU5.MX.PhV.phsB.cVal.mag.f
697	MMXU5.MX.PhV.phsB.cVal.ang.f
698	MMXU5.MX.PhV.phsC.cVal.mag.f
699	MMXU5.MX.PhV.phsC.cVal.ang.f
700	MMXU5.MX.A.phsA.cVal.mag.f
701	MMXU5.MX.A.phsA.cVal.ang.f
702	MMXU5.MX.A.phsB.cVal.mag.f
703	MMXU5.MX.A.phsB.cVal.ang.f
704	MMXU5.MX.A.phsC.cVal.mag.f
705	MMXU5.MX.A.phsC.cVal.ang.f
706	MMXU5.MX.A.neut.cVal.mag.f
707	MMXU5.MX.A.neut.cVal.ang.f
708	MMXU5.MX.W.phsA.cVal.mag.f
709	MMXU5.MX.W.phsB.cVal.mag.f
710	MMXU5.MX.W.phsC.cVal.mag.f
711	MMXU5.MX.VAr.phsA.cVal.mag.f
712	MMXU5.MX.VAr.phsB.cVal.mag.f
713	MMXU5.MX.VAr.phsC.cVal.mag.f
714	MMXU5.MX.VA.phsA.cVal.mag.f
715	MMXU5.MX.VA.phsB.cVal.mag.f
716	MMXU5.MX.VA.phsC.cVal.mag.f
717	MMXU5.MX.PF.phsA.cVal.mag.f
718	MMXU5.MX.PF.phsB.cVal.mag.f
719	MMXU5.MX.PF.phsC.cVal.mag.f
720	MMXU6.MX.TotW.mag.f
721	MMXU6.MX.TotVAr.mag.f
722	MMXU6.MX.TotVA.mag.f
723	MMXU6.MX.TotPF.mag.f
724	MMXU6.MX.Hz.mag.f
725	MMXU6.MX.PPV.phsAB.cVal.mag.f
726	MMXU6.MX.PPV.phsAB.cVal.ang.f
727	MMXU6.MX.PPV.phsBC.cVal.mag.f
728	MMXU6.MX.PPV.phsBC.cVal.ang.f
729	MMXU6.MX.PPV.phsCA.cVal.mag.f
730	MMXU6.MX.PPV.phsCA.cVal.ang.f
731	MMXU6.MX.PhV.phsA.cVal.mag.f
732	MMXU6.MX.PhV.phsA.cVal.ang.f
733	MMXU6.MX.PhV.phsB.cVal.mag.f
734	MMXU6.MX.PhV.phsB.cVal.ang.f
735	MMXU6.MX.PhV.phsC.cVal.mag.f
736	MMXU6.MX.PhV.phsC.cVal.ang.f
737	MMXU6.MX.A.phsA.cVal.mag.f

B

Enumeration	IEC 61850 report dataset items
738	MMXU6.MX.A.phsA.cVal.ang.f
739	MMXU6.MX.A.phsB.cVal.mag.f
740	MMXU6.MX.A.phsB.cVal.ang.f
741	MMXU6.MX.A.phsC.cVal.mag.f
742	MMXU6.MX.A.phsC.cVal.ang.f
743	MMXU6.MX.A.neut.cVal.mag.f
744	MMXU6.MX.A.neut.cVal.ang.f
745	MMXU6.MX.W.phsA.cVal.mag.f
746	MMXU6.MX.W.phsB.cVal.mag.f
747	MMXU6.MX.W.phsC.cVal.mag.f
748	MMXU6.MX.VAr.phsA.cVal.mag.f
749	MMXU6.MX.VAr.phsB.cVal.mag.f
750	MMXU6.MX.VAr.phsC.cVal.mag.f
751	MMXU6.MX.VA.phsA.cVal.mag.f
752	MMXU6.MX.VA.phsB.cVal.mag.f
753	MMXU6.MX.VA.phsC.cVal.mag.f
754	MMXU6.MX.PF.phsA.cVal.mag.f
755	MMXU6.MX.PF.phsB.cVal.mag.f
756	MMXU6.MX.PF.phsC.cVal.mag.f
757	GGIO4.MX.AnIn1.mag.f
758	GGIO4.MX.AnIn2.mag.f
759	GGIO4.MX.AnIn3.mag.f
760	GGIO4.MX.AnIn4.mag.f
761	GGIO4.MX.AnIn5.mag.f
762	GGIO4.MX.AnIn6.mag.f
763	GGIO4.MX.AnIn7.mag.f
764	GGIO4.MX.AnIn8.mag.f
765	GGIO4.MX.AnIn9.mag.f
766	GGIO4.MX.AnIn10.mag.f
767	GGIO4.MX.AnIn11.mag.f
768	GGIO4.MX.AnIn12.mag.f
769	GGIO4.MX.AnIn13.mag.f
770	GGIO4.MX.AnIn14.mag.f
771	GGIO4.MX.AnIn15.mag.f
772	GGIO4.MX.AnIn16.mag.f
773	GGIO4.MX.AnIn17.mag.f
774	GGIO4.MX.AnIn18.mag.f
775	GGIO4.MX.AnIn19.mag.f
776	GGIO4.MX.AnIn20.mag.f
777	GGIO4.MX.AnIn21.mag.f
778	GGIO4.MX.AnIn22.mag.f
779	GGIO4.MX.AnIn23.mag.f
780	GGIO4.MX.AnIn24.mag.f
781	GGIO4.MX.AnIn25.mag.f
782	GGIO4.MX.AnIn26.mag.f
783	GGIO4.MX.AnIn27.mag.f
784	GGIO4.MX.AnIn28.mag.f
785	GGIO4.MX.AnIn29.mag.f
786	GGIO4.MX.AnIn30.mag.f
787	GGIO4.MX.AnIn31.mag.f
788	GGIO4.MX.AnIn32.mag.f
789	XSWI1.ST.Loc.stVal
790	XSWI1.ST.Pos.stVal

Enumeration	IEC 61850 report dataset items
791	XSWI2.ST.Loc.stVal
792	XSWI2.ST.Pos.stVal
793	XSWI3.ST.Loc.stVal
794	XSWI3.ST.Pos.stVal
795	XSWI4.ST.Loc.stVal
796	XSWI4.ST.Pos.stVal
797	XSWI5.ST.Loc.stVal
798	XSWI5.ST.Pos.stVal
799	XSWI6.ST.Loc.stVal
800	XSWI6.ST.Pos.stVal
801	XSWI7.ST.Loc.stVal
802	XSWI7.ST.Pos.stVal
803	XSWI8.ST.Loc.stVal
804	XSWI8.ST.Pos.stVal
805	XSWI9.ST.Loc.stVal
806	XSWI9.ST.Pos.stVal
807	XSWI10.ST.Loc.stVal
808	XSWI10.ST.Pos.stVal
809	XSWI11.ST.Loc.stVal
810	XSWI11.ST.Pos.stVal
811	XSWI12.ST.Loc.stVal
812	XSWI12.ST.Pos.stVal
813	XSWI13.ST.Loc.stVal
814	XSWI13.ST.Pos.stVal
815	XSWI14.ST.Loc.stVal
816	XSWI14.ST.Pos.stVal
817	XSWI15.ST.Loc.stVal
818	XSWI15.ST.Pos.stVal
819	XSWI16.ST.Loc.stVal
820	XSWI16.ST.Pos.stVal
821	XSWI17.ST.Loc.stVal
822	XSWI17.ST.Pos.stVal
823	XSWI18.ST.Loc.stVal
824	XSWI18.ST.Pos.stVal
825	XSWI19.ST.Loc.stVal
826	XSWI19.ST.Pos.stVal
827	XSWI20.ST.Loc.stVal
828	XSWI20.ST.Pos.stVal
829	XSWI21.ST.Loc.stVal
830	XSWI21.ST.Pos.stVal
831	XSWI22.ST.Loc.stVal
832	XSWI22.ST.Pos.stVal
833	XSWI23.ST.Loc.stVal
834	XSWI23.ST.Pos.stVal
835	XSWI24.ST.Loc.stVal
836	XSWI24.ST.Pos.stVal
837	XCBR1.ST.Loc.stVal
838	XCBR1.ST.Pos.stVal
839	XCBR2.ST.Loc.stVal
840	XCBR2.ST.Pos.stVal
841	XCBR3.ST.Loc.stVal
842	XCBR3.ST.Pos.stVal
843	XCBR4.ST.Loc.stVal

Enumeration	IEC 61850 report dataset items
844	XCBR4.ST.Pos.stVal
845	XCBR5.ST.Loc.stVal
846	XCBR5.ST.Pos.stVal
847	XCBR6.ST.Loc.stVal
848	XCBR6.ST.Pos.stVal

F616
ENUMERATION: IEC 61850 GOOSE DATASET ITEMS

Enumeration	GOOSE dataset items
0	None
1	GGIO1.ST.Ind1.q
2	GGIO1.ST.Ind1.stVal
3	GGIO1.ST.Ind2.q
4	GGIO1.ST.Ind2.stVal
5	GGIO1.ST.Ind3.q
6	GGIO1.ST.Ind3.stVal
7	GGIO1.ST.Ind4.q
8	GGIO1.ST.Ind4.stVal
9	GGIO1.ST.Ind5.q
10	GGIO1.ST.Ind5.stVal
11	GGIO1.ST.Ind6.q
12	GGIO1.ST.Ind6.stVal
13	GGIO1.ST.Ind7.q
14	GGIO1.ST.Ind7.stVal
15	GGIO1.ST.Ind8.q
16	GGIO1.ST.Ind8.stVal
17	GGIO1.ST.Ind9.q
18	GGIO1.ST.Ind9.stVal
19	GGIO1.ST.Ind10.q
20	GGIO1.ST.Ind10.stVal
21	GGIO1.ST.Ind11.q
22	GGIO1.ST.Ind11.stVal
23	GGIO1.ST.Ind12.q
24	GGIO1.ST.Ind12.stVal
25	GGIO1.ST.Ind13.q
26	GGIO1.ST.Ind13.stVal
27	GGIO1.ST.Ind14.q
28	GGIO1.ST.Ind14.stVal
29	GGIO1.ST.Ind15.q
30	GGIO1.ST.Ind15.stVal
31	GGIO1.ST.Ind16.q
32	GGIO1.ST.Ind16.stVal
33	GGIO1.ST.Ind17.q
34	GGIO1.ST.Ind17.stVal
35	GGIO1.ST.Ind18.q
36	GGIO1.ST.Ind18.stVal
37	GGIO1.ST.Ind19.q
38	GGIO1.ST.Ind19.stVal
39	GGIO1.ST.Ind20.q
40	GGIO1.ST.Ind20.stVal
41	GGIO1.ST.Ind21.q
42	GGIO1.ST.Ind21.stVal
43	GGIO1.ST.Ind22.q
44	GGIO1.ST.Ind22.stVal
45	GGIO1.ST.Ind23.q
46	GGIO1.ST.Ind23.stVal
47	GGIO1.ST.Ind24.q
48	GGIO1.ST.Ind24.stVal
49	GGIO1.ST.Ind25.q
50	GGIO1.ST.Ind25.stVal
51	GGIO1.ST.Ind26.q
52	GGIO1.ST.Ind26.stVal
53	GGIO1.ST.Ind27.q
54	GGIO1.ST.Ind27.stVal
55	GGIO1.ST.Ind28.q
56	GGIO1.ST.Ind28.stVal
57	GGIO1.ST.Ind29.q
58	GGIO1.ST.Ind29.stVal
59	GGIO1.ST.Ind30.q
60	GGIO1.ST.Ind30.stVal
61	GGIO1.ST.Ind31.q
62	GGIO1.ST.Ind31.stVal
63	GGIO1.ST.Ind32.q
64	GGIO1.ST.Ind32.stVal
65	GGIO1.ST.Ind33.q
66	GGIO1.ST.Ind33.stVal
67	GGIO1.ST.Ind34.q
68	GGIO1.ST.Ind34.stVal
69	GGIO1.ST.Ind35.q
70	GGIO1.ST.Ind35.stVal
71	GGIO1.ST.Ind36.q
72	GGIO1.ST.Ind36.stVal
73	GGIO1.ST.Ind37.q
74	GGIO1.ST.Ind37.stVal
75	GGIO1.ST.Ind38.q
76	GGIO1.ST.Ind38.stVal
77	GGIO1.ST.Ind39.q
78	GGIO1.ST.Ind39.stVal
79	GGIO1.ST.Ind40.q
80	GGIO1.ST.Ind40.stVal
81	GGIO1.ST.Ind41.q
82	GGIO1.ST.Ind41.stVal
83	GGIO1.ST.Ind42.q
84	GGIO1.ST.Ind42.stVal
85	GGIO1.ST.Ind43.q
86	GGIO1.ST.Ind43.stVal
87	GGIO1.ST.Ind44.q
88	GGIO1.ST.Ind44.stVal
89	GGIO1.ST.Ind45.q
90	GGIO1.ST.Ind45.stVal
91	GGIO1.ST.Ind46.q
92	GGIO1.ST.Ind46.stVal
93	GGIO1.ST.Ind47.q
94	GGIO1.ST.Ind47.stVal
95	GGIO1.ST.Ind48.q

B

Enumeration	GOOSE dataset items
96	GGIO1.ST.Ind48.stVal
97	GGIO1.ST.Ind49.q
98	GGIO1.ST.Ind49.stVal
99	GGIO1.ST.Ind50.q
100	GGIO1.ST.Ind50.stVal
101	GGIO1.ST.Ind51.q
102	GGIO1.ST.Ind51.stVal
103	GGIO1.ST.Ind52.q
104	GGIO1.ST.Ind52.stVal
105	GGIO1.ST.Ind53.q
106	GGIO1.ST.Ind53.stVal
107	GGIO1.ST.Ind54.q
108	GGIO1.ST.Ind54.stVal
109	GGIO1.ST.Ind55.q
110	GGIO1.ST.Ind55.stVal
111	GGIO1.ST.Ind56.q
112	GGIO1.ST.Ind56.stVal
113	GGIO1.ST.Ind57.q
114	GGIO1.ST.Ind57.stVal
115	GGIO1.ST.Ind58.q
116	GGIO1.ST.Ind58.stVal
117	GGIO1.ST.Ind59.q
118	GGIO1.ST.Ind59.stVal
119	GGIO1.ST.Ind60.q
120	GGIO1.ST.Ind60.stVal
121	GGIO1.ST.Ind61.q
122	GGIO1.ST.Ind61.stVal
123	GGIO1.ST.Ind62.q
124	GGIO1.ST.Ind62.stVal
125	GGIO1.ST.Ind63.q
126	GGIO1.ST.Ind63.stVal
127	GGIO1.ST.Ind64.q
128	GGIO1.ST.Ind64.stVal
129	GGIO1.ST.Ind65.q
130	GGIO1.ST.Ind65.stVal
131	GGIO1.ST.Ind66.q
132	GGIO1.ST.Ind66.stVal
133	GGIO1.ST.Ind67.q
134	GGIO1.ST.Ind67.stVal
135	GGIO1.ST.Ind68.q
136	GGIO1.ST.Ind68.stVal
137	GGIO1.ST.Ind69.q
138	GGIO1.ST.Ind69.stVal
139	GGIO1.ST.Ind70.q
140	GGIO1.ST.Ind70.stVal
141	GGIO1.ST.Ind71.q
142	GGIO1.ST.Ind71.stVal
143	GGIO1.ST.Ind72.q
144	GGIO1.ST.Ind72.stVal
145	GGIO1.ST.Ind73.q
146	GGIO1.ST.Ind73.stVal
147	GGIO1.ST.Ind74.q
148	GGIO1.ST.Ind74.stVal

Enumeration	GOOSE dataset items
149	GGIO1.ST.Ind75.q
150	GGIO1.ST.Ind75.stVal
151	GGIO1.ST.Ind76.q
152	GGIO1.ST.Ind76.stVal
153	GGIO1.ST.Ind77.q
154	GGIO1.ST.Ind77.stVal
155	GGIO1.ST.Ind78.q
156	GGIO1.ST.Ind78.stVal
157	GGIO1.ST.Ind79.q
158	GGIO1.ST.Ind79.stVal
159	GGIO1.ST.Ind80.q
160	GGIO1.ST.Ind80.stVal
161	GGIO1.ST.Ind81.q
162	GGIO1.ST.Ind81.stVal
163	GGIO1.ST.Ind82.q
164	GGIO1.ST.Ind82.stVal
165	GGIO1.ST.Ind83.q
166	GGIO1.ST.Ind83.stVal
167	GGIO1.ST.Ind84.q
168	GGIO1.ST.Ind84.stVal
169	GGIO1.ST.Ind85.q
170	GGIO1.ST.Ind85.stVal
171	GGIO1.ST.Ind86.q
172	GGIO1.ST.Ind86.stVal
173	GGIO1.ST.Ind87.q
174	GGIO1.ST.Ind87.stVal
175	GGIO1.ST.Ind88.q
176	GGIO1.ST.Ind88.stVal
177	GGIO1.ST.Ind89.q
178	GGIO1.ST.Ind89.stVal
179	GGIO1.ST.Ind90.q
180	GGIO1.ST.Ind90.stVal
181	GGIO1.ST.Ind91.q
182	GGIO1.ST.Ind91.stVal
183	GGIO1.ST.Ind92.q
184	GGIO1.ST.Ind92.stVal
185	GGIO1.ST.Ind93.q
186	GGIO1.ST.Ind93.stVal
187	GGIO1.ST.Ind94.q
188	GGIO1.ST.Ind94.stVal
189	GGIO1.ST.Ind95.q
190	GGIO1.ST.Ind95.stVal
191	GGIO1.ST.Ind96.q
192	GGIO1.ST.Ind96.stVal
193	GGIO1.ST.Ind97.q
194	GGIO1.ST.Ind97.stVal
195	GGIO1.ST.Ind98.q
196	GGIO1.ST.Ind98.stVal
197	GGIO1.ST.Ind99.q
198	GGIO1.ST.Ind99.stVal
199	GGIO1.ST.Ind100.q
200	GGIO1.ST.Ind100.stVal
201	GGIO1.ST.Ind101.q

Enumeration	GOOSE dataset items
202	GGIO1.ST.Ind101.stVal
203	GGIO1.ST.Ind102.q
204	GGIO1.ST.Ind102.stVal
205	GGIO1.ST.Ind103.q
206	GGIO1.ST.Ind103.stVal
207	GGIO1.ST.Ind104.q
208	GGIO1.ST.Ind104.stVal
209	GGIO1.ST.Ind105.q
210	GGIO1.ST.Ind105.stVal
211	GGIO1.ST.Ind106.q
212	GGIO1.ST.Ind106.stVal
213	GGIO1.ST.Ind107.q
214	GGIO1.ST.Ind107.stVal
215	GGIO1.ST.Ind108.q
216	GGIO1.ST.Ind108.stVal
217	GGIO1.ST.Ind109.q
218	GGIO1.ST.Ind109.stVal
219	GGIO1.ST.Ind110.q
220	GGIO1.ST.Ind110.stVal
221	GGIO1.ST.Ind111.q
222	GGIO1.ST.Ind111.stVal
223	GGIO1.ST.Ind112.q
224	GGIO1.ST.Ind112.stVal
225	GGIO1.ST.Ind113.q
226	GGIO1.ST.Ind113.stVal
227	GGIO1.ST.Ind114.q
228	GGIO1.ST.Ind114.stVal
229	GGIO1.ST.Ind115.q
230	GGIO1.ST.Ind115.stVal
231	GGIO1.ST.Ind116.q
232	GGIO1.ST.Ind116.stVal
233	GGIO1.ST.Ind117.q
234	GGIO1.ST.Ind117.stVal
235	GGIO1.ST.Ind118.q
236	GGIO1.ST.Ind118.stVal
237	GGIO1.ST.Ind119.q
238	GGIO1.ST.Ind119.stVal
239	GGIO1.ST.Ind120.q
240	GGIO1.ST.Ind120.stVal
241	GGIO1.ST.Ind121.q
242	GGIO1.ST.Ind121.stVal
243	GGIO1.ST.Ind122.q
244	GGIO1.ST.Ind122.stVal
245	GGIO1.ST.Ind123.q
246	GGIO1.ST.Ind123.stVal
247	GGIO1.ST.Ind124.q
248	GGIO1.ST.Ind124.stVal
249	GGIO1.ST.Ind125.q
250	GGIO1.ST.Ind125.stVal
251	GGIO1.ST.Ind126.q
252	GGIO1.ST.Ind126.stVal
253	GGIO1.ST.Ind127.q
254	GGIO1.ST.Ind127.stVal

Enumeration	GOOSE dataset items
255	GGIO1.ST.Ind128.q
256	GGIO1.ST.Ind128.stVal
257	MMXU1.MX.TotW.mag.f
258	MMXU1.MX.TotVAr.mag.f
259	MMXU1.MX.TotVA.mag.f
260	MMXU1.MX.TotPF.mag.f
261	MMXU1.MX.Hz.mag.f
262	MMXU1.MX.PPV.phsAB.cVal.mag.f
263	MMXU1.MX.PPV.phsAB.cVal.ang.f
264	MMXU1.MX.PPV.phsBC.cVal.mag.f
265	MMXU1.MX.PPV.phsBC.cVal.ang.f
266	MMXU1.MX.PPV.phsCA.cVal.mag.f
267	MMXU1.MX.PPV.phsCA.cVal.ang.f
268	MMXU1.MX.PhV.phsA.cVal.mag.f
269	MMXU1.MX.PhV.phsA.cVal.ang.f
270	MMXU1.MX.PhV.phsB.cVal.mag.f
271	MMXU1.MX.PhV.phsB.cVal.ang.f
272	MMXU1.MX.PhV.phsC.cVal.mag.f
273	MMXU1.MX.PhV.phsC.cVal.ang.f
274	MMXU1.MX.A.phsA.cVal.mag.f
275	MMXU1.MX.A.phsA.cVal.ang.f
276	MMXU1.MX.A.phsB.cVal.mag.f
277	MMXU1.MX.A.phsB.cVal.ang.f
278	MMXU1.MX.A.phsC.cVal.mag.f
279	MMXU1.MX.A.phsC.cVal.ang.f
280	MMXU1.MX.A.neut.cVal.mag.f
281	MMXU1.MX.A.neut.cVal.ang.f
282	MMXU1.MX.W.phsA.cVal.mag.f
283	MMXU1.MX.W.phsB.cVal.mag.f
284	MMXU1.MX.W.phsC.cVal.mag.f
285	MMXU1.MX.VAr.phsA.cVal.mag.f
286	MMXU1.MX.VAr.phsB.cVal.mag.f
287	MMXU1.MX.VAr.phsC.cVal.mag.f
288	MMXU1.MX.VA.phsA.cVal.mag.f
289	MMXU1.MX.VA.phsB.cVal.mag.f
290	MMXU1.MX.VA.phsC.cVal.mag.f
291	MMXU1.MX.PF.phsA.cVal.mag.f
292	MMXU1.MX.PF.phsB.cVal.mag.f
293	MMXU1.MX.PF.phsC.cVal.mag.f
294	MMXU2.MX.TotW.mag.f
295	MMXU2.MX.TotVAr.mag.f
296	MMXU2.MX.TotVA.mag.f
297	MMXU2.MX.TotPF.mag.f
298	MMXU2.MX.Hz.mag.f
299	MMXU2.MX.PPV.phsAB.cVal.mag.f
300	MMXU2.MX.PPV.phsAB.cVal.ang.f
301	MMXU2.MX.PPV.phsBC.cVal.mag.f
302	MMXU2.MX.PPV.phsBC.cVal.ang.f
303	MMXU2.MX.PPV.phsCA.cVal.mag.f
304	MMXU2.MX.PPV.phsCA.cVal.ang.f
305	MMXU2.MX.PhV.phsA.cVal.mag.f
306	MMXU2.MX.PhV.phsA.cVal.ang.f
307	MMXU2.MX.PhV.phsB.cVal.mag.f

