GE Multilin

C70 Capacitor Bank Protection and Control System

UR Series Instruction Manual

C70 Revision: 6.0x

Manual P/N: 1601-9015-**X1** (GEK-113598)

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GE Multilin's Quality Management System is registered to ISO9001:2000
QMI # 005094
UL # A3775

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Please read this chapter to help guide you through the initial setup of your new GE Mutilin structured template.

1.1.1 CAUTIONS AND WARNINGS

Before attempting to install or use the relay, it is imperative that all NOTE, CAUTION and WARNING icons in this document are reviewed to help prevent personal injury, equipment damage, or downtime.

WARNING CAUTION

1.1.2 INSPECTION CHECKLIST

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.

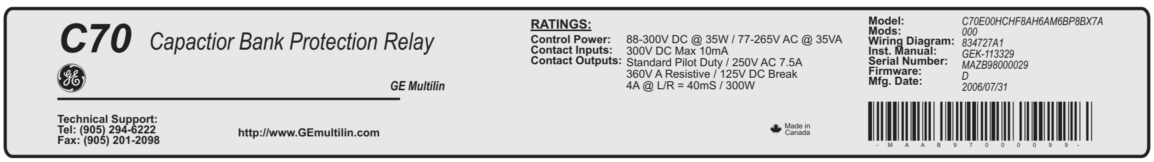

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Figure 1–1: REAR NAMEPLATE (EXAMPLE)

3. Ensure that the following items are included:
   - Instruction manual.
   - GE EnerVista CD (includes the EnerVista UR Setup software and manuals in PDF format).
   - Mounting screws.

For product information, instruction manual updates, and the latest software updates, please visit the GE Multilin website at http://www.GEmultilin.com.

NOTE

If there is any noticeable physical damage, or any of the contents listed are missing, please contact GE Multilin immediately.

***GE MULTILIN* CONTACT INFORMATION AND CALL CENTER FOR PRODUCT SUPPORT:**

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1.2.1 INTRODUCTION TO THE UR

Historically, substation protection, control, and metering functions were performed with electromechanical equipment. This first generation of equipment was gradually replaced by analog electronic equipment, most of which emulated the single-function approach of their electromechanical precursors. Both of these technologies required expensive cabling and auxiliary equipment to produce functioning systems.

Recently, digital electronic equipment has begun to provide protection, control, and metering functions. Initially, this equipment was either single function or had very limited multi-function capability, and did not significantly reduce the cabling and auxiliary equipment required. However, recent digital relays have become quite multi-functional, reducing cabling and auxiliaries significantly. These devices also transfer data to central control facilities and Human Machine Interfaces using electronic communications. The functions performed by these products have become so broad that many users now prefer the term IED (Intelligent Electronic Device).

It is obvious to station designers that the amount of cabling and auxiliary equipment installed in stations can be even further reduced, to 20% to 70% of the levels common in 1990, to achieve large cost reductions. This requires placing even more functions within the IEDs.

Users of power equipment are also interested in reducing cost by improving power quality and personnel productivity, and as always, in increasing system reliability and efficiency. These objectives are realized through software which is used to perform functions at both the station and supervisory levels. The use of these systems is growing rapidly.

High speed communications are required to meet the data transfer rates required by modern automatic control and monitoring systems. In the near future, very high speed communications will be required to perform protection signaling with a performance target response time for a command signal between two IEDs, from transmission to reception, of less than 3 milliseconds. This has been established by the IEC 61850 standard.

IEDs with the capabilities outlined above will also provide significantly more power system data than is presently available, enhance operations and maintenance, and permit the use of adaptive system configuration for protection and control systems. This new generation of equipment must also be easily incorporated into automation systems, at both the station and enterprise levels. The GE Multilin Universal Relay (UR) has been developed to meet these goals.

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 can communicate over a local area network (LAN) with an operator interface, a programming device, or another UR device.

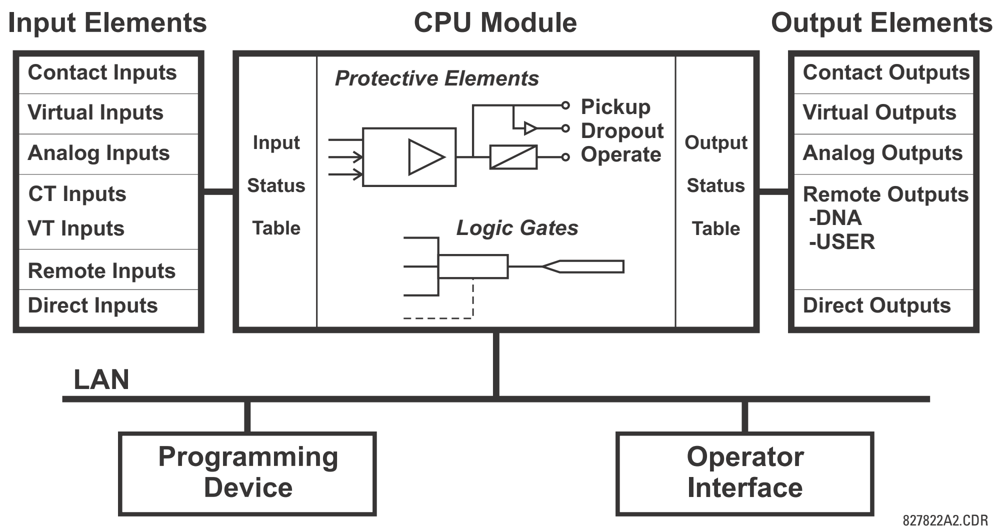


Figure 1–2: UR CONCEPT BLOCK DIAGRAM

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.

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 a 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.

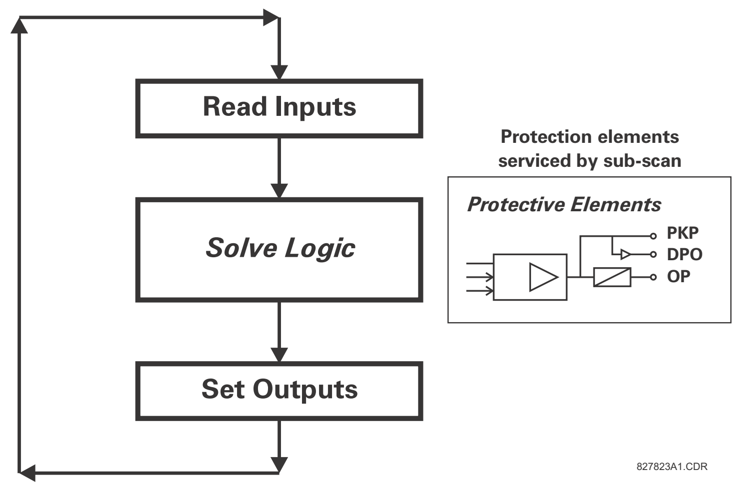


Figure 1–3: UR-SERIES SCAN OPERATION

1.2.3 SOFTWARE ARCHITECTURE

The firmware (software embedded in the relay) is designed in functional modules which 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, hmi, communications, or any functional entity in the system.

Employing OOD/OOP in the software architecture of the C70 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 functionality classes. This results in a *common look and feel* across the entire family of UR-series platform-based applications.

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. An explanation of the use of inputs from CTs and VTs is in the *Introduction to AC sources* section in 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 faceplate keypad and display or the EnerVista UR Setup software interface 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 PC monitor can display more information in a simple comprehensible format.

The following minimum requirements must be met for the EnerVista UR Setup software to properly operate on a PC.

- Pentium class or higher processor (Pentium II 300 MHz or higher recommended)
- Windows 95, 98, 98SE, ME, NT 4.0 (Service Pack 4 or higher), 2000, XP
- Internet Explorer 4.0 or higher
- 128 MB of RAM (256 MB recommended)
- 200 MB of available space on system drive and 200 MB of available space on installation drive
- Video capable of displaying 800 x 600 or higher in high-color mode (16-bit color)
- RS232 and/or Ethernet port for communications to the relay

The following qualified modems have been tested to be compliant with the C70 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

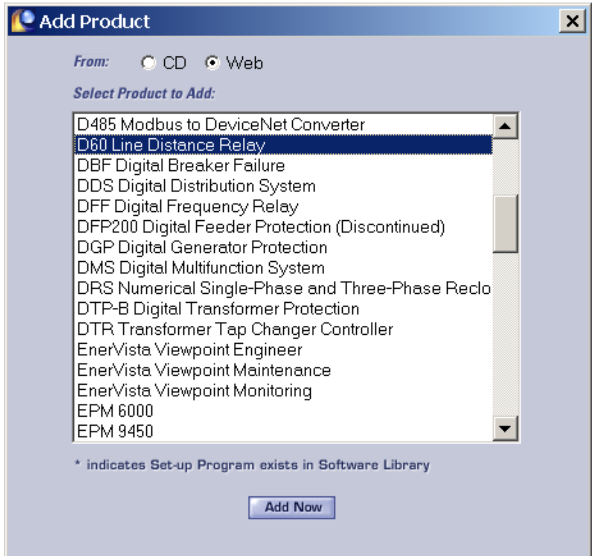
1.3.2 INSTALLATION

After ensuring the minimum requirements for using EnerVista UR Setup are met (see previous section), use the following procedure to install the EnerVista UR Setup from the enclosed GE EnerVista CD.

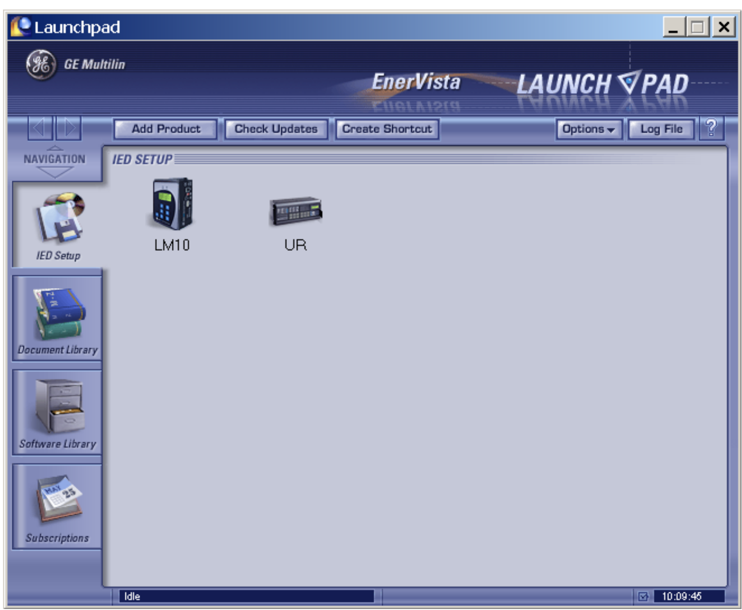
1. Insert the GE EnerVista CD into your CD-ROM drive.
2. Click the **Install Now** button and follow the installation instructions to install the no-charge EnerVista software.
3. When installation is complete, start the EnerVista Launchpad application.
4. Click the **IED Setup** section of the **Launch Pad** window.

5. In the EnerVista Launch Pad window, click the **Add Product** button and select the “C70 Capacitor Bank Protection and Control System” from the Install Software window as shown below. Select the “Web” option to ensure the most recent

software release, or select “CD” if you do not have a web connection, then click the **Add Now** button to list software items for the C70.



6. EnerVista Launchpad will obtain the software from the Web or CD and automatically start the installation program.
7. Select the complete path, including the new directory name, where the EnerVista UR Setup will be installed.
8. Click on **Next** to begin the installation. The files will be installed in the directory indicated and the installation program will automatically create icons and add EnerVista UR Setup to the Windows start menu.
9. Click **Finish** to end the installation. The UR-series device will be added to the list of installed IEDs in the EnerVista Launchpad window, as shown below.



1.3.3 CONFIGURING THE C70 FOR SOFTWARE ACCESS

a) OVERVIEW

The user can connect remotely to the C70 through the rear RS485 port or the rear Ethernet port with a PC running the EnerVista UR Setup software. The C70 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 C70 for remote access via the rear RS485 port(s), refer to the *Configuring Serial Communications* section.
- To configure the C70 for remote access via the rear Ethernet port, refer to the *Configuring Ethernet Communications* section. An Ethernet module must be specified at the time of ordering.
- To configure the C70 for local access with a laptop through either the front RS232 port or rear Ethernet port, refer to the *Using the Quick Connect Feature* section. An Ethernet module must be specified at the time of ordering for Ethernet communications.

b) CONFIGURING SERIAL COMMUNICATIONS

Before starting, verify that the serial cable is properly connected to the RS485 terminals on the back of the device. The faceplate RS232 port is intended for local use and is not described in this section; see the *Using the Quick Connect Feature* section for details on configuring the RS232 port.

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

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.GEmultilin.com). See the *Software Installation* section for installation details.
2. Select the “UR” device from the EnerVista Launchpad to start EnerVista UR Setup.
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 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 will use “Location 1” as the site name. Click the **OK** button when complete.
5. The new site will appear 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.
6. Click the **Add Device** button to define the new device.
7. Enter the desired name in the “Device Name” field and a description (optional) of the site.
8. Select “Serial” from the **Interface** drop-down list. This will display a number of interface parameters that must be entered for proper serial communications.

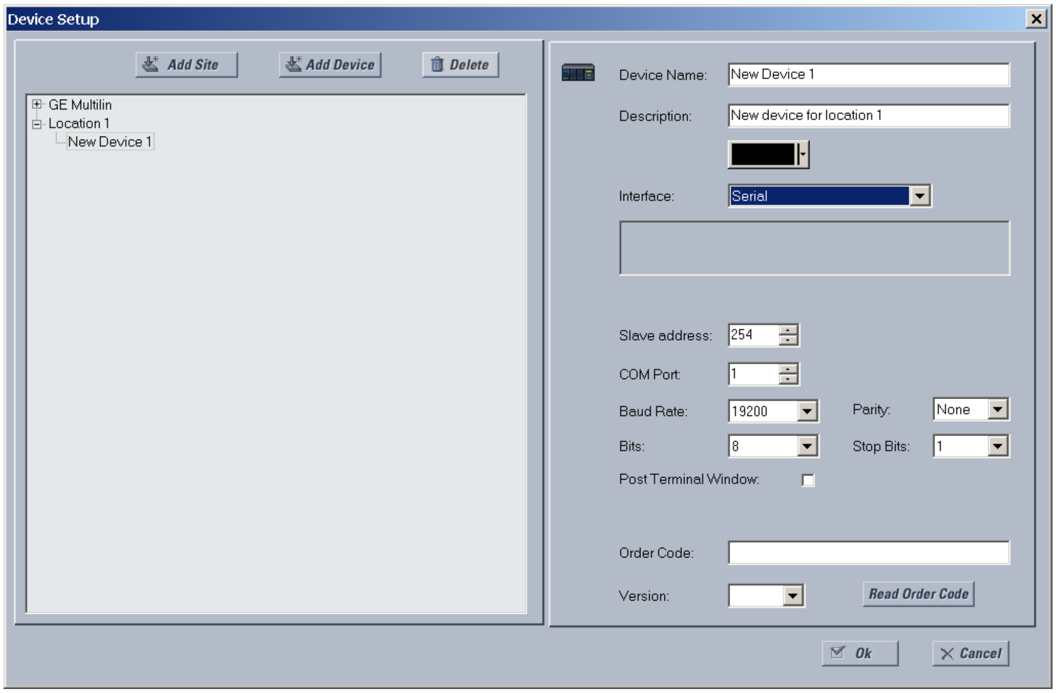


Figure 1–4: CONFIGURING SERIAL COMMUNICATIONS

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 C70 device and upload the order code. If an 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 “OK” when the relay order code has been received. The new device will be 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 RS232 communications. Proceed to the *Connecting to the C70* section to begin communications.

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, it will be necessary to define a Site, then add the relay as a Device at that site.

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.GEmultilin.com). See the *Software Installation* section for installation details.
2. Select the “UR” device from the EnerVista Launchpad to start EnerVista UR Setup.
3. Click the **Device Setup** button to open the Device Setup window, then click the **Add Site** button to define a new site.
4. 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 will use “Location 2” as the site name. Click the **OK** button when complete.
5. The new site will appear 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.
6. Click the **Add Device** button to define the new device.
7. Enter the desired name in the “Device Name” field and a description (optional) of the site.
8. Select “Ethernet” from the **Interface** drop-down list. This will display a number of interface parameters that must be entered for proper Ethernet functionality.

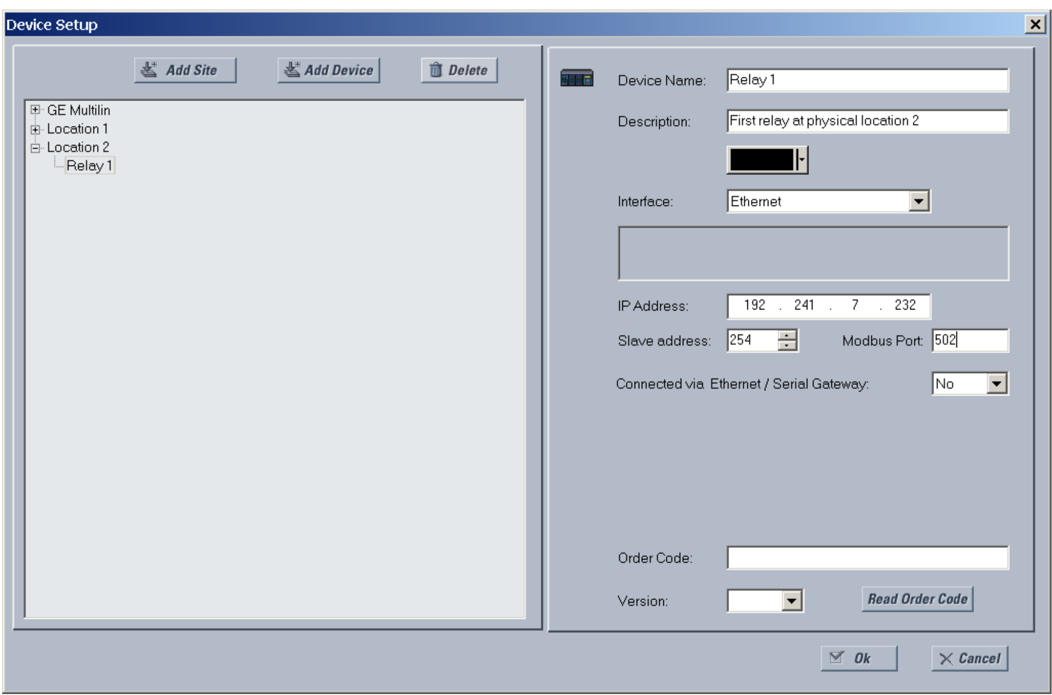


Figure 1–5: CONFIGURING ETHERNET COMMUNICATIONS

9. Enter the relay IP address specified in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK ⇨ IP ADDRESS**) in the “IP Address” field.
10. Enter the relay slave address and Modbus port address values from the respective settings in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ MODBUS PROTOCOL** menu.
11. Click the **Read Order Code** button to connect to the C70 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.
12. Click **OK** when the relay order code has been received. The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista UR Setup window.

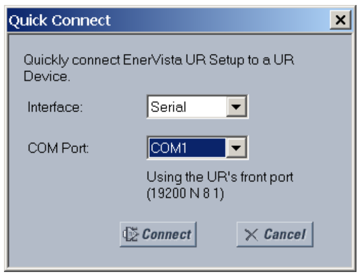
The Site Device has now been configured for Ethernet communications. Proceed to the *Connecting to the C70* section to begin communications.

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 laptop 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.GEmultilin.com). See the *Software Installation* section for installation details.
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 will create a site named “Quick Connect” with a corresponding device also named “Quick Connect” and display them on the upper-left corner of the screen. Expand the sections to view data directly from the C70 device.

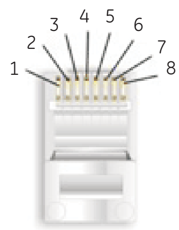
Each time the EnerVista UR Setup software is initialized, click the **Quick Connect** button to establish direct communications to the C70. This ensures that configuration of the EnerVista UR Setup software matches the C70 model number.

b) USING QUICK CONNECT VIA THE REAR ETHERNET PORTS

To use the Quick Connect feature to access the C70 from a laptop through Ethernet, first assign an IP address to the relay from the front panel keyboard.

1. Press the MENU key until the SETTINGS menu is displayed.
2. Navigate to the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK ⇨ IP ADDRESS** setting.
3. Enter an IP address of “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 of “255.0.0.0” and press the ENTER key to save the value.

Next, use an Ethernet cross-over cable to connect the laptop to the rear Ethernet port. The pinout for an Ethernet cross-over cable is shown below.



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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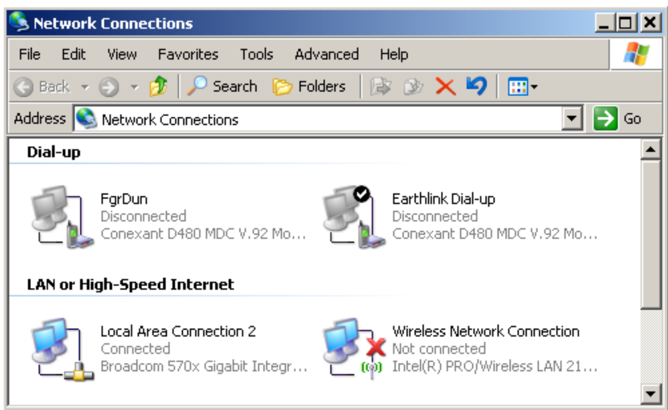
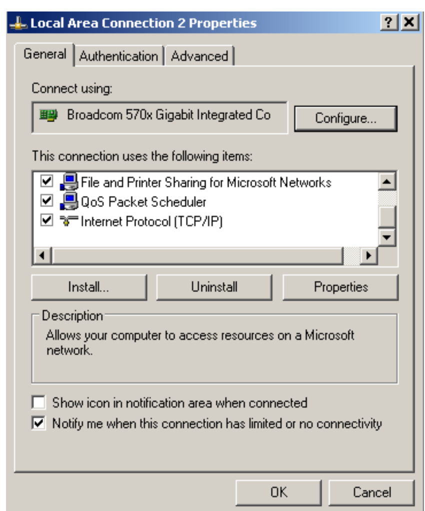
Figure 1–6: ETHERNET CROSS-OVER CABLE PIN LAYOUT

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

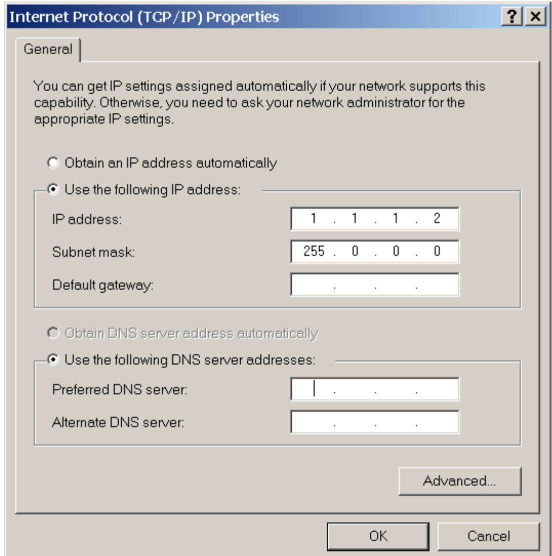
1. From the Windows desktop, right-click the **My Network Places** icon and select **Properties** to open the network connections window.



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



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



4. Click on 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 C70 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 C70 (in this example, 255.0.0.0).
7. Click OK to save the values.

Before continuing, it will be necessary to 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:

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

3. If the connection is successful, the system will return four replies as follows:

```
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 milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0 ms
```

4. Note that the values for `time` and `TTL` will vary depending on local network configuration.

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 milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0 ms

Pinging 1.1.1.1 with 32 bytes of data:
```

Verify the physical connection between the C70 and the laptop computer, and double-check the programmed IP address in the **PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK ⇨ IP ADDRESS** setting, then repeat step 2 in the above procedure.

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 milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0 ms

Pinging 1.1.1.1 with 32 bytes of data:
```

Verify the physical connection between the C70 and the laptop computer, and double-check the programmed IP address in the **PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK ⇨ IP ADDRESS** setting, then repeat step 2 in the above procedure.

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 milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0 ms

Pinging 1.1.1.1 with 32 bytes of data:
```

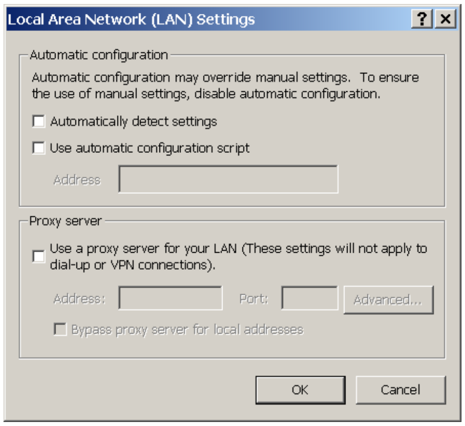
Verify the IP address is programmed in the local PC by entering the ipconfig command in the command window.

```
C:\WINNT>ipconfig

Windows 2000 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>
```

It may be necessary to restart the laptop for the change in IP address to take effect (Windows 98 or NT).

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

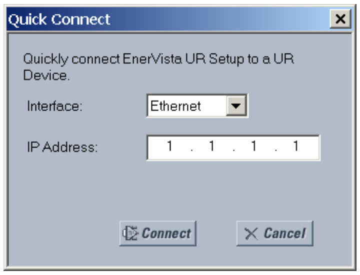
1. Start the Internet Explorer software.
2. Select the **Tools > Internet Options** menu item and click on **Connections** tab.
3. Click on the **LAN Settings** button to open the following window.



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 C70 relay.

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.GEmultilin.com). See the *Software Installation* section for installation details.
2. Start the Internet Explorer software.
3. Select the “UR” device from the EnerVista Launchpad to start EnerVista UR Setup.
4. Click the **Quick Connect** button to open the Quick Connect dialog box.



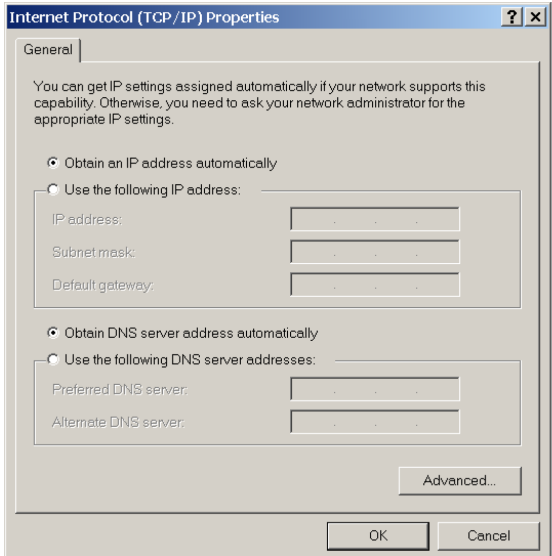
5. Select the **Ethernet** interface and enter the IP address assigned to the C70, then click **Connect**.
6. The EnerVista UR Setup software will create a site named “Quick Connect” with a corresponding device also named “Quick Connect” and display them on the upper-left corner of the screen. Expand the sections to view data directly from the C70 device.

Each time the EnerVista UR Setup software is initialized, click the **Quick Connect** button to establish direct communications to the C70. This ensures that configuration of the EnerVista UR Setup software matches the C70 model number.

When direct communications with the C70 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 below.



If this computer is used to connect to the Internet, re-enable any proxy server settings after the laptop has been disconnected from the C70 relay.

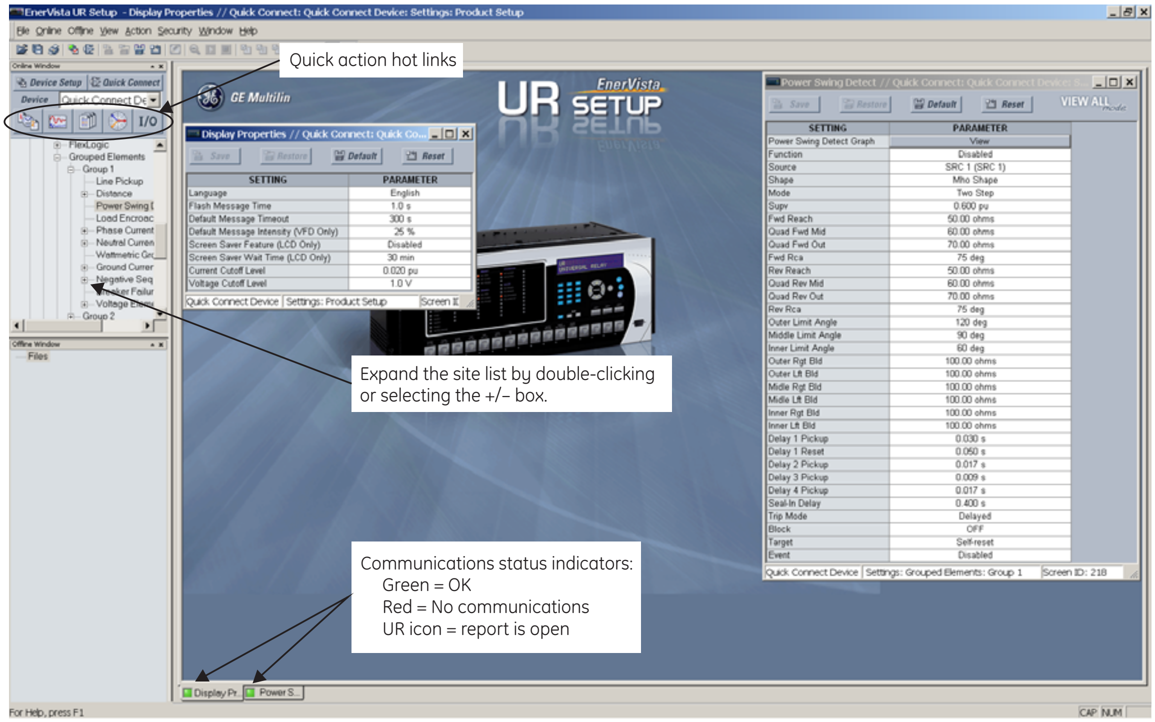
AUTOMATIC DISCOVERY OF ETHERNET DEVICES

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 will trigger the software to automatically detect any UR-series relays located on the network. The EnerVista UR Setup software will then proceed to configure all settings and order code options in the **Device Setup** menu, for the purpose of communicating to multiple relays. This feature allows the user to identify and interrogate, in seconds, all UR-series devices in a particular location.

1.3.5 CONNECTING TO THE C70 RELAY

1. Open the Display Properties window through the Site List tree as shown below:



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2. The Display Properties window will open with a status indicator on the lower left of the EnerVista UR Setup window.
3. 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.
4. The Display Properties settings can now be edited, printed, or changed according to user specifications.

NOTE **Refer to chapter 4 in this manual and the EnerVista UR Setup Help File for more information about the using the EnerVista UR Setup software interface.**

QUICK ACTION HOT LINKS

The EnerVista UR Setup software has several new quick action buttons that provide users with instant access to several functions that are often performed when using C70 relays. From the online window, users can select which relay to interrogate from a pull-down window, then click on the button for the action they wish to perform. The following quick action functions are available:

- View the C70 event record.
- View the last recorded oscillography record.
- View the status of all C70 inputs and outputs.
- View all of the C70 metering values.
- View the C70 protection summary.

1.4.1 MOUNTING AND WIRING

Please refer to Chapter 3: Hardware for detailed mounting and wiring instructions. Review all **WARNINGS** and **CAUTIONS** carefully.

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 PC COM1 or COM2 port as described in the *CPU communications ports* section of chapter 3.

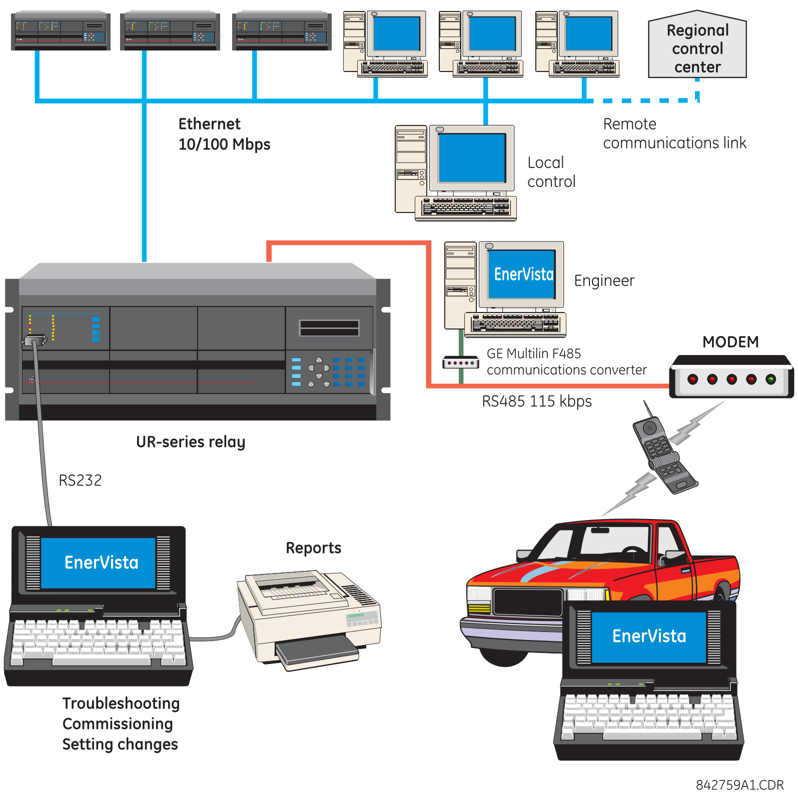

Figure 1–7: RELAY COMMUNICATIONS OPTIONS

To communicate through the C70 rear RS485 port from a PC 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 C70 rear communications port. The converter terminals (+, –, GND) are connected to the C70 communication module (+, –, COM) terminals. Refer to the *CPU communications ports* section in chapter 3 for option details. The line should be 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 2 × 20 backlit liquid crystal display (LCD) to make them visible under poor lighting conditions. Messages are descriptive and should not require the aid of an instruction manual for deciphering. While the keypad and display are not actively being used, the display will default to user-defined messages. Any high priority event driven message will automatically override the default message and appear 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 broken down further into logical subgroups.

The MESSAGE keys navigate through the subgroups. The VALUE keys scroll increment or decrement numerical setting values when in programming mode. These keys also scroll through alphanumeric values in the text edit mode. Alternatively, values may also be entered with the numeric keypad.

The decimal key initiates and advance to the next character in text edit mode or enters a decimal point. The HELP key may 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 the desired 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.

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

```
■■ SETTINGS          ◀▶   ■ PASSWORD    ◀▶   ACCESS LEVEL:
■■ PRODUCT SETUP          ■ SECURITY         Restricted

        ▲▼

■■ SETTINGS
■■ SYSTEM SETUP
```

1.5.4 RELAY ACTIVATION

The relay is defaulted to the “Not Programmed” state when it leaves the factory. This safeguards against the installation of a relay whose settings have not been entered. When powered up successfully, the Trouble LED will be on and the In Service LED off. The relay in the “Not Programmed” state will block signaling of any output relay. These conditions will 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
```

To put the relay in the “Programmed” state, press either of the VALUE keys once and then press ENTER. The faceplate Trouble LED will turn off and the In Service LED will turn on. The settings for the relay can be programmed manually (refer to *Chapter 5*) via the faceplate keypad or remotely (refer to the EnerVista UR Setup help file) via the EnerVista UR Setup software interface.

1.5.5 RELAY PASSWORDS

It is recommended that passwords be set up for each security level and assigned to specific personnel. There are two user password 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

Refer to the *Changing Settings* section in Chapter 4 for complete instructions on setting up security level passwords.

1.5.6 FLEXLOGIC™ CUSTOMIZATION

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

1.5.7 COMMISSIONING

The C70 requires a minimum amount of maintenance when it is commissioned into service. Since the C70 is a microprocessor-based relay, its characteristics do not change over time. As such, no further functional tests are required.

Furthermore, the C70 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 for details). However, it is recommended that C70 maintenance be scheduled with other system maintenance. This maintenance may involve the 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 during 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 prompt service.

2.1.1 OVERVIEW

The C70 Capacitor Bank Protection and Control System is a UR-series microprocessor-based relay for protection and control of small, medium, and large three-phase capacitor banks. The relay can be ordered with up to three CT/VT modules, allowing for flexible application to variety of bank configurations.

The key protection functions are designed to cover grounded and ungrounded, single and parallel banks. Sensitive protection functions support compensation for both external (system) unbalance and inherent unbalance of the capacitor bank itself. Both voltage and current-based balance protection functions are available. Algorithms are developed to automatically select compensation settings after repairs or other alternations of the bank.

The relay supports variety of bank configurations through flexible configurations of its AC inputs, installed voltage and current transformers, and resulting protection techniques.

The relay incorporates an *automatic voltage regulator* (AVR) responding to either voltage, reactive power, or power factor. A separate timer function initiates controls on a pre-defined time/date basis. These on-off type controls are meant to automatically close or open the associated breaker. A supervisory function is provided to program the local/remote, auto/manual functionality, temporary inhibit closing after tripping, and other auxiliary functions such as operation counters.

A capacitor control element provides remote/local and auto/manual control regulation, trip/close interlocking, and seal-in. A user-programmable time delay inhibits closing until after the bank discharges itself to a safe level.

Up to six contact input/output modules can be ordered. The relay can also equipped with a serial 64/128 kbps direct input/output module for fast and reliable peer-to-peer communication with other UR-series IEDs.

The C70 metering functions include true RMS and phasors for currents and voltages, current and voltage harmonics and THD, symmetrical components, frequency, power, power factor.

Diagnostic features include an event recorder capable of storing 1024 time-tagged events, oscillography capable of storing up to 64 records with programmable trigger, content and sampling rate, and data logger acquisition of up to 16 channels, with programmable content and sampling rate. The internal clock used for time-tagging can be synchronized with an IRIG-B signal or via the SNTP protocol over the Ethernet port. This precise time stamping allows the sequence of events to be determined throughout the system. Events can also be programmed (via FlexLogic™) to trigger oscillography data capture which may be set to record the measured parameters before and after the event for viewing on a personal computer. These tools significantly reduce troubleshooting time and simplify report generation in the event of a system fault.

A faceplate RS232 port may be used to connect to a PC for the programming of settings and the monitoring of actual values. A variety of communications modules are available. Two rear RS485 ports allow independent access by operating and engineering staff. All serial ports use the Modbus® RTU protocol. The RS485 ports may be connected to system computers with baud rates up to 115.2 kbps. The RS232 port has a fixed baud rate of 19.2 kbps. Optional communications modules include a 10/100Base-T or 10Base-F Ethernet interface which can be used to provide fast, reliable communications in noisy environments. Another option provides two 10BaseF fiber optic ports for redundancy. The Ethernet port supports IEC 61850, Modbus®/TCP, and TFTP protocols, and allows access to the relay via any standard web browser (C70 web pages). The IEC 60870-5-104 protocol is supported on the Ethernet port. DNP 3.0 and IEC 60870-5-104 cannot be enabled at the same time.

The C70 IEDs use flash memory technology which allows field upgrading as new features are added. The following single line diagram illustrates the relay functionality using ANSI (American National Standards Institute) device numbers.

Table 2–1: ANSI DEVICE NUMBERS AND FUNCTIONS

NUMBER	FUNCTION	NUMBER	FUNCTION
27P	Phase undervoltage	59N	Neutral overvoltage
50BF	Breaker failure	59NU	Neutral voltage unbalance
50DD	Disturbance detector	59P	Phase overvoltage
50G	Ground instantaneous overcurrent	59X	Auxiliary overvoltage
50N	Neutral instantaneous overcurrent	59_2	Negative-sequence overvoltage
50P	Phase instantaneous overcurrent	60N	Bank neutral current unbalance
50_2	Negative-sequence instantaneous overcurrent	60P	Bank phase current unbalance
51G	Ground time overcurrent	67N	Neutral directional overcurrent
51N	Neutral time overcurrent	67P	Phase directional overcurrent
51P	Phase time overcurrent	67_2	Negative-sequence directional overcurrent
51_2	Negative-sequence time overcurrent	87V	Bank voltage differential
59B	Bank phase overvoltage		

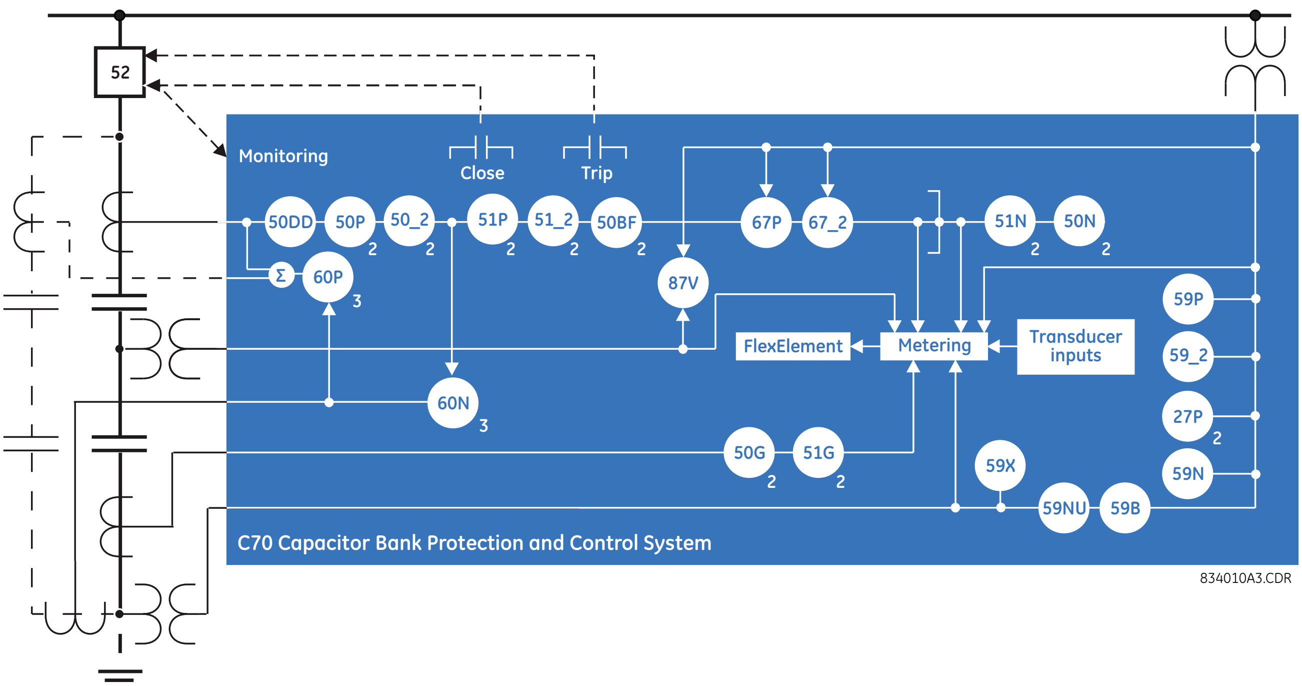

Figure 2–1: SINGLE LINE DIAGRAM

Table 2–2: OTHER DEVICE FUNCTIONS

FUNCTION	FUNCTION	FUNCTION
Breaker control	Direct inputs and outputs (32)	Time and date
Breaker flashover	Event recorder	Time synchronization over SNTP
Breaker restrike	FlexElements™ (16)	Transducer inputs and outputs
Capacitor control supervision	FlexLogic™ equations	User-definable displays
Contact inputs (up to 96)	Frequency metering	User-programmable fault reports
Contact outputs (up to 64)	IEC 61850 communications (optional)	User-programmable LEDs
Control pushbuttons	Modbus communications	User-programmable pushbuttons
Current metering: true RMS, phasors, symmetrical	Modbus user map	User-programmable self-tests
	Non-volatile latches	Virtual inputs (64)
Data logger	Non-volatile selector switch	Virtual outputs (96)
Digital counters (8)	Oscillography	Voltage metering: true RMS, phasors, symmetrical
Digital elements (48)	Power metering	
Disconnect switches (24)	Power factor metering	Voltage regulator
DNP 3.0 or IEC 60870-5-104 protocol	Setting groups (6)	VT fuse failure

2.1.2 ORDERING

a) OVERVIEW

The C70 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. Refer to the GE Multilin ordering page at http://www.GEindustrial.com/multilin/order.htm for the latest details concerning C70 ordering options.

The order code structure is dependent on the mounting option (horizontal or vertical) and the type of CT/VT modules (regular CT/VT modules or the HardFiber modules). The order code options are described in the following sub-sections.

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b) ORDER CODES WITH TRADITIONAL CTS AND VTS

The order codes for the horizontal mount units with standard CTs and VTs are shown below.

Table 2–3: C70 ORDER CODES (HORIZONTAL UNITS WITH TRADITIONAL CTS AND VTS)

	C70	- *	**	- *	*	*	- F **	- H **	- M **	- P **	- U **	- W/X **	Full Size Horizontal Mount
BASE UNIT	C70												Base Unit
CPU		E											RS485 and RS485
		G											RS485 and multi-mode ST 10Base-F
		H											RS485 and multi-mode ST redundant 10Base-F
		J											RS485 and multi-mode ST 100Base-FX
		S											RS485 and managed six-port Ethernet switch
SOFTWARE			00										No software options
			03										IEC 61850; not available for type E CPUs
			12										Enhanced capacitor bank control (time and date, capacitor control supervision, automatic voltage regulator)
			13										Enhanced capacitor bank control and IEC 61850; not available for type E CPUs
MOUNT/COATING				H									Horizontal (19” rack)
				A									Horizontal (19” rack) with harsh environmental coating
FACEPLATE/ DISPLAY					C								English display
					P								English 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						H							125 / 250 V AC/DC power supply
						L							24 to 48 V (DC only) power supply
CT/VT MODULES							8L		8L		8L		Standard 4CT/4VT with enhanced diagnostics
							8N		8N		8N		Standard 8CT with enhanced diagnostics
							8V		8V		8V		Standard 8VT with enhanced diagnostics
DIGITAL INPUTS/OUTPUTS								XX		XX		XX	No Module
								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, 2 Form-A (no monitoring) latching outputs, 8 digital inputs
TRANSDUCER INPUTS/OUTPUTS (maximum of 3 per unit)								5A	5A	5A	5A	5A	4 dcmA inputs, 4 dcmA outputs (only one 5A module is allowed)
INTER-RELAY COMMUNICATIONS (select a maximum of 1 per unit)											2G	2G	IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 1 Channel
											2H	2H	IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 2 Channels
												2S	Six-port managed Ethernet switch with high voltage power supply (110 to 250 V DC / 100 to 240 V AC)
												2T	Six-port managed Ethernet switch with low voltage power supply (48 V DC)
											77	77	IEEE C37.94, 820 nm, multimode, LED, 2 Channels
											7H	7H	820 nm, multi-mode, LED, 2 Channels
											7I	7I	1300 nm, multi-mode, LED, 2 Channels
											7S	7S	G.703, 2 Channels
											7W	7W	RS422, 2 Channels

The order codes for the reduced size vertical mount units with standard CTs and VTs are shown below.

Table 2–4: C70 ORDER CODES (REDUCED SIZE VERTICAL UNITS WITH TRADITIONAL CTS AND VTS)

	C70	- *	**	- *	*	*	- F **	- H **	- M **	- P/R **	Reduced Size Vertical Mount (see note regarding P/R slot below)
BASE UNIT	C70										Base Unit
CPU		E									RS485 and RS485
		G									RS485 and multi-mode ST 10Base-F
		H									RS485 and multi-mode ST redundant 10Base-F
		J									RS485 and multi-mode ST 100Base-FX
		S									RS485 and managed six-port Ethernet switch
SOFTWARE			00								No software options
			03								IEC 61850; not available for type E CPUs
			12								Enhanced capacitor bank control (time and date, capacitor control supervision, automatic voltage regulator)
			13								Enhanced capacitor bank control and IEC 61850; not available for type E CPUs
MOUNT/COATING				V							Vertical (3/4 rack)
				B							Vertical (3/4 rack) with harsh environmental coating
FACEPLATE/ DISPLAY					F						English 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 Russian display and user-programmable pushbuttons
					Y						Enhanced front panel with Chinese display and user-programmable pushbuttons
POWER SUPPLY						H					125 / 250 V AC/DC power supply
						L					24 to 48 V (DC only) power supply
CT/VT MODULES							8L		8L		Standard 4CT/4VT with enhanced diagnostics
							8N		8N		Standard 8CT with enhanced diagnostics
							8V		8V		Standard 8VT with enhanced diagnostics
DIGITAL INPUTS/OUTPUTS								XX		XX	No Module
								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, 2 Form-A (no monitoring) latching outputs, 8 digital inputs
TRANSDUCER INPUTS/OUTPUTS (maximum of 3 per unit)								5A	5A	5A	4 dcmA inputs, 4 dcmA outputs (only one 5A module is allowed)
INTER-RELAY COMMUNICATIONS (select a maximum of 1 per unit) For the last module, slot P is used for digital input/output modules; slot R is used for inter-relay communications modules.										2G	IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 1 Channel
										2H	IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 2 Channels
										2S	Six-port managed Ethernet switch with high voltage power supply (110 to 250 V DC / 100 to 240 V AC)
										2T	Six-port managed Ethernet switch with low voltage power supply (48 V DC)
										77	IEEE C37.94, 820 nm, multimode, LED, 2 Channels
										7H	820 nm, multi-mode, LED, 2 Channels
										7I	1300 nm, multi-mode, LED, 2 Channels
										7S	G.703, 2 Channels
										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 2–5: C70 ORDER CODES (HORIZONTAL UNITS WITH PROCESS BUS MODULE)

	C70	- *	**	- *	*	*	- F **	- H **	- M **	- P **	- U **	- W/X **	Full Size Horizontal Mount
BASE UNIT	C70												Base Unit
CPU		E											RS485 and RS485
		G											RS485 and multi-mode ST 10Base-F
		H											RS485 and multi-mode ST redundant 10Base-F
		J											RS485 and multi-mode ST 100Base-FX
SOFTWARE			00										No software options
			03										IEC 61850; not available for type E CPUs
			12										Enhanced capacitor bank control (time and date, capacitor control supervision, automatic voltage regulator)
			13										Enhanced capacitor bank control and IEC 61850; not available for type E CPUs
MOUNT/COATING				H									Horizontal (19” rack)
				A									Horizontal (19” rack) with harsh environmental coating
FACEPLATE/ DISPLAY					C								English display
					P								English 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
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	XX	No Module
										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
										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, 2 Form-A (no monitoring) latching outputs, 8 digital inputs
INTER-RELAY COMMUNICATIONS (select a maximum of 1 per unit)											2G	2G	IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 1 Channel
											2H	2H	IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 2 Channels
											77	77	IEEE C37.94, 820 nm, multimode, LED, 2 Channels
											7H	7H	820 nm, multi-mode, LED, 2 Channels
											7I	7I	1300 nm, multi-mode, LED, 2 Channels
											7S	7S	G.703, 2 Channels
											7W	7W	RS422, 2 Channels

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

Table 2–6: C70 ORDER CODES (REDUCED SIZE VERTICAL UNITS WITH PROCESS BUS MODULE)

	C70	- *	**	- *	*	*	- F **	- H **	- M **	- P/R **	Reduced Size Vertical Mount (see note regarding P/R slot below)
BASE UNIT	C70										Base Unit
CPU		E									RS485 and RS485
		G									RS485 and multi-mode ST 10Base-F
		H									RS485 and multi-mode ST redundant 10Base-F
		J									RS485 and multi-mode ST 100Base-FX
SOFTWARE			00								No software options
			03								IEC 61850; not available for type E CPUs
			12								Enhanced capacitor bank control (time and date, capacitor control supervision, automatic voltage regulator)
			13								Enhanced capacitor bank control and IEC 61850; not available for type E CPUs
MOUNT/COATING				V							Vertical (3/4 rack)
				B							Vertical (3/4 rack) with harsh environmental coating
FACEPLATE/ DISPLAY					F						English 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
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	No Module
											2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 digital inputs
											2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
											8 Form-C outputs
											16 digital inputs
											4 Form-C outputs, 8 digital inputs
											8 Fast Form-C outputs
											4 Form-A (voltage with optional current) outputs, 8 digital inputs
											6 Form-A (voltage with optional current) outputs, 4 digital inputs
											4 Form-C and 4 Fast Form-C outputs
											2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 digital inputs
											2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
											4 Form-A (current with optional voltage) outputs, 8 digital inputs
											6 Form-A (current with optional voltage) outputs, 4 digital inputs
											2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs
											2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
											4 Form-A (no monitoring) outputs, 8 digital inputs
											6 Form-A (no monitoring) outputs, 4 digital inputs
											2 Form-A outputs, 1 Form-C output, 2 Form-A (no monitoring) latching outputs, 8 digital inputs
INTER-RELAY										2G	IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 1 Channel
COMMUNICATIONS										2H	IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 2 Channels
(select a maximum of 1 per unit)										77	IEEE C37.94, 820 nm, multimode, LED, 2 Channels
For the last module, slot P is used for digital and transducer										7H	820 nm, multi-mode, LED, 2 Channels
input/output modules; slot R is used for inter-relay										7I	1300 nm, multi-mode, LED, 2 Channels
communications modules.										7S	G.703, 2 Channels
										7W	RS422, 2 Channels

2.1.3 REPLACEMENT MODULES

Replacement modules can be ordered separately as shown below. When ordering a replacement CPU module or face-plate, please provide the serial number of your existing unit.

NOTE

Not all replacement modules may be applicable to the C70 relay. Only the modules specified in the order codes are available as replacement modules.

NOTE

Replacement module codes are subject to change without notice. Refer to the GE Multilin ordering page at http://www.GEindustrial.com/multilin/order.htm for the latest details concerning C70 ordering options.

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

Table 2–7: ORDER CODES FOR REPLACEMENT MODULES, HORIZONTAL UNITS

	UR - ** - *	
POWER SUPPLY	1H	125 / 250 V AC/DC
(redundant supply only available in horizontal units;	1L	24 to 48 V (DC only)
must be same type as main supply)	RH	redundant 125 / 250 V AC/DC
	RH	redundant 24 to 48 V (DC only)
CPU	9E	RS485 and RS485 (Modbus RTU, DNP 3.0)
	9G	RS485 and 10Base-F (Ethernet, Modbus TCP/IP, DNP 3.0)
	9H	RS485 and Redundant 10Base-F (Ethernet, Modbus TCP/IP, DNP 3.0)
	9J	RS485 and multi-mode ST 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9K	RS485 and multi-mode ST redundant 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9L	RS485 and single mode SC 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9M	RS485 and single mode SC redundant 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9N	RS485 and 10/100Base-T
	9S	RS485 and six-port managed Ethernet switch
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	8F	Standard 4CT/4VT
MODULES	8G	Sensitive Ground 4CT/4VT
(NOT AVAILABLE FOR THE C30)	8H	Standard 8CT
	8J	Sensitive Ground 8CT
	8L	Standard 4CT/4VT with enhanced diagnostics
	8M	Sensitive Ground 4CT/4VT with enhanced diagnostics
	8N	Standard 8CT 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
	2S	Six-port managed Ethernet switch with high voltage power supply (110 to 250 V DC / 100 to 240 V AC)
	2T	Six-port managed Ethernet switch with low voltage power supply (48 V DC)
	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
TRANSDUCER	5A	4 dcmA inputs, 4 dcmA outputs (only one 5A module is allowed)
INPUTS/OUTPUTS	5C	8 RTD inputs
	5D	4 RTD inputs, 4 dcmA outputs (only one 5D module is allowed)
	5E	4 dcmA inputs, 4 RTD inputs
	5F	8 dcmA inputs

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

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

	UR - ** - *	
POWER SUPPLY	1H	125 / 250 V AC/DC
	1L	24 to 48 V (DC only)
CPU	9E	RS485 and RS485 (Modbus RTU, DNP 3.0)
	9G	RS485 and 10Base-F (Ethernet, Modbus TCP/IP, DNP 3.0)
	9H	RS485 and Redundant 10Base-F (Ethernet, Modbus TCP/IP, DNP 3.0)
	9J	RS485 and multi-mode ST 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9K	RS485 and multi-mode ST redundant 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9L	RS485 and single mode SC 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9M	RS485 and single mode SC redundant 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9N	RS485 and 10/100Base-T
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)	8F	Standard 4CT/4VT
	8G	Sensitive Ground 4CT/4VT
	8H	Standard 8CT
	8J	Sensitive Ground 8CT
	8L	Standard 4CT/4VT with enhanced diagnostics
	8M	Sensitive Ground 4CT/4VT with enhanced diagnostics
	8N	Standard 8CT 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, 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

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

2.2.1 PROTECTION ELEMENTS

NOTE

The operating times below 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. This should be taken 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.

VOLTAGE DIFFERENTIAL

Operation: per phase
Auto-setting: on demand from keypad, per phase
Number of elements: 1 per VT bank, maximum of 3
Matching factor: 0.5000 to 2000.0000 in steps of 0.0001, per phase
Number of trip/alarm stages: 4 per phase with individual timers per stage
Pickup threshold: 0.001 to 1.000 pu of bus voltage in steps of 0.001
Pickup level accuracy: 0.0015 pu
Hysteresis: 3% or 0.0005 pu whichever is greater
Pickup delay: 0 to 600.00 s in steps of 0.01
Time accuracy: ±3% or ±35 ms, whichever is greater
Operate time: <35 ms at 60 Hz

CAPACITOR CONTROL

Functionality: contains remote/local and auto/manual non-volatile latches, collects trip, open and close input requests and issues outputs to control tripping and closing
Closing inhibit delay: 0 to 60 minutes in steps of 1 second
Trip and close seal-in timers: 0 to 60.000 s in steps of 0.001

AUTOMATIC VOLTAGE REGULATOR

Number of elements: 1 per CT/VT module, maximum of 3
Modes: voltage with load drop compensation or reactive power with power factor limit
Minimum voltage supervision: 0.500 to 1.500 pu in steps of 0.001
Close voltage level: 0.750 to 1.500 pu in steps of 0.001
Open voltage level: 0.750 to 1.500 pu in steps of 0.001
Voltage pickup accuracy: ±0.5% of setting from 10 to 208 V
Close reactive power level: –1.50 to 1.50 pu in steps of 0.01
Open reactive power level: –1.50 to 1.50 pu in steps of 0.01
Power pickup accuracy: ±0.05 pu
Power factor limit 0.50 to 1.00 in steps of 0.01
Power factor accuracy: ±0.05
Hysteresis: 0.02 pu (voltage); 0.05 pu (vars)
Close delay: 0 to 65.353 s in steps of 0.001
Open delay: 0 to 65.353 s in steps of 0.001
Time accuracy: ±3% or ±20 ms, whichever is greater
Operate time: <80 ms at 60 Hz

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)
Timing accuracy: Operate at > 1.03 × actual pickup ±3.5% of operate time or ±½ cycle (whichever is greater)

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)
Timing accuracy: Operate at 1.5 × pickup ±3% or ±4 ms (whichever is greater)

NEGATIVE SEQUENCE TOC

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
Timing accuracy: Operate at > 1.03 × actual pickup ±3.5% of operate time or ±½ cycle (whichever is greater)

NEGATIVE SEQUENCE 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: < 20 ms at 3 × pickup at 60 Hz
Timing accuracy: Operate at 1.5 × pickup ±3% or ±4 ms (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
Polarizing voltage: V_0 or VX
Polarizing current: IG
Operating current: I_0
Level sensing: 3 × (|I_0| – *K* × |I_1|), IG Independent for forward and reverse
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

NEGATIVE SEQUENCE DIRECTIONAL OC

Directionality: Co-existing forward and reverse
Polarizing: Voltage
Polarizing voltage: V_2
Operating current: I_2
Level sensing:
Zero-sequence:|I_0| – *K* × |I_1|
Negative-sequence:|I_2| – *K* × |I_1|
Restraint, *K*: 0.000 to 0.500 in steps of 0.001
Characteristic angle: 0 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: 0.015 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 CURRENT UNBALANCE

Operation: per phase
Auto-setting: on demand from keypad, per phase
Number of elements: 1 per CT bank, maximum of 3
Inherent unbalance factor:–0.1000 to 0.1000 in steps of 0.0001, per phase
Number of trip/alarm stages: 4 per phase with individual timers per stage
Pickup threshold: 0.001 to 5.000 pu of split-phase CT nominal in steps of 0.001
Pickup level accuracy: 0.002 pu for <1 pu current and <20 CT mismatch between phase and differential CT
Hysteresis: 3% or 0.001 pu, whichever is greater
Pickup delay: 0 to 600.00 s in steps of 0.01
Time accuracy: ±3% or ±35 ms, whichever is greater
Operate time: <35 ms at 60 Hz

NEUTRAL CURRENT UNBALANCE

Auto-setting:	on demand from keypad
Number of elements:	1 per CT bank, to a maximum of 3
Inherent unbalance factor:	magnitude of 0 to 0.1500 in steps of 0.0001, angle of 0 to 359° in steps of 1
Number of trip/alarm stages:	4, with individual timers per stage
Pickup threshold:	0.001 to 5.000 pu of ground input CT in steps of 0.001
Pickup level accuracy:	0.002 pu for <1 pu current and < 20 CT mismatch between phase and neutral CT
Hysteresis:	3% or 0.001 pu, whichever is greater
Slope:	0.0 to 10.0% in steps of 0.1
Pickup delay:	0 to 600.00 s in steps of 0.01
Time accuracy:	±3% or ±35 ms, whichever is greater
Operate time:	<35 ms at 60 Hz

NEUTRAL VOLTAGE UNBALANCE

Operation:	compensated for inherent bank and system unbalance
Auto-setting:	on demand from keypad
Number of elements:	1 per VT bank, maximum of 3
Compensating factor:	0.7500 to 1.2500 in steps of 0.0001
Number of trip/alarm stages:	4 with individual timers
Pickup threshold:	0.001 to 1.000 pu of nominal of the bank neutral point VT in steps of 0.001
Slope:	0 to 10% in steps of 0.1
Pickup level accuracy:	0.002 pu for <10 VT mismatch between phase and neutral VT
Hysteresis:	3% or 0.001 pu whichever is greater
Pickup delay:	0 to 600.00 s in steps of 0.01
Time accuracy:	±3% or ±35 ms, whichever is greater
Operate time:	<35 ms at 60 Hz

PHASE 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 (0.1s base curve)
Curve multiplier:	Time dial = 0.00 to 600.00 in steps of 0.01
Timing accuracy:	Operate at < 0.90 × pickup ±3.5% of operate time or ±4 ms (whichever is greater)

BANK OVERVOLTAGE

Operation:	per phase, 3 stages of definite-time, 1 stage of inverse-time
Application:	grounded and ungrounded banks
Number of elements:	1 per VT bank, maximum of 3
Pickup threshold:	0.800 to 2.000 pu of bus voltage in steps of 0.001, per phase
Pickup level accuracy:	0.002 pu for operating voltage <70 V
Hysteresis:	0.02 pu
Pickup delay:	0 to 600.00 s in steps of 0.01
Curve:	any user-programmable FlexCurve
Time accuracy:	±3% or ±35 ms, whichever is greater
Operate time:	< 35 ms at 60 Hz

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
Timing accuracy:	±3% or ±4 ms (whichever is greater)

NEUTRAL 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:	0.00 to 600.00 s in steps of 0.01 (definite time) or user-defined curve
Reset delay:	0.00 to 600.00 s in steps of 0.01
Timing accuracy:	±3% or ±20 ms (whichever is greater)
Operate time:	< 30 ms at 1.10 × pickup at 60 Hz

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
Timing accuracy:	±3% of operate time or ±4 ms (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
Time accuracy:	±3% or ±20 ms, whichever is greater
Operate time:	< 30 ms at 1.10 × pickup at 60 Hz

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 FLASHOVER

Operating quantity:	phase current, voltage and voltage difference
Pickup level voltage:	0 to 1.500 pu in steps of 0.001
Dropout level voltage:	97 to 98% of pickup
Pickup level current:	0 to 1.500 pu in steps of 0.001
Dropout level current:	97 to 98% of pickup
Level accuracy:	±0.5% or ±0.1% of rated, whichever is greater
Pickup delay:	0 to 65.535 s in steps of 0.001
Time accuracy:	±3% or ±42 ms, whichever is greater
Operate time:	<42 ms at 1.10 × pickup at 60 Hz

BREAKER RESTRIKE

Principle:	detection of high-frequency overcurrent condition ¼ cycle after breaker opens
Availability:	one per CT/VT module (not including 8Z modules)
Pickup level:	0.1 to 2.00 pu in steps of 0.01
Reset delay:	0.000 to 65.535 s in steps of 0.001

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
Timing accuracy (cold curve):	±100 ms or 2%, whichever is greater
Timing 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
Time accuracy:	±3% or 10 ms, whichever is greater

2.2.2 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

FLEXELEMENTS™

Number of elements:	16
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

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

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

TIME OF DAY TIMERS
Number of timers: 5
Setting resolution: 1 minute

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

2.2.3 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

USER-PROGRAMMABLE FAULT REPORT
Number of elements: 2
Pre-fault trigger: any FlexLogic™ operand
Fault trigger: any FlexLogic™ operand
Recorder quantities: 32 (any FlexAnalog value)

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

2.2.4 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: ±1.0% of reading at $-0.8 < PF \le -1.0$ and $0.8 < PF \le 1.0$

REACTIVE POWER (VARS)
Accuracy: ±1.0% of reading at $-0.2 \le PF \le 0.2$

APPARENT POWER (VA)
Accuracy: ±1.0% of reading

CURRENT HARMONICS

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

Accuracy:

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

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

VOLTAGE HARMONICS

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

Accuracy:

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

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

FREQUENCY

Accuracy at
V = 0.8 to 1.2 pu: ±0.001 Hz (when voltage signal is used for frequency measurement)
I = 0.1 to 0.25 pu: ±0.05 Hz
I > 0.25 pu: ±0.001 Hz (when current signal is used for frequency measurement)

2.2.5 INPUTS

AC CURRENT

CT rated primary: 1 to 50000 A
CT rated secondary: 1 A or 5 A by connection
Nominal frequency: 20 to 65 Hz
Relay burden: < 0.2 VA at rated secondary
Conversion range:
Standard CT: 0.02 to 46 × CT rating RMS symmetrical
Current withstand: 20 ms at 250 times rated
1 sec. at 100 times rated
continuous at 3 times rated
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
Nominal frequency: 20 to 65 Hz
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

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

IRIG-B INPUT

Amplitude modulation: 1 to 10 V pk-pk
DC shift: TTL
Input impedance: 22 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

DIRECT INPUTS
Input points: 32
Remote devices: 16
Default states on loss of comms.: On, Off, Latest/Off, Latest/On
Ring configuration: Yes, No
Data rate: 64 or 128 kbps
CRC: 32-bit
CRC alarm:
  Responding to: Rate of messages failing the CRC
  Monitoring message count: 10 to 10000 in steps of 1
  Alarm threshold: 1 to 1000 in steps of 1
Unreturned message alarm:
  Responding to: Rate of unreturned messages in the ring configuration
  Monitoring message count: 10 to 10000 in steps of 1
  Alarm threshold: 1 to 1000 in steps of 1

2.2.6 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

2.2.7 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
Break at L/R of 40 ms: 0.25 A DC max.
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

2

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		

IRIG-B OUTPUT

Amplitude: 10 V peak-peak RS485 level

Maximum load: 100 ohms

Time delay: 1 ms for AM input
40 µs for DC-shift input

Isolation: 2 kV

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

DIRECT OUTPUTS

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

ETHERNET SWITCH (HIGH VOLTAGE, TYPE 2S)

Nominal DC voltage: 110 to 240 V DC

Minimum DC voltage: 88 V DC

Maximum DC voltage: 300 V DC

Input Current: 0.9 A DC maximum

Nominal AC voltage: 100 to 240 V AC, 0.26 to 0.16 A/26 to 39 VA at 50/60 Hz

Minimum AC voltage: 85 V AC, 0.31 A/22 VA at 50/60 Hz

Maximum AC voltage: 265 V AC, 0.16 A/42 VA at 50/60 Hz

Internal fuse: 3 A / 350 V AC, Ceramic, Axial SLO BLO;
Manufacturer: Conquer; Part number: SCD-A 003

ETHERNET SWITCH (LOW VOLTAGE, TYPE 2T)

Nominal voltage: 48 V DC, 0.31 A/15 W

Minimum voltage: 30 V DC, 0.43 A/16 W

Maximum voltage: 60 V DC

Internal fuse: 5 A / 350 V AC, Ceramic, Axial SLO BLO;
Manufacturer: Conquer; Part number: SCD-A 005

2.2.8 COMMUNICATIONS

RS232

Front port: 19.2 kbps, Modbus® RTU

RS485

1 or 2 rear ports: Up to 115 kbps, Modbus® RTU, isolated together at 36 Vpk

Typical distance: 1200 m

Isolation: 2 kV

ETHERNET (FIBER)

PARAMETER	FIBER TYPE	
	10MB MULTI-MODE	100MB MULTI-MODE[1]
Wavelength	820 nm	1310 nm
Connector	ST	ST
Transmit power	–20 dBm	–20 dBm
Receiver sensitivity	–30 dBm	–30 dBm
Power budget	10 dB	10 dB
Maximum input power	–7.6 dBm	–14 dBm
Typical distance	1.65 km	2 km
Duplex	full/half	full/half
Redundancy	yes	yes

1. UR-2S and UR-2T only support 100 Mb multi-mode

ETHERNET (10/100 MB TWISTED PAIR)

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

Connector: RJ45

SNTP clock synchronization error: <10 ms (typical)

ETHERNET SWITCH FIBER OPTIC PORTS

Maximum fiber segment length calculation:

The maximum fiber segment length between two adjacent switches or between a switch and a device is calculated as follows. First, calculate the optical power budget (OPB) of each device using the manufacturer's data sheets.

$$\text{OPB} = P_{T(MIN)} - P_{R(MIN)}$$

where OPB = optical power budget, P_T = transmitter output power, and P_R = receiver sensitivity.

The worst case optical power budget ($\text{OPB}_{\text{WORST}}$) is then calculated by taking the lower of the two calculated power budgets, subtracting 1 dB for LED aging, and then subtracting the total insertion loss. The total insertion loss is calculated by multiplying the number of connectors in each single fiber path by 0.5 dB. For example, with a single fiber cable between the two devices, there will be a minimum of two connections in either transmit or receive fiber paths for a total insertion loss of 1db for either direction:

$$\begin{aligned}\text{Total insertion loss} &= \text{number of connectors} \times 0.5\text{ dB}\\ &= 2 \times 0.5\text{ dB} = 1.0\text{ dB}\end{aligned}$$

The worst-case optical power budget between two type 2T or 2S modules using a single fiber cable is:

$$\text{OPB}_{\text{WORST}} = \text{OPB} - 1\text{ dB (LED aging)} - \text{total insertion loss}$$

$$10dB - 1dB - 1dB = 8dB$$

To calculate the maximum fiber length, divide the worst-case optical power budget by the cable attenuation per unit distance specified in the manufacturer data sheets. For example, typical attenuation for 62.5/125 μm glass fiber optic cable is approximately 2.8 dB per km. In our example, this would result in the following maximum fiber length:

$$\begin{aligned}\text{Maximum fiber length} &= \frac{\text{OPB}_{\text{WORST}}\text{ (in dB)}}{\text{cable loss (in dB/km)}}\\ &= \frac{8\text{ dB}}{2.8\text{ dB/km}} = 2.8km\end{aligned}$$

The customer must use the attenuation specified within the manufacturer data sheets for accurate calculation of the maximum fiber length.

ETHERNET SWITCH 10/100BASE-T PORTS

Connector type: RJ45

MAXIMUM 10 MBPS ETHERNET SEGMENT LENGTHS

Unshielded twisted pair: 100 m (328 ft.)

Shielded twisted pair: 150 m (492 ft.)

MAXIMUM STANDARD FAST ETHERNET SEGMENT LENGTHS

10Base-T (CAT 3, 4, 5 UTP): 100 m (328 ft.)

100Base-TX (CAT 5 UTP):100 m (328 ft.)

Shielded twisted pair: 150 m (492 ft.)

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2.2.9 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 1300nm ELED are calculated from the manufacturer's transmitter power and receiver sensitivity at ambient temperature. At extreme temperatures these values will deviate based on component tolerance. On average, the output power will decrease 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

NOTE **Typical distances listed are based on the following assumptions for system loss. As actual losses will 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
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

2.2.10 ENVIRONMENTAL

AMBIENT TEMPERATURES

Storage temperature: –40 to 85°C
Operating temperature: –40 to 60°C; the LCD contrast may 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, 6days).

OTHER

Altitude: 2000 m (maximum)
Pollution degree: II
Overvoltage category: II
Ingress protection: IP20 front, IP10 back

2.2.11 TYPE TESTS

C70 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

2.2.12 PRODUCTION TESTS

THERMAL

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

2.2.13 APPROVALS

APPROVALS

COMPLIANCE	APPLICABLE COUNCIL DIRECTIVE	ACCORDING TO
CE compliance	Low voltage directive	EN60255-5
	EMC directive	EN60255-26 / EN50263
		EN61000-6-5
North America	---	UL508
	---	UL1053
	---	C22.2 No. 14

2.2.14 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.

NOTE

Units that are stored in a de-energized state should be powered up once per year, for one hour continuously, to avoid deterioration of electrolytic capacitors.

3.1.1 PANEL CUTOUT

a) HORIZONTAL UNITS

The C70 Capacitor Bank Protection and Control 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. There is also a removable dust cover that fits over the faceplate, which must be removed when attempting to access the keypad or RS232 communications port.

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.

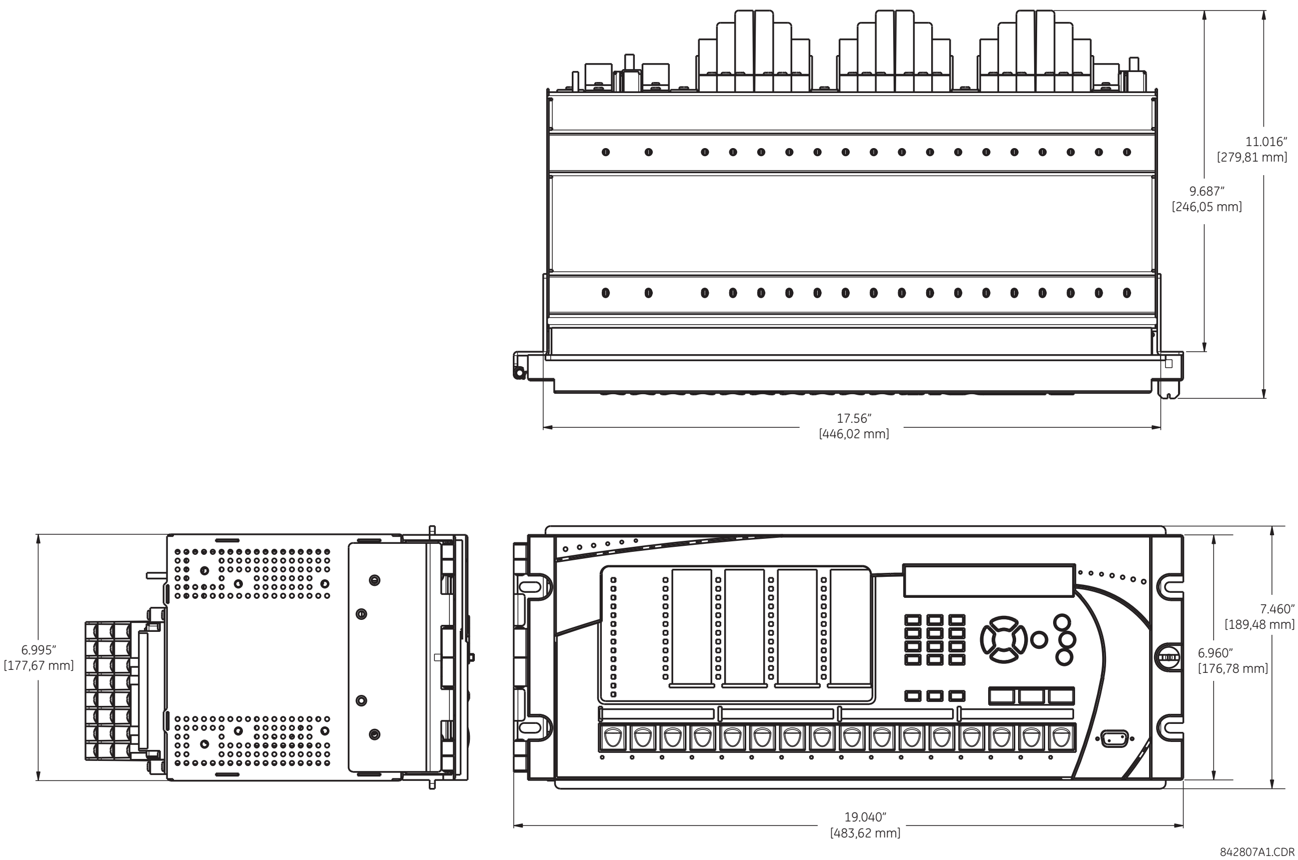


Figure 3–1: C70 HORIZONTAL DIMENSIONS (ENHANCED PANEL)

3

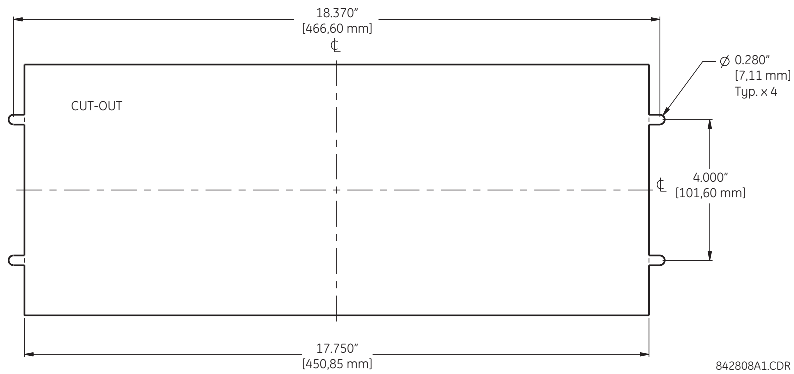


Figure 3–2: C70 HORIZONTAL MOUNTING (ENHANCED PANEL)

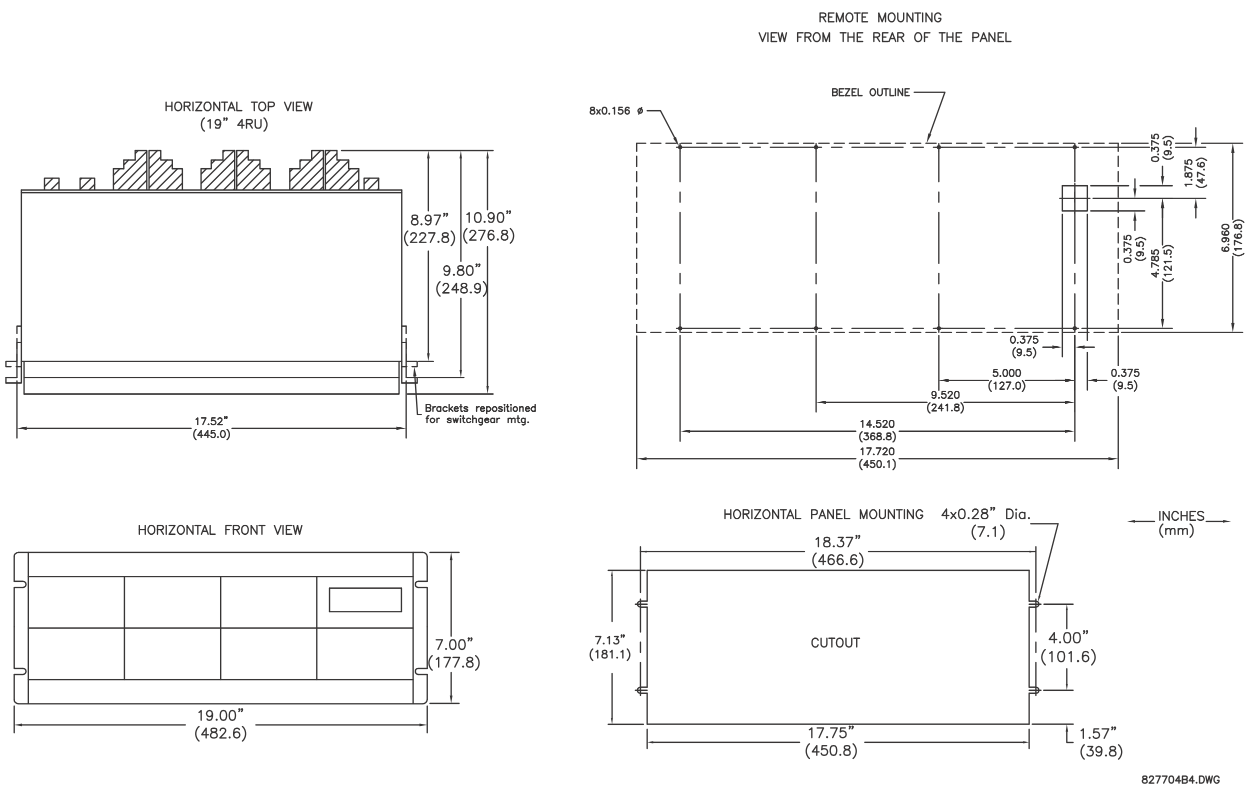


Figure 3–3: C70 HORIZONTAL MOUNTING AND DIMENSIONS (STANDARD PANEL)

b) VERTICAL UNITS

The C70 Capacitor Bank Protection and Control 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. There is also a removable dust cover that fits over the faceplate, which must be removed when attempting to access the keypad or RS232 communications port.

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.