B

Enumeration	GOOSE dataset items
308	MMXU2.MX.PhV.phsB.cVal.ang.f
309	MMXU2.MX.PhV.phsC.cVal.mag.f
310	MMXU2.MX.PhV.phsC.cVal.ang.f
311	MMXU2.MX.A.phsA.cVal.mag.f
312	MMXU2.MX.A.phsA.cVal.ang.f
313	MMXU2.MX.A.phsB.cVal.mag.f
314	MMXU2.MX.A.phsB.cVal.ang.f
315	MMXU2.MX.A.phsC.cVal.mag.f
316	MMXU2.MX.A.phsC.cVal.ang.f
317	MMXU2.MX.A.neut.cVal.mag.f
318	MMXU2.MX.A.neut.cVal.ang.f
319	MMXU2.MX.W.phsA.cVal.mag.f
320	MMXU2.MX.W.phsB.cVal.mag.f
321	MMXU2.MX.W.phsC.cVal.mag.f
322	MMXU2.MX.VAr.phsA.cVal.mag.f
323	MMXU2.MX.VAr.phsB.cVal.mag.f
324	MMXU2.MX.VAr.phsC.cVal.mag.f
325	MMXU2.MX.VA.phsA.cVal.mag.f
326	MMXU2.MX.VA.phsB.cVal.mag.f
327	MMXU2.MX.VA.phsC.cVal.mag.f
328	MMXU2.MX.PF.phsA.cVal.mag.f
329	MMXU2.MX.PF.phsB.cVal.mag.f
330	MMXU2.MX.PF.phsC.cVal.mag.f
331	MMXU3.MX.TotW.mag.f
332	MMXU3.MX.TotVAr.mag.f
333	MMXU3.MX.TotVA.mag.f
334	MMXU3.MX.TotPF.mag.f
335	MMXU3.MX.Hz.mag.f
336	MMXU3.MX.PPV.phsAB.cVal.mag.f
337	MMXU3.MX.PPV.phsAB.cVal.ang.f
338	MMXU3.MX.PPV.phsBC.cVal.mag.f
339	MMXU3.MX.PPV.phsBC.cVal.ang.f
340	MMXU3.MX.PPV.phsCA.cVal.mag.f
341	MMXU3.MX.PPV.phsCA.cVal.ang.f
342	MMXU3.MX.PhV.phsA.cVal.mag.f
343	MMXU3.MX.PhV.phsA.cVal.ang.f
344	MMXU3.MX.PhV.phsB.cVal.mag.f
345	MMXU3.MX.PhV.phsB.cVal.ang.f
346	MMXU3.MX.PhV.phsC.cVal.mag.f
347	MMXU3.MX.PhV.phsC.cVal.ang.f
348	MMXU3.MX.A.phsA.cVal.mag.f
349	MMXU3.MX.A.phsA.cVal.ang.f
350	MMXU3.MX.A.phsB.cVal.mag.f
351	MMXU3.MX.A.phsB.cVal.ang.f
352	MMXU3.MX.A.phsC.cVal.mag.f
353	MMXU3.MX.A.phsC.cVal.ang.f
354	MMXU3.MX.A.neut.cVal.mag.f
355	MMXU3.MX.A.neut.cVal.ang.f
356	MMXU3.MX.W.phsA.cVal.mag.f
357	MMXU3.MX.W.phsB.cVal.mag.f
358	MMXU3.MX.W.phsC.cVal.mag.f
359	MMXU3.MX.VAr.phsA.cVal.mag.f
360	MMXU3.MX.VAr.phsB.cVal.mag.f
361	MMXU3.MX.VAr.phsC.cVal.mag.f
362	MMXU3.MX.VA.phsA.cVal.mag.f
363	MMXU3.MX.VA.phsB.cVal.mag.f
364	MMXU3.MX.VA.phsC.cVal.mag.f
365	MMXU3.MX.PF.phsA.cVal.mag.f
366	MMXU3.MX.PF.phsB.cVal.mag.f
367	MMXU3.MX.PF.phsC.cVal.mag.f
368	MMXU4.MX.TotW.mag.f
369	MMXU4.MX.TotVAr.mag.f
370	MMXU4.MX.TotVA.mag.f
371	MMXU4.MX.TotPF.mag.f
372	MMXU4.MX.Hz.mag.f
373	MMXU4.MX.PPV.phsAB.cVal.mag.f
374	MMXU4.MX.PPV.phsAB.cVal.ang.f
375	MMXU4.MX.PPV.phsBC.cVal.mag.f
376	MMXU4.MX.PPV.phsBC.cVal.ang.f
377	MMXU4.MX.PPV.phsCA.cVal.mag.f
378	MMXU4.MX.PPV.phsCA.cVal.ang.f
379	MMXU4.MX.PhV.phsA.cVal.mag.f
380	MMXU4.MX.PhV.phsA.cVal.ang.f
381	MMXU4.MX.PhV.phsB.cVal.mag.f
382	MMXU4.MX.PhV.phsB.cVal.ang.f
383	MMXU4.MX.PhV.phsC.cVal.mag.f
384	MMXU4.MX.PhV.phsC.cVal.ang.f
385	MMXU4.MX.A.phsA.cVal.mag.f
386	MMXU4.MX.A.phsA.cVal.ang.f
387	MMXU4.MX.A.phsB.cVal.mag.f
388	MMXU4.MX.A.phsB.cVal.ang.f
389	MMXU4.MX.A.phsC.cVal.mag.f
390	MMXU4.MX.A.phsC.cVal.ang.f
391	MMXU4.MX.A.neut.cVal.mag.f
392	MMXU4.MX.A.neut.cVal.ang.f
393	MMXU4.MX.W.phsA.cVal.mag.f
394	MMXU4.MX.W.phsB.cVal.mag.f
395	MMXU4.MX.W.phsC.cVal.mag.f
396	MMXU4.MX.VAr.phsA.cVal.mag.f
397	MMXU4.MX.VAr.phsB.cVal.mag.f
398	MMXU4.MX.VAr.phsC.cVal.mag.f
399	MMXU4.MX.VA.phsA.cVal.mag.f
400	MMXU4.MX.VA.phsB.cVal.mag.f
401	MMXU4.MX.VA.phsC.cVal.mag.f
402	MMXU4.MX.PF.phsA.cVal.mag.f
403	MMXU4.MX.PF.phsB.cVal.mag.f
404	MMXU4.MX.PF.phsC.cVal.mag.f
405	MMXU5.MX.TotW.mag.f
406	MMXU5.MX.TotVAr.mag.f
407	MMXU5.MX.TotVA.mag.f
408	MMXU5.MX.TotPF.mag.f
409	MMXU5.MX.Hz.mag.f
410	MMXU5.MX.PPV.phsAB.cVal.mag.f
411	MMXU5.MX.PPV.phsAB.cVal.ang.f
412	MMXU5.MX.PPV.phsBC.cVal.mag.f
413	MMXU5.MX.PPV.phsBC.cVal.ang.f

Enumeration	GOOSE dataset items
414	MMXU5.MX.PPV.phsCA.cVal.mag.f
415	MMXU5.MX.PPV.phsCA.cVal.ang.f
416	MMXU5.MX.PhV.phsA.cVal.mag.f
417	MMXU5.MX.PhV.phsA.cVal.ang.f
418	MMXU5.MX.PhV.phsB.cVal.mag.f
419	MMXU5.MX.PhV.phsB.cVal.ang.f
420	MMXU5.MX.PhV.phsC.cVal.mag.f
421	MMXU5.MX.PhV.phsC.cVal.ang.f
422	MMXU5.MX.A.phsA.cVal.mag.f
423	MMXU5.MX.A.phsA.cVal.ang.f
424	MMXU5.MX.A.phsB.cVal.mag.f
425	MMXU5.MX.A.phsB.cVal.ang.f
426	MMXU5.MX.A.phsC.cVal.mag.f
427	MMXU5.MX.A.phsC.cVal.ang.f
428	MMXU5.MX.A.neut.cVal.mag.f
429	MMXU5.MX.A.neut.cVal.ang.f
430	MMXU5.MX.W.phsA.cVal.mag.f
431	MMXU5.MX.W.phsB.cVal.mag.f
432	MMXU5.MX.W.phsC.cVal.mag.f
433	MMXU5.MX.VAr.phsA.cVal.mag.f
434	MMXU5.MX.VAr.phsB.cVal.mag.f
435	MMXU5.MX.VAr.phsC.cVal.mag.f
436	MMXU5.MX.VA.phsA.cVal.mag.f
437	MMXU5.MX.VA.phsB.cVal.mag.f
438	MMXU5.MX.VA.phsC.cVal.mag.f
439	MMXU5.MX.PF.phsA.cVal.mag.f
440	MMXU5.MX.PF.phsB.cVal.mag.f
441	MMXU5.MX.PF.phsC.cVal.mag.f
442	MMXU6.MX.TotW.mag.f
443	MMXU6.MX.TotVAr.mag.f
444	MMXU6.MX.TotVA.mag.f
445	MMXU6.MX.TotPF.mag.f
446	MMXU6.MX.Hz.mag.f
447	MMXU6.MX.PPV.phsAB.cVal.mag.f
448	MMXU6.MX.PPV.phsAB.cVal.ang.f
449	MMXU6.MX.PPV.phsBC.cVal.mag.f
450	MMXU6.MX.PPV.phsBC.cVal.ang.f
451	MMXU6.MX.PPV.phsCA.cVal.mag.f
452	MMXU6.MX.PPV.phsCA.cVal.ang.f
453	MMXU6.MX.PhV.phsA.cVal.mag.f
454	MMXU6.MX.PhV.phsA.cVal.ang.f
455	MMXU6.MX.PhV.phsB.cVal.mag.f
456	MMXU6.MX.PhV.phsB.cVal.ang.f
457	MMXU6.MX.PhV.phsC.cVal.mag.f
458	MMXU6.MX.PhV.phsC.cVal.ang.f
459	MMXU6.MX.A.phsA.cVal.mag.f
460	MMXU6.MX.A.phsA.cVal.ang.f
461	MMXU6.MX.A.phsB.cVal.mag.f
462	MMXU6.MX.A.phsB.cVal.ang.f
463	MMXU6.MX.A.phsC.cVal.mag.f
464	MMXU6.MX.A.phsC.cVal.ang.f
465	MMXU6.MX.A.neut.cVal.mag.f
466	MMXU6.MX.A.neut.cVal.ang.f

Enumeration	GOOSE dataset items
467	MMXU6.MX.W.phsA.cVal.mag.f
468	MMXU6.MX.W.phsB.cVal.mag.f
469	MMXU6.MX.W.phsC.cVal.mag.f
470	MMXU6.MX.VAr.phsA.cVal.mag.f
471	MMXU6.MX.VAr.phsB.cVal.mag.f
472	MMXU6.MX.VAr.phsC.cVal.mag.f
473	MMXU6.MX.VA.phsA.cVal.mag.f
474	MMXU6.MX.VA.phsB.cVal.mag.f
475	MMXU6.MX.VA.phsC.cVal.mag.f
476	MMXU6.MX.PF.phsA.cVal.mag.f
477	MMXU6.MX.PF.phsB.cVal.mag.f
478	MMXU6.MX.PF.phsC.cVal.mag.f
479	GGIO4.MX.AnIn1.mag.f
480	GGIO4.MX.AnIn2.mag.f
481	GGIO4.MX.AnIn3.mag.f
482	GGIO4.MX.AnIn4.mag.f
483	GGIO4.MX.AnIn5.mag.f
484	GGIO4.MX.AnIn6.mag.f
485	GGIO4.MX.AnIn7.mag.f
486	GGIO4.MX.AnIn8.mag.f
487	GGIO4.MX.AnIn9.mag.f
488	GGIO4.MX.AnIn10.mag.f
489	GGIO4.MX.AnIn11.mag.f
490	GGIO4.MX.AnIn12.mag.f
491	GGIO4.MX.AnIn13.mag.f
492	GGIO4.MX.AnIn14.mag.f
493	GGIO4.MX.AnIn15.mag.f
494	GGIO4.MX.AnIn16.mag.f
495	GGIO4.MX.AnIn17.mag.f
496	GGIO4.MX.AnIn18.mag.f
497	GGIO4.MX.AnIn19.mag.f
498	GGIO4.MX.AnIn20.mag.f
499	GGIO4.MX.AnIn21.mag.f
500	GGIO4.MX.AnIn22.mag.f
501	GGIO4.MX.AnIn23.mag.f
502	GGIO4.MX.AnIn24.mag.f
503	GGIO4.MX.AnIn25.mag.f
504	GGIO4.MX.AnIn26.mag.f
505	GGIO4.MX.AnIn27.mag.f
506	GGIO4.MX.AnIn28.mag.f
507	GGIO4.MX.AnIn29.mag.f
508	GGIO4.MX.AnIn30.mag.f
509	GGIO4.MX.AnIn31.mag.f
510	GGIO4.MX.AnIn32.mag.f
511	GGIO5.ST.UIntIn1.q
512	GGIO5.ST.UIntIn1.stVal
513	GGIO5.ST.UIntIn2.q
514	GGIO5.ST.UIntIn2.stVal
515	GGIO5.ST.UIntIn3.q
516	GGIO5.ST.UIntIn3.stVal
517	GGIO5.ST.UIntIn4.q
518	GGIO5.ST.UIntIn4.stVal
519	GGIO5.ST.UIntIn5.q

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Enumeration	GOOSE dataset items
520	GGIO5.ST.UIntIn5.stVal
521	GGIO5.ST.UIntIn6.q
522	GGIO5.ST.UIntIn6.stVal
523	GGIO5.ST.UIntIn7.q
524	GGIO5.ST.UIntIn7.stVal
525	GGIO5.ST.UIntIn8.q
526	GGIO5.ST.UIntIn8.stVal
527	GGIO5.ST.UIntIn9.q
528	GGIO5.ST.UIntIn9.stVal
529	GGIO5.ST.UIntIn10.q
530	GGIO5.ST.UIntIn10.stVal
531	GGIO5.ST.UIntIn11.q
532	GGIO5.ST.UIntIn11.stVal
533	GGIO5.ST.UIntIn12.q
534	GGIO5.ST.UIntIn12.stVal
535	GGIO5.ST.UIntIn13.q
536	GGIO5.ST.UIntIn13.stVal
537	GGIO5.ST.UIntIn14.q
538	GGIO5.ST.UIntIn14.stVal
539	GGIO5.ST.UIntIn15.q
540	GGIO5.ST.UIntIn15.stVal
541	GGIO5.ST.UIntIn16.q
542	GGIO5.ST.UIntIn16.stVal
543	PDIF1.ST.Str.general
544	PDIF1.ST.Op.general
545	PDIF2.ST.Str.general
546	PDIF2.ST.Op.general
547	PDIF3.ST.Str.general
548	PDIF3.ST.Op.general
549	PDIF4.ST.Str.general
550	PDIF4.ST.Op.general
551	PDIS1.ST.Str.general
552	PDIS1.ST.Op.general
553	PDIS2.ST.Str.general
554	PDIS2.ST.Op.general
555	PDIS3.ST.Str.general
556	PDIS3.ST.Op.general
557	PDIS4.ST.Str.general
558	PDIS4.ST.Op.general
559	PDIS5.ST.Str.general
560	PDIS5.ST.Op.general
561	PDIS6.ST.Str.general
562	PDIS6.ST.Op.general
563	PDIS7.ST.Str.general
564	PDIS7.ST.Op.general
565	PDIS8.ST.Str.general
566	PDIS8.ST.Op.general
567	PDIS9.ST.Str.general
568	PDIS9.ST.Op.general
569	PDIS10.ST.Str.general
570	PDIS10.ST.Op.general
571	PIOC1.ST.Str.general
572	PIOC1.ST.Op.general

Enumeration	GOOSE dataset items
573	PIOC2.ST.Str.general
574	PIOC2.ST.Op.general
575	PIOC3.ST.Str.general
576	PIOC3.ST.Op.general
577	PIOC4.ST.Str.general
578	PIOC4.ST.Op.general
579	PIOC5.ST.Str.general
580	PIOC5.ST.Op.general
581	PIOC6.ST.Str.general
582	PIOC6.ST.Op.general
583	PIOC7.ST.Str.general
584	PIOC7.ST.Op.general
585	PIOC8.ST.Str.general
586	PIOC8.ST.Op.general
587	PIOC9.ST.Str.general
588	PIOC9.ST.Op.general
589	PIOC10.ST.Str.general
590	PIOC10.ST.Op.general
591	PIOC11.ST.Str.general
592	PIOC11.ST.Op.general
593	PIOC12.ST.Str.general
594	PIOC12.ST.Op.general
595	PIOC13.ST.Str.general
596	PIOC13.ST.Op.general
597	PIOC14.ST.Str.general
598	PIOC14.ST.Op.general
599	PIOC15.ST.Str.general
600	PIOC15.ST.Op.general
601	PIOC16.ST.Str.general
602	PIOC16.ST.Op.general
603	PIOC17.ST.Str.general
604	PIOC17.ST.Op.general
605	PIOC18.ST.Str.general
606	PIOC18.ST.Op.general
607	PIOC19.ST.Str.general
608	PIOC19.ST.Op.general
609	PIOC20.ST.Str.general
610	PIOC20.ST.Op.general
611	PIOC21.ST.Str.general
612	PIOC21.ST.Op.general
613	PIOC22.ST.Str.general
614	PIOC22.ST.Op.general
615	PIOC23.ST.Str.general
616	PIOC23.ST.Op.general
617	PIOC24.ST.Str.general
618	PIOC24.ST.Op.general
619	PIOC25.ST.Str.general
620	PIOC25.ST.Op.general
621	PIOC26.ST.Str.general
622	PIOC26.ST.Op.general
623	PIOC27.ST.Str.general
624	PIOC27.ST.Op.general
625	PIOC28.ST.Str.general

Enumeration	GOOSE dataset items
626	PIOC28.ST.Op.general
627	PIOC29.ST.Str.general
628	PIOC29.ST.Op.general
629	PIOC30.ST.Str.general
630	PIOC30.ST.Op.general
631	PIOC31.ST.Str.general
632	PIOC31.ST.Op.general
633	PIOC32.ST.Str.general
634	PIOC32.ST.Op.general
635	PIOC33.ST.Str.general
636	PIOC33.ST.Op.general
637	PIOC34.ST.Str.general
638	PIOC34.ST.Op.general
639	PIOC35.ST.Str.general
640	PIOC35.ST.Op.general
641	PIOC36.ST.Str.general
642	PIOC36.ST.Op.general
643	PIOC37.ST.Str.general
644	PIOC37.ST.Op.general
645	PIOC38.ST.Str.general
646	PIOC38.ST.Op.general
647	PIOC39.ST.Str.general
648	PIOC39.ST.Op.general
649	PIOC40.ST.Str.general
650	PIOC40.ST.Op.general
651	PIOC41.ST.Str.general
652	PIOC41.ST.Op.general
653	PIOC42.ST.Str.general
654	PIOC42.ST.Op.general
655	PIOC43.ST.Str.general
656	PIOC43.ST.Op.general
657	PIOC44.ST.Str.general
658	PIOC44.ST.Op.general
659	PIOC45.ST.Str.general
660	PIOC45.ST.Op.general
661	PIOC46.ST.Str.general
662	PIOC46.ST.Op.general
663	PIOC47.ST.Str.general
664	PIOC47.ST.Op.general
665	PIOC48.ST.Str.general
666	PIOC48.ST.Op.general
667	PIOC49.ST.Str.general
668	PIOC49.ST.Op.general
669	PIOC50.ST.Str.general
670	PIOC50.ST.Op.general
671	PIOC51.ST.Str.general
672	PIOC51.ST.Op.general
673	PIOC52.ST.Str.general
674	PIOC52.ST.Op.general
675	PIOC53.ST.Str.general
676	PIOC53.ST.Op.general
677	PIOC54.ST.Str.general
678	PIOC54.ST.Op.general

Enumeration	GOOSE dataset items
679	PIOC55.ST.Str.general
680	PIOC55.ST.Op.general
681	PIOC56.ST.Str.general
682	PIOC56.ST.Op.general
683	PIOC57.ST.Str.general
684	PIOC57.ST.Op.general
685	PIOC58.ST.Str.general
686	PIOC58.ST.Op.general
687	PIOC59.ST.Str.general
688	PIOC59.ST.Op.general
689	PIOC60.ST.Str.general
690	PIOC60.ST.Op.general
691	PIOC61.ST.Str.general
692	PIOC61.ST.Op.general
693	PIOC62.ST.Str.general
694	PIOC62.ST.Op.general
695	PIOC63.ST.Str.general
696	PIOC63.ST.Op.general
697	PIOC64.ST.Str.general
698	PIOC64.ST.Op.general
699	PIOC65.ST.Str.general
700	PIOC65.ST.Op.general
701	PIOC66.ST.Str.general
702	PIOC66.ST.Op.general
703	PIOC67.ST.Str.general
704	PIOC67.ST.Op.general
705	PIOC68.ST.Str.general
706	PIOC68.ST.Op.general
707	PIOC69.ST.Str.general
708	PIOC69.ST.Op.general
709	PIOC70.ST.Str.general
710	PIOC70.ST.Op.general
711	PIOC71.ST.Str.general
712	PIOC71.ST.Op.general
713	PIOC72.ST.Str.general
714	PIOC72.ST.Op.general
715	PTOC1.ST.Str.general
716	PTOC1.ST.Op.general
717	PTOC2.ST.Str.general
718	PTOC2.ST.Op.general
719	PTOC3.ST.Str.general
720	PTOC3.ST.Op.general
721	PTOC4.ST.Str.general
722	PTOC4.ST.Op.general
723	PTOC5.ST.Str.general
724	PTOC5.ST.Op.general
725	PTOC6.ST.Str.general
726	PTOC6.ST.Op.general
727	PTOC7.ST.Str.general
728	PTOC7.ST.Op.general
729	PTOC8.ST.Str.general
730	PTOC8.ST.Op.general
731	PTOC9.ST.Str.general

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Enumeration	GOOSE dataset items
732	PTOC9.ST.Op.general
733	PTOC10.ST.Str.general
734	PTOC10.ST.Op.general
735	PTOC11.ST.Str.general
736	PTOC11.ST.Op.general
737	PTOC12.ST.Str.general
738	PTOC12.ST.Op.general
739	PTOC13.ST.Str.general
740	PTOC13.ST.Op.general
741	PTOC14.ST.Str.general
742	PTOC14.ST.Op.general
743	PTOC15.ST.Str.general
744	PTOC15.ST.Op.general
745	PTOC16.ST.Str.general
746	PTOC16.ST.Op.general
747	PTOC17.ST.Str.general
748	PTOC17.ST.Op.general
749	PTOC18.ST.Str.general
750	PTOC18.ST.Op.general
751	PTOC19.ST.Str.general
752	PTOC19.ST.Op.general
753	PTOC20.ST.Str.general
754	PTOC20.ST.Op.general
755	PTOC21.ST.Str.general
756	PTOC21.ST.Op.general
757	PTOC22.ST.Str.general
758	PTOC22.ST.Op.general
759	PTOC23.ST.Str.general
760	PTOC23.ST.Op.general
761	PTOC24.ST.Str.general
762	PTOC24.ST.Op.general
763	PTOV1.ST.Str.general
764	PTOV1.ST.Op.general
765	PTOV2.ST.Str.general
766	PTOV2.ST.Op.general
767	PTOV3.ST.Str.general
768	PTOV3.ST.Op.general
769	PTOV4.ST.Str.general
770	PTOV4.ST.Op.general
771	PTOV5.ST.Str.general
772	PTOV5.ST.Op.general
773	PTOV6.ST.Str.general
774	PTOV6.ST.Op.general
775	PTOV7.ST.Str.general
776	PTOV7.ST.Op.general
777	PTOV8.ST.Str.general
778	PTOV8.ST.Op.general
779	PTOV9.ST.Str.general
780	PTOV9.ST.Op.general
781	PTOV10.ST.Str.general
782	PTOV10.ST.Op.general
783	PTRC1.ST.Tr.general
784	PTRC1.ST.Op.general