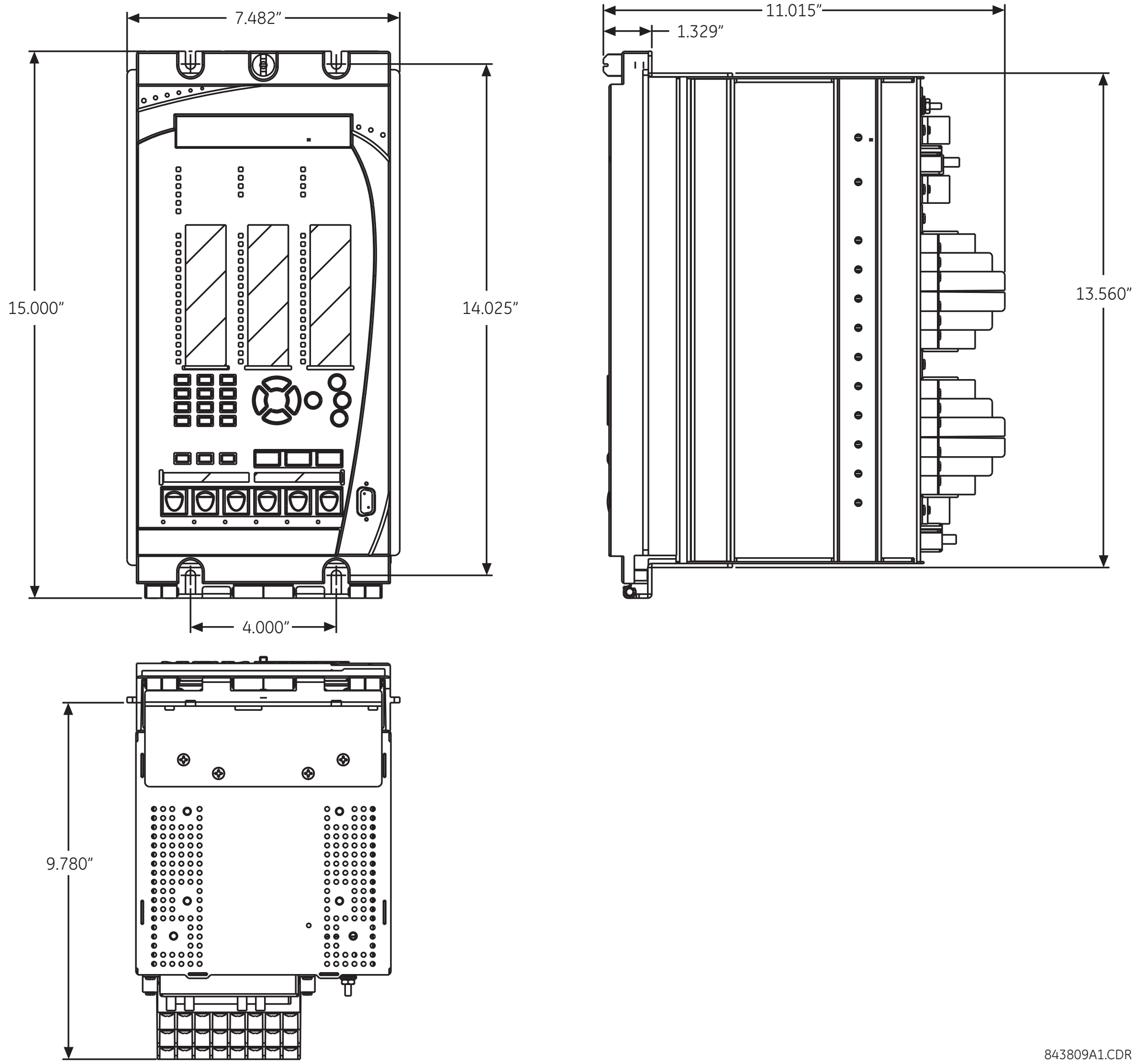


Figure 3–4: C70 VERTICAL DIMENSIONS (ENHANCED PANEL)

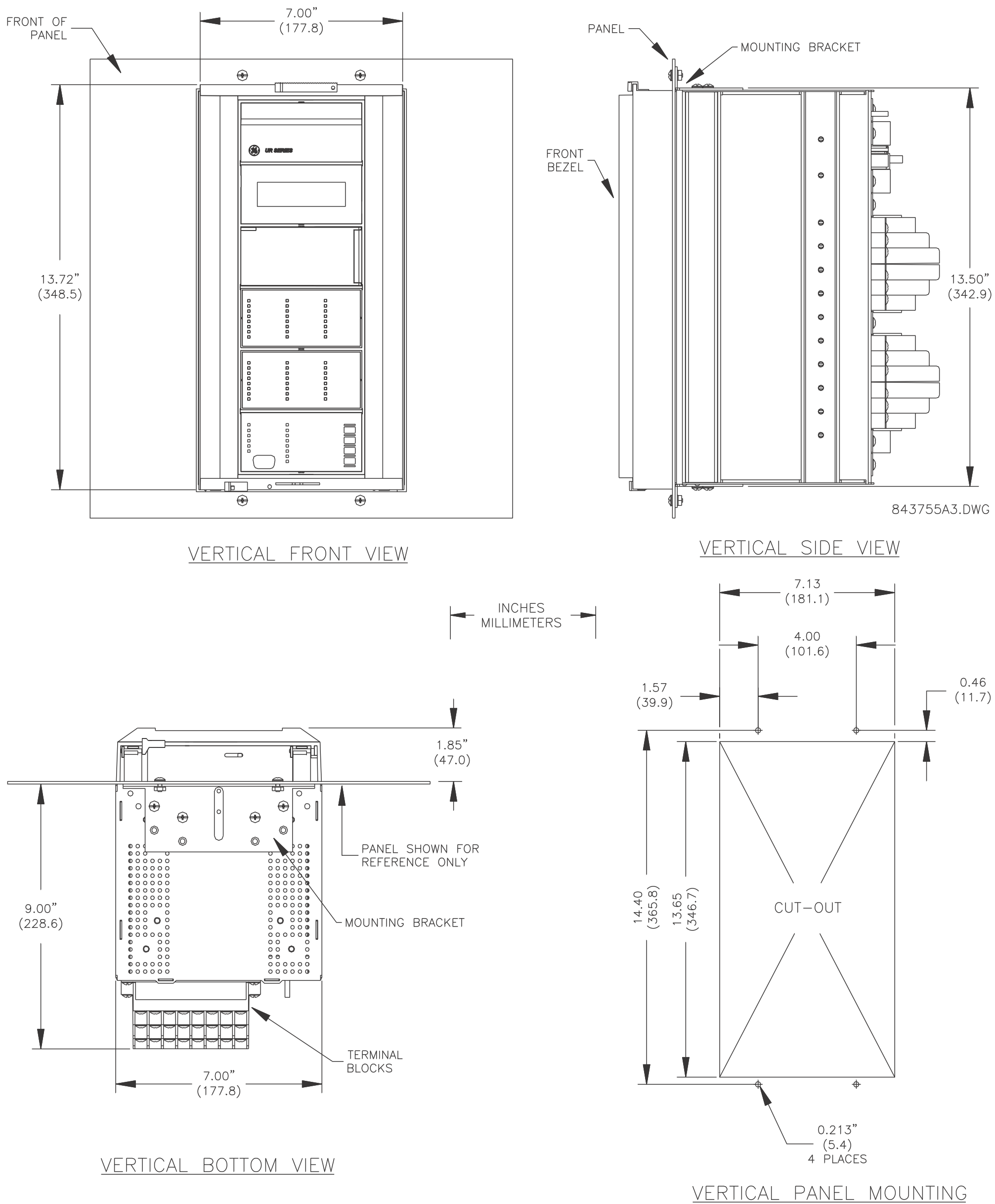


Figure 3–5: C70 VERTICAL MOUNTING AND DIMENSIONS (STANDARD PANEL)

For details on side mounting C70 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 C70 devices with the standard front panel, refer to the figures below.

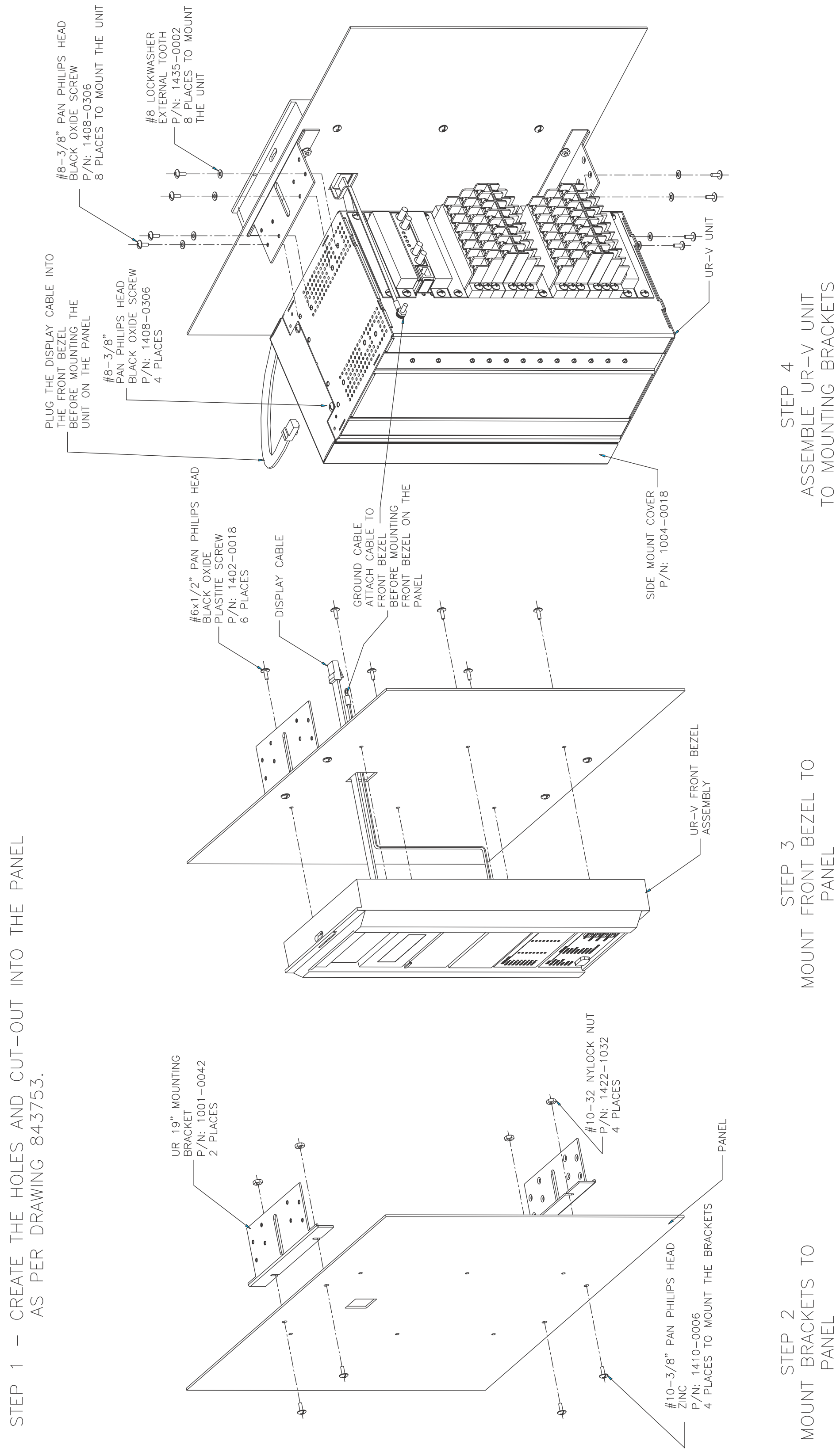


Figure 3–6: C70 VERTICAL SIDE MOUNTING INSTALLATION (STANDARD PANEL)

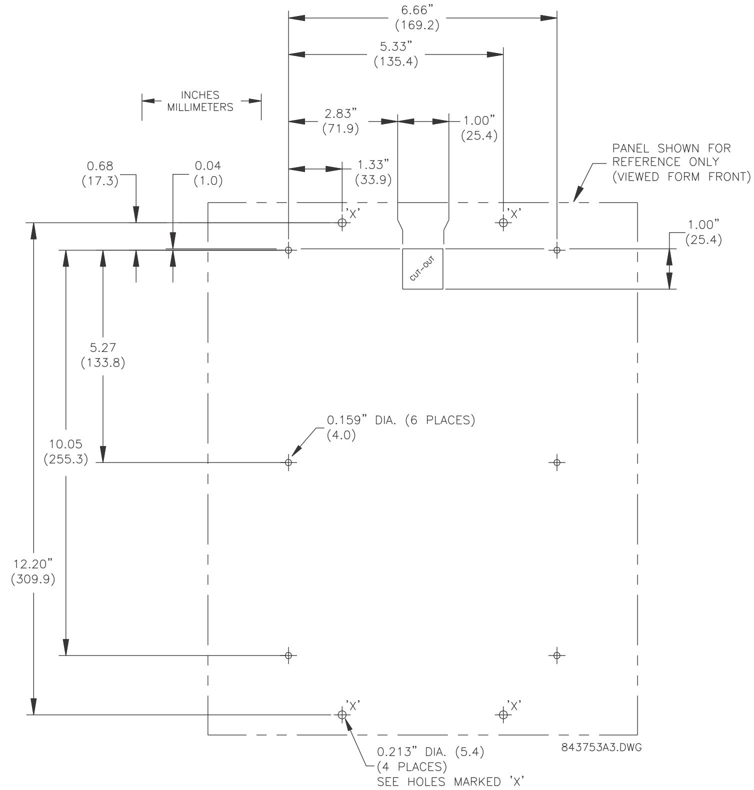


Figure 3–7: C70 VERTICAL SIDE MOUNTING REAR DIMENSIONS (STANDARD PANEL)

3.1.2 MODULE WITHDRAWAL AND INSERTION

WARNING

Module withdrawal and insertion may only be performed when control power has been removed from the unit. Inserting an incorrect module type into a slot may result in personal injury, damage to the unit or connected equipment, or undesired operation!

WARNING

Proper electrostatic discharge protection (for example, a static strap) must be used 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 C70.


842812A1.CDR

Figure 3–8: 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 3–9: 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

All CPU modules except the 9E are equipped with 10/100Base-T or 100Base-F Ethernet connectors. These connectors must be individually disconnected from the module before it can be removed from the chassis.

3

3.1.3 REAR TERMINAL LAYOUT

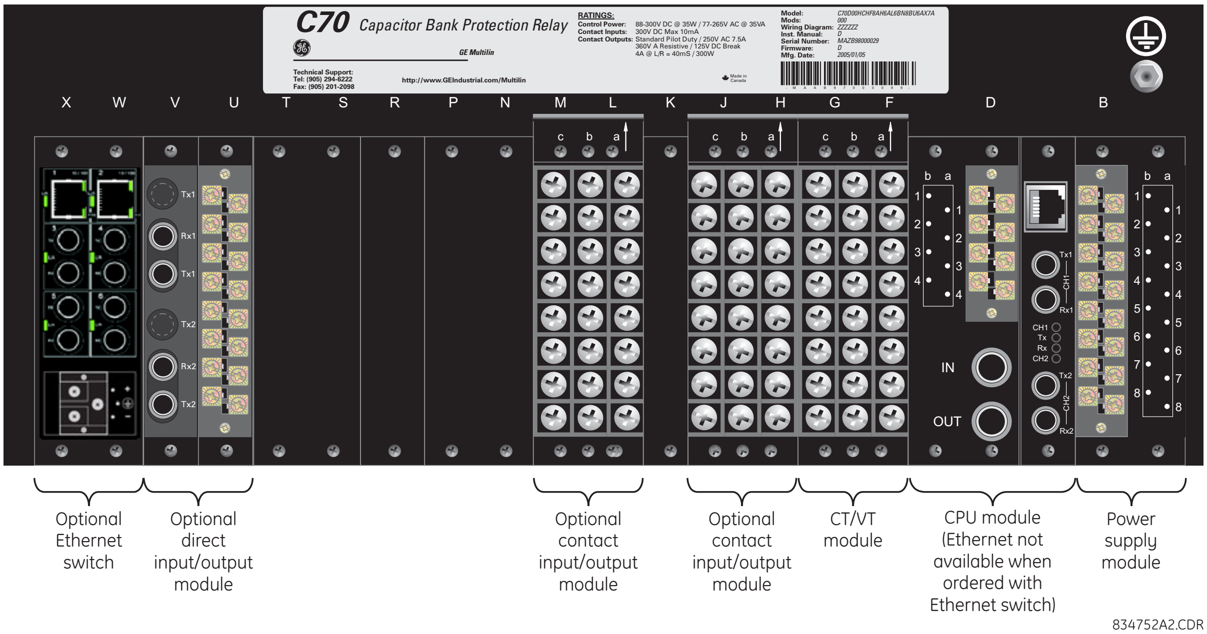


Figure 3–10: REAR TERMINAL VIEW

Do not touch any rear terminals while the relay is energized!

WARNING

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.

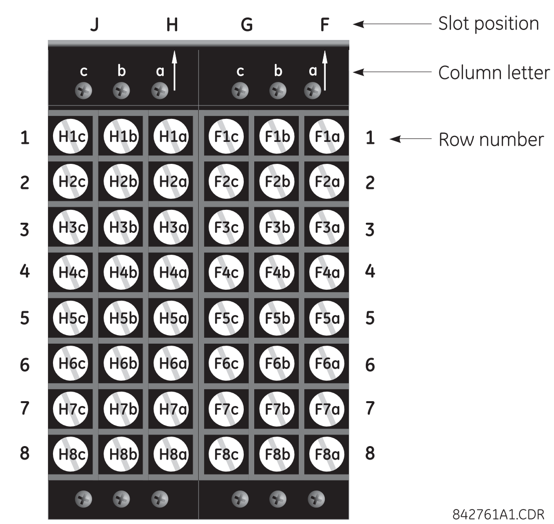


Figure 3–11: EXAMPLE OF MODULES IN F AND H SLOTS

3.2.1 TYPICAL WIRING

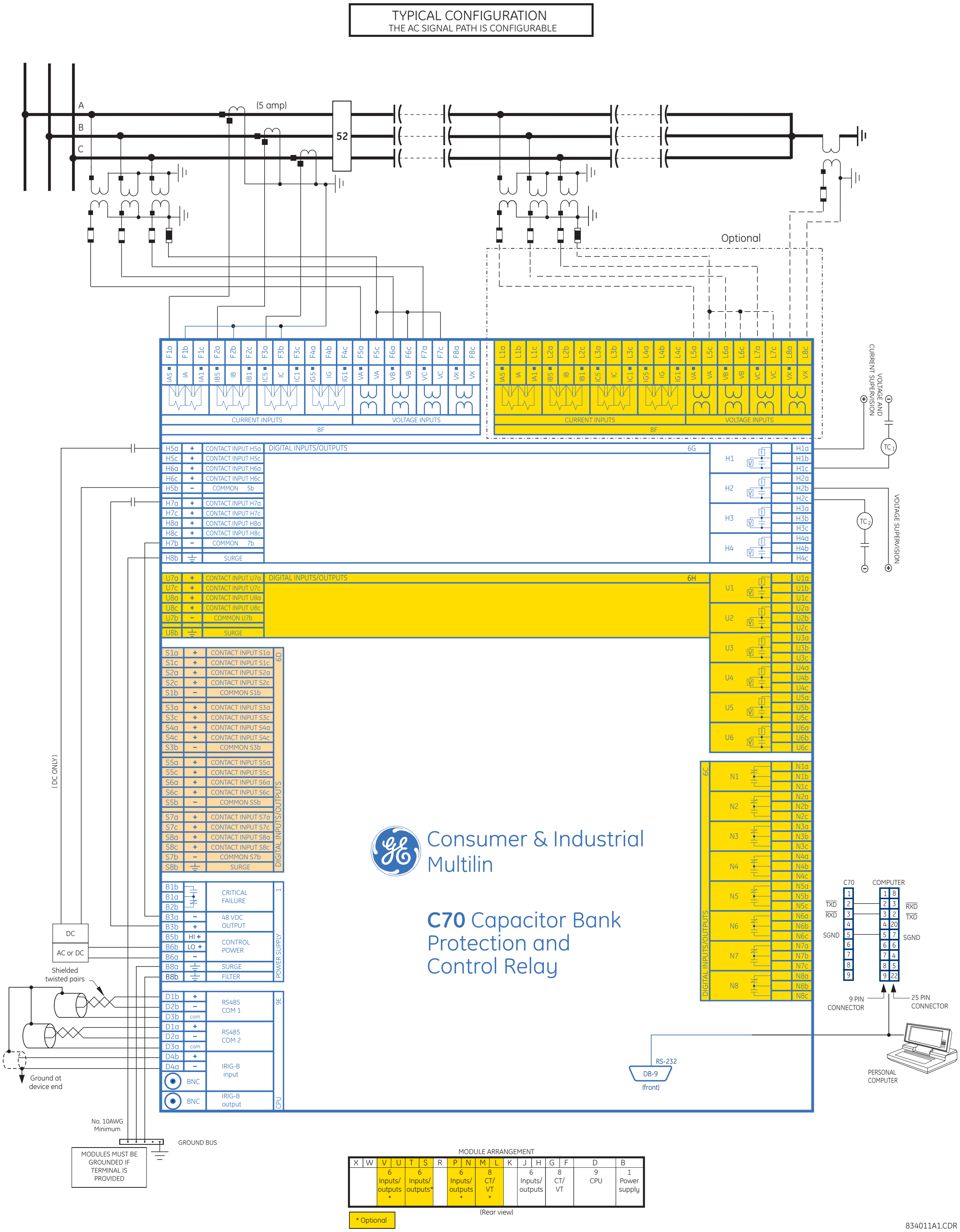


Figure 3–12: TYPICAL WIRING DIAGRAM

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

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

CAUTION

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 MAY OCCUR!

NOTE

The C70 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 will be 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 will de-energize.

For high reliability systems, the C70 has a redundant option in which two C70 power supplies are placed in parallel on the bus. If one of the power supplies become faulted, the second power supply will assume 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 will also indicate 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

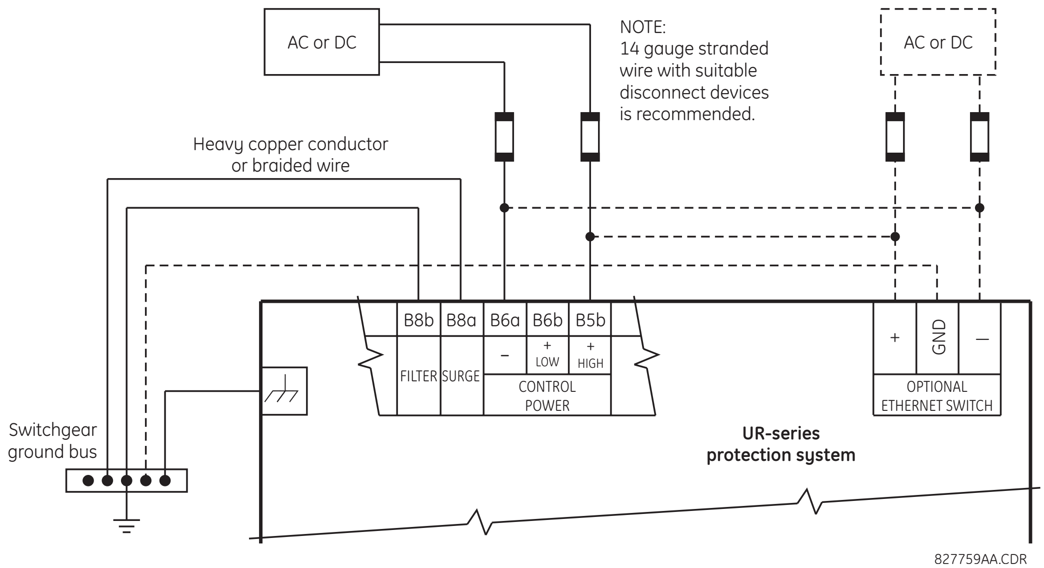


Figure 3–13: CONTROL POWER CONNECTION

3.2.4 CT/VT MODULES

A CT/VT module may 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).

CAUTION **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 may 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.

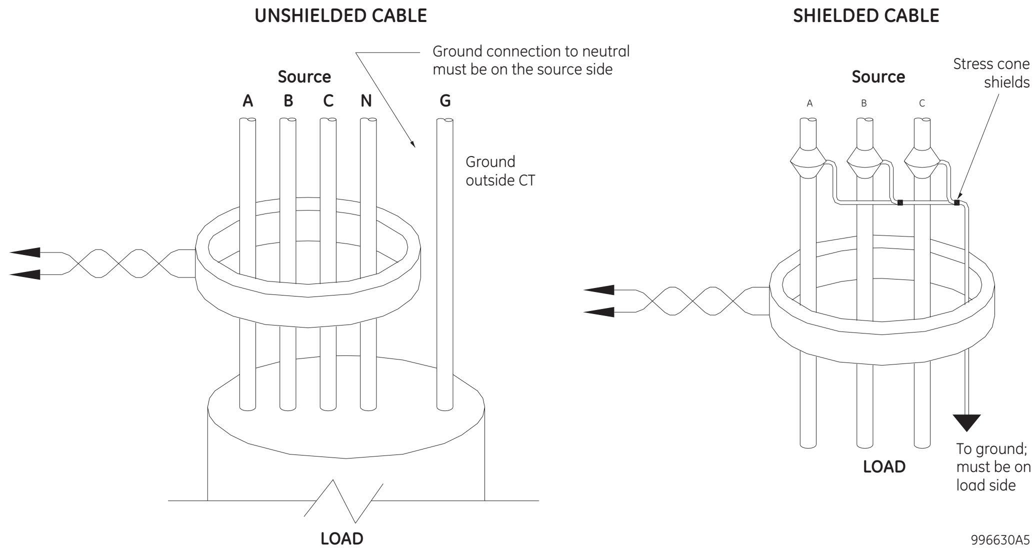


Figure 3–14: ZERO-SEQUENCE CORE BALANCE CT INSTALLATION

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.

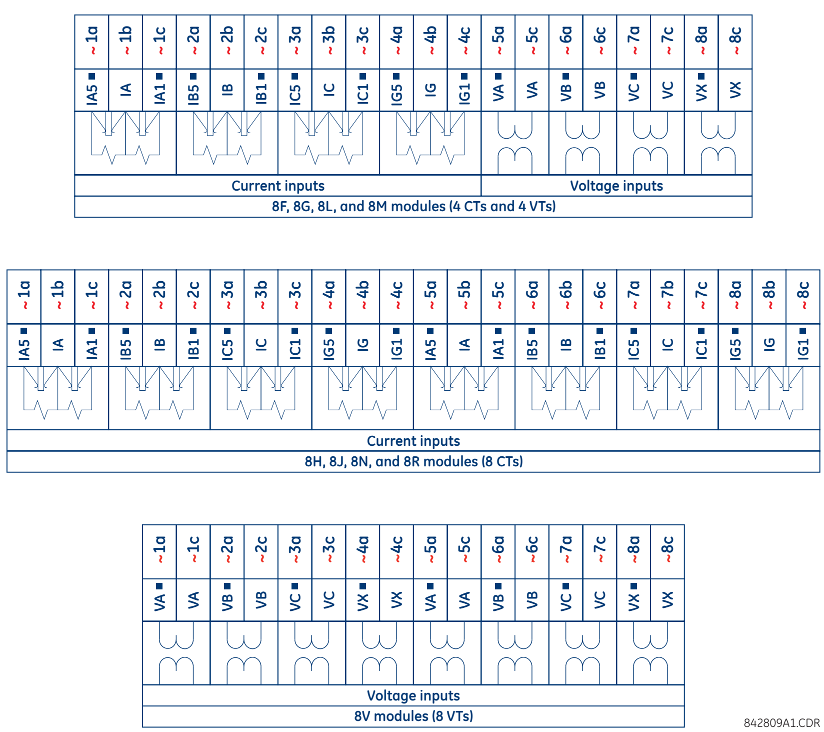


Figure 3–15: CT/VT MODULE WIRING

3.2.5 PROCESS BUS MODULES

The C70 can be ordered with a process bus interface module. This module is designed to interface with the GE Multilin HardFiber system, allowing bi-directional 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.

- Drastically reduces labor associated with design, installation, and testing of protection and control applications using the C70 by reducing the number of individual copper terminations.
- Integrates seamlessly with existing C70 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, refer to GE publication GEK-113500: HardFiber 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 may 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 C70 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 may 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 below 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.

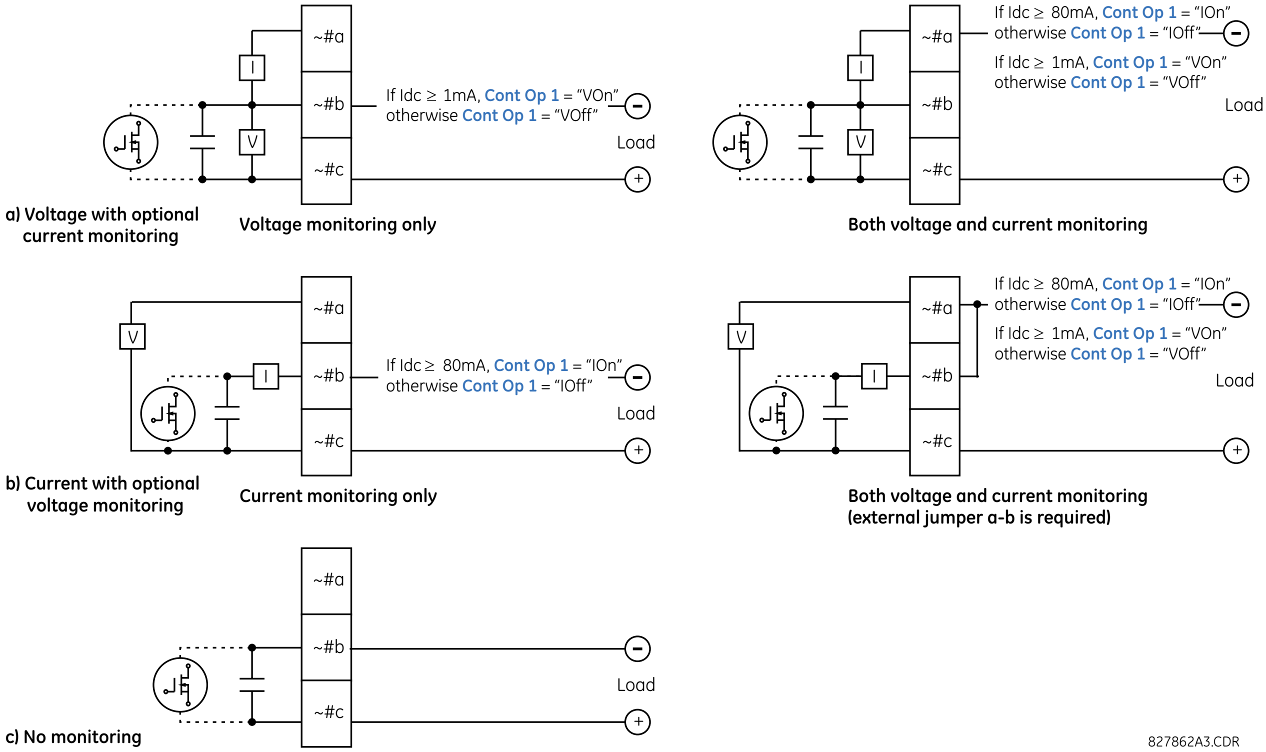


Figure 3–16: FORM-A AND SOLID-STATE CONTACT OUTPUTS WITH VOLTAGE AND CURRENT MONITORING

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

Relay contacts must be considered unsafe to touch when the unit is energized! If the relay contacts need to be used for low voltage accessible applications, it is the customer's responsibility to 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 clrcuit 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 to this problem 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

NOTE

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).

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 3–17: CONTACT INPUT AND OUTPUT MODULE WIRING (1 of 2)

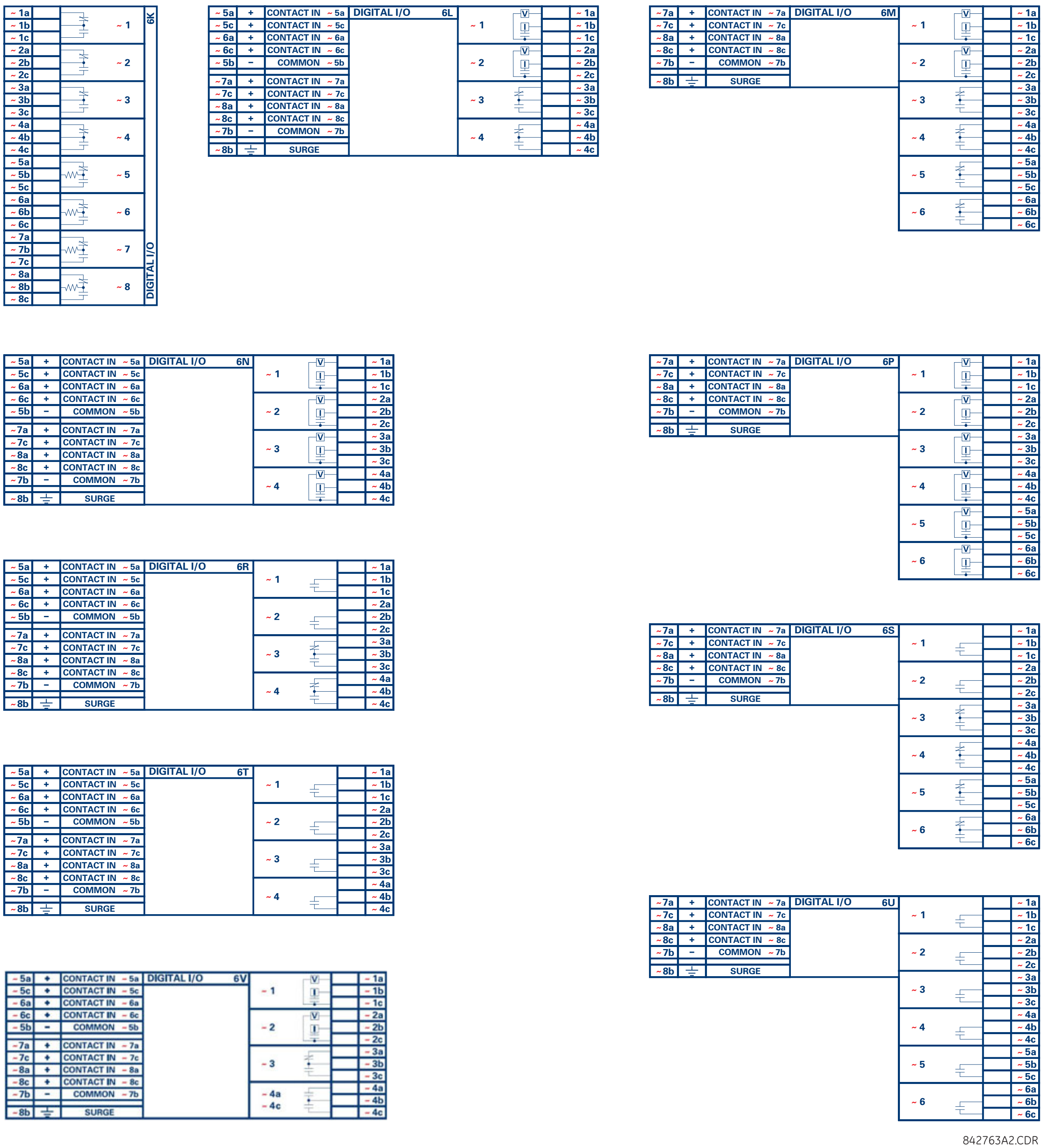


Figure 3–18: CONTACT INPUT AND OUTPUT MODULE WIRING (2 of 2)

CAUTION

CORRECT POLARITY MUST BE OBSERVED FOR ALL CONTACT INPUT AND SOLID STATE OUTPUT CONNECTIONS FOR PROPER FUNCTIONALITY.

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 will flow 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 will detect 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.

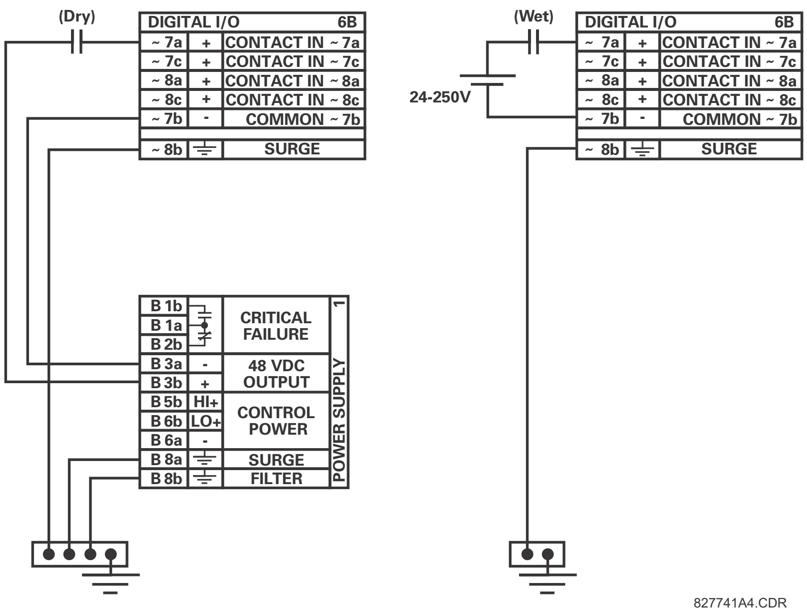


Figure 3–19: DRY AND WET CONTACT INPUT CONNECTIONS

NOTE

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

Contact outputs may be ordered as form-a or form-C. The form-A contacts may 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 will have a 5 second delay after a contact input changes state.

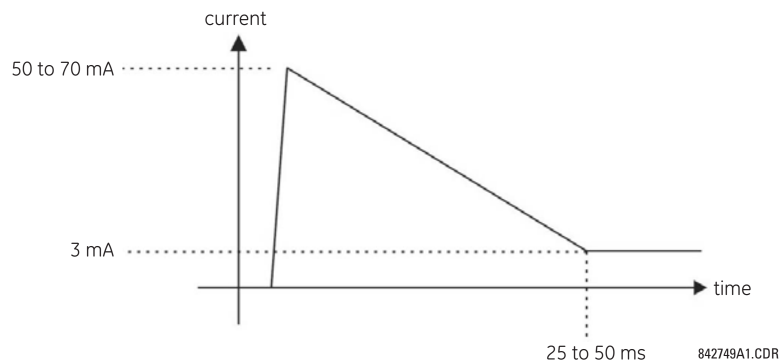


Figure 3–20: CURRENT THROUGH CONTACT INPUTS WITH AUTO-BURNISHING

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.

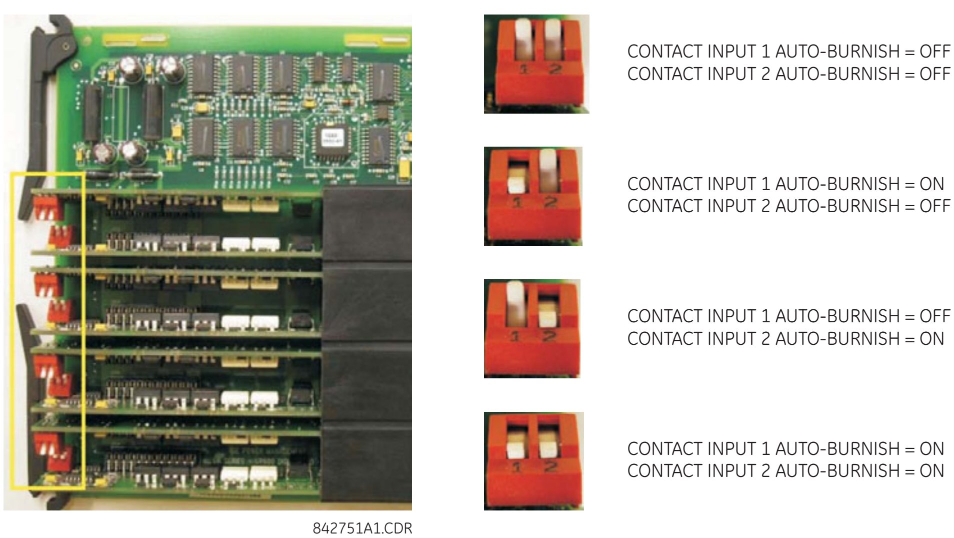


Figure 3–21: AUTO-BURNISH DIP SWITCHES

NOTE: The auto-burnish circuitry has an internal fuse for safety purposes. During regular maintenance, the auto-burnish functionality can be checked using an oscilloscope.

3.2.7 TRANSDUCER INPUTS/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 may 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 may be ordered for the relay.

NOTE

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

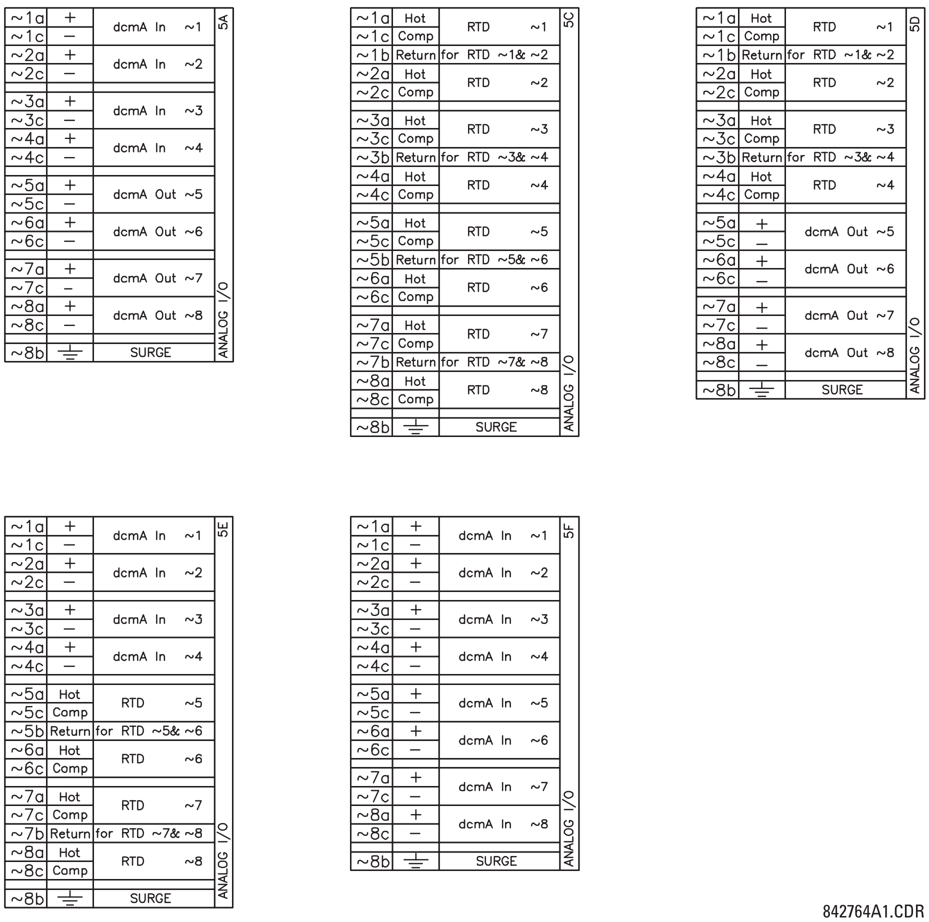


Figure 3–22: TRANSDUCER INPUT/OUTPUT MODULE WIRING

3.2.8 RS232 FACEPLATE PORT

A 9-pin RS232C serial port is located on the C70 faceplate for programming with a personal computer. All that is required to use this interface is a personal 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**.

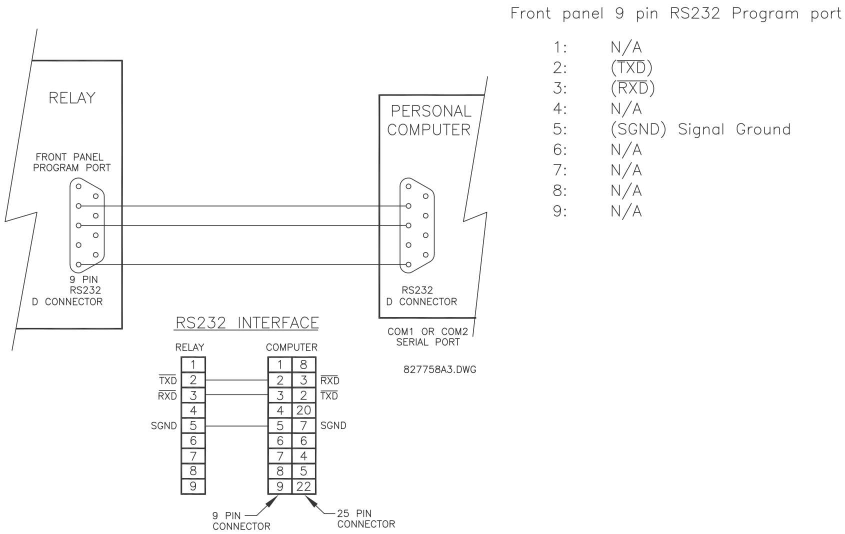


Figure 3–23: RS232 FACEPLATE PORT CONNECTION

3.2.9 CPU COMMUNICATION PORTS

a) OPTIONS

In addition to the faceplate RS232 port, the C70 provides two additional communication ports or a managed six-port Ethernet switch, depending on the installed CPU module.

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

Table 3–3: CPU MODULE COMMUNICATIONS

CPU TYPE	COM1	COM2
9E	RS485	RS485
9G	10Base-F and 10Base-T	RS485
9H	Redundant 10Base-F	RS485
9J	100Base-FX	RS485
9K	Redundant 100Base-FX	RS485
9L	100Base-FX	RS485
9M	Redundant 100Base-FX	RS485

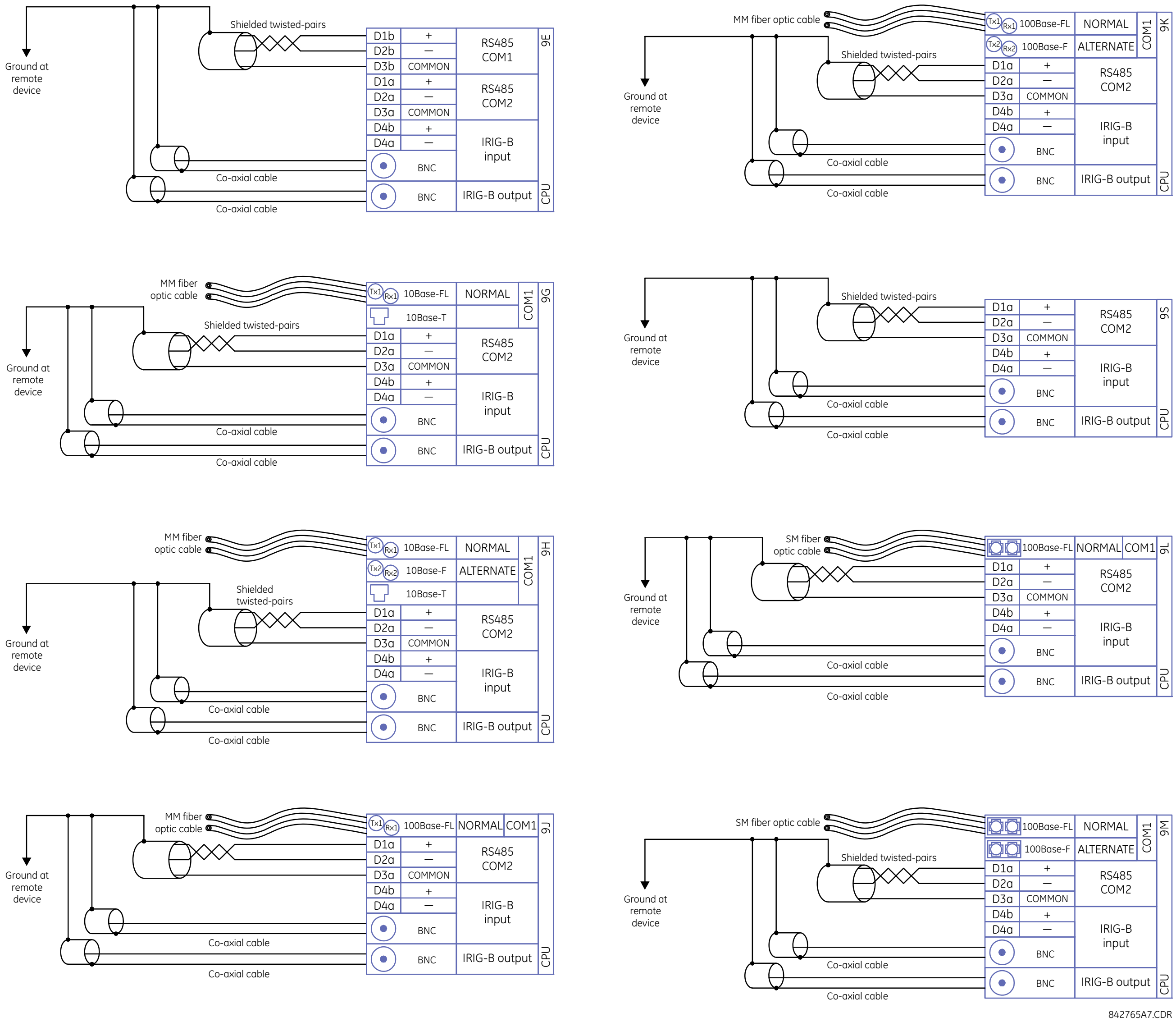


Figure 3–24: CPU MODULE COMMUNICATIONS WIRING

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 these ports, 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 C70 COM terminal (#3); others function correctly only if the common wire is connected to the C70 COM terminal, but insulated from the shield.

To avoid loop currents, the shield should be grounded 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 should also 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. Star or stub connections should be avoided 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.

Both ends of the RS485 circuit should also be terminated with an impedance as shown below.

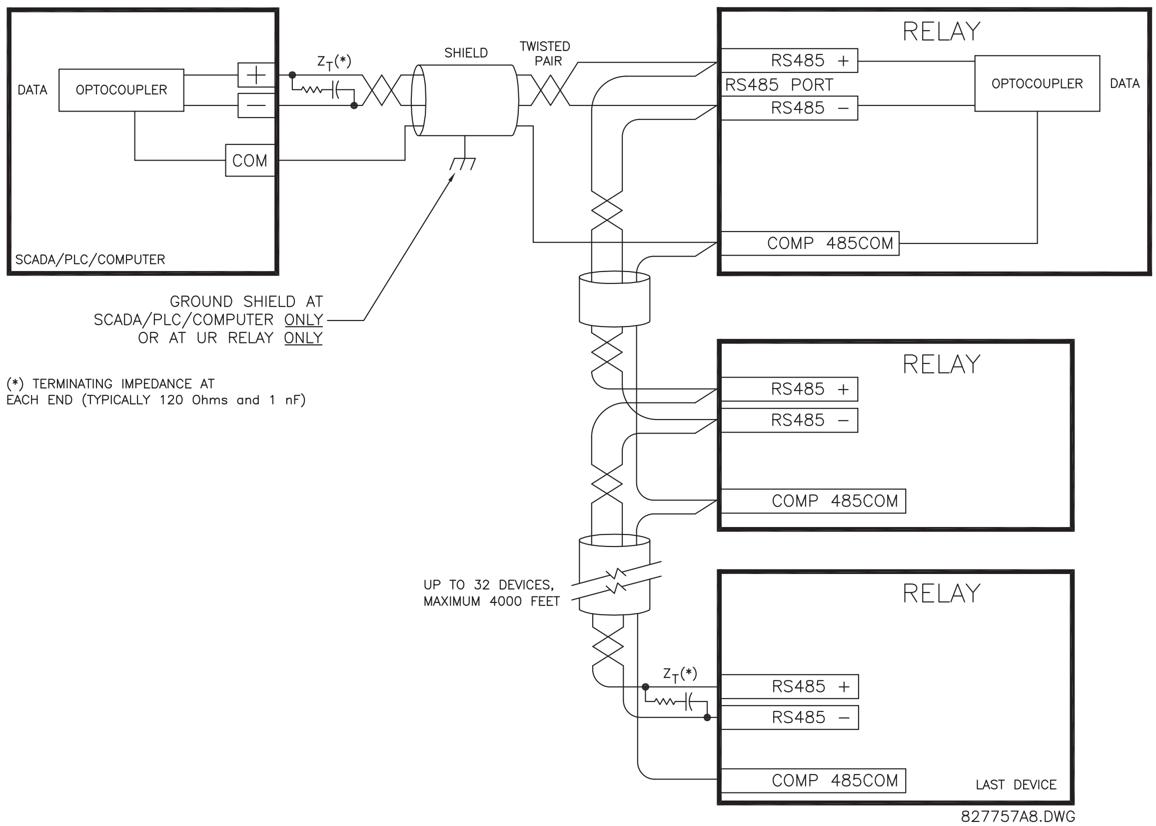


Figure 3–25: RS485 SERIAL CONNECTION

c) 10BASE-FL AND 100BASE-FX FIBER OPTIC PORTS

CAUTION

ENSURE 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 MAY CAUSE INJURY TO THE EYE.

The fiber optic communication ports allow for fast and efficient communications between relays at 10 Mbps or 100 Mbps. Optical fiber may be connected to the relay supporting a wavelength of 820 nm in multi-mode or 1310 nm in multi-mode and single-mode. The 10 Mbps rate is available for CPU modules 9G and 9H; 100Mbps is available for modules 9H, 9J, 9K, 9L, 9M, 9N, 9P, and 9R. The 9H, 9K, 9M, and 9R modules have a second pair of identical optical fiber transmitter and receiver for redundancy.

The optical fiber sizes supported include 50/125 µm, 62.5/125 µm and 100/140 µm for 10 Mbps. The fiber optic port is designed such that the response times will 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. In order to engage or disengage the ST type connector, only a quarter turn of the coupling is required.

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 which can be either DC level shifted or amplitude modulated (AM). Third party equipment is available for generating the IRIG-B signal; this equipment may use a GPS satellite system to obtain the time reference so that devices at different geographic locations can also be synchronized.

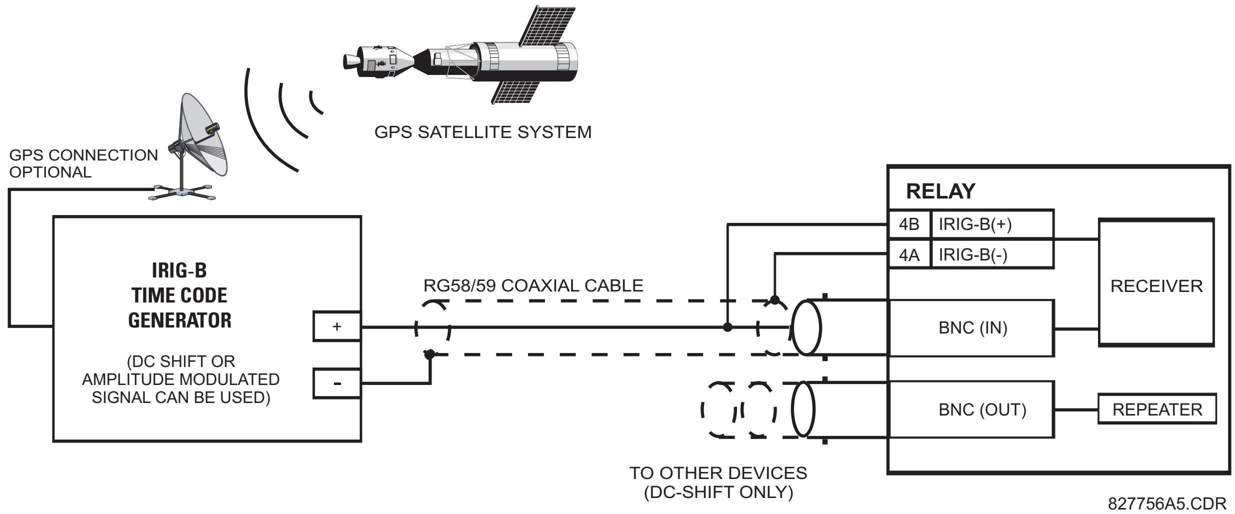


Figure 3–26: IRIG-B CONNECTION

The IRIG-B repeater provides an amplified DC-shift IRIG-B signal to other equipment. By using one IRIG-B serial connection, several UR-series relays can be synchronized. The IRIG-B repeater has a bypass function to maintain the time signal even when a relay in the series is powered down.

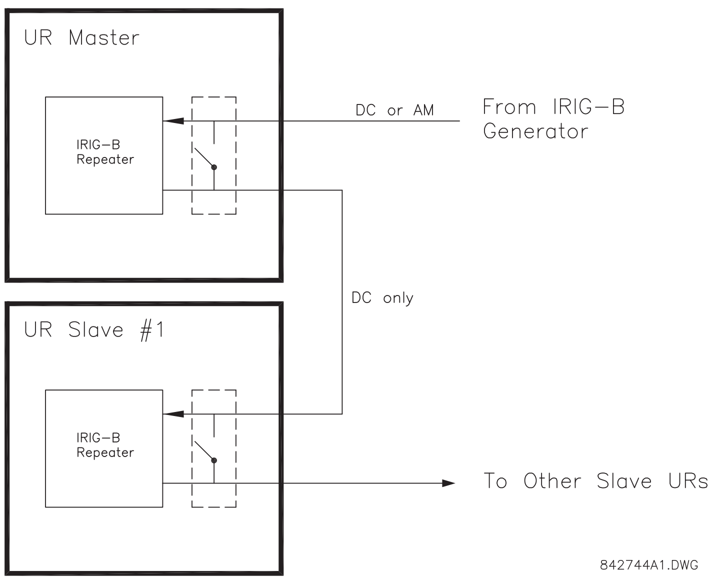


Figure 3–27: IRIG-B REPEATER

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

3.3.1 DESCRIPTION

The C70 direct inputs and outputs feature makes use of the type 7 series of communications modules. These modules are also used by the L90 Line Differential Relay for inter-relay communications. The direct input and output feature uses the communications channels provided by these modules to exchange digital state information between relays. This feature is available on all UR-series relay models except for the L90 Line Differential relay.

The communications channels are normally connected in a ring configuration as shown below. The transmitter of one module is connected to the receiver of the next module. The transmitter of this second module is then connected to the receiver of the next module in the ring. This is continued to form a communications ring. The figure below illustrates a ring of four UR-series relays with the following connections: UR1-Tx to UR2-Rx, UR2-Tx to UR3-Rx, UR3-Tx to UR4-Rx, and UR4-Tx to UR1-Rx. A maximum of sixteen (16) UR-series relays can be connected in a single ring

3

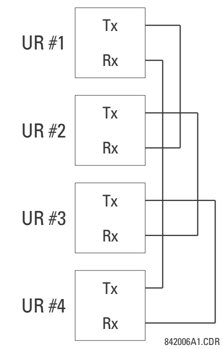


Figure 3–28: DIRECT INPUT AND OUTPUT SINGLE CHANNEL CONNECTION

The interconnection for dual-channel Type 7 communications modules is shown below. Two channel modules allow for a redundant ring configuration. That is, two rings can be created to provide an additional independent data path. The required connections are: UR1-Tx1 to UR2-Rx1, UR2-Tx1 to UR3-Rx1, UR3-Tx1 to UR4-Rx1, and UR4-Tx1 to UR1-Rx1 for the first ring; and UR1-Tx2 to UR4-Rx2, UR4-Tx2 to UR3-Rx2, UR3-Tx2 to UR2-Rx2, and UR2-Tx2 to UR1-Rx2 for the second ring.

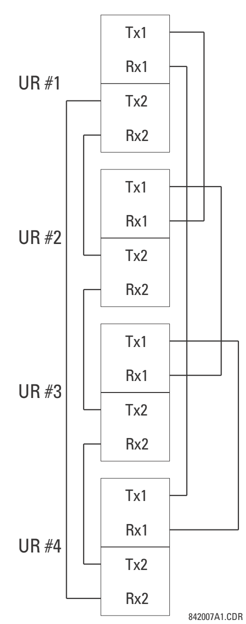


Figure 3–29: DIRECT INPUT AND OUTPUT DUAL CHANNEL CONNECTION

The following diagram shows the connection for three UR-series relays using two independent communication channels. UR1 and UR3 have single type 7 communication modules; UR2 has a dual-channel module. The two communication channels can be of different types, depending on the Type 7 modules used. To allow the direct input and output data to *cross-over* from channel 1 to channel 2 on UR2, the **DIRECT I/O CHANNEL CROSSOVER** setting should be "Enabled" on UR2. This forces UR2 to forward messages received on Rx1 out Tx2, and messages received on Rx2 out Tx1.

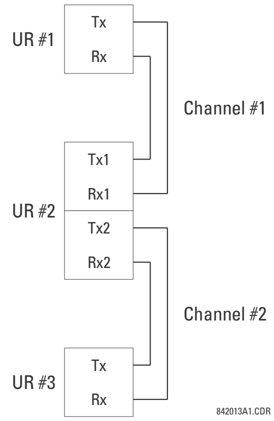


Figure 3–30: DIRECT INPUT AND OUTPUT SINGLE/DUAL CHANNEL COMBINATION CONNECTION

The interconnection requirements are described in further detail in this section for each specific variation of type 7 communications module. These modules are listed in the following table. All fiber modules use ST type connectors.

NOTE

Not all the direct input and output communications modules may be applicable to the C70 relay. Only the modules specified in the order codes are available as direct input and output communications modules.

Table 3–4: CHANNEL COMMUNICATION OPTIONS (Sheet 1 of 2)

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	Six-port managed Ethernet switch with high voltage power supply
2T	Six-port 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

Table 3–4: CHANNEL COMMUNICATION OPTIONS (Sheet 2 of 2)

MODULE	SPECIFICATION
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

CAUTION

OBSERVING ANY FIBER TRANSMITTER OUTPUT MAY CAUSE INJURY TO 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.

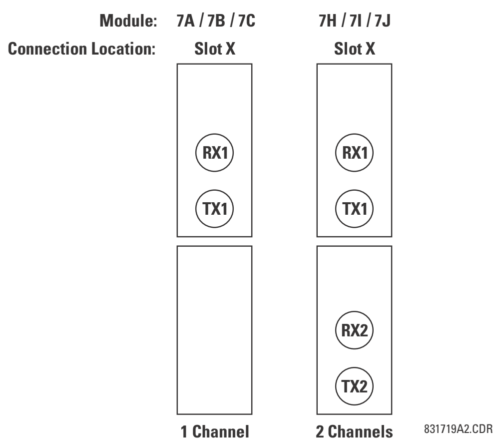


Figure 3–31: LED AND ELED FIBER MODULES

3.3.3 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.

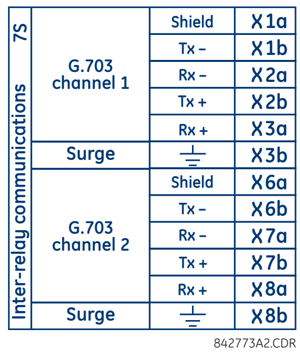


Figure 3–32: G.703 INTERFACE CONFIGURATION

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.

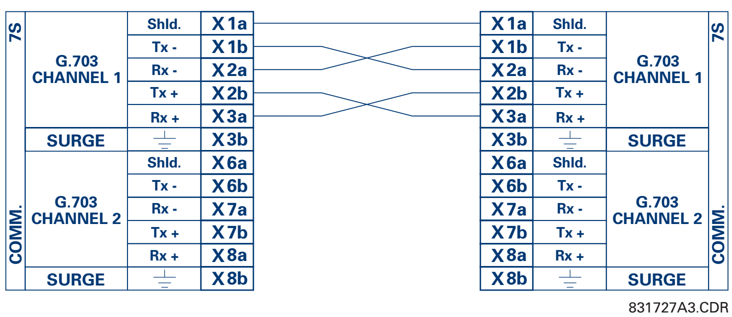


Figure 3–33: TYPICAL PIN INTERCONNECTION BETWEEN TWO G.703 INTERFACES

NOTE

Pin nomenclature may 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. Remove the G.703 module (7R or 7S). The ejector/inserter clips located at the top and at the bottom of each module, must be pulled simultaneously in order to release the module for removal. Before performing this action, **control power must be removed from the relay**. The original location of the module should be recorded to help ensure that the same or replacement module is inserted into the correct slot.
2. Remove the module cover screw.
3. Remove the top cover by sliding it towards the rear and then lift it upwards.
4. Set the timing selection switches (channel 1, channel 2) to the desired timing modes.
5. Replace the top cover and the cover screw.

6. 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 will be fully inserted.

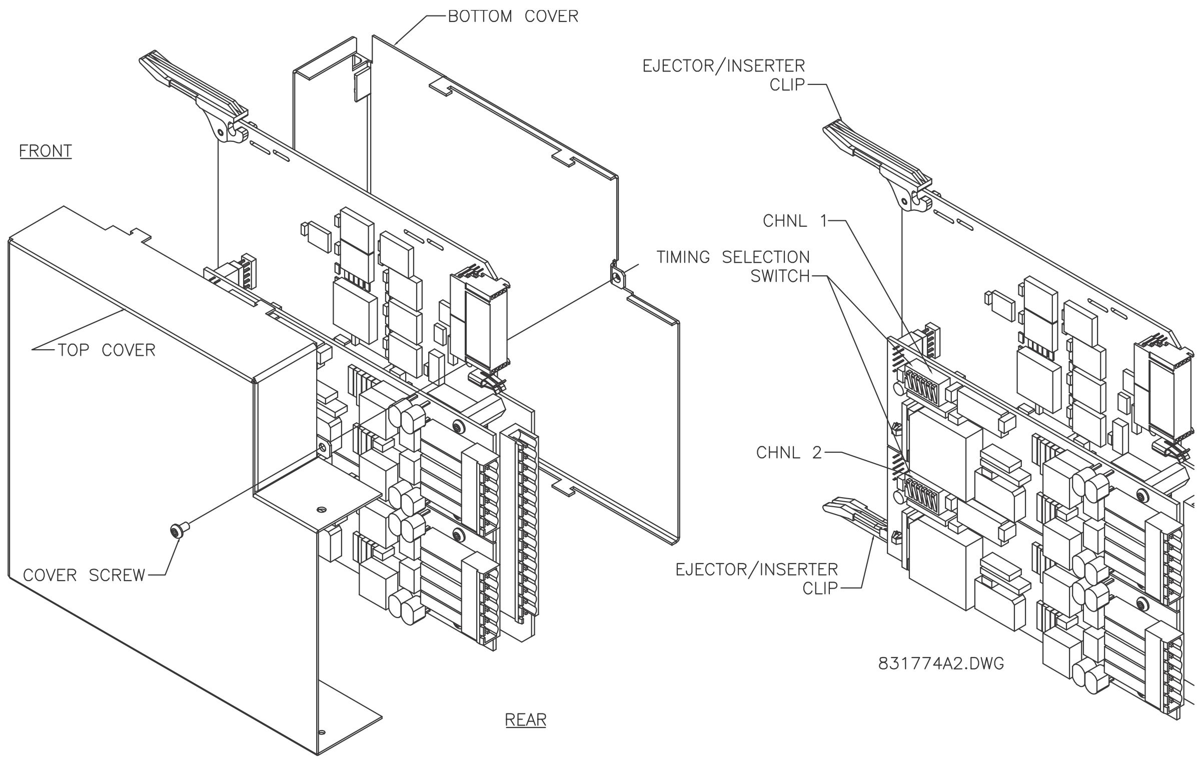


Figure 3–34: G.703 TIMING SELECTION SWITCH SETTING

Table 3–5: 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

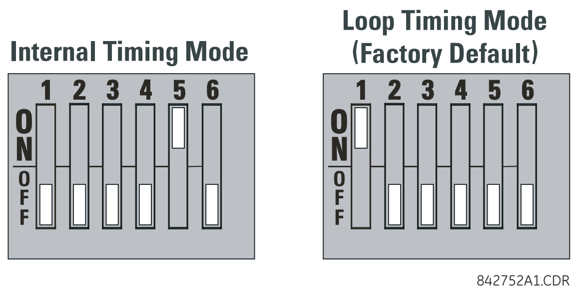
If octet timing is enabled (on), this 8 kHz signal will be asserted during the violation of bit 8 (LSB) necessary for connecting to higher order systems. When C70s are connected back to back, octet timing should be disabled (off).

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:



e) G.703 TEST MODES

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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.

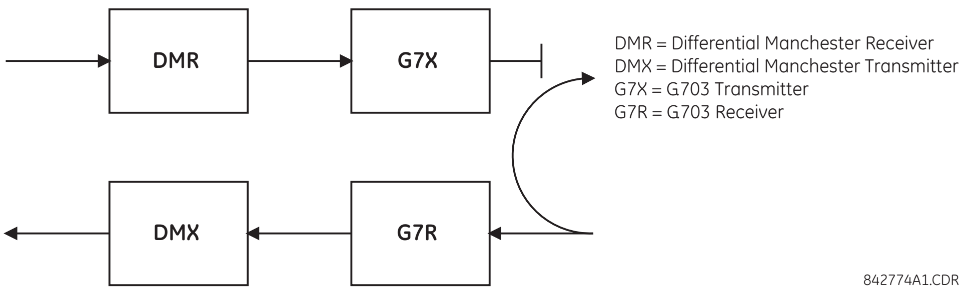


Figure 3–35: G.703 MINIMUM REMOTE LOOPBACK MODE

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.

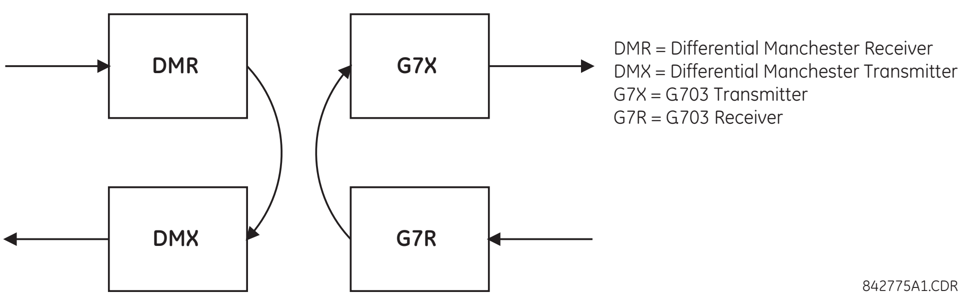


Figure 3–36: G.703 DUAL LOOPBACK MODE

3.3.4 RS422 INTERFACE

a) DESCRIPTION

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

The 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.

The clock terminating impedance should match the impedance of the line.

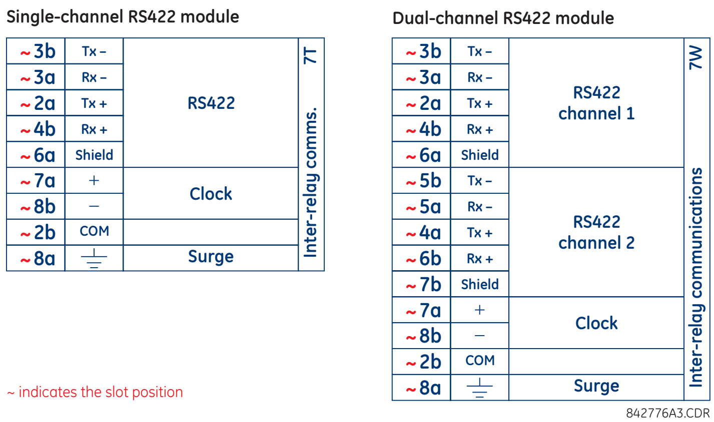


Figure 3–37: RS422 INTERFACE CONNECTIONS

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.

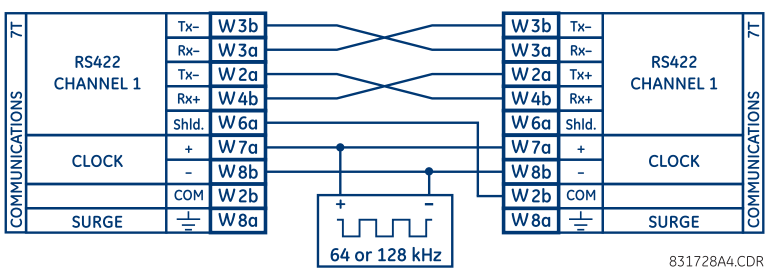


Figure 3–38: TYPICAL PIN INTERCONNECTION BETWEEN TWO RS422 INTERFACES

b) TWO-CHANNEL APPLICATION VIA MULTIPLEXERS

The RS422 interface may 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 will function correctly if 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), will connect to the clock inputs of the UR–RS422 interface in the usual fashion. In addition, the send timing outputs of data module 1 will also be 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 will be derived from a single clock source. As a result, data sampling for both of the UR–RS422 channels will be 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.

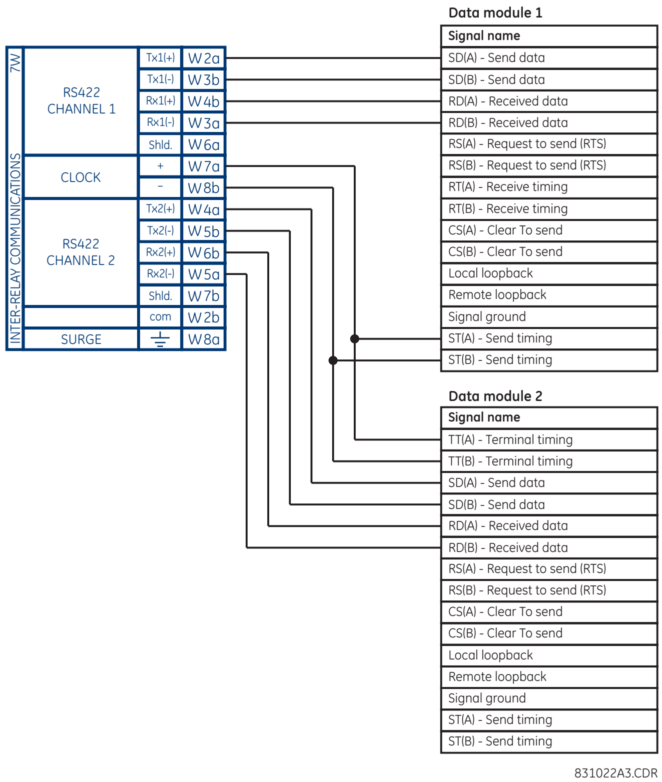


Figure 3–39: TIMING CONFIGURATION FOR RS422 TWO-CHANNEL, 3-TERMINAL APPLICATION

Data module 1 provides timing to the C70 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 may vary depending on the 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.

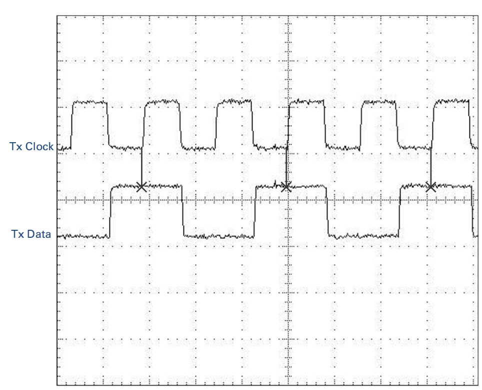


Figure 3–40: CLOCK AND DATA TRANSITIONS

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.

3.3.5 IEEE C37.94 INTERFACE

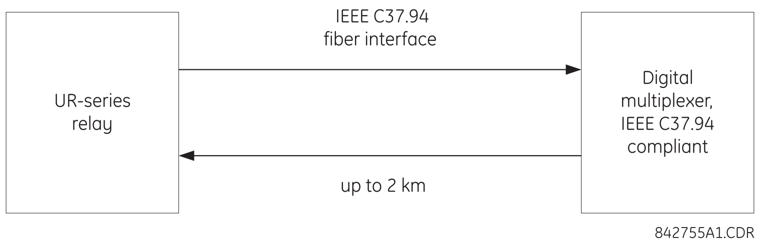
3

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 for firmware revisions 3.30 and higher. 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.

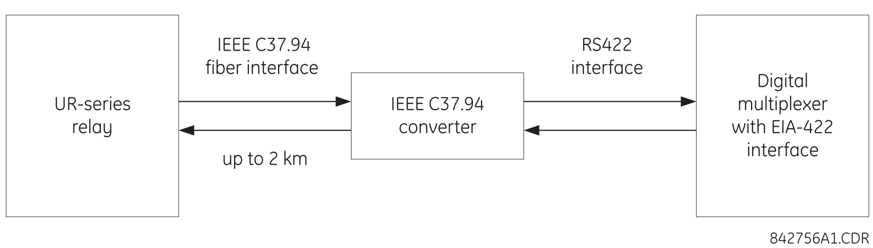
The specifications for the module are as follows:.

- 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.

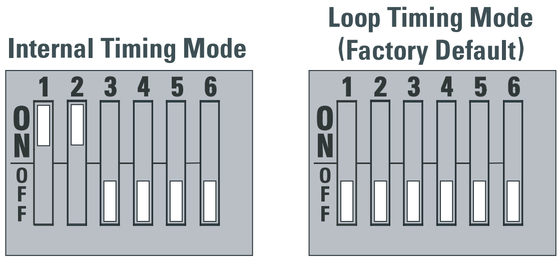
The UR-series C37.94 communication module can be connected directly to any compliant digital multiplexer that supports the IEEE C37.94 standard as shown below.



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 (6) switches that are used to set the clock configuration. The functions of these control switches is 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. Remove the IEEE C37.94 module (type 76 or 77 module):

   The ejector/inserter clips located at the top and at the bottom of each module, must be pulled simultaneously in order to release the module for removal. Before performing this action, **control power must be removed from the relay**. The original location of the module should be recorded to help ensure that the same or replacement module is inserted into the correct slot.

2. Remove the module cover screw.
3. Remove the top cover by sliding it towards the rear and then lift it upwards.
4. Set the timing selection switches (channel 1, channel 2) to the desired timing modes (see description above).
5. Replace the top cover and the cover screw.
6. 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 will be fully inserted.

3

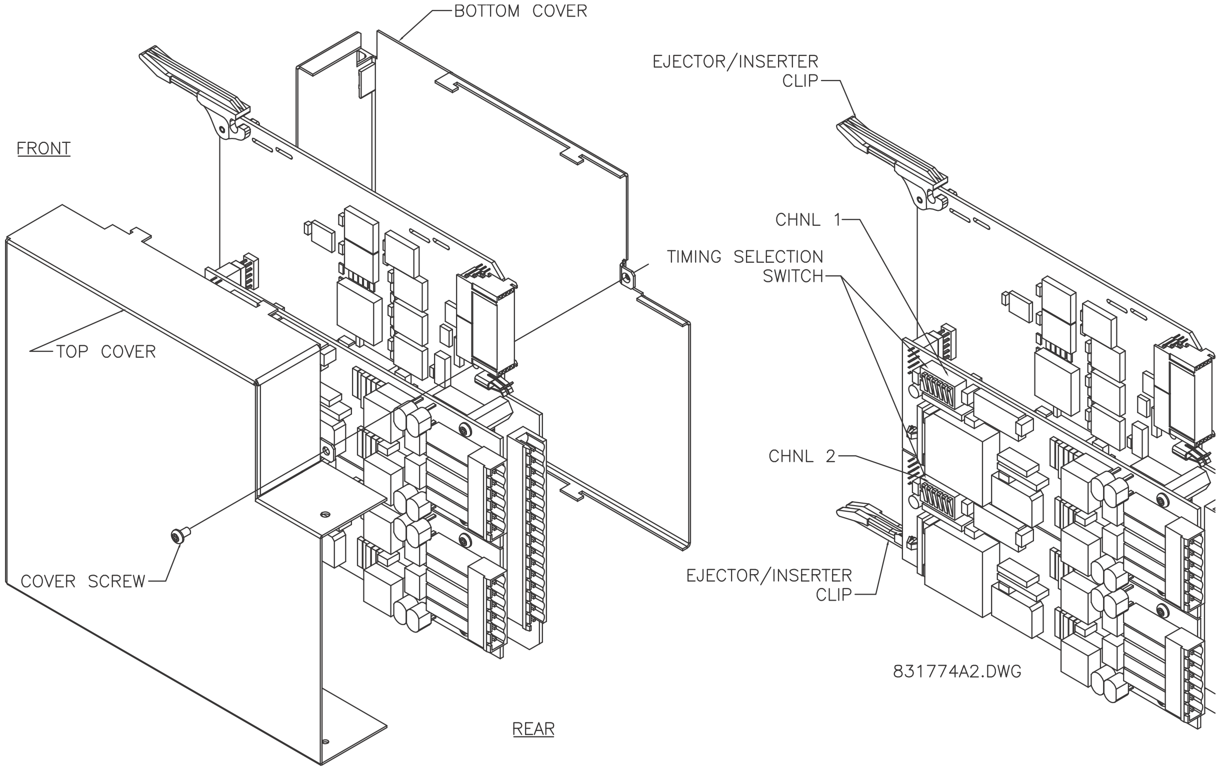


Figure 3–41: IEEE C37.94 TIMING SELECTION SWITCH SETTING

3.4.1 OVERVIEW

The type 2S and 2T embedded managed switch modules are supported by UR-series relays containing type 9S CPU modules with revisions 5.5x and higher. The modules communicate to the C70 through an internal Ethernet port (referred to as the UR port or port 7) and provide an additional six external Ethernet ports: two 10/100Base-T ports and four multimode ST 100Base-FX ports.

NOTE

The Ethernet switch module should be powered up before or at the same time as the C70. Otherwise, the switch module will not be detected on power up and the **EQUIPMENT MISMATCH: ORDERCODE XXX** self-test warning will be issued.

3.4.2 MANAGED ETHERNET SWITCH MODULE HARDWARE

The type 2S and 2T managed Ethernet switch modules provide two 10/100Base-T and four multimode ST 100Base-FX external Ethernet ports accessible through the rear of the module. In addition, a serial console port is accessible from the front of the module (requires the front panel faceplate to be open).

The pin assignment for the console port signals is shown in the following table.