Enumeration	GOOSE dataset items
785	PTRC2.ST.Tr.general
786	PTRC2.ST.Op.general
787	PTRC3.ST.Tr.general
788	PTRC3.ST.Op.general
789	PTRC4.ST.Tr.general
790	PTRC4.ST.Op.general
791	PTRC5.ST.Tr.general
792	PTRC5.ST.Op.general
793	PTRC6.ST.Tr.general
794	PTRC6.ST.Op.general
795	PTUV1.ST.Str.general
796	PTUV1.ST.Op.general
797	PTUV2.ST.Str.general
798	PTUV2.ST.Op.general
799	PTUV3.ST.Str.general
800	PTUV3.ST.Op.general
801	PTUV4.ST.Str.general
802	PTUV4.ST.Op.general
803	PTUV5.ST.Str.general
804	PTUV5.ST.Op.general
805	PTUV6.ST.Str.general
806	PTUV6.ST.Op.general
807	PTUV7.ST.Str.general
808	PTUV7.ST.Op.general
809	PTUV8.ST.Str.general
810	PTUV8.ST.Op.general
811	PTUV9.ST.Str.general
812	PTUV9.ST.Op.general
813	PTUV10.ST.Str.general
814	PTUV10.ST.Op.general
815	PTUV11.ST.Str.general
816	PTUV11.ST.Op.general
817	PTUV12.ST.Str.general
818	PTUV12.ST.Op.general
819	PTUV13.ST.Str.general
820	PTUV13.ST.Op.general
821	RBRF1.ST.OpEx.general
822	RBRF1.ST.OpIn.general
823	RBRF2.ST.OpEx.general
824	RBRF2.ST.OpIn.general
825	RBRF3.ST.OpEx.general
826	RBRF3.ST.OpIn.general
827	RBRF4.ST.OpEx.general
828	RBRF4.ST.OpIn.general
829	RBRF5.ST.OpEx.general
830	RBRF5.ST.OpIn.general
831	RBRF6.ST.OpEx.general
832	RBRF6.ST.OpIn.general
833	RBRF7.ST.OpEx.general
834	RBRF7.ST.OpIn.general
835	RBRF8.ST.OpEx.general
836	RBRF8.ST.OpIn.general
837	RBRF9.ST.OpEx.general

Enumeration	GOOSE dataset items
838	RBRF9.ST.OpIn.general
839	RBRF10.ST.OpEx.general
840	RBRF10.ST.OpIn.general
841	RBRF11.ST.OpEx.general
842	RBRF11.ST.OpIn.general
843	RBRF12.ST.OpEx.general
844	RBRF12.ST.OpIn.general
845	RBRF13.ST.OpEx.general
846	RBRF13.ST.OpIn.general
847	RBRF14.ST.OpEx.general
848	RBRF14.ST.OpIn.general
849	RBRF15.ST.OpEx.general
850	RBRF15.ST.OpIn.general
851	RBRF16.ST.OpEx.general
852	RBRF16.ST.OpIn.general
853	RBRF17.ST.OpEx.general
854	RBRF17.ST.OpIn.general
855	RBRF18.ST.OpEx.general
856	RBRF18.ST.OpIn.general
857	RBRF19.ST.OpEx.general
858	RBRF19.ST.OpIn.general
859	RBRF20.ST.OpEx.general
860	RBRF20.ST.OpIn.general
861	RBRF21.ST.OpEx.general
862	RBRF21.ST.OpIn.general
863	RBRF22.ST.OpEx.general
864	RBRF22.ST.OpIn.general
865	RBRF23.ST.OpEx.general
866	RBRF23.ST.OpIn.general
867	RBRF24.ST.OpEx.general
868	RBRF24.ST.OpIn.general
869	RFLO1.MX.FltDiskm.mag.f
870	RFLO2.MX.FltDiskm.mag.f
871	RFLO3.MX.FltDiskm.mag.f
872	RFLO4.MX.FltDiskm.mag.f
873	RFLO5.MX.FltDiskm.mag.f
874	RPSB1.ST.Str.general
875	RPSB1.ST.Op.general
876	RPSB1.ST.BlkZn.stVal
877	RREC1.ST.Op.general
878	RREC1.ST.AutoRecSt.stVal
879	RREC2.ST.Op.general
880	RREC2.ST.AutoRecSt.stVal
881	RREC3.ST.Op.general
882	RREC3.ST.AutoRecSt.stVal
883	RREC4.ST.Op.general
884	RREC4.ST.AutoRecSt.stVal
885	RREC5.ST.Op.general
886	RREC5.ST.AutoRecSt.stVal
887	RREC6.ST.Op.general
888	RREC6.ST.AutoRecSt.stVal
889	CSWI1.ST.Loc.stVal
890	CSWI1.ST.Pos.stVal

Enumeration	GOOSE dataset items
891	CSWI2.ST.Loc.stVal
892	CSWI2.ST.Pos.stVal
893	CSWI3.ST.Loc.stVal
894	CSWI3.ST.Pos.stVal
895	CSWI4.ST.Loc.stVal
896	CSWI4.ST.Pos.stVal
897	CSWI5.ST.Loc.stVal
898	CSWI5.ST.Pos.stVal
899	CSWI6.ST.Loc.stVal
900	CSWI6.ST.Pos.stVal
901	CSWI7.ST.Loc.stVal
902	CSWI7.ST.Pos.stVal
903	CSWI8.ST.Loc.stVal
904	CSWI8.ST.Pos.stVal
905	CSWI9.ST.Loc.stVal
906	CSWI9.ST.Pos.stVal
907	CSWI10.ST.Loc.stVal
908	CSWI10.ST.Pos.stVal
909	CSWI11.ST.Loc.stVal
910	CSWI11.ST.Pos.stVal
911	CSWI12.ST.Loc.stVal
912	CSWI12.ST.Pos.stVal
913	CSWI13.ST.Loc.stVal
914	CSWI13.ST.Pos.stVal
915	CSWI14.ST.Loc.stVal
916	CSWI14.ST.Pos.stVal
917	CSWI15.ST.Loc.stVal
918	CSWI15.ST.Pos.stVal
919	CSWI16.ST.Loc.stVal
920	CSWI16.ST.Pos.stVal
921	CSWI17.ST.Loc.stVal
922	CSWI17.ST.Pos.stVal
923	CSWI18.ST.Loc.stVal
924	CSWI18.ST.Pos.stVal
925	CSWI19.ST.Loc.stVal
926	CSWI19.ST.Pos.stVal
927	CSWI20.ST.Loc.stVal
928	CSWI20.ST.Pos.stVal
929	CSWI21.ST.Loc.stVal
930	CSWI21.ST.Pos.stVal
931	CSWI22.ST.Loc.stVal
932	CSWI22.ST.Pos.stVal
933	CSWI23.ST.Loc.stVal
934	CSWI23.ST.Pos.stVal
935	CSWI24.ST.Loc.stVal
936	CSWI24.ST.Pos.stVal
937	CSWI25.ST.Loc.stVal
938	CSWI25.ST.Pos.stVal
939	CSWI26.ST.Loc.stVal
940	CSWI26.ST.Pos.stVal
941	CSWI27.ST.Loc.stVal
942	CSWI27.ST.Pos.stVal
943	CSWI28.ST.Loc.stVal

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Enumeration	GOOSE dataset items
944	CSWI28.ST.Pos.stVal
945	CSWI29.ST.Loc.stVal
946	CSWI29.ST.Pos.stVal
947	CSWI30.ST.Loc.stVal
948	CSWI30.ST.Pos.stVal
949	XSWI1.ST.Loc.stVal
950	XSWI1.ST.Pos.stVal
951	XSWI2.ST.Loc.stVal
952	XSWI2.ST.Pos.stVal
953	XSWI3.ST.Loc.stVal
954	XSWI3.ST.Pos.stVal
955	XSWI4.ST.Loc.stVal
956	XSWI4.ST.Pos.stVal
957	XSWI5.ST.Loc.stVal
958	XSWI5.ST.Pos.stVal
959	XSWI6.ST.Loc.stVal
960	XSWI6.ST.Pos.stVal
961	XSWI7.ST.Loc.stVal
962	XSWI7.ST.Pos.stVal
963	XSWI8.ST.Loc.stVal
964	XSWI8.ST.Pos.stVal
965	XSWI9.ST.Loc.stVal
966	XSWI9.ST.Pos.stVal
967	XSWI10.ST.Loc.stVal
968	XSWI10.ST.Pos.stVal
969	XSWI11.ST.Loc.stVal
970	XSWI11.ST.Pos.stVal
971	XSWI12.ST.Loc.stVal
972	XSWI12.ST.Pos.stVal
973	XSWI13.ST.Loc.stVal
974	XSWI13.ST.Pos.stVal
975	XSWI14.ST.Loc.stVal
976	XSWI14.ST.Pos.stVal
977	XSWI15.ST.Loc.stVal
978	XSWI15.ST.Pos.stVal
979	XSWI16.ST.Loc.stVal
980	XSWI16.ST.Pos.stVal
981	XSWI17.ST.Loc.stVal
982	XSWI17.ST.Pos.stVal
983	XSWI18.ST.Loc.stVal
984	XSWI18.ST.Pos.stVal
985	XSWI19.ST.Loc.stVal
986	XSWI19.ST.Pos.stVal
987	XSWI20.ST.Loc.stVal
988	XSWI20.ST.Pos.stVal
989	XSWI21.ST.Loc.stVal
990	XSWI21.ST.Pos.stVal
991	XSWI22.ST.Loc.stVal
992	XSWI22.ST.Pos.stVal
993	XSWI23.ST.Loc.stVal
994	XSWI23.ST.Pos.stVal
995	XSWI24.ST.Loc.stVal
996	XSWI24.ST.Pos.stVal
997	XCBR1.ST.Loc.stVal
998	XCBR1.ST.Pos.stVal
999	XCBR2.ST.Loc.stVal
1000	XCBR2.ST.Pos.stVal
1001	XCBR3.ST.Loc.stVal
1002	XCBR3.ST.Pos.stVal
1003	XCBR4.ST.Loc.stVal
1004	XCBR4.ST.Pos.stVal
1005	XCBR5.ST.Loc.stVal
1006	XCBR5.ST.Pos.stVal
1007	XCBR6.ST.Loc.stVal
1008	XCBR6.ST.Pos.stVal

F617
ENUMERATION: LOGIN ROLES

Enumeration	Role
0	None
1	Administrator
2	Supervisor
3	Engineer
4	Operator
5	Factory

F620
ENUMERATION: PASSWORD CHANGE ROLES

Enumeration	Role
0	None
1	Administrator
2	Supervisor
3	Engineer
4	Operator

F621
ENUMERATION: MODBUS LOGIN ROLES

Enumeration	Role
0	None
1	Administrator
2	Supervisor
3	Engineer
4	Operator
5	Observer
6	Factory Service

F622
ENUMERATION: AUTORECLOSE 1P 3P MODE AUTOMATED

Enumeration	Mode
0	Mode 1 (1 and 3 Pole)
1	Mode 2 (1 Pole)
2	Mode 3 (3 Pole - A)
3	Mode 4 (3 Pole - B)

F623
ENUMERATION: RTC SYNCHRONIZING SOURCE CONFIGURATION

Enumeration	Item
0	None
1	PP/IRIG-B/PTP/SNTP
2	IRIG-B/PP/PTP/SNTP
3	PP/PTP/IRIG-B/SNTP

F624
ENUMERATION: RTC SYNCHRONZING SOURCE ACTUALS

Enumeration	Item
0	None
1	Port 1 PTP Clock
2	Port 2 PTP Clock
3	Port 3 PTP Clock
4	IRIG-B
5	SNTP

F625
ENUMERATION: PTP STATE

Enumeration	Item
0	Disabled
1	No Signal
2	Calibrating
3	Synchronized
4	Synchronized (No PDelay)

F626
ENUMERATION: NETWORK PORT FOR REMOTE DEVICE

Enumeration	Item
0	None
1	Network Port 1
2	Network Port 2
3	Network Port 3

F627
ENUMERATION: REDUNDANCY MODE

Enumeration	Item
0	None
1	Failover
2	PRP

F626
ENUMERATION: SECURITY BYPASS ACCESS (disables security on local access, remoted access, or both)

Enumeration	Item
0	Disabled
1	Local and Remote
2	Local
3	Remote

B

B

C.1.1 INTRODUCTION

The IEC 61850 standard is the result of electric utilities and vendors of electronic equipment to produce standardized communications systems. IEC 61850 is a series of standards describing client/server and peer-to-peer communications, substation design and configuration, testing, environmental and project standards. The complete set includes:

- IEC 61850-1: Introduction and overview
- IEC 61850-2: Glossary
- IEC 61850-3: General requirements
- IEC 61850-4: System and project management
- IEC 61850-5: Communications and requirements for functions and device models
- IEC 61850-6: Configuration description language for communication in electrical substations related to IEDs
- IEC 61850-7-1: Basic communication structure for substation and feeder equipment - Principles and models
- IEC 61850-7-2: Basic communication structure for substation and feeder equipment - Abstract communication service interface (ACSI)
- IEC 61850-7-3: Basic communication structure for substation and feeder equipment – Common data classes
- IEC 61850-7-4: Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes
- IEC 61850-8-1: Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
- IEC 61850-9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link
- IEC 61850-9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3
- IEC 61850-10: Conformance testing

These documents can be obtained from the IEC (http://www.iec.ch). It is strongly recommended that all those involved with any IEC 61850 implementation obtain this document set.

C.1.2 COMMUNICATION PROFILES

IEC 61850 specifies the use of the Manufacturing Message Specification (MMS) at the upper (application) layer for transfer of real-time data. This protocol has been in existence for several of years and provides a set of services suitable for the transfer of data within a substation LAN environment. Actual MMS protocol services are mapped to IEC 61850 abstract services in IEC 61850-8-1.

The L30 relay supports IEC 61850 server services over TCP/IP. The TCP/IP profile requires the L30 to have an IP address to establish communications. These addresses are located in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK** menu. It is possible to have up to five simultaneous connections (in addition to DNP and Modbus/TCP (non-IEC 61850) connections).

- **Client/server**: This is a connection-oriented type of communication. The connection is initiated by the client, and communication activity is controlled by the client. IEC 61850 clients are often substation computers running HMI programs or SOE logging software. Servers are usually substation equipment such as protection relays, meters, RTUs, transformer tap changers, or bay controllers.
- **Peer-to-peer**: This is a non-connection-oriented, high speed type of communication usually between substation equipment such as protection relays. GSSE and GOOSE are methods of peer-to-peer communication.
- **Substation configuration language (SCL)**: A substation configuration language is a number of files used to describe the configuration of substation equipment. Each configured device has an *IEC Capability Description* (ICD) file. The substation single line information is stored in a *System Specification Description* (SSD) file. The entire substation configuration is stored in a *Substation Configuration Description* (SCD) file. The SCD file is the combination of the individual ICD files and the SSD file.

C.2.1 OVERVIEW

IEC 61850 defines an object-oriented approach to data and services. An IEC 61850 *physical device* can contain one or more *logical device(s)*. Each logical device can contain many *logical nodes*. Each logical node can contain many *data objects*. Each data object is composed of *data attributes* and *data attribute components*. Services are available at each level for performing various functions, such as reading, writing, control commands, and reporting.

Each L30 IED represents one IEC 61850 physical device. The physical device contains one logical device, and the logical device contains many logical nodes. The logical node LPHD1 contains information about the L30 IED physical device. The logical node LLN0 contains information about the L30 IED logical device.

C.2.2 GGIO1: DIGITAL STATUS VALUES

The GGIO1 logical node is available in the L30 to provide access to as many 128 digital status points and associated time-stamps and quality flags. The data content must be configured before the data can be used. GGIO1 provides digital status points for access by clients.

It is intended that clients use GGIO1 in order to access digital status values from the L30. Configuration settings are provided to allow the selection of the number of digital status indications available in GGIO1 (8 to 128), and to allow the choice of the L30 FlexLogic operands that drive the status of the GGIO1 status indications. Clients can utilize the IEC 61850 buffered and unbuffered reporting features available from GGIO1 in order to build sequence of events (SOE) logs and HMI display screens. Buffered reporting should generally be used for SOE logs since the buffering capability reduces the chances of missing data state changes. Unbuffered reporting should generally be used for local status display.

C.2.3 GGIO2: DIGITAL CONTROL VALUES

The GGIO2 logical node is available to provide access to the L30 virtual inputs. Virtual inputs are single-point control (binary) values that can be written by clients. They are generally used as control inputs. GGIO2 provides access to the virtual inputs through the IEC 61850 standard control model (ctlModel) services:

- Status only.
- Direct control with normal security.
- SBO control with normal security.

Configuration settings are available to select the control model for each point. Each virtual input used through GGIO2 should have its **VIRTUAL INPUT 1(64) FUNCTION** setting programmed as “Enabled” and its corresponding **GGIO2 CF SPSCO1(64) CTLMODEL** setting programmed to the appropriate control configuration.

C.2.4 GGIO3: DIGITAL STATUS AND ANALOG VALUES FROM GOOSE DATA

The GGIO3 logical node is available to provide access for clients to values received via configurable GOOSE messages. The values of the digital status indications and analog values in GGIO3 originate in GOOSE messages sent from other devices.

C.2.5 GGIO4: GENERIC ANALOG MEASURED VALUES

The GGIO4 logical node provides access to as many as 32 analog value points, as well as associated timestamps and quality flags. The data content must be configured before the data can be used. GGIO4 provides analog values for access by clients.

It is intended that clients use GGIO4 to access generic analog values from the L30. Configuration settings allow the selection of the number of analog values available in GGIO4 (4 to 32) and the choice of the FlexAnalog values that determine the value of the GGIO4 analog inputs. Clients can utilize polling or the IEC 61850 unbuffered reporting feature available from GGIO4 in order to obtain the analog values provided by GGIO4.

C.2.6 MMXU: ANALOG MEASURED VALUES

A limited number of measured analog values are available through the MMXU logical nodes.

Each MMXU logical node provides data from a L30 current and voltage source. There is one MMXU available for each configurable source (programmed in the **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES** menu). MMXU1 provides data from L30 source 1, and MMXU2 provides data from L30 source 2.

MMXU data is provided in two forms: instantaneous and deadband. The instantaneous values are updated every time a read operation is performed by a client. The deadband values are calculated as described in IEC 61850 parts 7-1 and 7-3. The selection of appropriate deadband settings for the L30 is described in chapter 5 of this manual.

IEC 61850 buffered and unbuffered reporting capability is available in all MMXU logical nodes. MMXUx logical nodes provide the following data for each source:

- MMXU1.MX.TotW: three-phase real power
- MMXU1.MX.TotVAr: three-phase reactive power
- MMXU1.MX.TotVA: three-phase apparent power
- MMXU1.MX.TotPF: three-phase power factor
- MMXU1.MX.Hz: frequency
- MMXU1.MX.PPV.phsAB: phase AB voltage magnitude and angle
- MMXU1.MX.PPV.phsBC: phase BC voltage magnitude and angle
- MMXU1.MX.PPV.phsCA: Phase CA voltage magnitude and angle
- MMXU1.MX.PhV.phsA: phase AG voltage magnitude and angle
- MMXU1.MX.PhV.phsB: phase BG voltage magnitude and angle
- MMXU1.MX.PhV.phsC: phase CG voltage magnitude and angle
- MMXU1.MX.A.phsA: phase A current magnitude and angle
- MMXU1.MX.A.phsB: phase B current magnitude and angle
- MMXU1.MX.A.phsC: phase C current magnitude and angle
- MMXU1.MX.A.neut: ground current magnitude and angle
- MMXU1.MX.W.phsA: phase A real power
- MMXU1.MX.W.phsB: phase B real power
- MMXU1.MX.W.phsC: phase C real power
- MMXU1.MX.VAr.phsA: phase A reactive power
- MMXU1.MX.VAr.phsB: phase B reactive power
- MMXU1.MX.VAr.phsC: phase C reactive power
- MMXU1.MX.VA.phsA: phase A apparent power
- MMXU1.MX.VA.phsB: phase B apparent power
- MMXU1.MX.VA.phsC: phase C apparent power
- MMXU1.MX.PF.phsA: phase A power factor
- MMXU1.MX.PF.phsB: phase B power factor
- MMXU1.MX.PF.phsC: phase C power factor

C.2.7 PROTECTION AND OTHER LOGICAL NODES

The following list describes the protection elements for all UR-series relays. The L30 relay will contain a subset of protection elements from this list.

- PDIF: bus differential, transformer instantaneous differential, transformer percent differential, current differential

- PDIS: phase distance, ground distance
- PIOC: phase instantaneous overcurrent, neutral instantaneous overcurrent, ground instantaneous overcurrent, negative-sequence instantaneous overcurrent.
- PTOC: phase time overcurrent, neutral time overcurrent, ground time overcurrent, negative-sequence time overcurrent, neutral directional overcurrent, negative-sequence directional overcurrent
- PTUV: phase undervoltage, auxiliary undervoltage, third harmonic neutral undervoltage
- PTOV: phase overvoltage, neutral overvoltage, auxiliary overvoltage, negative sequence overvoltage
- RBRF: breaker failure
- RREC: autoreclosure
- RPSB: power swing detection
- RFLO: fault locator
- XCBR: breaker control
- XSWI: circuit switch
- CSWI: switch controller

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The protection elements listed above contain *start* (pickup) and *operate* flags. For example, the start flag for PIOC1 is PIOC1.ST.Str.general. The operate flag for PIOC1 is PIOC1.ST.Op.general. For the L30 protection elements, these flags take their values from the pickup and operate FlexLogic operands for the corresponding element.

Some protection elements listed above contain directional start values. For example, the directional start value for PDIS1 is PDIS1.ST.Str.dirGeneral. This value is built from the directional FlexLogic operands for the element.

The RFLO logical node contains the measurement of the distance to fault calculation in kilometers. This value originates in the fault locator function.

The XCBR logical node is directly associated with the breaker control feature.

- XCBR1.ST.Loc: This is the state of the XCBR1 local/remote switch. A setting is provided to assign a FlexLogic operand to determine the state. When local mode is true, IEC 61850 client commands will be rejected.
- XCBR1.ST.Opcnt: This is an operation counter as defined in IEC 61850. Command settings are provided to allow the counter to be cleared.
- XCBR1.ST.Pos: This is the position of the breaker. The breaker control FlexLogic operands are used to determine this state.
  - Intermediate state (00) is indicated when the BREAKER 1 OPEN and BREAKER 1 CLOSED operands are both On.
  - Off state (01) is indicated when the BREAKER 1 OPEN operand is On.
  - On state (10) is indicated when the BREAKER 1 CLOSED operand is On.
  - Bad state (11) is indicated when the BREAKER 1 OPEN and BREAKER 1 CLOSED operands are Off.
- XCBR1.ST.BlkOpn: This is the state of the block open command logic. When true, breaker open commands from IEC 61850 clients will be rejected.
- XCBR1.ST.BlkCls: This is the state of the block close command logic. When true, breaker close commands from IEC 61850 clients will be rejected.
- XCBR1.CO.Pos: This is where IEC 61850 clients can issue open or close commands to the breaker. SBO control with normal security is the only supported IEC 61850 control model.
- XCBR1.CO.BlkOpn: This is where IEC 61850 clients can issue block open commands to the breaker. Direct control with normal security is the only supported IEC 61850 control model.
- XCBR1.CO.BlkCls: This is where IEC 61850 clients can issue block close commands to the breaker. Direct control with normal security is the only supported IEC 61850 control model.

C.3.1 BUFFERED/UNBUFFERED REPORTING

IEC 61850 buffered and unbuffered reporting is provided in the GGIO1 logical nodes (for binary status values) and MMXU1 to MMXU6 (for analog measured values). Report settings can be configured using the EnerVista UR Setup software, substation configurator software, or via an IEC 61850 client. The following items can be configured:

- **TrgOps**: Trigger options. The following bits are supported by the L30:
  - Bit 1: data-change
  - Bit 4: integrity
  - Bit 5: general interrogation
- **OptFlds**: Option Fields. The following bits are supported by the L30:
  - Bit 1: sequence-number
  - Bit 2: report-time-stamp
  - Bit 3: reason-for-inclusion
  - Bit 4: data-set-name
  - Bit 5: data-reference
  - Bit 6: buffer-overflow (for buffered reports only)
  - Bit 7: entryID (for buffered reports only)
  - Bit 8: conf-revision
  - Bit 9: segmentation
- **IntgPd**: Integrity period.
- **BufTm**: Buffer time.

C.3.2 FILE TRANSFER

MMS file services are supported to allow transfer of oscillography, event record, or other files from a L30 relay.

C.3.3 TIMESTAMPS AND SCANNING

The timestamp values associated with all IEC 61850 data items represent the *time of the last change* of either the value or quality flags of the data item. To accomplish this functionality, all IEC 61850 data items must be regularly scanned for data changes, and the timestamp updated when a change is detected, regardless of the connection status of any IEC 61850 clients. For applications where there is no IEC 61850 client in use, the IEC 61850 **SERVER SCANNING** setting can be programmed as “Disabled”. If a client is in use, this setting should be programmed as “Enabled” to ensure the proper generation of IEC 61850 timestamps.

C.3.4 LOGICAL DEVICE NAME

The logical device name is used to identify the IEC 61850 logical device that exists within the L30. This name is composed of two parts: the IED name setting and the logical device instance. The complete logical device name is the combination of the two character strings programmed in the **IEDNAME** and **LD INST** settings. The default values for these strings are “IEDName” and “LDInst”. These values should be changed to reflect a logical naming convention for all IEC 61850 logical devices in the system.

C.3.5 LOCATION

The LPHD1 logical node contains a data attribute called *location* (LPHD1.DC.PhyNam.location). This is a character string meant to describe the physical location of the L30. This attribute is programmed through the **LOCATION** setting and its default value is “Location”. This value should be changed to describe the actual physical location of the L30.

C.3.6 LOGICAL NODE NAME PREFIXES

IEC 61850 specifies that each logical node can have a name with a total length of 11 characters. The name is composed of:

- A five or six-character name prefix.
- A four-character standard name (for example, MMXU, GGIO, PIOC, etc.).
- A one or two-character instantiation index.

Complete names are of the form `xxxxxxPIOC1`, where the `xxxxxx` character string is configurable. Details regarding the logical node naming rules are given in IEC 61850 parts 6 and 7-2. It is recommended that a consistent naming convention be used for an entire substation project.

C.3.7 CONNECTION TIMING

A built-in TCP/IP connection timeout of two minutes is employed by the L30 to detect 'dead' connections. If there is no data traffic on a TCP connection for greater than two minutes, the connection will be aborted by the L30. This frees up the connection to be used by other clients. Therefore, when using IEC 61850 reporting, clients should configure report control block items such that an integrity report will be issued at least every 2 minutes (120000 ms). This ensures that the L30 will not abort the connection. If other MMS data is being polled on the same connection at least once every 2 minutes, this timeout will not apply.

C.3.8 NON-IEC 61850 DATA

The L30 relay makes available a number of non-IEC 61850 data items. These data items can be accessed through the "UR" MMS domain. IEC 61850 data can be accessed through the standard IEC 61850 logical device. To access the non-IEC data items, the **INCLUDE NON-IEC DATA** setting must be "Enabled".

C.3.9 COMMUNICATION SOFTWARE UTILITIES

The exact structure and values of the supported IEC 61850 logical nodes can be seen by connecting to a L30 relay with an MMS browser, such as the "MMS Object Explorer and AXS4-MMS" DDE/OPC server from Sisco Inc.

C.4.1 OVERVIEW

IEC 61850 specifies two types of peer-to-peer data transfer services: Generic Substation State Events (GSSE) and Generic Object Oriented Substation Events (GOOSE). GSSE services are compatible with UCA 2.0 GOOSE. IEC 61850 GOOSE services provide virtual LAN (VLAN) support, Ethernet priority tagging, and Ethertype Application ID configuration. The support for VLANs and priority tagging allows for the optimization of Ethernet network traffic. GOOSE messages can be given a higher priority than standard Ethernet traffic, and they can be separated onto specific VLANs. Because of the additional features of GOOSE services versus GSSE services, it is recommended that GOOSE be used wherever backwards compatibility with GSSE (or UCA 2.0 GOOSE) is not required.

Devices that transmit GSSE and/or GOOSE messages also function as servers. Each GSSE publisher contains a “GSSE control block” to configure and control the transmission. Each GOOSE publisher contains a “GOOSE control block” to configure and control the transmission. The transmission is also controlled via device settings. These settings can be seen in the ICD and/or SCD files, or in the device configuration software or files.

IEC 61850 recommends a default priority value of 4 for GOOSE. Ethernet traffic that does not contain a priority tag has a default priority of 1. More details are specified in IEC 61850 part 8-1.

IEC 61850 recommends that the Ethertype Application ID number be configured according to the GOOSE source. In the L30, the transmitted GOOSE Application ID number must match the configured receive Application ID number in the receiver. A common number may be used for all GOOSE transmitters in a system. More details are specified in IEC 61850 part 8-1.

C.4.2 GSSE CONFIGURATION

IEC 61850 Generic Substation Status Event (GSSE) communication is compatible with UCA GOOSE communication. GSSE messages contain a number of double point status data items. These items are transmitted in two pre-defined data structures named DNA and UserSt. Each DNA and UserSt item is referred to as a ‘bit pair’. GSSE messages are transmitted in response to state changes in any of the data points contained in the message. GSSE messages always contain the same number of DNA and UserSt bit pairs. Depending the on the configuration, only some of these bit pairs may have values that are of interest to receiving devices.

The **GSSE FUNCTION**, **GSSE ID**, and **GSSE DESTINATION MAC ADDRESS** settings are used to configure GSSE transmission. **GSSE FUNCTION** is set to “Enabled” to enable the transmission. If a valid multicast Ethernet MAC address is entered for the **GSSE DESTINATION MAC ADDRESS** setting, this address will be used as the destination MAC address for GSSE messages. If a valid multicast Ethernet MAC address is not entered (for example, 00 00 00 00 00 00), the L30 will use the source Ethernet MAC address as the destination, with the multicast bit set.

C.4.3 FIXED GOOSE

The L30 supports two types of IEC 61850 Generic Object Oriented Substation Event (GOOSE) communication: fixed GOOSE and configurable GOOSE. All GOOSE messages contain IEC 61850 data collected into a *dataset*. It is this dataset that is transferred using GOOSE message services. The dataset transferred using the L30 fixed GOOSE is the same data that is transferred using the GSSE feature; that is, the DNA and UserSt bit pairs. The FlexLogic operands that determine the state of the DNA and UserSt bit pairs are configurable via settings, but the fixed GOOSE dataset always contains the same DNA/UserSt data structure. Upgrading from GSSE to GOOSE services is simply a matter of enabling fixed GOOSE and disabling GSSE. The remote inputs and outputs are configured in the same manner for both GSSE and fixed GOOSE.

It is recommended that the fixed GOOSE be used for implementations that require GOOSE data transfer between UR-series IEDs. Configurable GOOSE may be used for implementations that require GOOSE data transfer between UR-series IEDs and devices from other manufacturers.

C.4.4 CONFIGURABLE GOOSE

The configurable GOOSE feature allows for the configuration of the datasets to be transmitted or received from the L30. The L30 supports the configuration of eight (8) transmission and reception datasets, allowing for the optimization of data transfer between devices.

Items programmed for dataset 1 and 2 will have changes in their status transmitted as soon as the change is detected. Dataset 1 should be used for high-speed transmission of data that is required for applications such as transfer tripping, blocking, and breaker fail initiate. At least one digital status value needs to be configured in dataset 1 to enable transmission of all data configured for dataset 1. Configuring analog data only to dataset 1 will not activate transmission.

Items programmed for datasets 3 through 8 will have changes in their status transmitted at a maximum rate of every 100 ms. Datasets 3 through 8 will regularly analyze each data item configured within them every 100 ms to identify if any changes have been made. If any changes in the data items are detected, these changes will be transmitted through a GOOSE message. If there are no changes detected during this 100 ms period, no GOOSE message will be sent.

For all datasets 1 through 8, the integrity GOOSE message will still continue to be sent at the pre-configured rate even if no changes in the data items are detected.

The GOOSE functionality was enhanced to prevent the relay from flooding a communications network with GOOSE messages due to an oscillation being created that is triggering a message.

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The L30 has the ability of detecting if a data item in one of the GOOSE datasets is erroneously oscillating. This can be caused by events such as errors in logic programming, inputs improperly being asserted and de-asserted, or failed station components. If erroneously oscillation is detected, the L30 will stop sending GOOSE messages from the dataset for a minimum period of one second. Should the oscillation persist after the one second time-out period, the L30 will continue to block transmission of the dataset. The L30 will assert the **MAINTENANCE ALERT: GGIO Ind XXX oscill** self-test error message on the front panel display, where **XXX** denotes the data item detected as oscillating.

The configurable GOOSE feature is recommended for applications that require GOOSE data transfer between UR-series IEDs and devices from other manufacturers. Fixed GOOSE is recommended for applications that require GOOSE data transfer between UR-series IEDs.

IEC 61850 GOOSE messaging contains a number of configurable parameters, all of which must be correct to achieve the successful transfer of data. It is critical that the configured datasets at the transmission and reception devices are an exact match in terms of data structure, and that the GOOSE addresses and name strings match exactly. Manual configuration is possible, but third-party substation configuration software may be used to automate the process. The EnerVista UR Set-upsoftware can produce IEC 61850 ICD files and import IEC 61850 SCD files produced by a substation configurator (refer to the *IEC 61850 IED configuration* section later in this appendix).

NOTICE Use independent ports for IEC 61850 communication and take care when configuring the settings, else loss of protection or misoperation of the relay can result.

The following example illustrates the configuration required to transfer IEC 61850 data items between two devices. The general steps required for transmission configuration are:

1. Configure the transmission dataset.
2. Configure the GOOSE service settings.
3. Configure the data.

The general steps required for reception configuration are:

1. Configure the reception dataset.
2. Configure the GOOSE service settings.
3. Configure the data.

This example shows how to configure the transmission and reception of three IEC 61850 data items: a single point status value, its associated quality flags, and a floating point analog value.

The following procedure illustrates the transmission configuration.

1. Configure the transmission dataset by making the following changes in the **PRODUCT SETUP ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1 ⇨⇩ CONFIG GSE 1 DATASET ITEMS** settings menu:
   - Set **ITEM 1** to “GGIO1.ST.Ind1.q” to indicate quality flags for GGIO1 status indication 1.
   - Set **ITEM 2** to “GGIO1.ST.Ind1.stVal” to indicate the status value for GGIO1 status indication 1.

   The transmission dataset now contains a set of quality flags and a single point status Boolean value. The reception dataset on the receiving device must exactly match this structure.

2. Configure the GOOSE service settings by making the following changes in the **PRODUCT SETUP ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨ TRANSMISSION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1** settings menu:
   - Set **CONFIG GSE 1 FUNCTION** to "Enabled".
   - Set **CONFIG GSE 1 ID** to an appropriate descriptive string (the default value is "GOOSEOut_1").
   - Set **CONFIG GSE 1 DST MAC** to a multicast address (for example, 01 00 00 12 34 56).
   - Set the **CONFIG GSE 1 VLAN PRIORITY**; the default value of "4" is OK for this example.
   - Set the **CONFIG GSE 1 VLAN ID** value; the default value is "0", but some switches may require this value to be "1".
   - Set the **CONFIG GSE 1 ETYPE APPID** value. This setting represents the Ethertype application ID and must match the configuration on the receiver (the default value is "0").
   - Set the **CONFIG GSE 1 CONFREV** value. This value changes automatically as described in IEC 61850 part 7-2. For this example it can be left at its default value.

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3. Configure the data by making the following changes in the **PRODUCT SETUP ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨ GGIO1 STATUS CONFIGURATION** settings menu:
   - Set **GGIO1 INDICATION 1** to a FlexLogic operand used to provide the status of GGIO1.ST.Ind1.stVal (for example, a contact input, virtual input, a protection element status, etc.).

The L30 must be rebooted (control power removed and re-applied) before these settings take effect.

The following procedure illustrates the reception configuration.

1. Configure the reception dataset by making the following changes in the **PRODUCT SETUP ⇨⇩ COMMUNICATION ⇨⇩ IEC 61850 PROTOCOL ⇨ GSSE/GOOSE CONFIGURATION ⇨⇩ RECEPTION ⇨⇩ CONFIGURABLE GOOSE ⇨ CONFIGURABLE GOOSE 1 ⇨⇩ CONFIG GSE 1 DATASET ITEMS** settings menu:
   - Set **ITEM 1** to "GGIO3.ST.Ind1.q" to indicate quality flags for GGIO3 status indication 1.
   - Set **ITEM 2** to "GGIO3.ST.Ind1.stVal" to indicate the status value for GGIO3 status indication 1.

   The reception dataset now contains a set of quality flags, a single point status Boolean value, and a floating point analog value. This matches the transmission dataset configuration above.
2. Configure the GOOSE service settings by making the following changes in the **INPUTS/OUTPUTS ⇨⇩ REMOTE DEVICES ⇨⇩ REMOTE DEVICE 1** settings menu:
   - Set **REMOTE DEVICE 1 ID** to match the GOOSE ID string for the transmitting device. Enter "GOOSEOut_1".
   - Set **REMOTE DEVICE 1 ETYPE APPID** to match the Ethertype application ID from the transmitting device. This is "0" in the example above.
   - Set the **REMOTE DEVICE 1 DATASET** value. This value represents the dataset number in use. Since we are using configurable GOOSE 1 in this example, program this value as "GOOSEIn 1".
3. Configure the data by making the following changes in the **INPUTS/OUTPUTS ⇨⇩ REMOTE INPUTS ⇨⇩ REMOTE INPUT 1** settings menu:
   - Set **REMOTE IN 1 DEVICE** to "GOOSEOut_1".
   - Set **REMOTE IN 1 ITEM** to "Dataset Item 2". This assigns the value of the GGIO3.ST.Ind1.stVal single point status item to remote input 1.

Remote input 1 can now be used in FlexLogic equations or other settings. The L30 must be rebooted (control power removed and re-applied) before these settings take effect.

The value of remote input 1 (Boolean on or off) in the receiving device will be determined by the GGIO1.ST.Ind1.stVal value in the sending device. The above settings will be automatically populated by the EnerVista UR Setup software when a complete SCD file is created by third party substation configurator software.

C.4.5 ETHERNET MAC ADDRESS FOR GSSE/GOOSE

Ethernet capable devices each contain a unique identifying address called a Media Access Control (MAC) address. This address cannot be changed and is unique for each Ethernet device produced worldwide. The address is six bytes in length and is usually represented as six hexadecimal values (for example, 00 A0 F4 01 02 03). It is used in all Ethernet frames as the ‘source’ address of the frame. Each Ethernet frame also contains a *destination* address. The destination address can be different for each Ethernet frame depending on the intended destination of the frame.

A special type of destination address called a *multicast* address is used when the Ethernet frame can be received by more than one device. An Ethernet MAC address is multicast when the least significant bit of the first byte is set (for example, 01 00 00 00 00 00 is a multicast address).

GSSE and GOOSE messages must have multicast destination MAC addresses.

By default, the L30 is configured to use an automated multicast MAC scheme. If the L30 destination MAC address setting is not a valid multicast address (that is, the least significant bit of the first byte is not set), the address used as the destination MAC will be the same as the local MAC address, but with the multicast bit set. Thus, if the local MAC address is 00 A0 F4 01 02 03, then the destination MAC address will be 01 A0 F4 01 02 03.

C.4.6 GSSE ID AND GOOSE ID SETTINGS

GSSE messages contain an identifier string used by receiving devices to identify the sender of the message, defined in IEC 61850 part 8-1 as GsID. This is a programmable 65-character string. This string should be chosen to provide a descriptive name of the originator of the GSSE message.

GOOSE messages contain an identifier string used by receiving devices to identify the sender of the message, defined in IEC 61850 part 8-1 as GoID. This programmable 65-character string should be a descriptive name of the originator of the GOOSE message. GOOSE messages also contain two additional character strings used for identification of the message: DatSet - the name of the associated dataset, and GoCBRef - the reference (name) of the associated GOOSE control block. These strings are automatically populated and interpreted by the L30; no settings are required.

C.5.1 OVERVIEW

The L30 can be configured for IEC 61850 via the EnerVista UR Setup software as follows.

1. An ICD file is generated for the L30 by the EnerVista UR Setup software that describe the capabilities of the IED.
2. The ICD file is then imported into a system configurator along with other ICD files for other IEDs (from GE or other vendors) for system configuration.
3. The result is saved to a SCD file, which is then imported back to EnerVista UR Setup to create one or more settings file(s). The settings file(s) can then be used to update the relay(s) with the new configuration information.

The configuration process is illustrated below.

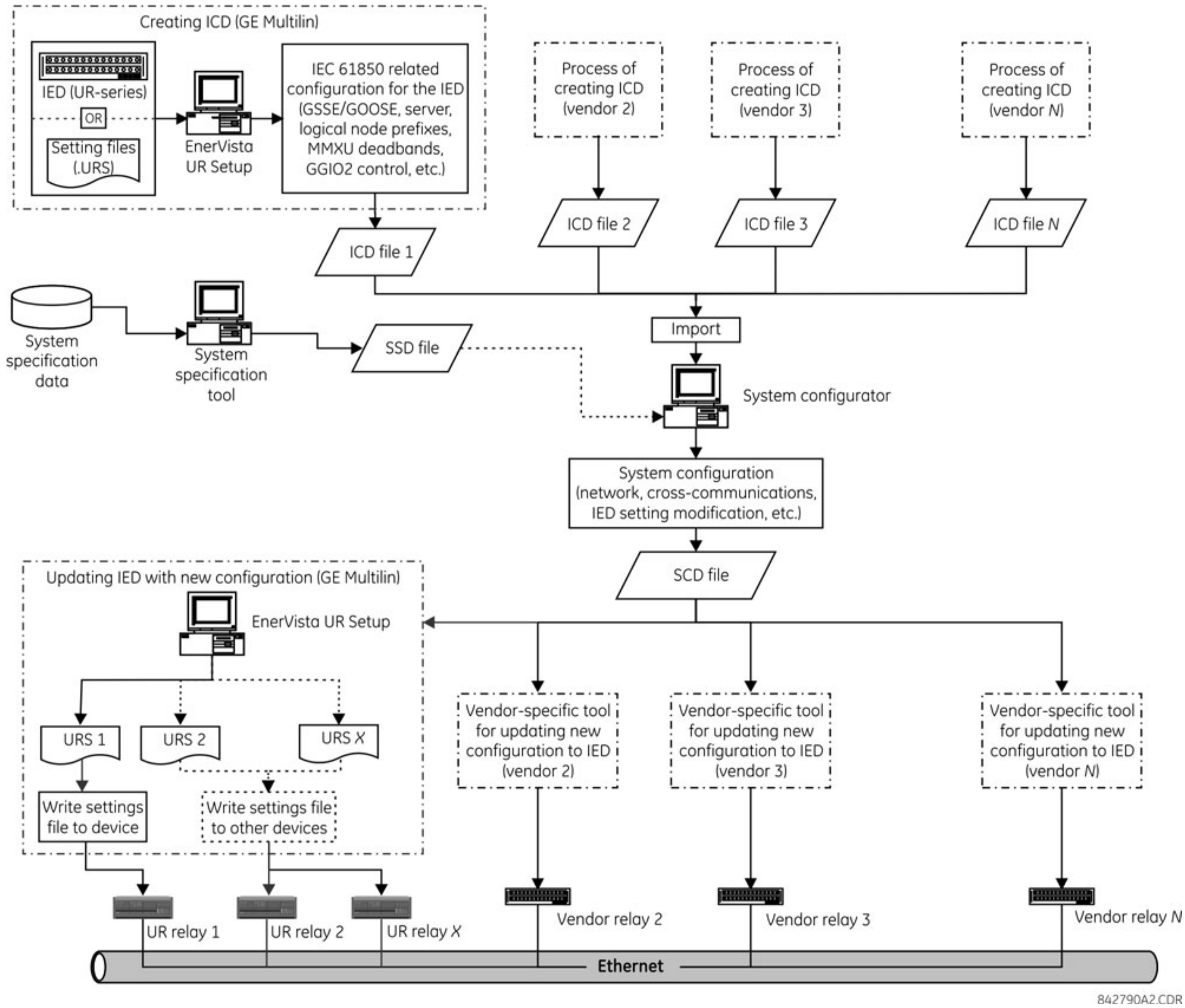


Figure C–1: IED CONFIGURATION PROCESS

The following acronyms and abbreviations are used in the procedures describing the IED configuration process for IEC 61850:

- BDA: Basic Data Attribute, that is not structured
- DAI: Instantiated Data Attribute
- DO: Data Object type or instance, depending on the context

- DOI: Instantiated Data Object
- IED: Intelligent Electronic Device
- LDInst: Instantiated Logical Device
- LNInst: Instantiated Logical Node
- SCL: Substation Configuration Description Language. The configuration language is an application of the Extensible Markup Language (XML) version 1.0.
- SDI: Instantiated Sub DATA; middle name part of a structured DATA name
- UR: GE Multilin Universal Relay series
- URI: Universal Resource Identifier
- URS: UR-series relay setting file
- XML: Extensible Markup Language

The following SCL variants are also used:

- ICD: IED Capability Description
- CID: Configured IED Description
- SSD: System Specification Description
- SCD: Substation Configuration Description

The following IEC related tools are referenced in the procedures that describe the IED configuration process for IEC 61850:

- **System configurator** or **Substation configurator**: This is an IED independent system level tool that can import or export configuration files defined by IEC 61850-6. It can import configuration files (ICD) from several IEDs for system level engineering and is used to add system information shared by different IEDs. The system configuration generates a substation related configuration file (SCD) which is fed back to the IED configurator (for example, EnerVista UR Setup) for system related IED configuration. The system configurator should also be able to read a system specification file (SSD) to use as base for starting system engineering, or to compare it with an engineered system for the same substation.
- **IED configurator**: This is a vendor specific tool that can directly or indirectly generate an ICD file from the IED (for example, from a settings file). It can also import a system SCL file (SCD) to set communication configuration parameters (that is, required addresses, reception GOOSE datasets, IDs of incoming GOOSE datasets, etc.) for the IED. The IED configurator functionality is implemented in the GE Multilin EnerVista UR Setup software.

C.5.2 CONFIGURING IEC 61850 SETTINGS

Before creating an ICD file, the user can customize the IEC 61850 related settings for the IED. For example, the IED name and logical device instance can be specified to uniquely identify the IED within the substation, or transmission GOOSE datasets created so that the system configurator can configure the cross-communication links to send GOOSE messages from the IED. Once the IEC 61850 settings are configured, the ICD creation process will recognize the changes and generate an ICD file that contains the updated settings.

Some of the IED settings will be modified during they system configuration process. For example, a new IP address may be assigned, line items in a Transmission GOOSE dataset may be added or deleted, or prefixes of some logical nodes may be changed. While all new configurations will be mapped to the L30 settings file when importing an SCD file, all unchanged settings will preserve the same values in the new settings file.

These settings can be configured either directly through the relay panel or through the EnerVista UR Setup software (preferred method). The full list of IEC 61850 related settings for are as follows:

- Network configuration: IP address, IP subnet mask, and default gateway IP address (access through the **Settings > Product Setup > Communications > Network** menu tree in EnerVista UR Setup).
- Server configuration: IED name and logical device instance (access through the **Settings > Product Setup > Communications > IEC 61850 > Server Configuration** menu tree in EnerVista UR Setup).
- Logical node prefixes, which includes prefixes for all logical nodes except LLN0 (access through the **Settings > Product Setup > Communications > IEC 61850 > Logical Node Prefixes** menu tree in EnerVista UR Setup).