Table 3–6: CONSOLE PORT PIN ASSIGNMENT

PIN	SIGNAL	DESCRIPTION
1	CD	Carrier detect (not used)
2	RXD	Receive data (input)
3	TXD	Transmit data (output)
4	N/A	Not used
5	GND	Signal ground
6 to 9	N/A	Not used

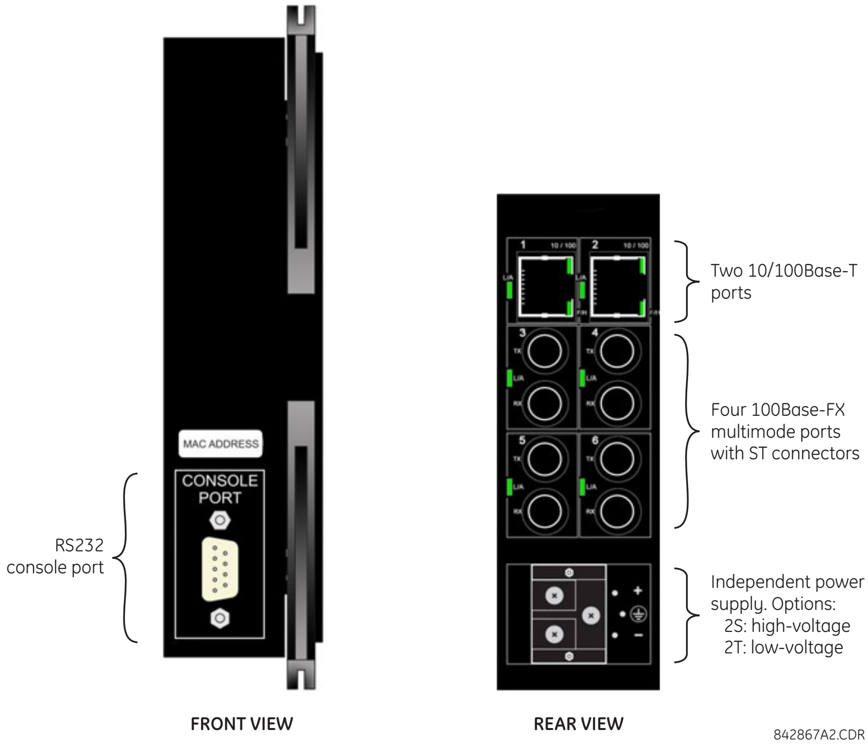


Figure 3–42: MANAGED ETHERNET SWITCHES HARDWARE

The wiring for the managed Ethernet switch module is shown below.

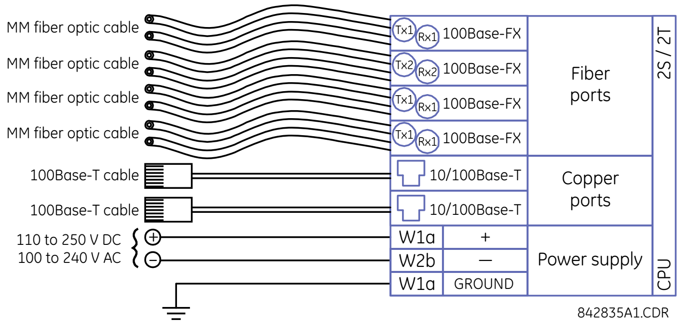


Figure 3–43: MANAGED ETHERNET SWITCH MODULE WIRING

3.4.3 MANAGED SWITCH LED INDICATORS

The 10/100Base-T and 100Base-FX ports have LED indicators to indicate the port status.

The 10/100Base-T ports have three LEDs to indicate connection speed, duplex mode, and link activity. The 100Base-FX ports have one LED to indicate linkup and activity.

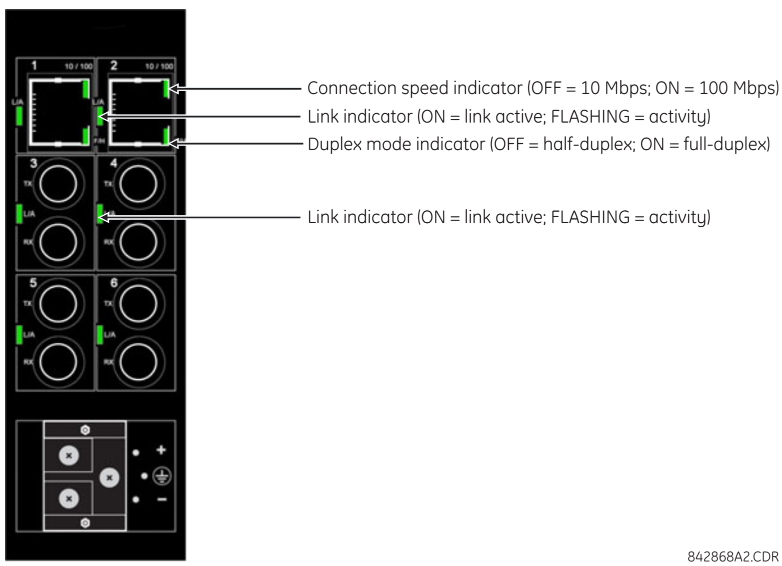


Figure 3–44: ETHERNET SWITCH LED INDICATORS

3.4.4 INITIAL SETUP OF THE ETHERNET SWITCH MODULE

a) DESCRIPTION

Upon initial power up of a C70 device with an installed Ethernet switch, the front panel trouble LED will be illuminated and the **ENET MODULE OFFLINE** error message will be displayed. It will be necessary to configure the Ethernet switch and then place it online. This involves two steps:

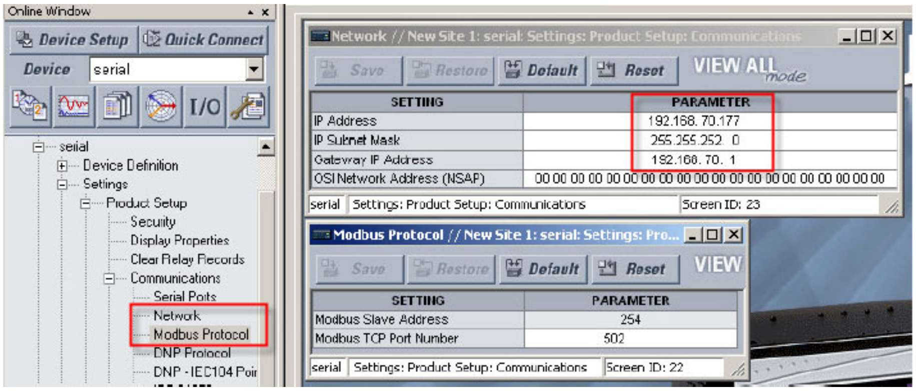
1. Configuring the network settings on the local PC.
2. Configuring the C70 switch module through EnerVista UR Setup.

These procedures are described in the following sections. When the C70 is properly configured, the LED will be off and the error message will be cleared.

b) CONFIGURING LAN COMMUNICATIONS

The following procedure describes how to initially configure the Ethernet switch to work on your LAN.

1. Initiate communications from a PC to the C70 through a front panel serial connection (refer to the *Configuring serial communications* section in chapter 1 for details), or if you are familiar with the UR keypad you can use it to set up the network IP address and check the Modbus slave address and Modbus TCP port.



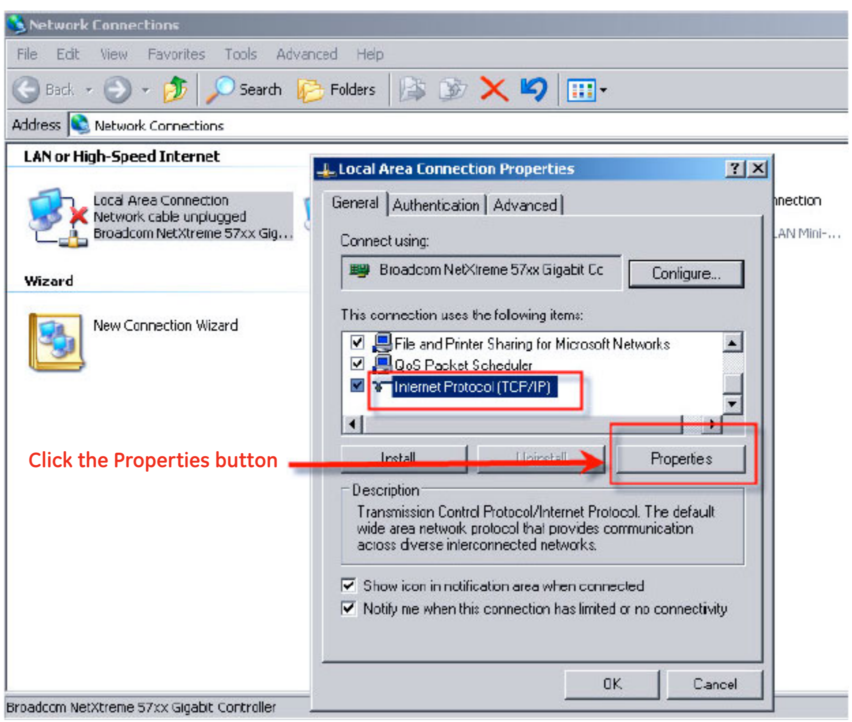
2. Ensure that the PC and the C70 are on the same IP network.

   If your computer is on another network or has a dynamic IP address assigned upon a network login, then setup your own IP address as follows

   2.1. From the Windows Start Menu, select the **Settings > Network Connections** menu item.

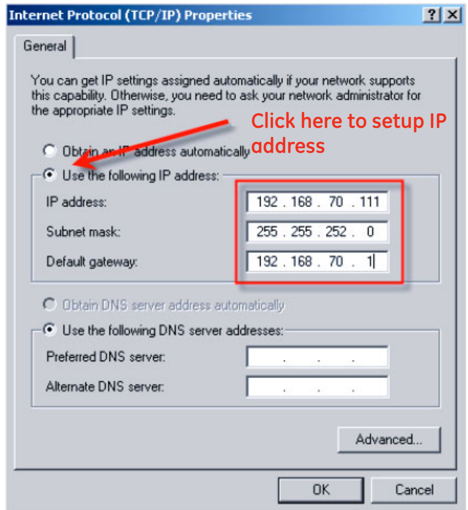
   2.2. Right-click on the **Local Area Connection** icon and select the **Properties** item. This will open the LAN properties window.

   2.3. Click the **Properties** button as shown below.



827790A1.CDR

2.4. The following window is displayed. Select the **Use the Following IP Address** option and enter appropriate **IP address**, **Subnet mask**, and **Default gateway** values. It may be necessary to contact your network administrator for assistance.

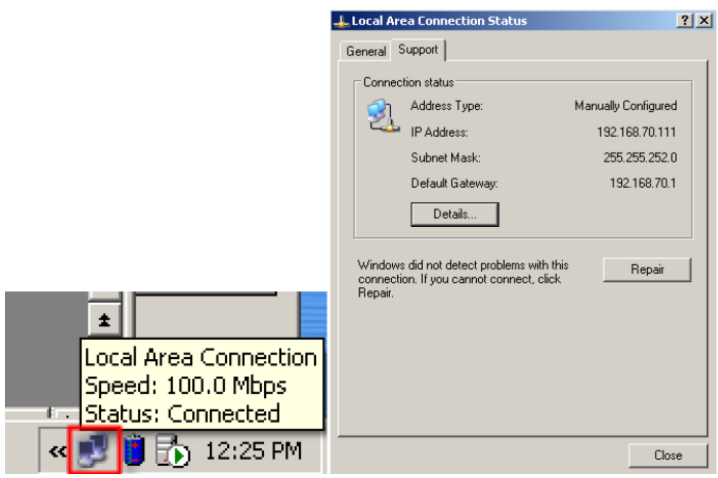


827803A1.CDR

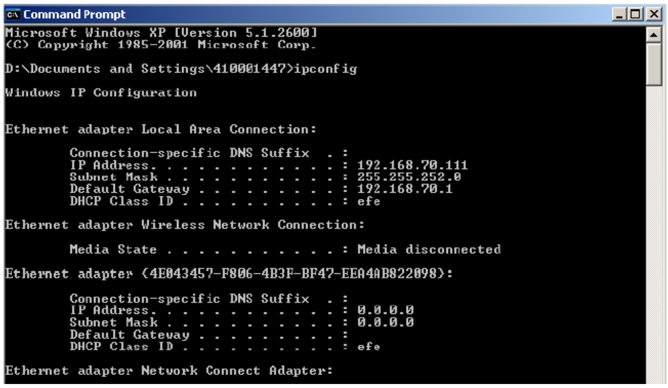
2.5. Save the settings by clicking the **OK** button.

2.6. Click the **Close** button to exit the LAN properties window.

3. Connect your PC to port 1 or port 2 of the Ethernet switch module (with an RJ-45 – CAT5 cable).
4. Verify that the two LEDs beside the connected port turn green.
5. After few seconds you should see your local area connection attempting to connect to the switch. Once connected, check your IP address by going to bottom of your screen and right-clicking the Local Area Connection icon as shown below.



Alternately, you can open a command window (type “cmd” from the **Run** item in the Start menu) and enter the **ipconfig** command.

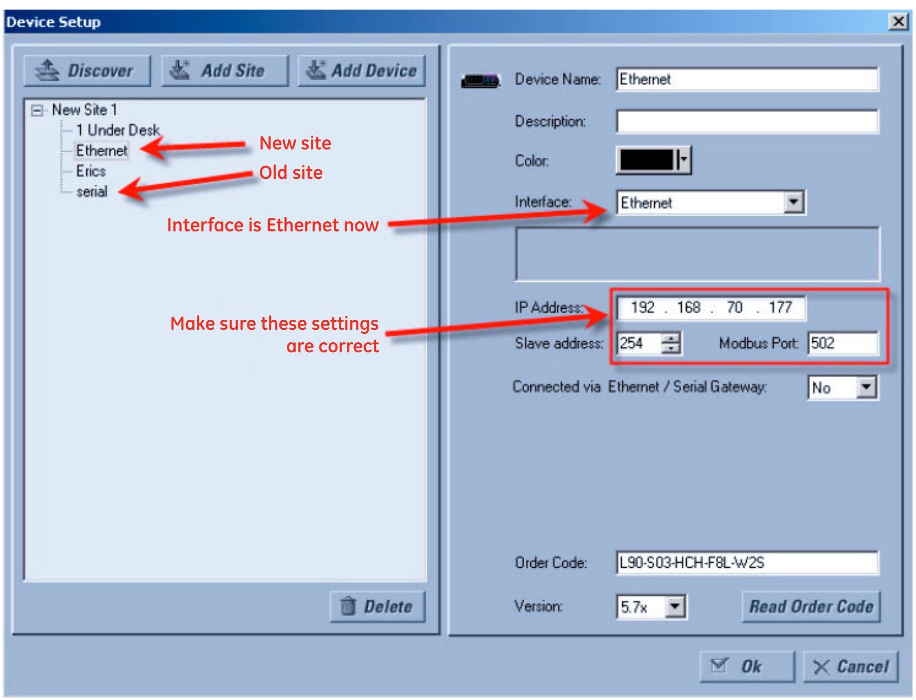


6. Now that the PC should be able to communicate to the UR relay through the UR Setup software.

c) INITIAL ETHERNET SWITCH MODULE SETUP

This procedure describes how to configure the C70 switch module through EnerVista UR Setup. Before starting this procedure, ensure that the local PC is properly configured on the same network as the C70 device as shown in the previous section.

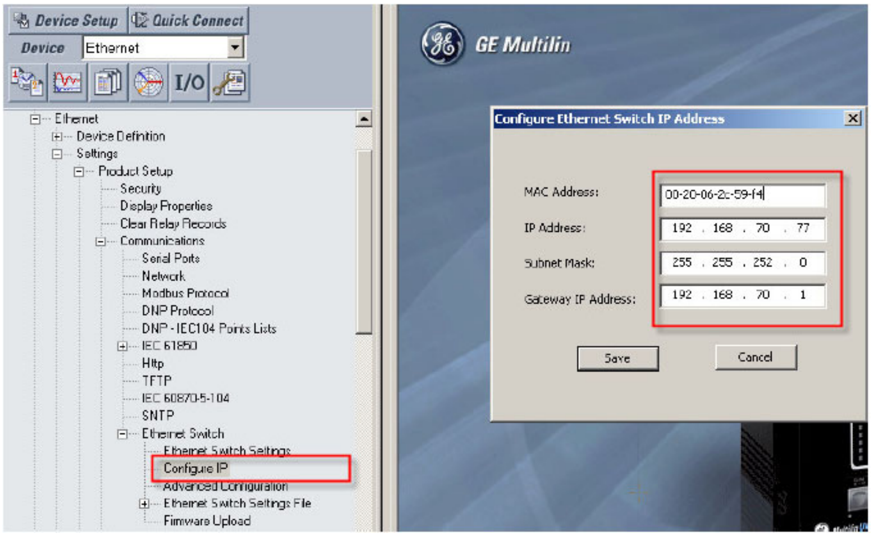
1. Launch the EnerVista UR Setup software.
2. Click the **Device Setup** button.
3. Click the **Add Site** button. This will launch the Device Setup window.
4. Set the **Interface** option to “Ethernet” and enter the **IP Address**, **Slave Address**, and **Modbus Port** values as shown below.



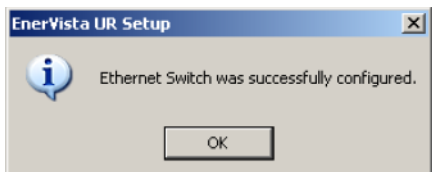
827804A1.CDR

5. Click the **Read Order Code** button. You should be able to communicate with the C70 device regardless of the value of the Ethernet switch IP address and even though the front panel display states that the Ethernet module is offline.

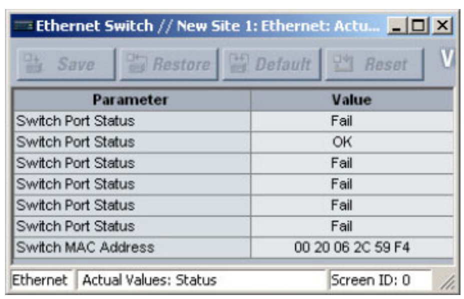
6. Select the **Settings > Product Setup > Communications > Ethernet Switch > Configure IP** menu item as shown below.



7. Enter (or verify) the **MAC Address**, **IP Address**, **Subnet Mask**, and **Gateway IP Address** settings.
8. Click the **Save** button. It will take few seconds to save the settings to the Ethernet switch module and the following message displayed.



9. Verify that the target message is cleared and that the C70 displays the MAC address of the Ethernet switch in the **Actual Values > Status > Ethernet Switch** window.



The C70 device and the Ethernet switch module communications setup is now complete.

3.4.5 CONFIGURING THE MANAGED ETHERNET SWITCH MODULE

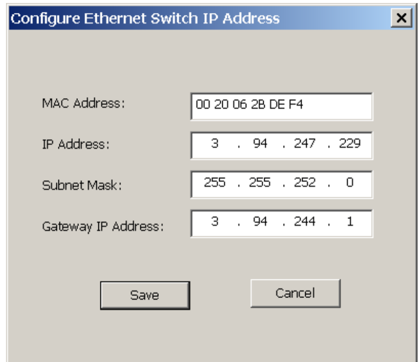
A suitable IP/gateway and subnet mask must be assigned to both the switch and the UR relay for correct operation. The Switch has been shipped with a default IP address of 192.168.1.2 and a subnet mask of 255.255.255.0. Consult your network administrator to determine if the default IP address, subnet mask or default gateway needs to be modified.

CAUTION **Do not connect to network while configuring the switch module.**

a) CONFIGURING THE SWITCH MODULE IP SETTINGS

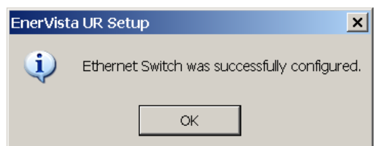
In our example configuration of both the Switch's IP address and subnet mask must be changed to 3.94.247.229 and 255.255.252.0 respectively. The IP address, subnet mask and default gateway can be configured using either EnerVista UR Setup software, the Switch's Secure Web Management (SWM), or through the console port using CLI.

1. Select the **Settings > Product Setup > Communications > Ethernet Switch > Configure IP** menu item to open the Ethernet switch configuration window.



2. Enter "3.94.247.229" in the **IP Address** field and "255.255.252.0" in the **Subnet Mask** field, then click **OK**.

   The software will send the new settings to the C70 and prompt as follows when complete.



3. Cycle power to the C70 and switch module to activate the new settings.

b) SAVING THE ETHERNET SWITCH SETTINGS TO A SETTINGS FILE

The C70 allows the settings information for the Ethernet switch module to be saved locally as a settings file. This file contains the advanced configuration details for the switch not contained within the standard C70 settings file.

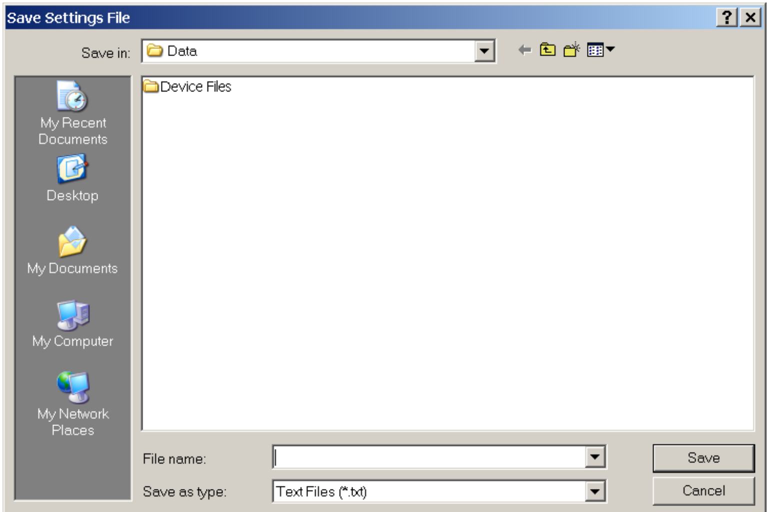
This feature allows the switch module settings to be saved locally before performing firmware upgrades. Saving settings files is also highly recommended before making any change to the module configuration or creating new setting files.

The following procedure describes how to save local settings files for the Ethernet switch module.

1. Select the desired device from site tree in the online window.
2. Select the **Settings > Product Setup > Communications > Ethernet Switch > Ethernet Switch Settings File > Retreive Settings File** item from the device settings tree.

3

The system will request the name and destination path for the settings file.



3. Enter an appropriate folder and file name and click **Save**.

All settings files will be saved as text files and the corresponding file extension automatically assigned.

c) UPLOADING ETHERNET SWITCH SETTINGS FILES TO THE MODULE

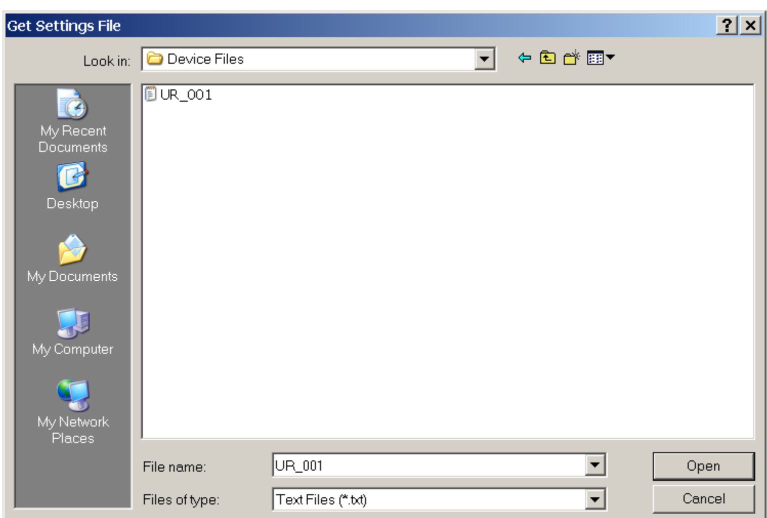
The following procedure describes how to upload local settings files to the Ethernet switch module. It is highly recommended that the current settings are saved to a settings file before uploading a new settings file.

NOTE

It is highly recommended to place the switch offline while transferring setting files to the switch. When transferring settings files from one switch to another, the user must reconfigure the IP address.

1. Select the desired device from site tree in the online window.
2. Select the **Settings > Product Setup > Communications > Ethernet Switch > Ethernet Switch Settings File > Transfer Settings File** item from the device settings tree.

   The system will request the name and destination path for the settings file.



3. Navigate to the folder containing the Ethernet switch settings file, select the file, then click **Open**.

The settings file will be transferred to the Ethernet switch and the settings uploaded to the device.

3.4.6 UPLOADING C70 SWITCH MODULE FIRMWARE

a) DESCRIPTION

This section describes the process for upgrading firmware on a UR-2S or UR-2T switch module.

There are several ways of updating firmware on a switch module:

- Using the EnerVista UR Setup software.
- Serially using the C70 switch module console port.
- Using FTP or TFTP through the C70 switch module console port.

It is highly recommended to use the EnerVista UR Setup software to upgrade firmware on a C70 switch module.

NOTE: Firmware upgrades using the serial port, TFTP, and FTP are described in detail in the switch module manual.

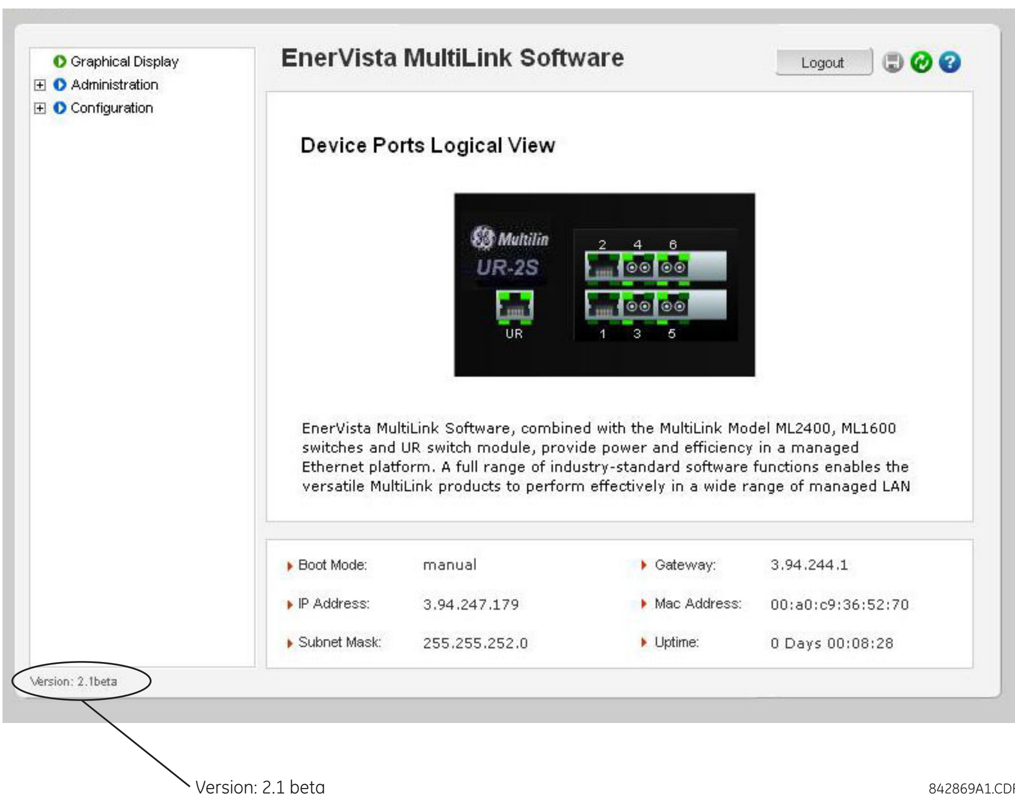
b) SELECTING THE PROPER SWITCH FIRMWARE VERSION

The latest switch module firmware is available as a download from the GE Multilin web site. Use the following procedure to determine the version of firmware currently installed on your switch

1. Log into the switch using the EnerVista web interface.

   NOTE: The default switch login ID is "manager" and the default password is "manager".

   The firmware version installed on the switch will appear on the lower left corner of the screen.



2. Using the EnerVista UR Setup program, select the **Settings > Product Setup > Communications > Ethernet Switch > Firmware Upload** menu item.

The following popup screen will appear warning that the settings will be lost when the firmware is upgraded.

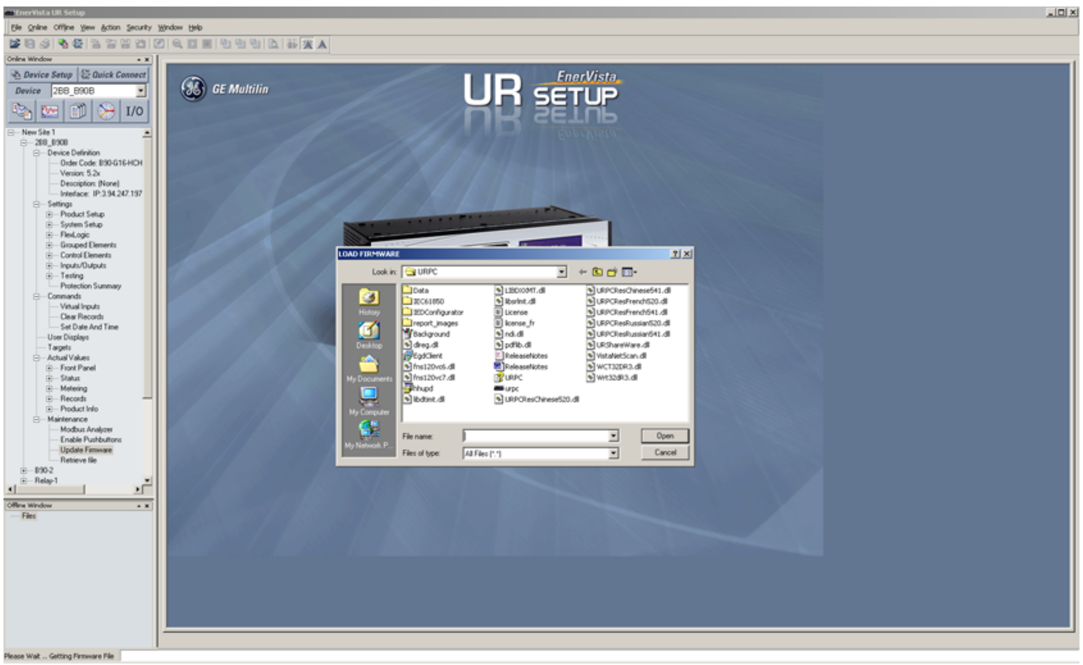
NOTE

It is highly recommended that you save the switch settings before upgrading the firmware.

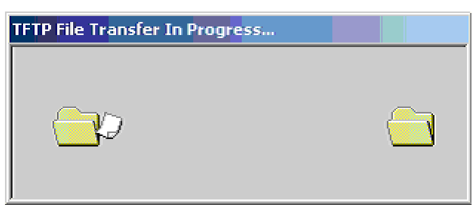
3. After saving the settings file, proceed with the firmware upload by selecting **Yes** to the above warning.

   Another window will open, asking you to point to the location of the firmware file to be uploaded.

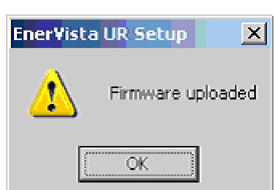
4. Select the firmware file to be loaded on to the Switch, and select the **Open** option.



The following window will pop up, indicating that the firmware file transfer is in progress.



If the firmware load was successful, the following window will appear:



NOTE

The switch will automatically reboot after a successful firmware file transfer.

5. Once the firmware has been successfully uploaded to the switch module, load the settings file using the procedure described earlier.

3.4.7 ETHERNET SWITCH SELF-TEST ERRORS

The following table provides details about Ethernet module self-test errors.

Be sure to enable the **ETHERNET SWITCH FAIL** setting in the **PRODUCT SETUP** ⇨⇩ **USER-PROGRAMMABLE SELF-TESTS** menu and the relevant **PORT 1 EVENTS** through **PORT 6 EVENTS** settings under the **PRODUCT SETUP** ⇨⇩ **COMMUNICATIONS** ⇨⇩ **ETHERNET SWITCH** menu.

Table 3–7: ETHERNET SWITCH SELF-TEST ERRORS

ACTIVATION SETTING (SET AS ENABLED)	EVENT NAME	EVENT CAUSE	POSSIBLE CAUSES
ETHERNET SWITCH FAIL	ETHERNET MODULE OFFLINE	No response has been received from the Ethernet module after five successive polling attempts.	• Loss of switch power. • IP/gateway/subnet. • Incompatibility between the CPU and the switch module. • UR port (port 7) configured incorrectly or blocked • Switch IP address assigned to another device in the same network.
PORT 1 EVENTS to PORT 6 EVENTS	ETHERNET PORT 1 OFFLINE to ETHERNET PORT 6 OFFLINE	An active Ethernet port has returned a FAILED status.	• Ethernet connection broken. • An inactive port’s events have been enabled.
No setting required; the C70 will read the state of a general purpose input/output port on the main CPU upon power-up and create the error if there is a conflict between the input/output state and the order code.	EQUIPMENT MISMATCH: Card XXX Missing	The C70 has not detected the presence of the Ethernet switch via the bus board.	The C70 failed to see the switch module on power-up, because switch won’t power up or is still powering up. To clear the fault, cycle power to the C70.

3

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 (refer to the *Faceplate interface* section in this chapter).

The EnerVista UR Setup software provides a single facility to configure, monitor, maintain, and trouble-shoot the operation of relay functions, connected over local or wide area communication networks. It can be used while disconnected (off-line) or connected (on-line) to a UR device. In off-line mode, settings files can be created for eventual downloading to the device. In on-line mode, you can communicate with the device in real-time.

The EnerVista UR Setup software, provided with every C70 relay, can be run from any computer supporting Microsoft Windows® 95, 98, NT, 2000, ME, and XP. 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, a site definition and device definition must first be created. See the EnerVista UR Setup Help File or refer to the *Connecting EnerVista UR Setup with the C70* section in Chapter 1 for details.

4.1.3 ENERVISTA UR SETUP OVERVIEW

a) ENGAGING A DEVICE

The EnerVista UR Setup software may be used in on-line mode (relay connected) to directly communicate with the C70 relay. Communicating relays are organized and grouped by communication interfaces and into sites. Sites may 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 off-line 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 C70 with settings files.

Modbus Slave Address
Modbus IP Port Number
RS485 COM1 Baud Rate
RS485 COM1 Parity
COM1 Minimum Response Time

RS485 COM2 Baud Rate
RS485 COM2 Parity
COM2 Minimum Response Time
COM2 Selection
RRTD Slave Address
RRTD Baud Rate
IP Address
IP Subnet Mask
Gateway IP Address
Ethernet Sub Module Serial Number
Network Address NSAP
IEC61850 Config GOOSE ConfRev

When a settings file is loaded to a C70 that is in-service, the following sequence will occur.

1. The C70 will take itself out of service.
2. The C70 will issue a **UNIT NOT PROGRAMMED** major self-test error.
3. The C70 will close the critical fail contact.

c) CREATING AND EDITING FLEXLOGIC™

You can 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 on-line or off-line 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 which is double clicked or opened will launch the application, or provide focus to the already opened application. If the file was a settings file (has a `URS` extension) which had been removed from the Settings List tree menu, it will be 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 which 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 which are dropped in the selected device menu in the Site List window will automatically be sent to the on-line communicating device.

g) FIRMWARE UPGRADES

The firmware of a C70 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 (i.e. default values, minimum/maximum values, data type, and item size) may 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 which 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.

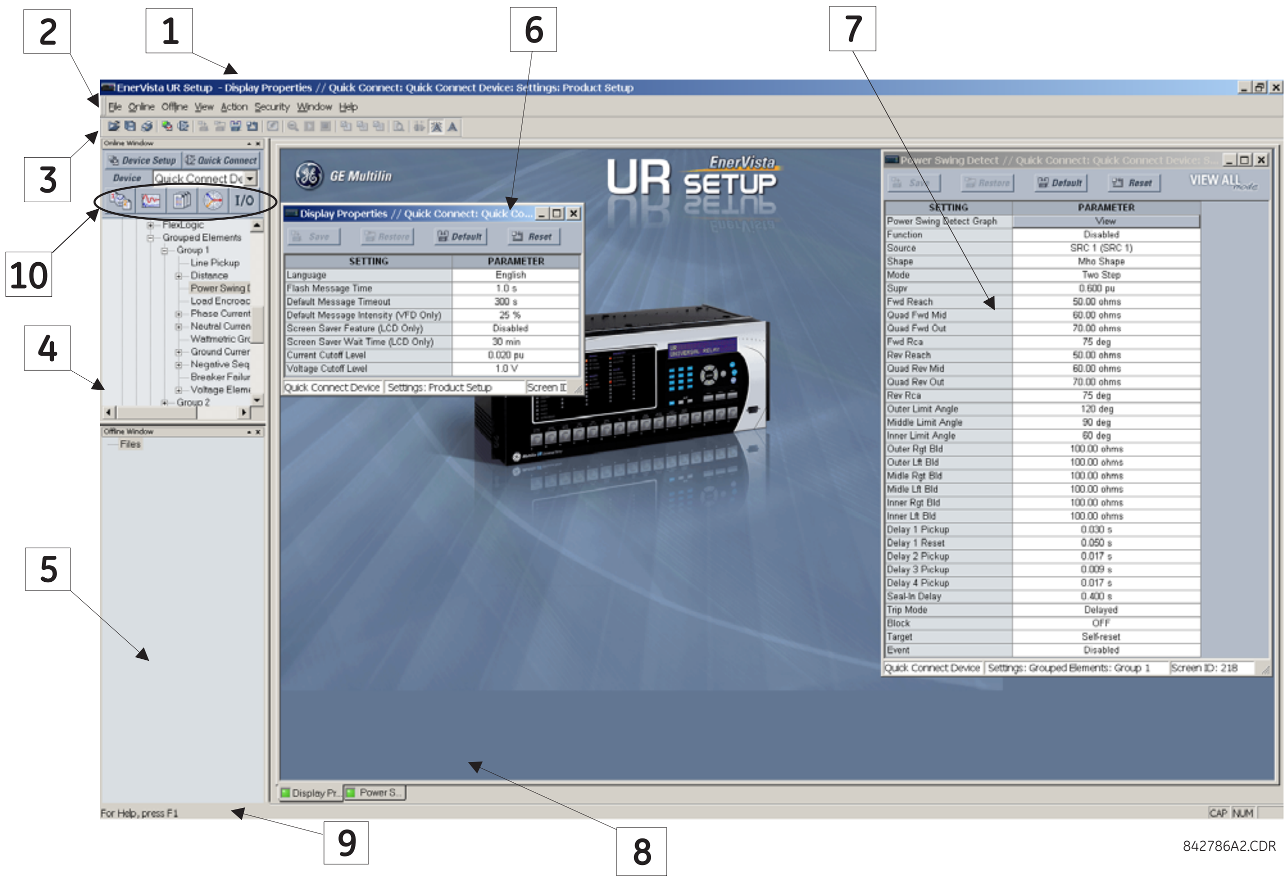


Figure 4–1: ENERVISTA UR SETUP SOFTWARE MAIN WINDOW

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 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 will be settings such as protection element pickup values and CT and VT ratios.

The settings template mode allows the user to define which settings will be 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.

NOTE: The settings template feature requires that *both* the EnerVista UR Setup software and the C70 firmware are at versions 5.40 or higher.

a) ENABLING THE SETTINGS TEMPLATE

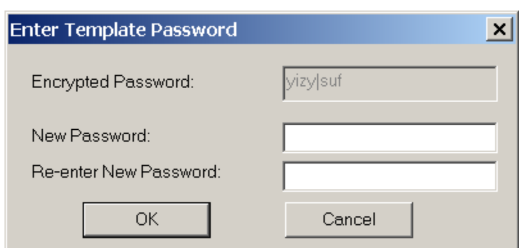
The settings file template feature is disabled by default. The following procedure describes how to enable the settings template for UR-series settings files.

1. Select a settings file from the offline window of the EnerVista UR Setup main screen.
2. Right-click on 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 on the selected device and select the **Template Mode > Create Template** option.



The software will prompt 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.

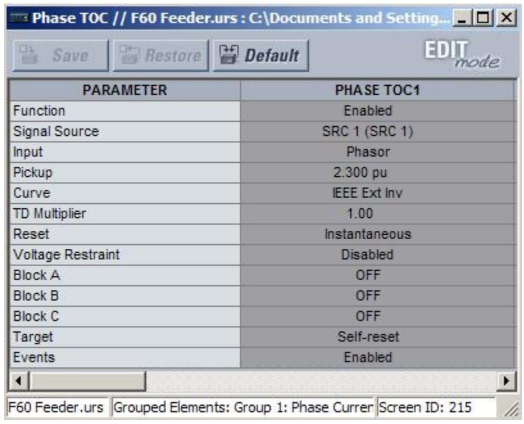
The online settings template is now enabled. The device is now in template editing mode.

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 will also indicate that EnerVista UR Setup is in **EDIT mode**. The following example shows the phase time overcurrent settings window in edit mode.

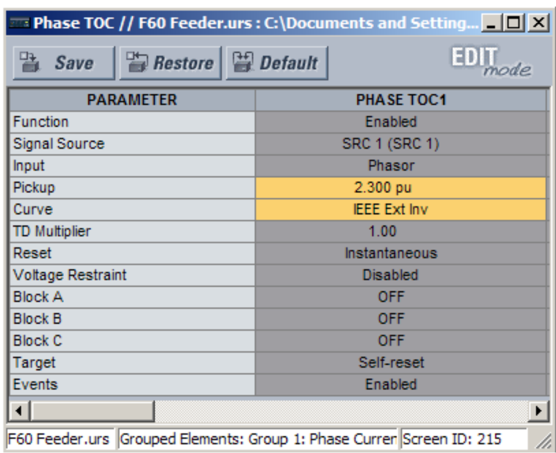


PARAMETER	PHASE TOC1
Function	Enabled
Signal Source	SRC 1 (SRC 1)
Input	Phasor
Pickup	2.300 pu
Curve	IEEE Ext Inv
TD Multiplier	1.00
Reset	Instantaneous
Voltage Restraint	Disabled
Block A	OFF
Block B	OFF
Block C	OFF
Target	Self-reset
Events	Enabled

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

5. Specify which settings to make viewable by clicking on them.

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



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

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.

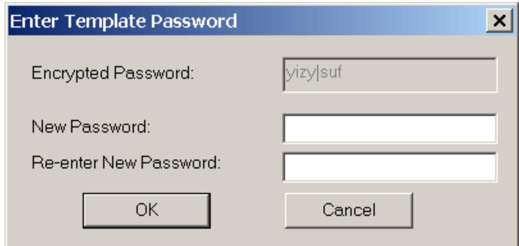
c) ADDING PASSWORD PROTECTION TO A TEMPLATE

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 will prompt 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

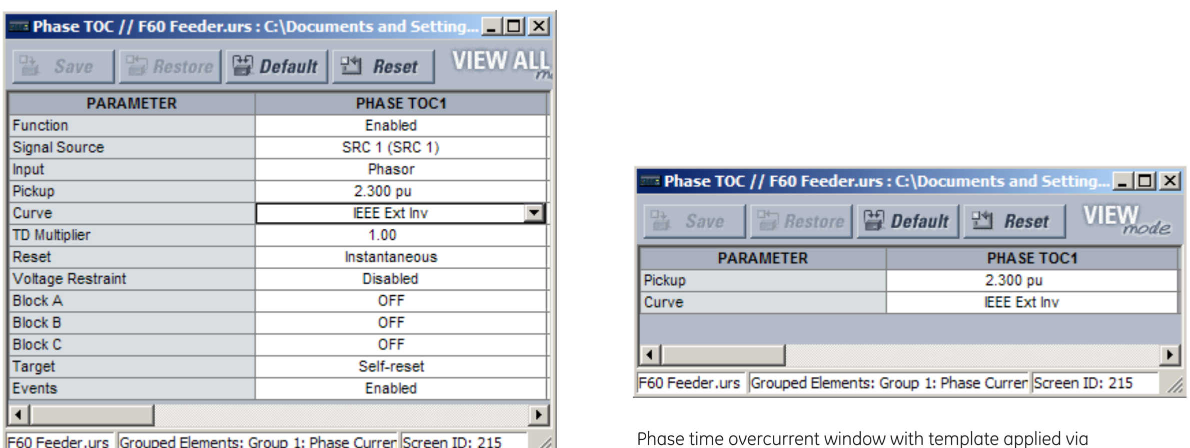
Once all necessary settings are specified for viewing, users are able to view the settings template on the online device or settings file. There are two ways to specify the settings view with the settings template feature:

- 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 will only be able 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.



Phase time overcurrent settings window without template applied.

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

842858A1.CDR

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.

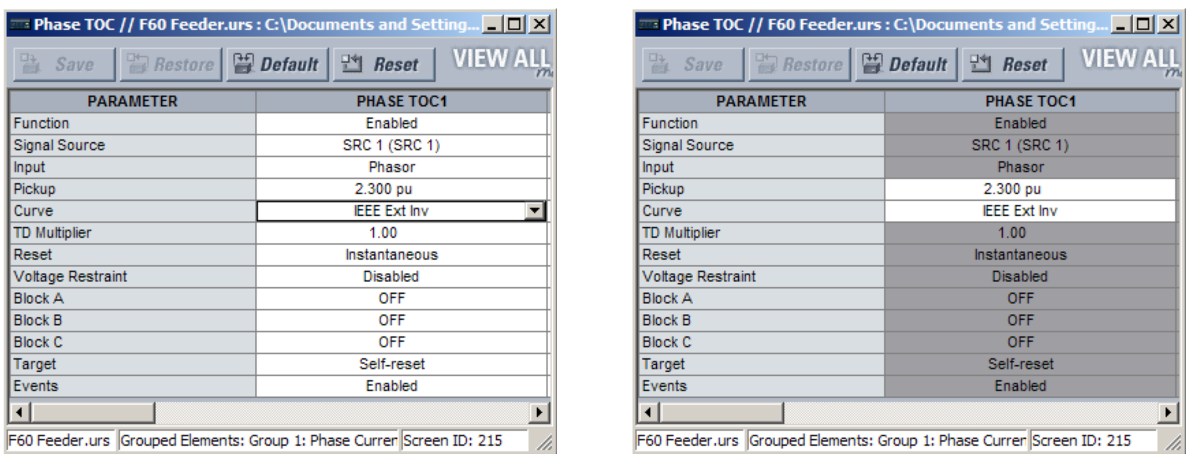
842860A1.CDR

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 will only be able to edit the settings specified by the template, but all settings will be 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

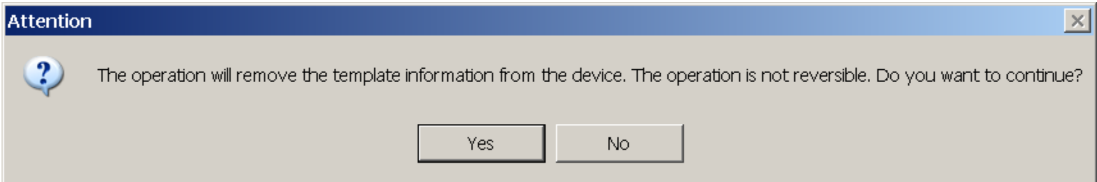
Figure 4–6: APPLYING TEMPLATES VIA THE VIEW ALL SETTINGS COMMAND

e) REMOVING THE SETTINGS TEMPLATE

It may be necessary at some point to remove a settings template. Once a template is removed, it cannot be reapplied and it will be 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. Verify one more time that you wish to remove the template by clicking **Yes**.



The EnerVista software will remove all template information and all settings will be 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 will remain secure when files are sent to and retrieved from any UR-series device.

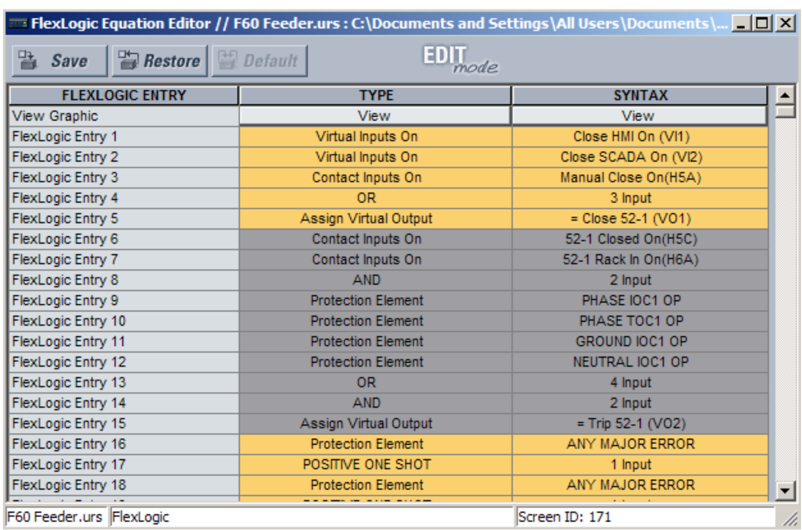
a) LOCKING FLEXLOGIC™ EQUATION ENTRIES

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 will also indicate that EnerVista UR Setup is in **EDIT mode**.
3. Specify which entries to lock by clicking on them.

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

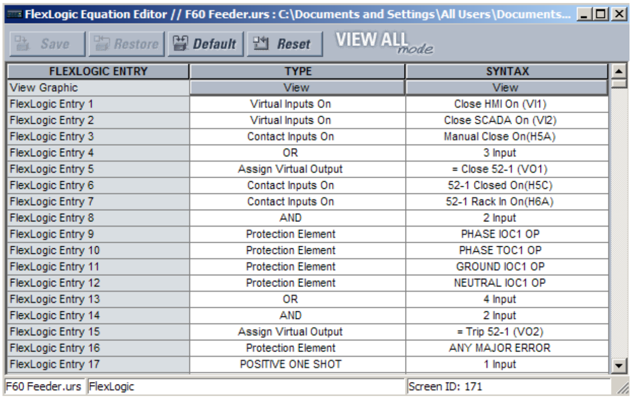


FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Inputs On	Close HMI On (VI1)
FlexLogic Entry 2	Virtual Inputs On	Close SCADA On (VI2)
FlexLogic Entry 3	Contact Inputs On	Manual Close On(H5A)
FlexLogic Entry 4	OR	3 Input
FlexLogic Entry 5	Assign Virtual Output	= Close 52-1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

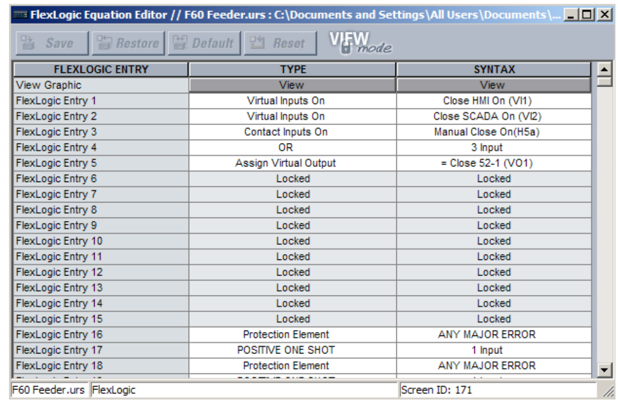
4. Click on **Save** to save and apply changes to the settings template.
5. Select the **Template Mode > View In Template Mode** option to view the template.
6. Apply a password to the template then click **OK** to secure the FlexLogic™ equation.

Once the template has been applied, users will only be able 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.



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

Typical FlexLogic™ entries without template applied.



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	Locked	Locked
FlexLogic Entry 7	Locked	Locked
FlexLogic Entry 8	Locked	Locked
FlexLogic Entry 9	Locked	Locked
FlexLogic Entry 10	Locked	Locked
FlexLogic Entry 11	Locked	Locked
FlexLogic Entry 12	Locked	Locked
FlexLogic Entry 13	Locked	Locked
FlexLogic Entry 14	Locked	Locked
FlexLogic Entry 15	Locked	Locked
FlexLogic Entry 16	Protection Element	ANY MAJOR ERROR
FlexLogic Entry 17	POSITIVE ONE SHOT	1 Input
FlexLogic Entry 18	Protection Element	ANY MAJOR ERROR

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

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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.

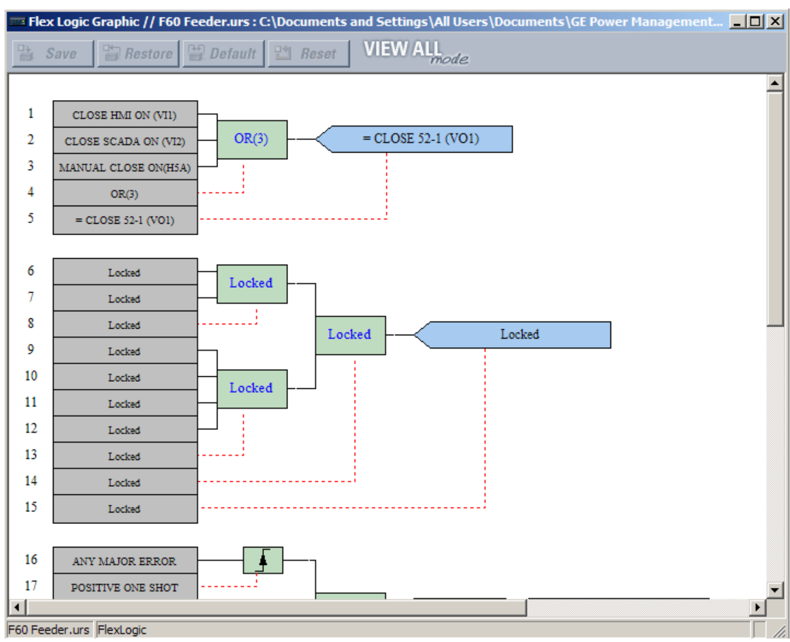

Figure 4–9: SECURED FLEXLOGIC™ IN GRAPHICAL VIEW

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.

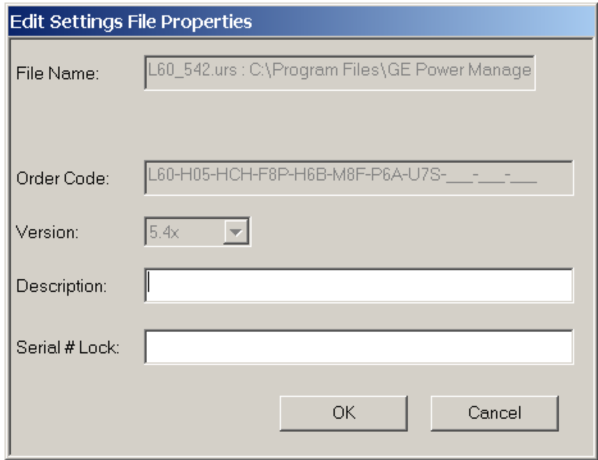

Figure 4–10: TYPICAL SETTINGS FILE PROPERTIES WINDOW

4

3. Enter the serial number of the C70 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 C70 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 C70 device have been changed since the time of installation from a settings file. When a settings file is transfered to a C70 device, the date, time, and serial number of the C70 are sent back to EnerVista UR Setup and added to the settings file on the local PC. This information can be compared with the C70 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 C70 device or obtained from the C70 device. Any partial settings transfers by way of drag and drop do not add the traceability information to the settings file.

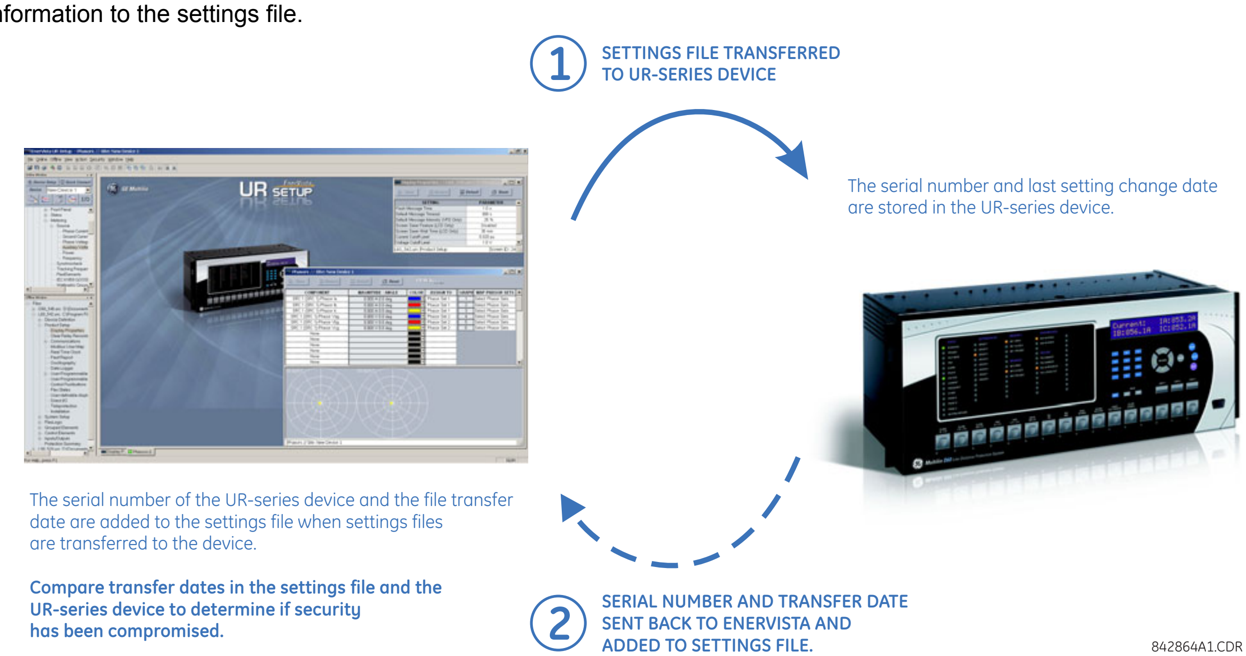

Figure 4–11: SETTINGS FILE TRACEABILITY MECHANISM

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

1. The transfer date of a setting file written to a C70 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 will indicate 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 sent to an C70 device.

The C70 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.

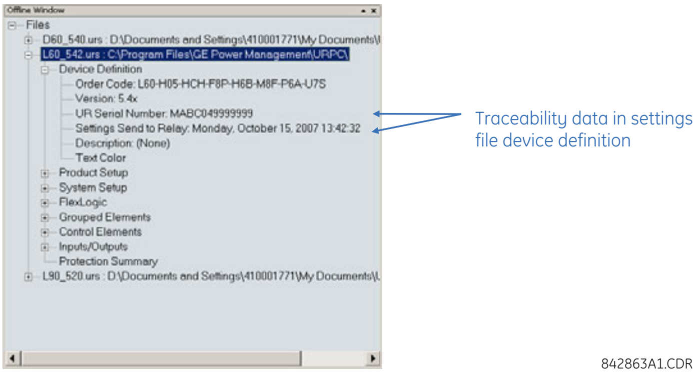

Figure 4–12: DEVICE DEFINITION SHOWING TRACEABILITY DATA

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

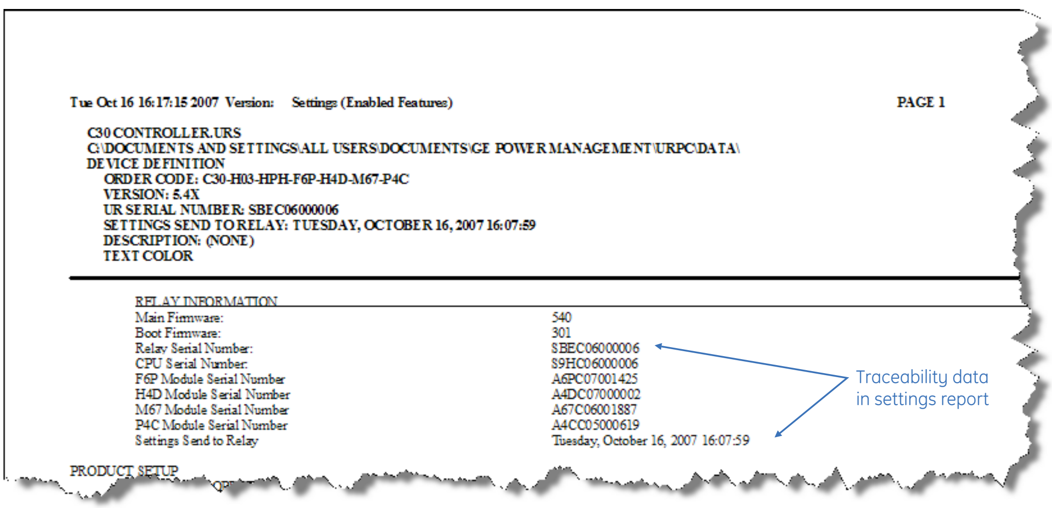

Figure 4–13: SETTINGS FILE REPORT SHOWING TRACEABILITY DATA

b) ONLINE DEVICE TRACEABILITY INFORMATION

The C70 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.

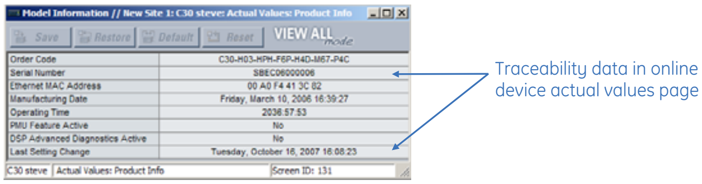

Figure 4–14: TRACEABILITY DATA IN ACTUAL VALUES WINDOW

This infomormation if also available from the front panel display through the following actual values:

ACTUAL VALUES ⇨⇩ PRODUCT INFO ⇨ MODEL INFORMATION ⇨⇩ SERIAL NUMBER
ACTUAL VALUES ⇨⇩ PRODUCT INFO ⇨ MODEL INFORMATION ⇨⇩ LAST SETTING CHANGE

4

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.

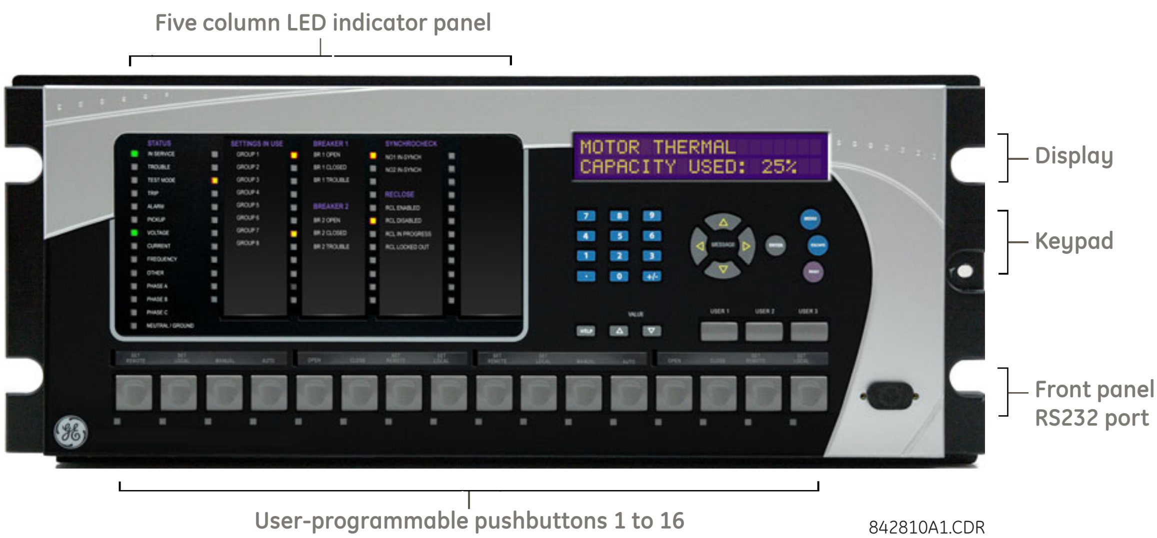

Figure 4–15: UR-SERIES ENHANCED FACEPLATE

b) STANDARD FACEPLATE

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

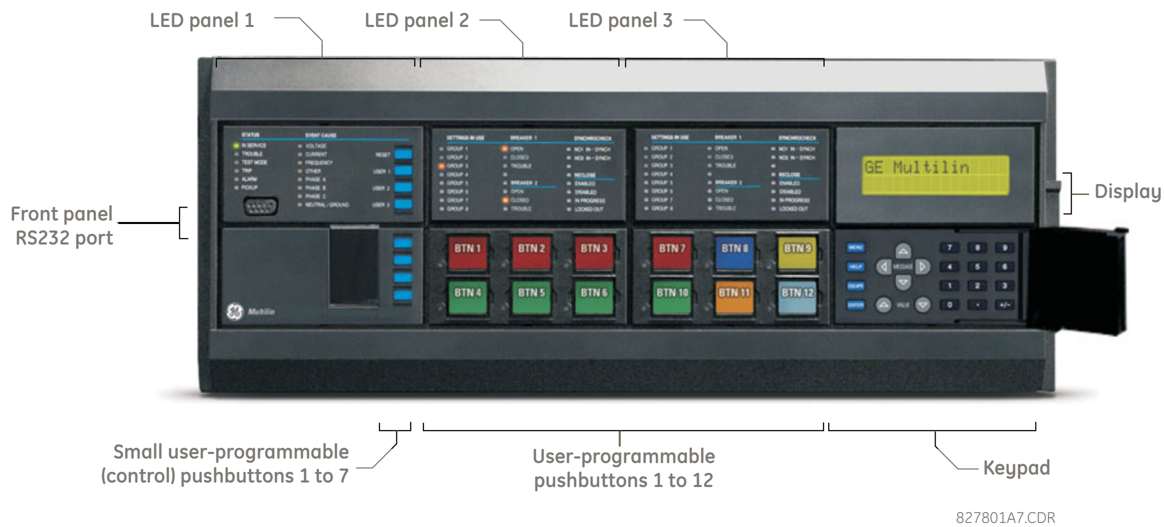

Figure 4–16: UR-SERIES STANDARD HORIZONTAL FACEPLATE PANELS

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

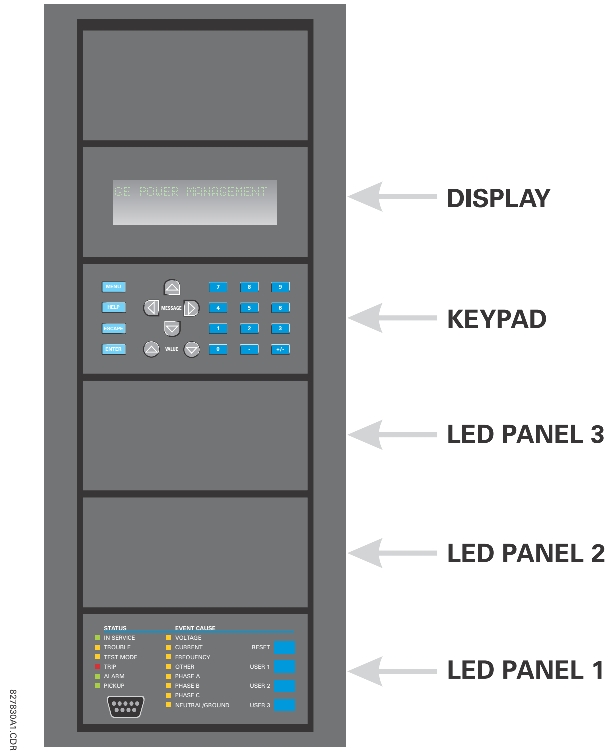

Figure 4–17: UR-SERIES STANDARD VERTICAL FACEPLATE PANELS

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 C70, 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.

4

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 intended for connection to a portable PC.

The USER keys are used by the breaker control feature.

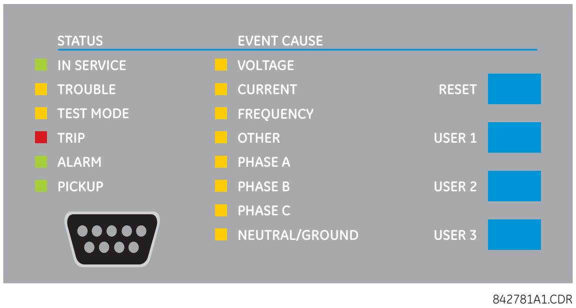

Figure 4–19: LED PANEL 1

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.

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.

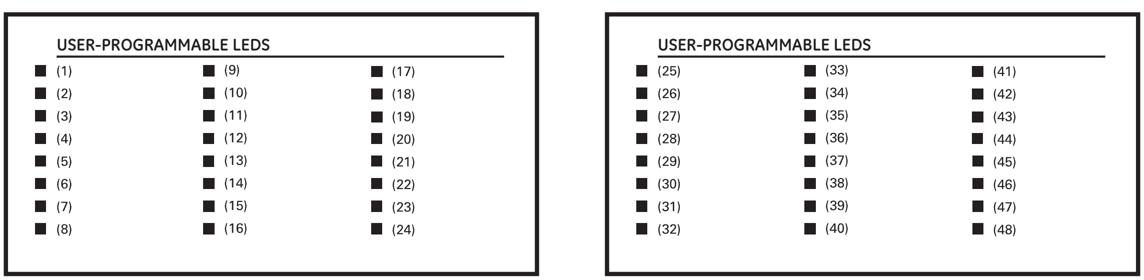

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Figure 4–20: LED PANELS 2 AND 3 (INDEX TEMPLATE)

DEFAULT LABELS FOR LED PANEL 2:

The default labels are intended to represent:

- **GROUP 1...6**: The illuminated GROUP is the active settings group.

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 the pre-requisites listed below.

- EnerVista UR Setup software is installed and operational.
- The C70 settings have been saved to a settings file.
- The C70 front panel label cutout sheet (GE Multilin part number 1006-0047) has been downloaded from http://www.GEindustrial.com/multilin/support/ur and printed.
- Small-bladed knife.

This procedure describes how 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 will be displayed.

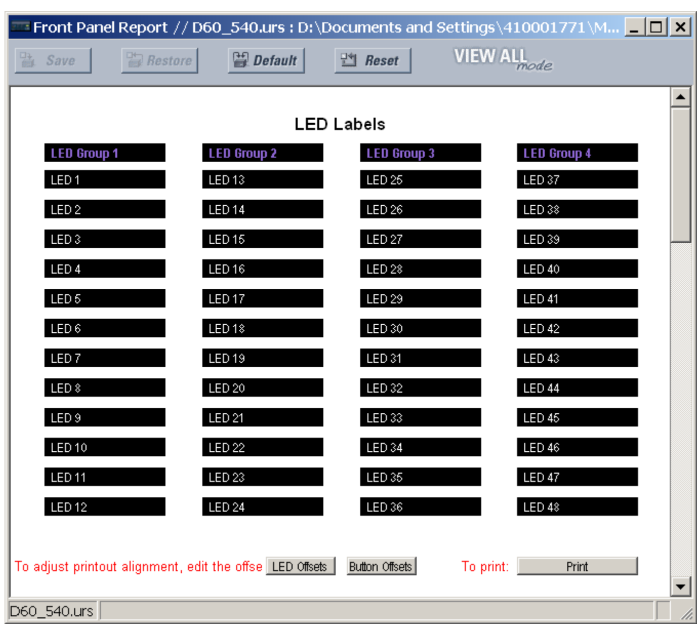


Figure 4–22: FRONT PANEL REPORT WINDOW

3. Enter the text to appear next to each LED and above each user-programmable pushbuttons in the fields provided.
4. Feed the C70 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 C70 label insert tool from the package and bend the tabs as described in the following procedures. These tabs will be 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.

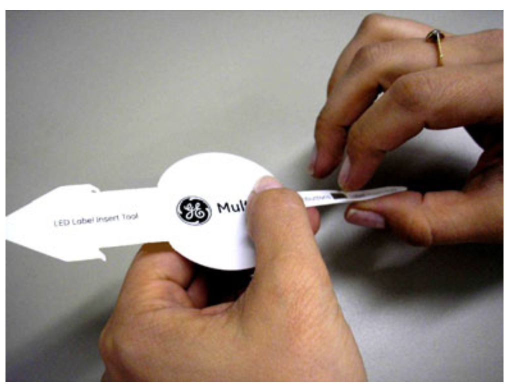
The label package shipped with every C70 contains the three default labels shown below, the custom label template sheet, and the label removal tool.

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 C70 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 will attach 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.

The following procedure describes how to remove the user-programmable pushbutton labels from the C70 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 will attach the label tool to the user-programmable pushbutton label.

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

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

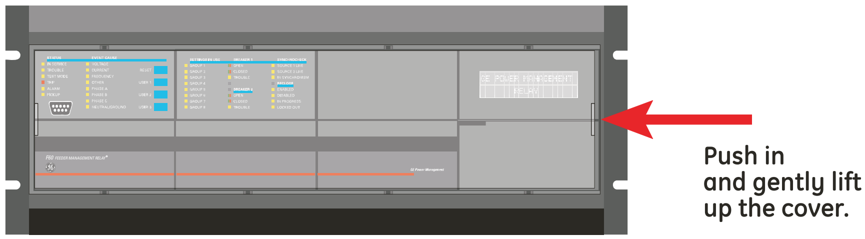
b) STANDARD FACEPLATE

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

http://www.GEindustrial.com/multilin/support/ur/

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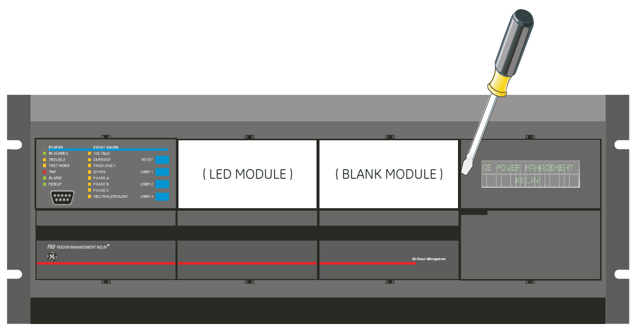
2. Pop out the LED module and/or the blank module with a screwdriver as shown below. Be careful not to damage the plastic covers.



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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 C70 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 C70 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 local PC 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 2 × 20 backlit liquid crystal display (LCD) to make them visible under poor lighting conditions. Messages are descriptive and should not require the aid of an instruction manual for deciphering. While the keypad and display are not actively being used, the display will default to user-defined messages. Any high priority event driven message will automatically override the default message and appear 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 broken down further into logical subgroups.

4

The MESSAGE keys navigate through the subgroups. The VALUE keys scroll increment or decrement numerical setting values when in programming mode. These keys also scroll through alphanumeric values in the text edit mode. Alternatively, values may also be entered with the numeric keypad.

The decimal key initiates and advance to the next character in text edit mode or enters a decimal point. The HELP key may 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 C70 can interface with associated circuit breakers. In many cases the application monitors the state of the breaker, which 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 may 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 may 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 will be maintained 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:

(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 the desired 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
■■ SYSTEM SETUP
```

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 ■■ SYSTEM SETUP	Press the MESSAGE DOWN key to move to the next Settings page. This page contains settings for System Setup. 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 will display the second setting sub-header associated with the Product Setup header.
⇩	
FLASH MESSAGE TIME: 1.0 s	Press the MESSAGE RIGHT key once more and this will 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.

4.3.8 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 will allow 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 will allow the setting selection to continue downward from the maximum value.

```
FLASH MESSAGE
TIME:   2.5 s
```

As an example, set the flash message time setting to 2.5 seconds. Press the appropriate numeric keys in the sequence "2 . 5". The display message will change 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 will momentarily appear as confirmation of the storing process. Numerical values which contain decimal places will be 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 may be comprised of upper case letters, lower case letters, numerals, and a selection of special characters.

There are several places where text messages may 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 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 will sequentially appear 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 will be 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.