- MMXU deadbands, which includes deadbands for all available MMXUs. The number of MMXUs is related to the number of CT/VT modules in the relay. There are two MMXUs for each CT/VT module. For example, if a relay contains two CT/VT modules, there will be four MMXUs available (access through the **Settings > Product Setup > Communications > IEC 61850 > MMXU Deadbands** menu tree in EnerVista UR Setup).
- GGIO1 status configuration, which includes the number of status points in GGIO1 as well as the potential internal mappings for each GGIO1 indication. However only the number of status points will be used in the ICD creation process (access through the **Settings > Product Setup > Communications > IEC 61850 > GGIO1 Status Configuration** menu tree in EnerVista UR Setup).
- GGIO2 control configuration, which includes ctlModels for all SPCSOs within GGIO2 (access through the **Settings > Product Setup > Communications > IEC 61850 > GGIO2 Control Configuration** menu tree in EnerVista UR Setup).
- Configurable transmission GOOSE, which includes eight configurable datasets that can be used for GOOSE transmission. The GOOSE ID can be specified for each dataset (it must be unique within the IED as well as across the whole substation), as well as the destination MAC address, VLAN priority, VLAN ID, ETYPE APPID, and the dataset items. The selection of the dataset item is restricted by firmware version; for version 7.1x, only GGIO1.ST.Indx.stVal and GGIO1.ST.Indx.q are valid selection (where *x* is between 1 to *N*, and *N* is determined by number of GGIO1 status points). Although configurable transmission GOOSE can also be created and altered by some third-party system configurators, we recommend configuring transmission GOOSE for GE Multilin IEDs before creating the ICD, and strictly within EnerVista UR Setup software or the front panel display (access through the **Settings > Product Setup > Communications > IEC 61850 > GSSE/GOOSE Configuration > Transmission > Tx Configurable GOOSE** menu tree in EnerVista UR Setup).
- Configurable reception GOOSE, which includes eight configurable datasets that can be used for GOOSE reception. However, unlike datasets for transmission, datasets for reception only contains dataset items, and they are usually created automatically by process of importing the SCD file (access through the **Settings > Product Setup > Communications > IEC 61850 > GSSE/GOOSE Configuration > Reception > Rx Configurable GOOSE** menu tree in EnerVista UR Setup).
- Remote devices configuration, which includes remote device ID (GOOSE ID or GoID of the incoming transmission GOOSE dataset), ETYPE APPID (of the GSE communication block for the incoming transmission GOOSE), and DATASET (which is the name of the associated reception GOOSE dataset). These settings are usually done automatically by process of importing SCD file (access through the **Settings > Inputs/Outputs > Remote Devices** menu tree in EnerVista UR Setup).
- Remote inputs configuration, which includes device (remote device ID) and item (which dataset item in the associated reception GOOSE dataset to map) values. Only the items with cross-communication link created in SCD file should be mapped. These configurations are usually done automatically by process of importing SCD file (access through the **Settings > Inputs/Outputs > Remote Inputs** menu tree in EnerVista UR Setup).

C.5.3 ABOUT ICD FILES

The SCL language is based on XML, and its syntax definition is described as a W3C XML Schema. ICD is one type of SCL file (which also includes SSD, CID and SCD files). The ICD file describes the capabilities of an IED and consists of four major sections:

- Header
- Communication
- IEDs
- DataTypeTemplates

The root file structure of an ICD file is illustrated below.

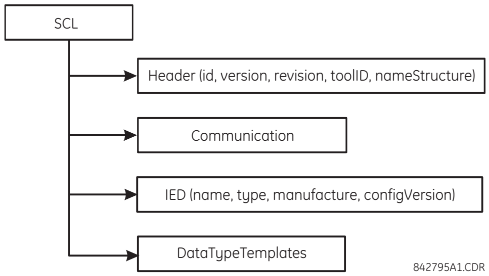


Figure C–2: ICD FILE STRUCTURE, SCL (ROOT) NODE

The **Header** node identifies the ICD file and its version, and specifies options for the mapping of names to signals

The **Communication** node describes the direct communication connection possibilities between logical nodes by means of logical buses (sub-networks) and IED access ports. The communication section is structured as follows.

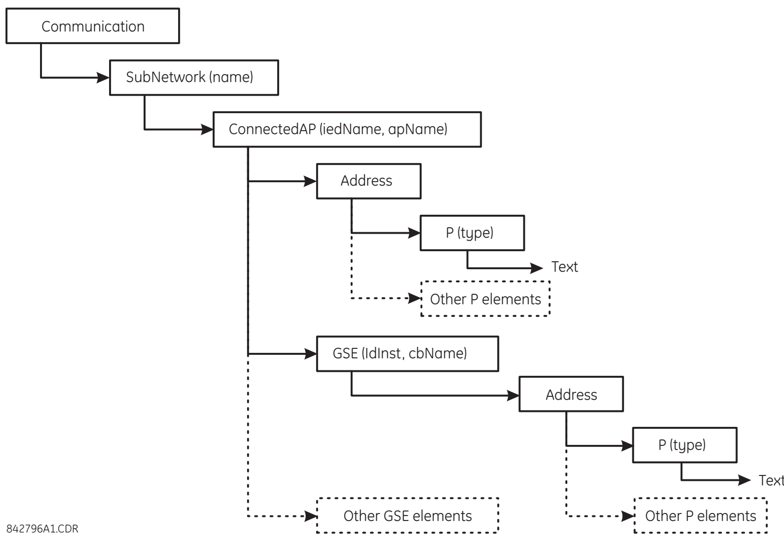


Figure C–3: ICD FILE STRUCTURE, COMMUNICATIONS NODE

The **SubNetwork** node contains all access points which can (logically) communicate with the sub-network protocol and without the intervening router. The **ConnectedAP** node describes the IED access point connected to this sub-network. The **Address** node contains the address parameters of the access point. The **GSE** node provides the address element for stating the control block related address parameters, where **IdInst** is the instance identification of the logical device within the IED on which the control block is located, and **cbName** is the name of the control block.

The **IED** node describes the (pre-)configuration of an IED: its access points, the logical devices, and logical nodes instantiated on it. Furthermore, it defines the capabilities of an IED in terms of communication services offered and, together with its **LNType**, instantiated data (DO) and its default or configuration values. There should be only one IED section in an ICD since it only describes one IED.

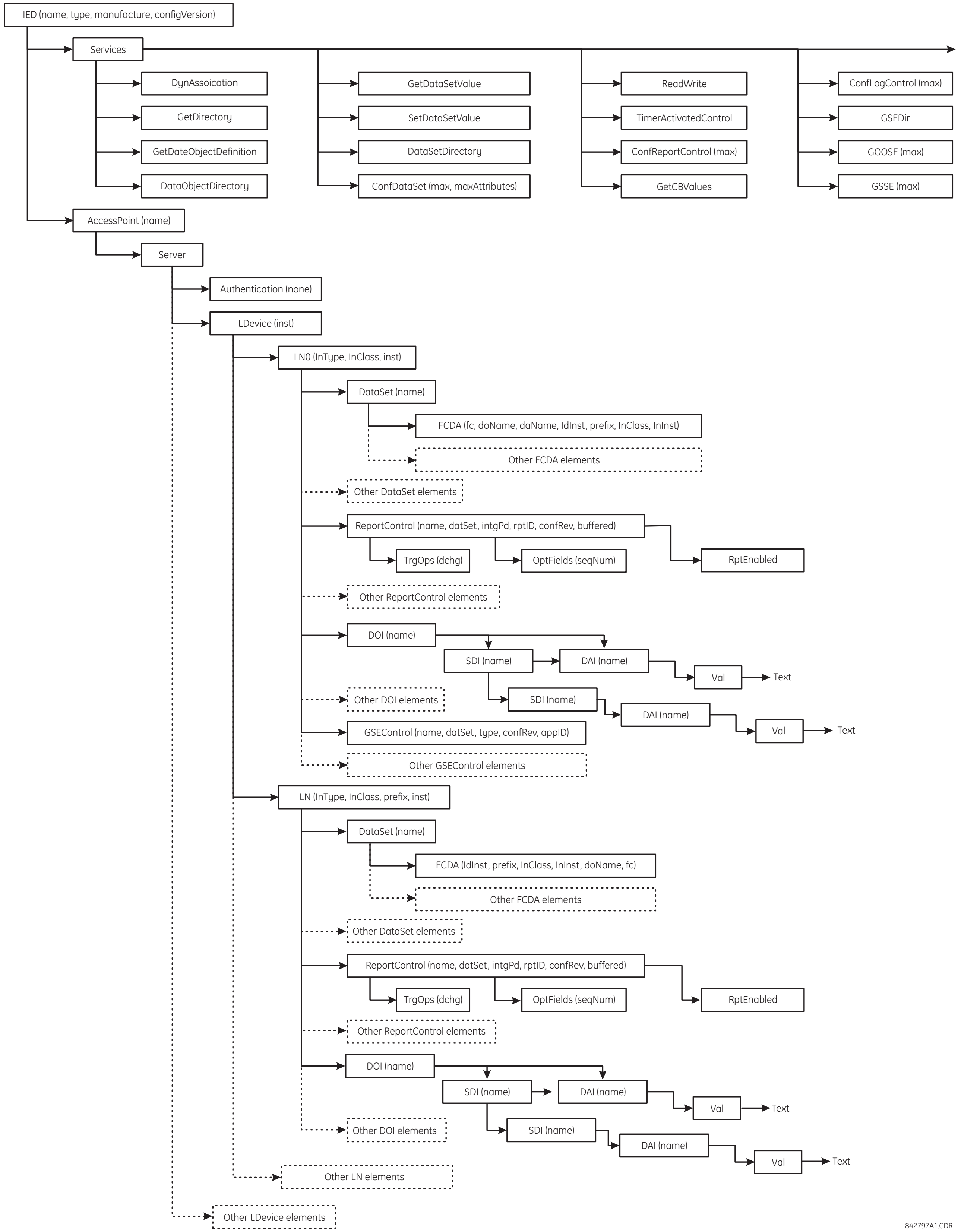


Figure C–4: ICD FILE STRUCTURE, IED NODE

The **DataTypeTemplates** node defines instantiable logical node types. A logical node type is an instantiable template of the data of a logical node. A **LnodeType** is referenced each time that this instantiable type is needed with an IED. A logical node type template is built from DATA (DO) elements, which again have a DO type, which is derived from the DATA classes (CDC). DOs consist of attributes (DA) or of elements of already defined DO types (SDO). The attribute (DA) has a functional constraint, and can either have a basic type, be an enumeration, or a structure of a **DAType**. The DAType is built from BDA elements, defining the structure elements, which again can be **BDA** elements of have a base type such as DA.

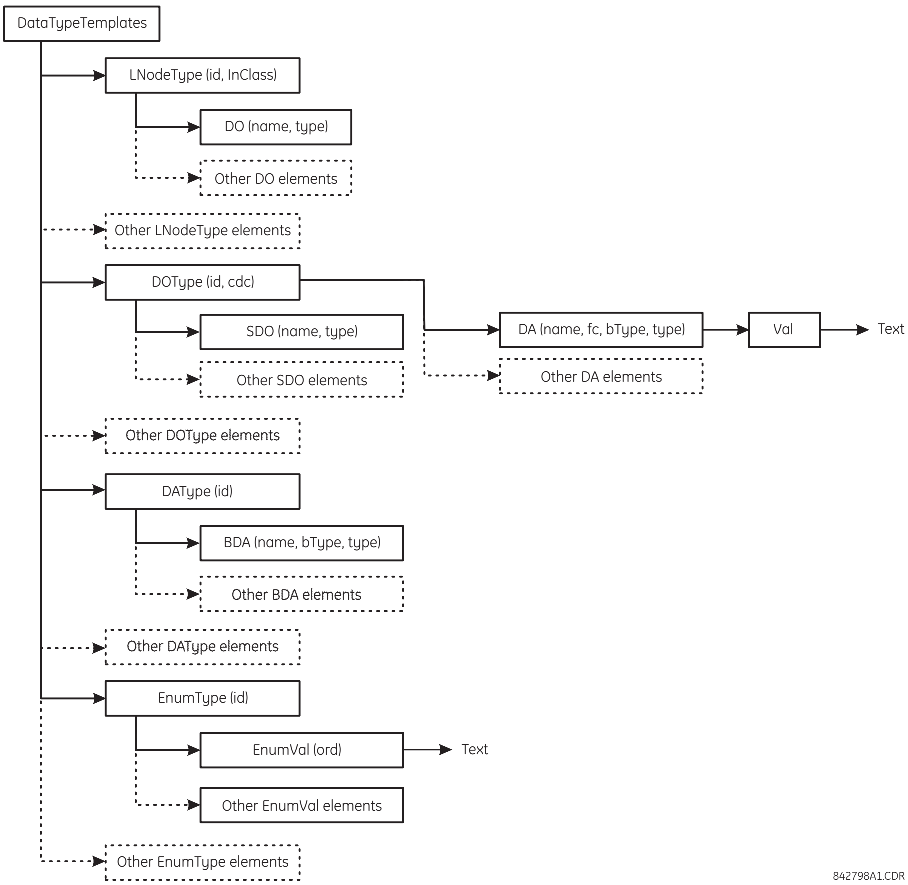
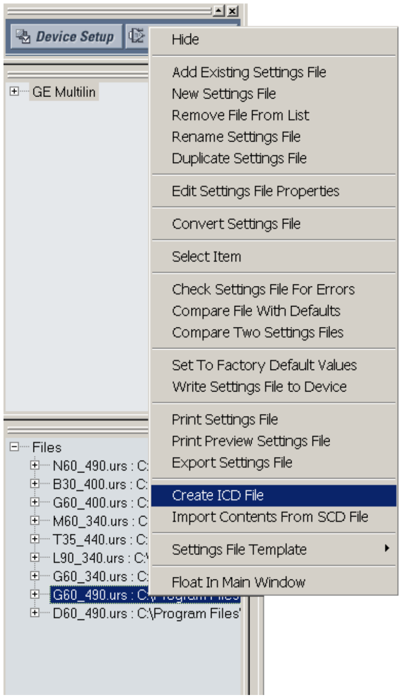


Figure C–5: ICD FILE STRUCTURE, DATATYPETEMPLATES NODE

C.5.4 CREATING AN ICD FILE WITH ENERVISTA UR SETUP

An ICD file can be created directly from a connected L30 IED or from an offline L30 settings file with the EnerVista UR Setup software using the following procedure:

1. Right-click the connected UR-series relay or settings file and select **Create ICD File**.



2. The EnerVista UR Setup will prompt to save the file. Select the file path and enter the name for the ICD file, then click **OK** to generate the file.

The time to create an ICD file from the offline L30 settings file is typically much quicker than create an ICD file directly from the relay.

C.5.5 ABOUT SCD FILES

System configuration is performed in the system configurator. While many vendors (including GE Multilin) are working their own system configuration tools, there are some system configurators available in the market (for example, Siemens DIGSI version 4.6 or above and ASE Visual SCL Beta 0.12).

Although the configuration tools vary from one vendor to another, the procedure is pretty much the same. First, a substation project must be created, either as an empty template or with some system information by importing a system specification file (SSD). Then, IEDs are added to the substation. Since each IED is represented by its associated ICD, the ICD files are imported into the substation project, and the system configurator validates the ICD files during the importing process. If the ICD files are successfully imported into the substation project, it may be necessary to perform some additional minor steps to attach the IEDs to the substation (see the system configurator manual for details).

Once all IEDs are inserted into the substation, further configuration is possible, such as:

- Assigning network addresses to individual IEDs.
- Customizing the prefixes of logical nodes.
- Creating cross-communication links (configuring GOOSE messages to send from one IED to others).

When system configurations are complete, the results are saved to an SCD file, which contains not only the configuration for each IED in the substation, but also the system configuration for the entire substation. Finally, the SCD file is passed back to the IED configurator (vendor specific tool) to update the new configuration into the IED.

The SCD file consists of at least five major sections:

C

- Header.
- Substation.
- Communication.
- IED section (one or more).
- DataTypeTemplates.

The root file structure of an SCD file is illustrated below.

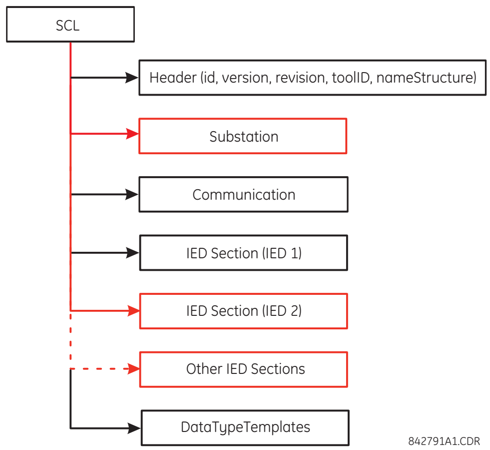


Figure C–6: SCD FILE STRUCTURE, SCL (ROOT) NODE

Like ICD files, the **Header** node identifies the SCD file and its version, and specifies options for the mapping of names to signals.

The **Substation** node describes the substation parameters:

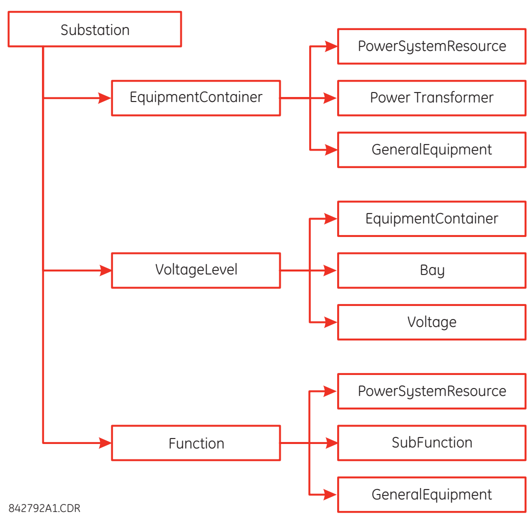


Figure C–7: SCD FILE STRUCTURE, SUBSTATION NODE

The **Communication** node describes the direct communication connection possibilities between logical nodes by means of logical buses (sub-networks) and IED access ports. The communication section is structured as follows.

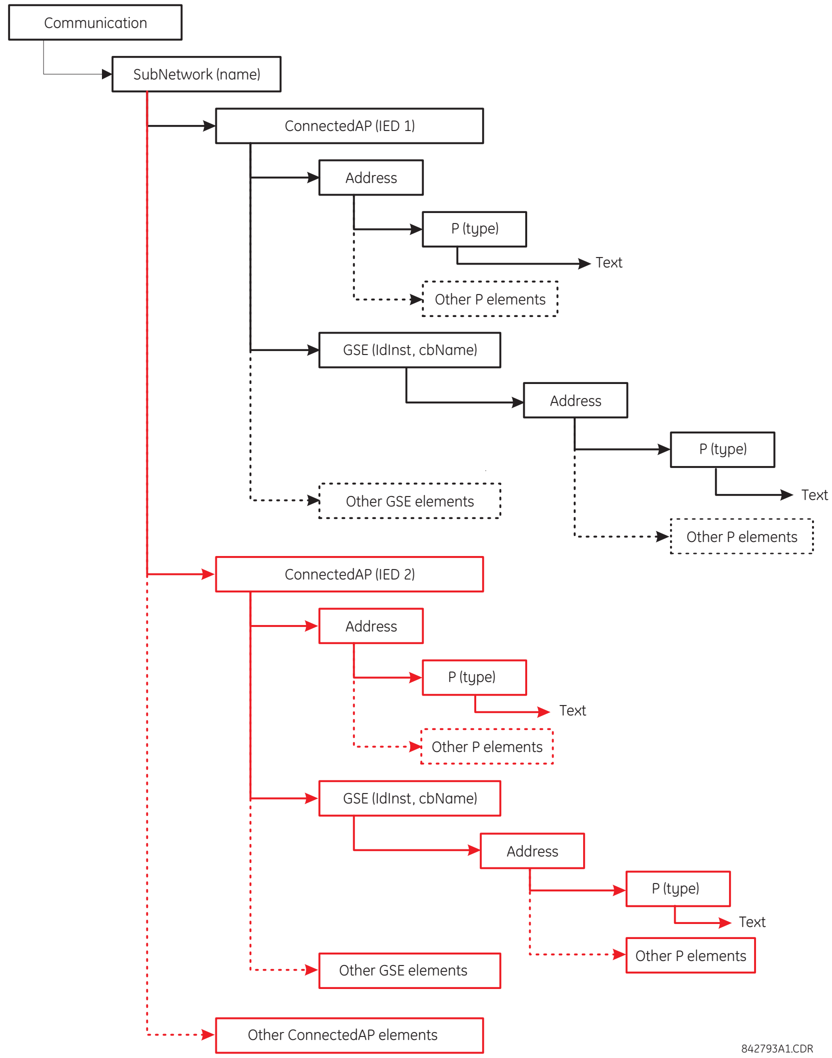


Figure C–8: SCD FILE STRUCTURE, COMMUNICATIONS NODE

The **SubNetwork** node contains all access points which can (logically) communicate with the sub-network protocol and without the intervening router. The **ConnectedAP** node describes the IED access point connected to this sub-network. The **Address** node contains the address parameters of the access point. The **GSE** node provides the address element for stating the control block related address parameters, where **IdInst** is the instance identification of the logical device within the IED on which the control block is located, and **cbName** is the name of the control block.

The **IED Section** node describes the configuration of an IED.

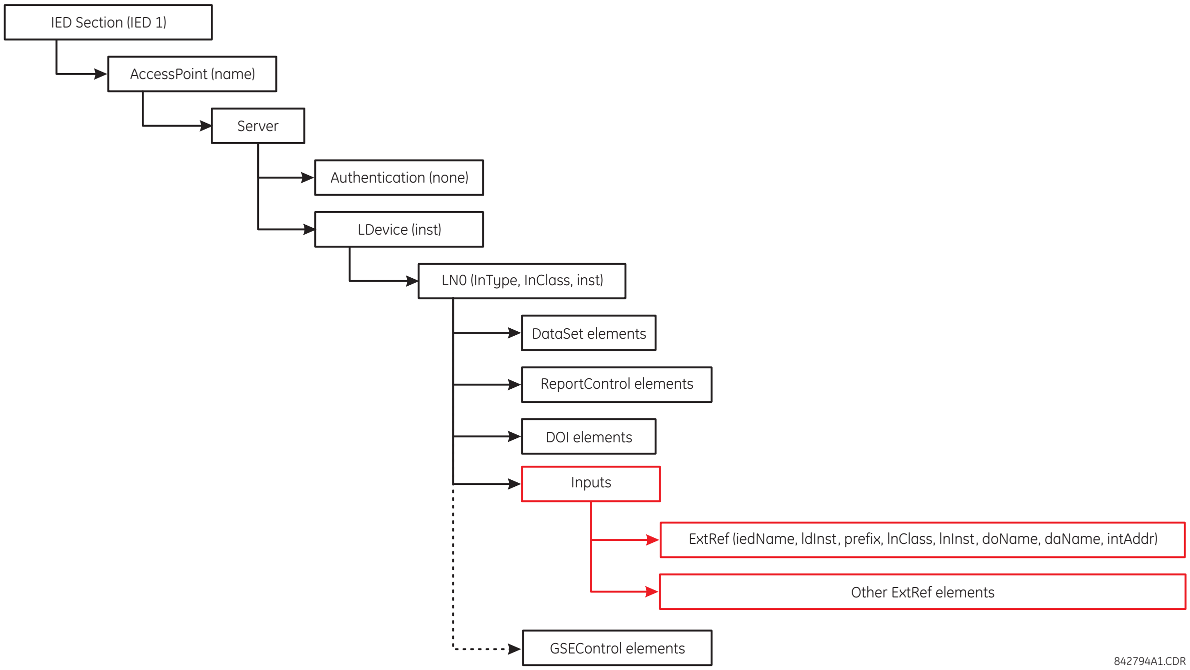
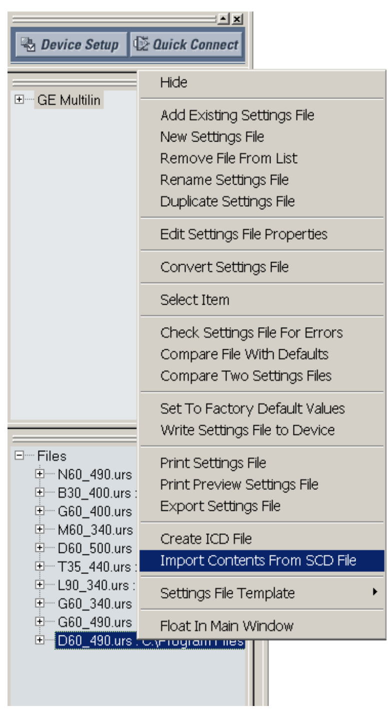


Figure C–9: SCD FILE STRUCTURE, IED NODE

C.5.6 IMPORTING AN SCD FILE WITH ENERVISTA UR SETUP

The following procedure describes how to update the L30 with the new configuration from an SCD file with the EnerVista UR Setup software.