```
SETTINGS
   ⇩
■■ SETTINGS          ◀▶   ■ PASSWORD
■■ PRODUCT SETUP          ■ SECURITY

                     ▲    ■ DISPLAY
                     ▼    ■ PROPERTIES
                               ↓
                     ▲    ■ INSTALLATION   ◀▶   RELAY SETTINGS:
                          ■                     Not Programmed
```

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 will be in "Programmed" state and the In Service LED will turn on.

e) ENTERING INITIAL PASSWORDS

The C70 supports password entry from a local or remote connection.

4

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 will prompt 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 will prompt you to type in the existing password (for each security level) before a new password can be entered.

In the event that a password has been lost (forgotten), submit the corresponding encrypted password from the **PASSWORD SECURITY** menu to the Factory for decoding.

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 will be set to "On" and the C70 will 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 will be set to "On" and the C70 will 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 will be set to "On" and the C70 will not allow Settings or Command access via the any external communications interface for the next ten minutes. The REMOTE ACCESS DENIED FlexLogic™ operand will be set to "Off" after the expiration of the ten-minute timeout.

5.1.1 SETTINGS MAIN MENU

Menu	Submenu	Reference
■■ SETTINGS ■■ PRODUCT SETUP	■ SECURITY ■	See page 5-8.
	■ DISPLAY ■ PROPERTIES	See page 5-12.
	■ CLEAR RELAY ■ RECORDS	See page 5-14.
	■ COMMUNICATIONS ■	See page 5-15.
	■ MODBUS USER MAP ■	See page 5-38.
	■ REAL TIME ■ CLOCK	See page 5-39.
	■ USER-PROGRAMMABLE ■ FAULT REPORT	See page 5-40.
	■ OSCILLOGRAPHY ■	See page 5-41.
	■ DATA LOGGER ■	See page 5-43.
	■ USER-PROGRAMMABLE ■ LEDS	See page 5-45.
	■ USER-PROGRAMMABLE ■ SELF TESTS	See page 5-48.
	■ CONTROL ■ PUSHBUTTONS	See page 5-49.
	■ USER-PROGRAMMABLE ■ PUSHBUTTONS	See page 5-50.
	■ FLEX STATE ■ PARAMETERS	See page 5-55.
	■ USER-DEFINABLE ■ DISPLAYS	See page 5-56.
	■ DIRECT I/O ■	See page 5-58.
	■ INSTALLATION ■	See page 5-66.
■■ SETTINGS ■■ SYSTEM SETUP	■ AC INPUTS ■	See page 5-68.
	■ POWER SYSTEM ■	See page 5-69.
	■ SIGNAL SOURCES ■	See page 5-71.
	■ BREAKERS ■	See page 5-73.

Menu	Submenu	Reference
	SWITCHES	See page 5-77.
	FLEXCURVES	See page 5-80.
SETTINGS FLEXLOGIC	FLEXLOGIC EQUATION EDITOR	See page 5-103.
	FLEXLOGIC TIMERS	See page 5-103.
	FLEXELEMENTS	See page 5-104.
	NON-VOLATILE LATCHES	See page 5-108.
SETTINGS GROUPED ELEMENTS	SETTING GROUP 1	See page 5-109.
	SETTING GROUP 2	
	↓	
	SETTING GROUP 6	
SETTINGS CONTROL ELEMENTS	TRIP BUS	See page 5-173.
	SETTING GROUPS	See page 5-175.
	SELECTOR SWITCH	See page 5-176.
	TIME OF DAY TIMERS	See page 5-182.
	CAPACITOR CONTROL	See page 5-183.
	AUTOMATIC VOLTAGE REGULATOR	See page 5-188.
	DIGITAL ELEMENTS	See page 5-193.
	DIGITAL COUNTERS	See page 5-196.
	MONITORING ELEMENTS	See page 5-198.
SETTINGS INPUTS / OUTPUTS	CONTACT INPUTS	See page 5-210.
	VIRTUAL INPUTS	See page 5-212.

Menu	Submenu	Reference
	■ CONTACT OUTPUTS ■	See page 5-213.
	■ VIRTUAL OUTPUTS ■	See page 5-215.
	■ REMOTE DEVICES ■	See page 5-216.
	■ REMOTE INPUTS ■	See page 5-217.
	■ REMOTE DPS INPUTS ■	See page 5-218.
	■ REMOTE OUTPUTS ■ DNA BIT PAIRS	See page 5-218.
	■ REMOTE OUTPUTS ■ UserSt BIT PAIRS	See page 5-219.
	■ RESETTING ■	See page 5-219.
	■ DIRECT INPUTS ■	See page 5-220.
	■ DIRECT OUTPUTS ■	See page 5-220.
	■ IEC 61850 ■ GOOSE ANALOGS	See page 5-223.
	■ IEC 61850 ■ GOOSE UINTEGERS	See page 5-224.
■■ SETTINGS ■■ TRANSDUCER I/O	■ DCMA INPUTS ■	See page 5-225.
	■ RTD INPUTS ■	See page 5-226.
	■ DCMA OUTPUTS ■	See page 5-228.
■■ SETTINGS ■■ TESTING	TEST MODE FUNCTION: Disabled	See page 5-231.
	TEST MODE FORCING: On	See page 5-231.
	■ FORCE CONTACT ■ INPUTS	See page 5-232.
	■ FORCE CONTACT ■ OUTPUTS	See page 5-233.

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 C70 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.

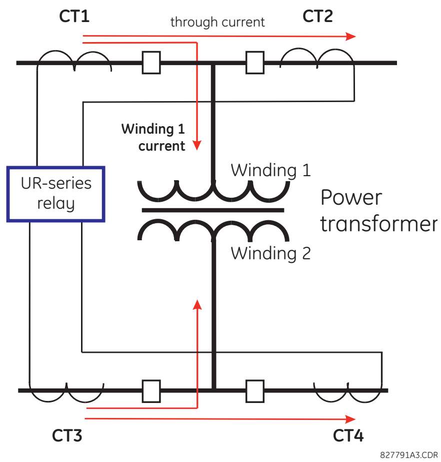


Figure 5–1: BREAKER-AND-A-HALF SCHEME

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:

INCREASING SLOT POSITION LETTER -->		
CT/VT MODULE 1	**CT/VT MODULE 2**	**CT/VT MODULE 3**
< bank 1 >	< bank 3 >	< bank 5 >
< bank 2 >	< bank 4 >	< bank 6 >

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	3
CT Bank (3 phase channels, 1 ground channel)	12
VT Bank (3 phase channels, 1 auxiliary channel)	6

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, M1, M5, U1, and U5.

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) MAIN MENU

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*

Two levels of password security are provided via the **ACCESS LEVEL** setting: command and setting. The factory service level is not available and intended for factory use only.

The following operations are under command password supervision:

- Changing the state of virtual inputs.
- Clearing the event records.
- Clearing the oscillography records.
- Changing the date and time.
- 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.

The C70 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 C70, 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.

The appropriate events are also logged in the Event Recorder as well. The FlexLogic™ operands and events are updated every five seconds.

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

b) 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. A password consists of 1 to 10 numerical characters. 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.

If an entered password is lost (or forgotten), consult the factory with the corresponding **ENCRYPTED PASSWORD**.

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

c) REMOTE PASSWORDS

The remote password settings are only visible from a remote connection via the EnerVista UR Setup software. Select the **Settings > Product Setup > Password Security** menu item to open the remote password settings window.

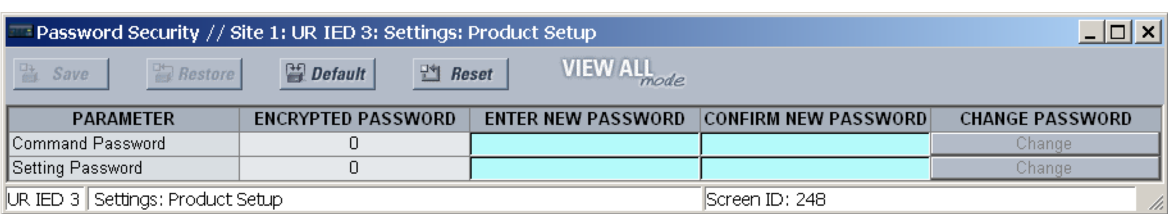
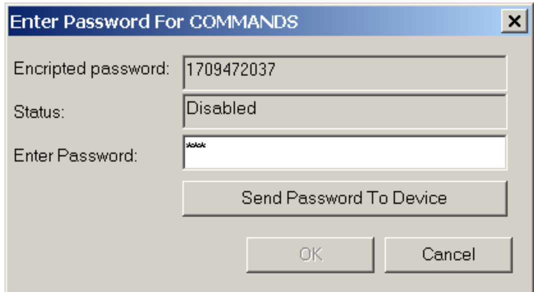


Figure 5–2: REMOTE PASSWORD SETTINGS WINDOW

Proper passwords are required to enable each command or setting level access. A command or setting password consists of 1 to 10 numerical characters and are initially programmed to "0". The following procedure describes how the set the command or setting password.

5

1. Enter the new password in the **Enter New Password** field.
2. Re-enter the password in the **Confirm New Password** field.
3. Click the **Change** button. This button will not be active until the new password matches the confirmation password.
4. If the original password is not “0”, then enter the original password in the **Enter Password** field and click the **Send Password to Device** button.



5. The new password is accepted and a value is assigned to the **ENCRYPTED PASSWORD** item.

If a command or setting password is lost (or forgotten), consult the factory with the corresponding **Encrypted Password** value.

d) 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 C70 will lockout password access after the number of invalid password entries specified by the **INVALID ATTEMPS BEFORE LOCKOUT** setting has occurred.

The C70 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.

If events or targets are required, the UNAUTHORIZED ACCESS operand can be assigned to a digital element programmed with event logs or targets enabled.

The 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.

e) 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.

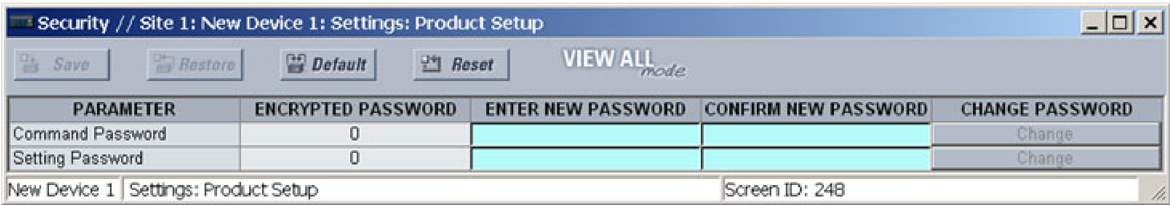
  If setting access is *not* authorized for local operation (front panel or RS232 interface) and the user attempts to obtain setting access, then the **UNAUTHORIZED ACCESS** message is displayed on the front panel.

- **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.

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 Authorization** 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.

The **Access Authorization Timeout** setting represents the timeout delay remote setting access. This setting is applicable when the **Remote Settings Authorization** 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 Authorization 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.

5.2.2 DISPLAY PROPERTIES

5

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 C70 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 C70 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.
- **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 C70 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 USER 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		RESET UNAUTH ACCESS: Off	*Range: FlexLogic™ operand*
MESSAGE		CLEAR DIR I/O STATS: Off	*Range: FlexLogic™ operand. Valid only for units with Direct I/O module.*

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 C70 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 5-16.
MESSAGE	△▽	■ MODBUS PROTOCOL ■	See page 5-16.
MESSAGE	△▽	■ DNP PROTOCOL ■	See page 5-17.
MESSAGE	△▽	■ DNP / IEC 104 ■ POINT LISTS	See page 5-20.
MESSAGE	△▽	■ IEC 61850 PROTOCOL ■	See page 5-21.
MESSAGE	△▽	■ WEB SERVER ■ HTTP PROTOCOL	See page 5-34.
MESSAGE	△▽	■ TFTP PROTOCOL ■	See page 5-35.
MESSAGE	△▽	■ IEC 60870-5-104 ■ PROTOCOL	See page 5-35.
MESSAGE	△▽	■ SNTP PROTOCOL ■	See page 5-36.
MESSAGE	△▽	■ EGD PROTOCOL ■	See page 5-36.
MESSAGE	△	■ ETHERNET SWITCH ■	See page 5-38.

b) SERIAL PORTS

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

■ SERIAL PORTS ■	◁▷	RS485 COM1 BAUD RATE: 19200	Range: 300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 57600, 115200. Only active if CPU Type E is ordered.
MESSAGE	△▽	RS485 COM1 PARITY: None	Range: None, Odd, Even Only active if CPU Type E is ordered
MESSAGE	△▽	RS485 COM1 RESPONSE MIN TIME: 0 ms	Range: 0 to 1000 ms in steps of 10 Only active if CPU Type E is ordered
MESSAGE	△▽	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 C70 is equipped with up to three independent serial communication ports. The faceplate RS232 port is intended for local use and is fixed at 19200 baud and no parity. The rear COM1 port type is selected when ordering: either an Ethernet or RS485 port. The rear COM2 port is RS485. The RS485 ports have settings for baud rate and parity. It is important that

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these parameters agree with the settings used on the computer or other equipment that is connected to these ports. Any of these ports may 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 PC using the RS485 ports.

NOTE

For each RS485 port, the minimum time before the port will transmit 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) NETWORK

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK

		Display	Range
■ NETWORK ■		IP ADDRESS: 0.0.0.0	Range: *Standard IP address format* *Not shown if CPU Type E is ordered.*
	MESSAGE	SUBNET IP MASK: 0.0.0.0	Range: *Standard IP address format* *Not shown if CPU Type E is ordered.*
	MESSAGE	GATEWAY IP ADDRESS: 0.0.0.0	Range: *Standard IP address format* *Not shown if CPU Type E is ordered.*
	MESSAGE	■ OSI NETWORK ■ ADDRESS (NSAP)	Range: *Select to enter the* **OSI NETWORK ADDRESS**. *Not shown if CPU Type E is ordered.*
	MESSAGE	ETHERNET OPERATION MODE: Full-Duplex	Range: *Half-Duplex, Full-Duplex* *Not shown if CPU Type E or N is ordered.*

These messages appear only if the C70 is ordered with an Ethernet card.

The IP addresses are used with the DNP, Modbus/TCP, IEC 61580, IEC 60870-5-104, TFTP, and HTTP protocols. The NSAP address is used with the IEC 61850 protocol over the OSI (CLNP/TP4) stack only. Each network protocol has a setting for the TCP/UDP port number. These settings are used only in advanced network configurations and should normally be left at their default values, but may be changed if required (for example, to allow access to multiple UR-series relays behind a router). By setting a different **TCP/UDP PORT NUMBER** for a given protocol on each UR-series relay, the router can map the relays to the same external IP address. The client software (EnerVista UR Setup, for example) must be configured to use the correct port number if these settings are used.

NOTE

When the NSAP address, any TCP/UDP port number, or any user map setting (when used with DNP) is changed, it will not become active until power to the relay has been cycled (off-on).

WARNING

Do not set more than one protocol to the same TCP/UDP PORT NUMBER, as this will result in unreliable operation of those protocols.

d) MODBUS PROTOCOL

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

		Display	Range
■ MODBUS PROTOCOL ■		MODBUS SLAVE ADDRESS: 254	Range: *1 to 254 in steps of 1*
	MESSAGE	MODBUS TCP PORT NUMBER: 502	Range: *1 to 65535 in steps of 1*

The serial communication ports utilize the Modbus protocol, unless configured for DNP or IEC 60870-5-104 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 C70 will respond regardless of the **MODBUS SLAVE ADDRESS** programmed. For the RS485 ports each C70 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. Refer to Appendix B for more information on the Modbus protocol.

NOTE

Changes to the MODBUS TCP PORT NUMBER setting will not take effect until the C70 is restarted.

e) DNP PROTOCOL

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

Menu		Setting	Range
■ DNP PROTOCOL ■		■ DNP CHANNELS ■	Range: see sub-menu below
	MESSAGE	DNP ADDRESS: 65519	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: 1 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
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 300 s in steps of 1

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The C70 supports the Distributed Network Protocol (DNP) version 3.0. The C70 can be used as a DNP slave device connected to multiple DNP masters (usually an RTU or a SCADA master station). Since the C70 maintains two sets of DNP data change buffers and connection information, two DNP masters can actively communicate with the C70 at one time.

NOTE

The IEC 60870-5-104 and DNP protocols cannot be simultaneously. When the IEC 60870-5-104 FUNCTION setting is set to "Enabled", the DNP protocol will not be operational. When this setting is changed it will 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, COM1 - RS485, COM2 - RS485, FRONT PANEL - RS232, NETWORK - TCP, NETWORK - UDP
MESSAGE	DNP CHANNEL 2 PORT: COM2 - RS485	Range: NONE, COM1 - RS485, 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. Note that COM1 can be used only in non-Ethernet UR relays. 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 will take effect only after power has been cycled to the relay.

The **DNP NETWORK CLIENT ADDRESS** settings can force the C70 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

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 C70 waits for a DNP master to confirm an unsolicited response. The **DNP UNSOL RESPONSE MAX RETRIES** setting determines the number of times the C70 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 C70 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 C70 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 C70 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 C70 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 C70 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 C70, the default deadbands will be in effect.

NOTE

The C70 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 C70. 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" C70 web page to view the points lists. This page can be viewed with a web browser by entering the C70 IP address to access the C70 "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 C70 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 C70 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 C70 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 C70. 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.

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

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

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

              MESSAGE ■ ANALOG INPUT / MME      Range: see sub-menu below
                      ■ POINTS
```

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   Point:    0      Range: FlexLogic™ operand
■ POINTS               Off

              MESSAGE  Point:    1      Range: FlexLogic™ operand
                       Off
                            ↓
              MESSAGE  Point:    255    Range: FlexLogic™ operand
                       Off
```

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   Point:    0      Range: any FlexAnalog parameter
■ POINTS               Off

              MESSAGE  Point:    1      Range: any FlexAnalog parameter
                       Off
                            ↓
              MESSAGE  Point:    255    Range: any FlexAnalog parameter
                       Off
```

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 C70 is restarted.

g) 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

SOFTWARE OPTION

The C70 Capacitor Bank Protection and Control 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 protocol features are not available if CPU type E is ordered.

The C70 supports the Manufacturing Message Specification (MMS) protocol as specified by IEC 61850. MMS is supported over two protocol stacks: TCP/IP over ethernet and TP4/CLNP (OSI) over ethernet. The C70 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:

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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 C70 GOOSE, and configurable GOOSE.

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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 C70 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*

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 C70 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 C70) 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: 010CDC010000	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

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The configurable GOOSE settings allow the C70 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 C70 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 C70. The C70 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 C70 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 C70 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 C70 will continue to block transmission of the dataset. The C70 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 C70 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 5–1: 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 C70 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".

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– 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 C70 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 C70 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 C70 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 C70 (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 C70 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 C70 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 C70 IEDs and devices from other manufacturers that support IEC 61850.

For intercommunication between C70 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 C70 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 C70 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		LOCATION: Location	Range: up to 80 alphanumeric characters
MESSAGE		IEC/MMS TCP PORT NUMBER: 102	Range: 1 to 65535 in steps of 1
MESSAGE		INCLUDE NON-IEC DATA: Enabled	Range: Disabled, Enabled
MESSAGE		SERVER SCANNING: Disabled	Range: Disabled, Enabled

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”.

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 will be not updated to the IEC 61850 logical node status values in the C70. Clients will still be able to connect to the server (C70 relay), but most data values will not be updated. This setting does not affect GOOSE/GSSE operation.

NOTE

Changes to the **IED NAME** setting, **LD INST** setting, and GOOSE dataset will not take effect until the C70 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 C70 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 C70 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)

■ 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 C70 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 C70 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 C70. 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.

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 C70. Changes to the dataset will only take effect when the C70 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 will not take effect until 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		XCBR2 ST.LOC OPERAND Off	Range: FlexLogic™ operand
MESSAGE		XCBR3 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 XCBR2 OpCnt: No	Range: No, Yes
MESSAGE		CLEAR XCBR3 OpCnt: No	Range: No, Yes
		↓	
MESSAGE		CLEAR XCBR6 OpCnt: No	Range: No, Yes

The **CLEAR XCBR1 OpCnt** setting represents 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 may result in very large OpCnt values over time. This setting allows the OpCnt to be reset to "0" for XCBR1.

5

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 will not usually be forwarded by network routers. However, GOOSE messages may be fowarded by routers if the router has been configured for VLAN functionality.

h) WEB SERVER HTTP PROTOCOL

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

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

The C70 contains an embedded web server and is capable of transferring web pages to a web browser such as Microsoft Internet Explorer or Mozilla Firefox. This feature is available only if the C70 has the ethernet option installed. The web pages are organized as a series of menus that can be accessed starting at the C70 “Main Menu”. Web pages are available showing DNP and IEC 60870-5-104 points lists, Modbus registers, event records, fault reports, etc. The web pages can be accessed by connecting the UR and a computer to an ethernet network. The main menu will be displayed in the web browser on the computer simply by entering the IP address of the C70 into the “Address” box on the web browser.

i) TFTP PROTOCOL

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

■ TFTP PROTOCOL ■		TFTP MAIN UDP PORT NUMBER: 69	Range: 1 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 C70 over a network. The C70 operates as a TFTP server. TFTP client software is available from various sources, including Microsoft Windows NT. The `dir.txt` file obtained from the C70 contains a list and description of all available files (event records, oscillography, etc.).

j) IEC 60870-5-104 PROTOCOL

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

■ IEC 60870-5-104 ■ PROTOCOL		IEC 60870-5-104 FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE		IEC TCP PORT NUMBER: 2404	Range: 1 to 65535 in steps of 1
MESSAGE		■ IEC NETWORK ■ CLIENT ADDRESSES	
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 OTHER DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1

The C70 supports the IEC 60870-5-104 protocol. The C70 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 C70 maintains two sets of IEC 60870-5-104 data change buffers, no more than two masters should actively communicate with the C70 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 C70 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 C70 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 C70, the default thresholds will be in effect.

NOTE

The C70 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 will not be operational. When this setting is changed it will not become active until power to the relay has been cycled (off-to-on).

k) SNTP PROTOCOL

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

Menu	Key	Setting	Range
■ 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 C70 supports the Simple Network Time Protocol specified in RFC-2030. With SNTP, the C70 can obtain clock time over an Ethernet network. The C70 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. Both unicast and broadcast SNTP are supported.

If SNTP functionality is enabled at the same time as IRIG-B, the IRIG-B signal provides the time value to the C70 clock for as long as a valid signal is present. If the IRIG-B signal is removed, the time obtained from the SNTP server is used. If either SNTP or IRIG-B is enabled, the C70 clock value cannot be changed using the front panel keypad.

To use SNTP in unicast mode, **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 C70 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 C70 clock is closely synchronized with the SNTP/NTP server. It may take up to two minutes for the C70 to signal an SNTP self-test error if the server is offline.

To use SNTP in broadcast mode, set the **SNTP SERVER IP ADDR** setting to “0.0.0.0” and **SNTP FUNCTION** to “Enabled”. The C70 then listens to SNTP messages sent to the “all ones” broadcast address for the subnet. The C70 waits up to eighteen minutes (>1024 seconds) without receiving an SNTP broadcast message before signaling an SNTP self-test error.

The UR-series relays do not support the multicast or anycast SNTP functionality.

l) EGD PROTOCOL

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

Menu	Key	Setting
■ EGD PROTOCOL ■	◀▶	■ FAST PROD EXCH 1 ■ CONFIGURATION
MESSAGE	▲▼	■ SLOW PROD EXCH 1 ■ CONFIGURATION
MESSAGE	▲	■ SLOW PROD EXCH 2 ■ CONFIGURATION

SOFTWARE OPTION

The C70 Capacitor Bank Protection and Control System is provided with optional Ethernet Global Data (EGD) 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 Ethernet Global Data (EGD) protocol feature is not available if CPU Type E is ordered.

The relay supports one fast Ethernet Global Data (EGD) exchange and two slow EGD exchanges. There are 20 data items in the fast-produced EGD exchange and 50 data items in each slow-produced exchange.

Ethernet Global Data (EGD) is a suite of protocols used for the real-time transfer of data for display and control purposes. The relay can be configured to ‘produce’ EGD data exchanges, and other devices can be configured to ‘consume’ EGD data exchanges. The number of produced exchanges (up to three), the data items in each exchange (up to 50), and the exchange production rate can be configured.

EGD cannot be used to transfer data between UR-series relays. The relay supports EGD production only. An EGD exchange will not be transmitted unless the destination address is non-zero, and at least the first data item address is set to a valid Modbus register address. Note that the default setting value of “0” is considered invalid.

The settings menu for the fast EGD exchange is shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ EGD PROTOCOL ⇨ FAST PROD EXCH 1 CONFIGURATION

■ FAST PROD EXCH 1 ■ CONFIGURATION		EXCH 1 FUNCTION: Disable	*Range: Disable, Enable*
MESSAGE		EXCH 1 DESTINATION: 0.0.0.0	*Range: standard IP address*
MESSAGE		EXCH 1 DATA RATE: 1000 ms	*Range: 50 to 1000 ms in steps of 1*
MESSAGE		EXCH 1 DATA ITEM 1: 0	*Range: 0 to 65535 in steps of 1 (Modbus register address range)*
MESSAGE		EXCH 1 DATA ITEM 2: 0	*Range: 0 to 65535 in steps of 1 (Modbus register address range)*
MESSAGE		EXCH 1 DATA ITEM 3: 0	*Range: 0 to 65535 in steps of 1 (Modbus register address range)*
		↓	
MESSAGE		EXCH 1 DATA ITEM 20: 0	*Range: 0 to 65535 in steps of 1 (Modbus register address range)*

Fast exchanges (50 to 1000 ms) are generally used in control schemes. The C70 has one fast exchange (exchange 1) and two slow exchanges (exchange 2 and 3).

The settings menu for the slow EGD exchanges is shown below:

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ EGD PROTOCOL ⇨ SLOW PROD EXCH 1(2) CONFIGURATION

■ SLOW PROD EXCH 1 ■ CONFIGURATION		EXCH 1 FUNCTION: Disable	*Range: Disable, Enable*
MESSAGE		EXCH 1 DESTINATION: 0.0.0.0	*Range: standard IP address*
MESSAGE		EXCH 1 DATA RATE: 1000 ms	*Range: 500 to 1000 ms in steps of 1*
MESSAGE		EXCH 1 DATA ITEM 1: 0	*Range: 0 to 65535 in steps of 1 (Modbus register address range in decimal)*
MESSAGE		EXCH 1 DATA ITEM 2: 0	*Range: 0 to 65535 in steps of 1 (Modbus register address range in decimal)*
MESSAGE		EXCH 1 DATA ITEM 3: 0	*Range: 0 to 65535 in steps of 1 (Modbus register address range in decimal)*
		↓	
MESSAGE		EXCH 1 DATA ITEM 50: 0	*Range: 0 to 65535 in steps of 1 (Modbus register address range in decimal)*

Slow EGD exchanges (500 to 1000 ms) are generally used for the transfer and display of data items. The settings for the fast and slow exchanges are described below:

- **EXCH 1 DESTINATION**: This setting specifies the destination IP address of the produced EGD exchange. This is usually unicast or broadcast.
- **EXCH 1 DATA RATE**: This setting specifies the rate at which this EGD exchange is transmitted. If the setting is 50 ms, the exchange data will be updated and sent once every 50 ms. If the setting is 1000 ms, the exchange data will be updated and sent once per second. EGD exchange 1 has a setting range of 50 to 1000 ms. Exchanges 2 and 3 have a setting range of 500 to 1000 ms.

- **EXCH 1 DATA ITEM 1 to 20/50**: These settings specify the data items that are part of this EGD exchange. Almost any data from the C70 memory map can be configured to be included in an EGD exchange. The settings are the starting Modbus register address for the data item in decimal format. Refer to *Appendix B* for the complete Modbus memory map. Note that the Modbus memory map displays shows addresses in hexadecimal format. as such, it will be necessary to convert these values to decimal format before entering them as values for these setpoints.

  To select a data item to be part of an exchange, it is only necessary to choose the starting Modbus address of the item. That is, for items occupying more than one Modbus register (for example, 32 bit integers and floating point values), only the first Modbus address is required. The EGD exchange configured with these settings contains the data items up to the first setting that contains a Modbus address with no data, or 0. That is, if the first three settings contain valid Modbus addresses and the fourth is 0, the produced EGD exchange will contain three data items.

m) ETHERNET SWITCH

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ ETHERNET SWITCH

Menu		Display	Range
■ ETHERNET SWITCH ■	◁▷	SWITCH IP ADDRESS: 127.0.0.1	Range: *standard IP address format*
MESSAGE	△▽	SWITCH MODBUS TCP PORT NUMBER: 502	Range: *1 to 65535 in steps of 1*
MESSAGE	△▽	PORT 1 EVENTS: Disabled	Range: *Enabled, Disabled*
MESSAGE	△▽	PORT 2 EVENTS: Disabled	Range: *Enabled, Disabled*
		↓	
MESSAGE	△	PORT 6 EVENTS: Disabled	Range: *Enabled, Disabled*

These settings appear only if the C70 is ordered with an Ethernet switch module (type 2S or 2T).

The IP address and Modbus TCP port number for the Ethernet switch module are specified in this menu. These settings are used in advanced network configurations. Please consult the network administrator before making changes to these settings. The client software (EnerVista UR Setup, for example) is the preferred interface to configure these settings.

The **PORT 1 EVENTS** through **PORT 6 EVENTS** settings allow Ethernet switch module events to be logged in the event recorder.

5.2.5 MODBUS USER MAP

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ MODBUS USER MAP

Menu		Display	Range
■ 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 (this value must be converted from hex to decimal format). The corresponding value is displayed 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” will be displayed for all registers. Different **ADDRESS** values can be entered as required in any of the register positions.

5.2.6 REAL TIME CLOCK

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ REAL TIME CLOCK

Menu		Setting	Range
■ REAL TIME ■ CLOCK	◁▷	IRIG-B SIGNAL TYPE: None	Range: None, DC Shift, Amplitude Modulated
MESSAGE	△▽	REAL TIME CLOCK EVENTS: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	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: April	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: 2:00	Range: 0:00 to 23:00
MESSAGE	△▽	DST STOP MONTH: April	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: 2:00	Range: 0:00 to 23:00

The date and time can be synchronized a known time base and to other relays using an IRIG-B signal. It has the same accuracy as an electronic watch, approximately ±1 minute per month. If an IRIG-B signal is connected to the relay, only the current year needs to be entered. See the **COMMANDS ⇨⇩ SET DATE AND TIME** menu to manually set the relay clock.

The **REAL TIME CLOCK EVENTS** setting allows changes to the date and/or time to be captured in the event record.

The **LOCAL TIME OFFSET FROM UTC** setting is used to specify the local time zone offset from Universal Coordinated Time (Greenwich Mean Time) in hours. This setting has two uses. When the C70 is time synchronized with IRIG-B, or has no permanent time synchronization, the offset is used to calculate UTC time for IEC 61850 features. When the C70 is time synchronized with SNTP, the offset is used to determine the local time for the C70 clock, since SNTP provides UTC time.

The daylight savings time (DST) settings can be used to allow the C70 clock can follow the DST rules of the local time zone. Note that when IRIG-B time synchronization is active, the DST settings are ignored. The DST settings are used when the C70 is synchronized with SNTP, or when neither SNTP nor IRIG-B is used.

NOTE: Only timestamps in the event recorder and communications protocols are affected by the daylight savings time settings. The reported real-time clock value does not change.

5.2.7 USER-PROGRAMMABLE FAULT REPORTS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE FAULT REPORT ⇨ USER-PROGRAMMABLE FAULT REPORT 1(2)

		Display	Range
■ USER-PROGRAMMABLE ■ FAULT REPORT 1	◁▷	FAULT REPORT 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	PRE-FAULT 1 TRIGGER: Off	Range: FlexLogic™ operand
MESSAGE	△▽	FAULT 1 TRIGGER: Off	Range: FlexLogic™ operand
MESSAGE	△▽	FAULT REPORT 1 #1: Off	Range: Off, any actual value analog parameter
MESSAGE	△▽	FAULT REPORT 1 #2: Off	Range: Off, any actual value analog parameter
MESSAGE	△▽	FAULT REPORT 1 #3: Off	Range: Off, any actual value analog parameter
		↓	
MESSAGE	△	FAULT REPORT 1 #32: Off	Range: Off, any actual value analog parameter

When enabled, this function monitors the pre-fault trigger. The pre-fault data are stored in the memory for prospective creation of the fault report on the rising edge of the pre-fault trigger. The element waits for the fault trigger as long as the pre-fault trigger is asserted, but not shorter than 1 second. When the fault trigger occurs, the fault data is stored and the complete report is created. If the fault trigger does not occur within 1 second after the pre-fault trigger drops out, the element resets and no record is created.

The user programmable record contains the following information: the user-programmed relay name, detailed firmware revision (5.9x, for example) and relay model (C70), the date and time of trigger, the name of pre-fault trigger (a specific FlexLogic™ operand), the name of fault trigger (a specific FlexLogic™ operand), the active setting group at pre-fault trigger, the active setting group at fault trigger, pre-fault values of all programmed analog channels (one cycle before pre-fault trigger), and fault values of all programmed analog channels (at the fault trigger).

Each fault report is stored as a file to a maximum capacity of ten files. An eleventh trigger overwrites the oldest file. The EnerVista UR Setup software is required to view all captured data. A FAULT RPT TRIG event is automatically created when the report is triggered.

The relay includes two user-programmable fault reports to enable capture of two types of trips (for example, trip from thermal protection with the report configured to include temperatures, and short-circuit trip with the report configured to include voltages and currents). Both reports feed the same report file queue.

The last record is available as individual data items via communications protocols.

- **PRE-FAULT 1 TRIGGER:** Specifies the FlexLogic™ operand to capture the pre-fault data. The rising edge of this operand stores one cycle-old data for subsequent reporting. The element waits for the fault trigger to actually create a record as long as the operand selected as **PRE-FAULT 1 TRIGGER** is "On". If the operand remains "Off" for 1 second, the element resets and no record is created.
- **FAULT 1 TRIGGER:** Specifies the FlexLogic™ operand to capture the fault data. The rising edge of this operand stores the data as fault data and results in a new report. The trigger (not the pre-fault trigger) controls the date and time of the report.
- **FAULT REPORT 1 #1** to **FAULT REPORT 1 #32:** These settings specify an actual value such as voltage or current magnitude, true RMS, phase angle, frequency, temperature, etc., to be stored should the report be created. Up to 32 channels can be configured. Two reports are configurable to cope with variety of trip conditions and items of interest.

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.

Table 5–2: OSCILLOGRAPHY CYCLES/RECORD EXAMPLE

RECORDS	CT/VTS	SAMPLE RATE	DIGITALS	ANALOGS	CYCLES/ RECORD
1	1	8	0	0	1872.0
1	1	16	16	0	1685.0
8	1	16	16	0	276.0
8	1	16	16	4	219.5
8	2	16	16	4	93.5
8	2	16	63	16	93.5
8	2	32	63	16	57.6
8	2	64	63	16	32.3
32	2	64	63	16	9.5

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.

WARNING

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

Menu		Setting	Range
■ 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

Menu		Setting	Range
■ 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.

NOTE

The source harmonic indices appear as oscillography analog channels numbered from 0 to 23. These correspond directly to the to the 2nd to 25th harmonics in the relay as follows:

Analog channel 0 ↔ 2nd harmonic
Analog channel 1 ↔ 3rd harmonic
...
Analog channel 23 ↔ 25th harmonic

5.2.9 DATA LOGGER

PATH: SETTINGS ⇨⇩ PRODUCT SETUP ⇨⇩ DATA LOGGER

■ 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 5–3: 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.

5

- **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 5-47.
MESSAGE	▲▼	■ USER-PROGRAMMABLE ■ LED 1	See page 5-47.
MESSAGE	▲▼	■ USER-PROGRAMMABLE ■ LED 2	
		↓	
MESSAGE	▲	■ USER-PROGRAMMABLE ■ LED 48	

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.

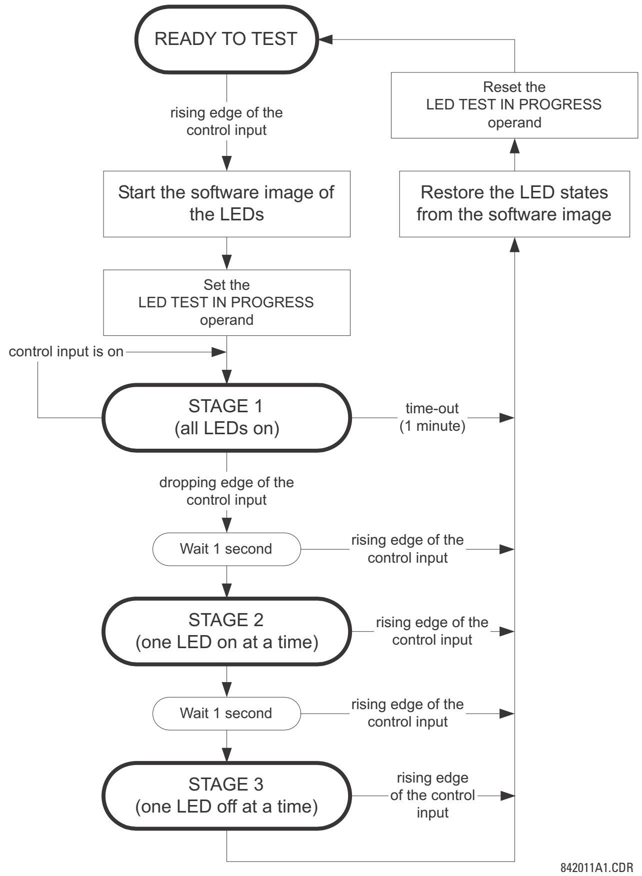

Figure 5–3: LED TEST SEQUENCE

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.

c) TRIP AND ALARM LEDS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE LEDS ⇨⇩ TRIP & ALARM LEDS

■ TRIP & ALARM LEDS ■		TRIP LED INPUT: Off	Range: FlexLogic™ operand
	MESSAGE	ALARM LED INPUT: Off	Range: FlexLogic™ operand

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		LED 1 OPERAND: Off	Range: FlexLogic™ operand
	MESSAGE	LED 1 TYPE: Self-Reset	Range: Self-Reset, Latched

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 5–4: 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	Off
LED 3 operand	SETTING GROUP ACT 3	LED 15 operand	Off
LED 4 operand	SETTING GROUP ACT 4	LED 16 operand	Off
LED 5 operand	SETTING GROUP ACT 5	LED 17 operand	Off
LED 6 operand	SETTING GROUP ACT 6	LED 18 operand	Off
LED 7 operand	Off	LED 19 operand	Off
LED 8 operand	Off	LED 20 operand	Off
LED 9 operand	Off	LED 21 operand	Off
LED 10 operand	Off	LED 22 operand	Off
LED 11 operand	Off	LED 23 operand	Off
LED 12 operand	Off	LED 24 operand	Off

Refer to the *Control of setting groups* example in the *Control elements* section of this chapter for group activation.

5.2.11 USER-PROGRAMMABLE SELF TESTS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE SELF TESTS

■ USER-PROGRAMMABLE ■ SELF TESTS	DIRECT RING BREAK FUNCTION: Enabled	*Range: Disabled, Enabled. Valid for units equipped with Direct Input/Output module.*
MESSAGE	DIRECT DEVICE OFF FUNCTION: Enabled	*Range: Disabled, Enabled. Valid for units equipped with Direct Input/Output module.*
MESSAGE	REMOTE DEVICE OFF FUNCTION: Enabled	*Range: Disabled, Enabled. Valid for units that contain a CPU with Ethernet capability.*
MESSAGE	PRI. ETHERNET FAIL FUNCTION: Disabled	*Range: Disabled, Enabled. Valid for units that contain a CPU with a primary fiber port.*
MESSAGE	SEC. ETHERNET FAIL FUNCTION: Disabled	*Range: Disabled, Enabled. Valid for units that contain a CPU with a redundant fiber port.*
MESSAGE	BATTERY FAIL FUNCTION: Enabled	*Range: Disabled, Enabled.*
MESSAGE	SNTP FAIL FUNCTION: Enabled	*Range: Disabled, Enabled. Valid for units that contain a CPU with Ethernet capability.*
MESSAGE	IRIG-B FAIL FUNCTION: Enabled	*Range: Disabled, Enabled.*
MESSAGE	ETHERNET SWITCH 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 5–4: CONTROL PUSHBUTTONS (ENHANCED FACEPLATE)

An additional four control pushbuttons are included on the standard faceplate when the C70 is ordered with the twelve user-programmable pushbutton option.

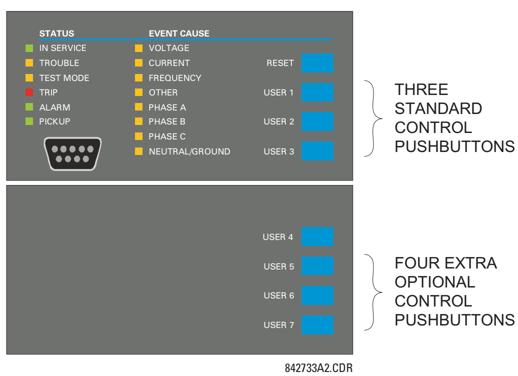

Figure 5–5: CONTROL PUSHBUTTONS (STANDARD FACEPLATE)

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.

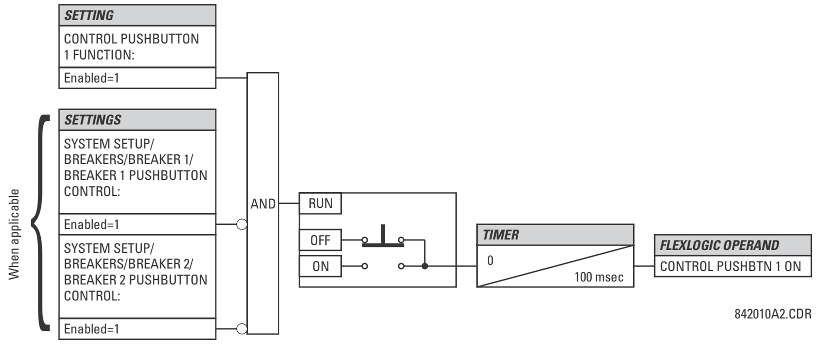

Figure 5–6: CONTROL PUSHBUTTON LOGIC

5.2.13 USER-PROGRAMMABLE PUSHBUTTONS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE PUSHBUTTONS ⇨ USER PUSHBUTTON 1(16)

	Display	Range
■ 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

5

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.

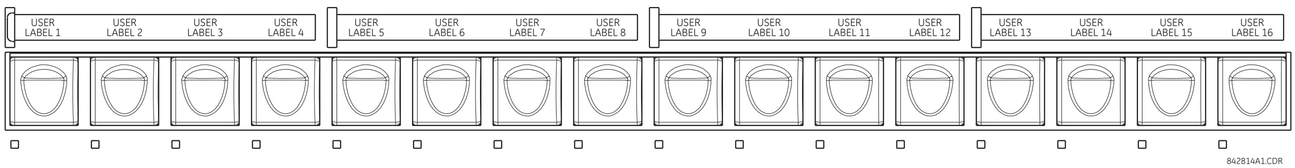

Figure 5–7: USER-PROGRAMMABLE PUSHBUTTONS (ENHANCED FACEPLATE)

The user-configurable pushbuttons for the standard faceplate are shown below.

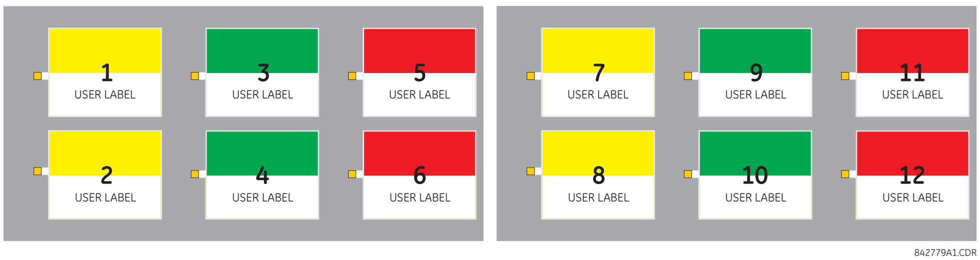

Figure 5–8: USER-PROGRAMMABLE PUSHBUTTONS (STANDARD FACEPLATE)

Both the standard and enhanced faceplate pushbuttons can be custom labeled with a factory-provided template, available online at http://www.GEmultilin.com. 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.

5

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.

- **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 pushbutton 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.

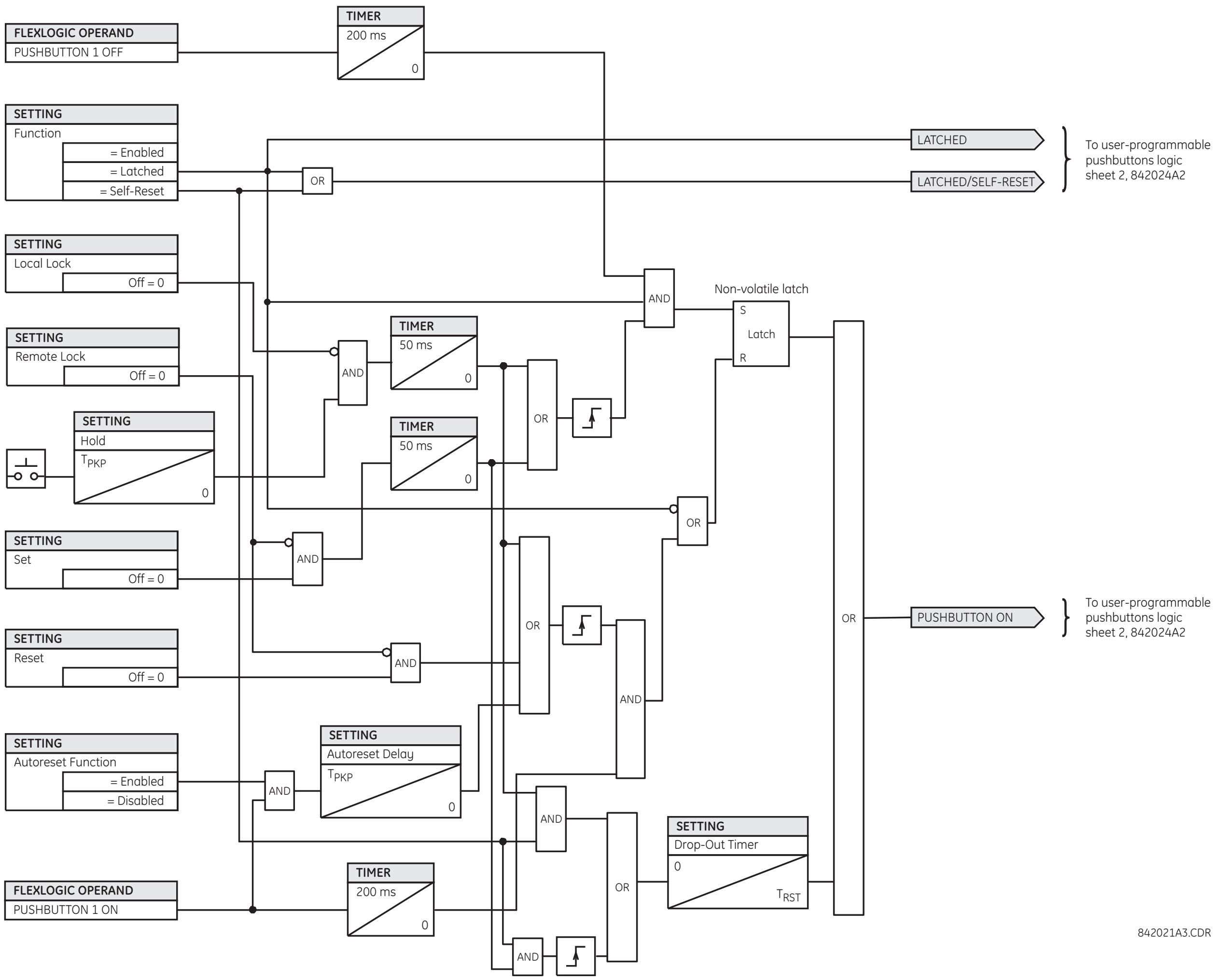

Figure 5–9: USER-PROGRAMMABLE PUSHBUTTON LOGIC (Sheet 1 of 2)

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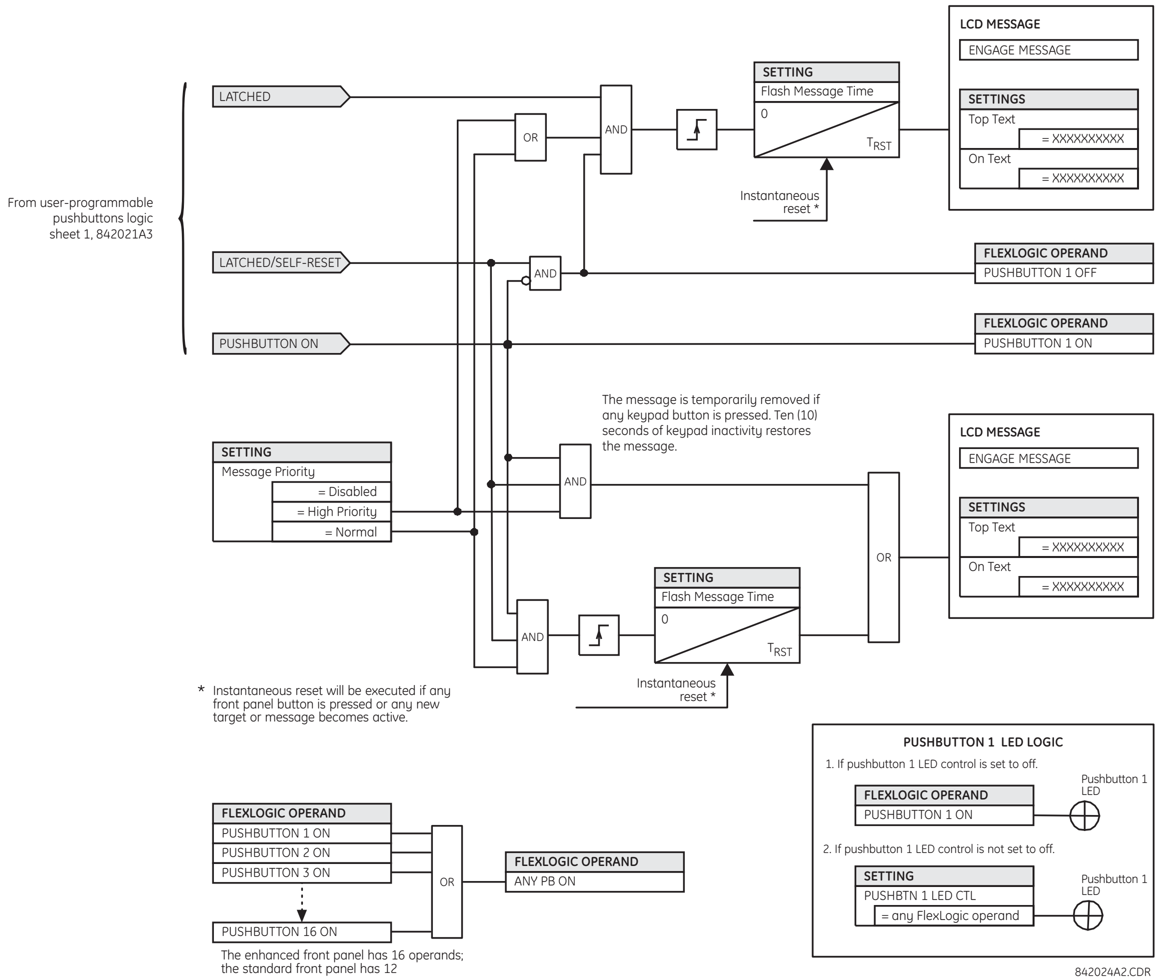

Figure 5–10: USER-PROGRAMMABLE PUSHBUTTON LOGIC (Sheet 2 of 2)

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(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 DIRECT INPUTS AND OUTPUTS

a) MAIN MENU

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ DIRECT I/O

■ DIRECT I/O ■	DIRECT OUTPUT DEVICE ID: 1	*Range: 1 to 16*
MESSAGE	DIRECT I/O CH1 RING CONFIGURATION: Yes	*Range: Yes, No*
MESSAGE	DIRECT I/O CH2 RING CONFIGURATION: Yes	*Range: Yes, No*
MESSAGE	DIRECT I/O DATA RATE: 64 kbps	*Range: 64 kbps, 128 kbps*
MESSAGE	DIRECT I/O CHANNEL CROSSOVER: Disabled	*Range: Disabled, Enabled*
MESSAGE	■ CRC ALARM CH1 ■	See page 5-64.
MESSAGE	■ CRC ALARM CH2 ■	See page 5-64.
MESSAGE	■ UNRETURNED ■ MESSAGES ALARM CH1	See page 5-65.
MESSAGE	■ UNRETURNED ■ MESSAGES ALARM CH2	See page 5-65.

Direct inputs and outputs are intended for exchange of status information (inputs and outputs) between UR-series relays connected directly via type 7 digital communications cards. The mechanism is very similar to IEC 61850 GSSE, except that communications takes place over a non-switchable isolated network and is optimized for speed. On type 7 cards that support two channels, direct output messages are sent from both channels simultaneously. This effectively sends direct output messages both ways around a ring configuration. On type 7 cards that support one channel, direct output messages are sent only in one direction. Messages will be resent (forwarded) when it is determined that the message did not originate at the receiver.

Direct output message timing is similar to GSSE message timing. Integrity messages (with no state changes) are sent at least every 1000 ms. Messages with state changes are sent within the main pass scanning the inputs and asserting the outputs unless the communication channel bandwidth has been exceeded. Two self-tests are performed and signaled by the following FlexLogic™ operands:

1. DIRECT RING BREAK (direct input/output ring break). This FlexLogic™ operand indicates that direct output messages sent from a UR-series relay are not being received back by the relay.
2. DIRECT DEVICE 1 OFF to DIRECT DEVICE 16 OFF (direct device offline). These FlexLogic™ operands indicate that direct output messages from at least one direct device are not being received.

Direct input and output settings are similar to remote input and output settings. The equivalent of the remote device name strings for direct inputs and outputs is the **DIRECT OUTPUT DEVICE ID**. The **DIRECT OUTPUT DEVICE ID** setting identifies the relay in all direct output messages. All UR-series IEDs in a ring should have unique numbers assigned. The IED ID is used to identify the sender of the direct input and output message.

If the direct input and output scheme is configured to operate in a ring (**DIRECT I/O CH1 RING CONFIGURATION** or **DIRECT I/O CH2 RING CONFIGURATION** is “Yes”), all direct output messages should be received back. If not, the direct input/output ring break self-test is triggered. The self-test error is signaled by the DIRECT RING BREAK FlexLogic™ operand.

Select the **DIRECT I/O DATA RATE** to match the data capabilities of the communications channel. All IEDs communicating over direct inputs and outputs must be set to the same data rate. UR-series IEDs equipped with dual-channel communications cards apply the same data rate to both channels. Delivery time for direct input and output messages is approximately 0.2 of a power system cycle at 128 kbps and 0.4 of a power system cycle at 64 kbps, per each ‘bridge’.

Table 5–5: DIRECT INPUT AND OUTPUT DATA RATES

MODULE	CHANNEL	SUPPORTED DATA RATES
74	Channel 1	64 kbps
	Channel 2	64 kbps
7L	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
7M	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
7P	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
7T	Channel 1	64 kbps, 128 kbps
7W	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
7V	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
2A	Channel 1	64 kbps
2B	Channel 1	64 kbps
	Channel 2	64 kbps
2G	Channel 1	128 kbps
2H	Channel 1	128 kbps
76	Channel 1	64 kbps
77	Channel 1	64 kbps
	Channel 2	64 kbps
75	Channel 1	64 kbps
	Channel 2	64 kbps
7E	Channel 1	64 kbps
	Channel 2	64 kbps
7F	Channel 1	64 kbps
	Channel 2	64 kbps
7G	Channel 1	64 kbps
	Channel 2	64 kbps
7Q	Channel 1	64 kbps
	Channel 2	64 kbps
7R	Channel 1	64 kbps
7S	Channel 1	64 kbps
	Channel 2	64 kbps

NOTE

The G.703 modules are fixed at 64 kbps. The **DIRECT I/O DATA RATE** setting is not applicable to these modules.

The **DIRECT I/O CHANNEL CROSSOVER** setting applies to C70s with dual-channel communication cards and allows crossing over messages from channel 1 to channel 2. This places all UR-series IEDs into one direct input and output network regardless of the physical media of the two communication channels.

The following application examples illustrate the basic concepts for direct input and output configuration. Please refer to the *Inputs and outputs* section in this chapter for information on configuring FlexLogic™ operands (flags, bits) to be exchanged.

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Example 1: Extending the input/output capabilities of a UR-series relay

Consider an application that requires additional quantities of digital inputs or output contacts or lines of programmable logic that exceed the capabilities of a single UR-series chassis. The problem is solved by adding an extra UR-series IED, such as the C30, to satisfy the additional input and output and programmable logic requirements. The two IEDs are connected via single-channel digital communication cards as shown in the figure below.

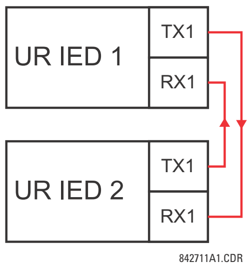

Figure 5–11: INPUT AND OUTPUT EXTENSION VIA DIRECT INPUTS AND OUTPUTS

In the above application, the following settings should be applied. For UR-series IED 1:

DIRECT OUTPUT DEVICE ID: “1”
DIRECT I/O CH1 RING CONFIGURATION: “Yes”
DIRECT I/O DATA RATE: “128 kbps”

For UR-series IED 2:

DIRECT OUTPUT DEVICE ID: “2”
DIRECT I/O CH1 RING CONFIGURATION: “Yes”
DIRECT I/O DATA RATE: “128 kbps”

The message delivery time is about 0.2 of power cycle in both ways (at 128 kbps); that is, from device 1 to device 2, and from device 2 to device 1. Different communications cards can be selected by the user for this back-to-back connection (for example: fiber, G.703, or RS422).

Example 2: Interlocking busbar protection

A simple interlocking busbar protection scheme could be accomplished by sending a blocking signal from downstream devices, say 2, 3, and 4, to the upstream device that monitors a single incomer of the busbar, as shown below.

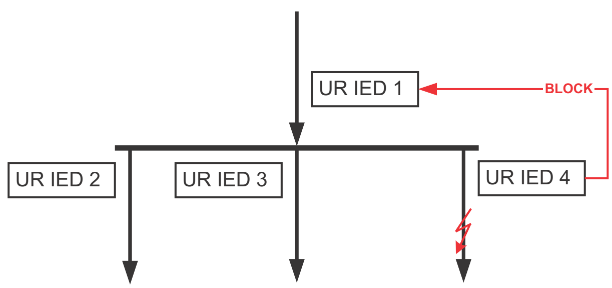

Figure 5–12: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME

For increased reliability, a dual-ring configuration (shown below) is recommended for this application.

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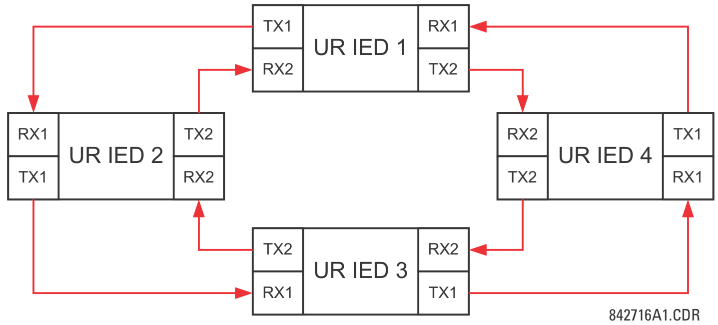

Figure 5–13: INTERLOCKING BUS PROTECTION SCHEME VIA DIRECT INPUTS/OUTPUTS

In the above application, the following settings should be applied. For UR-series IED 1:

DIRECT OUTPUT DEVICE ID: “1”
DIRECT I/O CH1 RING CONFIGURATION: “Yes”
DIRECT I/O CH2 RING CONFIGURATION: “Yes”

For UR-series IED 2:

DIRECT OUTPUT DEVICE ID: “1”
DIRECT I/O CH1 RING CONFIGURATION: “Yes”
DIRECT I/O CH2 RING CONFIGURATION: “Yes”

For UR-series IED 3:

DIRECT OUTPUT DEVICE ID: “1”
DIRECT I/O CH1 RING CONFIGURATION: “Yes”
DIRECT I/O CH2 RING CONFIGURATION: “Yes”

For UR-series IED 4:

DIRECT OUTPUT DEVICE ID: “1”
DIRECT I/O CH1 RING CONFIGURATION: “Yes”
DIRECT I/O CH2 RING CONFIGURATION: “Yes”

Message delivery time is approximately 0.2 of power system cycle (at 128 kbps) times number of ‘bridges’ between the origin and destination. Dual-ring configuration effectively reduces the maximum ‘communications distance’ by a factor of two.

In this configuration the following delivery times are expected (at 128 kbps) if both rings are healthy:

IED 1 to IED 2: 0.2 of power system cycle;
IED 1 to IED 3: 0.4 of power system cycle;
IED 1 to IED 4: 0.2 of power system cycle;
IED 2 to IED 3: 0.2 of power system cycle;
IED 2 to IED 4: 0.4 of power system cycle;
IED 3 to IED 4: 0.2 of power system cycle.

If one ring is broken (say TX2-RX2) the delivery times are as follows:

IED 1 to IED 2: 0.2 of power system cycle;
IED 1 to IED 3: 0.4 of power system cycle;
IED 1 to IED 4: 0.6 of power system cycle;
IED 2 to IED 3: 0.2 of power system cycle;
IED 2 to IED 4: 0.4 of power system cycle;
IED 3 to IED 4: 0.2 of power system cycle.

A coordinating timer for this bus protection scheme could be selected to cover the worst case scenario (0.4 of a power system cycle). Upon detecting a broken ring, the coordination time should be adaptively increased to 0.6 of a power system cycle. The complete application requires addressing a number of issues such as failure of both the communications rings, failure or out-of-service conditions of one of the relays, etc. Self-monitoring flags of the direct inputs and outputs feature would be primarily used to address these concerns.

Example 3: Pilot-Aided Schemes

Consider the three-terminal line protection application shown below:

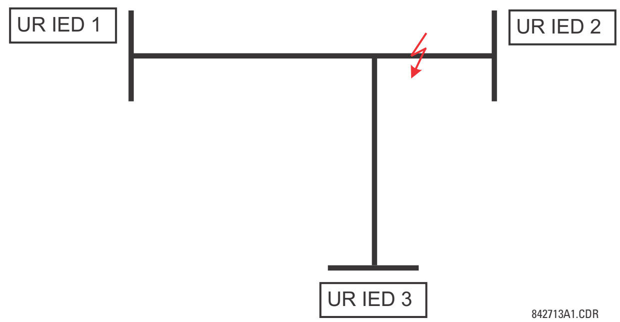

Figure 5–14: THREE-TERMINAL LINE APPLICATION

A permissive pilot-aided scheme could be implemented in a two-ring configuration as shown below (IEDs 1 and 2 constitute a first ring, while IEDs 2 and 3 constitute a second ring):

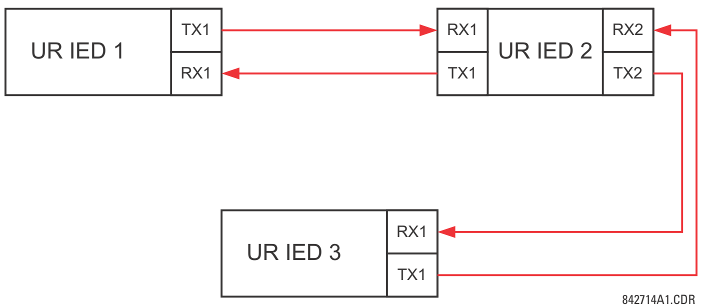

Figure 5–15: SINGLE-CHANNEL OPEN LOOP CONFIGURATION

In the above application, the following settings should be applied. For UR-series IED 1:

DIRECT OUTPUT DEVICE ID: "1"
DIRECT I/O CH1 RING CONFIGURATION: "Yes"
DIRECT I/O CH2 RING CONFIGURATION: "Yes"

For UR-series IED 2:

DIRECT OUTPUT DEVICE ID: "1"
DIRECT I/O CH1 RING CONFIGURATION: "Yes"
DIRECT I/O CH2 RING CONFIGURATION: "Yes"

For UR-series IED 3:

DIRECT OUTPUT DEVICE ID: "1"
DIRECT I/O CH1 RING CONFIGURATION: "Yes"
DIRECT I/O CH2 RING CONFIGURATION: "Yes"

In this configuration the following delivery times are expected (at 128 kbps):

IED 1 to IED 2: 0.2 of power system cycle;
IED 1 to IED 3: 0.5 of power system cycle;
IED 2 to IED 3: 0.2 of power system cycle.

In the above scheme, IEDs 1 and 3 do not communicate directly. IED 2 must be configured to forward the messages as explained in the *Inputs and outputs* section. A blocking pilot-aided scheme should be implemented with more security and, ideally, faster message delivery time. This could be accomplished using a dual-ring configuration as shown below.

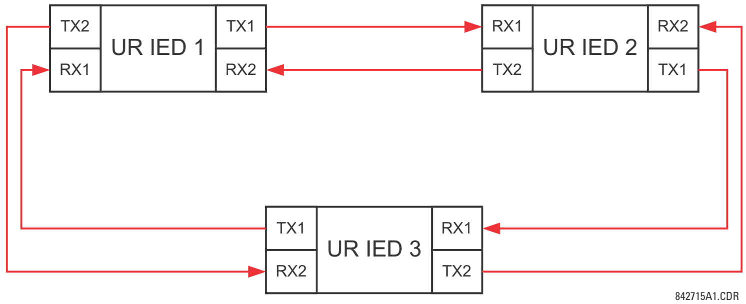

Figure 5–16: DUAL-CHANNEL CLOSED LOOP (DUAL-RING) CONFIGURATION

In the above application, the following settings should be applied. For UR-series IED 1:

DIRECT OUTPUT DEVICE ID: "1"
DIRECT I/O CH1 RING CONFIGURATION: "Yes"
DIRECT I/O CH2 RING CONFIGURATION: "Yes"

For UR-series IED 2:

DIRECT OUTPUT DEVICE ID: "1"
DIRECT I/O CH1 RING CONFIGURATION: "Yes"
DIRECT I/O CH2 RING CONFIGURATION: "Yes"

For UR-series IED 3:

DIRECT OUTPUT DEVICE ID: "1"
DIRECT I/O CH1 RING CONFIGURATION: "Yes"
DIRECT I/O CH2 RING CONFIGURATION: "Yes"

In this configuration the following delivery times are expected (at 128 kbps) if both the rings are healthy:

IED 1 to IED 2: 0.2 of power system cycle;
IED 1 to IED 3: 0.2 of power system cycle;
IED 2 to IED 3: 0.2 of power system cycle.

The two communications configurations could be applied to both permissive and blocking schemes. Speed, reliability and cost should be taken into account when selecting the required architecture.

b) CRC ALARM CH1(2)

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ DIRECT I/O ⇨⇩ CRC ALARM CH1(2)

■ CRC ALARM CH1 ■		CRC ALARM CH1 FUNCTION: Disabled	*Range: Enabled, Disabled*
MESSAGE		CRC ALARM CH1 MESSAGE COUNT: 600	*Range: 100 to 10000 in steps of 1*
MESSAGE		CRC ALARM CH1 THRESHOLD: 10	*Range: 1 to 1000 in steps of 1*
MESSAGE		CRC ALARM CH1 EVENTS: Disabled	*Range: Enabled, Disabled*

The C70 checks integrity of the incoming direct input and output messages using a 32-bit CRC. The CRC alarm function is available for monitoring the communication medium noise by tracking the rate of messages failing the CRC check. The monitoring function counts all incoming messages, including messages that failed the CRC check. A separate counter adds up messages that failed the CRC check. When the failed CRC counter reaches the user-defined level specified by the **CRC ALARM CH1 THRESHOLD** setting within the user-defined message count **CRC ALARM 1 CH1 COUNT**, the DIR IO CH1 CRC ALARM FlexLogic™ operand is set.

When the total message counter reaches the user-defined maximum specified by the **CRC ALARM CH1 MESSAGE COUNT** setting, both the counters reset and the monitoring process is restarted.

The operand shall be configured to drive an output contact, user-programmable LED, or selected communication-based output. Latching and acknowledging conditions - if required - should be programmed accordingly.

The CRC alarm function is available on a per-channel basis. The total number of direct input and output messages that failed the CRC check is available as the **ACTUAL VALUES ⇨ STATUS ⇨⇩ DIRECT INPUTS ⇨⇩ CRC FAIL COUNT CH1** actual value.

- *Message count and length of the monitoring window*: To monitor communications integrity, the relay sends 1 message per second (at 64 kbps) or 2 messages per second (128 kbps) even if there is no change in the direct outputs. For example, setting the **CRC ALARM CH1 MESSAGE COUNT** to “10000”, corresponds a time window of about 160 minutes at 64 kbps and 80 minutes at 128 kbps. If the messages are sent faster as a result of direct outputs activity, the monitoring time interval will shorten. This should be taken into account when determining the **CRC ALARM CH1 MESSAGE COUNT** setting. For example, if the requirement is a maximum monitoring time interval of 10 minutes at 64 kbps, then the **CRC ALARM CH1 MESSAGE COUNT** should be set to 10 × 60 × 1 = 600.
- *Correlation of failed CRC and bit error rate (BER)*: The CRC check may fail if one or more bits in a packet are corrupted. Therefore, an exact correlation between the CRC fail rate and the BER is not possible. Under certain assumptions an approximation can be made as follows. A direct input and output packet containing 20 bytes results in 160 bits of data being sent and therefore, a transmission of 63 packets is equivalent to 10,000 bits. A BER of 10^{-4} implies 1 bit error for every 10000 bits sent or received. Assuming the best case of only 1 bit error in a failed packet, having 1 failed packet for every 63 received is about equal to a BER of 10^{-4}.

c) UNRETURNED MESSAGES ALARM CH1(2)

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ DIRECT I/O ⇨⇩ UNRETURNED MESSAGES ALARM CH1(2)

■ UNRETURNED ■ MESSAGES ALARM CH1	◀▶	UNRET MSGS ALARM CH1 FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE	▲▼	UNRET MSGS ALARM CH1 MESSAGE COUNT: 600	Range: 100 to 10000 in steps of 1
MESSAGE	▲▼	UNRET MSGS ALARM CH1 THRESHOLD: 10	Range: 1 to 1000 in steps of 1
MESSAGE	▲	UNRET MSGS ALARM CH1 EVENTS: Disabled	Range: Enabled, Disabled

The C70 checks integrity of the direct input and output communication ring by counting unreturned messages. In the ring configuration, all messages originating at a given device should return within a pre-defined period of time. The unreturned messages alarm function is available for monitoring the integrity of the communication ring by tracking the rate of unreturned messages. This function counts all the outgoing messages and a separate counter adds the messages have failed to return. When the unreturned messages counter reaches the user-definable level specified by the **UNRET MSGS ALARM CH1 THRESHOLD** setting and within the user-defined message count **UNRET MSGS ALARM CH1 COUNT**, the DIR IO CH1 UNRET ALM FlexLogic™ operand is set.

When the total message counter reaches the user-defined maximum specified by the **UNRET MSGS ALARM CH1 MESSAGE COUNT** setting, both the counters reset and the monitoring process is restarted.

The operand shall be configured to drive an output contact, user-programmable LED, or selected communication-based output. Latching and acknowledging conditions, if required, should be programmed accordingly.

The unreturned messages alarm function is available on a per-channel basis and is active only in the ring configuration. The total number of unreturned input and output messages is available as the **ACTUAL VALUES ⇨ STATUS ⇨⇩ DIRECT INPUTS ⇨⇩ UNRETURNED MSG COUNT CH1** actual value.

5

5.2.17 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. This name is also used to identify specific devices which are engaged in automatically sending/receiving data over the Ethernet communications channel using the IEC 61850 protocol.

5.3.1 REMOTE RESOURCES CONFIGURATION

When C70 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 configuring HardFiber system.

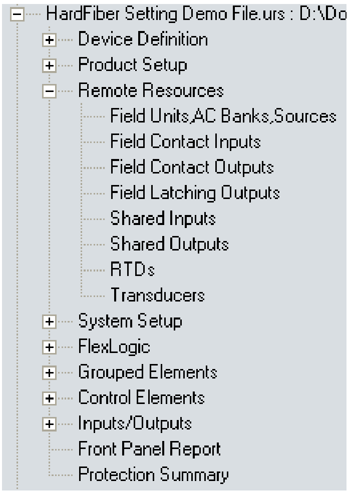

Figure 5–17: REMOTE RESOURCES CONFIGURATION MENU

The remote resources settings configure a C70 with a process bus module to work with devices called *Bricks*. Remote resources configuration is only available through the EnerVista UR Setup software, and is not available through the C70 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 C70 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 C70 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 C70 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, please refer to GE publication number GEK-113500: HardFiber System Instruction Manual.

5.4.1 AC INPUTS

a) CURRENT BANKS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨ CURRENT BANK F1(U5)

■ 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

Six 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**, **M**, **U**} 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 If the following current banks:

- F1: CT bank with 500:1 ratio.
- F5: CT bank with 1000: ratio.
- M1: CT bank with 800:1 ratio.

The following rule applies:

$$\text{SRC 1} = \text{F1} + \text{F5} + \text{M1} \quad \textbf{(EQ 5.6)}$$

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).

b) VOLTAGE BANKS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨⇩ VOLTAGE BANK F5(U5)

		Display	Range
■ 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*

Three 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**, **M**, **U**} 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.

NOTE

If the **PHASE VT F5 CONNECTION** is set to "Delta", the relay will not calculate voltage harmonics.

5.4.2 POWER SYSTEM

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ POWER SYSTEM

		Display	Range
■ 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. These results in very precise correlation of time tagging in the event recorder between different UR-series relays provided the relays have an IRIG-B connection.

NOTE

FREQUENCY TRACKING should only be set to **"**Disabled**"** in very unusual circumstances; consult the factory for special variable-frequency applications.

NOTE

The frequency tracking feature will function only when the C70 is in the “Programmed” mode. If the C70 is “Not Programmed”, then metering values will be available but may exhibit significant errors.

5.4.3 SIGNAL SOURCES

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES ⇨ SOURCE 1(6)

■ 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, M5, U5 Only phase voltage inputs will be displayed.*
	MESSAGE	SOURCE 1 AUX VT: None	*Range: None, F5, M5, U5 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 intended for use in conjunction with measuring elements, blocking of current based elements (to prevent maloperation as a result of the wrong settings), and starting oscillography data capture. 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:

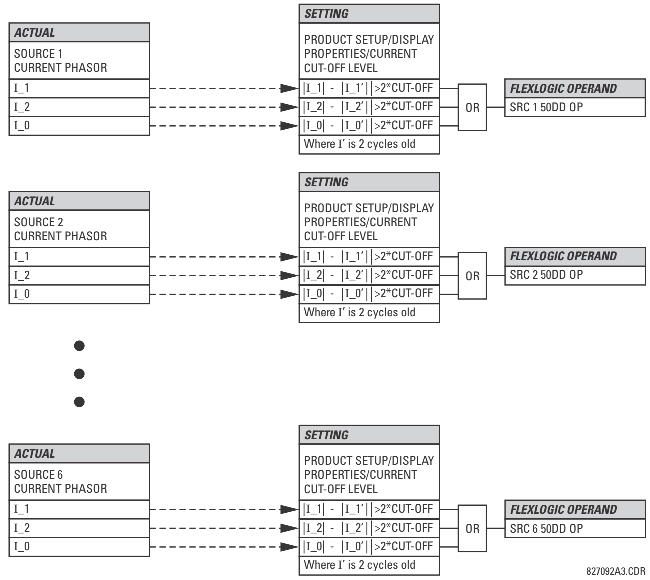

Figure 5–18: DISTURBANCE DETECTOR LOGIC DIAGRAM

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.

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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	CTs	VTs

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.

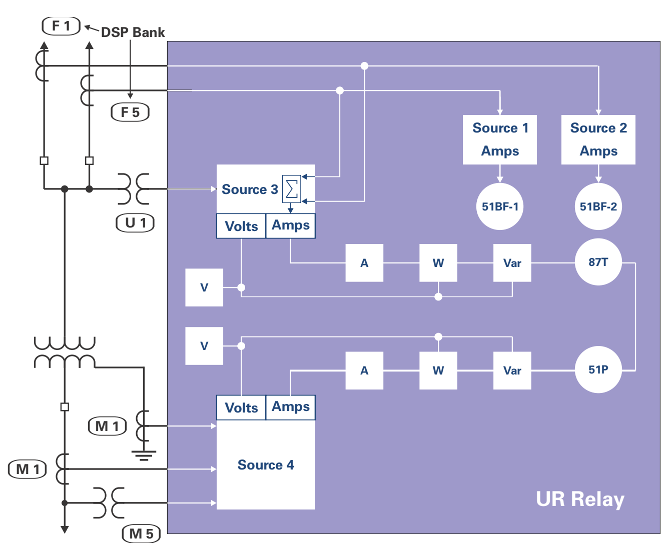

Figure 5–19: EXAMPLE USE OF SOURCES

5.4.4 BREAKERS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ BREAKERS ⇨ BREAKER 1

■ 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

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 C70. 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.

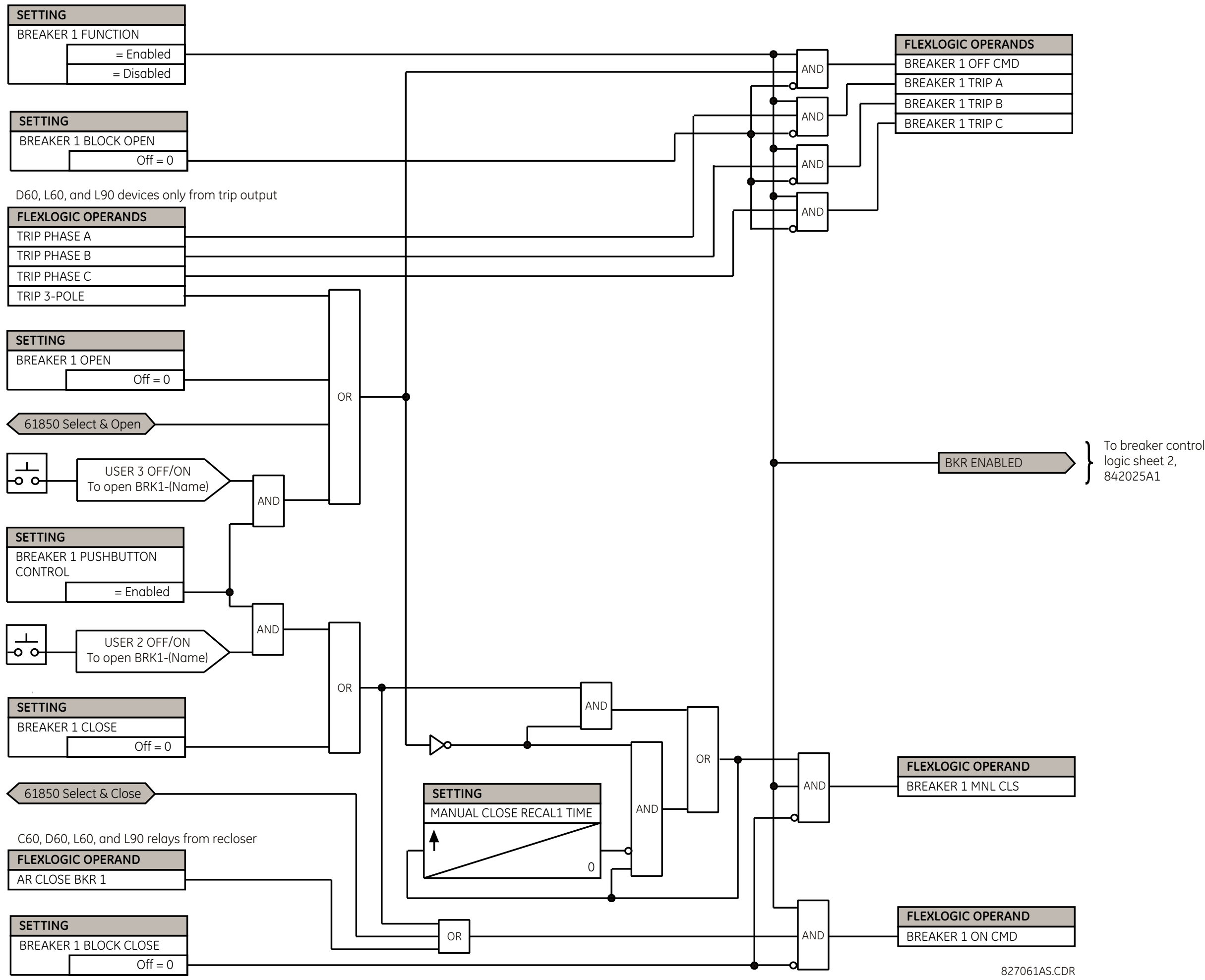

Figure 5–20: DUAL BREAKER CONTROL SCHEME LOGIC (Sheet 1 of 2)

NOTE

IEC 61850 functionality is permitted when the C70 is in "Programmed" mode and not in the local control mode.

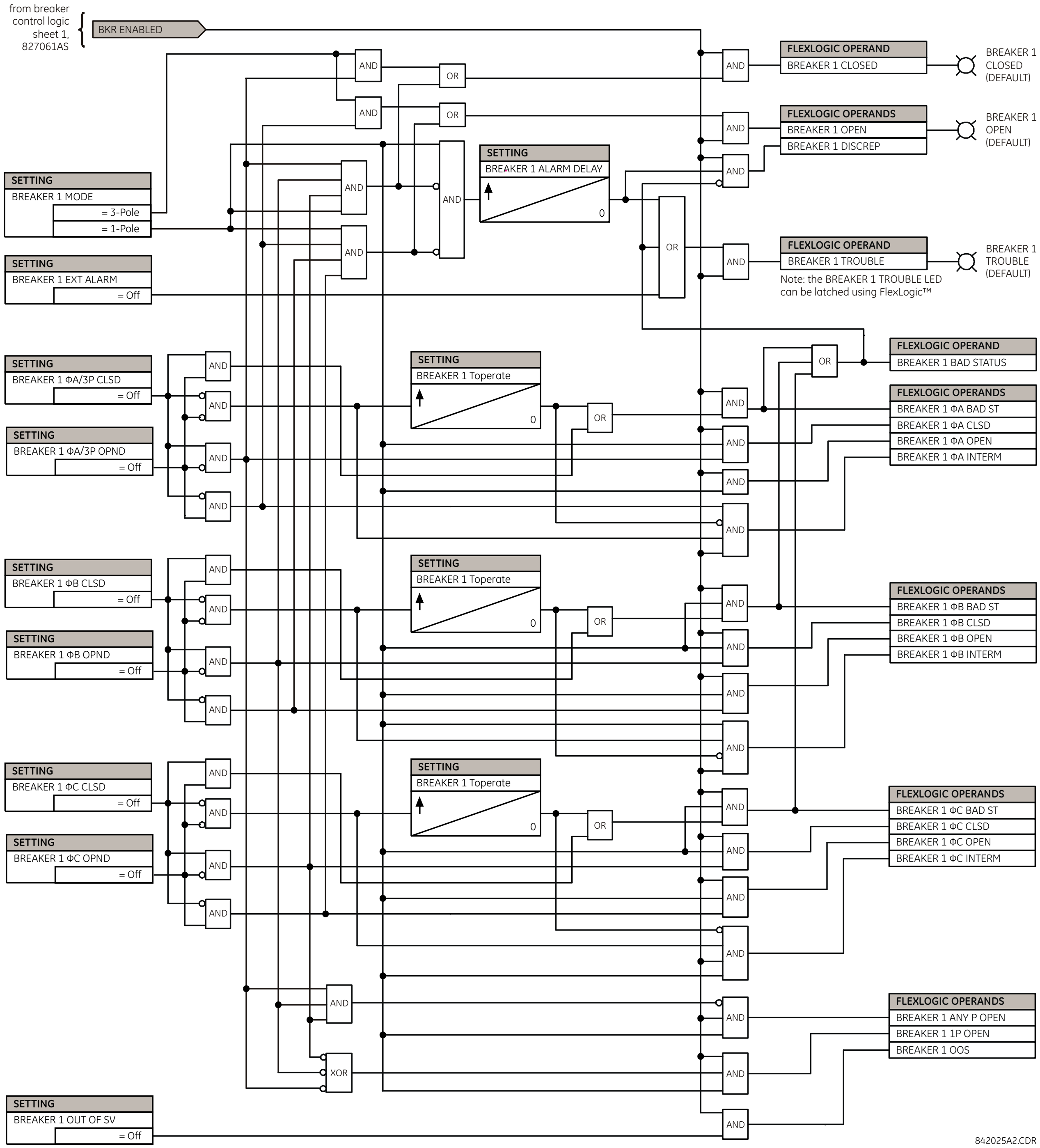

Figure 5–21: DUAL BREAKER CONTROL SCHEME LOGIC (Sheet 2 of 2)

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5.4.5 DISCONNECT SWITCHES

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SWITCHES ⇨ SWITCH 1

	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 52/a and 52/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 C70.

- **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 all disconnect switch poles are operated simultaneously, or “1-Pole” mode where all disconnect switch poles are operated either independently or simultaneously.

- **SWITCH 1 OPEN:** This setting selects an operand that creates a programmable signal to operate an output relay 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 an output relay 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 52/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.
- **SWITCH 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 disconnect switch is open. If a separate 52/b contact input is not available, then the inverted SWITCH 1 CLOSED 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 52/a and 52/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 C70 is in “Programmed” mode and not in the local control mode.

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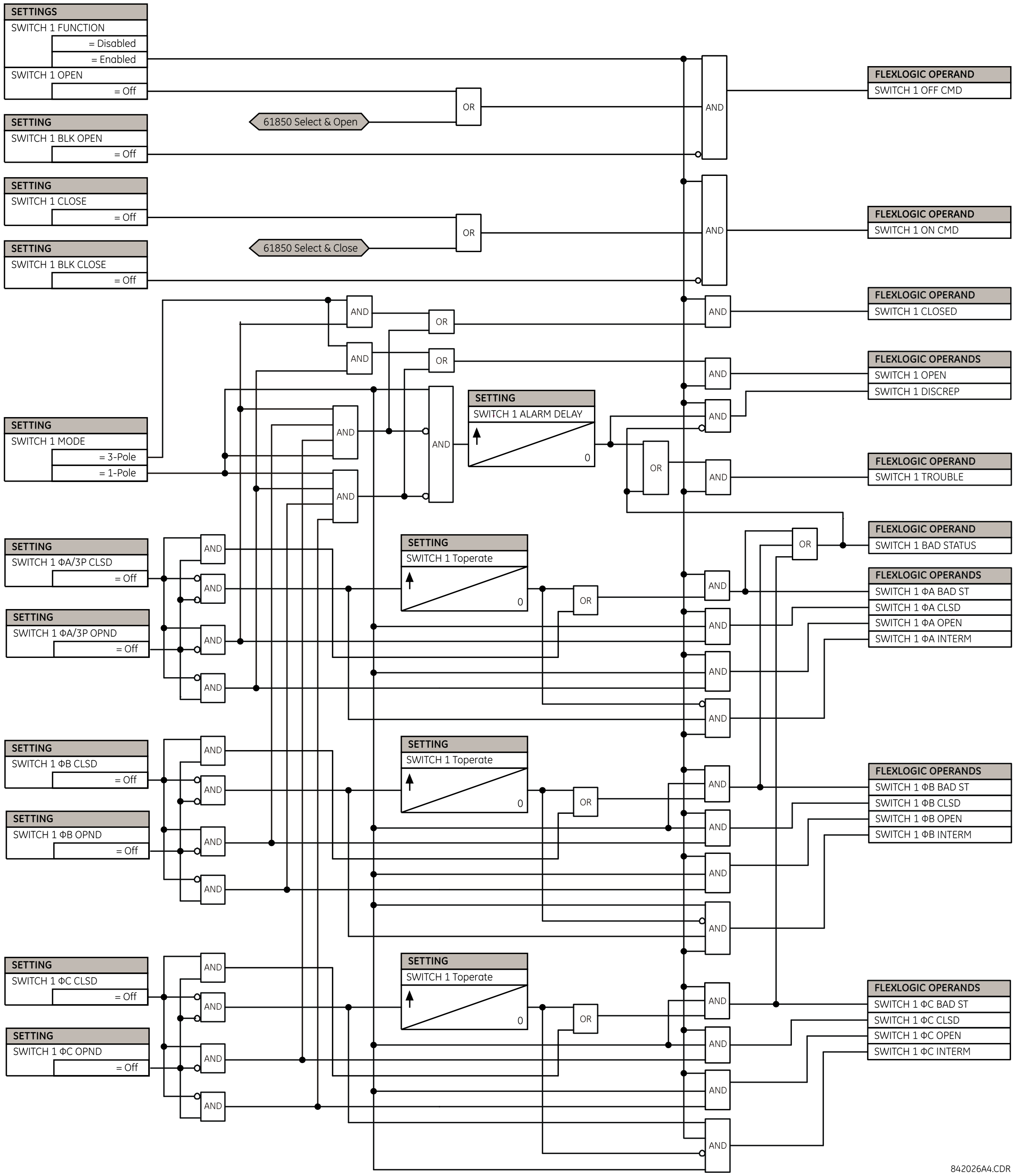

Figure 5–22: DISCONNECT SWITCH SCHEME LOGIC

5.4.6 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 5–6: 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.

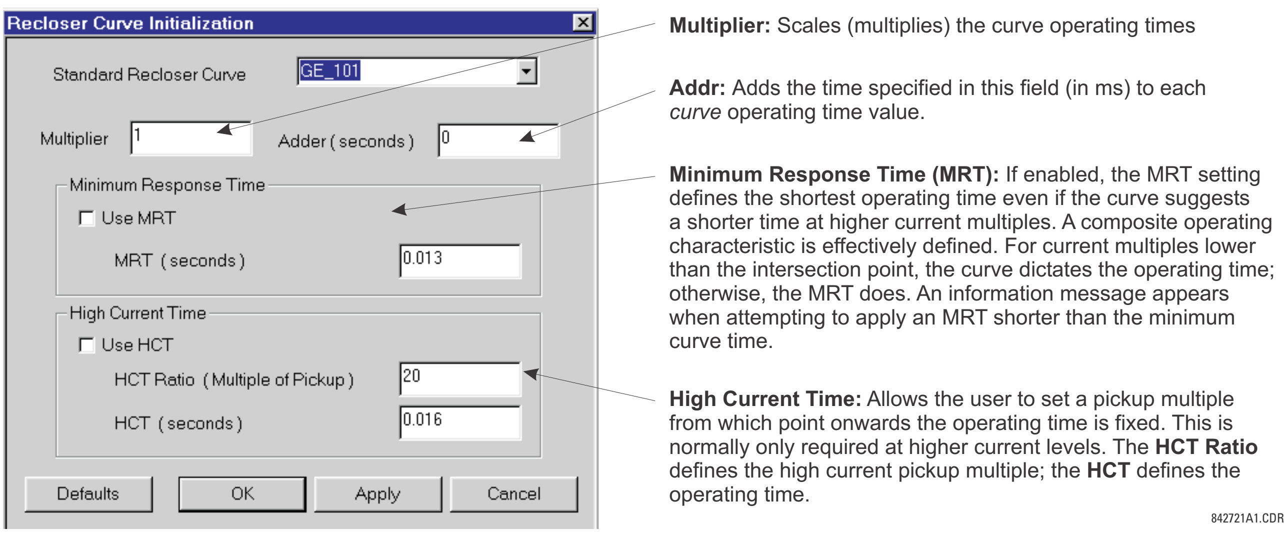

Figure 5–23: RECLOSER CURVE INITIALIZATION

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).

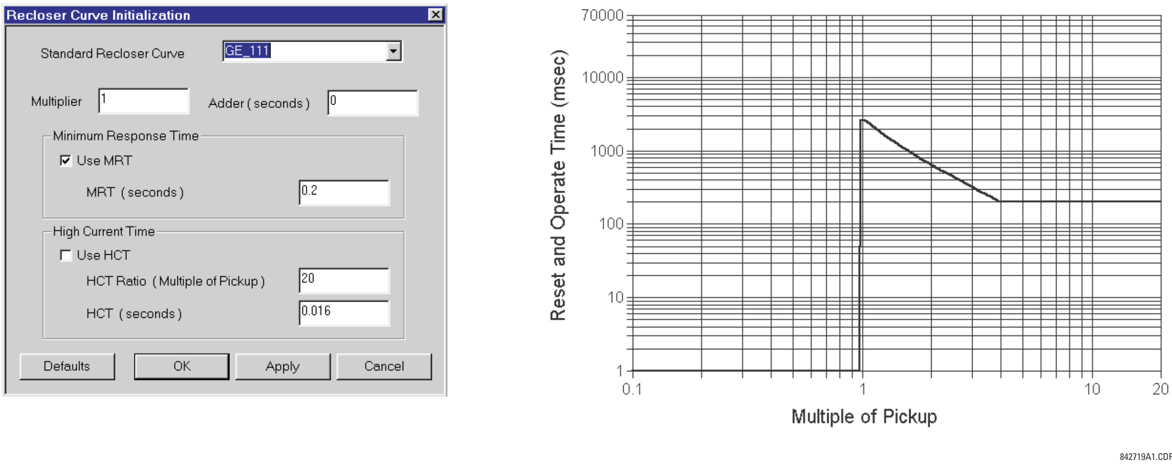

Figure 5–24: COMPOSITE RECLOSER CURVE WITH HCT DISABLED

With the HCT feature enabled, the operating time reduces to 30 ms for pickup multiples exceeding 8 times pickup.

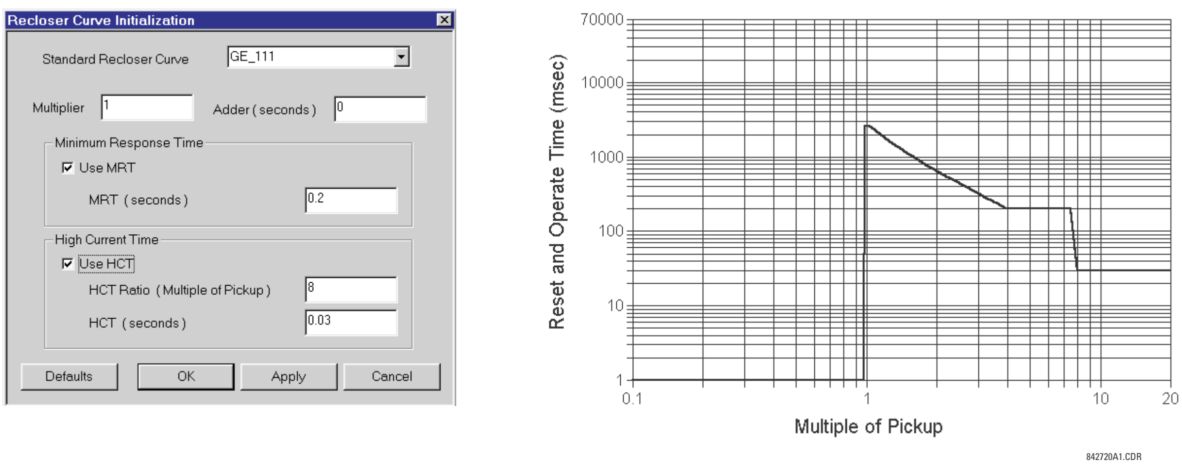

Figure 5–25: COMPOSITE RECLOSER CURVE WITH HCT ENABLED

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 C70 are displayed in the following graphs.

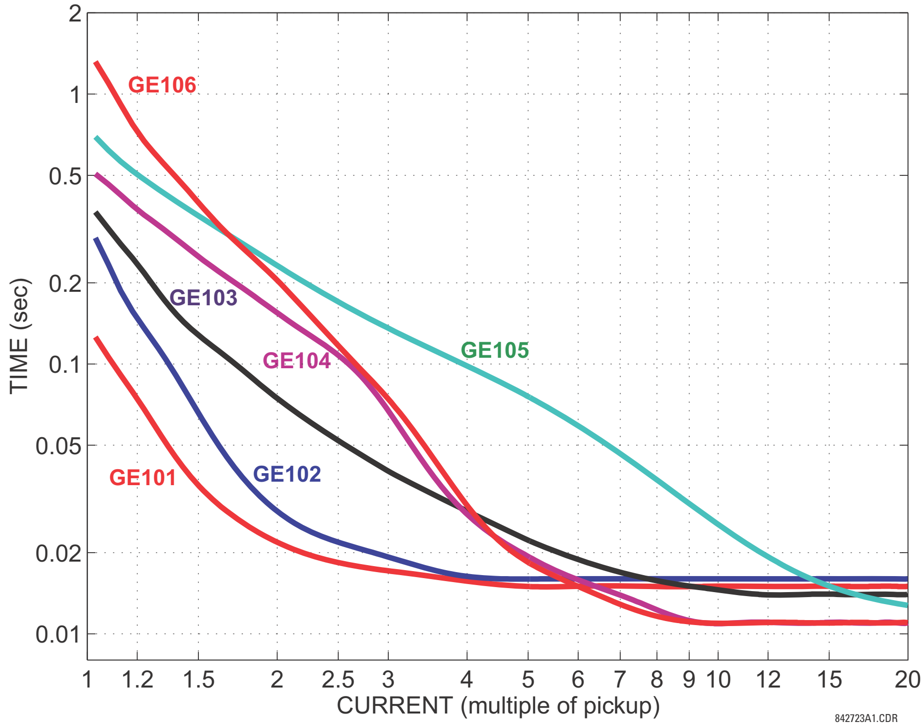

Figure 5–26: RECLOSER CURVES GE101 TO GE106

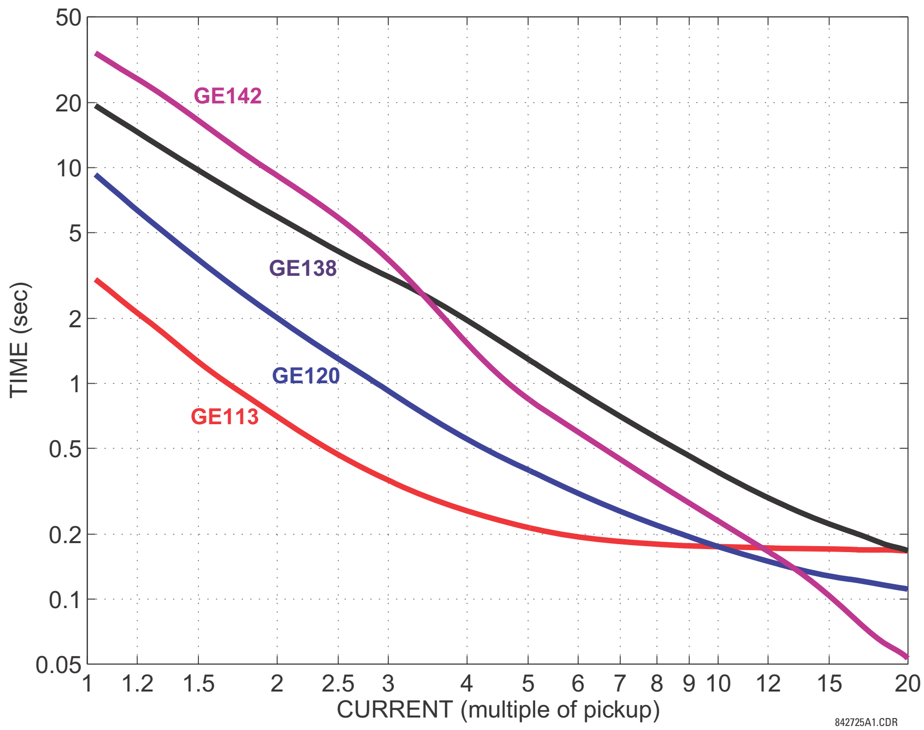

Figure 5–27: RECLOSER CURVES GE113, GE120, GE138 AND GE142

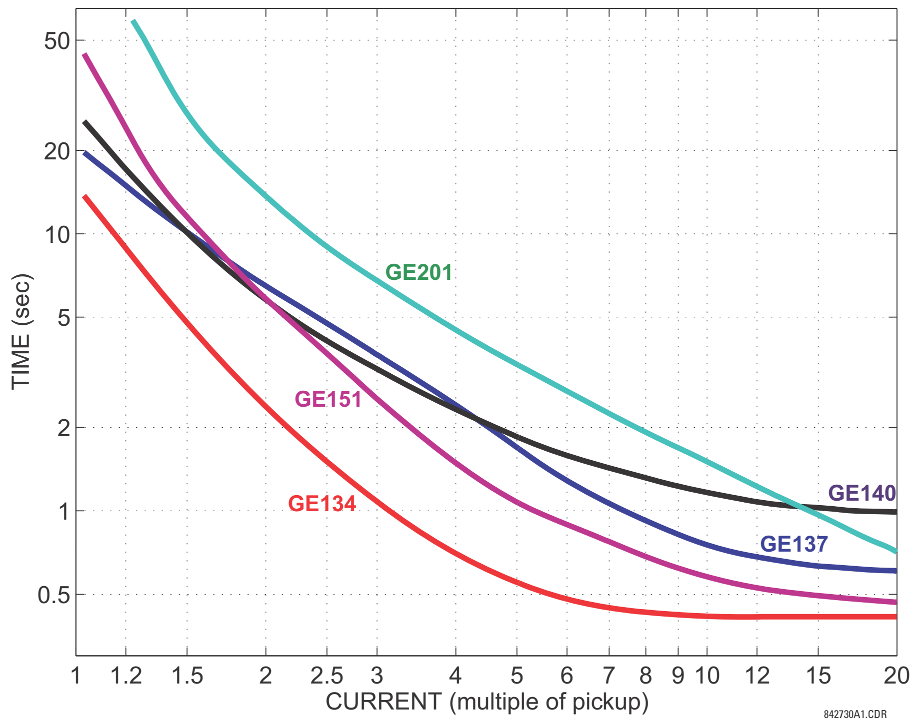

Figure 5–28: RECLOSER CURVES GE134, GE137, GE140, GE151 AND GE201

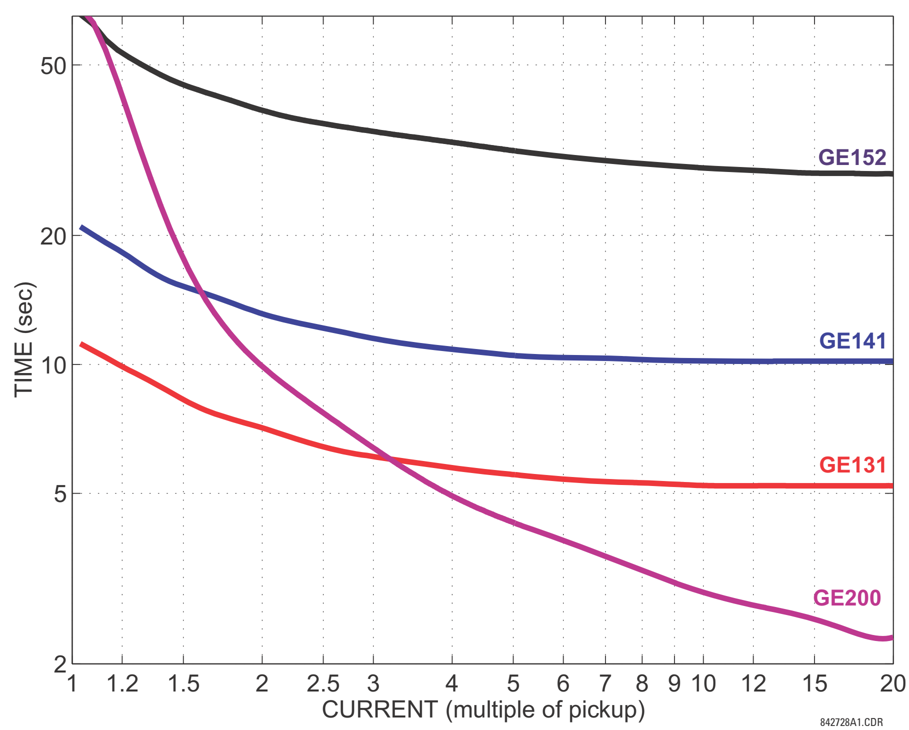

Figure 5–29: RECLOSER CURVES GE131, GE141, GE152, AND GE200

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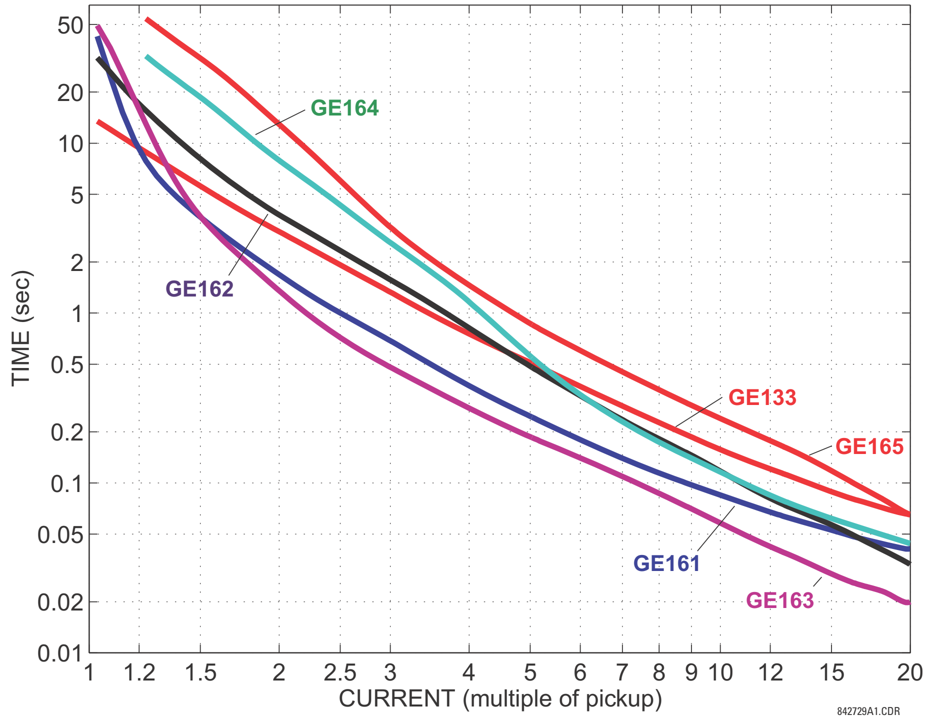

Figure 5–30: RECLOSER CURVES GE133, GE161, GE162, GE163, GE164 AND GE165

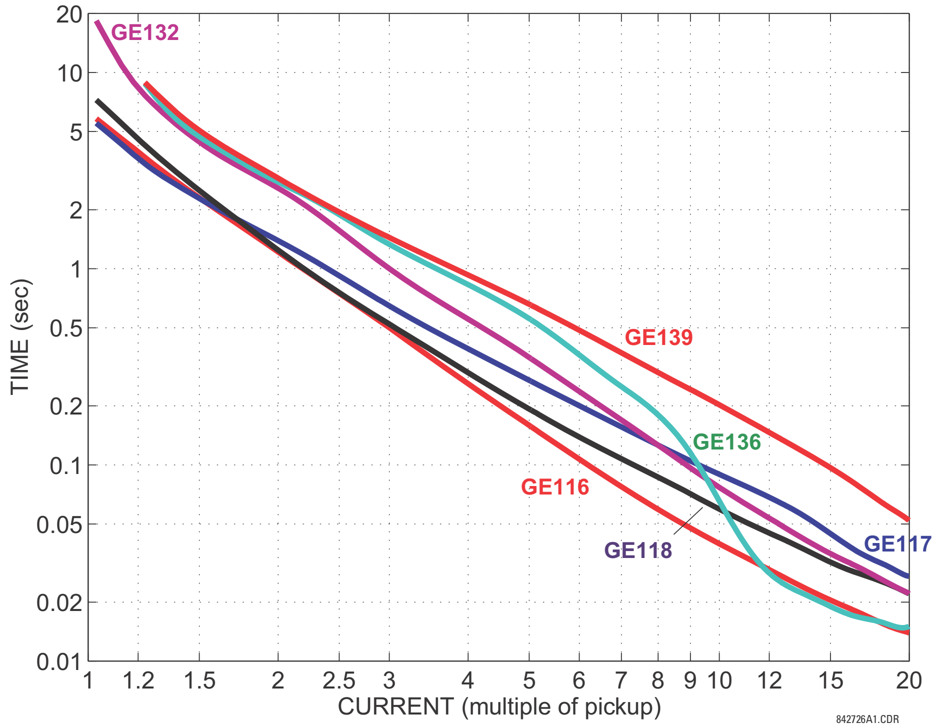

Figure 5–31: RECLOSER CURVES GE116, GE117, GE118, GE132, GE136, AND GE139

5

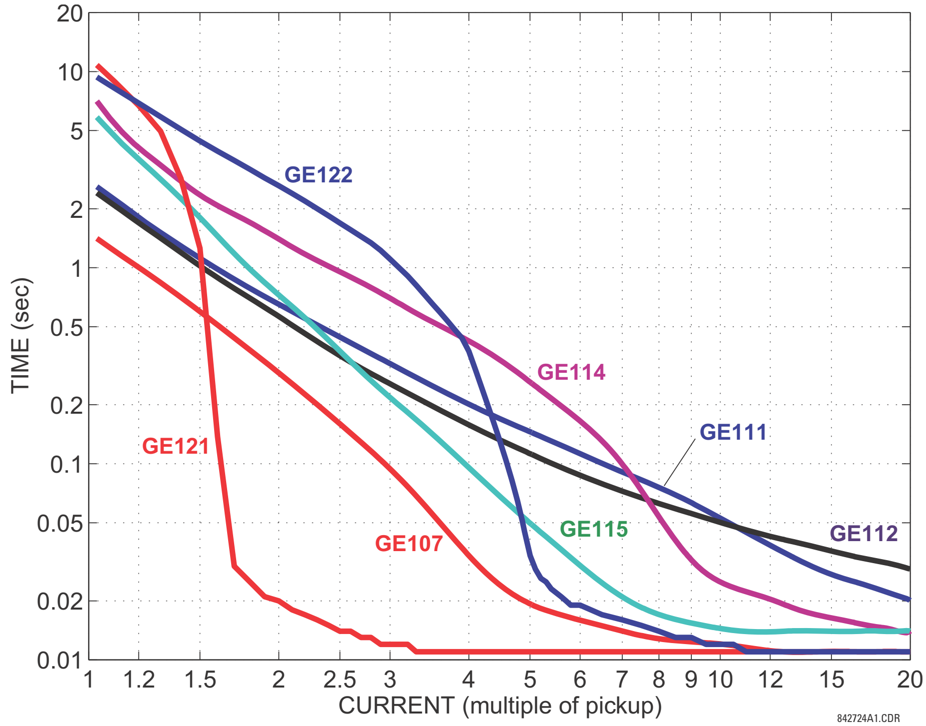

Figure 5–32: RECLOSER CURVES GE107, GE111, GE112, GE114, GE115, GE121, AND GE122

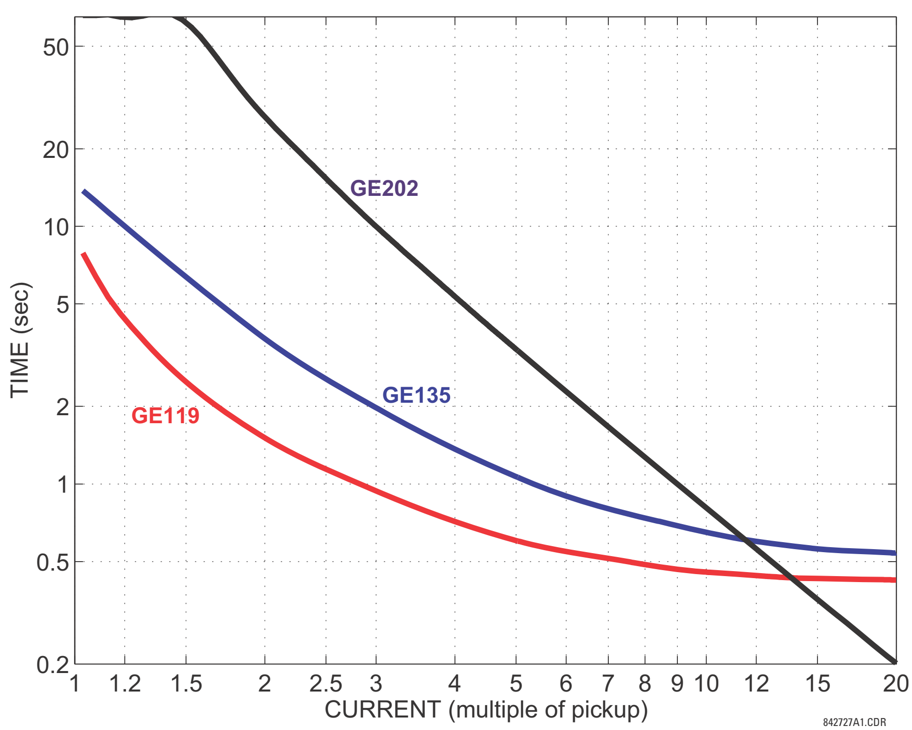

Figure 5–33: RECLOSER CURVES GE119, GE135, AND GE202

5

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.

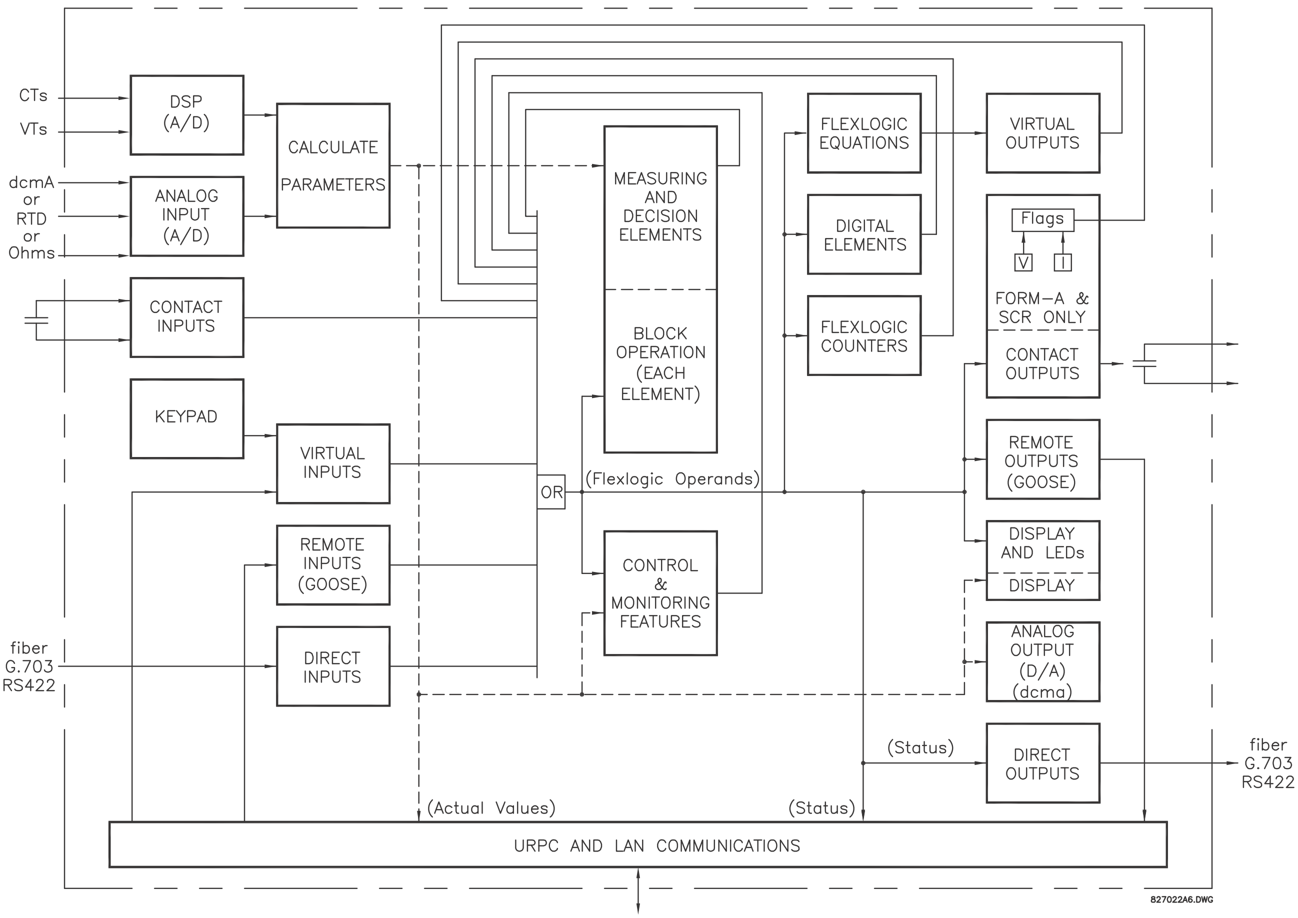

Figure 5–34: UR ARCHITECTURE OVERVIEW

The states of all digital signals used in the C70 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 5–7: C70 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 5–8: C70 FLEXLOGIC™ OPERANDS (Sheet 1 of 9)

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
DIRECT DEVICES	DIRECT DEVICE 1On ↓ DIRECT DEVICE 16On DIRECT DEVICE 1Off ↓ DIRECT DEVICE 16Off	Flag is set, logic=1 ↓ Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
DIRECT INPUT/ OUTPUT CHANNEL MONITORING	DIR IO CH1 CRC ALARM	The rate of direct input messages received on channel 1 and failing the CRC exceeded the user-specified level.
	DIR IO CH2 CRC ALARM	The rate of direct input messages received on channel 2 and failing the CRC exceeded the user-specified level.
	DIR IO CH1 UNRET ALM	The rate of returned direct input/output messages on channel 1 exceeded the user-specified level (ring configurations only).
	DIR IO CH2 UNRET ALM	The rate of returned direct input/output messages on channel 2 exceeded the user-specified level (ring configurations only).
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: Automatic voltage regulator	AVR 1 CLOSE PKP AVR 1 CLOSE OP AVR 1 CLOSE DPO AVR 1 OPEN PKP AVR 1 OPEN OP AVR 1 OPEN DPO	Automatic voltage regulator 1 picked up; close command pending Automatic voltage regulator 1 issued a close command Close command of automatic voltage regulator 1 dropped out Automatic voltage regulator 1 picked up; open command pending Automatic voltage regulator 1 issued an open command Open command of automatic voltage regulator 1 dropped out
	AVR 2 to AVR 3	Same set of operands as shown for AVR 1
ELEMENT: Bank phase overvoltage	BANK OV 1 STG 1A PKP BANK OV 1 STG 1B PKP BANK OV 1 STG 1C PKP BANK OV 1 STG 2A PKP BANK OV 1 STG 2B PKP BANK OV 1 STG 2C PKP BANK OV 1 STG 3A PKP BANK OV 1 STG 3B PKP BANK OV 1 STG 3C PKP BANK OV 1 STG 4A PKP BANK OV 1 STG 4B PKP BANK OV 1 STG 4C PKP BANK OV 1 PKP A BANK OV 1 PKP B BANK OV 1 PKP C BANK OV 1 PKP BANK OV 1 DPO BANK OV 1 STG 1A OP BANK OV 1 STG 1B OP BANK OV 1 STG 1C OP BANK OV 1 STG 2A OP BANK OV 1 STG 2B OP BANK OV 1 STG 2C OP BANK OV 1 STG 3A OP BANK OV 1 STG 3B OP BANK OV 1 STG 3C OP BANK OV 1 STG 4A OP BANK OV 1 STG 4B OP BANK OV 1 STG 4C OP BANK OV 1 OP A BANK OV 1 OP B BANK OV 1 OP C BANK OV 1 OP	Bank overvoltage element 1 picked up in phase A of stage 1 Bank overvoltage element 1 picked up in phase B of stage 1 Bank overvoltage element 1 picked up in phase C of stage 1 Bank overvoltage element 1 picked up in phase A of stage 2 Bank overvoltage element 1 picked up in phase B of stage 2 Bank overvoltage element 1 picked up in phase C of stage 2 Bank overvoltage element 1 picked up in phase A of stage 3 Bank overvoltage element 1 picked up in phase B of stage 3 Bank overvoltage element 1 picked up in phase C of stage 3 Bank overvoltage element 1 picked up in phase A of stage 4 Bank overvoltage element 1 picked up in phase B of stage 4 Bank overvoltage element 1 picked up in phase C of stage 4 Bank overvoltage element 1 picked up in phase A Bank overvoltage element 1 picked up in phase B Bank overvoltage element 1 picked up in phase C Bank overvoltage element 1 picked up Bank overvoltage element 1 dropped out Bank overvoltage element 1 operated in phase A of stage 1 Bank overvoltage element 1 operated in phase B of stage 1 Bank overvoltage element 1 operated in phase C of stage 1 Bank overvoltage element 1 operated in phase A of stage 2 Bank overvoltage element 1 operated in phase B of stage 2 Bank overvoltage element 1 operated in phase C of stage 2 Bank overvoltage element 1 operated in phase A of stage 3 Bank overvoltage element 1 operated in phase B of stage 3 Bank overvoltage element 1 operated in phase C of stage 3 Bank overvoltage element 1 operated in phase A of stage 4 Bank overvoltage element 1 operated in phase B of stage 4 Bank overvoltage element 1 operated in phase C of stage 4 Bank overvoltage element 1 operated in phase A Bank overvoltage element 1 operated in phase B Bank overvoltage element 1 operated in phase C Bank overvoltage element 1 operated
	BANK OV 2 to BANK OV 3	Same set of operands as shown for BANK OV 1

Table 5–8: C70 FLEXLOGIC™ OPERANDS (Sheet 2 of 9)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT Breaker flashover	BKR 1 FLSHOVR PKP A BKR 1 FLSHOVR PKP B BKR 1 FLSHOVR PKP C BKR 1 FLSHOVR PKP BKR 1 FLSHOVR OP A BKR 1 FLSHOVR OP B BKR 1 FLSHOVR OP C BKR 1 FLSHOVR OP BKR 1 FLSHOVR DPO A BKR 1 FLSHOVR DPO B BKR 1 FLSHOVR DPO C BKR 1 FLSHOVR DPO	Breaker 1 flashover element phase A has picked up Breaker 1 flashover element phase B has picked up Breaker 1 flashover element phase C has picked up Breaker 1 flashover element has picked up Breaker 1 flashover element phase A has operated Breaker 1 flashover element phase B has operated Breaker 1 flashover element phase C has operated Breaker 1 flashover element has operated Breaker 1 flashover element phase A has dropped out Breaker 1 flashover element phase B has dropped out Breaker 1 flashover element phase C has dropped out Breaker 1 flashover element has dropped out
	BKR 2 FLSHOVR...	Same set of operands as shown for BKR 1 FLSHOVR
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
ELEMENT Breaker restrike	BRK RESTRIKE 1 OP BRK RESTRIKE 1 OP A BRK RESTRIKE 1 OP B BRK RESTRIKE 1 OP C	Breaker restrike detected in any phase of the breaker control 1 element. Breaker restrike detected in phase A of the breaker control 1 element. Breaker restrike detected in phase B of the breaker control 1 element. Breaker restrike detected in phase C of the breaker control 1 element.
	BKR RESTRIKE 2...	Same set of operands as shown for BKR RESTRIKE 1
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 ΦA INTERM BREAKER 1 ΦB CLSD BREAKER 1 ΦB OPEN BREAKER 1 ΦC BAD ST BREAKER 1 ΦA 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 A 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 A 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: Capacitor control	CAP 1 IN REMOTE CAP 1 IN LOCAL CAP 1 IN AUTO CAP 1 IN MAN CAP 1 DISCHARGING CAP 1 BKR TRIP CAP 1 BKR CLOSE	Capacitor control element 1 in remote control mode Capacitor control element 1 in local control mode Capacitor control element 1 in automatic mode Capacitor control element 1 in manual mode Capacitor 1 is discharging; asserted till discharge delay expires Capacitor 1 breaker trip command Capacitor 1 breaker close command
	CAP 2 to CAP 4	Same set of operands as shown for CAP 1

Table 5–8: C70 FLEXLOGIC™ OPERANDS (Sheet 3 of 9)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
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: Phase current unbalance	CUR BAL 1 STG1A PKP CUR BAL 1 STG1B PKP CUR BAL 1 STG1C PKP CUR BAL 1 STG2A PKP CUR BAL 1 STG2B PKP CUR BAL 1 STG2C PKP CUR BAL 1 STG3A PKP CUR BAL 1 STG3B PKP CUR BAL 1 STG3C PKP CUR BAL 1 STG4A PKP CUR BAL 1 STG4B PKP CUR BAL 1 STG4C PKP CUR BAL 1 PKP A CUR BAL 1 PKP B CUR BAL 1 PKP C CUR BAL 1 PKP CUR BAL 1 DPO CUR BAL 1 STG1A OP CUR BAL 1 STG1B OP CUR BAL 1 STG1C OP CUR BAL 1 STG2A OP CUR BAL 1 STG2B OP CUR BAL 1 STG2C OP CUR BAL 1 STG3A OP CUR BAL 1 STG3B OP CUR BAL 1 STG3C OP CUR BAL 1 STG4A OP CUR BAL 1 STG4B OP CUR BAL 1 STG4C OP CUR BAL 1 OP A CUR BAL 1 OP B CUR BAL 1 OP C CUR BAL 1 OP	Phase current unbalance element 1 picked up in phase A of stage 1 Phase current unbalance element 1 picked up in phase B of stage 1 Phase current unbalance element 1 picked up in phase C of stage 1 Phase current unbalance element 1 picked up in phase A of stage 2 Phase current unbalance element 1 picked up in phase B of stage 2 Phase current unbalance element 1 picked up in phase C of stage 2 Phase current unbalance element 1 picked up in phase A of stage 3 Phase current unbalance element 1 picked up in phase B of stage 3 Phase current unbalance element 1 picked up in phase C of stage 3 Phase current unbalance element 1 picked up in phase A of stage 4 Phase current unbalance element 1 picked up in phase B of stage 4 Phase current unbalance element 1 picked up in phase C of stage 4 Phase current unbalance element 1 picked up in phase A Phase current unbalance element 1 picked up in phase B Phase current unbalance element 1 picked up in phase C Phase current unbalance element 1 picked up. Phase current unbalance element 1 dropped out Phase current unbalance element 1 operated in phase A of stage 1 Phase current unbalance element 1 operated in phase B of stage 1 Phase current unbalance element 1 operated in phase C of stage 1 Phase current unbalance element 1 operated in phase A of stage 2 Phase current unbalance element 1 operated in phase B of stage 2 Phase current unbalance element 1 operated in phase C of stage 2 Phase current unbalance element 1 operated in phase A of stage 3 Phase current unbalance element 1 operated in phase B of stage 3 Phase current unbalance element 1 operated in phase C of stage 3 Phase current unbalance element 1 operated in phase A of stage 4 Phase current unbalance element 1 operated in phase B of stage 4 Phase current unbalance element 1 operated in phase C of stage 4 Phase current unbalance element 1 operated in phase A Phase current unbalance element 1 operated in phase B Phase current unbalance element 1 operated in phase C Phase current unbalance element 1 operated
	CUR BAL 2 to CUR BAL 3	Same set of operands as shown for CUR BAL 1
ELEMENT: Time of day timer day	DAY SUNDAY DAY MONDAY DAY TUESDAY DAY WEDNESDAY DAY THURSDAY DAY FRIDAY DAY SATURDAY	Current day is Sunday Current day is Monday Current day is Tuesday Current day is Wednesday Current day is Thursday Current day is Friday Current day is Saturday
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 16	Same set of operands as shown for FxE 1
ELEMENT: Ground instantaneous overcurrent	GROUND IOC1 PKP GROUND IOC1 OP GROUND IOC1 DPO	Ground instantaneous overcurrent 1 has picked up Ground instantaneous overcurrent 1 has operated Ground instantaneous overcurrent 1 has dropped out
	GROUND IOC2 to IOC12	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 to TOC6	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

Table 5–8: C70 FLEXLOGIC™ OPERANDS (Sheet 4 of 9)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Time of day timer month	MONTH JANUARY MONTH FEBRUARY MONTH MARCH MONTH APRIL MONTH MAY MONTH JUNE MONTH JULY MONTH AUGUST MONTH SEPTEMBER MONTH OCTOBER MONTH NOVEMBER MONTH DECEMBER	Current month is January Current month is February Current month is March Current month is April Current month is May Current month is June Current month is July Current month is August Current month is September Current month is October Current month is November Current month is December
ELEMENT: Negative-sequence directional overcurrent	NEG SEQ DIR OC1 FWD NEG SEQ DIR OC1 REV NEG SEQ DIR OC2 FWD NEG SEQ DIR OC2 REV	Negative-sequence directional overcurrent 1 forward has operated Negative-sequence directional overcurrent 1 reverse has operated Negative-sequence directional overcurrent 2 forward has operated Negative-sequence directional overcurrent 2 reverse has operated
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
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 to IOC12	Same set of operands as shown for NEUTRAL IOC1
ELEMENT: Neutral overvoltage	NEUTRAL OV1 PKP NEUTRAL OV1 DPO NEUTRAL OV1 OP	Neutral overvoltage element 1 has picked up Neutral overvoltage element 1 has dropped out Neutral overvoltage element 1 has operated
ELEMENT: Neutral time overcurrent	NEUTRAL TOC1 PKP NEUTRAL TOC1 OP NEUTRAL TOC1 DPO	Neutral time overcurrent 1 has picked up Neutral time overcurrent 1 has operated Neutral time overcurrent 1 has dropped out
	NEUTRAL TOC2 to TOC6	Same set of operands as shown for NEUTRAL TOC1
ELEMENT: Neutral current unbalance	NTRL CUR 1 STG1 PKP NTRL CUR 1 STG2 PKP NTRL CUR 1 STG3 PKP NTRL CUR 1 STG4 PKP NTRL CUR 1 PKP NTRL CUR 1 DPO NTRL CUR 1 STG1 OP NTRL CUR 1 STG2 OP NTRL CUR 1 STG3 OP NTRL CUR 1 STG4 OP NTRL CUR 1 OP	Neutral current unbalance element 1 picked up in stage 1 Neutral current unbalance element 1 picked up in stage 2 Neutral current unbalance element 1 picked up in stage 3 Neutral current unbalance element 1 picked up in stage 4 Neutral current unbalance element 1 picked up Neutral current unbalance element 1 dropped out Neutral current unbalance element 1 operated in stage 1 Neutral current unbalance element 1 operated in stage 2 Neutral current unbalance element 1 operated in stage 3 Neutral current unbalance element 1 operated in stage 4 Neutral current unbalance element 1 operated
	NTRL CUR 2 to NTRL CUR 3	Same set of operands as shown for NTRL CUR 1
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
ELEMENT: Neutral voltage unbalance	NTRL VOLT 1 STG1 PKP NTRL VOLT 1 STG2 PKP NTRL VOLT 1 STG3 PKP NTRL VOLT 1 STG4 PKP NTRL VOLT 1 PKP NTRL VOLT 1 DPO NTRL VOLT 1 STG1 OP NTRL VOLT 1 STG2 OP NTRL VOLT 1 STG3 OP NTRL VOLT 1 STG4 OP NTRL VOLT 1 OP	Neutral voltage unbalance element 1 picked up in stage 1 Neutral voltage unbalance element 1 picked up in stage 2 Neutral voltage unbalance element 1 picked up in stage 3 Neutral voltage unbalance element 1 picked up in stage 4 Neutral voltage unbalance element 1 picked up Neutral voltage unbalance element 1 dropped out Neutral voltage unbalance element 1 operated in stage 1 Neutral voltage unbalance element 1 operated in stage 2 Neutral voltage unbalance element 1 operated in stage 3 Neutral voltage unbalance element 1 operated in stage 4 Neutral voltage unbalance element 1 operated
	NTRL VOLT 2 to NTRL VOLT 3	Same set of operands as shown for NTRL VOLT 1

Table 5–8: C70 FLEXLOGIC™ OPERANDS (Sheet 5 of 9)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
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
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: 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

Table 5–8: C70 FLEXLOGIC™ OPERANDS (Sheet 6 of 9)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Sub-harmonic stator ground fault detector	SH STAT GND STG1 PKP SH STAT GND STG1 DPO SH STAT GND STG1 OP SH STAT GND STG2 PKP SH STAT GND STG2 DPO SH STAT GND STG2 OP SH STAT GND OC PKP SH STAT GND OC DPO SH STAT GND OC OP SH STAT GND TRB PKP SH STAT GND TRB DPO SH STAT GND TRB OP	--- --- --- --- --- --- --- --- --- --- --- ---
ELEMENT: Disturbance detector	SRC1 50DD OP SRC2 50DD OP SRC3 50DD OP SRC4 50DD OP SRC5 50DD OP SRC6 50DD OP	Source 1 disturbance detector has operated Source 2 disturbance detector has operated Source 3 disturbance detector has operated Source 4 disturbance detector has operated Source 5 disturbance detector has operated Source 6 disturbance detector has operated
ELEMENT: VTFF (Voltage transformer fuse failure)	SRC1 VT FUSE FAIL OP SRC1 VT FUSE FAIL DPO SRC1 VT FUSE FAIL VOL LOSS	Source 1 VT fuse failure detector has operated Source 1 VT fuse failure detector has dropped out Source 1 has lost voltage signals (V2 below 15% AND V1 below 5% of nominal)
	SRC1 VT NEU WIRE OPEN	Source 1 VT neutral wire open detected.
	SRC2 VT FUSE FAIL to SRC6 VT FUSE FAIL	Same set of operands as shown for SRC1 VT FUSE FAIL
ELEMENT: Disconnect switch	SWITCH 1 OFF CMD SWITCH 1 ON CMD SWITCH 1 ΦA BAD ST SWITCH 1 ΦA INTERM SWITCH 1 ΦA CLSD SWITCH 1 ΦA OPEN SWITCH 1 ΦB BAD ST SWITCH 1 ΦA INTERM SWITCH 1 ΦB CLSD SWITCH 1 ΦB OPEN SWITCH 1 ΦC BAD ST SWITCH 1 ΦA INTERM SWITCH 1 ΦC CLSD SWITCH 1 ΦC OPEN SWITCH 1 BAD STATUS SWITCH 1 CLOSED SWITCH 1 OPEN SWITCH 1 DISCREP SWITCH 1 TROUBLE	Disconnect switch 1 open command initiated Disconnect switch 1 close command initiated 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 A is closed Disconnect switch 1 phase A is open Disconnect switch 1 phase B 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 C 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 C is closed Disconnect switch 1 phase C is open Disconnect switch 1 bad status is detected on any pole Disconnect switch 1 is closed Disconnect switch 1 is open Disconnect switch 1 has discrepancy Disconnect switch 1 trouble alarm
	SWITCH 2...	Same set of operands as shown for SWITCH 1
ELEMENT: Time of day timer	TIME OF DAY 1 ON TIME OF DAY 1 START TIME OF DAY 1 STOP	Time of day timer 1 is on One-second pulse at set time of day timer 1 start time One-second pulse at set time of day timer 1 stop time
	TIME OF DAY 2 to 5	Same set of operands as shown for TIME OF DAY 1
ELEMENT Trip bus	TRIP BUS 1 PKP TRIP BUS 1 OP	Asserted when the trip bus 1 element picks up. Asserted when the trip bus 1 element operates.
	TRIP BUS 2...	Same set of operands as shown for TRIP BUS 1

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Table 5–8: C70 FLEXLOGIC™ OPERANDS (Sheet 7 of 9)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Voltage differential	VOLT DIF 1 STG1A PKP VOLT DIF 1 STG1B PKP VOLT DIF 1 STG1C PKP VOLT DIF 1 STG2A PKP VOLT DIF 1 STG2B PKP VOLT DIF 1 STG2C PKP VOLT DIF 1 STG3A PKP VOLT DIF 1 STG3B PKP VOLT DIF 1 STG3C PKP VOLT DIF 1 STG4A PKP VOLT DIF 1 STG4B PKP VOLT DIF 1 STG4C PKP VOLT DIF 1 PKP A VOLT DIF 1 PKP B VOLT DIF 1 PKP C VOLT DIF 1 PKP VOLT DIF 1 DPO VOLT DIF 1 STG1A OP VOLT DIF 1 STG1B OP VOLT DIF 1 STG1C OP VOLT DIF 1 STG2A OP VOLT DIF 1 STG2B OP VOLT DIF 1 STG2C OP VOLT DIF 1 STG3A OP VOLT DIF 1 STG3B OP VOLT DIF 1 STG3C OP VOLT DIF 1 STG4A OP VOLT DIF 1 STG4B OP VOLT DIF 1 STG4C OP VOLT DIF 1 OP A VOLT DIF 1 OP B VOLT DIF 1 OP C VOLT DIF 1 OP	Voltage differential element 1 picked up in phase A of stage 1 Voltage differential element 1 picked up in phase B of stage 1 Voltage differential element 1 picked up in phase C of stage 1 Voltage differential element 1 picked up in phase A of stage 2 Voltage differential element 1 picked up in phase B of stage 2 Voltage differential element 1 picked up in phase C of stage 2 Voltage differential element 1 picked up in phase A of stage 3 Voltage differential element 1 picked up in phase B of stage 3 Voltage differential element 1 picked up in phase C of stage 3 Voltage differential element 1 picked up in phase A of stage 4 Voltage differential element 1 picked up in phase B of stage 4 Voltage differential element 1 picked up in phase C of stage 4 Voltage differential element 1 picked up in phase A Voltage differential element 1 picked up in phase B Voltage differential element 1 picked up in phase C Voltage differential element 1 picked up Voltage differential element 1 dropped out Voltage differential element 1 operated in phase A of stage 1 Voltage differential element 1 operated in phase B of stage 1 Voltage differential element 1 operated in phase C of stage 1 Voltage differential element 1 operated in phase A of stage 2 Voltage differential element 1 operated in phase B of stage 2 Voltage differential element 1 operated in phase C of stage 2 Voltage differential element 1 operated in phase A of stage 3 Voltage differential element 1 operated in phase B of stage 3 Voltage differential element 1 operated in phase C of stage 3 Voltage differential element 1 operated in phase A of stage 4 Voltage differential element 1 operated in phase B of stage 4 Voltage differential element 1 operated in phase C of stage 4 Voltage differential element 1 operated in phase A Voltage differential element 1 operated in phase B Voltage differential element 1 operated in phase C Voltage differential element 1 operated
	VOLT DIF 2 to 3	Same set of operands as shown for VOLT DIF 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) ↓
INPUTS/OUTPUTS Direct inputs	DIRECT INPUT 1 On ↓ DIRECT INPUT 32 On	Flag is set, logic=1 ↓ Flag is set, logic=1
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

Table 5–8: C70 FLEXLOGIC™ OPERANDS (Sheet 8 of 9)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
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 C70.
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
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.

Table 5–8: C70 FLEXLOGIC™ OPERANDS (Sheet 9 of 9)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
SELF-DIAGNOSTICS	ANY MAJOR ERROR ANY MINOR ERROR ANY SELF-TESTS BATTERY FAIL DIRECT DEVICE OFF DIRECT RING BREAK EQUIPMENT MISMATCH ETHERNET SWITCH FAIL FLEXLOGIC ERR TOKEN IRIG-B FAILURE LATCHING OUT ERROR MAINTENANCE ALERT PORT 1 OFFLINE PORT 2 OFFLINE PORT 3 OFFLINE PORT 4 OFFLINE PORT 5 OFFLINE PORT 6 OFFLINE PRI ETHERNET FAIL PROCESS BUS FAILURE REMOTE DEVICE OFF RRTD COMM FAIL SEC 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) See description in *Chapter 7: Commands and targets*
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 5–9: 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 5–10: 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.

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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.

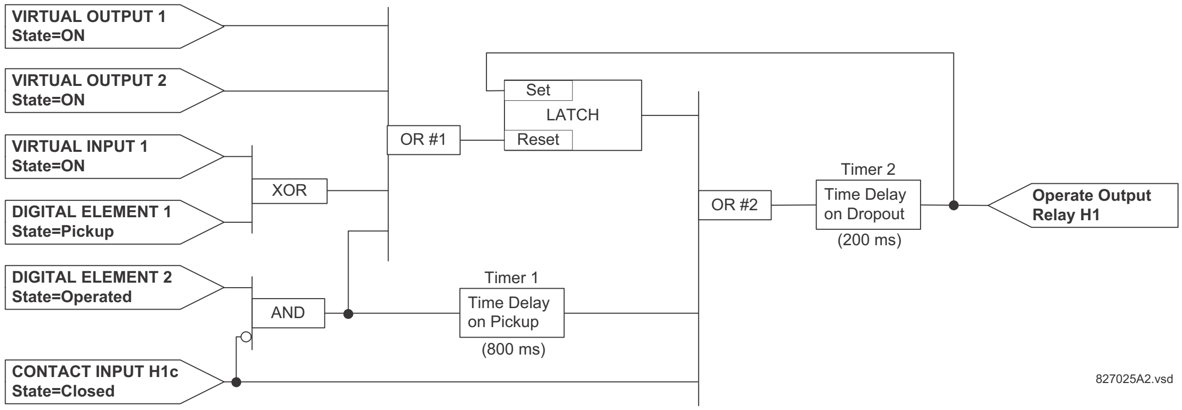

Figure 5–35: EXAMPLE LOGIC SCHEME

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.

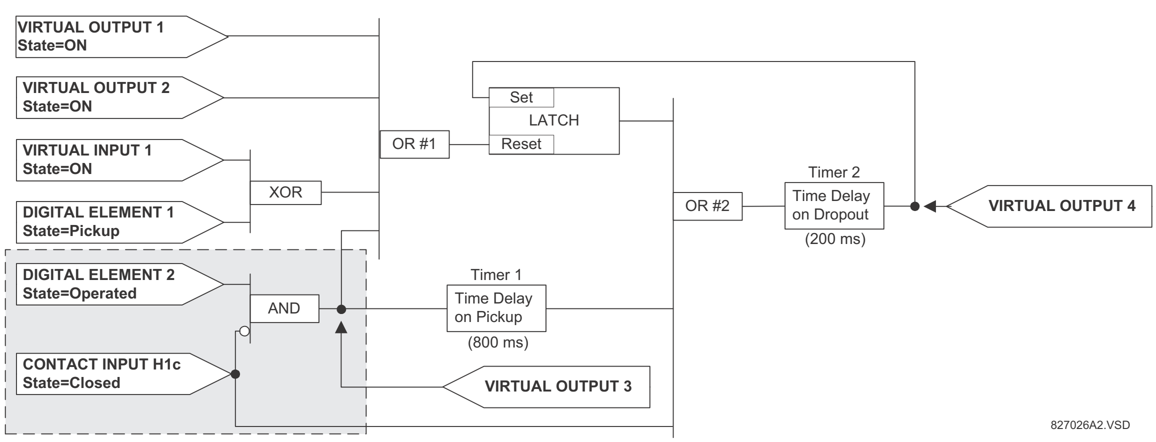

Figure 5–36: LOGIC EXAMPLE WITH VIRTUAL OUTPUTS

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.

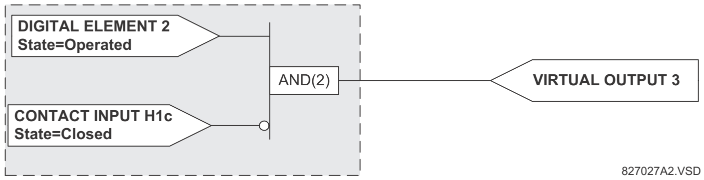

Figure 5–37: LOGIC FOR VIRTUAL OUTPUT 3

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.

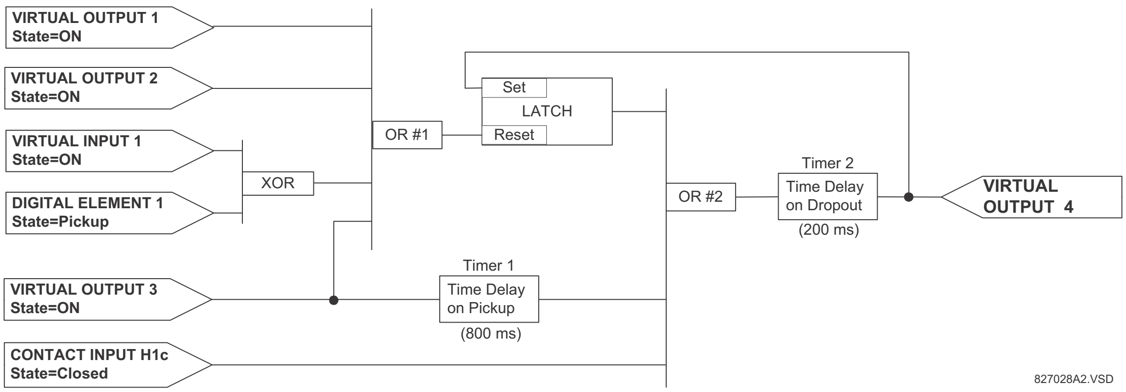

Figure 5–38: LOGIC FOR VIRTUAL OUTPUT 4

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.

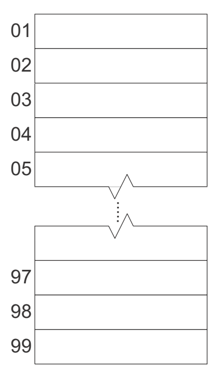

Figure 5–39: FLEXLOGIC™ WORKSHEET

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.

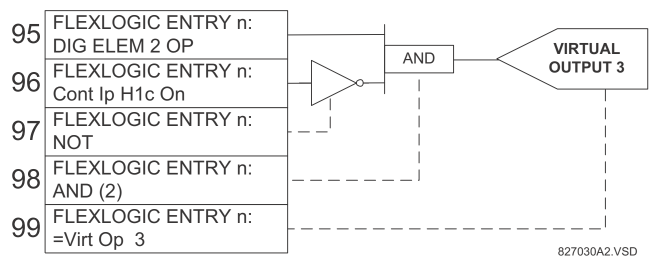

Figure 5–40: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 3

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.

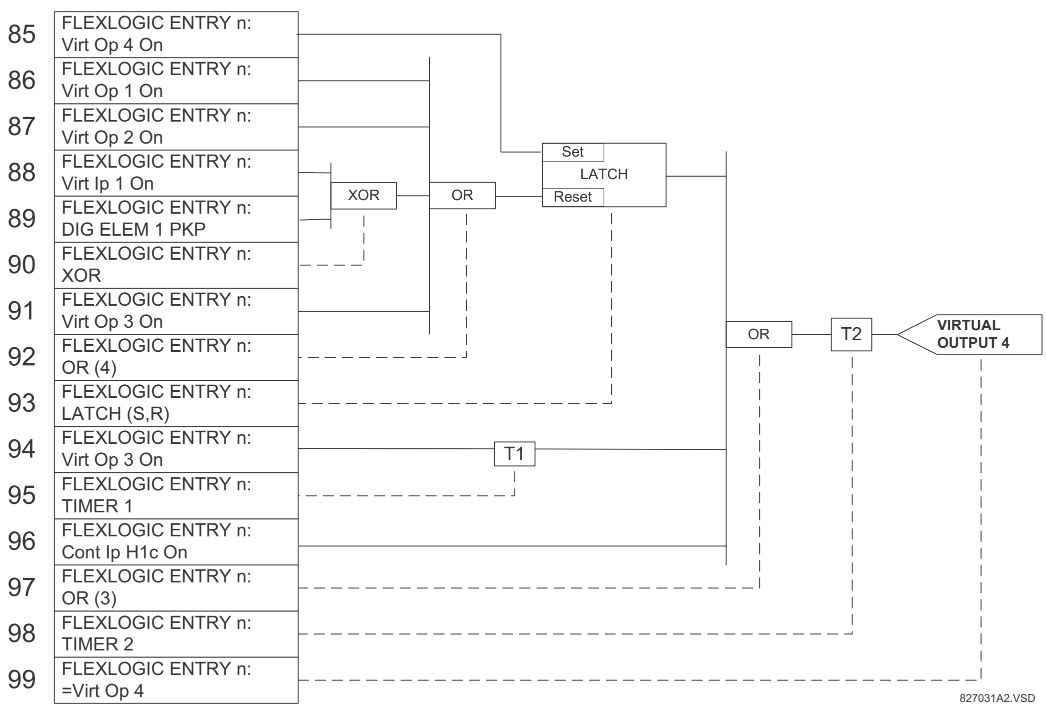

Figure 5–41: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 4

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(16)

		Setting	Range
■ 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.

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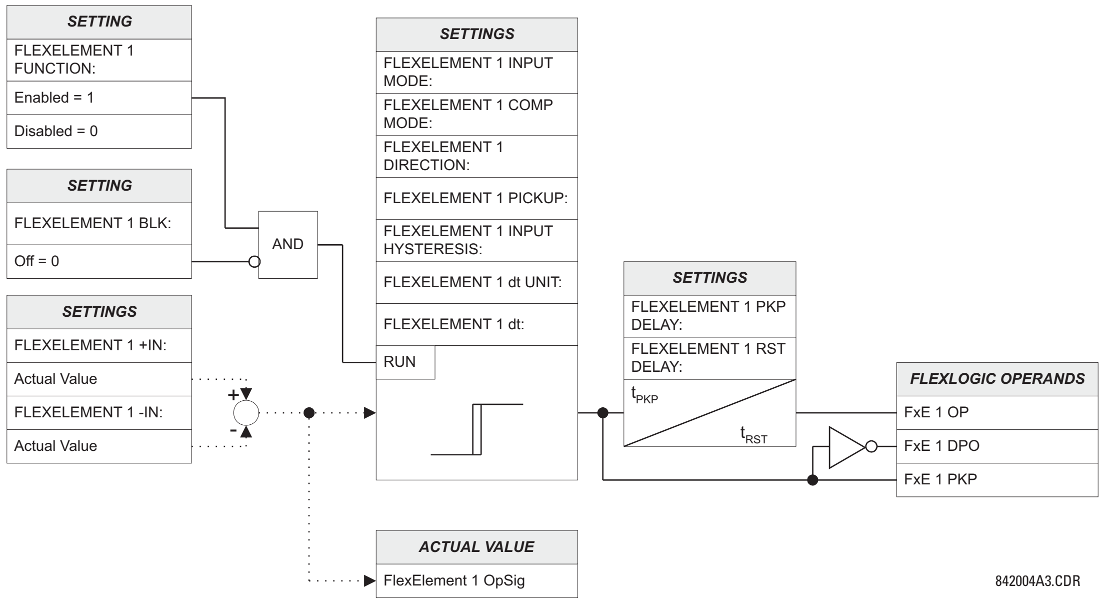

Figure 5–42: FLEXELEMENT™ SCHEME LOGIC

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.

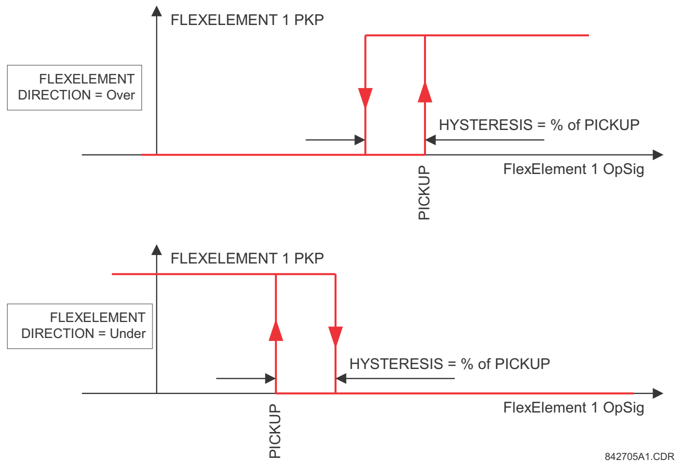

Figure 5–43: FLEXELEMENT™ DIRECTION, PICKUP, AND HYSTERESIS

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.

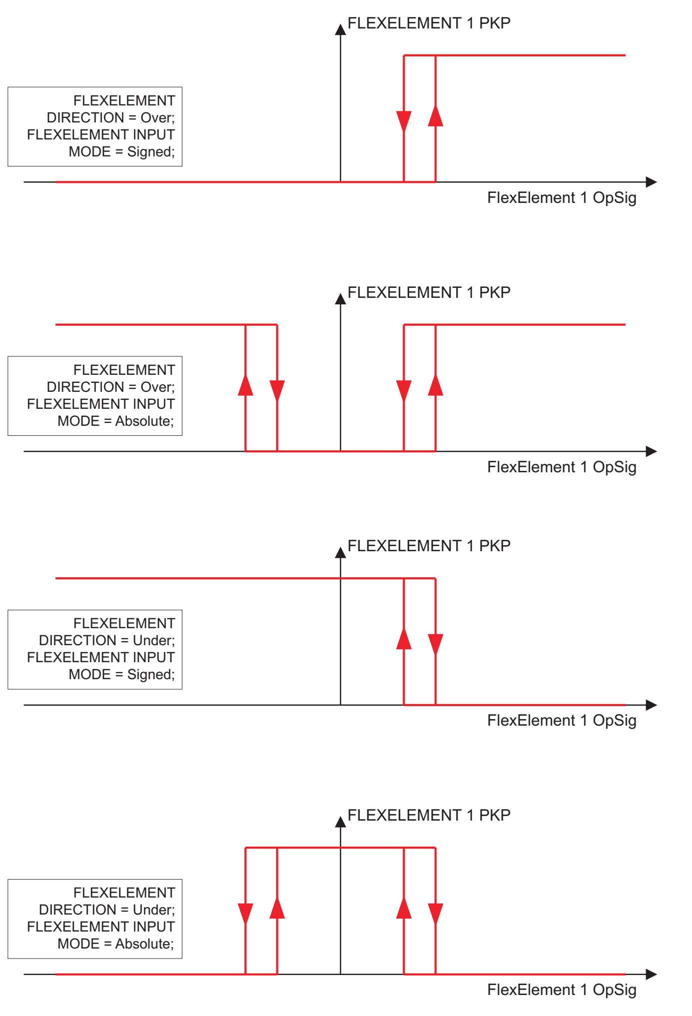

Figure 5–44: FLEXELEMENT™ INPUT MODE SETTING

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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 5–11: FLEXELEMENT™ BASE UNITS

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 THD & HARMONICS	BASE = 1%
SOURCE VOLTAGE	V_{BASE} = maximum nominal primary RMS value of 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.

5.5.8 NON-VOLATILE LATCHES

PATH: SETTINGS ⇨⇩ FLEXLOGIC ⇨⇩ NON-VOLATILE LATCHES ⇨ LATCH 1(16)

■ 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

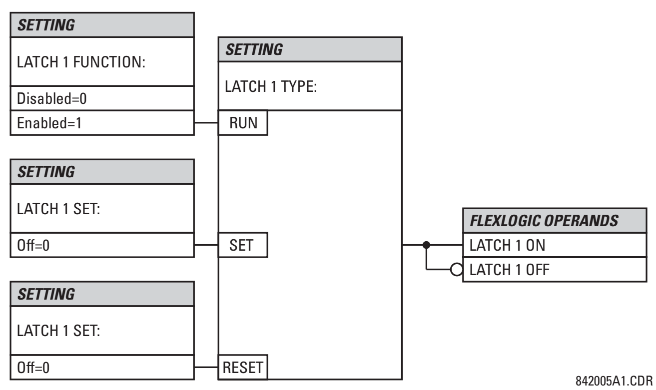

Figure 5–45: NON-VOLATILE LATCH OPERATION TABLE (N = 1 to 16) AND LOGIC

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 ■		■ BREAKER FAILURE ■	See page 5-110.
	MESSAGE	■ PHASE CURRENT ■	See page 5-119.
	MESSAGE	■ NEUTRAL CURRENT ■	See page 5-135.
	MESSAGE	■ GROUND CURRENT ■	See page 5-147.
	MESSAGE	■ NEGATIVE SEQUENCE ■ CURRENT	See page 5-149.
	MESSAGE	■ VOLTAGE ELEMENTS ■	See page 5-154.

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 BREAKER FAILURE

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ BREAKER FAILURE ⇨ BREAKER FAILURE 1

	Setting	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

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.

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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.

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:

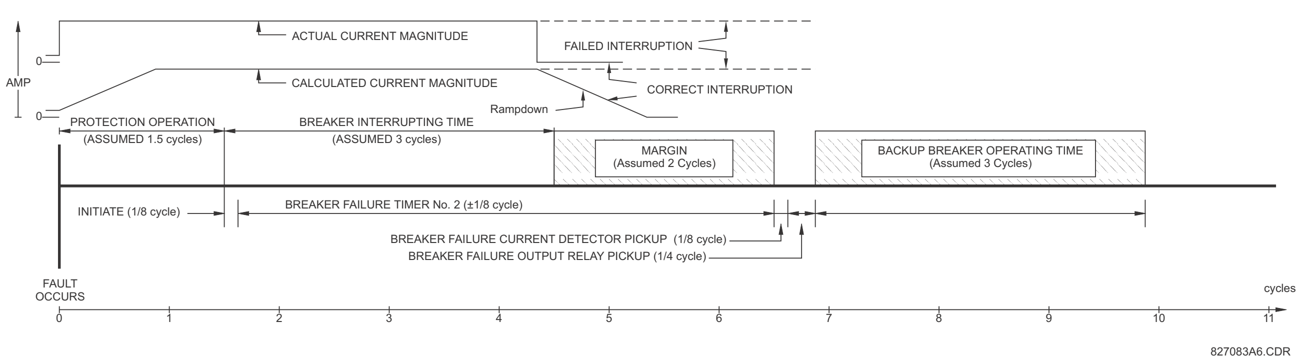

Figure 5–46: BREAKER FAILURE MAIN PATH SEQUENCE

The current supervision elements reset in less than 0.7 of a power cycle for any multiple of pickup current as shown below.

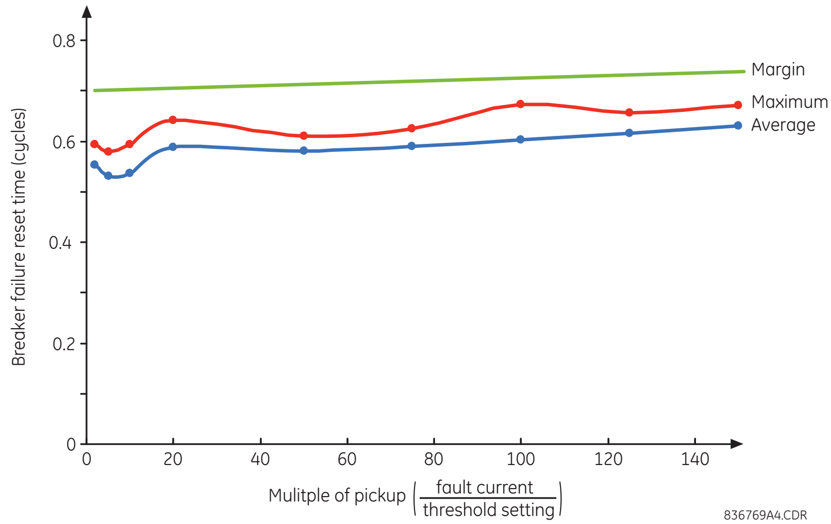

Figure 5–47: BREAKER FAILURE OVERCURRENT SUPERVISION RESET TIME

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 C70 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.

- **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.

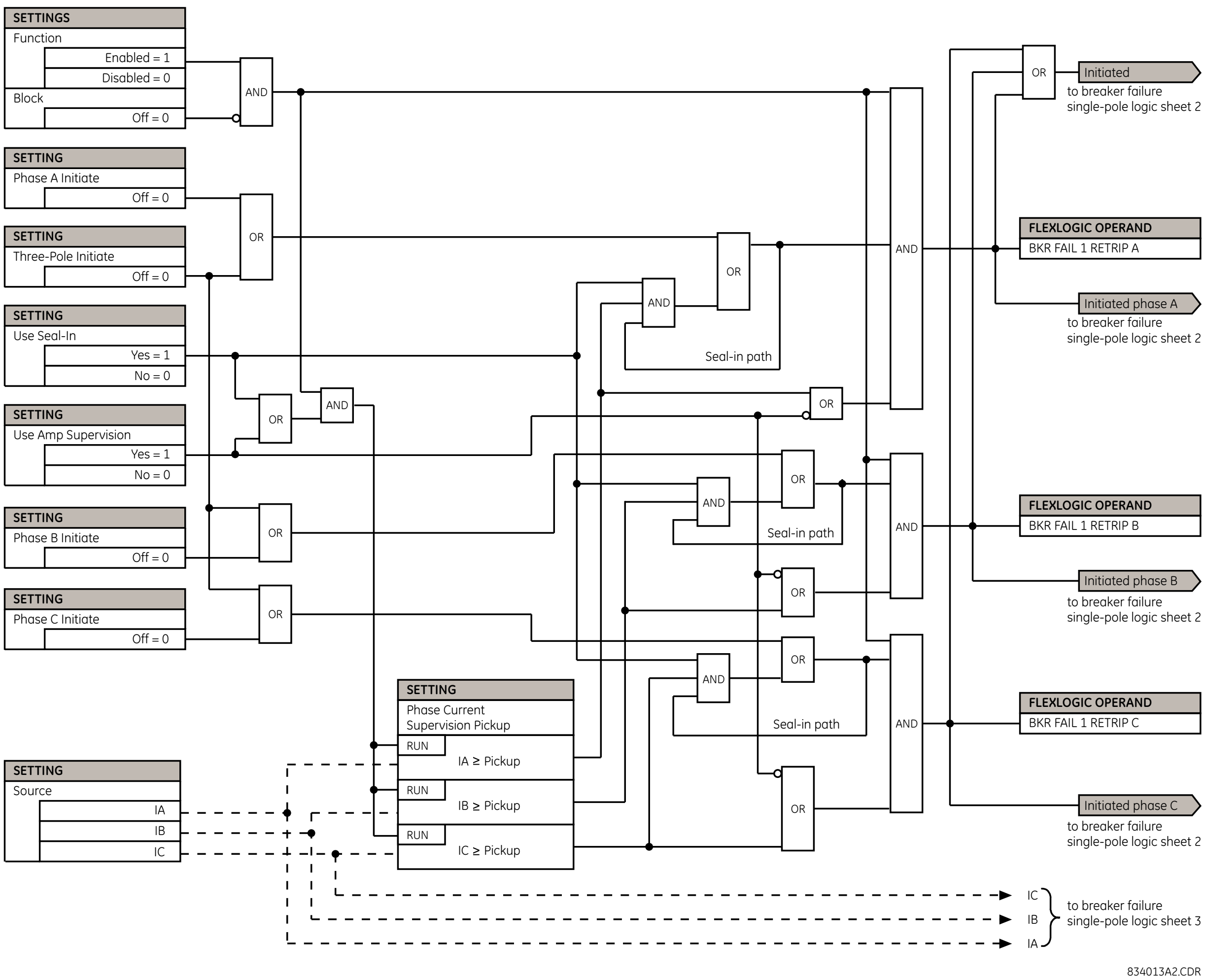

Figure 5–48: SINGLE-POLE BREAKER FAILURE, INITIATE (Sheet 1 of 2)

5

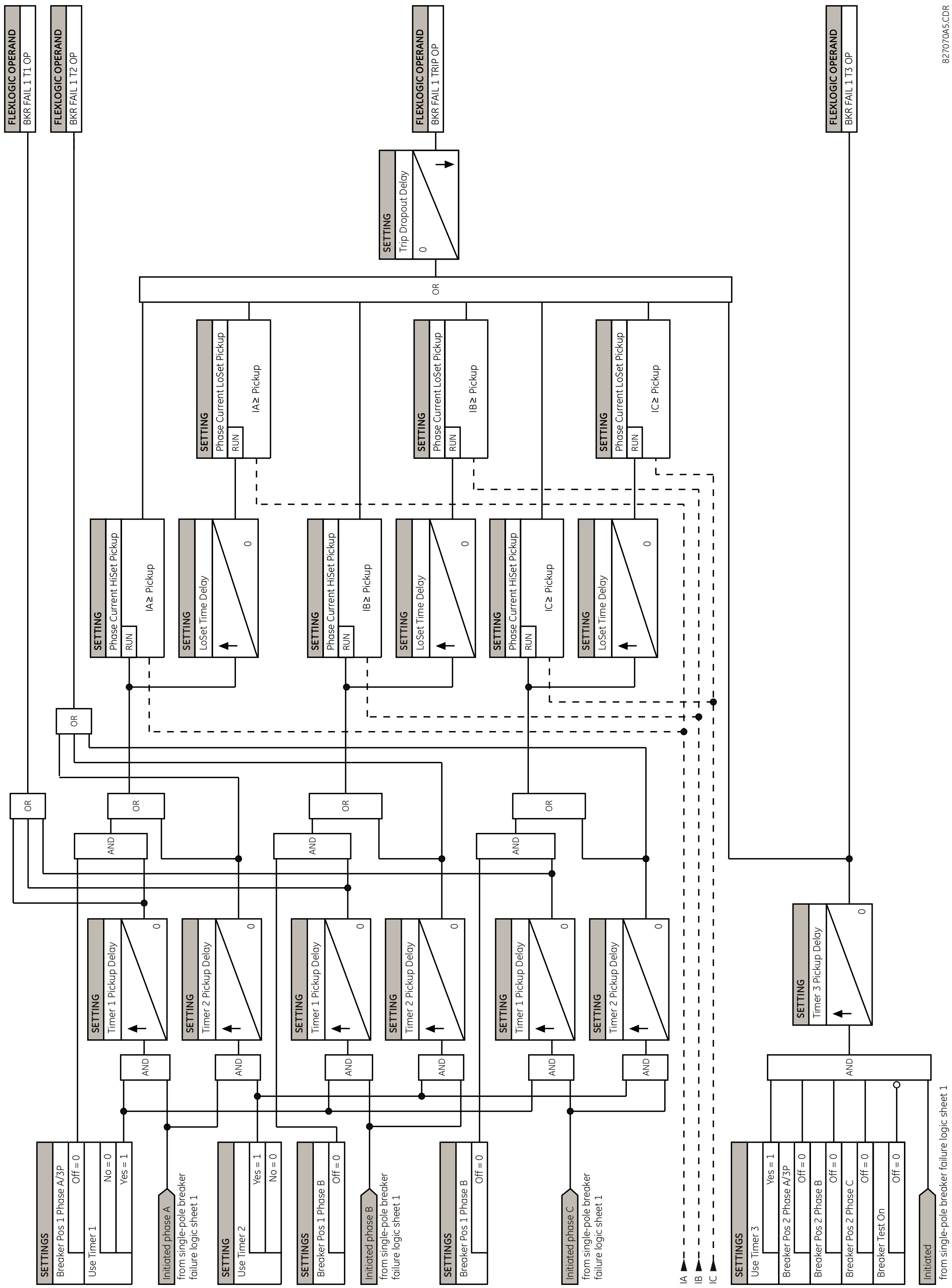

Figure 5–49: SINGLE-POLE BREAKER FAILURE, TIMERS (Sheet 2 of 2)

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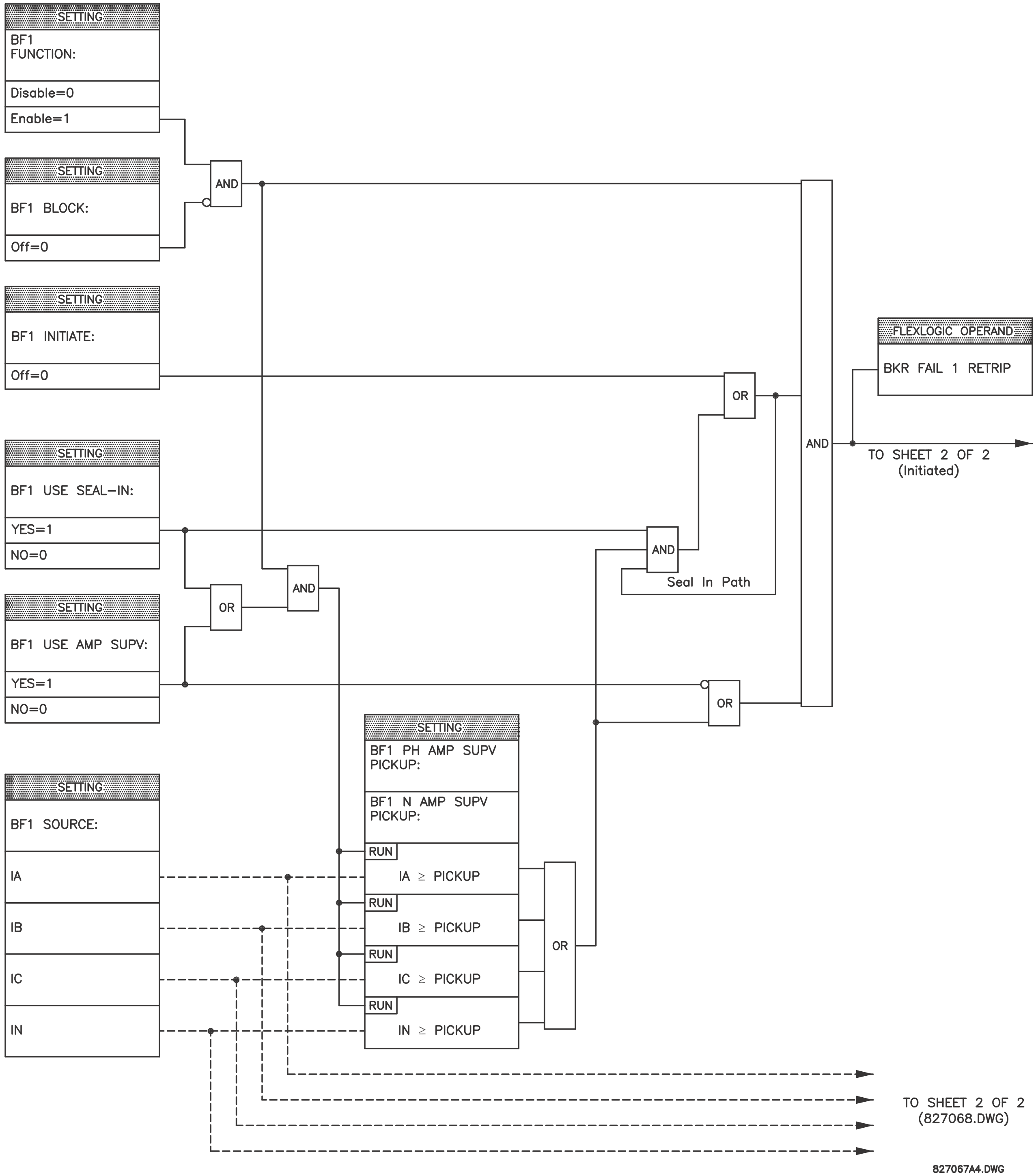

Figure 5–50: THREE-POLE BREAKER FAILURE, INITIATE (Sheet 1 of 2)

5

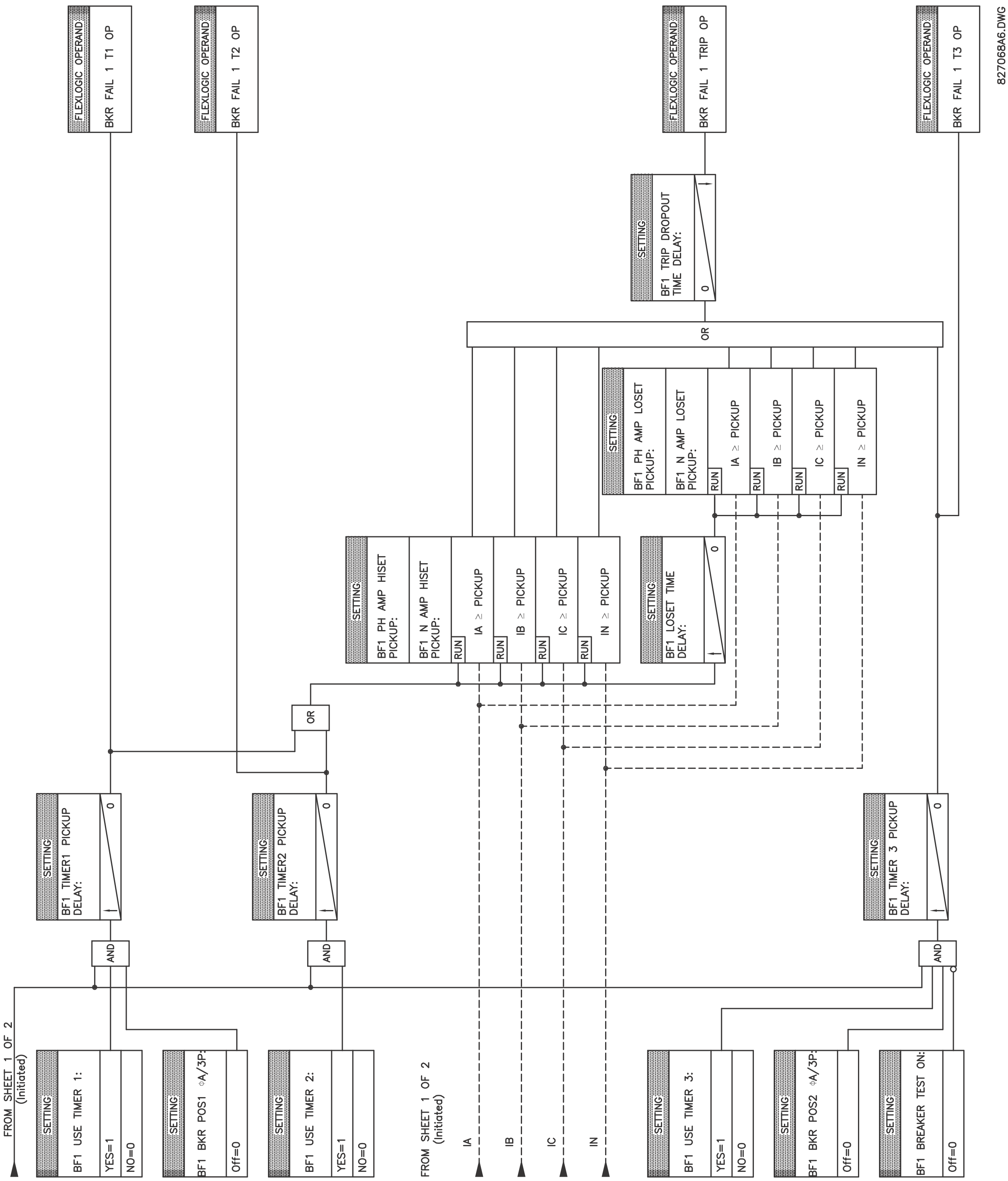

Figure 5–51: THREE-POLE BREAKER FAILURE, TIMERS (Sheet 2 of 2)

5.6.4 PHASE CURRENT

a) MAIN MENU

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ PHASE CURRENT

	Display	
	■ PHASE CURRENT ■	
	■ PHASE TOC1 ■	See page 5–125.
MESSAGE	■ PHASE TOC2 ■	See page 5–125.
	↓	
MESSAGE	■ PHASE TOC6 ■	See page 5–125.
MESSAGE	■ PHASE IOC1 ■	See page 5–127.
MESSAGE	■ PHASE IOC2 ■	See page 5–127.
	↓	
MESSAGE	■ PHASE IOC12 ■	See page 5–127.
MESSAGE	■ PHASE ■ DIRECTIONAL 1	See page 5–129.
MESSAGE	■ PHASE ■ DIRECTIONAL 2	See page 5–129.
MESSAGE	■ PHASE CURRENT ■ UNBALANCE 1	See page 5–132.
MESSAGE	■ PHASE CURRENT ■ UNBALANCE 2	See page 5–132.
MESSAGE	■ PHASE CURRENT ■ UNBALANCE 3	See page 5–132.

b) INVERSE TOC CURVE CHARACTERISTICS

The inverse time overcurrent curves used by the time overcurrent elements are the IEEE, IEC, GE Type IAC, and I^2t standard curve shapes. This allows for simplified coordination with downstream devices.