1. Right-click anywhere in the files panel and select the **Import Contents From SCD File** item.



2. Select the saved SCD file and click **Open**.

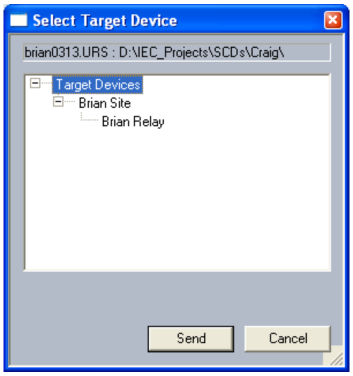
3. The software will open the SCD file and then prompt the user to save a UR-series settings file. Select a location and name for the URS (UR-series relay settings) file.

   If there is more than one GE Multilin IED defined in the SCD file, the software prompt the user to save a UR-series settings file for each IED.

4. After the URS file is created, modify any settings (if required).

5. To update the relay with the new settings, right-click on the settings file in the settings tree and select the **Write Settings File to Device** item.

6. The software will prompt for the target device. Select the target device from the list provided and click **Send**. The new settings will be updated to the selected device.



C.6.1 ACSI BASIC CONFORMANCE STATEMENT

SERVICES		SERVER/ PUBLISHER	UR-FAMILY
CLIENT-SERVER ROLES			
B11	**Server** side (of Two-party Application-Association)	**c1**	**Yes**
B12	**Client** side (of Two-party Application-Association)	**---**	
SCSMS SUPPORTED			
B21	**SCSM**: IEC 61850-8-1 used		**Yes**
B22	**SCSM**: IEC 61850-9-1 used		
B23	**SCSM**: IEC 61850-9-2 used		
B24	**SCSM**: other		
GENERIC SUBSTATION EVENT MODEL (GSE)			
B31	**Publisher** side	**O**	**Yes**
B32	**Subscriber** side	**---**	**Yes**
TRANSMISSION OF SAMPLED VALUE MODEL (SVC)			
B41	**Publisher** side	**O**	
B42	**Subscriber** side	**---**	

NOTE

c1: shall be "M" if support for LOGICAL-DEVICE model has been declared
O: Optional
M: Mandatory

C.6.2 ACSI MODELS CONFORMANCE STATEMENT

SERVICES		SERVER/ PUBLISHER	UR-FAMILY
IF SERVER SIDE (B11) SUPPORTED			
M1	**Logical device**	**c2**	**Yes**
M2	**Logical node**	**c3**	**Yes**
M3	**Data**	**c4**	**Yes**
M4	**Data set**	**c5**	**Yes**
M5	**Substitution**	**O**	
M6	**Setting group control**	**O**	
	REPORTING		
M7	**Buffered report control**	**O**	**Yes**
M7-1	sequence-number		
M7-2	report-time-stamp		
M7-3	reason-for-inclusion		
M7-4	data-set-name		
M7-5	data-reference		
M7-6	buffer-overflow		
M7-7	entryID		
M7-8	BufTm		
M7-9	IntgPd		
M7-10	GI		
M8	**Unbuffered report control**	**O**	**Yes**
M8-1	sequence-number		
M8-2	report-time-stamp		
M8-3	reason-for-inclusion		

SERVICES		SERVER/ PUBLISHER	UR-FAMILY
M8-4	data-set-name		
M8-5	data-reference		
M8-6	BufTm		
M8-7	IntgPd		
M8-8	GI		
	Logging	**O**	
M9	**Log control**	**O**	
M9-1	IntgPd		
M10	**Log**	**O**	
M11	**Control**	**M**	**Yes**
IF GSE (B31/32) IS SUPPORTED			
	GOOSE	**O**	**Yes**
M12-1	entryID		
M12-2	DataRefInc		
M13	**GSSE**	**O**	**Yes**
IF SVC (B41/B42) IS SUPPORTED			
M14	Multicast SVC	**O**	
M15	Unicast SVC	**O**	
M16	**Time**	**M**	**Yes**
M17	**File transfer**	**O**	**Yes**

NOTE

c2: shall be "M" if support for LOGICAL-NODE model has been declared
c3: shall be "M" if support for DATA model has been declared
c4: shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time models has been declared
c5: shall be "M" if support for Report, GSE, or SMV models has been declared
M: Mandatory

C.6.3 ACSI SERVICES CONFORMANCE STATEMENT

In the table below, the acronym AA refers to Application Associations (TP: Two Party / MC: Multicast). The c6 to c10 entries are defined in the notes following the table.

SERVICES		AA: TP/MC	SERVER/ PUBLISHER	UR FAMILY
SERVER (CLAUSE 7)				
S1	ServerDirectory	TP	M	Yes
APPLICATION ASSOCIATION (CLAUSE 8)				
S2	Associate	TP	M	Yes
S3	Abort	TP	M	Yes
S4	Release	TP	M	Yes
LOGICAL DEVICE (CLAUSE 9)				
S5	LogicalDeviceDirectory	TP	M	Yes
LOGICAL NODE (CLAUSE 10)				
S6	LogicalNodeDirectory	TP	M	Yes
S7	GetAllDataValues	TP	M	Yes
DATA (CLAUSE 11)				
S8	GetDataValues	TP	M	Yes
S9	SetDataValues	TP	O	Yes
S10	GetDataDirectory	TP	M	Yes
S11	GetDataDefinition	TP	M	Yes

SERVICES		AA: TP/MC	SERVER/ PUBLISHER	UR FAMILY
DATA SET (CLAUSE 12)				
S12	GetDataSetValues	TP	M	Yes
S13	SetDataSetValues	TP	O	
S14	CreateDataSet	TP	O	
S15	DeleteDataSet	TP	O	
S16	GetDataSetDirectory	TP	O	Yes
SETTING GROUP CONTROL (CLAUSE 16)				
S18	SelectActiveSG	TP	O	
S19	SelectEditSG	TP	O	
S20	SetSGValues	TP	O	
S21	ConfirmEditSGValues	TP	O	
S22	GetSGValues	TP	O	
S23	GetSGCBValues	TP	O	
REPORTING (CLAUSE 17)				
	BUFFERED REPORT CONTROL BLOCK (BRCB)			
S24	Report	TP	c6	Yes
S24-1	data-change (dchg)			Yes
S24-2	qchg-change (qchg)			
S24-3	data-update (dupd)			
S25	GetBRCBValues	TP	c6	Yes
S26	SetBRCBValues	TP	c6	Yes
	UNBUFFERED REPORT CONTROL BLOCK (URCB)			
S27	Report	TP	c6	Yes
S27-1	data-change (dchg)			Yes
S27-2	qchg-change (qchg)			
S27-3	data-update (dupd)			
S28	GetURCBValues	TP	c6	Yes
S29	SetURCBValues	TP	c6	Yes
LOGGING (CLAUSE 17)				
	LOG CONTROL BLOCK			
S30	GetLCBValues	TP	M	
S31	SetLCBValues	TP	M	
	LOG			
S32	QueryLogByTime	TP	M	
S33	QueryLogByEntry	TP	M	
S34	GetLogStatusValues	TP	M	
GENERIC SUBSTATION EVENT MODEL (GSE) (CLAUSE 18, ANNEX C)				
	GOOSE-CONTROL-BLOCK (CLAUSE 18)			
S35	SendGOOSEMessage	MC	c8	Yes
S36	GetReference	TP	c9	
S37	GetGOOSEElementNumber	TP	c9	
S38	GetGoCBValues	TP	O	Yes
S39	SetGoCBValues	TP	O	Yes
	GSSE-CONTROL-BLOCK (ANNEX C)			
S40	SendGSSEMessage	MC	c8	Yes
S41	GetReference	TP	c9	
S42	GetGSSEElementNumber	TP	c9	
S43	GetGsCBValues	TP	O	Yes

SERVICES		AA: TP/MC	SERVER/ PUBLISHER	UR FAMILY
S44	SetGsCBValues	TP	O	Yes
TRANSMISSION OF SAMPLED VALUE MODEL (SVC) (CLAUSE 19)				
	MULTICAST SVC			
S45	SendMSVMessage	MC	c10	
S46	GetMSVCBValues	TP	O	
S47	SetMSVCBValues	TP	O	
	UNICAST SVC			
S48	SendUSVMessage	MC	c10	
S49	GetUSVCBValues	TP	O	
S50	SetUSVCBValues	TP	O	
CONTROL (CLAUSE 20)				
S51	Select		O	Yes
S52	SelectWithValue	TP	O	
S53	Cancel	TP	O	Yes
S54	Operate	TP	M	Yes
S55	Command-Termination	TP	O	
S56	TimeActivated-Operate	TP	O	
FILE TRANSFER (CLAUSE 23)				
S57	GetFile	TP	M	Yes
S58	SetFile	TP	O	
S59	DeleteFile	TP	O	
S60	GetFileAttributeValues	TP	M	Yes
TIME (CLAUSE 5.5)				
T1	Time resolution of internal clock (nearest negative power of 2 in seconds)			20
T2	Time accuracy of internal clock			SNTP, IRIG-B
T3	Supported TimeStamp resolution (nearest value of 2^{-n} in seconds, according to 6.1.2.9.3.2)			20

NOTE

c6: shall declare support for at least one (BRCB or URCB)
c7: shall declare support for at least one (QueryLogByTime or QueryLogAfter)
c8: shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage)
c9: shall declare support if TP association is available
c10: shall declare support for at least one (SendMSVMessage or SendUSVMessage)

C.7.1 LOGICAL NODES TABLE

The UR-series of relays supports IEC 61850 logical nodes as indicated in the following table. Note that the actual instantiation of each logical node is determined by the product order code. For example. the logical node “PDIS” (distance protection) is available only in the D60 Line Distance Relay.

Table C–1: IEC 61850 LOGICAL NODES (Sheet 1 of 4)

NODES	UR-FAMILY
L: SYSTEM LOGICAL NODES	
LPHD: Physical device information	Yes
LLN0: Logical node zero	Yes
LCCH: Physical communication channel supervision	---
LGOS: GOOSE subscription	---
LSVS: Sampled value subscription	---
LTIM: Time management	---
LTMS: Time master supervision	---
LTRK: Service tracking	---
A: LOGICAL NODES FOR AUTOMATIC CONTROL	
ANCR: Neutral current regulator	---
ARCO: Reactive power control	---
ATCC: Automatic tap changer controller	---
AVCO: Voltage control	---
C: LOGICAL NODES FOR CONTROL	
CALH: Alarm handling	---
CCGR: Cooling group control	---
CILO: Interlocking	---
CPOW: Point-on-wave switching	---
CSWI: Switch controller	Yes
CSYN: Synchronizer controller	---
F: LOGICAL NODES FOR FUNCTIONAL BLOCKS	
FCNT: Counter	---
FCSD: Curve shape description	---
FFIL: Generic filler	---
FLIM: Control function output limitation	---
FPID: PID regulator	---
FRMP: Ramp function	---
FSPT: Set-point control function	---
FXOT: Action at over threshold	---
FXUT: Action at under threshold	---
G: LOGICAL NODES FOR GENERIC REFERENCES	
GAPC: Generic automatic process control	---
GGIO: Generic process I/O	Yes
GLOG: Generic log	---
GSAL: Generic security application	---
I: LOGICAL NODES FOR INTERFACING AND ARCHIVING	
IARC: Archiving	---
IHMI: Human machine interface	---
ISAF: Safety alarm function	---
ITCI: Telecontrol interface	---
ITMI: Telemonitoring interface	---

Table C–1: IEC 61850 LOGICAL NODES (Sheet 2 of 4)

NODES	UR-FAMILY
ITPC: Teleprotection communication interfaces	---
K: LOGICAL NODES FOR MECHANICAL AND NON-ELECTRIC PRIMARY EQUIPMENT	
KFAN: Fan	---
KFIL: Filter	---
KPMP: Pump	---
KTNK: Tank	---
KVLV: Valve control	---
M: LOGICAL NODES FOR METERING AND MEASUREMENT	
MENV: Environmental information	---
MFLK: Flicker measurement name	---
MHAI: Harmonics or interharmonics	---
MHAN: Non phase related harmonics or interharmonics	---
MHYD: Hydrological information	---
MMDC: DC measurement	---
MMET: Meteorological information	---
MMTN: Metering	---
MMTR: Metering	---
MMXN: Non-phase-related measurement	Yes
MMXU: Measurement	Yes
MSQI: Sequence and imbalance	Yes
MSTA: Metering statistics	---
P: LOGICAL NODES FOR PROTECTION FUNCTIONS	
PDIF: Differential	Yes
PDIR: Direction comparison	---
PDIS: Distance	Yes
PDOP: Directional overpower	---
PDUP: Directional underpower	---
PFRC: Rate of change of frequency	---
PHAR: Harmonic restraint	---
PHIZ: Ground detector	---
PIOC: Instantaneous overcurrent	Yes
PMRI Motor restart inhibition	---
PMSS: Motor starting time supervision	---
POPF: Over power factor	---
PPAM: Phase angle measuring	---
PRTR: Rotor protection	---
PSCH: Protection scheme	---
PSDE: Sensitive directional earth fault	---
PTEF: Transient earth fault	---
PTOC: Time overcurrent	Yes
PTOF: Overfrequency	---
PTOV: Overvoltage	Yes
PTRC: Protection trip conditioning	Yes
PTTR: Thermal overload	---
PTUC: Undercurrent	---
PTUF: Underfrequency	---
PTUV: Undervoltage	Yes

Table C–1: IEC 61850 LOGICAL NODES (Sheet 3 of 4)

NODES	UR-FAMILY
PUPF: Underpower factor	---
PVOC: Voltage controlled time overcurrent	---
PVPH: Volts per Hz	---
PZSU: Zero speed or underspeed	---
Q: LOGICAL NODES FOR POWER QUALITY EVENTS	
QFVR: Frequency variation	---
QITR: Current transient	---
QIUB: Current unbalance variation	---
QVTR: Voltage transient	---
QVUB: Voltage unbalance variation	---
QVVR: Voltage variation	---
R: LOGICAL NODES FOR PROTECTION-RELATED FUNCTIONS	
RADR: Disturbance recorder channel analogue	---
RBDR: Disturbance recorder channel binary	---
RBRF: Breaker failure	---
RDIR: Directional element	---
RDRE: Disturbance recorder function	---
RDRS: Disturbance record handling	---
RFLO: Fault locator	Yes
RMXU: Differential measurements	---
RPSB: Power swing detection/blocking	Yes
RREC: Autoreclosing	Yes
RSYN: Synchronism-check or synchronizing	---
S: LOGICAL NODES FOR SENSORS AND MONITORING	
SARC: Monitoring and diagnostics for arcs	---
SCBR: Circuit breaker supervision	---
SIMG: Insulation medium supervision (gas)	---
SIML: Insulation medium supervision (liquid)	---
SLTC: Tap changer supervision	---
SOPM: Supervision of operating mechanism	---
SPDC: Monitoring and diagnostics for partial discharges	---
SPTR: Power transformer supervision	---
SSWI: Circuit switch supervision	---
STMP: Temperature supervision	---
SVBR: Vibration supervision	---
T: LOGICAL NODES FOR INSTRUMENT TRANSFORMERS	
TANG: Angle	---
TAXD: Axial displacement	---
TCTR: Current transformer	---
TDST: Distance	---
TFLW: Liquid flow	---
TFRQ: Frequency	---
TGSN: Generic sensor	---
THUM: Humidity	---
TLVL: Media level	---
TMGF: Magnetic field	---
TMVM: Movement sensor	---

Table C–1: IEC 61850 LOGICAL NODES (Sheet 4 of 4)

NODES	UR-FAMILY
TPOS: Position indicator	---
TPRS: Pressure sensor	---
TRTN: Rotation transmitter	---
TSND: Sound pressure sensor	---
TTMP: Temperature sensor	---
TTNS: Mechanical tension	---
TVBR: Vibration sensor	---
TVTR: Voltage transformer	---
TWPH: Water acidity	---
X: LOGICAL NODES FOR SWITCHGEAR	
XCBR: Circuit breaker	Yes
XSWI: Circuit switch	Yes
Y: LOGICAL NODES FOR POWER TRANSFORMERS	
YEFN: Earth fault neutralizer (Petersen coil)	---
YLTC: Tap changer	---
YPSH: Power shunt	---
YPTR: Power transformer	---
Z: LOGICAL NODES FOR FURTHER POWER SYSTEM EQUIPMENT	
ZAXN: Auxiliary network	---
ZBAT: Battery	---
ZBSH: Bushing	---
ZCAB: Power cable	---
ZCAP: Capacitor bank	---
ZCON: Converter	---
ZGEN: Generator	---
ZGIL: Gas insulated line	---
ZLIN: Power overhead line	---
ZMOT: Motor	---
ZREA: Reactor	---
ZRES: Resistor	---
ZRRC: Rotating reactive component	---
ZSAR: Surge arrestor	---
ZSCR: Semi-conductor controlled rectifier	---
ZSMC: Synchronous machine	---
ZTCF: Thyristor controlled frequency converter	---
ZTRC: Thyristor controlled reactive component	---

C

C

D.1.1 INTEROPERABILITY DOCUMENT

This document is adapted from the IEC 60870-5-104 standard. For this section the boxes indicate the following: ☒ – used in standard direction; ☐ – not used; ■ – cannot be selected in IEC 60870-5-104 standard.

1. SYSTEM OR DEVICE:

☐ System Definition

☐ Controlling Station Definition (Master)

☒ **Controlled Station Definition (Slave)**

2. NETWORK CONFIGURATION:

■ ~~Point-to-Point~~ ■ ~~Multipoint~~

■ ~~Multiple Point-to-Point~~ ■ ~~Multipoint Star~~

3. PHYSICAL LAYER

Transmission Speed (control direction):

Unbalanced Interchange Circuit V.24/V.28 Standard:	**Unbalanced Interchange Circuit V.24/V.28 Recommended if >1200 bits/s:**	**Balanced Interchange Circuit X.24/X.27:**
■ ~~100 bits/sec.~~	■ ~~2400 bits/sec.~~	■ ~~2400 bits/sec.~~
■ ~~200 bits/sec.~~	■ ~~4800 bits/sec.~~	■ ~~4800 bits/sec.~~
■ ~~300 bits/sec.~~	■ ~~9600 bits/sec.~~	■ ~~9600 bits/sec.~~
■ ~~600 bits/sec.~~		■ ~~19200 bits/sec.~~
■ ~~1200 bits/sec.~~		■ ~~38400 bits/sec.~~
		■ ~~56000 bits/sec.~~
		■ ~~64000 bits/sec.~~

Transmission Speed (monitor direction):

Unbalanced Interchange Circuit V.24/V.28 Standard:	**Unbalanced Interchange Circuit V.24/V.28 Recommended if >1200 bits/s:**	**Balanced Interchange Circuit X.24/X.27:**
■ ~~100 bits/sec.~~	■ ~~2400 bits/sec.~~	■ ~~2400 bits/sec.~~
■ ~~200 bits/sec.~~	■ ~~4800 bits/sec.~~	■ ~~4800 bits/sec.~~
■ ~~300 bits/sec.~~	■ ~~9600 bits/sec.~~	■ ~~9600 bits/sec.~~
■ ~~600 bits/sec.~~		■ ~~19200 bits/sec.~~
■ ~~1200 bits/sec.~~		■ ~~38400 bits/sec.~~
		■ ~~56000 bits/sec.~~
		■ ~~64000 bits/sec.~~

4. LINK LAYER

Link Transmission Procedure:	**Address Field of the Link:**
■ ~~Balanced Transmission~~	■ ~~Not Present (Balanced Transmission Only)~~
■ ~~Unbalanced Transmission~~	■ ~~One Octet~~
	■ ~~Two Octets~~
	■ ~~Structured~~
	■ ~~Unstructured~~
Frame Length (maximum length, number of octets): Not selectable in companion IEC 60870-5-104 standard	

D

When using an unbalanced link layer, the following ADSU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

■ ~~The standard assignment of ADSUs to class 2 messages is used as follows~~:

■ ~~A special assignment of ADSUs to class 2 messages is used as follows~~:

5. APPLICATION LAYER

Transmission Mode for Application Data:
Mode 1 (least significant octet first), as defined in Clause 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common Address of ADSU:

■ ~~One Octet~~

☒ Two Octets

Information Object Address:

■ ~~One Octet~~

■ ~~Two Octets~~

☒ Three Octets

☒ Structured

☒ Unstructured

Cause of Transmission:

■ ~~One Octet~~

☒ Two Octets (with originator address). Originator address is set to zero if not used.

Maximum Length of APDU: 253 (the maximum length may be reduced by the system.

Selection of standard ASDUs:

For the following lists, the boxes indicate the following: ☒ – used in standard direction; ☐ – not used; ■ – cannot be selected in IEC 60870-5-104 standard.

Process information in monitor direction

☒ <1> := Single-point information	M_SP_NA_1
■ ~~<2> := Single-point information with time tag~~	~~M_SP_TA_1~~
☐ <3> := Double-point information	M_DP_NA_1
■ ~~<4> := Double-point information with time tag~~	~~M_DP_TA_1~~
☐ <5> := Step position information	M_ST_NA_1
■ ~~<6> := Step position information with time tag~~	~~M_ST_TA_1~~
☐ <7> := Bitstring of 32 bits	M_BO_NA_1
■ ~~<8> := Bitstring of 32 bits with time tag~~	~~M_BO_TA_1~~
☐ <9> := Measured value, normalized value	M_ME_NA_1
■ ~~<10> := Measured value, normalized value with time tag~~	~~M_NE_TA_1~~
☐ <11> := Measured value, scaled value	M_ME_NB_1
■ ~~<12> := Measured value, scaled value with time tag~~	~~M_NE_TB_1~~
☒ <13> := Measured value, short floating point value	M_ME_NC_1
■ ~~<14> := Measured value, short floating point value with time tag~~	~~M_NE_TC_1~~
☒ <15> := Integrated totals	M_IT_NA_1
■ ~~<16> := Integrated totals with time tag~~	~~M_IT_TA_1~~
■ ~~<17> := Event of protection equipment with time tag~~	~~M_EP_TA_1~~
■ ~~<18> := Packed start events of protection equipment with time tag~~	~~M_EP_TB_1~~
■ ~~<19> := Packed output circuit information of protection equipment with time tag~~	~~M_EP_TC_1~~
☐ <20> := Packed single-point information with status change detection	M_SP_NA_1

☐ <21> := Measured value, normalized value without quantity descriptor	M_ME_ND_1
☒ <30> := Single-point information with time tag CP56Time2a	M_SP_TB_1
☐ <31> := Double-point information with time tag CP56Time2a	M_DP_TB_1
☐ <32> := Step position information with time tag CP56Time2a	M_ST_TB_1
☐ <33> := Bitstring of 32 bits with time tag CP56Time2a	M_BO_TB_1
☐ <34> := Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
☐ <35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
☐ <36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
☒ <37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐ <38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐ <39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐ <40> := Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Either the ASDUs of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, and <19> or of the set <30> to <40> are used.

D

Process information in control direction

☒ <45> := Single command	C_SC_NA_1
☐ <46> := Double command	C_DC_NA_1
☐ <47> := Regulating step command	C_RC_NA_1
☐ <48> := Set point command, normalized value	C_SE_NA_1
☐ <49> := Set point command, scaled value	C_SE_NB_1
☐ <50> := Set point command, short floating point value	C_SE_NC_1
☐ <51> := Bitstring of 32 bits	C_BO_NA_1
☒ <58> := Single command with time tag CP56Time2a	C_SC_TA_1
☐ <59> := Double command with time tag CP56Time2a	C_DC_TA_1
☐ <60> := Regulating step command with time tag CP56Time2a	C_RC_TA_1
☐ <61> := Set point command, normalized value with time tag CP56Time2a	C_SE_TA_1
☐ <62> := Set point command, scaled value with time tag CP56Time2a	C_SE_TB_1
☐ <63> := Set point command, short floating point value with time tag CP56Time2a	C_SE_TC_1
☐ <64> := Bitstring of 32 bits with time tag CP56Time2a	C_BO_TA_1

Either the ASDUs of the set <45> to <51> or of the set <58> to <64> are used.

System information in monitor direction

☒ <70> := End of initialization	M_EI_NA_1

System information in control direction

☒ <100> := Interrogation command	C_IC_NA_1
☒ <101> := Counter interrogation command	C_CI_NA_1
☒ <102> := Read command	C_RD_NA_1
☒ <103> := Clock synchronization command (see Clause 7.6 in standard)	C_CS_NA_1
■ ~~<104> := Test command~~	~~C_TS_NA_1~~
☒ <105> := Reset process command	C_RP_NA_1
■ <106> := Delay acquisition command	C_CD_NA_1
☒ <107> := Test command with time tag CP56Time2a	C_TS_TA_1

Parameter in control direction

☐ <110> := Parameter of measured value, normalized value	PE_ME_NA_1
☐ <111> := Parameter of measured value, scaled value	PE_ME_NB_1
☒ <112> := Parameter of measured value, short floating point value	PE_ME_NC_1
☐ <113> := Parameter activation	PE_AC_NA_1

File transfer

☐ <120> := File Ready	F_FR_NA_1
☐ <121> := Section Ready	F_SR_NA_1
☐ <122> := Call directory, select file, call file, call section	F_SC_NA_1
☐ <123> := Last section, last segment	F_LS_NA_1
☐ <124> := Ack file, ack section	F_AF_NA_1
☐ <125> := Segment	F_SG_NA_1
☐ <126> := Directory (blank or X, available only in monitor [standard] direction)	C_CD_NA_1

D

Type identifier and cause of transmission assignments
(station-specific parameters)

In the following table:

•Shaded boxes are not required.

•Black boxes are not permitted in this companion standard.

•Blank boxes indicate functions or ASDU not used.

•'**X**' if only used in the standard direction

TYPE IDENTIFICATION		CAUSE OF TRANSMISSION																	
		PERIODIC, CYCLIC	BACKGROUND SCAN	SPONTANEOUS	INITIALIZED	REQUEST OR REQUESTED	ACTIVATION	ACTIVATION CONFIRMATION	DEACTIVATION	DEACTIVATION CONFIRMATION	ACTIVATION TERMINATION	RETURN INFO CAUSED BY LOCAL CMD	FILE TRANSFER	INTERROGATED BY GROUP <NUMBER>	REQUEST BY GROUP <N> COUNTER REQ	UNKNOWN TYPE IDENTIFICATION	UNKNOWN CAUSE OF TRANSMISSION	UNKNOWN COMMON ADDRESS OF ADSU	UNKNOWN INFORMATION OBJECT ADDR	UNKNOWN INFORMATION OBJECT ADDR
NO.	**MNEMONIC**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**20 to 36**	**37 to 41**	**44**	**45**	**46**	**47**
<1>	M_SP_NA_1			X		X						X	X		X					
<2>	M_SP_TA_1																			
<3>	M_DP_NA_1																			
<4>	M_DP_TA_1																			
<5>	M_ST_NA_1																			
<6>	M_ST_TA_1																			
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1																			

TYPE IDENTIFICATION		CAUSE OF TRANSMISSION																		
		PERIODIC, CYCLIC	BACKGROUND SCAN	SPONTANEOUS	INITIALIZED	REQUEST OR REQUESTED	ACTIVATION	ACTIVATION CONFIRMATION	DEACTIVATION	DEACTIVATION CONFIRMATION	ACTIVATION TERMINATION	RETURN INFO CAUSED BY LOCAL CMD	FILE TRANSFER	INTERROGATED BY GROUP <NUMBER>	REQUEST BY GROUP <N> COUNTER REQ	UNKNOWN TYPE IDENTIFICATION	UNKNOWN CAUSE OF TRANSMISSION	UNKNOWN COMMON ADDRESS OF ADSU	UNKNOWN INFORMATION OBJECT ADDR	UNKNOWN INFORMATION OBJECT ADDR
NO.	MNEMONIC	1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<10>	M_ME_TA_1																			
<11>	M_ME_NB_1																			
<12>	M_ME_TB_1																			
<13>	M_ME_NC_1	X		X		X									X					
<14>	M_ME_TC_1																			
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1																			
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1																			
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X								X	X							
<31>	M_DP_TB_1																			
<32>	M_ST_TB_1																			
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1																			
<35>	M_ME_TE_1																			
<36>	M_ME_TF_1																			
<37>	M_IT_TB_1			X												X				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						X	X	X	X	X									
<46>	C_DC_NA_1																			
<47>	C_RC_NA_1																			
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1																			
<50>	C_SE_NC_1																			
<51>	C_BO_NA_1																			
<58>	C_SC_TA_1						X	X	X	X	X									
<59>	C_DC_TA_1																			
<60>	C_RC_TA_1																			

D

TYPE IDENTIFICATION		CAUSE OF TRANSMISSION																		
		PERIODIC, CYCLIC	BACKGROUND SCAN	SPONTANEOUS	INITIALIZED	REQUEST OR REQUESTED	ACTIVATION	ACTIVATION CONFIRMATION	DEACTIVATION	DEACTIVATION CONFIRMATION	ACTIVATION TERMINATION	RETURN INFO CAUSED BY LOCAL CMD	FILE TRANSFER	INTERROGATED BY GROUP <NUMBER>	REQUEST BY GROUP <N> COUNTER REQ	UNKNOWN TYPE IDENTIFICATION	UNKNOWN CAUSE OF TRANSMISSION	UNKNOWN COMMON ADDRESS OF ADSU	UNKNOWN INFORMATION OBJECT ADDR	UNKNOWN INFORMATION OBJECT ADDR
NO.	MNEMONIC	1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<61>	C_SE_TA_1																			
<62>	C_SE_TB_1																			
<63>	C_SE_TC_1																			
<64>	C_BO_TA_1																			
<70>	M_EI_NA_1*)				X															
<100>	C_IC_NA_1						X	X	X	X	X									
<101>	C_CI_NA_1						X	X			X									
<102>	C_RD_NA_1					X														
<103>	C_CS_NA_1			X			X	X												
<104>	C_TS_NA_1																			
<105>	C_RP_NA_1						X	X												
<106>	C_CD_NA_1																			
<107>	C_TS_TA_1																			
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1						X	X							X					
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1*)																			

6. BASIC APPLICATION FUNCTIONS

Station Initialization:

☒ Remote initialization

Cyclic Data Transmission:

☒ Cyclic data transmission

Read Procedure:

☒ Read procedure

Spontaneous Transmission:

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous:

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single point information: M_SP_NA_1, M_SP_TA_1, M_SP_TB_1, and M_PS_NA_1

☐ Double point information: M_DP_NA_1, M_DP_TA_1, and M_DP_TB_1

☐ Step position information: M_ST_NA_1, M_ST_TA_1, and M_ST_TB_1

☐ Bitstring of 32 bits: M_BO_NA_1, M_BO_TA_1, and M_BO_TB_1 (if defined for a specific project)

☐ Measured value, normalized value: M_ME_NA_1, M_ME_TA_1, M_ME_ND_1, and M_ME_TD_1

☐ Measured value, scaled value: M_ME_NB_1, M_ME_TB_1, and M_ME_TE_1

☐ Measured value, short floating point number: M_ME_NC_1, M_ME_TC_1, and M_ME_TF_1

Station interrogation:

☒ Global

☒ Group 1	☒ Group 5	☒ Group 9	☒ Group 13
☒ Group 2	☒ Group 6	☒ Group 10	☒ Group 14
☒ Group 3	☒ Group 7	☒ Group 11	☒ Group 15
☒ Group 4	☒ Group 8	☒ Group 12	☒ Group 16

Clock synchronization:

☒ Clock synchronization (optional, see Clause 7.6)

Command transmission:

☒ Direct command transmission

☐ Direct setpoint command transmission

☒ Select and execute command

☐ Select and execute setpoint command

☒ C_SE ACTTERM used

☒ No additional definition

☒ Short pulse duration (duration determined by a system parameter in the outstation)

☒ Long pulse duration (duration determined by a system parameter in the outstation)

☒ Persistent output

☒ Supervision of maximum delay in command direction of commands and setpoint commands

Maximum allowable delay of commands and setpoint commands: **10 s**

Transmission of integrated totals:

☒ Mode A: Local freeze with spontaneous transmission

☒ Mode B: Local freeze with counter interrogation

☒ Mode C: Freeze and transmit by counter-interrogation commands

☒ Mode D: Freeze by counter-interrogation command, frozen values reported simultaneously

☒ Counter read

☒ Counter freeze without reset

D

☒ Counter freeze with reset

☒ Counter reset

☒ General request counter

☒ Request counter group 1

☒ Request counter group 2

☒ Request counter group 3

☒ Request counter group 4

Parameter loading:

☒ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured values

☐ High limit for transmission of measured values

Parameter activation:

☐ Activation/deactivation of persistent cyclic or periodic transmission of the addressed object

Test procedure:

☐ Test procedure

File transfer:

File transfer in monitor direction:

☐ Transparent file

☐ Transmission of disturbance data of protection equipment

☐ Transmission of sequences of events

☐ Transmission of sequences of recorded analog values

File transfer in control direction:

☐ Transparent file

Background scan:

☐ Background scan

Acquisition of transmission delay:

■ ~~Acquisition of transmission delay~~

Definition of time outs:

PARAMETER	DEFAULT VALUE	REMARKS	SELECTED VALUE
t_0	30 s	Timeout of connection establishment	120 s
t_1	15 s	Timeout of send or test APDUs	15 s
t_2	10 s	Timeout for acknowledgements in case of no data messages $t_2 < t_1$	10 s
t_3	20 s	Timeout for sending test frames in case of a long idle state	20 s

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

Maximum number of outstanding I-format APDUs *k* and latest acknowledge APDUs (*w*):

PARAMETER	DEFAULT VALUE	REMARKS	SELECTED VALUE
k	12 APDUs	Maximum difference receive sequence number to send state variable	12 APDUs
w	8 APDUs	Latest acknowledge after receiving *w* I-format APDUs	8 APDUs

Maximum range of values *k*: 1 to 32767 (2^{15} – 1) APDUs, accuracy 1 APDU

Maximum range of values *w*: 1 to 32767 APDUs, accuracy 1 APDU
Recommendation: *w* should not exceed two-thirds of *k*.

Portnumber:

PARAMETER	VALUE	REMARKS
Portnumber	2404	In all cases

RFC 2200 suite:

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

☒ Ethernet 802.3

☐ Serial X.21 interface

☐ Other selection(s) from RFC 2200 (list below if selected)

D.1.2 POINT LIST

The IEC 60870-5-104 data points are configured through the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP / IEC104 POINT LISTS** menu. Refer to the *Communications* section of Chapter 5 for additional details.

D

E.1.1 DNP V3.00 DEVICE PROFILE

The following table provides a 'Device Profile Document' in the standard format defined in the DNP 3.0 Subset Definitions Document.

Table E–1: DNP V3.00 DEVICE PROFILE (Sheet 1 of 3)

(Also see the IMPLEMENTATION TABLE in the following section)	
Vendor Name: **General Electric Multilin**	
Device Name: **UR Series Relay**	
Highest DNP Level Supported: For Requests: **Level 2** For Responses: **Level 2**	**Device Function:** ☐ Master ☒ **Slave**
Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table): **Binary Inputs (Object 1)** **Binary Input Changes (Object 2)** **Binary Outputs (Object 10)** **Control Relay Output Block (Object 12)** **Binary Counters (Object 20)** **Frozen Counters (Object 21)** **Counter Change Event (Object 22)** **Frozen Counter Event (Object 23)** **Analog Inputs (Object 30)** **Analog Input Changes (Object 32)** **Analog Deadbands (Object 34)** **Time and Date (Object 50)** **File Transfer (Object 70)** **Internal Indications (Object 80)**	
Maximum Data Link Frame Size (octets): Transmitted: **292** Received: **292**	**Maximum Application Fragment Size (octets):** Transmitted: **configurable up to 2048** Received: **2048**
Maximum Data Link Re-tries: ☒ **None** ☐ Fixed at 3 ☐ Configurable	**Maximum Application Layer Re-tries:** ☒ **None** ☐ Configurable
Requires Data Link Layer Confirmation: ☒ Never ☐ Always ☐ Sometimes ☐ Configurable	

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Table E–1: DNP V3.00 DEVICE PROFILE (Sheet 2 of 3)

Requires Application Layer Confirmation:

- ☐ Never
- ☐ Always
- ☒ When reporting Event Data
- ☒ When sending multi-fragment responses
- ☐ Sometimes
- ☐ Configurable

Timeouts while waiting for:

Data Link Confirm:	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Complete Appl. Fragment:	☒ **None**	☐ Fixed at ____	☐ Variable	☐ Configurable
Application Confirm:	☐ None	☒ **Fixed at 10 s**	☐ Variable	☐ Configurable
Complete Appl. Response:	☒ **None**	☐ Fixed at ____	☐ Variable	☐ Configurable

Others:

Transmission Delay:	**No intentional delay**
Need Time Interval:	**Configurable (default = 24 hrs.)**
Select/Operate Arm Timeout:	**10 s**
Binary input change scanning period:	**8 times per power system cycle**
Analog input change scanning period:	**500 ms**
Counter change scanning period:	**500 ms**
Frozen counter event scanning period:	**500 ms**
Unsolicited response notification delay:	**100 ms**
Unsolicited response retry delay	**configurable 0 to 60 sec.**

Sends/Executes Control Operations:

WRITE Binary Outputs	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
DIRECT OPERATE	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
DIRECT OPERATE – NO ACK	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable

Count > 1	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Pulse Off	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Latch On	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Latch Off	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable

Queue	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable

Explanation of 'Sometimes': Object 12 points are mapped to UR Virtual Inputs. The persistence of Virtual Inputs is determined by the **VIRTUAL INPUT X TYPE** settings. Both "Pulse On" and "Latch On" operations perform the same function in the UR; that is, the appropriate Virtual Input is put into the "On" state. If the Virtual Input is set to "Self-Reset", it will reset after one pass of FlexLogic. The On/Off times and Count value are ignored. "Pulse Off" and "Latch Off" operations put the appropriate Virtual Input into the "Off" state. "Trip" and "Close" operations both put the appropriate Virtual Input into the "On" state.

Table E–1: DNP V3.00 DEVICE PROFILE (Sheet 3 of 3)

Reports Binary Input Change Events when no specific variation requested: ☐ Never ☒ **Only time-tagged** ☐ Only non-time-tagged ☐ Configurable	**Reports time-tagged Binary Input Change Events when no specific variation requested:** ☐ Never ☒ Binary Input Change With Time ☐ Binary Input Change With Relative Time ☐ Configurable (attach explanation)
Sends Unsolicited Responses: ☐ **Never** ☒ Configurable ☐ Only certain objects ☐ Sometimes (attach explanation) ☒ ENABLE/DISABLE unsolicited Function codes supported	**Sends Static Data in Unsolicited Responses:** ☒ Never ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ☐ No Counters Reported ☐ Configurable (attach explanation) ☒ **Default Object: 20** **Default Variation: 1** ☒ **Point-by-point list attached**	**Counters Roll Over at:** ☐ No Counters Reported ☐ Configurable (attach explanation) ☒ **16 Bits (Counter 8)** ☒ **32 Bits (Counters 0 to 7, 9)** ☐ Other Value: _____ ☒ **Point-by-point list attached**
Sends Multi-Fragment Responses: ☒ **Yes** ☐ No	

E.1.2 IMPLEMENTATION TABLE

The following table identifies the variations, function codes, and qualifiers supported by the L30 in both request messages and in response messages. For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Static object requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event objects, qualifiers 17 or 28 are always responded.

Table E–2: IMPLEMENTATION TABLE (Sheet 1 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
1	0	Binary Input (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	1	Binary Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	2	Binary Input with Status	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
2	0	Binary Input Change (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
	1	Binary Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	Binary Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response 130 (unsol. resp.)	17, 28 (index)
	3	Binary Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
10	0	Binary Output Status (Variation 0 is used to request default variation)	1 (read)	00, 01(start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	2	Binary Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
12	1	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	00, 01 (start-stop) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	echo of request
20	0	Binary Counter (Variation 0 is used to request default variation)	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01(start-stop) 06(no range, or all) 07, 08(limited quantity) 17, 28(index)		
	1	32-Bit Binary Counter	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*

Note 1: A default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The default variations for object types 1, 2, 20, 21, 22, 23, 30, and 32 are selected via relay settings. Refer to the *Communications* section in Chapter 5 for details. This optimizes the class 0 poll data size.

Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01 (for change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: Cold restarts are implemented the same as warm restarts – the L30 is not restarted, but the DNP process is restarted.

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Table E–2: IMPLEMENTATION TABLE (Sheet 2 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
20 cont'd	2	16-Bit Binary Counter	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	5	32-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	6	16-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
21	0	Frozen Counter (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	1	32-Bit Frozen Counter	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	2	16-Bit Frozen Counter	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	9	32-Bit Frozen Counter without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	10	16-Bit Frozen Counter without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
22	0	Counter Change Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
	1	32-Bit Counter Change Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	16-Bit Counter Change Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	5	32-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	6	16-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
23	0	Frozen Counter Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
	1	32-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	16-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)

Note 1: A default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The default variations for object types 1, 2, 20, 21, 22, 23, 30, and 32 are selected via relay settings. Refer to the *Communications* section in Chapter 5 for details. This optimizes the class 0 poll data size.

Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01 (for change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: Cold restarts are implemented the same as warm restarts – the L30 is not restarted, but the DNP process is restarted.

Table E–2: IMPLEMENTATION TABLE (Sheet 3 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
23 cont'd	5	32-Bit Frozen Counter Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	6	16-Bit Frozen Counter Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
30	0	Analog Input (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	1	32-Bit Analog Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	2	16-Bit Analog Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	3	32-Bit Analog Input without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	4	16-Bit Analog Input without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	5	short floating point	1 (read) 22 (assign class)	00, 01 (start-stop) 06(no range, or all) 07, 08(limited quantity) 17, 28(index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
32	0	Analog Change Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
	1	32-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	16-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	3	32-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	4	16-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	5	short floating point Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	7	short floating point Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
34	0	Analog Input Reporting Deadband (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	1	16-bit Analog Input Reporting Deadband (default – see Note 1)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
			2 (write)	00, 01 (start-stop) 07, 08 (limited quantity) 17, 28 (index)		

Note 1: A default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The default variations for object types 1, 2, 20, 21, 22, 23, 30, and 32 are selected via relay settings. Refer to the *Communications* section in Chapter 5 for details. This optimizes the class 0 poll data size.

Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01 (for change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: Cold restarts are implemented the same as warm restarts – the L30 is not restarted, but the DNP process is restarted.

Table E–2: IMPLEMENTATION TABLE (Sheet 4 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	**VARIATION NO.**	**DESCRIPTION**	**FUNCTION CODES (DEC)**	**QUALIFIER CODES (HEX)**	**FUNCTION CODES (DEC)**	**QUALIFIER CODES (HEX)**
34 cont'd	2	32-bit Analog Input Reporting Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
			2 (write)	00, 01 (start-stop) 07, 08 (limited quantity) 17, 28 (index)		
	3	Short floating point Analog Input Reporting Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
50	1	Time and Date (default – see Note 1)	1 (read) 2 (write)	00, 01 (start-stop) 06 (no range, or all) 07 (limited qty=1) 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
52	2	Time Delay Fine			129 (response)	07 (limited quantity) (quantity = 1)
60	0	Class 0, 1, 2, and 3 Data	1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class)	06 (no range, or all)		
	1	Class 0 Data	1 (read) 22 (assign class)	06 (no range, or all)		
	2	Class 1 Data	1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class)	06 (no range, or all) 07, 08 (limited quantity)		
	3	Class 2 Data				
	4	Class 3 Data				
70	0	File event - any variation	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
			22 (assign class)	06 (no range, or all)		
	2	File authentication	29 (authenticate)	5b (free format)	129 (response)	5b (free format)
	3	File command	25 (open) 27 (delete)	5b (free format)		
	4	File command status	26 (close) 30 (abort)	5b (free format)	129 (response) 130 (unsol. resp.)	5b (free format)
	5	File transfer	1 (read) 2 (write)	5b (free format)	129 (response) 130 (unsol. resp.)	5b (free format)
	6	File transfer status			129 (response) 130 (unsol. resp.)	5b (free format)
	7	File descriptor	28 (get file info.)	5b (free format)	129 (response) 130 (unsol. resp.)	5b (free format)
80	1	Internal Indications	1 (read)	00, 01 (start-stop) (index =7)	129 (response)	00, 01 (start-stop)
			2 (write) *(see Note 3)*	00 (start-stop) (index =7)		
---		No Object (function code only) *see Note 3*	13 (cold restart)			
---		No Object (function code only)	14 (warm restart)			
---		No Object (function code only)	23 (delay meas.)			

Note 1: A default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The default variations for object types 1, 2, 20, 21, 22, 23, 30, and 32 are selected via relay settings. Refer to the *Communications* section in Chapter 5 for details. This optimizes the class 0 poll data size.

Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01 (for change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: Cold restarts are implemented the same as warm restarts – the L30 is not restarted, but the DNP process is restarted.

E.2.1 BINARY INPUT POINTS

The DNP binary input data points are configured through the **PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP / IEC104 POINT LISTS ⇨ BINARY INPUT / MSP POINTS** menu. Refer to the *Communications* section of Chapter 5 for additional details. When a freeze function is performed on a binary counter point, the frozen value is available in the corresponding frozen counter point.

BINARY INPUT POINTS

Static (Steady-State) Object Number: **1**

Change Event Object Number: **2**

Request Function Codes supported: **1 (read), 22 (assign class)**

Static Variation reported when variation 0 requested: **2 (Binary Input with status), Configurable**

Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time), Configurable**

Change Event Scan Rate: **8 times per power system cycle**

Change Event Buffer Size: **500**

Default Class for All Points: **1**

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E.2.2 BINARY AND CONTROL RELAY OUTPUT

Supported Control Relay Output Block fields: Pulse On, Pulse Off, Latch On, Latch Off, Paired Trip, Paired Close.