If none of these curve shapes is adequate, FlexCurves™ 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 5–12: 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.

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:

$$T = TDM \times \left[\frac{A}{\left(\frac{I}{I_{pickup}}\right)^p - 1} + B \right], T_{RESET} = TDM \times \left[\frac{t_r}{1 - \left(\frac{I}{I_{pickup}}\right)^2} \right] \quad \textbf{(EQ 5.7)}$$

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 5–13: 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 5–14: IEEE CURVE TRIP TIMES (IN SECONDS)

MULTIPLIER (TDM)	CURRENT (I / I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEEE EXTREMELY INVERSE										
0.5	11.341	4.761	1.823	1.001	0.648	0.464	0.355	0.285	0.237	0.203
1.0	22.682	9.522	3.647	2.002	1.297	0.927	0.709	0.569	0.474	0.407
2.0	45.363	19.043	7.293	4.003	2.593	1.855	1.418	1.139	0.948	0.813
4.0	90.727	38.087	14.587	8.007	5.187	3.710	2.837	2.277	1.897	1.626
6.0	136.090	57.130	21.880	12.010	7.780	5.564	4.255	3.416	2.845	2.439
8.0	181.454	76.174	29.174	16.014	10.374	7.419	5.674	4.555	3.794	3.252
10.0	226.817	95.217	36.467	20.017	12.967	9.274	7.092	5.693	4.742	4.065
IEEE VERY INVERSE										
0.5	8.090	3.514	1.471	0.899	0.654	0.526	0.450	0.401	0.368	0.345
1.0	16.179	7.028	2.942	1.798	1.308	1.051	0.900	0.802	0.736	0.689
2.0	32.358	14.055	5.885	3.597	2.616	2.103	1.799	1.605	1.472	1.378
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:

$$T = TDM \times \left[\frac{K}{(I/I_{pickup})^E - 1}\right],\ T_{RESET} = TDM \times \left[\frac{t_r}{1-(I/I_{pickup})^2}\right] \qquad \textbf{(EQ 5.8)}$$

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 5–15: 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 5–16: 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:

$$T = \text{TDM} \times \left(A + \frac{B}{(I/I_{pkp}) - C} + \frac{D}{((I/I_{pkp}) - C)^2} + \frac{E}{((I/I_{pkp}) - C)^3} \right), \; T_{RESET} = TDM \times \left[\frac{t_r}{1 - (I/I_{pkp})^2} \right] \quad \textbf{(EQ 5.9)}$$

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 5–17: 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 5–18: 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:

$$T = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{pickup}}\right)^2} \right], \; T_{RESET} = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{pickup}}\right)^{-2}} \right] \quad \textbf{(EQ 5.10)}$$

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 5–19: 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™:

The custom FlexCurves™ are described in detail in the FlexCurves™ section of this chapter. The curve shapes for the FlexCurves™ are derived from the formulae:

$$T = \text{TDM} \times \left[\text{FlexCurve Time at} \left(\frac{I}{I_{pickup}}\right) \right] \quad \text{when} \left(\frac{I}{I_{pickup}}\right) \geq 1.00 \quad \textbf{(EQ 5.11)}$$

$$T_{RESET} = \text{TDM} \times \left[\text{FlexCurve Time at} \left(\frac{I}{I_{pickup}}\right) \right] \quad \text{when} \left(\frac{I}{I_{pickup}}\right) \leq 0.98 \quad \textbf{(EQ 5.12)}$$

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.

$$T = \text{TDM} \;\text{ in seconds, when } I > I_{pickup} \quad \textbf{(EQ 5.13)}$$

$$T_{RESET} = \text{TDM} \;\text{ in seconds} \quad \textbf{(EQ 5.14)}$$

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 C70 uses the FlexCurve™ feature to facilitate programming of 41 recloser curves. Please refer to the FlexCurve™ section in this chapter for additional details.

5

c) PHASE TIME OVERCURRENT (ANSI 51P)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ PHASE CURRENT ⇨ PHASE TOC1(6)

	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.

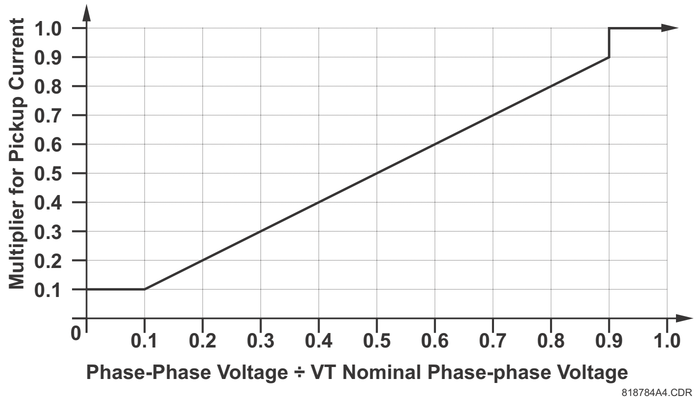

Figure 5–52: PHASE TIME OVERCURRENT VOLTAGE RESTRAINT CHARACTERISTIC

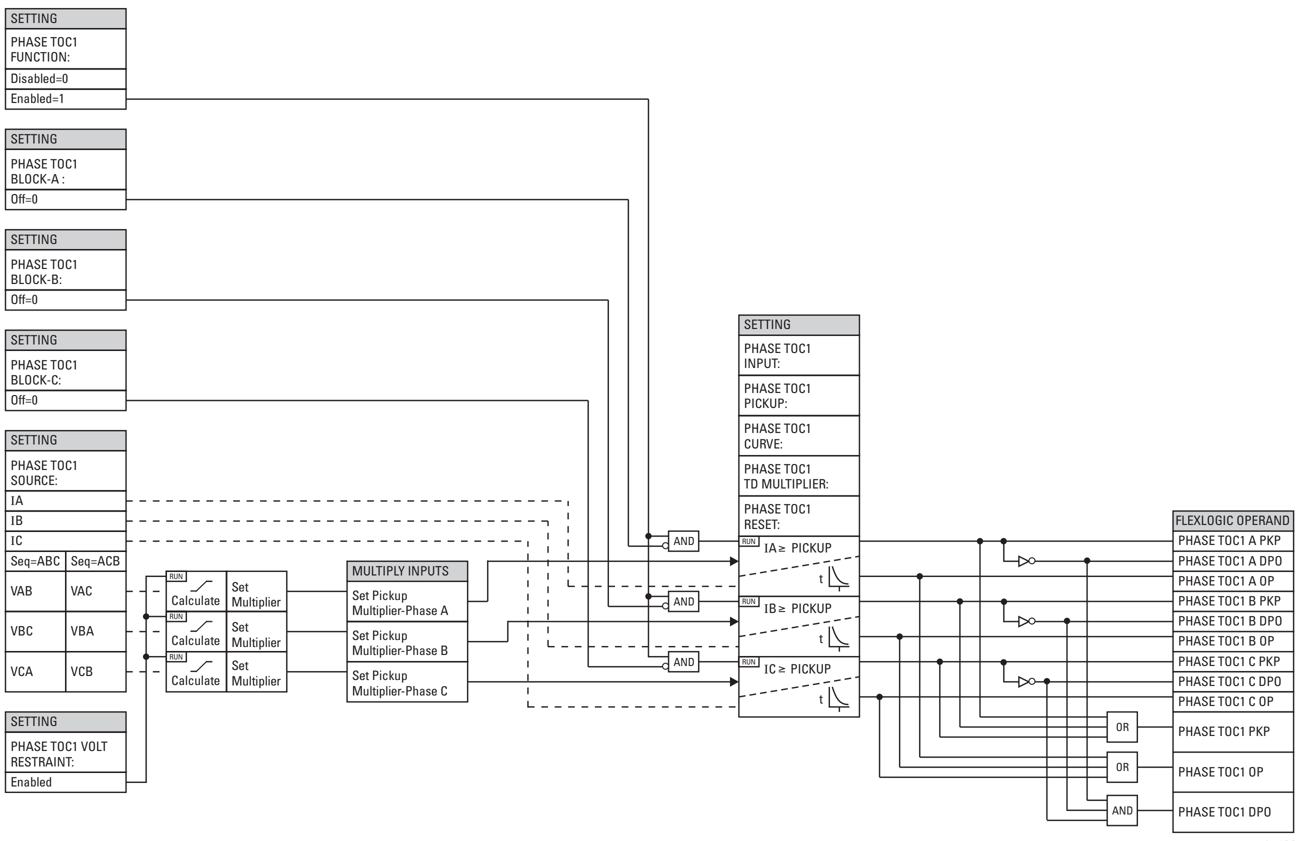

Figure 5–53: PHASE TIME OVERCURRENT 1 SCHEME LOGIC

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d) PHASE INSTANTANEOUS OVERCURRENT (ANSI 50P)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ PHASE CURRENT ⇨ PHASE IOC 1(12)

■ 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. The phase instantaneous overcurrent timing curves are shown below for form-A contacts in a 60 Hz system.

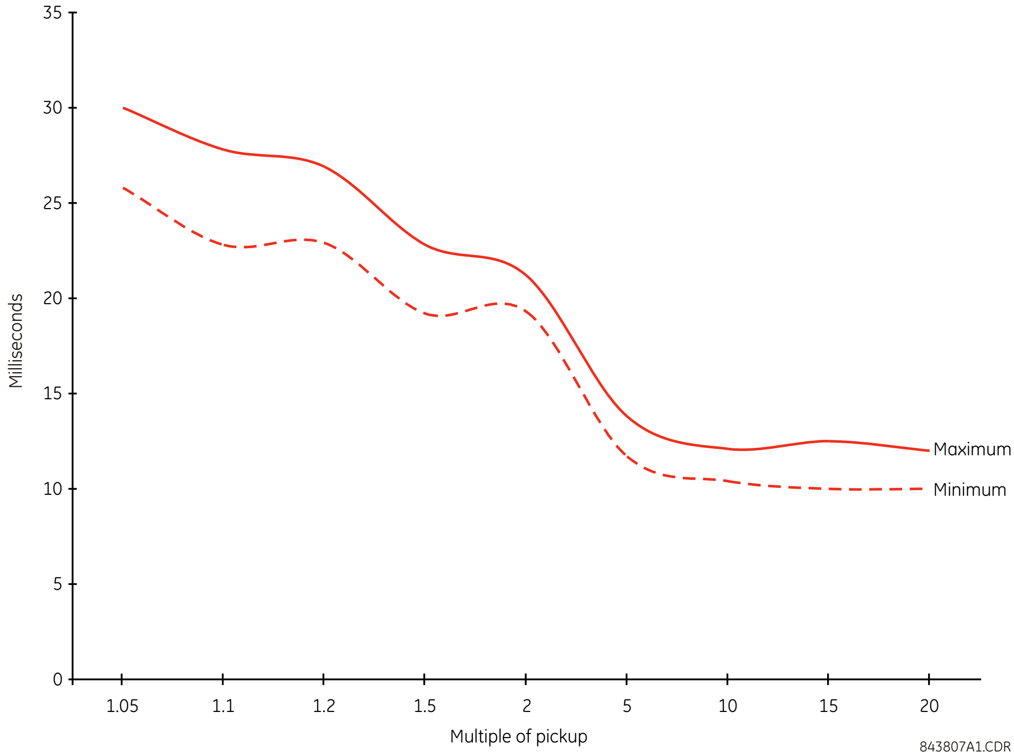

Figure 5–54: PHASE INSTANTANEOUS OVERCURRENT TIMING CURVES

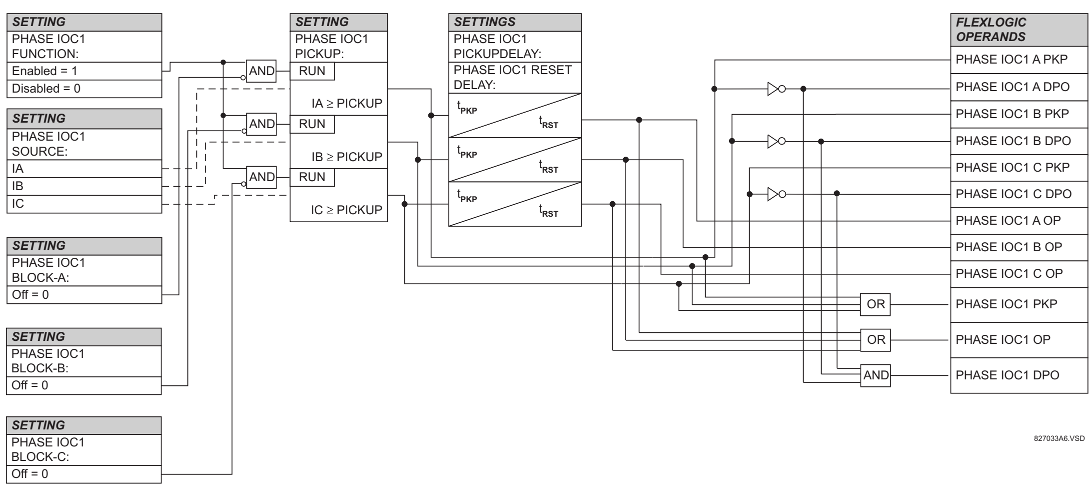

Figure 5–55: PHASE INSTANTANEOUS OVERCURRENT 1 SCHEME LOGIC

e) PHASE DIRECTIONAL OVERCURRENT (ANSI 67P)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ PHASE CURRENT ⇨ PHASE DIRECTIONAL 1

■ 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

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.

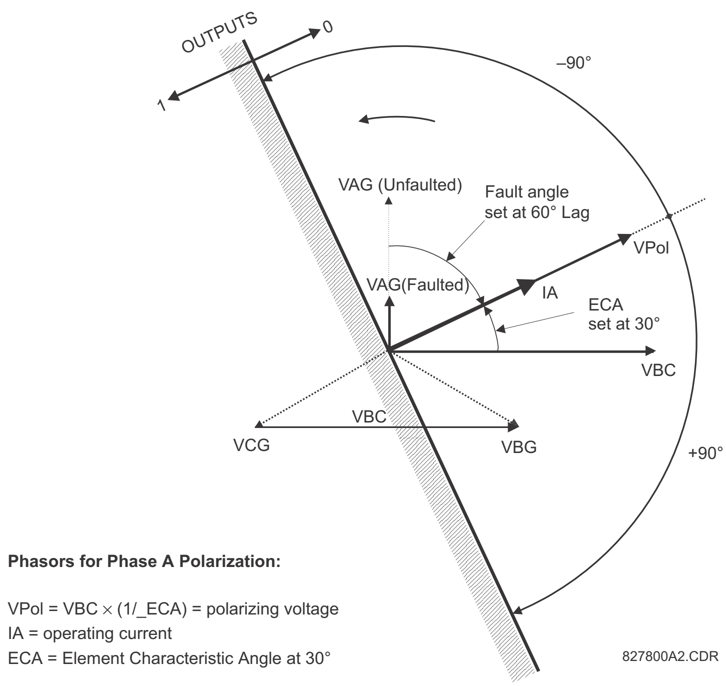

Figure 5–56: PHASE A DIRECTIONAL POLARIZATION

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.

5

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.

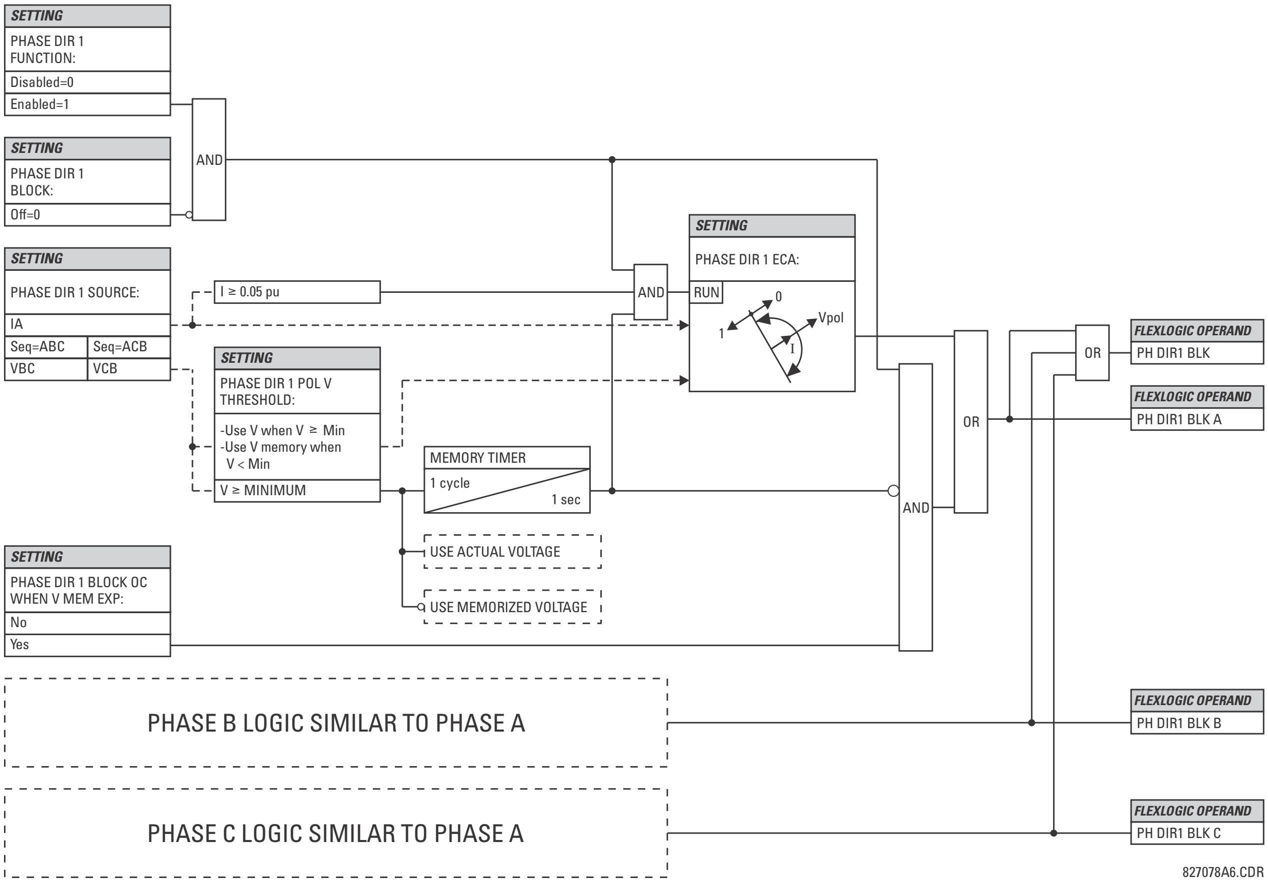

Figure 5–57: PHASE DIRECTIONAL SCHEME LOGIC

f) PHASE CURRENT UNBALANCE (ANSI 60P)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ PHASE CURRENT ⇨⇩ PHASE CURRENT UNBALANCE 1(3)

■ PHASE CURRENT ■ UNBALANCE 1	◁▷	CUR UNBALCE 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	△▽	CUR UNBALCE 1 DIF SOURCE: SRC 1	*Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6*
MESSAGE	△▽	CUR UNBALCE 1 BANK SOURCE: SRC 1	*Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6*
MESSAGE	△▽	CUR UNBALCE 1 INHNT FACTOR A: 0.0000	*Range: –0.1000 to 0.1000 in steps of 0.0001*
MESSAGE	△▽	CUR UNBALCE 1 INHNT FACTOR B: 0.0000	*Range: –0.1000 to 0.1000 in steps of 0.0001*
MESSAGE	△▽	CUR UNBALCE 1 INHNT FACTOR C: 0.0000	*Range: –0.1000 to 0.1000 in steps of 0.0001*
MESSAGE	△▽	CUR UNBALCE 1 STG 1A PICKUP: 0.020 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 2A PICKUP: 0.030 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 3A PICKUP: 0.040 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 4A PICKUP: 0.050 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 1B PICKUP: 0.020 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 2B PICKUP: 0.030 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 3B PICKUP: 0.040 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 4B PICKUP: 0.050 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 1C PICKUP: 0.020 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 2C PICKUP: 0.030 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 3C PICKUP: 0.040 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 4C PICKUP: 0.050 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
MESSAGE	△▽	CUR UNBALCE 1 STG 1 PKP DELAY: 30.00 s	*Range: 0.00 to 600.00 s in steps of 0.01*
MESSAGE	△▽	CUR UNBALCE 1 STG 2 PKP DELAY: 10.00 s	*Range: 0.00 to 600.00 s in steps of 0.01*
MESSAGE	△▽	CUR UNBALCE 1 STG 3 PKP DELAY: 1.00 s	*Range: 0.00 to 600.00 s in steps of 0.01*

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MESSAGE	CUR UNBALCE 1 STG 4 PKP DELAY: 0.20 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	CUR UNBALCE 1 DPO DELAY: 0.25 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	CUR UNBL 1 BLK STG1: Off	Range: FlexLogic™ operand
MESSAGE	CUR UNBL 1 BLK STG2: Off	Range: FlexLogic™ operand
MESSAGE	CUR UNBL 1 BLK STG3: Off	Range: FlexLogic™ operand
MESSAGE	CUR UNBL 1 BLK STG4: Off	Range: FlexLogic™ operand
MESSAGE	CUR UNBALCE 1 TARGET: Self-Reset	Range: Self-reset, Latched, Disabled
MESSAGE	CUR UNBALCE 1 EVENTS: Disabled	Range: Disabled, Enabled

Up to three identical phase current unbalance elements, one per each CT/VT module configured in hardware, are provided.

The element responds to a differential current signal measured via window-type CTs as a vectorial current difference between two parallel banks. With the two capacitors in the same phase identical, the said differential current is zero. Small differences between the capacitors of a given phase result in a small circulating current. Subtracting an adequate portion of the total bank current in a given phase compensates for this inherent unbalance current.

The relay allows manual setting of the inherent unbalance factors, or automatically via the **COMMANDS** menu. For more information, refer to the *Theory of Operation* and *Application of Settings* chapters.

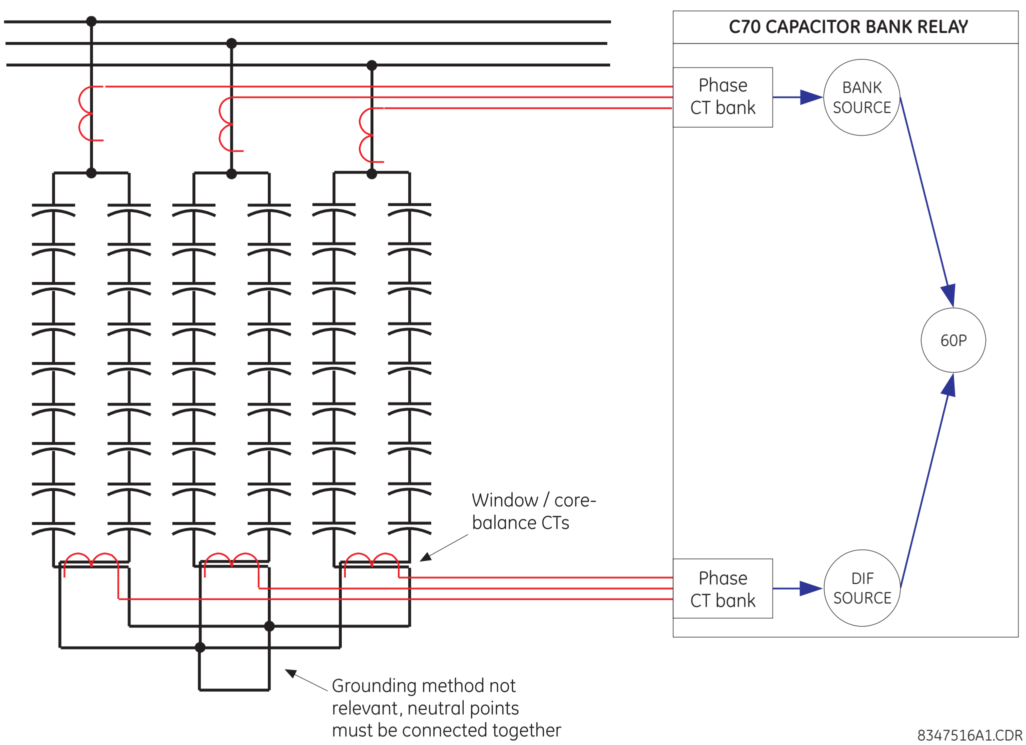

Figure 5–58: PHASE CURRENT UNBALANCE BASIC CONNECTIONS

The following settings are available for all three elements.

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- **CUR UNBALCE 1 STG 1A PICKUP** to **CUR UNBALCE 1 STG 4C PICKUP**: These settings specify pickup thresholds for stages 1 through 4 in phases A through C in per-units (pu) of the nominal current of the differential source. A value of 1 pu is the nominal secondary current, or the nominal primary current, respectively, as configured under the differential source of this function.
- **CUR UNBALCE 1 STG 1 PKP DELAY** to **CUR UNBALCE 1 STG 4 PKP DELAY**: This setting specifies the pickup time delay, individually per each stage of alarming/tripping. Note that each of the twelve comparators (four stages in three phases) uses an individual timer, but settings for these timers are controlled individually per each stage, not per phase. The timers use a common drop out time delay specified by the next setting.
- **CUR UNBALCE 1 DPO DELAY**: This setting controls a drop out delay for the operate FlexLogic™ operands. Note that individual stages apply individually configurable pickup delays, but use this common drop out delay.
- **CUR UNBL 1 BLK STG1** to **CUR UNBL 1 BLK STG4**: These settings are used to block the function on a per-stage basis when required. At minimum this function shall be blocked when the two banks are not paralleled. Note that when unblocked, the function becomes operational after five cycles of intentional delay. High-set instantaneous protection on energization can be provided by a separate instantaneous overcurrent function.

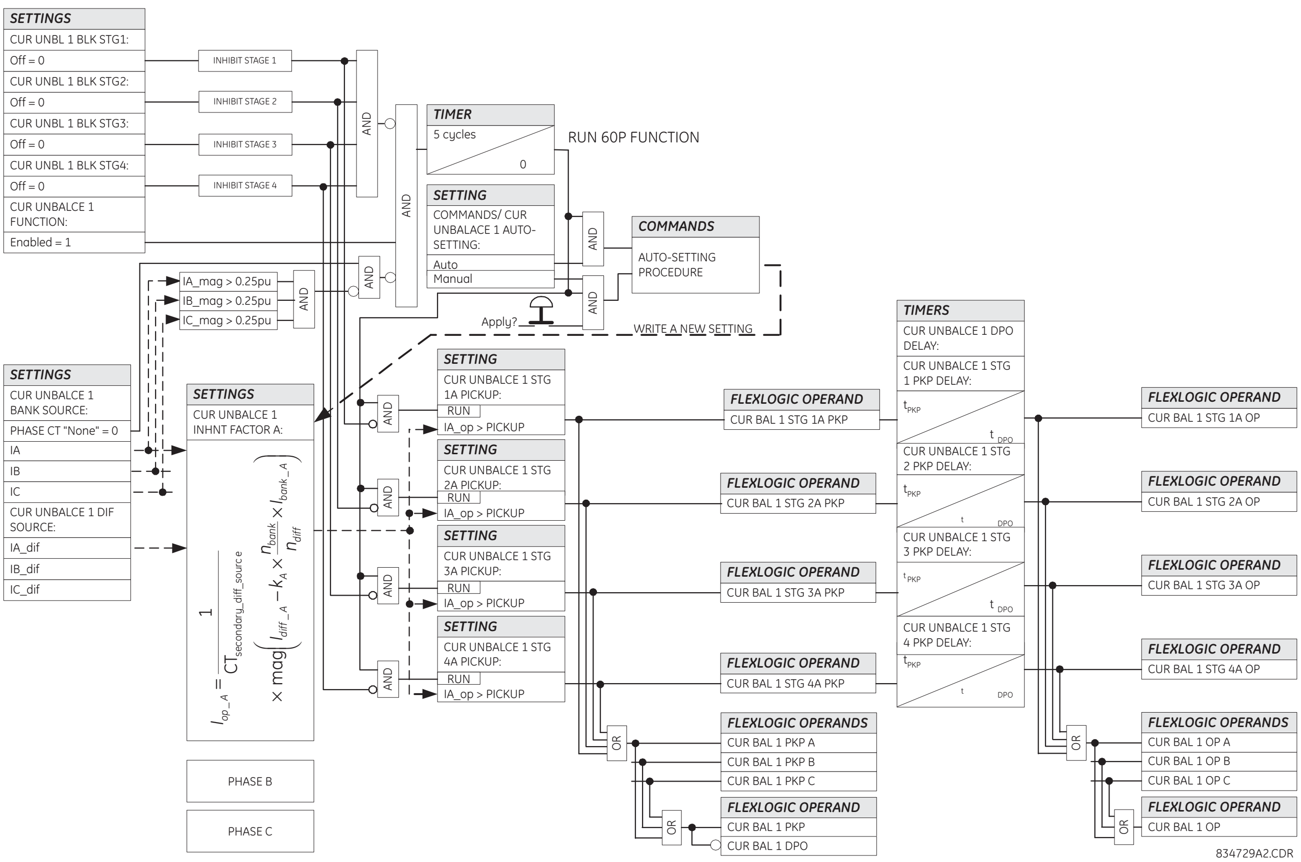

Figure 5–59: PHASE CURRENT UNBALANCE SCHEME LOGIC

5.6.5 NEUTRAL CURRENT

a) MAIN MENU

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEUTRAL CURRENT

■ NEUTRAL CURRENT ■	◁▷	■ NEUTRAL TOC1 ■	See page 5-136.
	MESSAGE	■ NEUTRAL TOC2 ■	See page 5-136.
		↓	
	MESSAGE	■ NEUTRAL TOC6 ■	See page 5-136.
	MESSAGE	■ NEUTRAL IOC1 ■	See page 5-137.
	MESSAGE	■ NEUTRAL IOC2 ■	See page 5-137.
		↓	
	MESSAGE	■ NEUTRAL IOC12 ■	See page 5-137.
	MESSAGE	■ NEUTRAL ■ DIRECTIONAL OC1	See page 5-138.
	MESSAGE	■ NEUTRAL CURRENT ■ UNBALANCE 1	See page 5-142.
	MESSAGE	■ NEUTRAL CURRENT ■ UNBALANCE 2	See page 5-142.
	MESSAGE	■ NEUTRAL CURRENT ■ UNBALANCE 3	See page 5-142.

The C70 contains protection elements for neutral time overcurrent (ANSI device 51G), neutral instantaneous overcurrent (ANSI device 50G), and neutral current unbalance (ANSI device 60N). A maximum of six ground time overcurrent and twelve ground instantaneous overcurrent elements are available, dependent on the CT/VT modules ordered with the relay. Three neutral current unbalance elements are available.

b) NEUTRAL TIME OVERCURRENT (ANSI 51N)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEUTRAL CURRENT ⇨ NEUTRAL TOC1(6)

	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*

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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.

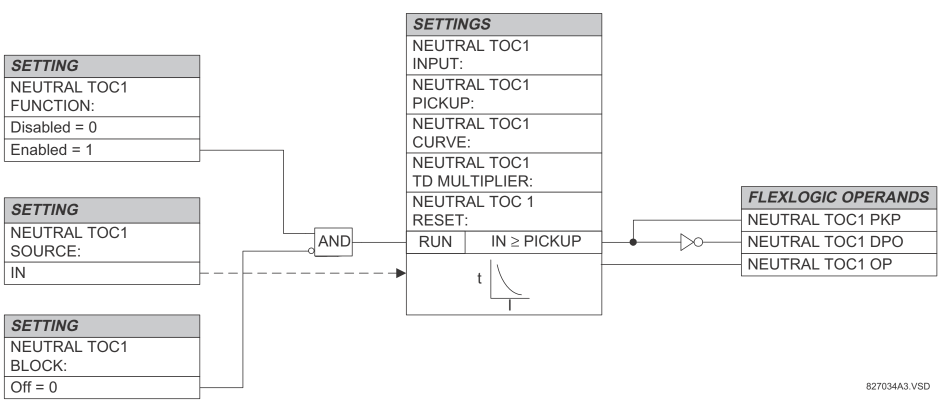

Figure 5–60: NEUTRAL TIME OVERCURRENT 1 SCHEME LOGIC

c) NEUTRAL INSTANTANEOUS OVERCURRENT (ANSI 50N)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEUTRAL CURRENT ⇨⇩ NEUTRAL IOC1(12)

	Display	Range
■ 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

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:

$$I_{op} = 3 \times (|I\_0| - K \cdot |I\_1|) \quad \text{where } K = 1/16 \qquad \textbf{(EQ 5.15)}$$

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: $I_{op} = 3 \times I_{injected}$).

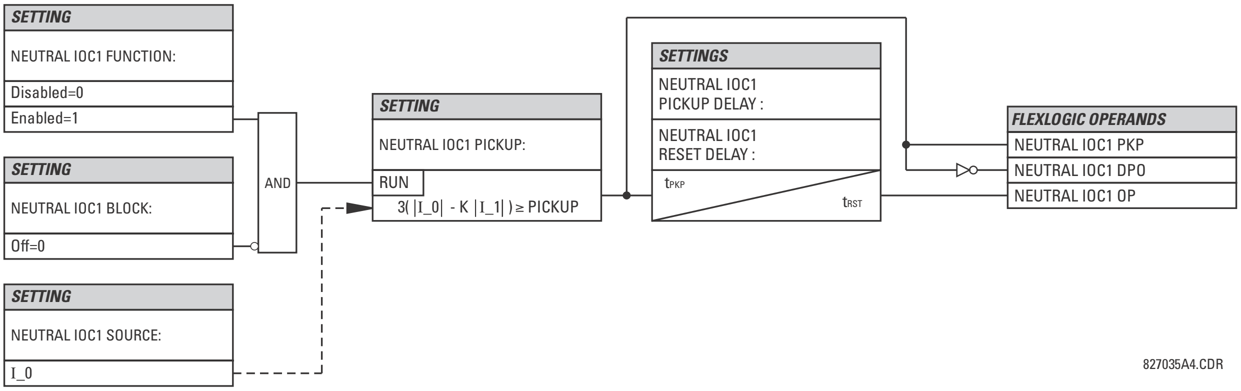

Figure 5–61: NEUTRAL IOC1 SCHEME LOGIC

d) NEUTRAL DIRECTIONAL OVERCURRENT (ANSI 67N)

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
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.

$$I_{op} = 3 \times (|I\_0| - K \times |I\_1|) \quad \textbf{(EQ 5.16)}$$

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 following tables define the neutral directional overcurrent element.

Table 5–20: 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	$I_{op} = 3 \times (\lvert I\_0 \rvert - K \times \lvert I\_1 \rvert)$ if $\lvert I_1 \rvert > 0.8$ pu $I_{op} = 3 \times (\lvert I\_0 \rvert)$ if $\lvert I_1 \rvert \le 0.8$ pu
	Reverse	–V_0 + Z_offset × I_0	–I_0 × 1∠ECA	
Current	Forward	IG	I_0	
	Reverse	IG	–I_0	
Dual	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 5–21: 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	$I_{op} = \lvert IG \rvert$
	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.

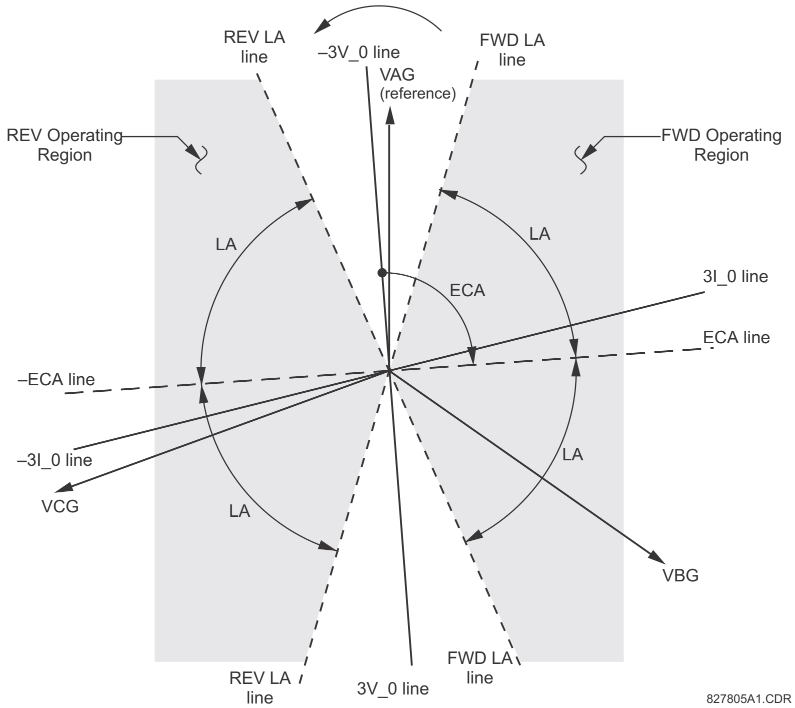

Figure 5–62: NEUTRAL DIRECTIONAL VOLTAGE-POLARIZED CHARACTERISTICS

- **NEUTRAL DIR OC1 POLARIZING:** This setting selects the polarizing mode for the directional unit.
  - If “Voltage” polarizing is selected, the element uses the zero-sequence voltage angle for polarization. The user can use either the zero-sequence voltage V_0 calculated from the phase voltages, or the zero-sequence voltage supplied externally as the auxiliary voltage V_X, both from the **NEUTRAL DIR OC1 SOURCE**.

    The calculated V_0 can be used as polarizing voltage only if the voltage transformers are connected in Wye. The auxiliary voltage can be used as the polarizing voltage provided **SYSTEM SETUP ⇨ AC INPUTS ⇨⇩ VOLTAGE BANK ⇨⇩ AUXILIARY VT CONNECTION** is set to “Vn” and the auxiliary voltage is connected to a zero-sequence voltage source (such as open delta connected secondary of VTs).

    The zero-sequence (V_0) or auxiliary voltage (V_X), accordingly, must be greater than 0.02 pu 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" or "Dual" 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.
- **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.

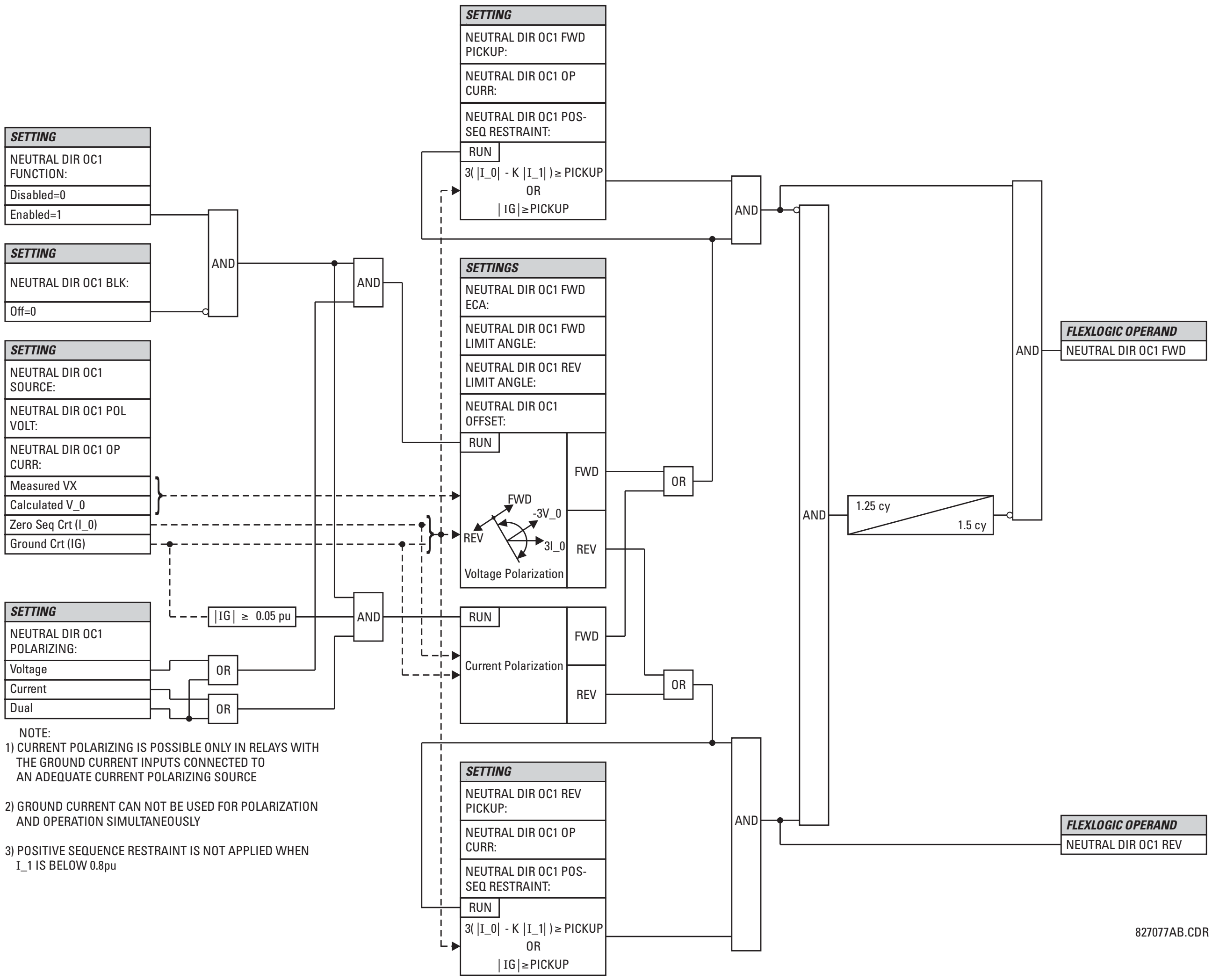

Figure 5–63: NEUTRAL DIRECTIONAL OVERCURRENT LOGIC

e) NEUTRAL CURRENT UNBALANCE (ANSI 51NU)

PATH: SETTINGS ⇨⇩ GROUPED... ⇨ SETTING GROUP 1(6) ⇨⇩ NEUTRAL CURRENT ⇨⇩ NEUTRAL CURRENT UNBALANCE 1(3)

■ NEUTRAL CURRENT ■ UNBALANCE 1		NTRL CUR UNBALCE 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
	MESSAGE	NTRL CUR UNBALCE 1 BANK SOURCE: SRC 1	*Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6*
	MESSAGE	NTRL CUR UNBALCE 1 K MAG: 0.0000	*Range: 0.0000 to 0.1500 in steps of 0.0001*
	MESSAGE	NTRL CUR UNBALCE 1 K ANG: 0°	*Range: 0 to 359° in steps of 1*
	MESSAGE	NTRL CUR UNBALCE 1 STG 1 PKP: 0.020 pu	*Range: 0.001 to 5.000 pu in steps of 0.001*
	MESSAGE	NTRL CUR UNBALCE 1 STG 1 SLOPE: 2.0%	*Range: 0.0 to 10.% in steps of 0.1*

MESSAGE	NTRL CUR UNBALCE 1 STG 2 PKP: 0.030 pu	Range: 0.001 to 5.000 pu in steps of 0.001
MESSAGE	NTRL CUR UNBALCE 1 STG 2 SLOPE: 2.0%	Range: 0.0 to 10.% in steps of 0.1
MESSAGE	NTRL CUR UNBALCE 1 STG 3 PKP: 0.040 pu	Range: 0.001 to 5.000 pu in steps of 0.001
MESSAGE	NTRL CUR UNBALCE 1 STG 3 SLOPE: 2.0%	Range: 0.0 to 10.% in steps of 0.1
MESSAGE	NTRL CUR UNBALCE 1 STG 4 PKP: 0.050 pu	Range: 0.001 to 5.000 pu in steps of 0.001
MESSAGE	NTRL CUR UNBALCE 1 STG 4 SLOPE: 5.0%	Range: 0.0 to 10.% in steps of 0.1
MESSAGE	NTRL CUR UNBALCE 1 STG 1 DEL: 30.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL CUR UNBALCE 1 STG 2 DEL: 10.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL CUR UNBALCE 1 STG 3 DEL: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL CUR UNBALCE 1 STG 4 DEL: 0.20 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL CUR UNBALCE 1 DPO DELAY: 0.25 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL CUR 1 BLK STG1: Off	Range: FlexLogic™ operand
MESSAGE	NTRL CUR 1 BLK STG2: Off	Range: FlexLogic™ operand
MESSAGE	NTRL CUR 1 BLK STG3: Off	Range: FlexLogic™ operand
MESSAGE	NTRL CUR 1 BLK STG4: Off	Range: FlexLogic™ operand
MESSAGE	NTRL CUR UNBALCE 1 TARGET: Self-Reset	Range: Self-reset, Latched, Disabled
MESSAGE	NTRL CUR UNBALCE 1 EVENTS: Disabled	Range: Disabled, Enabled

Up to three identical neutral current unbalance elements, one per each installed CT/VT module.

The neutral current unbalance element responds to a differential current signal measured as a vectorial current difference between neutral currents of parallel banks. In case of ungrounded banks, regular, preferably low-ratio CT can be used. In case of grounded banks, a window or core-balance CT shall be used for increased accuracy/sensitivity.

The function applies simplified compensation for the inherent bank unbalance. Accurate compensation requires three balancing factors that are difficult to measure in practical situations. Instead, a simple and practical compensation responding to both the positive-sequence current and negative-sequence current is applied. This method is easy to apply and remains accurate as long as the zero-sequence bank currents are relatively small. Under large zero-sequence bank currents, the applied method of compensation for the inherent bank unbalance is less accurate. The solution to this problem is to use a small portion of the zero-sequence current at the bank terminals to produce extra restraint and preserve high sensitivity of this protection method.

By setting both the slope and the inherent unbalance compensating factor to zero one could apply the function as a plain overcurrent element responding to the split-phase neutral current.

The relay allows manual setting of the inherent unbalance factor or automatic setting via a dedicated command. For additional information, refer to the *Theory of operation* and *Application of settings* chapters.

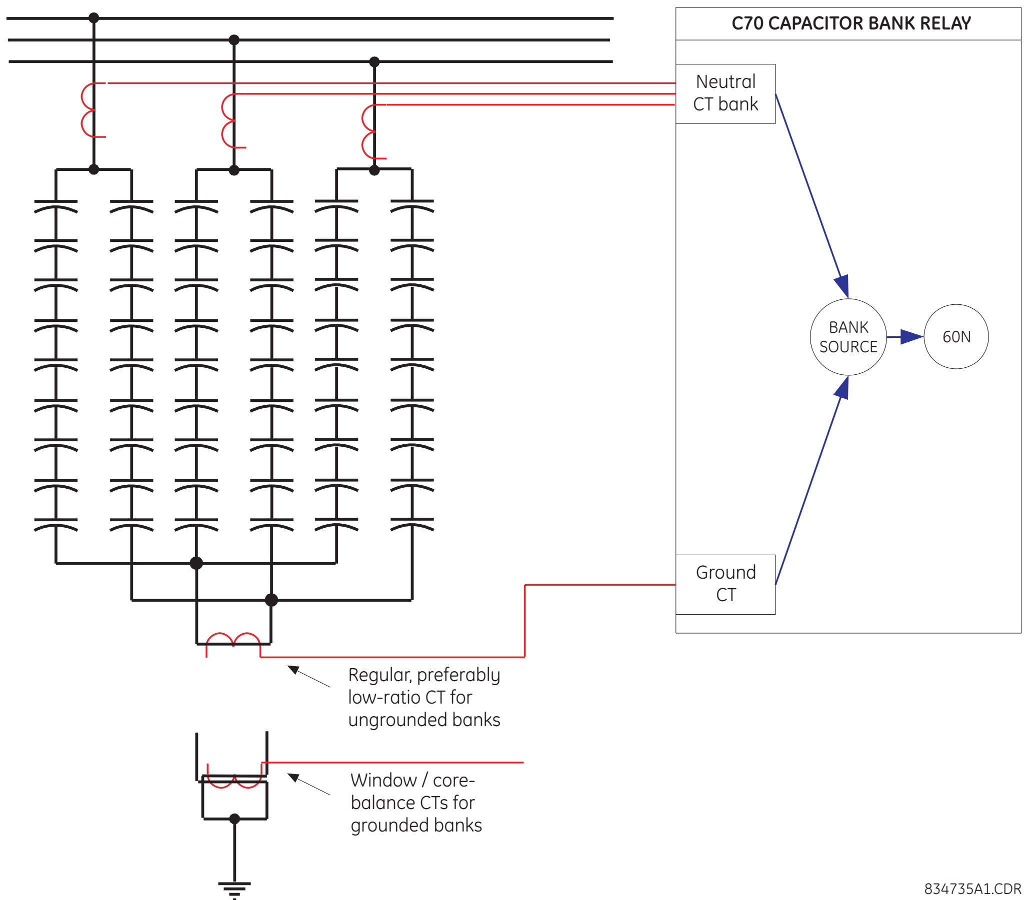

Figure 5–64: NEUTRAL CURRENT UNBALANCE CONNECTIONS

The following settings are available. The settings shown below are for the neutral current unbalance 1 element. The same descriptions apply to the neutral current unbalance 2 and 3 elements.

- **NTRL CUR UNBALCE 1 BANK SOURCE**: This setting indicates the signal source that signifies the split-phase neutral current in its ground current channel. At minimum the ground channel of this source must be set. If the factor compensating for inherent bank unbalance is set above zero signalling the intent of using the compensation, the phase currents of this source must be configured as well. Without the phase currents configured under this source, the function would run only if the magnitude of the inherent unbalance factor is set to zero.

  To improve accuracy, a relatively low-ratio window CT can be used for instrumentation of the split-phase neutral current, and be wired to a 1 A or even sensitive ground relay input for extra sensitivity. CT primary and secondary ratings are entered under a separate menu. Directionality of wiring of the split-phase current is not important for proper functioning of the feature as long as the angle of the factor compensating for the inherent unbalance is set appropriately.

- **NTRL CUR UNBALCE 1 K MAG**: This setting defines magnitude of the factor compensating for the inherent unbalance of the bank. Under balanced conditions, the amount of the spill current measured in the neutral connection between the banks is proportional to the positive-sequence component of the total current of the two banks. This setting defines the magnitude of the proportionality factor. Quality of balancing the bank with a given value of this setting can be viewed under **ACTUAL VALUES** menu. An automatic setting procedure is available via the **COMMANDS** menu to calculate the compensating factor automatically. Setting the compensating factor to zero effectively disables the compensation. If further the slope is set to zero as well, this feature becomes a plain overcurrent element responding to the neutral split-phase current.

- **NTRL CUR UNBALCE 1 K ANG**: This setting defines angle of the factor compensating for the inherent unbalance of the bank. Under balanced conditions, the amount of the spill current measured in the neutral connection between the banks is proportional to the positive-sequence component of the total current of the two banks. This setting defines the angle of the proportionality factor. Quality of balancing the bank with a given value of this setting can be viewed under **ACTUAL VALUES** menu. An automatic setting procedure is available under the **COMMANDS** menu to calculate the compensating factor automatically. Refer to the *Theory of operation* chapter for more information regarding the meaning of the inherent unbalance compensating factor of this protection method.

- **NTRL CUR UNBALCE 1 STG1 PKP** to **NTRL CUR UNBALCE 1 STG4 PKP**: These settings specify pickup thresholds for stages 1 through 4 in per-units (pu) of the nominal current of the ground current channel of the bank source. A value of 1 pu is the nominal secondary current, or the nominal primary current, respectively, as configured under the bank source of this function.
- **NTRL CUR UNBALCE 1 STG1 SLOPE** to **NTRL CUR UNBALCE 1 STG4 SLOPE**: These settings specify the slopes for stages 1 through 4. The slope setting is applied if the phase CTs are configured under the bank source. The magnitude of the zero-sequence current is applied as a restraining signal. Typically few percent of slope is enough to ensure security of the function. The factor compensating for the inherent bank unbalance zeroes out the operating signal under relatively balanced bank currents. If the said currents contain a significant zero sequence component, the quality of compensation is lower, hence the need for the restraint, and this slope setting. Refer to the *Theory of operation* chapter for more information on this protection method.
- **NTRL CUR UNBALCE 1 STG1 DEL** to **NTRL CUR UNBALCE 1 STG4 DEL**: This setting specifies the pickup time delay, individually per each stage of alarming/tripping. The timers use a common drop out time delay specified by the next setting.
- **NTRL CUR UNBALCE 1 DPO DELAY**: This setting controls a drop out delay for the operate FlexLogic™ operands. Note that individual stages apply individually configurable pickup delays, but use this common drop out delay.
- **NTRL CUR 1 BLK STG1** to **NTRL CUR 1 BLK STG4**: These settings are used to block the function on a per stage basis when required. At minimum this function shall be blocked when the two banks are not paralleled. Note that when unblocked, the function becomes operational after five cycles of intentional delay. High-set instantaneous protection on energization can be provided by a separate instantaneous overcurrent function.

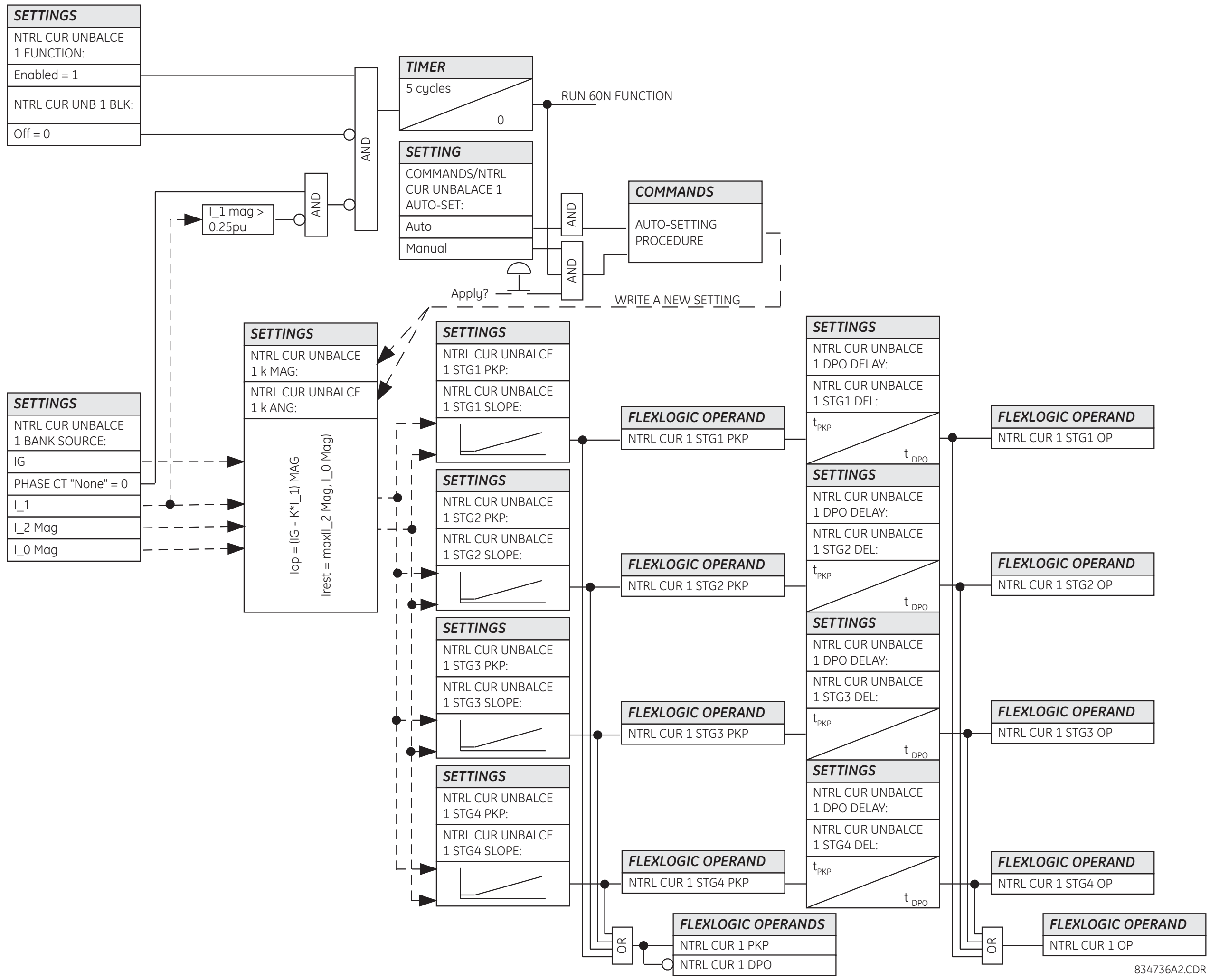

Figure 5–65: NEUTRAL CURRENT UNBALANCE SCHEME LOGIC

5.6.6 GROUND CURRENT

a) MAIN MENU

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ GROUND CURRENT

■ GROUND CURRENT ■	◁▷	■ GROUND TOC1 ■	See page 5–148.
MESSAGE	△▽	■ GROUND TOC2 ■	See page 5–148.
		↓	
MESSAGE	△▽	■ GROUND TOC6 ■	See page 5–148.
MESSAGE	△▽	■ GROUND IOC1 ■	See page 5–149.
MESSAGE	△▽	■ GROUND IOC2 ■	See page 5–149.
		↓	
MESSAGE	△	■ GROUND IOC12 ■	See page 5–149.

The C70 contains protection elements for ground time overcurrent (ANSI device 51G) and ground instantaneous overcurrent (ANSI device 50G). A maximum of six ground time overcurrent and eight ground instantaneous overcurrent elements are available, dependent on the CT/VT modules ordered with the relay. See the following table for details.

CT/VT MODULES		GROUND CURRENT ELEMENTS	
SLOT F	SLOT M	TIME OVERCURRENT	INSTANTANEOUS OVERCURRENT
8F/8G	8F/8G	4	4
	8H/8J	6	6
8H/8J	8F/8G	6	6
	8H/8J	6	8

5

b) GROUND TIME OVERCURRENT (ANSI 51G)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ GROUND CURRENT ⇨ GROUND TOC1(6)

	Setting	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*

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.

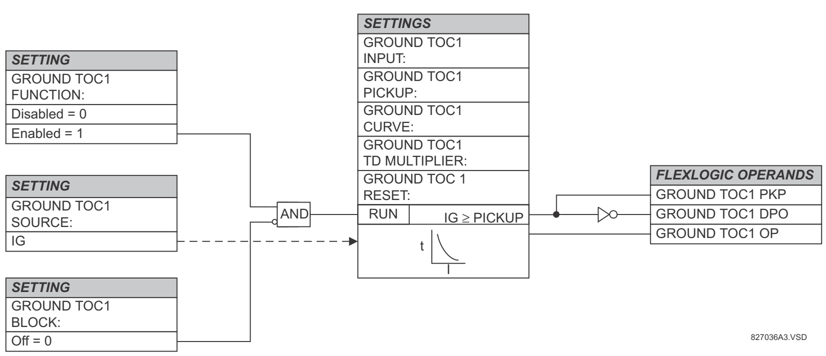

Figure 5–66: GROUND TOC1 SCHEME LOGIC

5

c) GROUND INSTANTANEOUS OVERCURRENT (ANSI 50G)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ GROUND CURRENT ⇨⇩ GROUND IOC1(12)

■ 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.

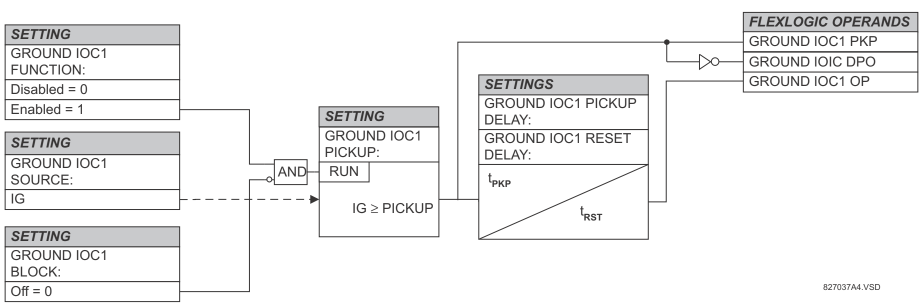

Figure 5–67: GROUND IOC1 SCHEME LOGIC

5.6.7 NEGATIVE SEQUENCE CURRENT

a) MAIN MENU

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEGATIVE SEQUENCE CURRENT

■ NEGATIVE SEQUENCE ■ CURRENT	■ NEG SEQ DIR OC1 ■	See page 5-150.
MESSAGE	■ NEG SEQ DIR OC2 ■	See page 5-150.

The C70 relay provides two (2) negative-sequence directional overcurrent elements..

5

b) NEGATIVE SEQUENCE DIRECTIONAL OVERCURRENT (ANSI 67_2)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEGATIVE SEQUENCE CURRENT ⇨⇩ NEG SEQ DIR OC1

■ NEG SEQ DIR OC1 ■	◀▶	NEG SEQ DIR OC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	NEG SEQ DIR OC1 SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	▲▼	NEG SEQ DIR OC1 OFFSET: 0.00 Ω	Range: 0.00 to 250.00 ohms in steps of 0.01
MESSAGE	▲▼	NEG SEQ DIR OC1 TYPE: Neg Sequence	Range: Neg Sequence, Zero Sequence
MESSAGE	▲▼	NEG SEQ DIR OC1 POS- SEQ RESTRAINT: 0.063	Range: 0.000 to 0.500 in steps of 0.001
MESSAGE	▲▼	NEG SEQ DIR OC1 FWD ECA: 75° Lag	Range: 0 to 90° Lag in steps of 1
MESSAGE	▲▼	NEG SEQ DIR OC1 FWD LIMIT ANGLE: 90°	Range: 40 to 90° in steps of 1
MESSAGE	▲▼	NEG SEQ DIR OC1 FWD PICKUP: 0.050 pu	Range: 0.015 to 30.000 pu in steps of 0.001
MESSAGE	▲▼	NEG SEQ DIR OC1 REV LIMIT ANGLE: 90°	Range: 40 to 90° in steps of 1
MESSAGE	▲▼	NEG SEQ DIR OC1 REV PICKUP: 0.050 pu	Range: 0.015 to 30.000 pu in steps of 0.001
MESSAGE	▲▼	NEG SEQ DIR OC1 BLK: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	NEG SEQ DIR OC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	NEG SEQ DIR OC1 EVENTS: Disabled	Range: Disabled, Enabled

There are two negative-sequence directional overcurrent protection elements available. The element provides both forward and reverse fault direction indications through its output operands NEG SEQ DIR OC1 FWD and NEG SEQ DIR OC1 REV, 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** of the element essentially responds to the magnitude of a fundamental frequency phasor of either the negative-sequence or zero-sequence current as per user selection. The zero-sequence current should not be mistaken with the neutral current (factor 3 difference).

A positive-sequence restraint is applied for better performance: a small user-programmable portion of the positive-sequence current magnitude is subtracted from the negative or zero-sequence current magnitude, respectively, when forming the element operating quantity.

$$I_{op} = |I\_2| - K \times |I\_1| \quad \text{or} \quad I_{op} = 3 \times (|I\_0| - K \times |I\_1|) \qquad \textbf{(EQ 5.17)}$$

The positive-sequence restraint allows for more sensitive settings by counterbalancing spurious negative-sequence and zero-sequence currents resulting from:

- System unbalances under heavy load conditions.
- Transformation errors of current transformers (CTs).
- Fault inception and switch-off transients.

The positive-sequence restraint must be considered when testing for pick-up accuracy and response time (multiple of pickup). The positive-sequence restraint is removed for low currents. If the positive-sequence current is less than 0.8 pu, then the restraint is removed by changing the constant *K* to zero. This results in better response to high-resistance faults when the unbalance is very small and there is no danger of excessive CT errors, since the current is low.

The *operating quantity* depends on the way the test currents are injected into the C70. For single phase injection:

- $I_{op} = ⅓ \times (1 – K) \times I_{injected}$ for I_2 mode.
- $I_{op} = (1 – K) \times I_{injected}$ for I_0 mode if I_1 > 0.8 pu.

The *directional unit* uses the negative-sequence current (I_2) and negative-sequence voltage (V_2).

The following tables define the negative-sequence directional overcurrent element.

Table 5–22: NEGATIVE-SEQUENCE DIRECTIONAL OVERCURRENT UNIT

MODE	OPERATING CURRENT
Negative-sequence	I_{op} = |I_2| – *K* × I_1|
Zero-sequence	I_{op} = 3 × (|I_0| – *K* × |I_1|) if |I_1| > 0.8 pu I_{op} = 3 × |I_0| if |I_1| ≤ 0.8 pu

Table 5–23: NEGATIVE-SEQUENCE DIRECTIONAL UNIT

DIRECTION	COMPARED PHASORS	
Forward	–V_2 + Z_offset × I_2	I_2 × 1∠ECA
Reverse	–V_2 + Z_offset × I_2	–(I_2 × 1∠ECA)
Forward	–V_2 + Z_offset × I_2	I_2 × 1∠ECA
Reverse	–V_2 + Z_offset × I_2	–(I_2 × 1∠ECA)

The negative-sequence voltage must be greater than 0.02 pu to be validated for use as a polarizing signal. If the polarizing signal is not validated neither forward nor reverse indication is given. The following figure explains the usage of the voltage polarized directional unit of the element.

The figure below shows the phase angle comparator characteristics for a phase A to ground fault, with settings of:

ECA = 75° (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)

5

The element incorporates a current reversal logic: if the reverse direction is indicated for at least 1.25 of a power system cycle, the prospective forward indication will be delayed by 1.5 of a power system cycle. The element is designed to emulate an electromechanical directional device. Larger operating and polarizing signals will result in faster directional discrimination bringing more security to the element operation.

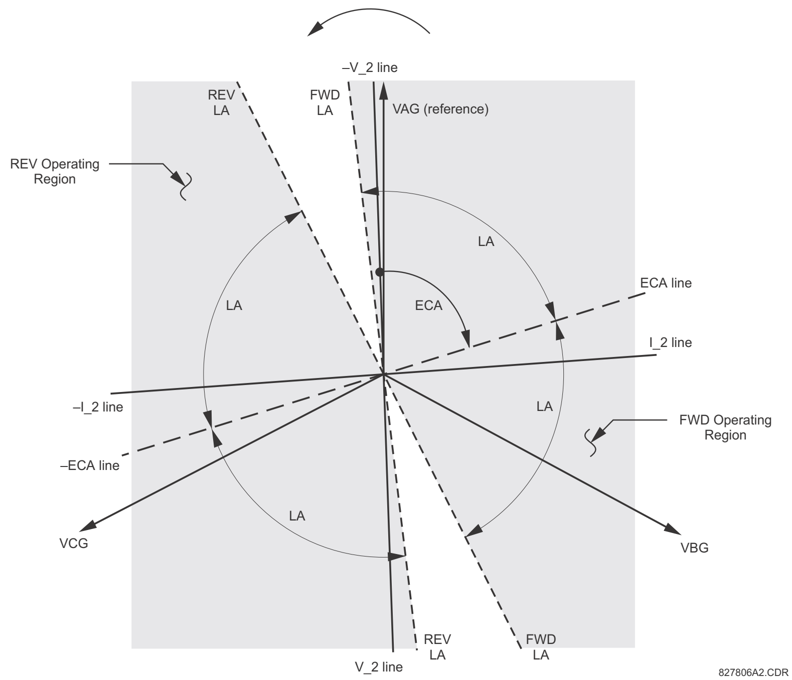

Figure 5–68: NEGATIVE-SEQUENCE DIRECTIONAL CHARACTERISTIC

The forward-looking function is designed to be more secure as compared to the reverse-looking function, and therefore should be used for the tripping direction. The reverse-looking function is designed to be faster as compared to the forward-looking function and should be used for the blocking direction. This allows for better protection coordination. The above bias should be taken into account when using the negative-sequence directional overcurrent element to directionalize other protection elements. The negative-sequence directional pickup must be greater than the **PRODUCT SETUP ⇨⇩ DISPLAY PROPERTIES ⇨⇩ CURRENT CUT-OFF LEVEL** setting value.

- **NEG SEQ 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 (see the *Application of settings* chapter for information on how to calculate this setting). In regular applications, the offset impedance ensures proper operation even if the negative-sequence voltage at the relaying point is very small. If this is the intent, the offset impedance shall not be larger than the negative-sequence impedance of the protected circuit. Practically, it shall be several times smaller. The offset impedance shall be entered in secondary ohms. See the *Theory of operation* chapter for additional details.
- **NEG SEQ DIR OC1 TYPE:** This setting selects the operating mode for the overcurrent unit of the element. The choices are “Neg Sequence” and “Zero Sequence”. In some applications it is advantageous to use a directional negative-sequence overcurrent function instead of a directional zero-sequence overcurrent function as inter-circuit mutual effects are minimized.
- **NEG SEQ DIR OC1 POS-SEQ RESTRAINT**: This setting controls the positive-sequence restraint. Set to 0.063 (in “Zero Sequence” mode) or 0.125 (in “Neg Sequence” mode) for backward compatibility with revisions 3.40 and earlier. Set to zero to remove the restraint. Set higher if large system unbalances or poor CT performance are expected.
- **NEG SEQ DIR OC1 FWD ECA:** This setting select the element characteristic angle (ECA) for the forward direction. The element characteristic angle in the reverse direction is the angle set for the forward direction shifted by 180°.
- **NEG SEQ DIR OC1 FWD LIMIT ANGLE:** This setting defines a symmetrical (in both directions from the ECA) limit angle for the forward direction.

- **NEG SEQ DIR OC1 FWD PICKUP:** This setting defines the pickup level for the overcurrent unit in the forward direction. Upon **NEG SEQ DIR OC1 TYPE** selection, this pickup threshold applies to zero- or negative-sequence current. When selecting this setting it must be kept in mind that the design uses a *positive-sequence restraint* technique.
- **NEG SEQ DIR OC1 REV LIMIT ANGLE:** This setting defines a symmetrical (in both directions from the ECA) limit angle for the reverse direction.
- **NEG SEQ DIR OC1 REV PICKUP:** This setting defines the pickup level for the overcurrent unit in the reverse direction. Upon **NEG SEQ DIR OC1 TYPE** selection, this pickup threshold applies to zero- or negative-sequence current. When selecting this setting it must be kept in mind that the design uses a *positive-sequence restraint* technique.

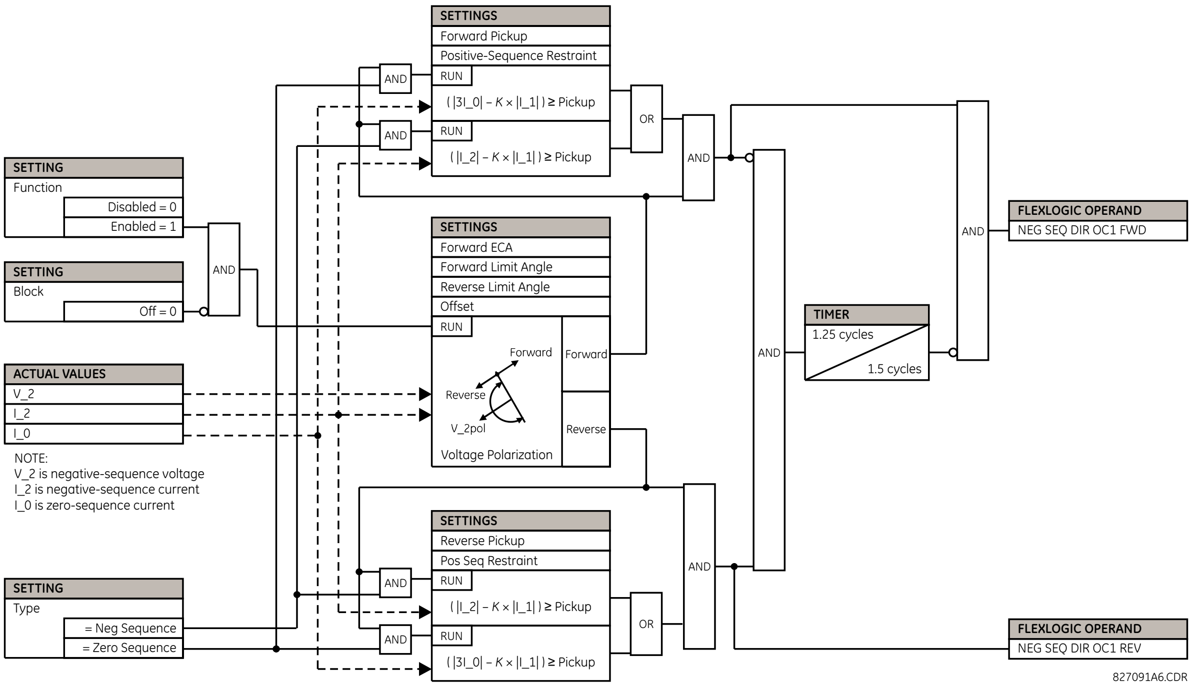

Figure 5–69: NEGATIVE SEQUENCE DIRECTIONAL OC1 SCHEME LOGIC

5.6.8 VOLTAGE ELEMENTS

a) MAIN MENU

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS

■ VOLTAGE ELEMENTS ■	◀▶	■ PHASE ■ UNDERVOLTAGE1	See page 5–156.
MESSAGE	▲▼	■ PHASE ■ UNDERVOLTAGE2	See page 5–156.
MESSAGE	▲▼	■ PHASE ■ OVERVOLTAGE1	See page 5–157.
MESSAGE	▲▼	■ NEUTRAL OV1 ■	See page 5–158.
MESSAGE	▲▼	■ NEUTRAL OV2 ■	See page 5–158.
MESSAGE	▲▼	■ NEUTRAL OV3 ■	See page 5–158.
MESSAGE	▲▼	■ NEG SEQ OV1 ■	See page 5–159.
MESSAGE	▲▼	■ NEG SEQ OV2 ■	See page 5–159.
MESSAGE	▲▼	■ NEG SEQ OV3 ■	See page 5–159.
MESSAGE	▲▼	■ AUXILIARY OV1 ■	See page 5–160.
MESSAGE	▲▼	■ AUXILIARY OV2 ■	See page 5–160.
MESSAGE	▲▼	■ AUXILIARY OV3 ■	See page 5–160.
MESSAGE	▲▼	■ VOLTAGE ■ DIFFERENTIAL 1	See page 5–161.
MESSAGE	▲▼	■ VOLTAGE ■ DIFFERENTIAL 2	See page 5–161.
MESSAGE	▲▼	■ VOLTAGE ■ DIFFERENTIAL 3	See page 5–161.
MESSAGE	▲▼	■ BANK ■ OVERVOLTAGE	See page 5–164.
MESSAGE	▲▼	■ NEUTRAL VOLTAGE ■ UNBALANCE 1	See page 5–168.
MESSAGE	▲▼	■ NEUTRAL VOLTAGE ■ UNBALANCE 2	See page 5–168.
MESSAGE	▲	■ NEUTRAL VOLTAGE ■ UNBALANCE 3	See page 5–168.

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.

$$T = \frac{D}{\left(1 - \frac{V}{V_{pickup}}\right)} \quad \textbf{(EQ 5.18)}$$

where: T = operating time
D = undervoltage delay setting (D = 0.00 operates instantaneously)
V = secondary voltage applied to the relay
V_{pickup} = pickup level

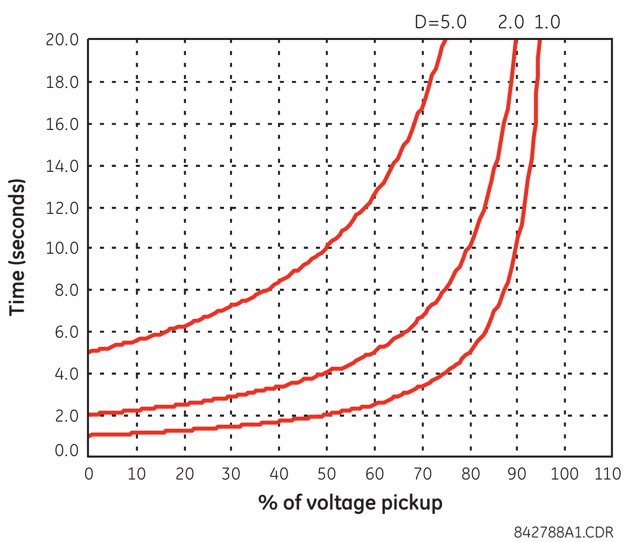

Figure 5–70: INVERSE TIME UNDERVOLTAGE CURVES

NOTE

At 0% of pickup, the operating time equals the UNDERVOLTAGE DELAY setting.

b) PHASE UNDERVOLTAGE (ANSI 27P)

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).

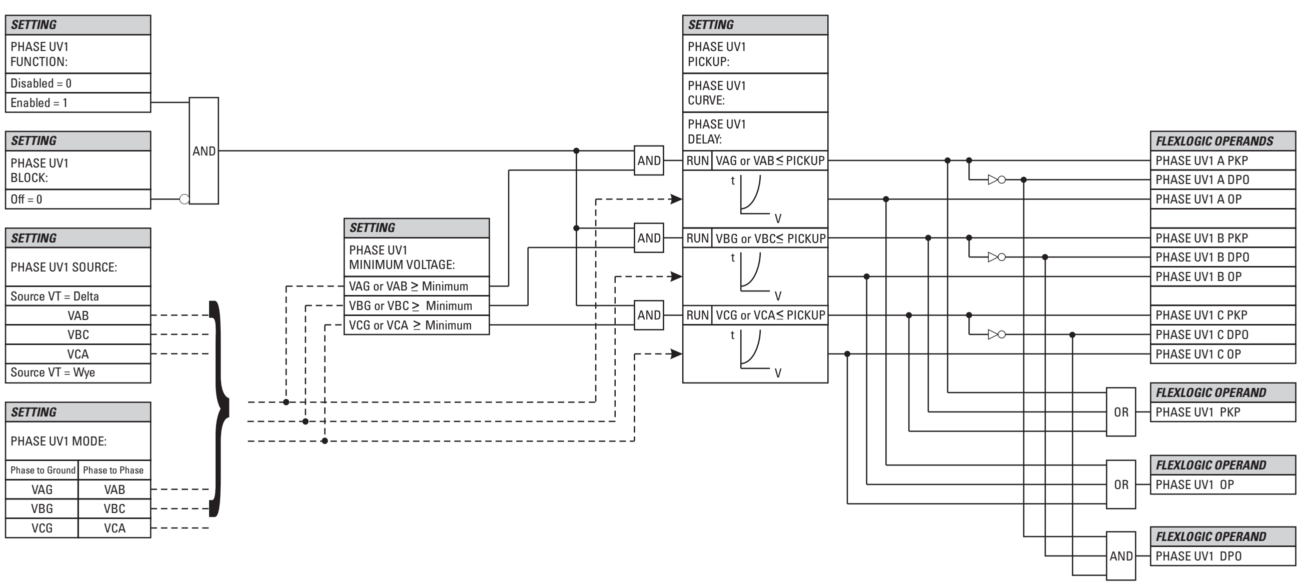

Figure 5–71: PHASE UNDERVOLTAGE1 SCHEME LOGIC

c) PHASE OVERVOLTAGE (ANSI 59P)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ PHASE OVERVOLTAGE1

	Setting	Range
■ 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.