BINARY OUTPUT STATUS POINTS
Object Number: **10**
Request Function Codes supported: **1 (read)**
Default Variation reported when Variation 0 requested: **2 (Binary Output Status)**
CONTROL RELAY OUTPUT BLOCKS
Object Number: **12**
Request Function Codes supported: **3 (select), 4 (operate), 5 (direct operate), 6 (direct operate, noack)**

Table E–3: BINARY/CONTROL OUTPUTS

POINT	NAME/DESCRIPTION
0	Virtual Input 1
1	Virtual Input 2
2	Virtual Input 3
3	Virtual Input 4
4	Virtual Input 5
5	Virtual Input 6
6	Virtual Input 7
7	Virtual Input 8
8	Virtual Input 9
9	Virtual Input 10
10	Virtual Input 11
11	Virtual Input 12
12	Virtual Input 13
13	Virtual Input 14
14	Virtual Input 15
15	Virtual Input 16
16	Virtual Input 17
17	Virtual Input 18
18	Virtual Input 19
19	Virtual Input 20
20	Virtual Input 21
21	Virtual Input 22
22	Virtual Input 23
23	Virtual Input 24
24	Virtual Input 25
25	Virtual Input 26
26	Virtual Input 27
27	Virtual Input 28
28	Virtual Input 29
29	Virtual Input 30
30	Virtual Input 31
31	Virtual Input 32

Table E–3: BINARY/CONTROL OUTPUTS

POINT	NAME/DESCRIPTION
32	Virtual Input 33
33	Virtual Input 34
34	Virtual Input 35
35	Virtual Input 36
36	Virtual Input 37
37	Virtual Input 38
38	Virtual Input 39
39	Virtual Input 40
40	Virtual Input 41
41	Virtual Input 42
42	Virtual Input 43
43	Virtual Input 44
44	Virtual Input 45
45	Virtual Input 46
46	Virtual Input 47
47	Virtual Input 48
48	Virtual Input 49
49	Virtual Input 50
50	Virtual Input 51
51	Virtual Input 52
52	Virtual Input 53
53	Virtual Input 54
54	Virtual Input 55
55	Virtual Input 56
56	Virtual Input 57
57	Virtual Input 58
58	Virtual Input 59
59	Virtual Input 60
60	Virtual Input 61
61	Virtual Input 62
62	Virtual Input 63
63	Virtual Input 64

E.2.3 COUNTERS

The following table lists both Binary Counters (Object 20) and Frozen Counters (Object 21). When a freeze function is performed on a Binary Counter point, the frozen value is available in the corresponding Frozen Counter point.

BINARY COUNTERS

Static (Steady-State) Object Number: **20**

Change Event Object Number: **22**

Request Function Codes supported: **1 (read), 7 (freeze), 8 (freeze noack), 9 (freeze and clear), 10 (freeze and clear, noack), 22 (assign class)**

Static Variation reported when variation 0 requested: **1 (32-Bit Binary Counter with Flag)**

Change Event Variation reported when variation 0 requested: **1 (32-Bit Counter Change Event without time)**

Change Event Buffer Size: **10**

Default Class for all points: **3**

FROZEN COUNTERS

Static (Steady-State) Object Number: **21**

Change Event Object Number: **23**

Request Function Codes supported: **1 (read)**

Static Variation reported when variation 0 requested: **1 (32-Bit Frozen Counter with Flag)**

Change Event Variation reported when variation 0 requested: **1 (32-Bit Frozen Counter Event without time)**

Change Event Buffer Size: **10**

Default Class for all points: **3**

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Table E–4: BINARY AND FROZEN COUNTERS

POINT INDEX	NAME/DESCRIPTION
0	Digital Counter 1
1	Digital Counter 2
2	Digital Counter 3
3	Digital Counter 4
4	Digital Counter 5
5	Digital Counter 6
6	Digital Counter 7
7	Digital Counter 8
8	Oscillography Trigger Count
9	Events Since Last Clear

A counter freeze command has no meaning for counters 8 and 9. L30 Digital Counter values are represented as 32-bit integers. The DNP 3.0 protocol defines counters to be unsigned integers. Care should be taken when interpreting negative counter values.

E.2.4 ANALOG INPUTS

The DNP analog input data points are configured through the **PRODUCT SETUP** ⇨⇩ **COMMUNICATIONS** ⇨⇩ **DNP / IEC104 POINT LISTS** ⇨ **ANALOG INPUT / MME POINTS** menu. Refer to the *Communications* section of Chapter 5 for additional details.

It is important to note that 16-bit and 32-bit variations of analog inputs are transmitted through DNP as signed numbers. Even for analog input points that are not valid as negative values, the maximum positive representation is 32767 for 16-bit values and 2147483647 for 32-bit values. This is a DNP requirement.

The deadbands for all Analog Input points are in the same units as the Analog Input quantity. For example, an Analog Input quantity measured in volts has a corresponding deadband in units of volts. This is in conformance with DNP Technical Bulletin 9809-001: Analog Input Reporting Deadband. Relay settings are available to set default deadband values according to data type. Deadbands for individual Analog Input Points can be set using DNP Object 34.

Static (Steady-State) Object Number: **30**

Change Event Object Number: **32**

Request Function Codes supported: **1 (read), 2 (write, deadbands only), 22 (assign class)**

Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input)**

Change Event Variation reported when variation 0 requested: **1 (Analog Change Event without Time)**

Change Event Scan Rate: defaults to **500 ms**

Change Event Buffer Size: **256**

Default Class for all Points: **2**

F.1.1 RADIUS SERVER CONFIGURATION

The following procedure is an example of how to set up a simple RADIUS server, where the third-party tool used is also an example.

1. Download and install FreeRADIUS as the RADIUS server.
2. In the RADIUSD.CONF file, locate the "bind_address" field and enter your RADIUS server IP address.
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 == "Testing1!1"
->GE-UR-Role = Administrator
```

4. In the CLIENTS.CONF file in the <Path_to_Radius>\etc\raddb folder, add the following text to define 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
##############################################################
```

6. In the dictionary file in the <Path_to_Radius>\etc\raddb folder, add the following line.

```
$INCLUDE dictionary.ge
```

7. For the first start, run the RADIUS server in debug mode by entering

```
<Path_to_Radius>/start_radiusd_debug.bat
```

8. Set up the RADIUS client on the UR as follows. Access **Device > 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.

F

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G.1.1 REVISION HISTORY

Table G–1: REVISION HISTORY

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-Z2	7.1x	22 September 2013	13-0469

G.1.2 CHANGES TO THE L30 MANUAL

Table G–2: MAJOR UPDATES FOR L30 MANUAL REVISION Z2

PAGE (Z1)	PAGE (Z2)	CHANGE	DESCRIPTION
---	---	Update	General revision throughout document
5-106	5-106	Update	Updated hysteresis numbers and logic diagrams in section 5.4.8 Phasor Measurement Unit
5-190	5-190	Update	Updated Figure 5-85 Negative-Sequence Overvoltage Scheme Logic
8-	---	Delete	Security chapter - Moved content to other parts of manual and deleted the Security chapter
---	11-	Add	Added Maintenance chapter, moving module replacement content from chapter 3, adding battery replacement instructions, and moving battery disposal instructions from beginning of manual
---	F-	Add	Added appendix on RADIUS server configuration

Table G–3: MAJOR UPDATES FOR L30 MANUAL REVISION Z1

PAGE (Y3)	PAGE (Z1)	CHANGE	DESCRIPTION
---	---	Add	Added CPU options U and V to order code tables in chapter 2, a note above Rear Terminal View figure in chapter 3, and CPU Module Communications Wiring figure in chapter 3
---	---	Add	Added Parallel Redundancy Protocol (PRP) to order code tables and specifications in chapter 2, section 5.2.5d Settings > Product Setup > Communications > Network, section 6.3.1 Actual Values > Status > PRP, and Appendix B Modbus table and F627 and F628 enumeration tables
1-1	1-1	Add	Added General Cautions and Warnings to section 1.1.1
1-5	1-5	Update	Revised section 1.3.1 on system requirements, including addition of support for Windows 7 and Windows Server 2008
2-17	2-17	Update	Updated several specifications
5-24	5-24	Add	Added section 5.2.5e Routing
5-84	5-84	Update	Updated Figures 5-21 and 5-22 Dual Breaker Control Scheme Logic, sheets 1 and 2
5-88	5-88	Update	Updated Figure 5-23 Disconnect Switch Scheme Logic
5-143	5-143	Update	Updated Figure 5-60 Current Differential Scheme Logic
5-228	5-228	Add	Reinserted section 5.8.5d Remote Devices: ID of Device for Receiving GSSE/GOOSE Messages, meaning the Settings > Input/Outputs > Remote Devices settings

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Table G–4: MAJOR UPDATES FOR L30 MANUAL REVISION Y3

PAGE (Y2)	PAGE (Y3)	CHANGE	DESCRIPTION
--	xi	Add	Added battery disposal information as chapter 0

Table G–5: MAJOR UPDATES FOR L30 MANUAL REVISION Y2

PAGE (Y1)	PAGE (Y2)	CHANGE	DESCRIPTION
All	All	Update	Minor changes throughout document
All	All	Delete	Deleted CPU options U and V
1-1	1-1	Update	Updated Figure 1-1 Rear Nameplate
3-8	3-8	Update	Updated Figure 3-10 Rear Terminal View

Table G–6: MAJOR UPDATES FOR L30 MANUAL REVISION Y1 (Sheet 1 of 2)

PAGE (X2)	PAGE (Y1)	CHANGE	DESCRIPTION
All	All	Delete	Deleted content pertaining to Ethernet switch
Title	Title	Update	Changed part numbers. Updated address and contact information.
1-1	1-1	Update	Updated address and contact information
2-1	2-1	Update	Updated Table 2-1 Device Numbers and Functions
2-2	2-2	Update	Updated Figure 2-1 Single Line Diagram
2-	2-	Add	Added CPU options T, U, and V to order code table
2-	2-	Delete	Removed E, G, H, J, S from CPU options from order code tables
2-10	2-10	Delete	Deleted 9S, 2S, 2T from replacement module order code Tables 2-7 and 2-8
2-25	2-25	Update	Updated Ethernet fiber table in section 2.4.8 Communications
3-9	3-9	Update	Updated Figure 3-12 Typical Wiring Diagram
3-22	3-22	Update	Deleted references to COM 1 RS485 port in section 3.2.9 CPU Communication Ports. Revised text and Figure 3-24 CPU Module Communications Wiring to include only modules T, U, V in section 3.2.9a.
5-1	5-1	Update	Updated the front panel main menu to include the CyberSentry security menu
5-15	5-15	Update	Update Communications main menu to remove the SNTP Protocol submenu
5-15	5-15	Delete	Deleted references to COM 1 RS485 port in section 5.2.4b Serial Ports
5-16	5-16	Add	Added section 5.2.4c Ethernet Network Topology
5-16	5-16	Update	Updated Networks section 5.2.4d to include all three Ethernet ports
5-16	5-16	Update	Added 0 as valid number to section 5.2.4e Modbus Protocol section
5-37	5-	Delete	Deleted Local Time Offset, Daylight Savings Time, DST (start/stop for month/day/hour) from Real Time Clock menu
5-	5-37	Add	Added submenus Precision Time Protocol, SNTP Protocol, and Local Time and Synchronizing Source settings to Real Time Clock menu
5-	5-39	Add	Added new Precision Time Protocol (1588) menu and setting descriptions
5-	5-	Update	Changed Communication to Real Time Clock in SNTP protocol settings path. Moved SNTP Protocol menu and settings descriptions to Real Time Clock subsection
5-36	5-	Delete	Deleted section k) SNTP Protocol and the settings descriptions
5-	5-42	Add	Added new section for Local Time menu settings and settings description
5-	5-51	Add	Added new PTP Fail menu item to the User-Programmable Self Tests menu
5-	5-	Add	Added PTP Failure and CLOCK UNSYNCHRONIZED to Flexlogic Operands table
5-73	5-73	Update	Updated Figure 5-15 Channel Asymmetry Compensation Logic and added definition for Local GPS Trouble in preceding text
5-89	5-89	Update	Updated PMU main menu to add aggregator and control block menu items

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Table G–6: MAJOR UPDATES FOR L30 MANUAL REVISION Y1 (Sheet 2 of 2)

PAGE (X2)	PAGE (Y1)	CHANGE	DESCRIPTION
5-	5-89	Add	Added UR Synchrophasor Implementation of IEC61850-90-5 to the PMU software option description
5-89	5-89	Update	Updated Figure: Complete Synchrophasor Implementation
5-	5-90	Add	Added Figure: N60 Support For Four Logical Device PMU
5-90	5-90	Update	Updated Table: Implementation By Model Number
5-	5-91	Add	Added Figure: Logical Nodes Supported In Each Logical Device
5-	5-92	Add	Added Figure: Data Set Created From User Selected Internal Items
5-	5-93	Add	Added Figure: Example Of Aggregator Data Sets
5-	5-93	Add	Added Figure: CFG-2 Based Configuration Solution
5-	5-93	Add	Added examples for a syncrophasor dataset and the creation of different datasets
5-	5-93	Add	Added example for a CFG-2 based configuration
5-95	5-95	Update	Updated PMU 1 basic configuration menu to add 37.118 and 90-5 configuration settings submenus
5-	5-96	Add	Added PMU 1 configuration menus for 37.118 and 90-5 with settings descriptions
5-96	5-96	Update	Changed PMU 1 Function setting description
5-	5-106	Add	Added PMU AGGR 1 configuration menu and setting descriptions
5-	5-106	Add	Added new aggregators section with PMU 1 aggregators menu and setting descriptions
5-106	5-106	Update	Updated PMU 1 aggregators menu to include 37.118 and 90-5 aggregator configuration submenus
5-	5-107	Add	Added 90-5 AGGR 1 configuration menu and setting descriptions
5-	5-108	Add	Added Table 5- # Of ASDUs
5-	5-108	Add	Added new control block section with IEC 90-5 MSVCB configuration menu and setting descriptions
5-	5-129	Update	Added row for DeltaTime to Table 5-: FlexElement Base Units
5-220	5-220	Delete	Deleted section 5.8.5d Remote Devices: ID of Device for Receiving GSSE/GOOSE Messages, meaning the Settings > Input/Outputs > Remote Devices settings
5-	5-237	Add	Added new CyberSentry security section and main menu, local passwords, session settings, restore defaults, and supervisory subsections to Chapter 5
6-1	6-1	Update	Update Actual Values main menu to include Real Time Clock Synchronization submenu
6-	6-7	Add	Added new section for Real Time Clock synchronizing consisting of the menu of settings and the setting descriptions
6-10	6-10	Delete	Deleted section 6.2.17 Ethernet Switch
6-	6-10	Add	Added new section 6.2.18 Remaining Connection Status
7-	7-1	Add	Added Security command to the Commands main menu
7-	7-3	Add	Added Reboot Relay command and description to the Relay Maintenance menu items
7-	7-	Add	Added Security menu and submenu commands and descriptions to the Command menu
7-	7-	Add	Added to Minor self-test error message **Bad PTP Signal**
8-	8-4	Add	Added new section for CyberSentry software option with overview and security menu subsections
A-	A-	Add	Added Flexanalog item PTP–IRIG-B Delta to Table A-1: Flexanalog Data Items
B-8	B-8	Update	Updated Modbus memory map table to include port 0 for Modbus slave address, TCP, DNP, HTTP, TFTP, MMS, and removed references to COM 1 RS485 port
C-23	C-23	Update	Updated tables in sections C.6.3 ACSI Services Conformance Statement and C.7.1 Logical Nodes Table

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G.2.1 STANDARD ABBREVIATIONS

A..................... Ampere
AC .... Alternating Current
A/D .... Analog to Digital
AE .... Accidental Energization, Application Entity
AMP .... Ampere
ANG .... Angle
ANSI............... American National Standards Institute
AR .... Automatic Reclosure
ASDU .... Application-layer Service Data Unit
ASYM .... Asymmetry
AUTO .... Automatic
AUX................ Auxiliary
AVG................ Average

BCS................ Best Clock Selector
BER................ Bit Error Rate
BF................... Breaker Fail
BFI.................. Breaker Failure Initiate
BKR................ Breaker
BLK .... Block
BLKG.............. Blocking
BPNT.............. Breakpoint of a characteristic
BRKR .... Breaker

CAP................ Capacitor
CC .... Coupling Capacitor
CCVT .... Coupling Capacitor Voltage Transformer
CFG................ Configure / Configurable
.CFG............... Filename extension for oscillography files
CHK................ Check
CHNL .... Channel
CLS .... Close
CLSD.............. Closed
CMND .... Command
CMPRSN........ Comparison
CO.................. Contact Output
COM............... Communication
COMM............ Communications
COMP .... Compensated, Comparison
CONN............. Connection
CONT .... Continuous, Contact
CO-ORD......... Coordination
CPU................ Central Processing Unit
CRC .... Cyclic Redundancy Code
CRT, CRNT .... Current
CSA................ Canadian Standards Association
CT .... Current Transformer
CVT .... Capacitive Voltage Transformer

D/A .... Digital to Analog
DC (dc)........... Direct Current
DD .... Disturbance Detector
DFLT .... Default
DGNST........... Diagnostics
DI.................... Digital Input
DIFF .... Differential
DIR .... Directional
DISCREP .... Discrepancy
DIST .... Distance
DMD .... Demand
DNP................ Distributed Network Protocol
DPO .... Dropout
DSP................ Digital Signal Processor
dt .... Rate of Change
DTT .... Direct Transfer Trip
DUTT.............. Direct Under-reaching Transfer Trip

ENCRMNT ..... Encroachment
EPRI............... Electric Power Research Institute
.EVT .... Filename extension for event recorder files
EXT .... Extension, External

F..................... Field
FAIL................ Failure
FD .... Fault Detector
FDH................ Fault Detector high-set
FDL .... Fault Detector low-set
FLA................. Full Load Current

FO.................. Fiber Optic
FREQ............. Frequency
FSK................ Frequency-Shift Keying
FTP .... File Transfer Protocol
FxE .... FlexElement™
FWD............... Forward

G .... Generator
GE.................. General Electric
GND............... Ground
GNTR............. Generator
GOOSE.......... General Object Oriented Substation Event
GPS .... Global Positioning System

HARM .... Harmonic / Harmonics
HCT .... High Current Time
HGF .... High-Impedance Ground Fault (CT)
HIZ................. High-Impedance and Arcing Ground
HMI .... Human-Machine Interface
HTTP .... Hyper Text Transfer Protocol
HYB .... Hybrid

I...................... Instantaneous
I_0.................. Zero Sequence current
I_1.................. Positive Sequence current
I_2.................. Negative Sequence current
IA .... Phase A current
IAB .... Phase A minus B current
IB .... Phase B current
IBC................. Phase B minus C current
IC .... Phase C current
ICA................. Phase C minus A current
ID .... Identification
IED................. Intelligent Electronic Device
IEC................. International Electrotechnical Commission
IEEE............... Institute of Electrical and Electronic Engineers
IG .... Ground (not residual) current
Igd.................. Differential Ground current
IN .... CT Residual Current (3Io) or Input
INC SEQ .... Incomplete Sequence
INIT................ Initiate
INST............... Instantaneous
INV................. Inverse
I/O .... Input/Output
IOC .... Instantaneous Overcurrent
IOV................. Instantaneous Overvoltage
IRIG .... Inter-Range Instrumentation Group
ISO................. International Standards Organization
IUV................. Instantaneous Undervoltage

K0 .... Zero Sequence Current Compensation
kA................... kiloAmpere
kV................... kiloVolt

LED................ Light Emitting Diode
LEO................ Line End Open
LFT BLD .... Left Blinder
LOOP............. Loopback
LPU................ Line Pickup
LRA................ Locked-Rotor Current
LTC .... Load Tap-Changer

M.................... Machine
mA .... MilliAmpere
MAG............... Magnitude
MAN .... Manual / Manually
MAX .... Maximum
MIC .... Model Implementation Conformance
MIN .... Minimum, Minutes
MMI................ Man Machine Interface
MMS .... Manufacturing Message Specification
MRT .... Minimum Response Time
MSG............... Message
MTA................ Maximum Torque Angle
MTR .... Motor
MVA .... MegaVolt-Ampere (total 3-phase)
MVA_A........... MegaVolt-Ampere (phase A)
MVA_B........... MegaVolt-Ampere (phase B)

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MVA_C .... MegaVolt-Ampere (phase C)
MVAR .... MegaVar (total 3-phase)
MVAR_A......... MegaVar (phase A)
MVAR_B......... MegaVar (phase B)
MVAR_C .... MegaVar (phase C)
MVARH .... MegaVar-Hour
MW................. MegaWatt (total 3-phase)
MW_A .... MegaWatt (phase A)
MW_B .... MegaWatt (phase B)
MW_C .... MegaWatt (phase C)
MWH .... MegaWatt-Hour

N..................... Neutral
N/A, n/a .... Not Applicable
NEG .... Negative
NMPLT .... Nameplate
NOM............... Nominal
NTR................ Neutral

O .... Over
OC, O/C .... Overcurrent
O/P, Op........... Output
OP .... Operate
OPER .... Operate
OPERATG...... Operating
O/S .... Operating System
OSI .... Open Systems Interconnect
OSB................. Out-of-Step Blocking
OUT................. Output
OV .... Overvoltage
OVERFREQ ... Overfrequency
OVLD .... Overload

P..................... Phase
PC .... Phase Comparison, Personal Computer
PCNT .... Percent
PF................... Power Factor (total 3-phase)
PF_A .... Power Factor (phase A)
PF_B .... Power Factor (phase B)
PF_C .... Power Factor (phase C)
PFLL............... Phase and Frequency Lock Loop
PHS................ Phase
PICS............... Protocol Implementation & Conformance Statement
PKP .... Pickup
PLC .... Power Line Carrier
POS................ Positive
POTT.............. Permissive Over-reaching Transfer Trip
PRESS .... Pressure
PRI .... Primary
PROT .... Protection
PSEL .... Presentation Selector
pu .... Per Unit
PUIB............... Pickup Current Block
PUIT .... Pickup Current Trip
PUSHBTN ...... Pushbutton
PUTT.............. Permissive Under-reaching Transfer Trip
PWM .... Pulse Width Modulated
PWR............... Power

QUAD............. Quadrilateral

R..................... Rate, Reverse
RCA................ Reach Characteristic Angle
REF .... Reference
REM .... Remote
REV................ Reverse
RI.................... Reclose Initiate
RIP .... Reclose In Progress
RGT BLD........ Right Blinder
ROD .... Remote Open Detector
RST .... Reset
RSTR .... Restrained
RTD................ Resistance Temperature Detector
RTU................ Remote Terminal Unit
RX (Rx) .... Receive, Receiver

s .... second
S..................... Sensitive

SAT ....CT Saturation
SBO ....Select Before Operate
SCADA ....Supervisory Control and Data Acquisition
SEC ....Secondary
SEL ....Select / Selector / Selection
SENS ....Sensitive
SEQ ....Sequence
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
TSEL...............Transport Selector
TUC ....Time Undercurrent
TUV.................Time Undervoltage
TX (Tx)............Transmit, Transmitter

U ....Under
UC...................Undercurrent
UCA ....Utility Communications Architecture
UDP ....User Datagram Protocol
UL ....Underwriters Laboratories
UNBAL............Unbalance
UR...................Universal Relay
URC ....Universal Recloser Control
.URS ....Filename extension for settings files
UV ....Undervoltage

V/Hz ....Volts per Hertz
V_0 ....Zero Sequence voltage
V_1 ....Positive Sequence voltage
V_2 ....Negative Sequence voltage
VA ....Phase A voltage
VAB ....Phase A to B voltage
VAG ....Phase A to Ground voltage
VARH ....Var-hour voltage
VB ....Phase B voltage
VBA.................Phase B to A voltage
VBG ....Phase B to Ground voltage
VC...................Phase C voltage
VCA ....Phase C to A voltage
VCG ....Phase C to Ground voltage
VF ....Variable Frequency
VIBR ....Vibration
VT ....Voltage Transformer
VTFF...............Voltage Transformer Fuse Failure
VTLOS ....Voltage Transformer Loss Of Signal

WDG ....Winding
WH..................Watt-hour
w/ opt ....With Option
WRT................With Respect To

X ....Reactance
XDUCER.........Transducer
XFMR..............Transformer

Z......................Impedance, Zone

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G.3.1 GE MULTILIN WARRANTY

GE MULTILIN RELAY WARRANTY

GE Multilin warrants each relay it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, GE Multilin will undertake to repair or replace the relay providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any relay which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a GE Multilin authorized factory outlet.

GE Multilin is not liable for special, indirect or consequential damages or for loss of profit or for expenses sustained as a result of a relay malfunction, incorrect application or adjustment.

For complete text of Warranty (including limitations and disclaimers), refer to GE Multilin Standard Conditions of Sale.

Numerics

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