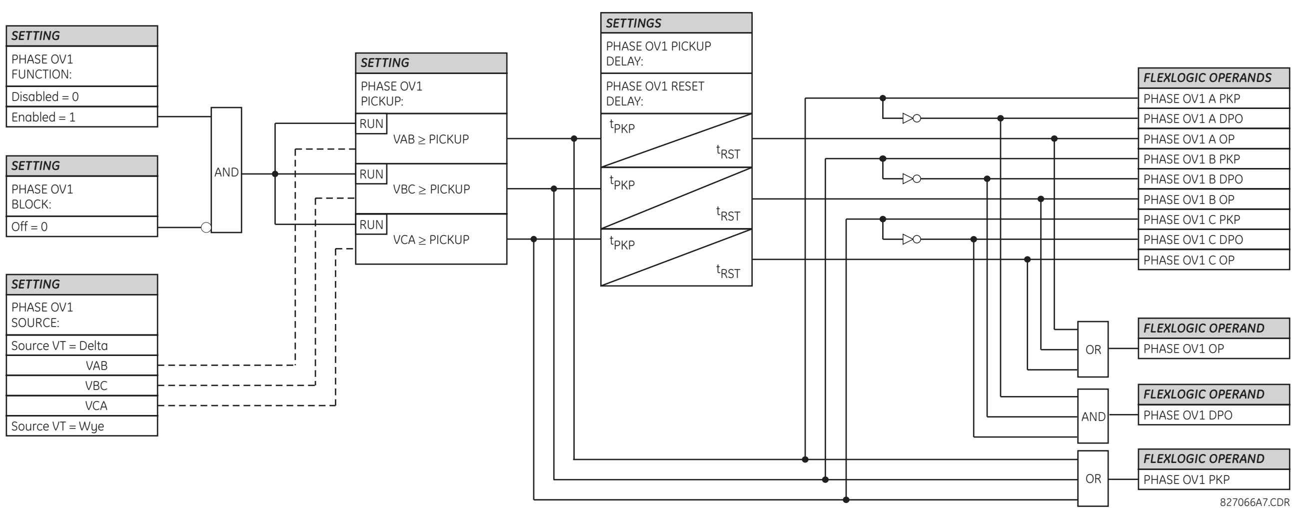

Figure 5–72: PHASE OVERVOLTAGE SCHEME LOGIC

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}.

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d) NEUTRAL OVERVOLTAGE (ANSI 59N)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ NEUTRAL OV1(3)

		Display	Range
■ NEUTRAL OV1 ■	◁▷	NEUTRAL OV1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	NEUTRAL OV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	△▽	NEUTRAL OV1 PICKUP: 0.300 pu	Range: 0.000 to 3.000 pu in steps of 0.001
MESSAGE	△▽	NEUTRAL OV1 CURVE: Definite time	Range: Definite time, FlexCurve A, FlexCurve B, FlexCurve C
MESSAGE	△▽	NEUTRAL OV1 PICKUP: DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	△▽	NEUTRAL OV1 RESET: DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	△▽	NEUTRAL OV1 BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	△▽	NEUTRAL OV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	△	NEUTRAL OV1 EVENTS: Disabled	Range: Disabled, Enabled

There are three neutral overvoltage elements available. The neutral overvoltage element can be used to detect asymmetrical system voltage condition due to a ground fault or to the loss of one or two phases of the source. The element responds to the system neutral voltage (3V_0), calculated from the phase voltages. The nominal secondary voltage of the phase voltage channels entered under **SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨⇩ VOLTAGE BANK ⇨ PHASE VT SECONDARY** is the p.u. base used when setting the pickup level.

The neutral overvoltage element can provide a time-delayed operating characteristic versus the applied voltage (initialized from FlexCurves A, B, or C) or be used as a definite time element. The **NEUTRAL OV1 PICKUP DELAY** setting applies only if the **NEUTRAL OV1 CURVE** setting is "Definite time". The source assigned to this element must be configured for a phase VT.

VT errors and normal voltage unbalance must be considered when setting this element. This function requires the VTs to be wye-connected.

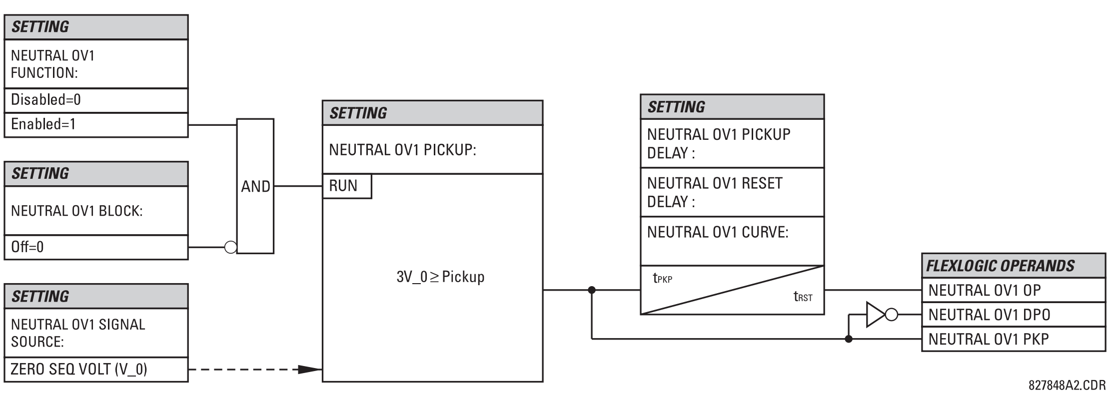

Figure 5–73: NEUTRAL OVERVOLTAGE1 SCHEME LOGIC

e) NEGATIVE-SEQUENCE OVERVOLTAGE(ANSI 59_2)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ NEG SEQ OV1(3)

		Display	Range
■ 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 is one negative-sequence overvoltage element available per CT bank, to a maximum of three.

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.

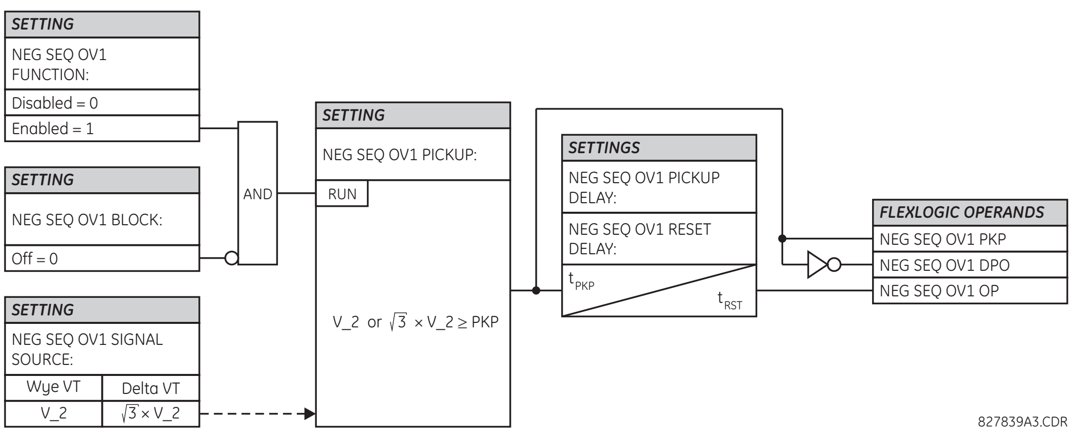

Figure 5–74: NEGATIVE-SEQUENCE OVERVOLTAGE SCHEME LOGIC

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f) AUXILIARY OVERVOLTAGE (ANSI 59X)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ AUXILIARY OV1(3)

■ 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 C70 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.

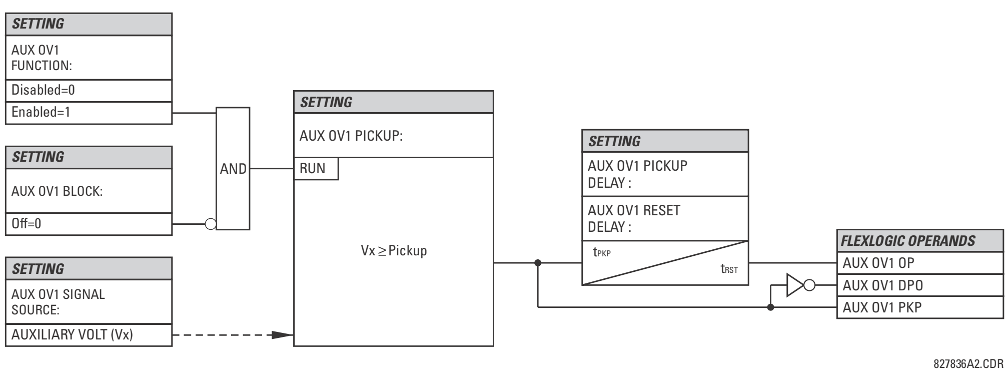


Figure 5–75: AUXILIARY OVERVOLTAGE SCHEME LOGIC

g) BANK VOLTAGE DIFFERENTIAL (ANSI 87V)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ VOLTAGE DIFFERENTIAL 1(3)

■ VOLTAGE ■ DIFFERENTIAL 1	◁▷	VOLTAGE DIF 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	VOLTAGE DIF 1 BUS SOURCE: SRC 1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE	△▽	VOLTAGE DIF 1 TAP SOURCE: SRC 1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE	△▽	VOLTAGE DIF 1 BANK GROUND: Grounded	Range: Grounded, Ungrounded
MESSAGE	△▽	VOLTAGE DIF 1 MATCH FACTOR A: 2.0000	Range: 0.5000 to 2000.0000 in steps of 0.0001
MESSAGE	△▽	VOLTAGE DIF 1 MATCH FACTOR B: 2.0000	Range: 0.5000 to 2000.0000 in steps of 0.0001
MESSAGE	△▽	VOLTAGE DIF 1 MATCH FACTOR C: 2.0000	Range: 0.5000 to 2000.0000 in steps of 0.0001
MESSAGE	△▽	VOLTAGE DIF 1 STG 1A PICKUP: 0.010 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 2A PICKUP: 0.020 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 3A PICKUP: 0.030 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 4A PICKUP: 0.040 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 1B PICKUP: 0.010 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 2B PICKUP: 0.020 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 3B PICKUP: 0.030 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 4B PICKUP: 0.040 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 1C PICKUP: 0.010 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 2C PICKUP: 0.020 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 3C PICKUP: 0.030 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 4C PICKUP: 0.040 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	△▽	VOLTAGE DIF 1 STG 1 PKP DELAY: 30.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	△▽	VOLTAGE DIF 1 STG 2 PKP DELAY: 10.00 s	Range: 0.00 to 600.00 s in steps of 0.01

MESSAGE	VOLTAGE DIF 1 STG 3 PKP DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	VOLTAGE DIF 1 STG 4 PKP DELAY: 0.20 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	VOLTAGE DIF 1 DPO DELAY: 0.25 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	VOLT DIF 1 BLK STG1: Off	Range: FlexLogic™ operand
MESSAGE	VOLT DIF 1 BLK STG 2: Off	Range: FlexLogic™ operand
MESSAGE	VOLT DIF 1 BLK STG 3: Off	Range: FlexLogic™ operand
MESSAGE	VOLT DIF 1 BLK STG 4: Off	Range: FlexLogic™ operand
MESSAGE	VOLT DIF 1 TARGET: Self-Reset	Range: Self-reset, Latched, Disabled
MESSAGE	VOLT DIF 1 EVENTS: Disabled	Range: Disabled, Enabled

5

Up to three identical voltage differential elements, one per each VT bank configured in hardware, are provided.

The element responds to a differential signal between magnitudes of the bus and tap voltages. The latter is scaled using a matching factor to account for the position of the tap. An automatic setting procedure is available under the **COMMAND** menu to calculate automatically the matching factor when installing the relay or after repairs of the bank.

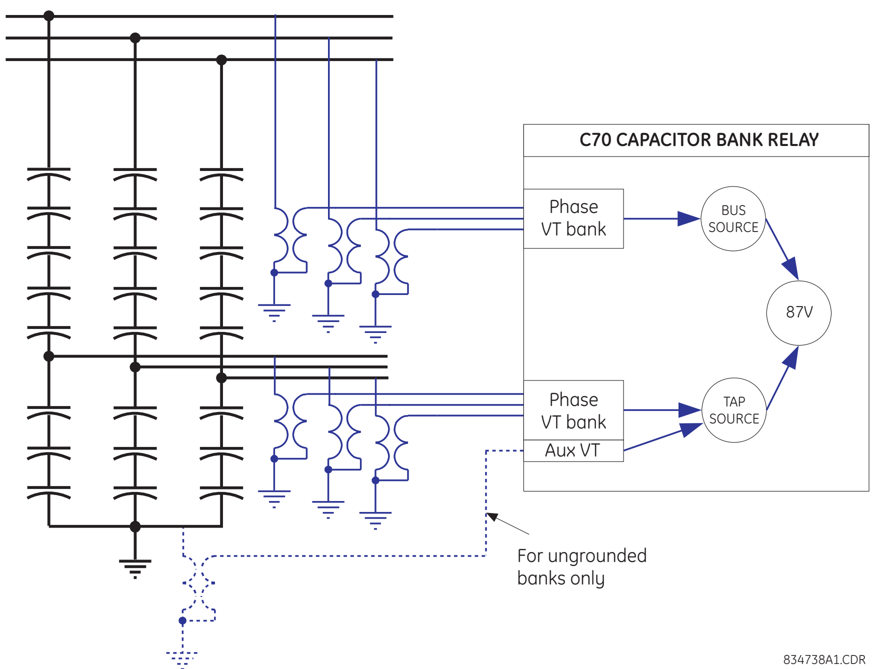


Figure 5–76: VOLTAGE DIFFERENTIAL BASIC CONNECTIONS

The function works with grounded and ungrounded banks. In the latter case, the neutral point voltage must be measured by the relay. For additional information, refer to the *Theory of Operation* and *Application of Settings* chapters.

The following settings are available for each voltage differential element.

- **VOLTAGE DIF 1 BUS SOURCE**: Indicate signal source that signifies the bus voltage of the bank. The function uses this source as reference for pu settings of pickup thresholds, and scales the tap voltages to this signal level. The VT ratio and secondary nominal voltage are set under separate menu. Voltages of this source must be connected in wye for the function to operate.
- **VOLTAGE DIF 1 TAP SOURCE**: Indicate signal source that signifies the tap voltage of the bank. The function scales this voltage to the bus level using the matching factor setting. The matching is performed on primary voltages, or per unit of the bus voltage. The VT ratio and secondary nominal voltage are set under separate menu. Voltages of this source must be connected in wye for the function to operate. If this function is used on ungrounded banks, the tap source must have the neutral point voltage of the bank configured under the auxiliary voltage channel. That auxiliary voltage must be labelled "Vn" under the VT setup menu.
- **VOLTAGE DIF 1 BANK GROUND**: Indicate if the protected bank is grounded or ungrounded. In the latter case, the auxiliary voltage configured under the tap source will be subtracted from the phase voltages of both the bus and tap. This results in the actual voltage drop along the capacitor string, and thus facilitates the voltage differential principle. The relay automatically compensates for different VT ratios and secondary voltages of the neutral point voltage and the bus and tap voltages.
- **VOLTAGE DIF 1 MATCH FACTOR A** to **VOLTAGE DIF 1 MATCH FACTOR C**: This setting specifies the division ratio of the healthy bank, i.e. the ratio between the bus and tap voltages (value greater than 1). The matching factor is applied as multiplier for the primary tap voltage before comparing with the primary bus voltage. Quality of balancing the bank with a given value of this setting can be viewed under **ACTUAL VALUES** menu. An automatic setting procedure is available under the **COMMANDS** menu to calculate the matching factors automatically.
- **VOLTAGE DIF 1 STG 1A PICKUP** to **VOLTAGE DIF 1 STG 4C PICKUP**: These settings specify pickup thresholds for stages 1 through 4 for phases A to C in per-units (pu) of the nominal bus voltage. A value of 1 pu is a product of the nominal secondary voltage and VT ratio of the voltage bank configured under the bus source of this function. Four independent stages are provided for each phase of protection.
- **VOLTAGE DIF 1 STG 1 PKP DELAY**: This setting specifies the pickup time delay, individually per each stage of alarming/tripping. Note that each of the twelve comparators (four stages in three phases) uses an individual timer, but settings for these timers are controlled individually per each stage, not per phase. The timers use a common drop out time delay specified by the next setting.
- **VOLTAGE DIF 1 DPO DELAY**: This setting controls a drop out delay for the operate FlexLogic™ operands. Note that individual stages apply individually configurable pickup delays, but use this common drop out delay.
- **VOLT DIF 1 BLK STG 1** to **VOLT DIF 1 BLK STG 4**: These inputs are used to block the function on a per stage basis when required. At minimum this function shall be blocked when the bank is off-line, or else it will operate unnecessarily. Either breaker position or undercurrent indication via any available instantaneous function, or a combination, may be used for blocking. The VT fuse fail condition from both the bus and tap VT should also be considered. Note that when unblocked, the function becomes operational after five cycles of intentional delay.

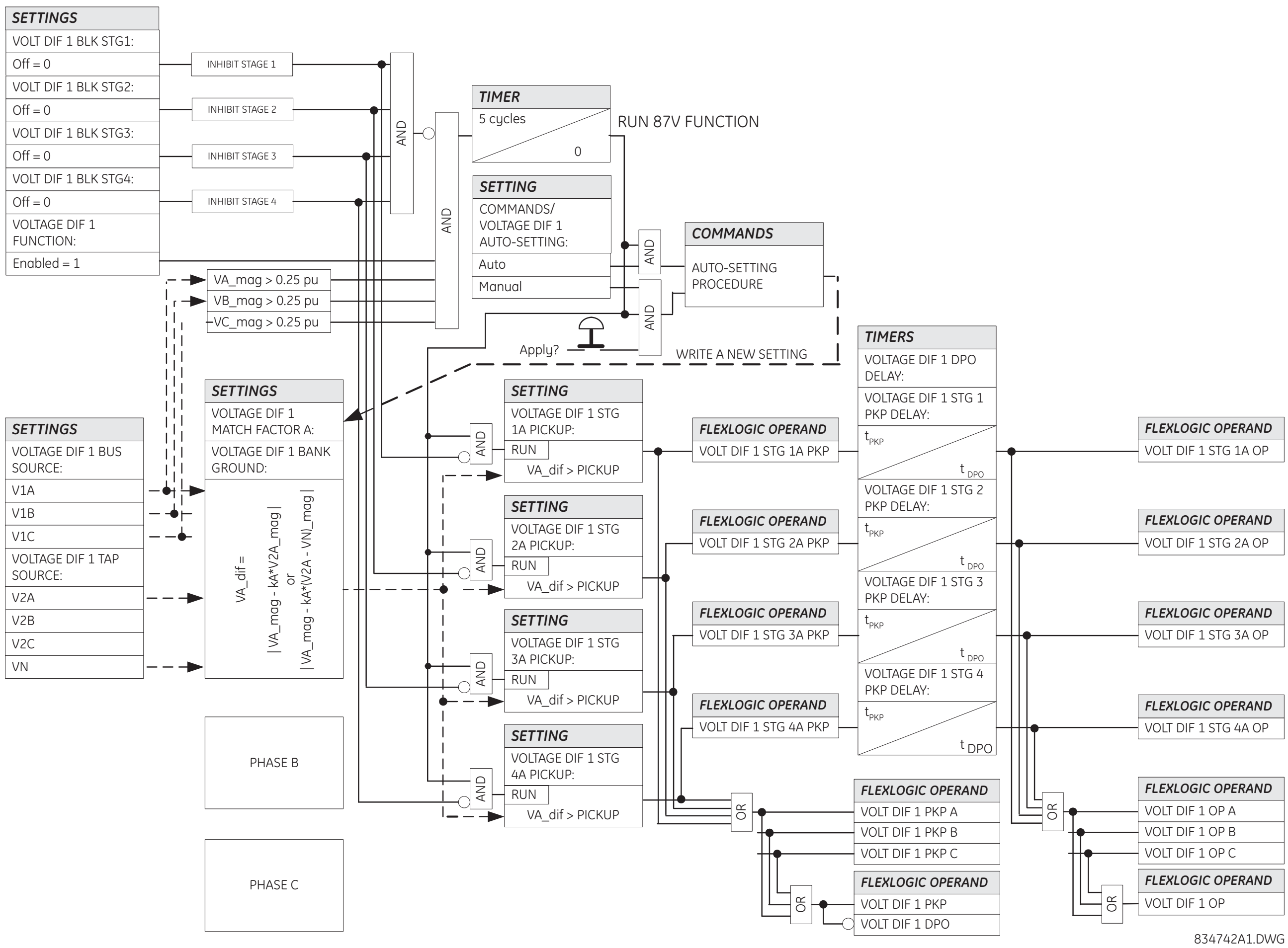


Figure 5–77: VOLTAGE DIFFERENTIAL SCHEME LOGIC

h) BANK PHASE OVERVOLTAGE (ANSI 59B)

PATH: SETTINGS ⇨⇩ GROUPED... ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE... ⇨⇩ BANK OVERVOLTAGE ⇨ BANK OVERVOLTAGE 1

■ BANK OVERVOLTAGE 1 ■		BANK OV 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE		BANK OV 1 BUS SOURCE: SRC 1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE		BANK OV 1 NTRL SOURCE: SRC 1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE		BANK OV 1 BANK GROUND: Grounded	Range: Grounded, Ungrounded, Ungr w/o Vn
MESSAGE		BANK OV 1 CURVE: FlexCurve A	Range: FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D
MESSAGE		BANK OV 1 CURVE TIME MULTIPLIER: 1.00	Range: 1.00 to 10.00 in steps of 0.01
MESSAGE		BANK OV 1 STG 1A PICKUP: 1.050 pu	Range: 0.800 to 2.000 pu in steps of 0.001

MESSAGE	BANK OV 1 STG 2A PICKUP: 1.100 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 3A PICKUP: 1.200 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 4A PICKUP: 1.050 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 1B PICKUP: 1.050 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 2B PICKUP: 1.100 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 3B PICKUP: 1.200 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 4B PICKUP: 1.050 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 1C PICKUP: 1.050 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 2C PICKUP: 1.100 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 3C PICKUP: 1.200 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 4C PICKUP: 1.050 pu	Range: 0.800 to 2.000 pu in steps of 0.001
MESSAGE	BANK OV 1 STG 1 PKP DELAY: 60.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	BANK OV 1 STG 2 PKP DELAY: 10.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	BANK OV 1 STG 3 PKP DELAY: 2.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	BANK OV 1 STG 4 PKP DELAY: 0.20 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	BANK OV 1 DPO DELAY: 0.25 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	BANK OV 1 BLK: Off	Range: FlexLogic™ operand
MESSAGE	BANK OV 1 TARGET: Self-Reset	Range: Self-reset, Latched, Disabled
MESSAGE	BANK OV 1 EVENTS: Disabled	Range: Disabled, Enabled

Up to three identical bank overvoltage elements, one per each VT bank configured in hardware, are provided.

The bank phase overvoltage element responds to voltages across the capacitors of the bank. Three stages of definite time operation, and one stage of inverse time operation are provided. Pickup thresholds of this function are adjustable on a per-phase basis. The shape of the inverse time curve is user-programmable (via FlexCurves™) with individual pickup levels and a multiplier common for all three phases. The definite time delays are individually programmable per stage.

The function works with grounded and ungrounded banks. With ungrounded banks, either the neutral point voltage is measured by the relay and used to derive the true bank voltage based on the bus and neutral-point voltages, or a simplified method to provide proper voltage protection is used responding to vector differences between the phase-to-phase voltages.

When fed from wye-connected VTs, thus function responds to phase-to-ground voltages. When fed from delta-connected VTs, this function responds to the vector difference between the phase-to-phase voltages.

The function responds to true RMS voltages to account for effects of harmonics (harmonics impacting losses in the capacitor, harmonics increasing peak values in the voltages compared with the filtered fundamental frequency magnitudes).

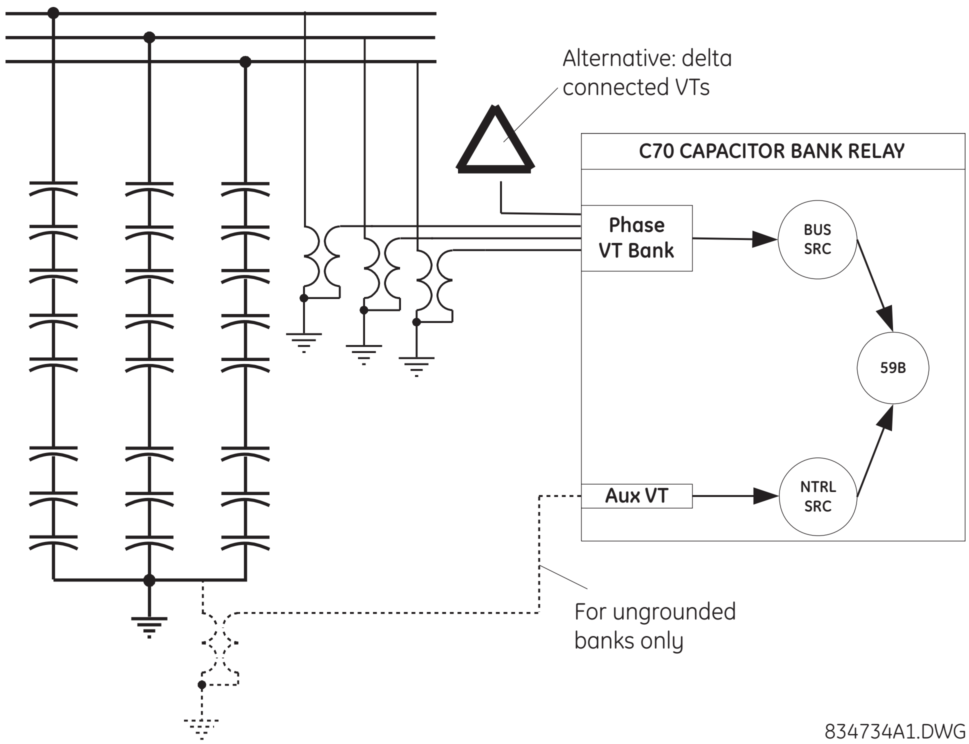


Figure 5–78: BANK OVERVOLTAGE BASIC CONNECTIONS

For more information refer to the *Theory of Operation* and *Application of Settings* chapters. The following settings are available for each bank phase overvoltage element.

- **BANK OV 1 BUS SOURCE**: This setting indicates the signal source that signifies the bus voltage of the capacitor bank. The function uses this source as reference for per-unit (pu) settings of the pickup thresholds. The VT ratio and secondary nominal voltage are set under the **SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨⇩ VOLTAGE BANK** menu.
- **BANK OV 1 NTRL SOURCE**: This setting indicates the signal source that signifies the neutral-point voltage of the bank. The auxiliary voltage channel of this source is used, and must be labelled "Vn" under the VT setup menu. The neutral point voltage is used only when the function is applied to an ungrounded bank, to derive the true voltage drop across the capacitors. The VT ratio and secondary nominal voltage are set under the **SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨⇩ VOLTAGE BANK** menu.
- **BANK OV 1 BANK GROUND**: This setting indicates if the protected bank is grounded, ungrounded with the neutral point voltage measured, and ungrounded without the neutral point voltage. The relay automatically compensates for potentially different VT ratios and secondary voltages of the bus and neutral point voltages. The following table explains the operating signals of the function based on the input signals available to the relay.

VT CONNECTION	BANK CONFIGURATION		
	GROUNDED	UNGROUNDED	UNGROUNDED W/O VN
Wye	Vop_A = VA Vop_B = VB Vop_C = VC	Vop_A = VA – VX Vop_B = VB – VX Vop_C = VC – VX	Vop_A = (VCA – VAB) / 3 Vop_B = (VAB – VBC) / 3 Vop_C = (VBC – VCA) / 3
Delta	Vop_A = (VCA – VAB) / 3 Vop_B = (VAB – VBC) / 3 Vop_C = (VBC – VCA) / 3		

- **BANK OV 1 CURVE**: This setting specifies a FlexCurve™ used by the fourth inverse time stage of this function. FlexCurves™ are user-programmable on a point-by-point basis. This function applies a common curve shape in all three phases. However, the curve is specified as time versus multiple of pickup. With three individually programmable pickup values per phase one accommodates possible differences between individual phases of the bank even though a common curve shape is used.

  Implementation of the inverse-time stage is based on the concept of a *virtual disk* emulating electromechanical relays. When above the pickup level, the function integrates towards the trip level at the rate dictated by the curve at a given multiple of pickup. When activated but with the operating signal below the pickup, the function integrates down toward a complete reset. This mode of operation assures dependability in situations when the voltage oscillates and causes stress to the protected capacitor in repetitive cycles each lasting too short to expire a straight timer. As a result of this implementation, the shape of the curve below multiple of pickup of 1 is important as it controls the speed of reset of a partially energized function.

- **BANK OV 1 STG 1A PICKUP** to **BANK OV 1 STG 3C PICKUP**: These settings specify pickup thresholds for stages 1 through 3 in phases A through C in per-units (pu) of the nominal phase-to-ground bus voltage. A value of 1 pu is a product of the nominal secondary voltage and VT ratio of the voltage bank configured under the bus source of this function. With a delta VT configuration, a value of 1 pu is a product of the nominal secondary voltage and VT ratio divided by $\sqrt{3}$. Three independent stages of definite-time operation are provided for each phase of the bank.

- **BANK OV 1 STG 4A PICKUP** to **BANK OV 1 STG 4C PICKUP**: These settings specify pickup thresholds for the inverse time stage 4 in phase A through C in per-units (pu) of the nominal phase-to-ground bus voltage. With a wye VT configuration, a value of 1 pu is a product of the nominal secondary voltage and VT ratio of the voltage bank configured under the bus source of this function. With a delta VT configuration, a value of 1 pu is a product of the nominal secondary voltage and VT ratio divided by $\sqrt{3}$. The inverse time stage uses a user-programmable FlexCurve™ selected by the **BANK OV 1 CURVE** setting.

- **BANK OV 1 STG 1 PKP DELAY** to **BANK OV 1 STG 3 PKP DELAY**: These settings specify the pickup time delays for each definite time stage of alarming/tripping. Note that each of the nine comparators (three definite-time stages in three phases) uses an individual timer, but settings for these timers are controlled individually per each stage, not per phase. The timers use a common dropout time delay specified by the **BANK OV 1 DPO DELAY** setting.

- **BANK OV 1 DPO DELAY**: This setting controls a dropout delay for the operate FlexLogic™ operands. Note that individual stages apply individually configurable pickup delays, but use this common dropout delay.

- **BANK OV 1 BLK**: This input is used to block the function when required; in particular, when the bank is offline.

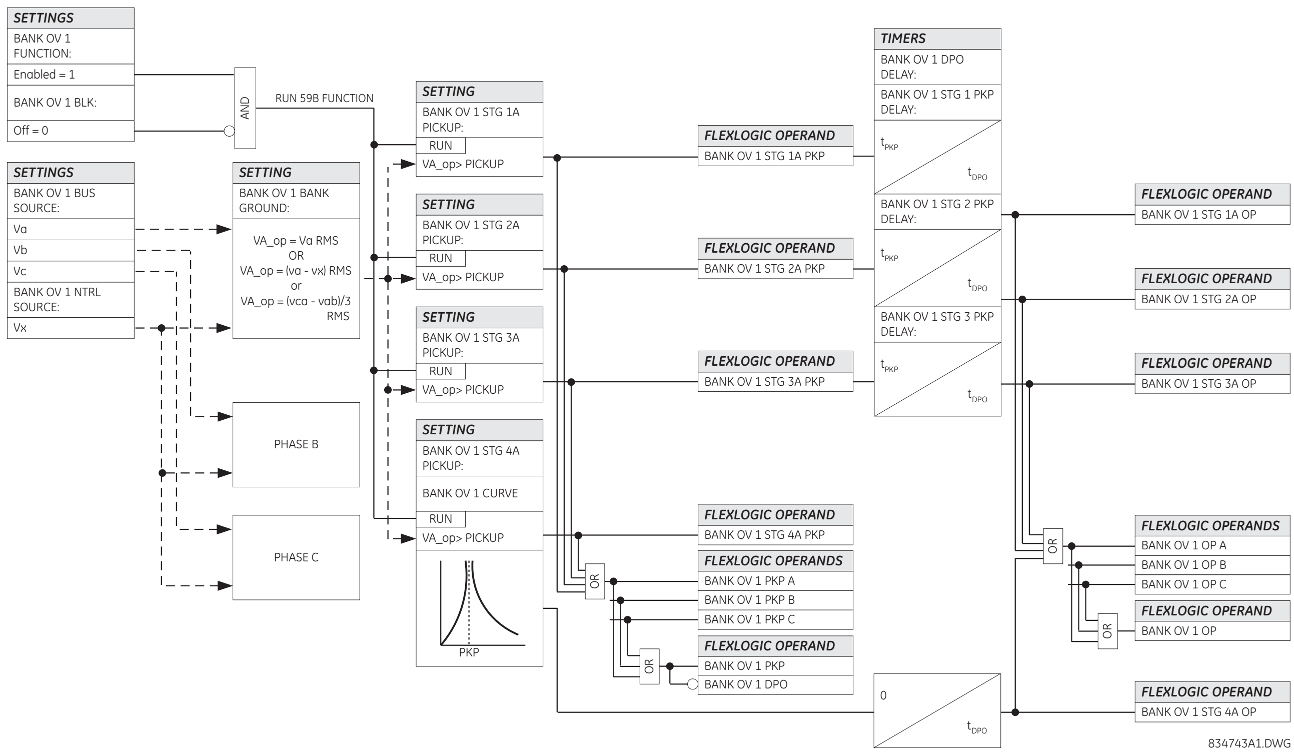


Figure 5–79: BANK PHASE OVERVOLTAGE SCHEME LOGIC

i) NEUTRAL VOLTAGE UNBALANCE (ANSI 59NU)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ NEUTRAL VOLTAGE UNBALANCE 1(3)

■ NEUTRAL VOLTAGE ■ UNBALANCE 1	NTRL VOL UNBAL 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	NTRL VOL UNBAL 1 NTRL SOURCE: SRC 1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE	NTRL VOL UNBAL 1 BUS SOURCE: SRC 1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE	NTRL VOL UNBAL 1 BUS 3V0: Calculated	Range: Calculated, Measured
MESSAGE	NTRL VOL UNBAL 1 GROUND: VT (ungrnd)	Range: VT (ungrnd), CTxR (grnd)
MESSAGE	NTRL VOL UNBAL 1 AB RATIO: 1.0000	Range: 0.7500 to 1.2500 in steps of 0.0001
MESSAGE	NTRL VOL UNBAL 1 AC RATIO: 1.0000	Range: 0.7500 to 1.2500 in steps of 0.0001
MESSAGE	NTRL VOL UNBAL 1 STG 1 PKP: 0.010 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	NTRL VOL UNBAL 1 STG 1 SLOPE: 0.0%	Range: 0.0 to 10.0% in steps of 0.1
MESSAGE	NTRL VOL UNBAL 1 STG 2 PKP: 0.020 pu	Range: 0.001 to 1.000 pu in steps of 0.001

MESSAGE	NTRL VOL UNBAL 1 STG 2 SLOPE: 0.0%	Range: 0.0 to 10.0% in steps of 0.1
MESSAGE	NTRL VOL UNBAL 1 STG 3 PKP: 0.020 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	NTRL VOL UNBAL 1 STG 3 SLOPE: 5.0%	Range: 0.0 to 10.0% in steps of 0.1
MESSAGE	NTRL VOL UNBAL 1 STG 4 PKP: 0.030 pu	Range: 0.001 to 1.000 pu in steps of 0.001
MESSAGE	NTRL VOL UNBAL 1 STG 4 SLOPE: 5.0%	Range: 0.0 to 10.0% in steps of 0.1
MESSAGE	NTRL VOL UNBAL 1 STG 1 PKP DELAY: 30.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL VOL UNBAL 1 STG 2 PKP DELAY: 10.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL VOL UNBAL 1 STG 3 PKP DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL VOL UNBAL 1 STG 4 PKP DELAY: 0.20 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL VOL UNBAL 1 DPO DELAY: 0.25 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NTRL VOL 1 BLK STG1: Off	Range: FlexLogic™ operand
MESSAGE	NTRL VOL 1 BLK STG2: Off	Range: FlexLogic™ operand
MESSAGE	NTRL VOL 1 BLK STG3: Off	Range: FlexLogic™ operand
MESSAGE	NTRL VOL 1 BLK STG4: Off	Range: FlexLogic™ operand
MESSAGE	NTRL VOL UNBAL 1 TARGET: Self-Reset	Range: Self-reset, Latched, Disabled
MESSAGE	NTRL VOL UNBAL 1 EVENTS: Disabled	Range: Disabled, Enabled

Up to three identical neutral voltage unbalance elements, one per each VT bank configured in hardware, are provided.

The element responds to the voltage signal at the neutral point of the capacitor bank. The operating equations are properly compensated for both the system unbalance such as during close-in external faults, and the inherent bank unbalance. The bus zero-sequence voltage required for compensation of the system unbalance can be measured internally to the relay from phase voltages, or delivered as a 3V0 signal from an open-corner-delta VT via an auxiliary voltage channel of the relay.

Compensation for the inherent unbalance of the protected bank uses the B and C phase voltages, and thus this function requires wye connected phase VTs. The inherent unbalance is zeroed out using ratios of the reactances between the reference phase A, and the two other phases. An automatic setting procedure is available under the **COMMAND** menu to calculate the compensating factors automatically when installing the relay, or after repairs of the bank.

To enhance performance under large system unbalances when the neutral-point and system zero-sequence voltages may become significant, a concept of a restraint is introduced. The slope of the operating characteristic is user adjustable, and if desired, it can be effectively removed yielding a straight compensated overvoltage function.

For additional information refer to the *Theory of operation* and *Application of settings* chapters.

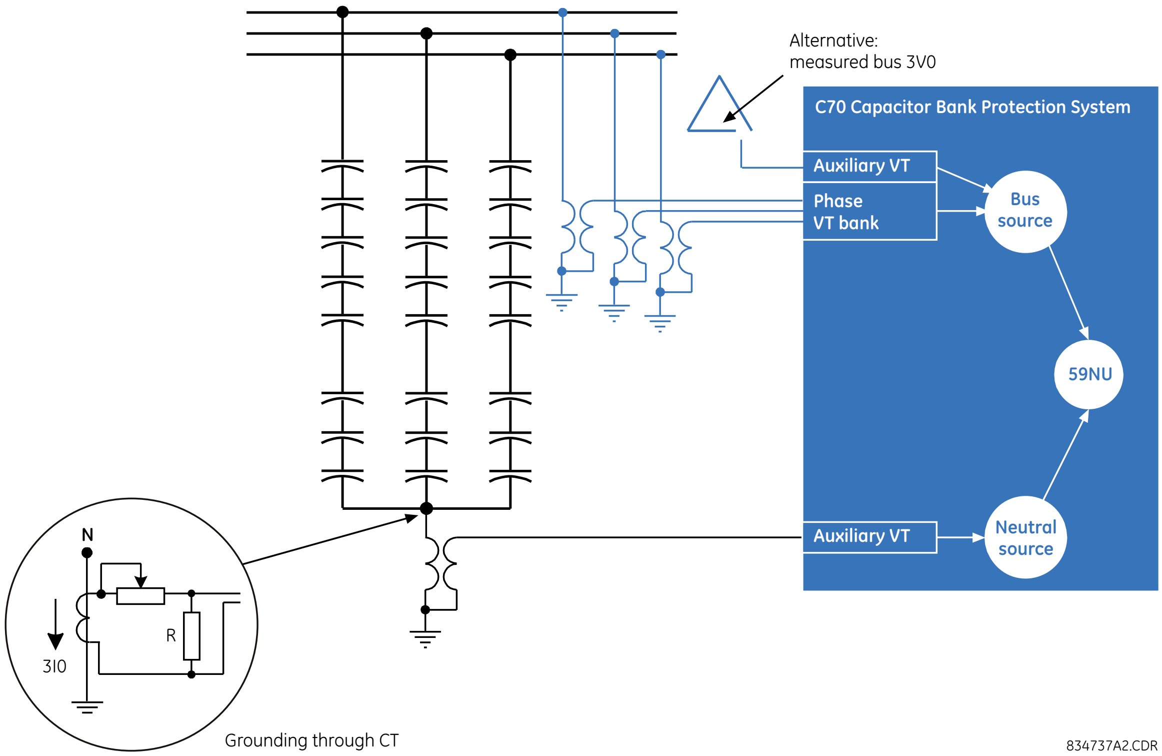


Figure 5–80: NEUTRAL VOLTAGE UNBALANCE BASIC CONNECTION

The following settings are available for all three neutral voltage unbalance elements.

- **NTRL VOL UNBAL 1 NTRL SOURCE**: Indicate signal source that signifies the neutral-point voltage of the protected bank. This single-phase voltage is to be configured under the auxiliary VT channel. The VT ratio and secondary nominal voltage are set under separate menu. Nominal voltage of this auxiliary channel becomes a unit (1 pu) for the pickup settings of this function.
- **NTRL VOL UNBAL 1 BUS SOURCE**: Indicate signal source that signifies the bus voltages of the bank. This source must have the phase voltages configured in order to facilitate compensation for the inherent unbalance of the bank. The zero-sequence voltage required for system unbalance compensation can be derived from the phase voltages, or delivered to the relay from an external source, typically a broken-delta VT (the selection is controlled by the next setting of this function). In the latter case, the 3V0 signal is expected and must be wired and configured under the auxiliary voltage channel of this source. This 3V0 voltage must be labelled as "Vn" under the VT configuration. The VT ratio and secondary nominal voltage are set under separate menu. Phase voltages of this source must be connected in wye for the function to operate. The function uses several voltages potentially produced by VTs of different ratios and nominal secondary values. The relay scales all the signals automatically for meaningful calculations.
- **NTRL VOL UNBAL 1 BUS 3V0**: This setting specifies the source of the bus zero-sequence voltage required for system unbalance compensation. If set to "Calculated", the relay would derive the zero-sequence voltage as a vector sum of the three phase voltages and will run the function if voltage in all three phases is greater than 0.25 pu. If set to "Measured", the relay expects the 3V0 signal (not a V0) to be wired to the relay under the auxiliary channel of the bus source, and labelled as "Vn". In this case, the voltage check to run this function is not performed.
- **NTRL VOL UNBAL 1 GROUND**: This setting selects the grounding arrangement of the bank. For ungrounded banks it should be set to "VT (ungrnd)". When the bank neutral is solidly grounded through the CT with a resistor in the CT secondary, then this setting should be chosen as "CTxR (grnd)".

  When the "CTxR (grnd)" value is selected, the measured bank neutral point voltage is shifted by 90° lagging to compensate for the angular difference between the bus neutral voltage and the voltage derived from the bank neutral point current. The value of resistor *R* should be chosen so the voltage measured by the auxiliary input of the relay matches bus *V*0 during system faults (for example, an SLG fault at the bus). This is accomplished by the following condition:

$$\frac{3V0_{BUS}}{n_{BUS\_VT}} - \frac{3I0_{NTRL} \times R \times n_{NTRL\_VT}}{n_{NTRL\_CT} \times n_{BUS\_VT}} = 0 \qquad \textbf{(EQ 5.19)}$$

The terms used in the above equation are defined as follows.

– $V0_{BUS}$ is the bus primary zero-sequence voltage during system fault.

– $3I0_{NTRL}$ is the primary current in the bank neutral during system fault.

– n_{BUS_VT} is the bus VT ratio set in the source selected by the **NTRL VOL UNBAL 1 BUS SOURCE** setting.

– n_{NTRL_VT} is a neutral point VT ratio set in the source selected by the **NTRL VOL UNBAL 1 NTRL SOURCE** setting. If *R* can be chosen precisely, then n_{NTRL_VT} can be set same as n_{BUS_VT}. If *R* cannot be chosen precisely, then n_{NTRL_VT} is used to match zero-sequence voltage as per the equation above.

– n_{NTRL_CT} is the CT ratio in the bank neutral.

- **NTRL VOL UNBAL 1 AB RATIO**: This setting compensates for the bank inherent unbalance. Physically this value is a ratio of the reactance in phase A divided by the reactance in phase B. Auto-setting procedure is available under the Commands menu to calculate this value automatically. When tuning this setting manually, after bank repairs, this ratio shall be increased or decreased from the nominal value of 1.00 depending on whether the A or B phase got affected by failures or repairs and whether a given reactance increased or decreased as a result of the failure or repair. This setting should only be used when **NTRL VOL UNBAL 1 BUS 3V0** setting is set as “Calculated”.
- **NTRL VOL UNBAL 1 AC RATIO**: This setting compensates for the bank inherent unbalance. Physically this value is a ratio of the reactance in phase A divided by the reactance in phase C. Auto-setting procedure is available under the Commands menu to calculate this value automatically. When tuning this setting manually, after bank repairs, this ratio shall be increased or decreased from the nominal value of 1.00 depending on whether the A or C phase got affected by failures or repairs and whether a given reactance increased or decreased as a result of the failure or repair. This setting should only be used when **NTRL VOL UNBAL 1 BUS 3V0** setting is set as “Calculated”.
- **NTRL VOL UNBAL 1 STG 1 PKP** to **NTRL VOL UNBAL 1 STG 1 PKP**: These settings specify pickup thresholds for stages 1 through 4 of the function in per-units (pu) of the nominal value of the neutral-point VT (the auxiliary channel of the neutral source).
- **NTRL VOL UNBAL 1 STG 1 SLOPE** to **NTRL VOL UNBAL 1 STG 4 SLOPE**: These settings specify the slopes of the operating characteristic. Neglecting compensation for the inherent bank unbalance, the operating signal is a vectorial difference between the neutral point voltage and the zero-sequence bus voltage. Therefore, the optimum restraining signal is a vectorial sum of the two signals. During external ground faults, the two voltages are approximately in phase generating a large restraining signal being twice the zero-sequence voltage at the bus. A slope of few percent is typically sufficient to provide good security under large system unbalances. If a given stage is used with a time delay longer than the expected external fault duration, the slope may be reduced or eliminated. In general, the slope can be understood as a adaptive threshold, and the user is provided with three ways to control sensitivity and security: pickup, time delay and slope. Refer to the *Application of settings* chapter for more information.
- **NTRL VOL UNBAL 1 STG 1 PKP DELAY** to **NTRL VOL UNBAL 1 STG 4 PKP DELAY**: These settings specify the pickup time delays for each stage of alarming or tripping. Note that each of the four comparators (four stages) uses an individual pickup timer, but a common drop out time delay as specified by the next setting.
- **NTRL VOL UNBAL 1 DPO DELAY**: This setting controls a drop out delay for the operate FlexLogic™ operands. Note that individual stages apply individually configurable pickup delays, but use this common drop out delay.
- **NTRL VOL 1 BLK STG1** to **NTRL VOL 1 BLK STG4**: These settings are used to block the function when required on a per-stage basis. At minimum this function shall be blocked when the bank is off-line, or else it will operate unnecessarily during external ground faults and/or natural system unbalance if set sensitive. Either breaker position or undercurrent indication via any available instantaneous overcurrent function, or a combination, may be used for blocking. Note that when unblocked, the function becomes operational after five cycles of intentional delay. Optionally only the sensitive stages are blocked, and one stage set high enough to ride through possible problems is left operational. This stage can be used for abnormal conditions such as a failure of one pole of the breaker to close. The function becomes blocked if all four blocking inputs are asserted. The individual blocking inputs inhibit the associated stages of the function.

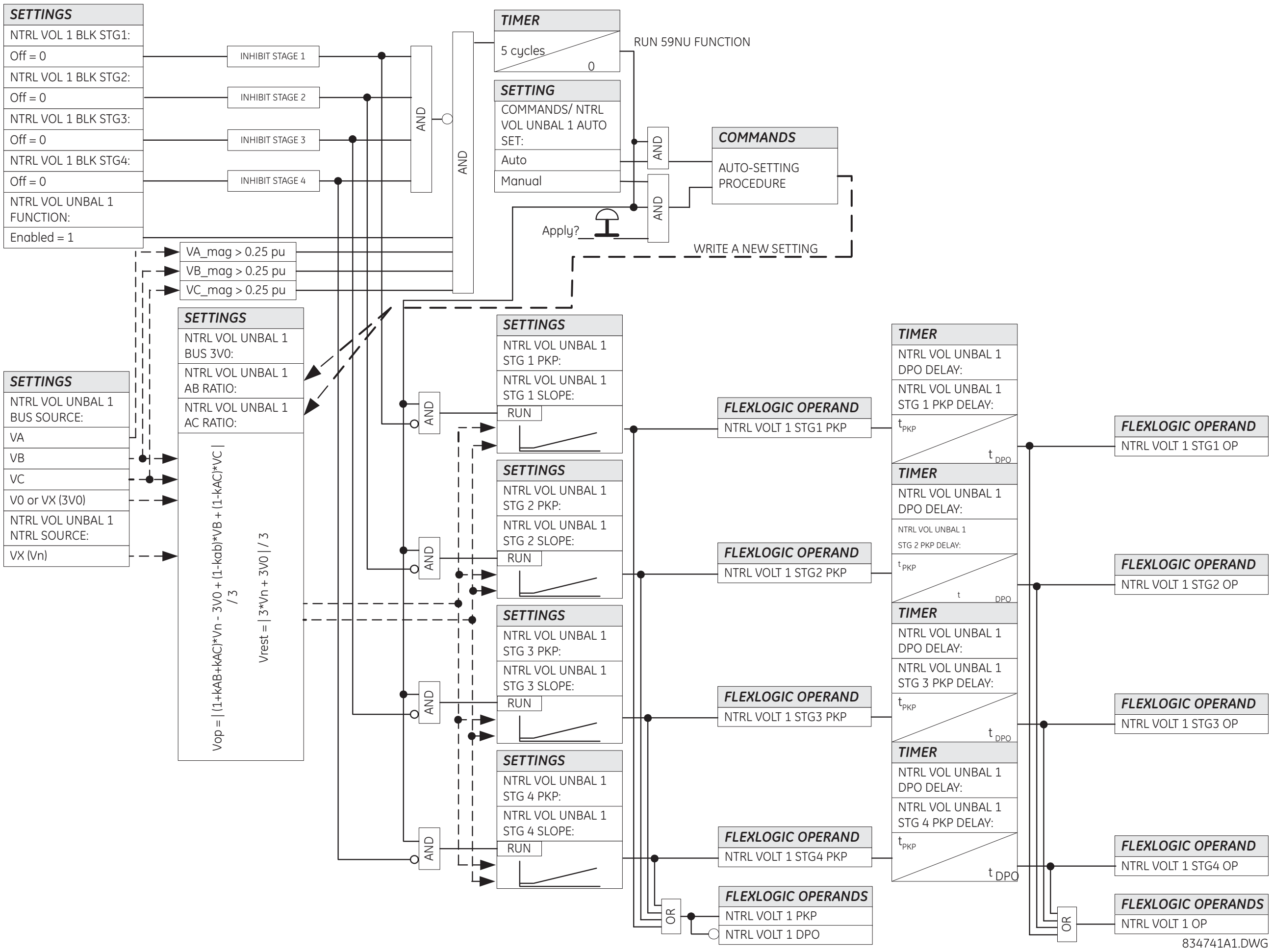


Figure 5–81: NEUTRAL VOLTAGE UNBALANCE LOGIC

5

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.

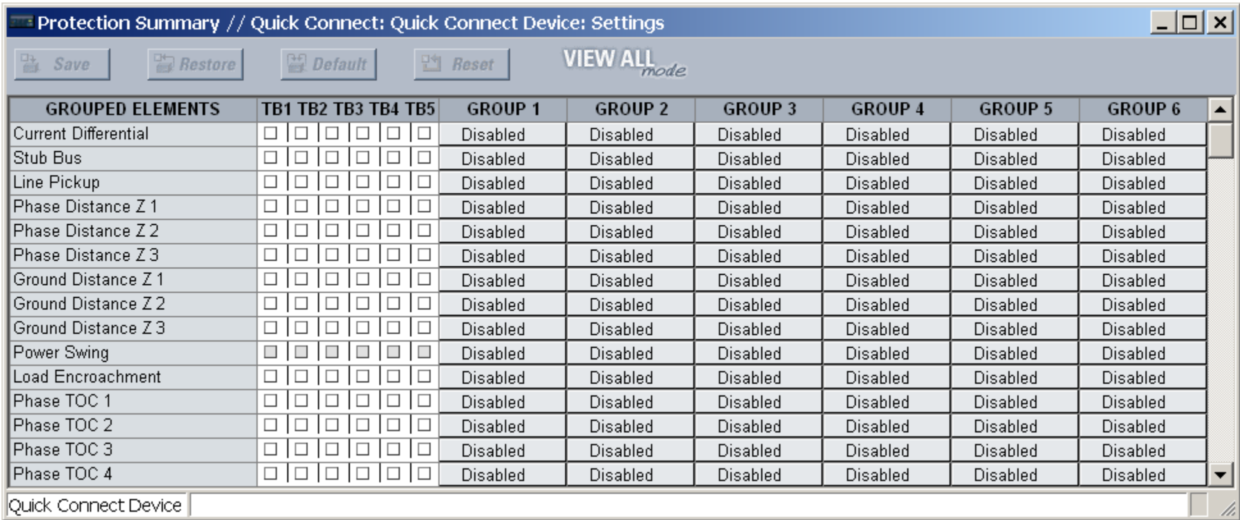
5.7.2 TRIP BUS

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.


Protection Summary // Quick Connect: Quick Connect Device: Settings

Save | Restore | Default | Reset | VIEW ALL mode

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

Quick Connect Device

Figure 5–82: 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.

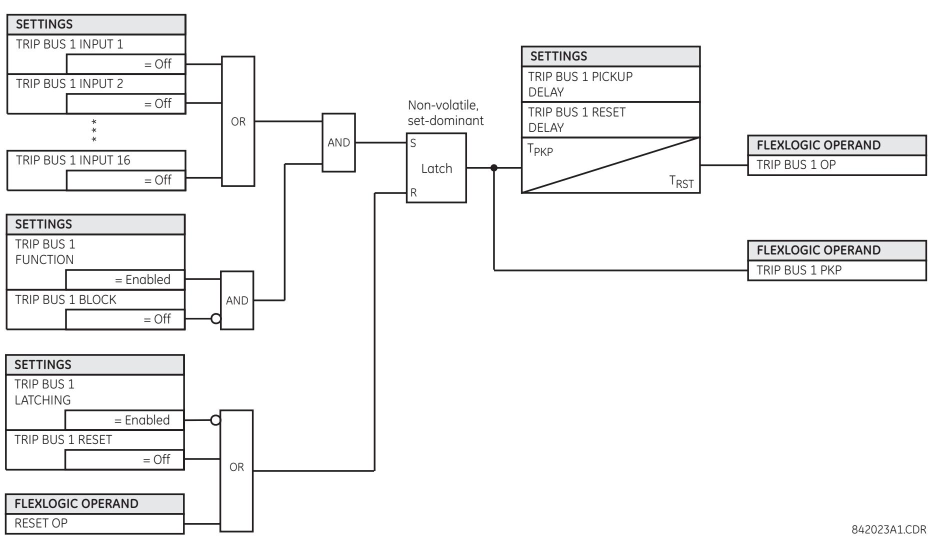


Figure 5–83: TRIP BUS LOGIC

5.7.3 SETTING GROUPS

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨ SETTINGS GROUPS

■ SETTING GROUPS ■	SETTING GROUPS FUNCTION: Disabled	*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 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, will make 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 which 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 to user to assign a name to each of the six settings groups. Once programmed, this name will appear 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 figure below) 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.

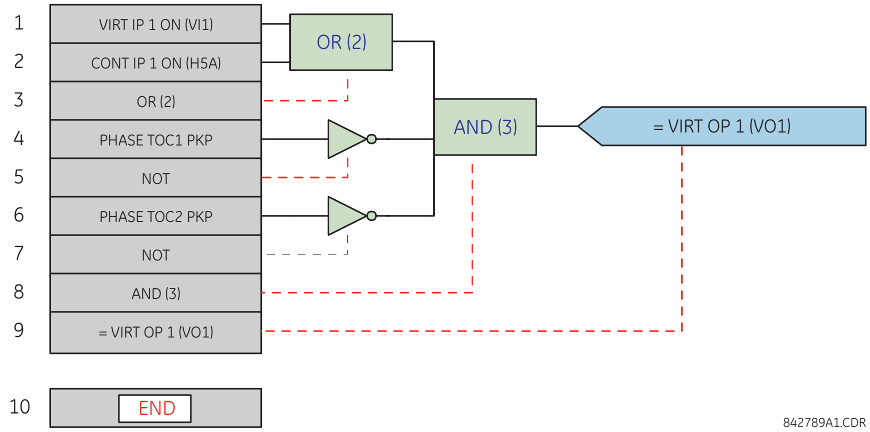


Figure 5–84: EXAMPLE FLEXLOGIC™ CONTROL OF A SETTINGS GROUP

5.7.4 SELECTOR SWITCH

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ SELECTOR SWITCH ⇨ SELECTOR SWITCH 1(2)

		Setting	Range
■ 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

5

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.

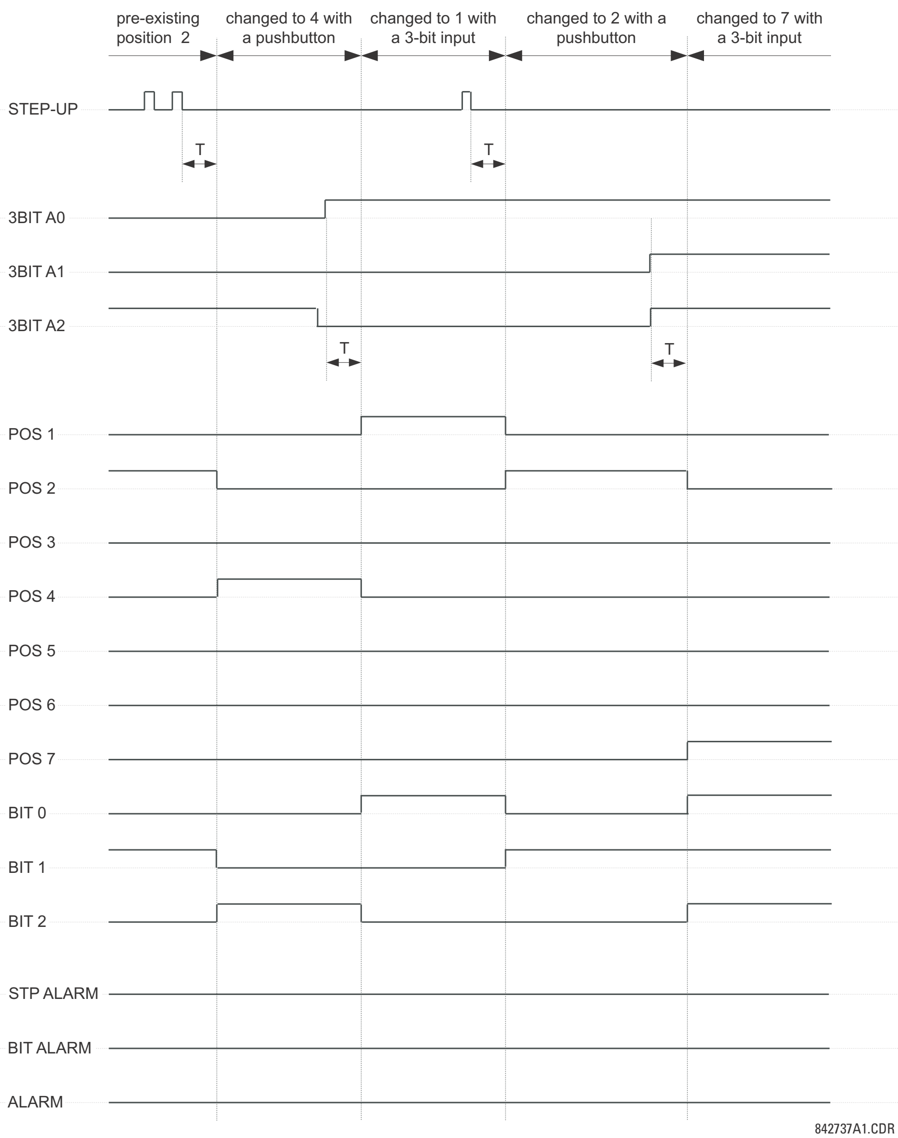


Figure 5–85: TIME-OUT MODE

5

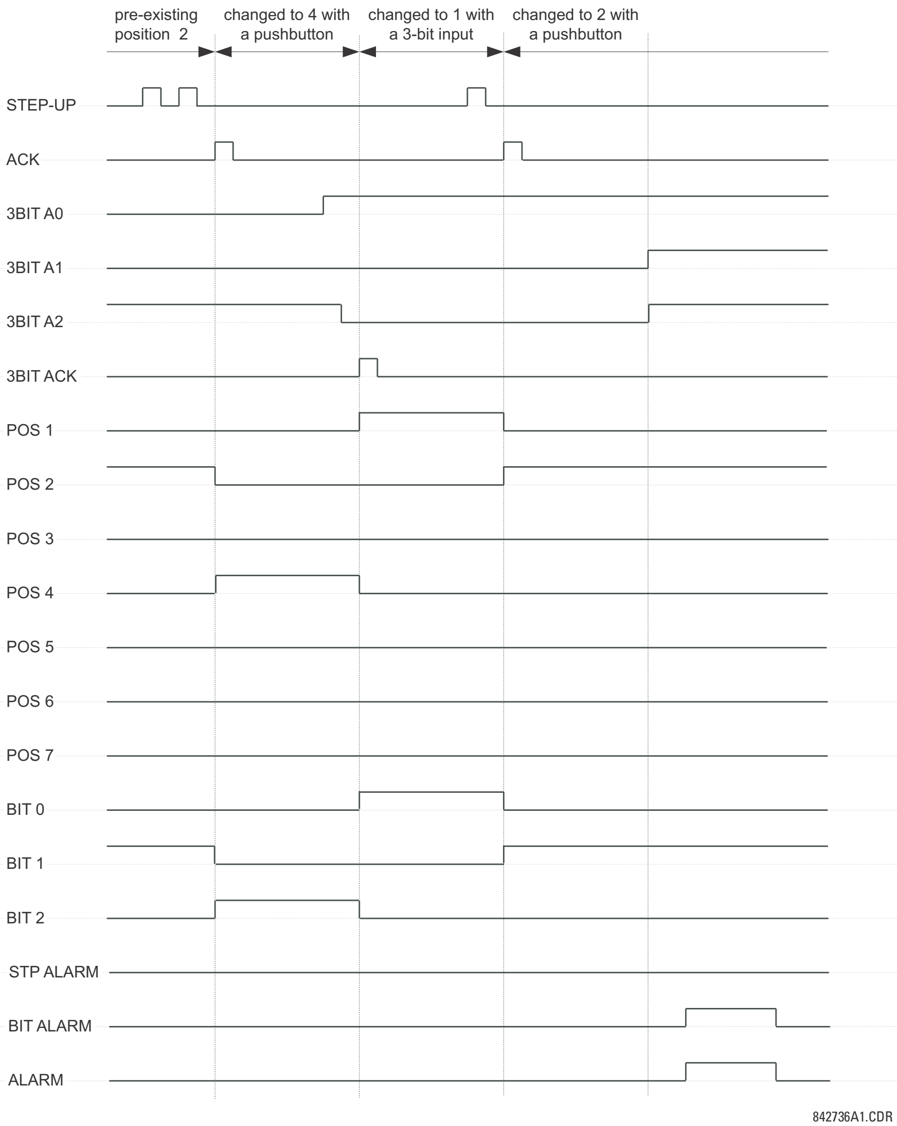


Figure 5–86: ACKNOWLEDGE MODE

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:

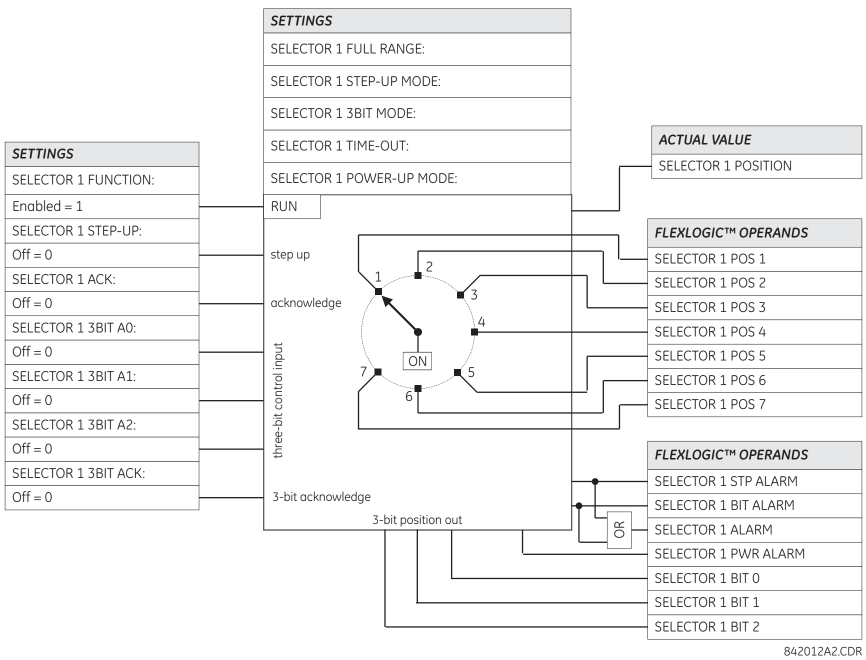


Figure 5–87: SELECTOR SWITCH LOGIC

5.7.5 TIME OF DAY TIMERS

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ TIME OF DAY TIMERS ⇨ TIME OF DAY TIMER 1(5)

■ TIME OF DAY TIMER 1 ■		TIME OF DAY TIMER 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
	MESSAGE	TIME OF DAY TIMER 1 START TIME: 00:00	*Range: 00:00 to 23:59 in steps of 00:01*
	MESSAGE	TIME OF DAY TIMER 1 STOP TIME: 23:59	*Range: 00:00 to 23:59 in steps of 00:01*
	MESSAGE	TIME OF DAY TIMER 1 TARGETS: Disabled	*Range: Self-reset, Latched, Disabled*
	MESSAGE	TIME OF DAY TIMER 1 EVENTS: Disabled	*Range: Disabled, Enabled*

The time of day timer function provides the ability to program control actions based on real time. There are five identical time of day timers, each with an independent start and stop time setting. Each timer is on when the C70 real-time clock/calendar value is later than its programmed start time, and earlier than its programmed stop time. The timers wrap around 24 h as illustrated below.

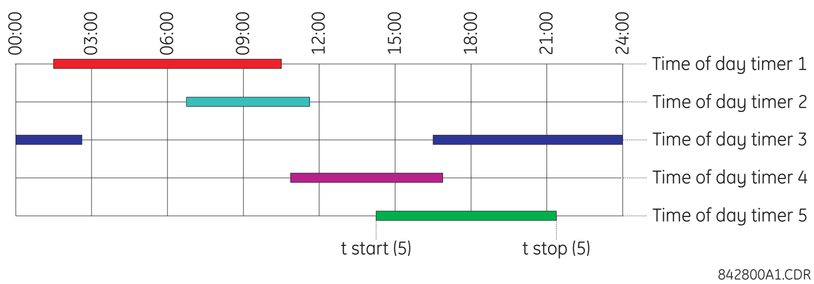


Figure 5–88: TIME OF DAY TIMER EXAMPLE

The TIME OF DAY 1 ON FlexLogic™ operand follows the state of the timers. In addition, one-second pulses are generated on the TIME OF DAY 1 START and TIME OF DAY 1 STOP FlexLogic™ operands when the timers turn on and off, respectively (see the figure below). These operands can be combined in FlexLogic™ with the day and month FlexLogic™ operands and/or with FlexElements™ operating on the DAYOFYEAR, DAYOFMONTH, and SECONDOFDAY FlexAnalog parameters to create virtually any time and date condition for custom time or season-based control actions. To activate these FlexAnalog parameters, enable at least one time of day timer.

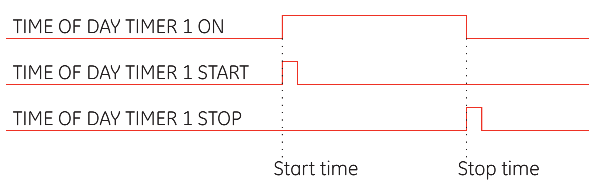


Figure 5–89: CLOSE/OPEN/MAINTAIN CONTROL VIA FLEXLOGIC™ OPERANDS

If the relay is connected to an external clock that follows daylight time changes, care should be taken that the changes do not result in undesired operation. The following settings are available for each time of day timer element.

- **TIME OF DAY TIMER 1 START**: This setting is used to program the relay clock/calendar value for which the timer turns on.
- **TIME OF DAY TIMER 1 STOP**: This setting is used to program the relay clock/calendar value for which the timer turns off.
- **TIME OF DAY TIMER 1 EVENTS**: If enabled, the TIME OF DAY TIMER 1 ON and TIME OF DAY TIMER 1 OFF events are logged.

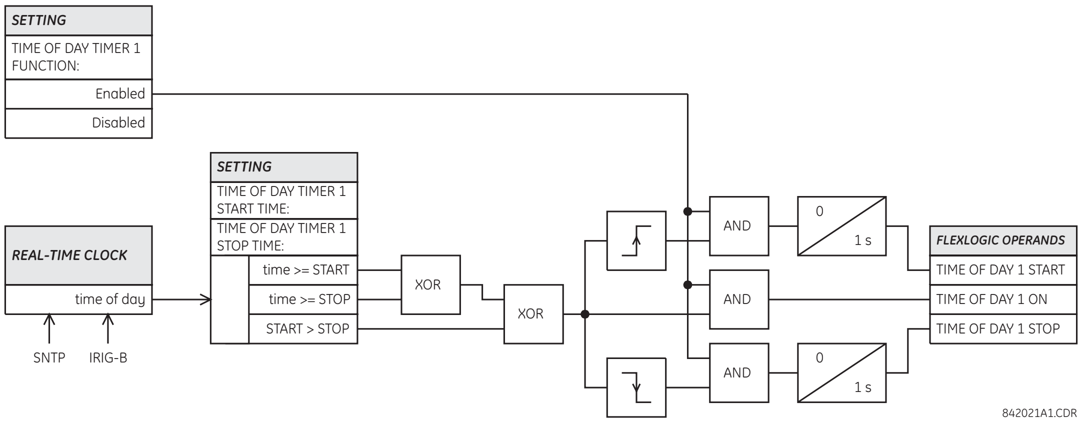


Figure 5–90: TIME OF DAY TIMER LOGIC

5.7.6 CAPACITOR CONTROL

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ CAPACITOR CONTROL ⇨ CAPACITOR CONTROL 1(4)

■ CAPACITOR CONTROL 1 ■		CAP 1 CTRL FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE		CAP 1 SET REMOTE 1: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 SET REMOTE 2: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 SET LOCAL 1: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 SET LOCAL 2: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 RMT CTRL EN: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 LCL CTRL EN: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 RMT SET AUTO: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 LCL SET AUTO: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 RMT SET MAN: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 LCL SET MAN: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 TRIP 1: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 TRIP 2: Off	Range: FlexLogic™ operand
MESSAGE		CAP 1 TRIP 3: Off	Range: FlexLogic™ operand

MESSAGE	CAP 1 TRIP 4: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 TRIP 5: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 TRIP 6: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 SWITCH TO MANUAL ON TRIP: Yes	Range: Yes, No
MESSAGE	CAP 1 AUTO CTRL EN: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 MAN CTRL EN: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 REMOTE OPEN: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 LOCAL OPEN: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 AUTO OPEN: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 BKR OPEN 52b: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 TRIP SEAL-IN DELAY: 0.400 s	Range: 0.000 to 60.000 s in steps of 0.001
MESSAGE	CAP 1 REMOTE CLOSE: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 LOCAL CLOSE: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 AUTO CLOSE: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 BKR CLSD 52a: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 DISCHARGE DELAY: 300 s	Range: 0 to 3600 s in steps of 1
MESSAGE	CAP 1 CLOSE SEAL-IN DELAY: 0.400 s	Range: 0.000 to 60.000 s in steps of 0.001
MESSAGE	CAP 1 BKR CLOSE BLK: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 CLS OVERRIDE: Off	Range: FlexLogic™ operand
MESSAGE	CAP 1 TARGETS: Disabled	Range: Self-reset, Latched, Disabled
MESSAGE	CAP 1 EVENTS: Disabled	Range: Disabled, Enabled

The capacitor control element gathers on/off commands from various sources and executes them, while maintaining remote/local and auto/manual control rights. Local control refers to control from the front panel of the relay. Remote control refers to control via communications from outside of the relay, an on-site interface, and/or from an off-site control center. However, there is flexibility to support other configurations.

This element provides a user-programmable time delay that inhibits closing after the bank has been switched out of service until the bank has had time to discharge any trapped charge. If the capacitor were to be closed with trapped charge of opposite polarity from the system voltage at that instant, larger than normal transients would occur. A FlexAnalog value is available to inform the time remaining before the next permissible close operation.

Seal-in is provided to stretch short input commands to lengths suitable for breaker control. An interlock prevents simultaneous trip and close output, which could result in breaker pumping. To prevent a continuous close input from causing reclosing of the breaker following a trip command, the interlock is sealed-in for the duration of any close input.

A provision is provided to force the auto/manual mode to manual on protection operation. This is to prevent the capacitor automatic switching scheme from attempting to close a faulted capacitor. A setting is used to control the automatic switchover to manual upon the protection trip.

The following settings are available for each capacitor control element.

- **CAP 1 CTRL FUNCTION**: This setting is used to enable the element. When disabled, the remote/local latch is forced to local, the auto/manual latch is forced to manual, the trip and close command outputs are forced off, and their seal-in latches and timers are reset.
- **CAP 1 SET REMOTE 1(2)**: Sets one or two FlexLogic™ operands to select the remote mode. It is expected that one of these settings is programmed to a pushbutton "on" operand. This allows a local operator to hand over control to remote operators. Where appropriate, the other one of these settings may be set to a virtual input. This allows remote operators to grant themselves control rights.
- **CAP 1 SET LOCAL 1(2)**: Similar to previous setting, but selects local mode.
- **CAP 1 RMT CTRL EN**: Selects a FlexLogic™ operand to enables remote auto/manual and open/close control. It is expected that this will be set to CAP 1 IN REMOTE to obtain the baseline functionality, but variations via FlexLogic™ are possible. For example, should it be required that remote control is always available, this setting may be set to "On".
- **CAP 1 LCL CTRL EN**: Similar to previous setting, but enables local controls. Expected to be set to CAP 1 IN LOCAL.
- **CAP 1 RMT SET AUTO**: Selects a FlexLogic™ operand that selects auto mode when remote control is enabled. It is expected that this will be set to a virtual input to enables HMI/SCADA access via one of the supported protocols.
- **CAP 1 LCL SET AUTO**: Similar to previous setting, but expected to be set to a pushbutton "on" operand.
- **CAP 1 RMT SET MAN**: Similar to the **CAP RMT SET AUTO** setting, but selects manual mode.
- **CAP 1 LCL SET MAN**: Similar to the **CAP LCL SET AUTO** setting, but selects manual mode.
- **CAP 1 TRIP 1(6)**: Selects up to six FlexLogic™ operands to activate the CAP 1 BKR TRIP operand, no matter what control modes prevail. Expected to be set to the appropriate protection element operate operand.
- **CAP 1 SWITCH TO MANUAL ON TRIP**: This setting allows controlling the auto/manual mode when issuing a trip command. If set to "Yes" the element will switch to manual mode upon tripping the bank from protection.
- **CAP 1 AUTO CTRL EN**: Selects a FlexLogic™ operand to enable automatic open/close control. It is expected that this will be set to CAP 1 IN AUTO to obtain the baseline functionality, but variations are possible.
- **CAP 1 MAN CTRL EN**: Similar to previous setting, but enables manual controls. Expected to be set to CAP 1 IN MAN.
- **CAP 1 REMOTE OPEN**: Selects a FlexLogic™ operand to activate the CAP 1 BKR TRIP operand when both remote and manual control are enabled. It is expected that this will be set to a virtual input, and that the contact output wired to the capacitor breaker trip coil is set to CAP 1 BKR TRIP.
- **CAP 1 LOCAL OPEN**: Similar to previous setting, but requires both local and manual control to be enabled. Expected to be set to a pushbutton "on" operand.
- **CAP 1 AUTO OPEN**: Similar to previous setting, but requires automatic control to be enabled. Expected to be set to the open command of the voltage regulator either built-in or customer via FlexLogic™.
- **CAP 1 BKR OPEN 52b**: Selects a FlexLogic™ operand that cancels the trip seal-in. Expected to be set to the contact input to which a contact is wired that is closed when the capacitor breaker is open. When both 52a and 52b contacts

are used for security, the appropriate filtering logic possibly including discrepancy alarming can be programmed in FlexLogic™, and the resulting virtual output can be configured under this setting.

- **CAP 1 TRIP SEAL-IN DELAY**: Sets a maximum trip seal-in duration for where the **CAP 1 BKR OPEN 52B** setting is not configured or fails to operate.
- **CAP 1 REMOTE CLOSE**: Similar to the **CAP 1 REMOTE OPEN** setting, but closes the breaker.
- **CAP 1 LOCAL CLOSE**: Similar to the **CAP 1 LOCAL OPEN** setting, but closes the breaker.
- **CAP 1 AUTO CLOSE**: Similar to the **CAP 1 AUTO OPEN** setting, but closes the breaker.
- **CAP 1 BKR CLSD 52a**: Similar to the **CAP 1 BKR OPEN 52B** setting, but cancels the close seal-in, and is expected to be set to a contact that is closed when the breaker is closed. The selected operand also triggers the CAP 1 DISCHARGE TIME. When both 52a and 52b contacts are used for security, the appropriate filtering logic possibly including discrepancy alarming can be programmed in FlexLogic™, and the resulting virtual output can be configured under this setting.
- **CAP 1 CLOSE SEAL-IN DELAY**: Sets a maximum close seal-in duration for where the **CAP BKR CLOSED 52A** setting is not configured or fails to operate.
- **CAP 1 DISCHARGE TIME**: Sets a time delay that inhibits closing after the bank has been switched out-of-service (the **CAP BKR CLOSE 52A** setting goes low or trip command terminates) until the bank has had time to discharge any trapped charge. The correct value for this setting depends on the specifics of the capacitor installation.
- **CAP 1 BKR CLOSE BLK**: Selects a FlexLogic™ operand that triggers the CAP 1 BKR CLOSE interlock logic. Its signal is expected to originate from capacitor breaker trips external to the relay, and thus not otherwise able to block relay closing (for example, from the opposite group's capacitor protection).
- **CAP 1 CLS OVERRIDE**: Selects a FlexLogic™ operand that overrides all inhibits for the breaker close command and allows the CLOSE command to be issued from any source as per the logic diagram.

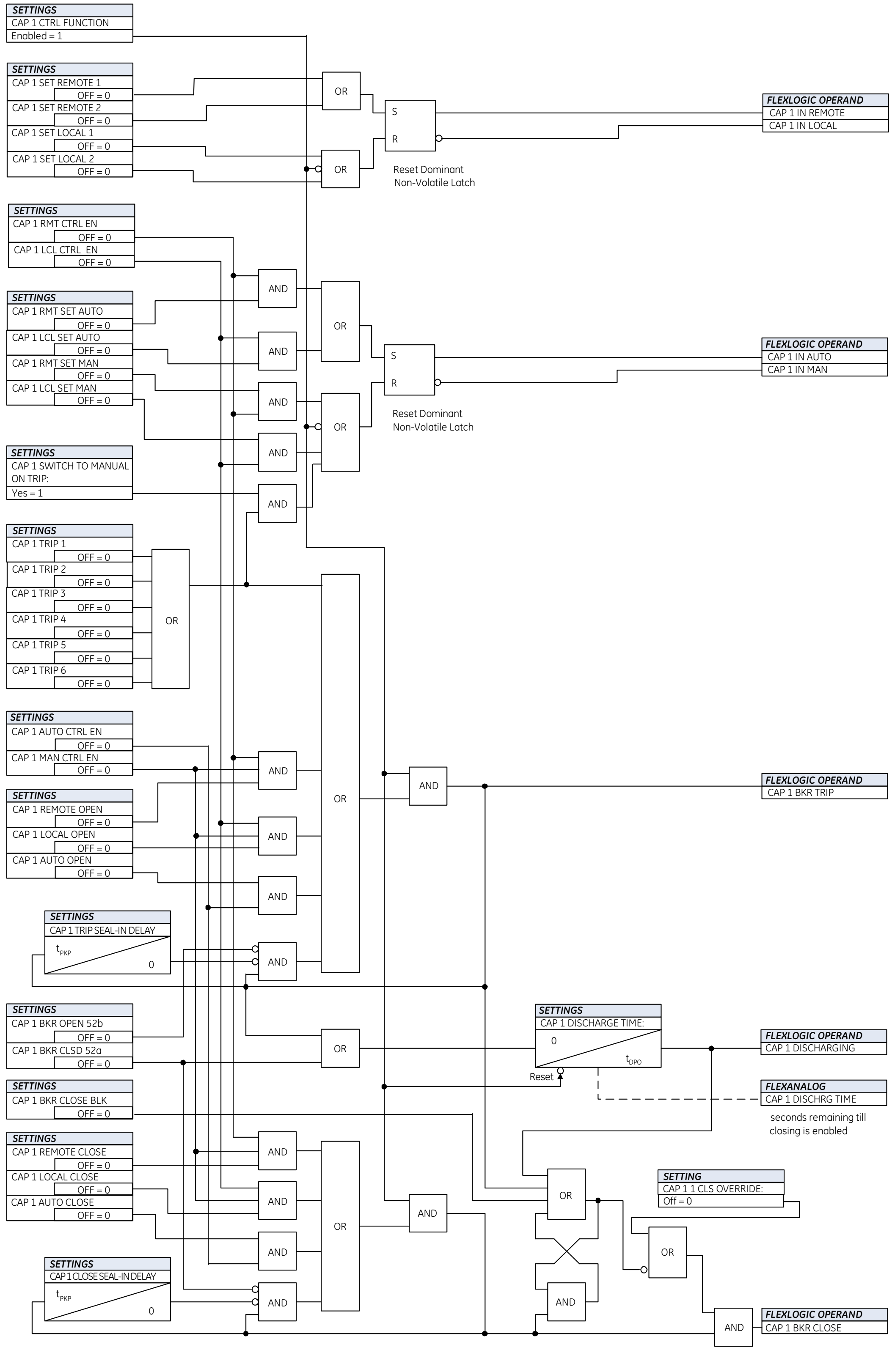


Figure 5–91: CAPACITOR BANK CONTROL SCHEME LOGIC

5

5.7.7 AUTOMATIC VOLTAGE REGULATOR

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ AUTOMATIC VOLTAGE REGULATOR ⇨ AUTOMATIC VOLTAGE REGULATOR 1(3)

■ AUTOMATIC VOLTAGE ■ REGULATOR 1	AVR 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	AVR 1 SOURCE: SRC 1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE	AVR 1 MINIMUM VOLTAGE: 0.500 pu	Range: 0.500 to 1.500 pu in steps of 0.001
MESSAGE	AVR 1 CONTROL MODE: Voltage	Range: Voltage, VAR
MESSAGE	AVR 1 VOLT OPERATING SIGNAL: V1	Range: Vab, Vbc, Vca, Vaver, V1, Vaux, Vag, Vbg, Vcg
MESSAGE	AVR 1 VOLT LEVEL TO CLOSE: 0.950 pu	Range: 0.750 to 1.500 pu in steps of 0.001
MESSAGE	AVR 1 VOLT LEVEL TO OPEN: 1.050 pu	Range: 0.750 to 1.500 pu in steps of 0.001
MESSAGE	AVR 1 VOLT DROP COMPENS Z: 0.00 Ω	Range: 0 to 250.00 ohms in steps of 0.01
MESSAGE	AVR 1 VOLT DROP COMPENS RCA: 75°	Range: 30 to 90° in steps of 1
MESSAGE	AVR 1 VAR LEVEL TO CLOSE: 0.500 pu	Range: –1.500 to 1.500 pu in steps of 0.001
MESSAGE	AVR 1 VAR LEVEL TO OPEN: -0.500 pu	Range: –1.500 to 1.500 pu in steps of 0.001
MESSAGE	AVR 1 POWER FACTOR LIMIT: 1.00	Range: 0.50 to 1.00 pu in steps of 0.01
MESSAGE	AVR 1 VAR OPEN MODE: Minimize No. of Ops.	Range: Minimize Uptime, Minimize No. of Ops.
MESSAGE	AVR 1 DELAY BEFORE CLOSE: 1.000 s	Range: 0.000 to 65.353 s in steps of 0.001
MESSAGE	AVR 1 DELAY BEFORE OPEN: 1.000 s	Range: 0.000 to 65.353 s in steps of 0.001
MESSAGE	AVR 1 BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	AVR 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	AVR 1 EVENTS: Disabled	Range: Disabled, Enabled

The automatic voltage regulator element (AVR) is intended to switch a static capacitor bank breaker close and open to regulate either system voltage, load voltage, power factor, or reactive power. The following figure illustrates some possible applications.

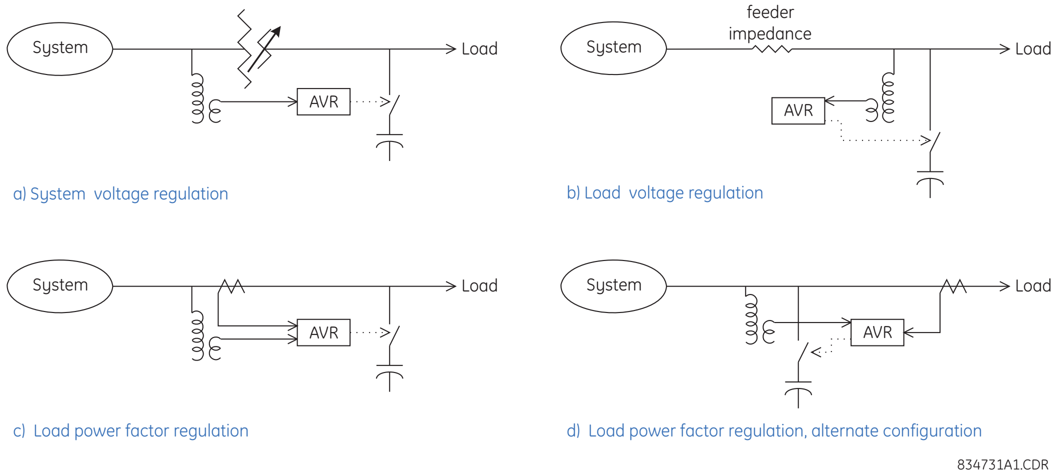


Figure 5–92: APPLICATIONS OF THE CAPACITOR AUTOMATIC VOLTAGE REGULATOR FUNCTION

Up to three identical automatic voltage regulator elements are provided, allowing the relay to be used with capacitor banks divided into sections for finer compensation steps, to provide switching speed dependant on the extent of the voltage or power deviation, or to provide different settings depending on a user-programmable factor such as time of day.

Each element can be set to operate in either “Voltage” mode or “VAR” mode. The voltage mode can be used with relatively short time delay settings as a system stability aid, or with longer time delay settings to assist in the regulation of steady state voltage. When the voltage decreases to the volts level to close setting, after the set close delay the capacitor is closed, raising the voltage. When the voltage increases to the level to open setting, after the set open delay the capacitor is opened, lowering the voltage. The load drop compensation feature can be used to effectively sense the voltage at a location remote from the relay.

The “VAR” mode can be used to regulate the var and power factor of a load to reduce transmission and distribution costs. If the capacitor deployment objective is to minimize system power losses, set the power factor limit to 1.000 to disable it and set the var open and close levels symmetrically about zero reactive power, with a difference between levels equal to the reactive power produced by the capacitor plus margin. Larger margins result in less frequent switching.

If on the other hand the deployment objective is solely to minimize power factor rate charges, set the power factor limit to the value at which power factor penalties are incurred, typically 0.9. Set the var close level to the vars that would flow should the power factor be at the limit when at the minimum expected kW demand. The open command characteristics can be selected to suit whether the preference is to minimize the amount of time the capacitor is online or to minimize the number of capacitor close operations. For the former preference, set the var open mode to “Minimize Uptime” and set the var open level below the close level by an amount equal to the capacitor var rating plus margin. For the latter preference, set the var open mode to “Minimize No. of Ops” (minimize number of operations) and set the var open level to the negative of the close level.

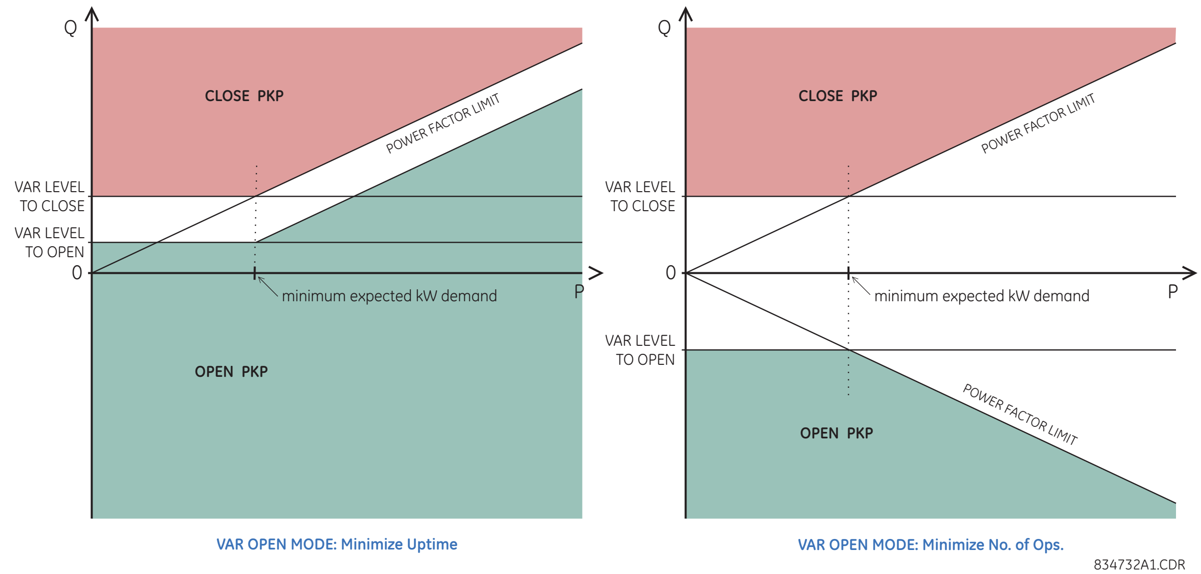


Figure 5–93: AUTOMATIC VOLTAGE REGULATOR PICKUP CHARACTERISTICS IN “VAR” MODE

Care should be taken that the settings do not result in the capacitor being continuously cycled close and open. In the voltage mode the close voltage settings should be lower than the open voltage setting by more than the voltage change expected from capacitor switching, plus margin. Similarly in the “VAR” mode the close var setting should be higher than the open var setting by more than the expected var change due to capacitor switching, plus margin. For configurations where the capacitor current is not included in the measured current, there could still be a measured var change due to loads whose power factor increases with increasing voltage. In general, the larger the margin, the less often the capacitor will be switched.

Delays should be set long enough to avoid undesired operations on transient conditions. Depending on the application, this could include operations for noise hits, for transient voltage depressions accompanying successful fault clearance, and short-term voltage conditions pending automatic reclosure. Delays can also be used to time co-ordinate the switching of multiple capacitor banks, or sections of the same bank.

The following settings are available.

- **AVR 1 SOURCE**: Selects signal source of the control variables of interest. In case of voltage control applications, the selected source needs to have the appropriate voltages configured for proper operation. For example, when using positive-sequence voltage as a control variable, phase voltages must be configured under the source; or when using single-phase auxiliary voltage, the auxiliary source voltage must be configured. In case of “VAR” mode and of voltage mode with voltage drop compensation, the indicated source must be configured with phase voltages and currents into the regulated load or bus, and should include the capacitor current. If the source indicated here does not support the control variable selected, the function will restrain itself from operating, and assert neither the close or open command.
- **AVR 1 MINIMUM VOLTAGE**: This value sets the minimum voltage for capacitor switching, to discriminate against loss of voltage. For voltage mode, this setting applies to the voltage selected for control. For “VAR” mode, this setting applies to the positive sequence voltage.
- **AVR 1 CONTROL MODE**: This setting selects either voltage control for voltage regulation applications, or var control for power factor/reactive power regulation applications.
- **AVR 1 VOLT OPERATING SIGNAL**: When the control mode is voltage, this setting is used to select whether the AVR responds to an individual phase-to-phase voltage or phase-to-ground voltage, the average of the three phase-to-phase voltages, the positive sequence voltage, or the auxiliary RMS voltage. The ability to select the same voltage quantity as is used by other AVRs facilitates coordination with those AVRs.
- **AVR 1 VOLT LEVEL TO CLOSE**: In the voltage mode, this setting specifies the voltage level at or below which to issue the close command.

- **AVR 1 VOLT LEVEL TO OPEN**: In the voltage mode, this setting specifies the voltage level at or above which to issue the open command. The following figure illustrates voltage control level settings.

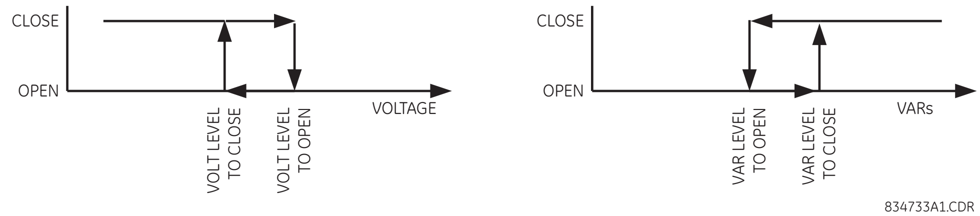


Figure 5–94: CLOSE AND OPEN LEVELS WHEN CONTROLLING VOLTAGE OR VARS

- **AVR 1 VOLT DROP COMPENS Z**: In the voltage mode, this setting allows compensating for voltage drop on the line when the relay measuring point is located upstream of the load. Positive-sequence line impedance is entered in secondary ohms. Compensation cannot exceed 20% of the nominal phase voltage.
- **AVR 1 VOLT DROP COMPENS RCA**: In the voltage mode, this setting specifies the angle of the line impedance for voltage drop calculations.
- **AVR 1 VAR LEVEL TO CLOSE**: In the "VAR" mode, this setting specifies level for the three-phase reactive power level at or above which to issue the close command. The 1 pu value is the product of the nominal primary phase-to-phase voltage, the CT primary, and $\sqrt{3}$. When the source current is an internal summation of two or more CT bank currents, the largest CT primary is used to define the 1 pu value for this setting.
- **AVR 1 VAR LEVEL TO OPEN**: In the "VAR" mode, this setting specifies level for the three-phase reactive power level at or below which to issue the OPEN command. The 1 pu value is defined as for the **VAR LEVEL TO CLOSE** setting.
- **AVR 1 POWER FACTOR LIMIT**: In the "VAR" mode, this setting specifies the power factor below which close commands are allowed. Also affects open commands as shown in the above figure. If set to "1.00", the power factor has no effect.
- **AVR 1 VAR OPEN MODE**: Selects the close command characteristic, either "Minimize No. of Ops." (minimize number of operations) or "Minimize Uptime", as described earlier in the *Automatic voltage regulator pickup characteristics in "VAR" mode* diagram.
- **AVR 1 DELAY BEFORE CLOSE**: This setting specifies delay before issuing the close command, and is used to coordinate with other regulators, or to ride through abnormal system conditions such as faults or re-close sequences.
- **AVR 1 DELAY BEFORE OPEN**: This setting specifies delay before issuing the open command, and is used to coordinate with other regulators, or to ride through abnormal system conditions such as faults or re-close sequences.
- **AVR 1 BLOCK**: This setting specifies a dynamic blocking condition. When blocked the element resets its output flags and internal timers. VT fuse fail is a typical application.

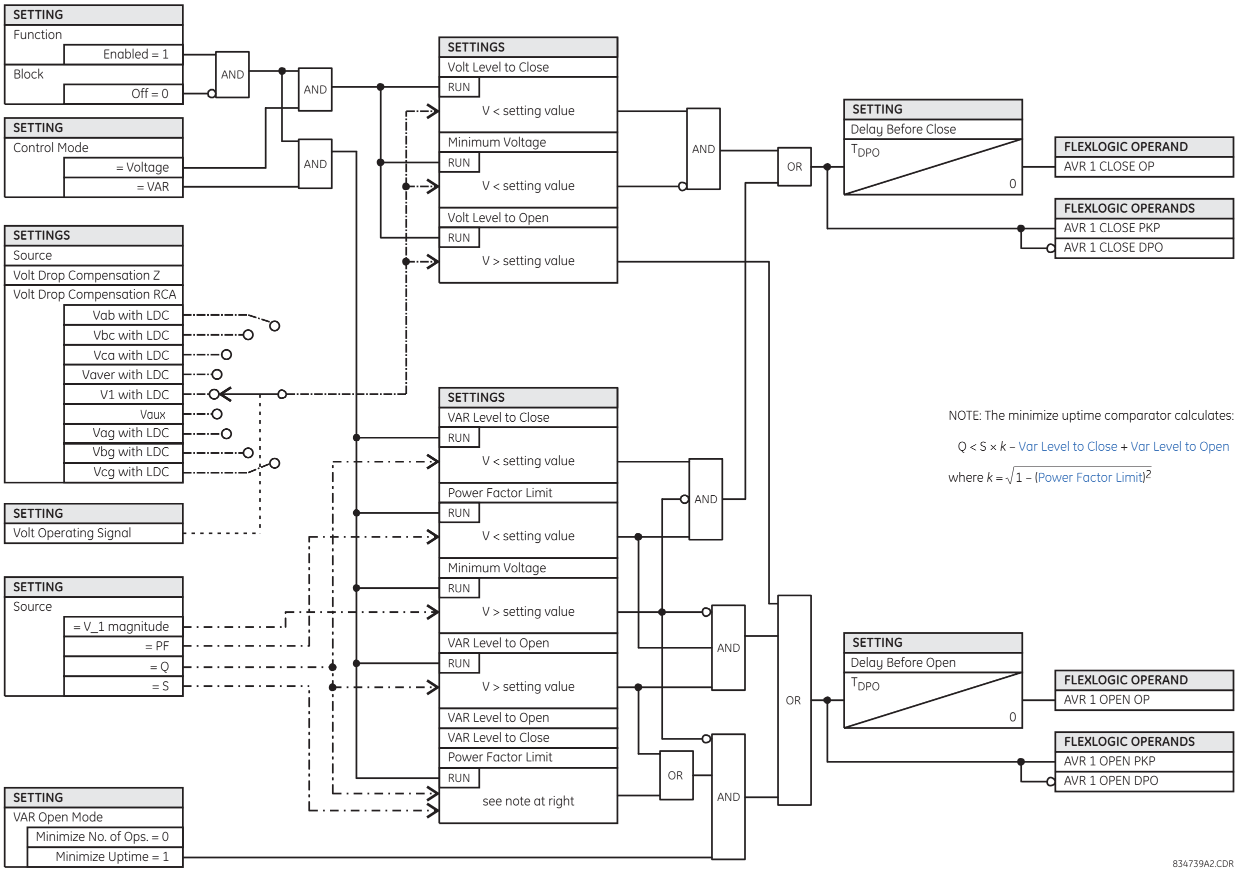


Figure 5–95: AUTOMATIC VOLTAGE REGULATOR SCHEME LOGIC

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.

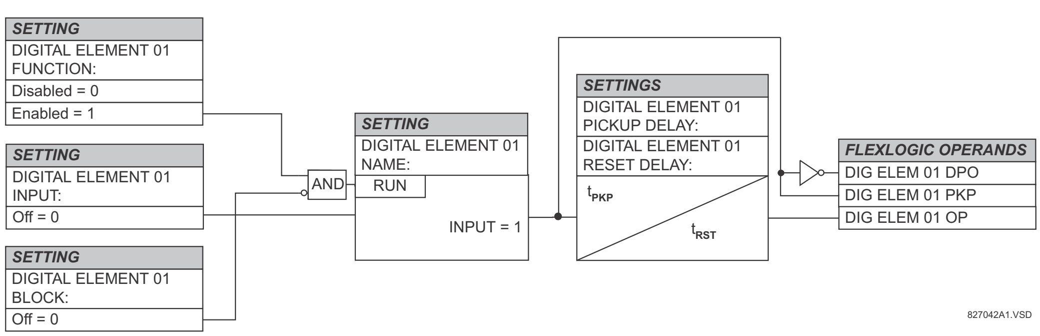


Figure 5–96: DIGITAL ELEMENT SCHEME LOGIC

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.

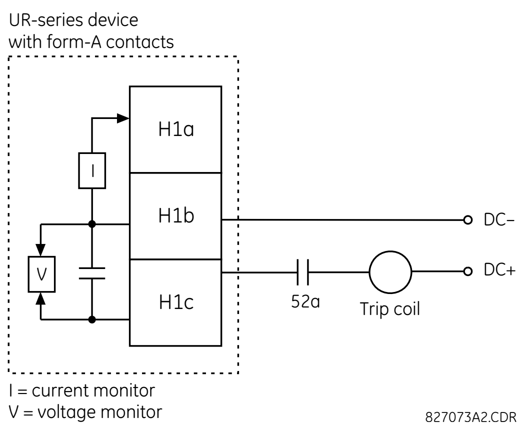
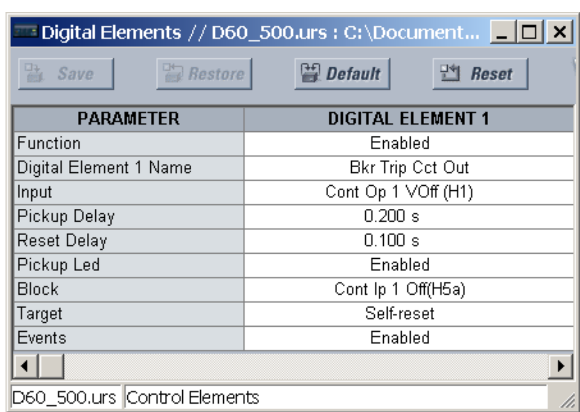


Figure 5–97: TRIP CIRCUIT EXAMPLE 1

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):



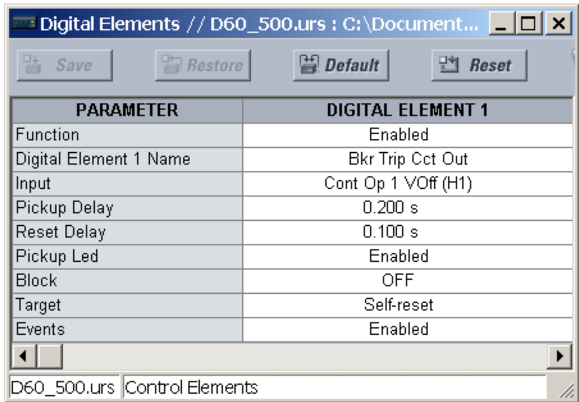
PARAMETER	DIGITAL ELEMENT 1
Function	Enabled
Digital Element 1 Name	Bkr Trip Cct Out
Input	Cont Op 1 VOff (H1)
Pickup Delay	0.200 s
Reset Delay	0.100 s
Pickup Led	Enabled
Block	Cont Ip 1 Off(H5a)
Target	Self-reset
Events	Enabled

NOTE

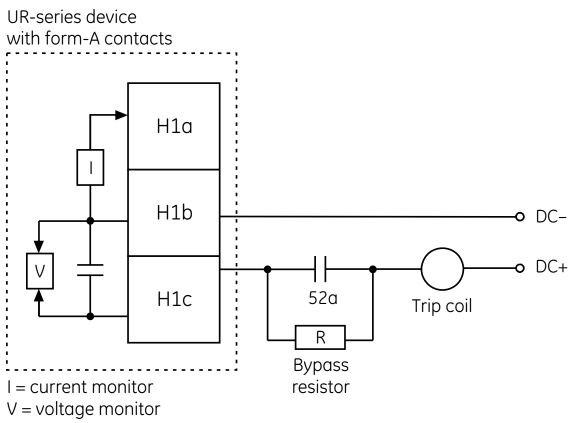
The PICKUP DELAY setting should be greater than the operating time of the breaker to avoid nuisance alarms.

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 5–98: 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)

Menu		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.

5

- **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.

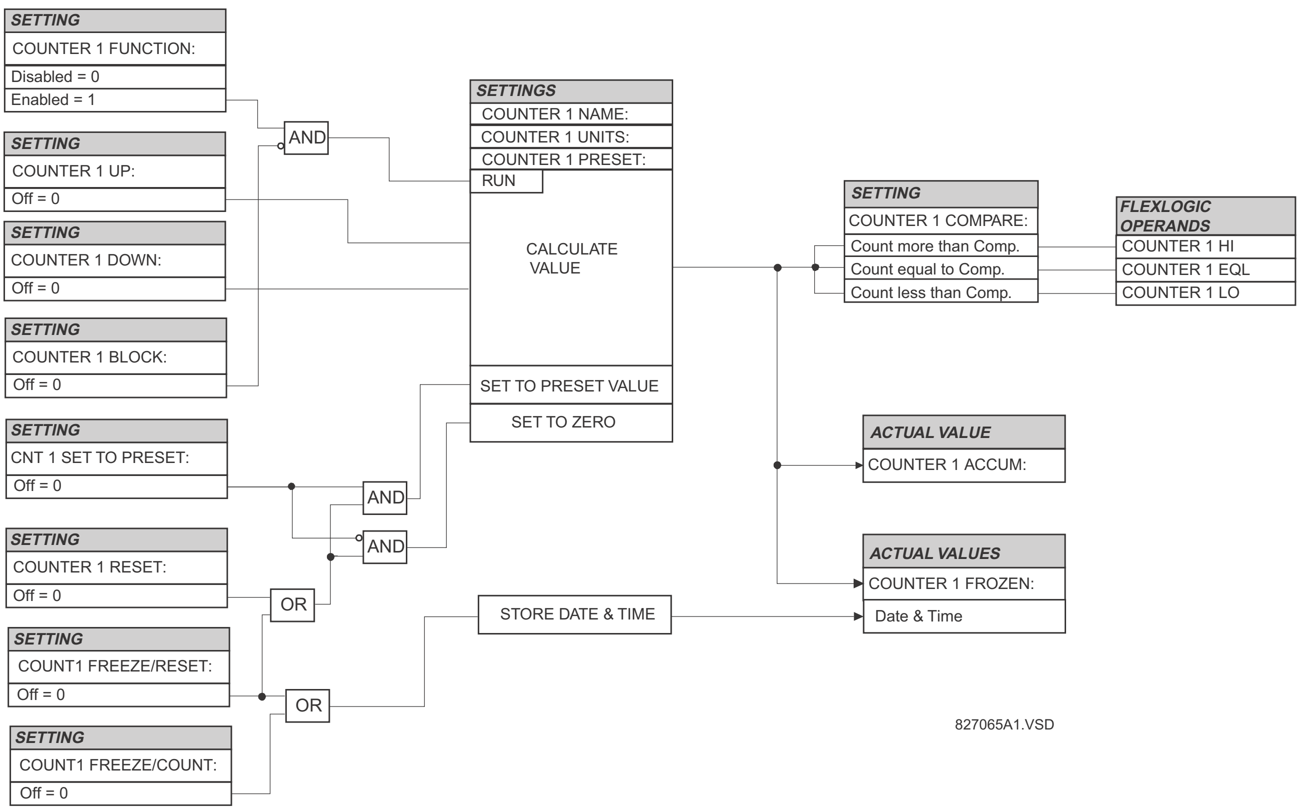


Figure 5–99: DIGITAL COUNTER SCHEME LOGIC

5

5.7.10 MONITORING ELEMENTS

a) MAIN MENU

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS

■ MONITORING ■ ELEMENTS	◀▶	■ BREAKER ■ FLASHOVER 1	See page 5-199.
MESSAGE	▲▼	■ BREAKER RESTRIKE 1 ■	See page 5-203.
MESSAGE	▲▼	■ BREAKER RESTRIKE 2 ■	See page 5-203.
MESSAGE	▲▼	■ BREAKER RESTRIKE 3 ■	See page 5-203.
MESSAGE	▲▼	■ VT FUSE FAILURE 1 ■	See page 5-205.
MESSAGE	▲▼	■ VT FUSE FAILURE 2 ■	See page 5-205.
MESSAGE	▲▼	■ VT FUSE FAILURE 3 ■	See page 5-205.
MESSAGE	▲▼	■ VT FUSE FAILURE 4 ■	See page 5-205.
MESSAGE	▲▼	■ VT FUSE FAILURE 5 ■	See page 5-205.
MESSAGE	▲▼	■ VT FUSE FAILURE 6 ■	See page 5-205.
MESSAGE	▲	■ THERMAL OVERLOAD ■ PROTECTION	See page 5-207.

b) BREAKER FLASHOVER

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨ BREAKER FLASHOVER 1

Menu		Setting	Range
■ BREAKER ■ FLASHOVER 1	◀▶	BKR 1 FLSHOVR FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	BKR 1 FLSHOVR SIDE 1 SRC: SRC 1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE	▲▼	BKR 1 FLSHOVR SIDE 2 SRC: None	Range: None, SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE	▲▼	BKR 1 STATUS CLSD A: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 STATUS CLSD B: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 STATUS CLSD C: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR V PKP: 0.850 pu	Range: 0.000 to 1.500 pu in steps of 0.001
MESSAGE	▲▼	BKR 1 FLSHOVR DIFF V PKP: 1000 V	Range: 0 to 100000 V in steps of 1
MESSAGE	▲▼	BKR 1 FLSHOVR AMP PKP: 0.600 pu	Range: 0.000 to 1.500 pu in steps of 0.001
MESSAGE	▲▼	BKR 1 FLSHOVR PKP DELAY: 0.100 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	▲▼	BKR 1 FLSHOVR SPV A: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR SPV B: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR SPV C: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	BKR 1 FLSHOVR EVENTS: Disabled	Range: Disabled, Enabled

The detection of the breaker flashover is based on the following condition:

1. Breaker open,
2. Voltage drop measured from either side of the breaker during the flashover period,
3. Voltage difference drop, and
4. Measured flashover current through the breaker.

Furthermore, the scheme is applicable for cases where either one or two sets of three-phase voltages are available across the breaker.

Three VT Breaker Flashover Application

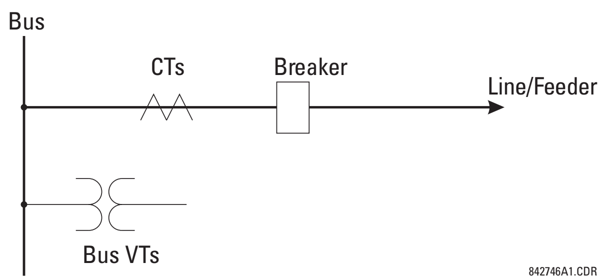
When only one set of VTs is available across the breaker, the **BRK 1 FLSHOVR SIDE 2 SRC** setting should be "None". To detect an open breaker condition in this application, the scheme checks if the per-phase voltages were recovered (picked up), the status of the breaker is open (contact input indicating the breaker status is off), and no flashover current is flowing. A contact showing the breaker status must be provided to the relay. The voltage difference will not be considered as a condition for open breaker in this part of the logic.

NOTE **Voltages must be present prior to flashover conditions. If the three VTs are placed after the breaker on the line (or feeder), and the downstream breaker is open, the measured voltage would be zero and the flashover element will not be initiated.**

The flashover detection will reset if the current drops back to zero, the breaker closes, or the selected FlexLogic™ operand for supervision changes to high. Using supervision through the **BRK 1 FLSHOVR SPV A**, **BRK 1 FLSHOVR SPV B**, and **BRK 1 FLSHOVR SPV C** settings is recommended by selecting a trip operand that will not allow the flashover element to pickup prior to the trip.

The flashover detection can be used for external alarm, re-tripping the breaker, or energizing the lockout relay.

Consider the following configuration:



The source 1 (SRC1) phase currents are feeder CTs and phase voltages are bus VTs, and Contact Input 1 is set as Breaker 52a contact. The conditions prior to flashover detection are:

1. 52a status = 0.
2. VAg, VBg, or VCg is greater than the pickup setting.
3. IA, IB, IC = 0; no current flows through the breaker.
4. ∆VA is greater than pickup (not applicable in this scheme).

The conditions at flashover detection are:

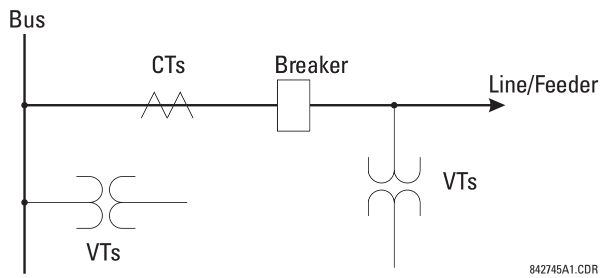
1. 52a status = 0.
2. VAg, VBg, or VCg is lower than the pickup setting.
3. IA, IB, or IC is greater than the pickup current flowing through the breaker.
4. ∆VA is greater than pickup (not applicable in this scheme).

Six VT Breaker Flashover Application

The per-phase voltage difference approaches zero when the breaker is closed. The is well below any typical minimum pickup voltage. Select the level of the **BRK 1 FLSHOVR DIFF V PKP** setting to be less than the voltage difference measured across the breaker when the close or open breaker resistors are left in service. Prior to flashover, the voltage difference is larger than **BRK 1 FLSHOVR DIFF V PKP**. This applies to either the difference between two live voltages per phase or when the voltage from one side of the breaker has dropped to zero (line de-energized), at least one per-phase voltage is larger than the **BRK 1 FLSHOVR V PKP** setting, and no current flows through the breaker poles. During breaker flashover, the per-phase voltages from both sides of the breaker drops below the pickup value defined by the **BRK 1 FLSHOVR V PKP** setting, the voltage difference drops below the pickup setting, and flashover current is detected. These flashover conditions initiate FlexLogic™ pickup operands and start the **BRK 1 FLSHOVR PKP DELAY** timer.

This application do not require detection of breaker status via a 52a contact, as it uses a voltage difference larger than the **BRK 1 FLSHOVR DIFF V PKP** setting. However, monitoring the breaker contact will ensure scheme stability.

Consider the following configuration:



The source 1 (SRC1) phase currents are CTs and phase voltages are bus VTs. The source 2 (SRC2) phase voltages are line VTs. Contact input 1 is set as the breaker 52a contact (optional).

The conditions prior to flashover detection are:

1. ∆VA is greater than pickup
2. VAg, VBg, or VCg is greater than the pickup setting
3. IA, IB, IC = 0; no current flows through the breaker
4. 52a status = 0 (optional)

The conditions at flashover detection are:

1. ∆VA is less than pickup
2. VAg, VBg, or VCg is lower than the pickup setting
3. IA, IB, or IC is greater than the pickup current flowing through the breaker
4. 52a status = 0 (optional)

NOTE **The element is operational only when phase-to-ground voltages are connected to relay terminals. The flashover element will not operate if delta voltages are applied.**

The breaker flashover settings are described below.

- **BRK 1 FLSHOVR SIDE 1 SRC**: This setting specifies a signal source used to provide three-phase voltages and three-phase currents from one side of the current breaker. The source selected as a setting and must be configured with breaker phase voltages and currents, even if only three (3) VTs are available across the breaker.
- **BRK 1 FLSHOVR SIDE 2 SRC**: This setting specifies a signal source used to provide another set of three phase voltages whenever six (6) VTs are available across the breaker.
- **BRK 1 STATUS CLSD A** to **BRK 1 STATUS CLSD C**: These settings specify FlexLogic™ operands to indicate the open status of the breaker. A separate FlexLogic™ operand can be selected to detect individual breaker pole status and provide flashover detection. The recommended setting is 52a breaker contact or another operand defining the breaker poles open status.
- **BRK 1 FLSHOVR V PKP**: This setting specifies a pickup level for the phase voltages from both sides of the breaker. If six VTs are available, opening the breaker leads to two possible combinations – live voltages from only one side of the breaker, or live voltages from both sides of the breaker. Either case will set the scheme ready for flashover detection upon detection of voltage above the selected value. Set **BRK FLSHOVR V PKP** to 85 to 90% of the nominal voltage.
- **BRK 1 FLSHOVR DIFF V PKP**: This setting specifies a pickup level for the phase voltage difference when two VTs per phase are available across the breaker. The pickup voltage difference should be below the monitored voltage difference when close or open breaker resistors are left in service. The setting is selected as primary volts difference between the sources.
- **BRK 1 FLSHOVR AMP PKP**: This setting specifies the normal load current which can flow through the breaker. Depending on the flashover protection application, the flashover current can vary from levels of the charging current when the line is de-energized (all line breakers open), to well above the maximum line (feeder) load (line/feeder connected to load).
- **BRK 1 FLSHOVR SPV A** to **BRK 1 FLSHOVR SPV C**: These settings specifiy FlexLogic™ operands (per breaker pole) that supervise the operation of the element per phase. Supervision can be provided by operation of other protec-

tion elements, breaker failure, and close and trip commands. A six-cycle time delay applies after the selected FlexLogic™ operand resets.

- **BRK FLSHOVR PKP DELAY**: This setting specifies the time delay to operate after a pickup condition is detected.

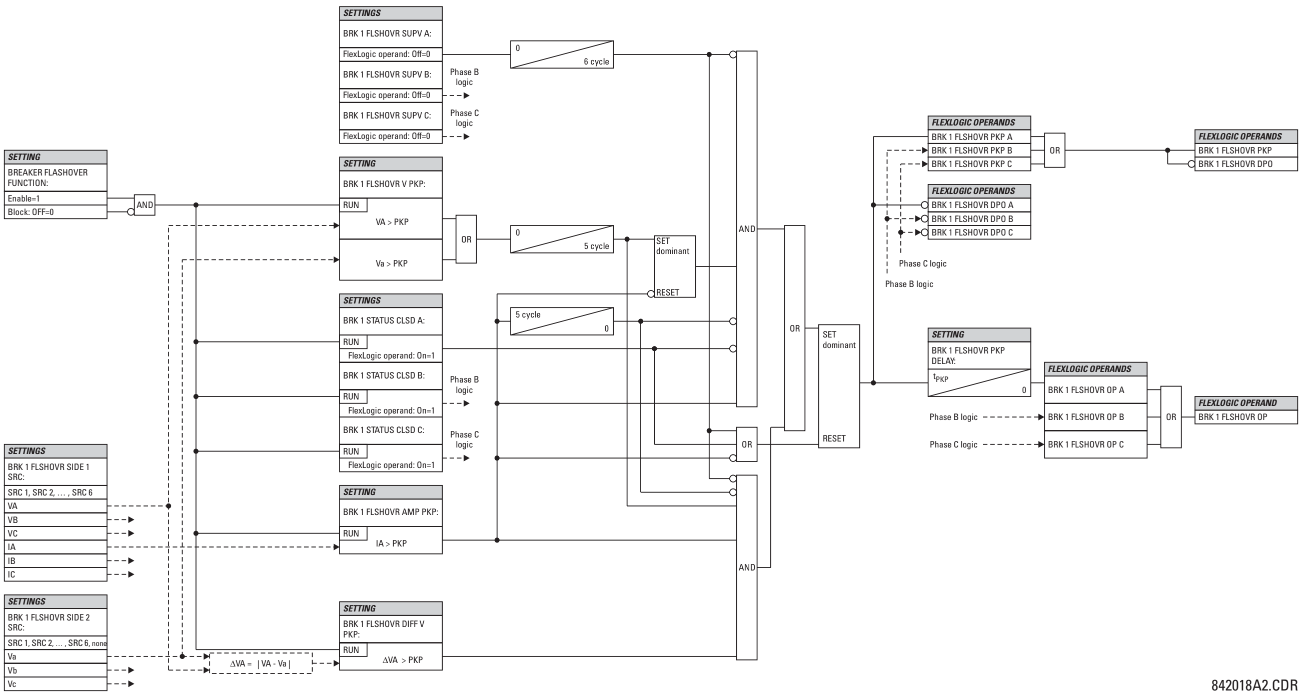


Figure 5–100: BREAKER FLASHOVER SCHEME LOGIC

c) BREAKER RESTRIKE

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨⇩ BREAKER RESTRIKE 1(3)

■ BREAKER RESTRIKE 1 ■	◁▷	BREAKER RESTRIKE 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	BKR RSTR 1 BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	△▽	BREAKER RESTRIKE 1 SOURCE: SRC 1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
MESSAGE	△▽	BREAKER RESTRIKE 1 PICKUP: 0.500 pu	Range: 0.10 to 2.00 pu in steps of 0.01
MESSAGE	△▽	BREAKER RESTRIKE 1 RESET DELAY: 0.100 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	△▽	BKR RSTR 1 BKR OPEN: Off	Range: FlexLogic™ operand
MESSAGE	△▽	BKR RSTR 1 OPEN CMD: Off	Range: FlexLogic™ operand
MESSAGE	△▽	BKR RSTR 1 CLS CMD: Off	Range: FlexLogic™ operand
MESSAGE	△▽	BREAKER RESTRIKE 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	△	BREAKER RESTRIKE 1 EVENTS: Disabled	Range: Disabled, Enabled

One breaker restrike element is provided for each CT/VT module in the C70.

According to IEEE standard C37.100: *IEEE Standard Definitions for Power Switchgear*, restrike is defined as "a resumption of current between the contacts of a switching device during an opening operation after an interval of zero current of ¼ cycle at normal frequency or longer".

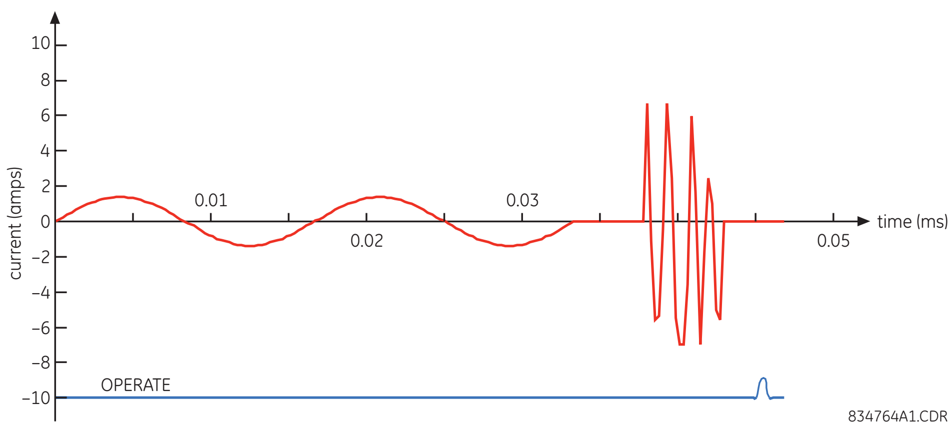


Figure 5–101: TYPICAL RESTRIKE WAVEFORM AND DETECTION FLAG

The breakrer restrike algorithm responds to a successful interruption of the phase current following a declaration of capacitor bank offline as per the breaker pole indication. If a high-frequency current with a magnitude greater than the threshold is resumed at least ¼ of a cycle later than the phase current interruption, then a breaker restrike condition is declared in the corresponding phase and the BRK RESTRIKE 1 OP operand is asserted for a short period of time. The user can add counters and other logic to facilitate the decision making process as to the appropriate actions upon detecting a single restrike or a series of consecutive restrikes.

A restrike event (FlexLogic™ operand) is declared if all of the following hold:

- The current is initially interrupted.
- The breaker status is open.
- An elevated high frequency current condition occurs and the current subsequently drops out again.

The algorithm is illustrated in the state machine diagram shown below.

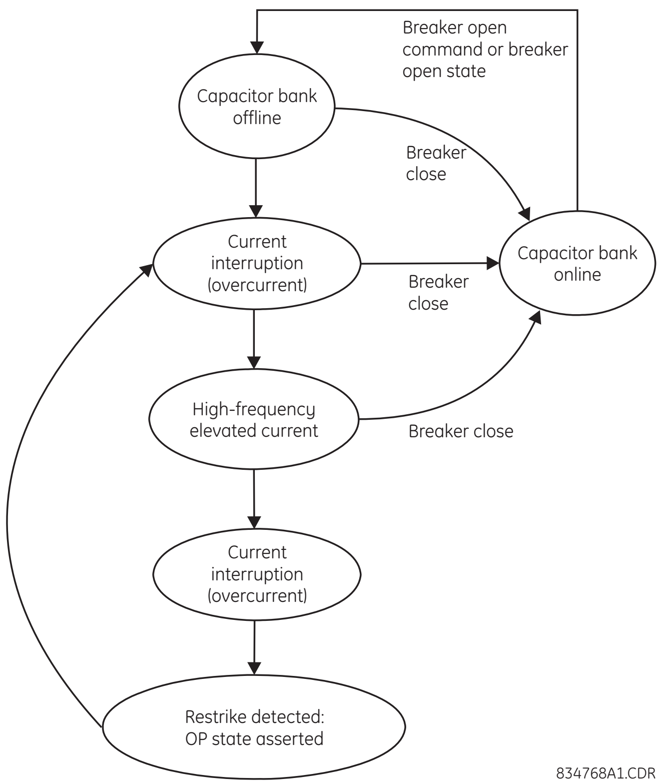


Figure 5–102: ALGORITHM ILLUSTRATION – STATE MACHINE TO DETECT RESTRIKE

In this way, a distinction is made between a self-extinguishing restrike and permanent breaker failure condition. The latter can be detected by the breaker failure function or a regular instantaneous overcurrent element. Also, a fast succession of restrikes will be picked up by breaker failure or instantaneous overcurrent protection.

The following settings are available for each element.

- **BREAKER RESTRIKE 1 FUNCTION**: This setting enable and disables operation of the breaker restrike detection element.
- **BRK RSTR 1 BLOCK**: This setting is used to block operation of the breaker restrike detection element.
- **BREAKER RESTRIKE 1 SOURCE**: This setting selects the source of the current for this element. This source must have a valid CT bank assigned.
- **BREAKER RESTRIKE 1 PICKUP**: This setting specifies the pickup level of the overcurrent detector in per-unit values of CT nominal current.
- **BREAKER RESTRIKE 1 RESET DELAY**: This setting specifies the reset delay for this element. When set to "0 ms", then FlexLogic™ operand will be picked up for only 1/8th of the power cycle.
- **BRK RSTR 1 BRK OPEN**: This setting assigns a FlexLogic™ operand indicating the open position of the breaker. It must be logic "1" when breaker is open.
- **BRK RSTR 1 OPEN CMD**: This setting assigns a FlexLogic™ operand indicating a breaker open command. It must be logic "1" when breaker is opened, either manually or from protection logic.
- **BRK RSTR 1 CLS CMD**: This setting assigns a FlexLogic™ operand indicating a breaker close command. It must be logic "1" when breaker is closed.

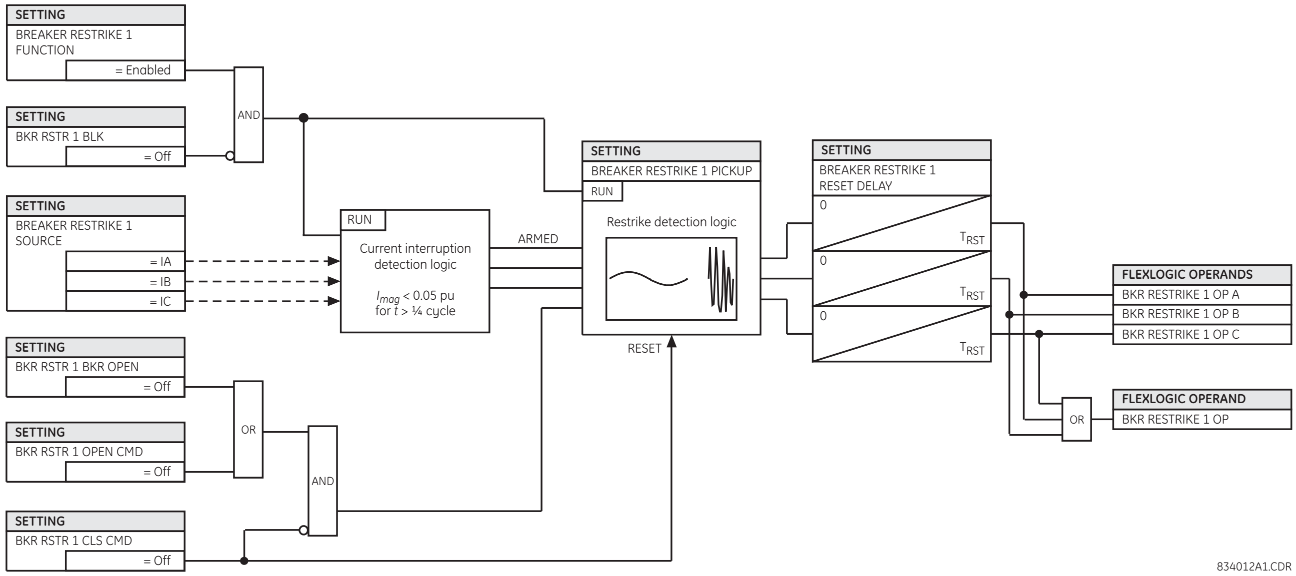


Figure 5–103: BREAKER RESTRIKE SCHEME LOGIC

d) VT FUSE FAILURE

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨⇩ VT FUSE FAILURE 1(6)

■ 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 may 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. These noted indications of fuse failure could 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 will be 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 function setting enables and disables the fuse failure feature for each source.

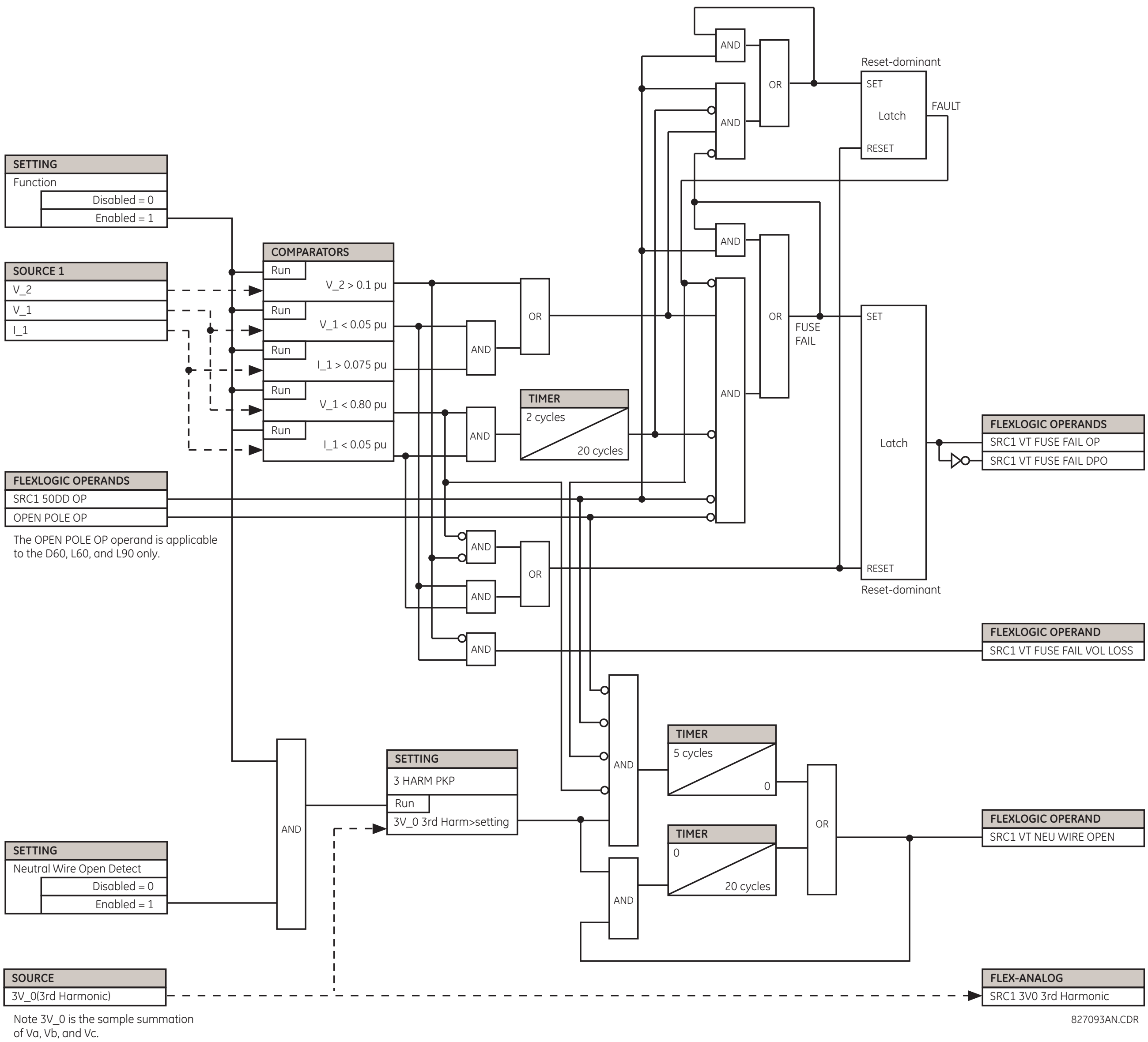


Figure 5–104: VT FUSE FAIL SCHEME LOGIC

e) THERMAL OVERLOAD PROTECTION

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨⇩ THERMAL OVERLOAD PROTECTION ⇨⇩ THERMAL PROTECTION 1(2)

■ THERMAL ■ PROTECTION 1	◀▶	THERMAL PROTECTION 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	THERMAL PROTECTION 1 SOURCE: SRC1	Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6
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:

$$t_{op} = \tau_{op} \times \ln\left(\frac{I^2}{I^2 - (kI_B)^2}\right) \quad \textbf{(EQ 5.20)}$$

The IEC255-8 hot curve is defined as follows:

$$t_{op} = \tau_{op} \times \ln\left(\frac{I^2 - I_p^2}{I^2 - (kI_B)^2}\right) \quad \textbf{(EQ 5.21)}$$

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.

5

The reset time of the thermal overload protection element is also time delayed using following formula:

$$t_{rst} = \tau_{rst} \times \ln\left(\frac{(kI_B)^2}{\left|I^2 - (kI_B)^2\right|}\right) + T_{min} \quad \textbf{(EQ 5.22)}$$

In the above equation,

- τ_{rst} = thermal protection trip time constant.
- T_{min} is a minimum reset time setting

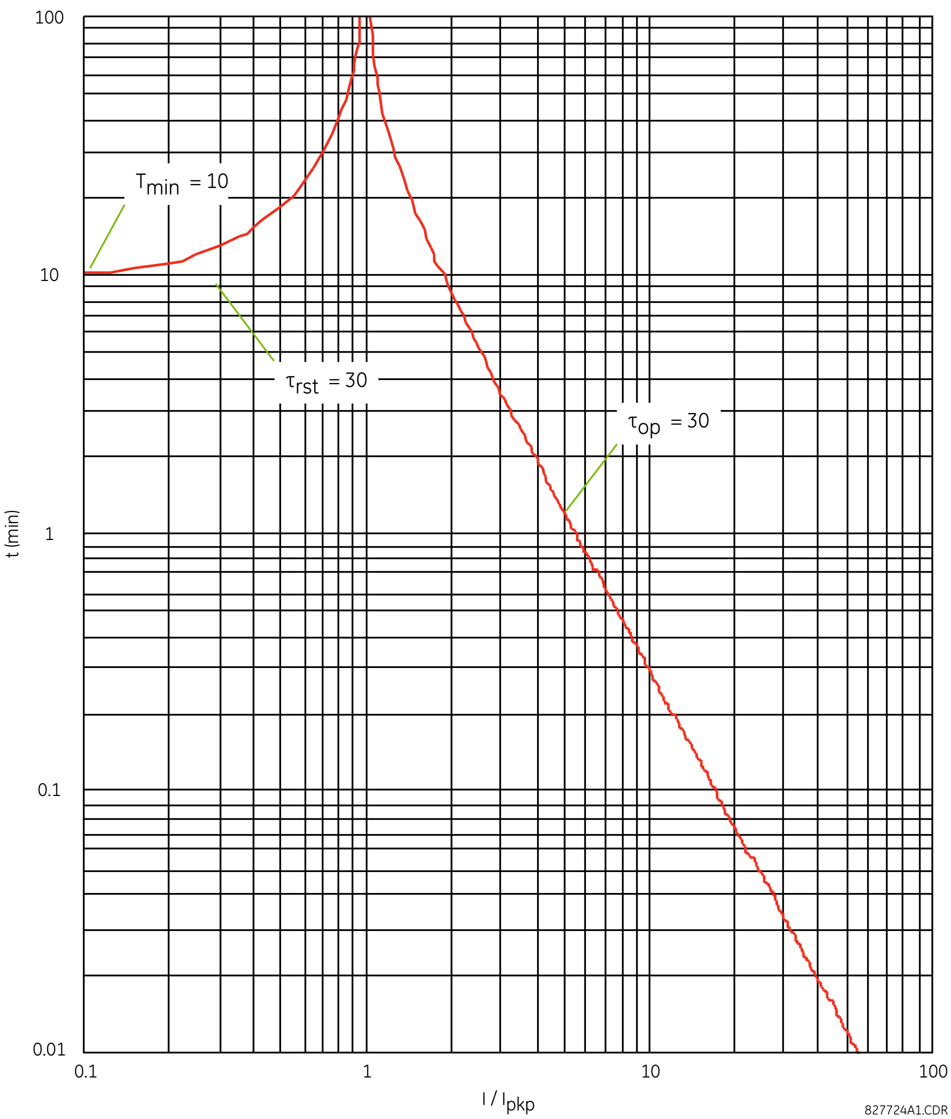


Figure 5–105: IEC 255-8 SAMPLE OPERATE AND RESET CURVES

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:

$$E_n = E_{n-1} + \frac{\Delta t}{t_{op(In)}} \quad \textbf{(EQ 5.23)}$$

When current is less than the dropout level, $I_n > 0.97 \times k \times I_B$, the element starts decreasing the thermal energy:

$$E_n = E_{n-1} - \frac{\Delta t}{t_{rst(In)}} \quad \textbf{(EQ 5.24)}$$

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.
- 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 5–24: 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.

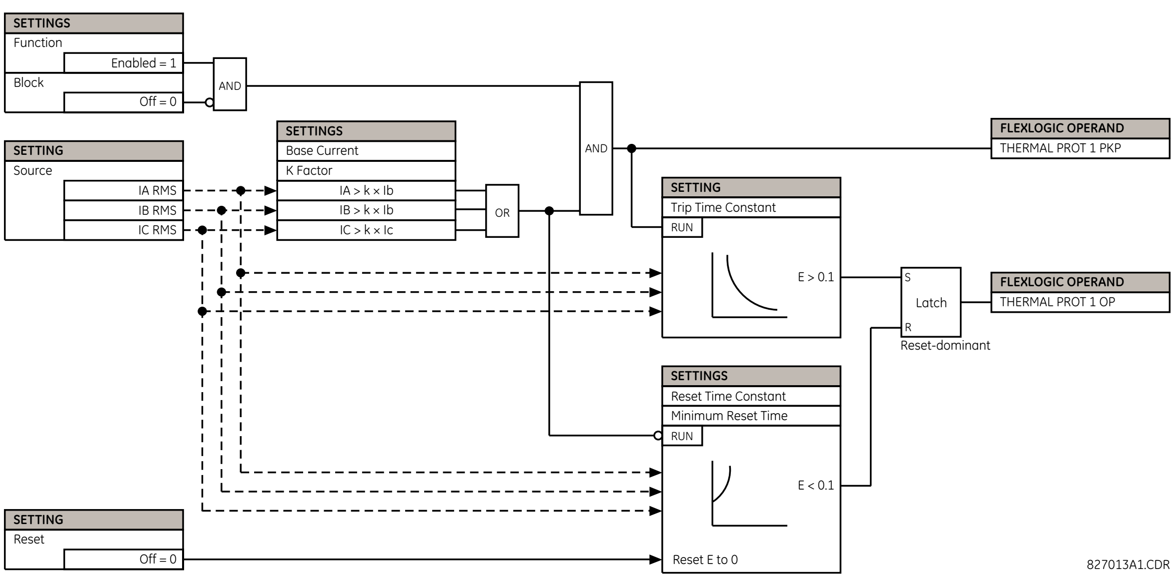


Figure 5–106: THERMAL OVERLOAD PROTECTION SCHEME LOGIC

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 C70 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.

5

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.

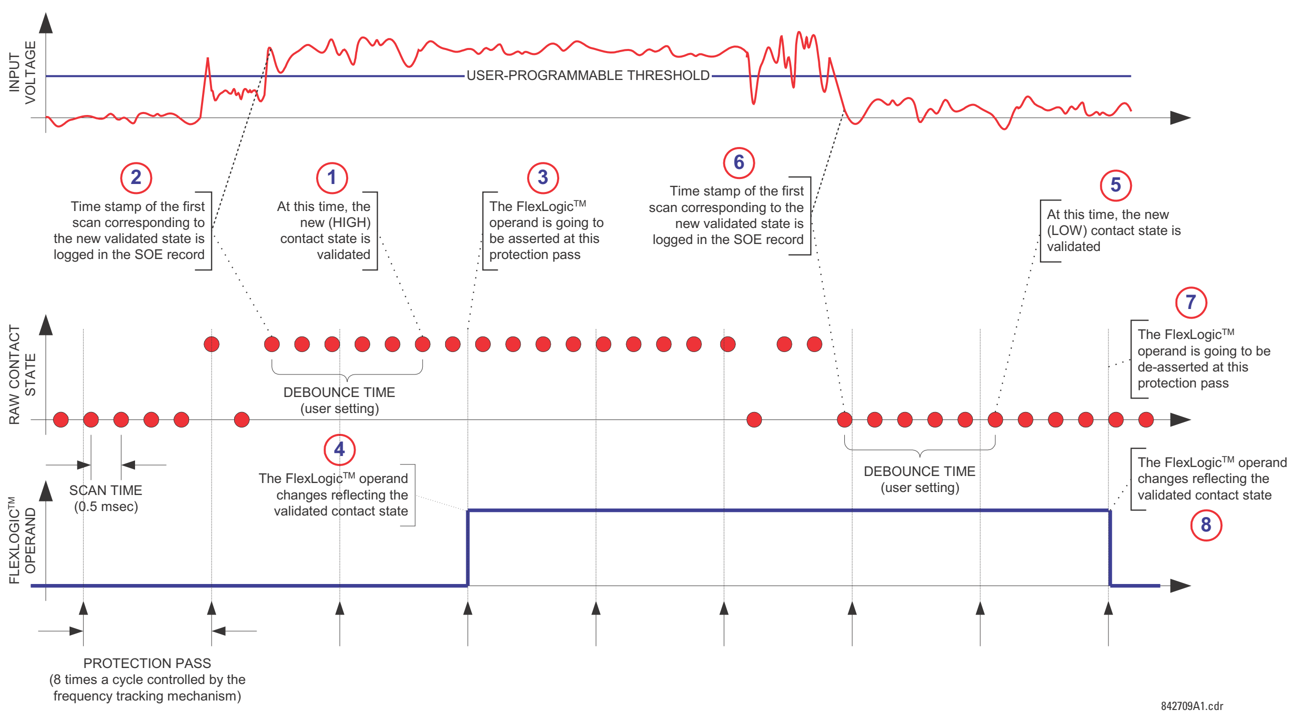


Figure 5–107: INPUT CONTACT DEBOUNCING MECHANISM AND TIME-STAMPING SAMPLE TIMING

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)

```
■ 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.

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.

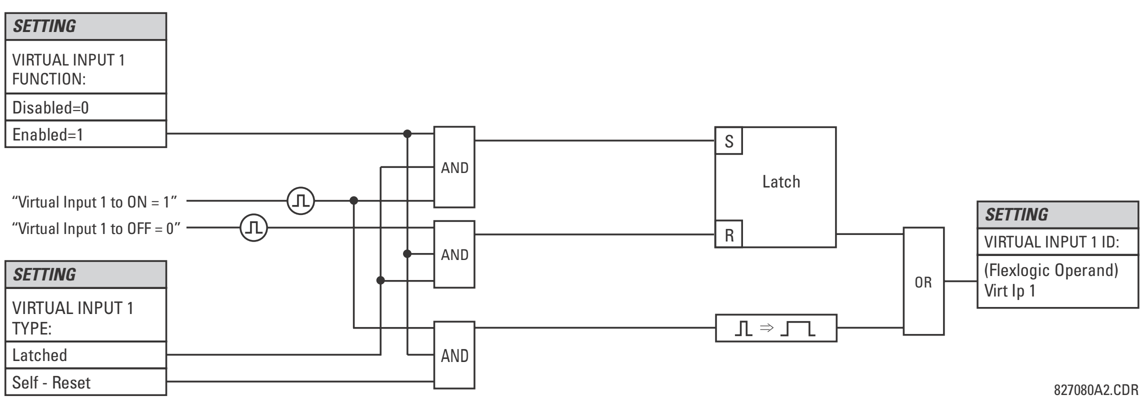


Figure 5–108: VIRTUAL INPUTS SCHEME LOGIC

5.8.3 CONTACT OUTPUTS

a) DIGITAL OUTPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS ⇨ CONTACT OUTPUT H1

■ CONTACT OUTPUT H1 ■	◀▶	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 C70 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 ■	◀▶	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 C70 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".

5

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/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.

NOTE

The IEC 61850 specification requires that communications between devices be implemented on Ethernet. For UR-series relays, Ethernet communications is provided on all CPU modules except type 9E.

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 C70 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 three 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.

b) LOCAL DEVICES: ID OF DEVICE FOR TRANSMITTING GSSE MESSAGES

In a C70 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 C70 releases previous to 5.0x, these name strings were represented by the **RELAY NAME** setting.

c) REMOTE DEVICES: ID OF DEVICE FOR RECEIVING GSSE 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 C70 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.

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 ⇨ CONFIGIGURABLE 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 OUPUTS 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 5–25: 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 OPERAND:     Range: FlexLogic™ operand
■ UserSt- 1 BIT PAIR        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.

The following setting represents the time between sending GSSE/GOOSE messages when there has been no change of state of any selected digital point. This setting is located in the **PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ GSSE/GOOSE CONFIGURATION** settings menu.

```
DEFAULT GSSE/GOOSE        Range: 1 to 60 s in steps of 1
UPDATE TIME: 60 s
```

NOTE **For more information on GSSE/GOOSE messaging, refer to *Remote Inputs/Outputs Overview* in the *Remote Devices* section.**

5.8.9 RESETTING

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ RESETTING

```
■ RESETTING          RESET OPERAND:      Range: FlexLogic™ operand
■                    Off
```

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.

5.8.10 DIRECT INPUTS AND OUTPUTS

a) DIRECT INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ DIRECT INPUTS ⇨ DIRECT INPUT 1(32)

■ DIRECT INPUT 1 ■		DIRECT INPUT 1 NAME: Dir Ip 1	Range: *up to 12 alphanumeric characters*
MESSAGE		DIRECT INPUT 1 DEVICE ID: 1	Range: *1 to 16*
MESSAGE		DIRECT INPUT 1 BIT NUMBER: 1	Range: *1 to 32*
MESSAGE		DIRECT INPUT 1 DEFAULT STATE: Off	Range: *On, Off, Latest/On, Latest/Off*
MESSAGE		DIRECT INPUT 1 EVENTS: Disabled	Range: *Enabled, Disabled*

These settings specify how the direct input information is processed. The **DIRECT INPUT 1 NAME** setting allows the user to assign a descriptive name to the direct input. The **DIRECT INPUT 1 DEVICE ID** represents the source of direct input 1. The specified direct input is driven by the device identified here.

The **DIRECT INPUT 1 BIT NUMBER** is the bit number to extract the state for direct input 1. Direct Input 1 is driven by the bit identified as **DIRECT INPUT 1 BIT NUMBER**. This corresponds to the direct output number of the sending device.

The **DIRECT INPUT 1 DEFAULT STATE** represents the state of the direct input when the associated direct device is offline. The following choices are available:

- Setting **DIRECT INPUT 1 DEFAULT STATE** to “On” value defaults the input to Logic 1.
- Setting **DIRECT INPUT 1 DEFAULT STATE** to “Off” value defaults the input to Logic 0.
- Setting **DIRECT INPUT 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 **DIRECT INPUT 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.

b) DIRECT OUTPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ DIRECT OUTPUTS ⇨ DIRECT OUTPUT 1(32)

■ DIRECT OUTPUT 1 ■		DIRECT OUT 1 NAME: Dir Out 1	Range: *up to 12 alphanumeric characters*
MESSAGE		DIRECT OUT 1 OPERAND: Off	Range: *FlexLogic™ operand*
MESSAGE		DIRECT OUTPUT 1 EVENTS: Disabled	Range: *Enabled, Disabled*

The **DIRECT OUT 1 NAME** setting allows the user to assign a descriptive name to the direct output. The **DIR OUT 1 OPERAND** is the FlexLogic™ operand that determines the state of this direct output.

c) APPLICATION EXAMPLES

The examples introduced in the earlier *Direct inputs and outputs* section (part of the *Product Setup* section) are continued below to illustrate usage of the direct inputs and outputs.

Example 1: Extending input/output capabilities of a C70 relay

Consider an application that requires additional quantities of digital inputs or output contacts or lines of programmable logic that exceed the capabilities of a single UR-series chassis. The problem is solved by adding an extra UR-series IED, such as the C30, to satisfy the additional inputs/outputs and programmable logic requirements. The two IEDs are connected via single-channel digital communication cards as shown below.

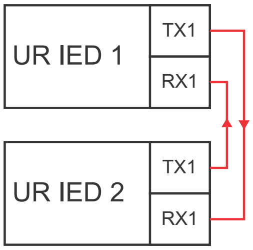


Figure 5–109: INPUT AND OUTPUT EXTENSION VIA DIRECT INPUTS AND OUTPUTS

Assume contact input 1 from UR IED 2 is to be used by UR IED 1. The following settings should be applied (Direct Input 5 and bit number 12 are used, as an example):

UR IED 1: **DIRECT INPUT 5 DEVICE ID** = "2"
DIRECT INPUT 5 BIT NUMBER = "12"

UR IED 2: **DIRECT OUT 12 OPERAND** = "Cont Ip 1 On"

The Cont Ip 1 On operand of UR IED 2 is now available in UR IED 1 as DIRECT INPUT 5 ON.

Example 2: Interlocking busbar protection

A simple interlocking busbar protection scheme can be accomplished by sending a blocking signal from downstream devices, say 2, 3 and 4, to the upstream device that monitors a single incomer of the busbar, as shown in the figure below.

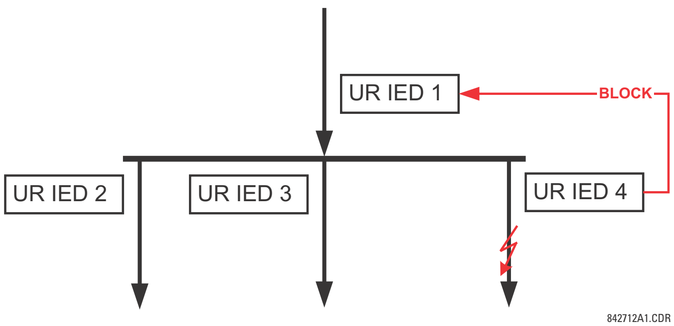


Figure 5–110: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME

Assume that Phase Instantaneous Overcurrent 1 is used by Devices 2, 3, and 4 to block Device 1. If not blocked, Device 1 would trip the bus upon detecting a fault and applying a short coordination time delay.

The following settings should be applied (assume Bit 3 is used by all 3 devices to sent the blocking signal and Direct Inputs 7, 8, and 9 are used by the receiving device to monitor the three blocking signals):

UR IED 2: **DIRECT OUT 3 OPERAND**: "PHASE IOC1 OP"

UR IED 3: **DIRECT OUT 3 OPERAND**: "PHASE IOC1 OP"

UR IED 4: **DIRECT OUT 3 OPERAND**: "PHASE IOC1 OP"

UR IED 1: **DIRECT INPUT 7 DEVICE ID**: "2"
DIRECT INPUT 7 BIT NUMBER: "3"
DIRECT INPUT 7 DEFAULT STATE: select "On" for security, select "Off" for dependability

DIRECT INPUT 8 DEVICE ID: "3"
DIRECT INPUT 8 BIT NUMBER: "3"
DIRECT INPUT 8 DEFAULT STATE: select "On" for security, select "Off" for dependability

DIRECT INPUT 9 DEVICE ID: "4"
DIRECT INPUT 9 BIT NUMBER: "3"
DIRECT INPUT 9 DEFAULT STATE: select "On" for security, select "Off" for dependability

Now the three blocking signals are available in UR IED 1 as DIRECT INPUT 7 ON, DIRECT INPUT 8 ON, and DIRECT INPUT 9 ON. Upon losing communications or a device, the scheme is inclined to block (if any default state is set to "On"), or to trip the bus on any overcurrent condition (all default states set to "Off").

Example 2: Pilot-aided schemes

Consider a three-terminal line protection application shown in the figure below.

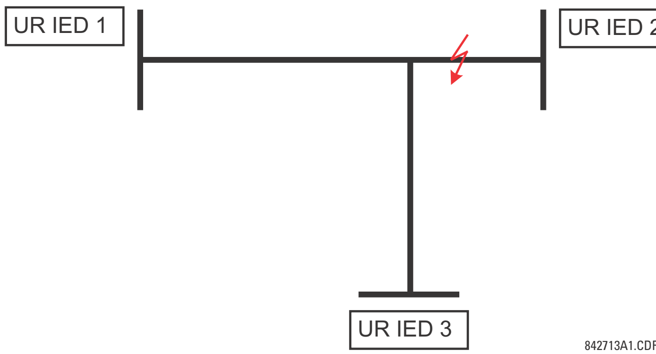


Figure 5–111: THREE-TERMINAL LINE APPLICATION

Assume the Hybrid Permissive Overreaching Transfer Trip (Hybrid POTT) scheme is applied using the architecture shown below. The scheme output operand HYB POTT TX1 is used to key the permission.

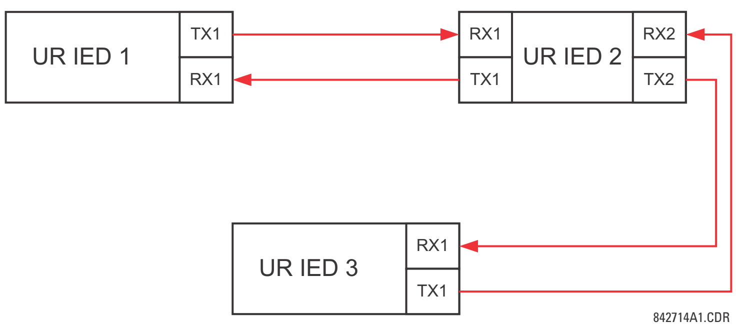


Figure 5–112: SINGLE-CHANNEL OPEN-LOOP CONFIGURATION

In the above architecture, Devices 1 and 3 do not communicate directly. Therefore, Device 2 must act as a 'bridge'. The following settings should be applied:

UR IED 1: **DIRECT OUT 2 OPERAND:** "HYB POTT TX1"
DIRECT INPUT 5 DEVICE ID: "2"
DIRECT INPUT 5 BIT NUMBER: "2" (this is a message from IED 2)
DIRECT INPUT 6 DEVICE ID: "2"
DIRECT INPUT 6 BIT NUMBER: "4" (effectively, this is a message from IED 3)

UR IED 3: **DIRECT OUT 2 OPERAND:** "HYB POTT TX1"
DIRECT INPUT 5 DEVICE ID: "2"
DIRECT INPUT 5 BIT NUMBER: "2" (this is a message from IED 2)
DIRECT INPUT 6 DEVICE ID: "2"
DIRECT INPUT 6 BIT NUMBER: "3" (effectively, this is a message from IED 1)

UR IED 2: **DIRECT INPUT 5 DEVICE ID:** "1"
DIRECT INPUT 5 BIT NUMBER: "2"
DIRECT INPUT 6 DEVICE ID: "3"
DIRECT INPUT 6 BIT NUMBER: "2"

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DIRECT OUT 2 OPERAND: "HYB POTT TX1"
DIRECT OUT 3 OPERAND: "DIRECT INPUT 5" (forward a message from 1 to 3)
DIRECT OUT 4 OPERAND: "DIRECT INPUT 6" (forward a message from 3 to 1)

Signal flow between the three IEDs is shown in the figure below:

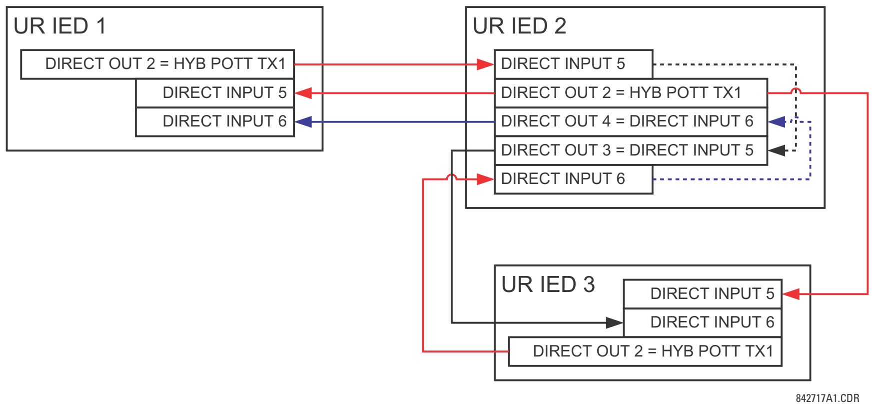

Figure 5–113: SIGNAL FLOW FOR DIRECT INPUT AND OUTPUT – EXAMPLE 3

In three-terminal applications, both the remote terminals must grant permission to trip. Therefore, at each terminal, direct inputs 5 and 6 should be ANDed in FlexLogic™ and the resulting operand configured as the permission to trip (**HYB POTT RX1** setting).

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 C70 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 5–26: GOOSE ANALOG INPUT BASE UNITS

ELEMENT	BASE UNITS
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 THD & HARMONICS	BASE = 1%
SOURCE VOLTAGE	V_{BASE} = maximum nominal primary RMS value of the +IN and –IN inputs

The GOOSE analog input FlexAnalog™ values are available for use in other C70 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 C70 functions that use FlexInteger™ values.

5.9.1 DCMA INPUTS

PATH: SETTINGS ⇨⇩ TRANSDUCER I/O ⇨⇩ DCMA INPUTS ⇨ DCMA INPUT F1(U8)

■ DCMA INPUT F1 ■		DCMA INPUT F1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE		DCMA INPUT F1 ID: DCMA Ip 1	Range: up to 20 alphanumeric characters
MESSAGE		DCMA INPUT F1 UNITS: µA	Range: 6 alphanumeric characters
MESSAGE		DCMA INPUT F1 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 F1 MIN VALUE: 0.000	Range: –9999.999 to +9999.999 in steps of 0.001
MESSAGE		DCMA INPUT F1 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 F.

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 F1 RANGE** setting specifies the mA DC range of the transducer connected to the input channel.

The **DCMA INPUT F1 MIN VALUE** and **DCMA INPUT F1 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 F1 MIN VALUE** value is "0" and the **DCMA INPUT F1 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 F1 MIN VALUE** value would be "–20" and the **DCMA INPUT F1 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 F1(U8)

■ RTD INPUT F1 ■	◀▶	RTD INPUT F1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	RTD INPUT F1 ID: RTD Ip 1	Range: Up to 20 alphanumeric characters
MESSAGE	▲	RTD INPUT F1 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 5–27: 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 F1(U8)

■ DCMA OUTPUT F1 ■		DCMA OUTPUT F1 SOURCE: Off	Range: Off, any analog actual value parameter
MESSAGE		DCMA OUTPUT F1 RANGE: –1 to 1 mA	Range: –1 to 1 mA, 0 to 1 mA, 4 to 20 mA
MESSAGE		DCMA OUTPUT F1 MIN VAL: 0.000 pu	Range: –90.000 to 90.000 pu in steps of 0.001
MESSAGE		DCMA OUTPUT F1 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:

$$I_{out} = \begin{cases} I_{min} & \text{if } x < \textbf{MIN VAL} \\ I_{max} & \text{if } x > \textbf{MAX VAL} \\ k(x - \textbf{MIN VAL}) + I_{min} & \text{otherwise} \end{cases} \quad \textbf{(EQ 5.25)}$$

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:

$$k = \frac{I_{max} - I_{min}}{\textbf{MAX VAL} - \textbf{MIN VAL}} \quad \textbf{(EQ 5.26)}$$

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.

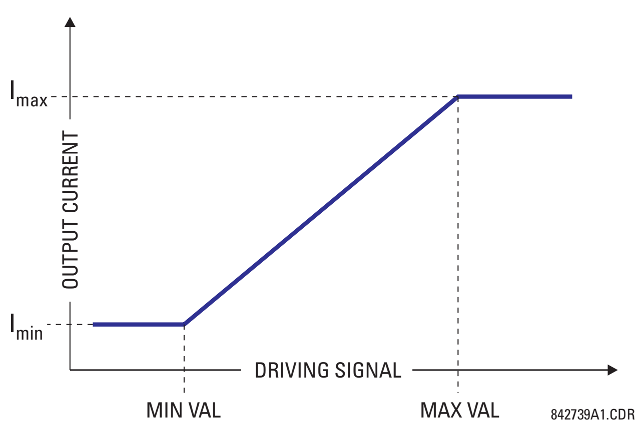

Figure 5–114: DCMA OUTPUT CHARACTERISTIC

The dcmA output settings are described below.

- **DCMA OUTPUT F1 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 F1 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 F1 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 F1 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 F1 MIN VAL** and **DCMA OUTPUT F1 MAX VAL** settings are ignored for power factor base units (i.e. if the **DCMA OUTPUT F1 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:

$$P = \sqrt{3} \times 13.8\text{ kV} \times 0.8\text{ kA} \times 0.9 = 17.21\text{ MW} \quad \textbf{(EQ 5.27)}$$

The three-phase power with 20% overload margin is:

$$P_{max} = 1.2 \times 17.21\text{ MW} = 20.65\text{ MW} \quad \textbf{(EQ 5.28)}$$

The base unit for power (refer to the FlexElements section in this chapter for additional details) is:

$$P_{BASE} = 115\text{ V} \times 120 \times 1.2\text{ kA} = 16.56\text{ MW} \quad \textbf{(EQ 5.29)}$$

The minimum and maximum power values to be monitored (in pu) are:

$$\text{minimum power} = \frac{-20.65\text{ MW}}{16.56\text{ MW}} = -1.247\text{ pu}, \quad \text{maximum power} = \frac{20.65\text{ MW}}{16.56\text{ MW}} = 1.247\text{ pu} \quad \textbf{(EQ 5.30)}$$

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:

$$I_{max} = 1.5 \times 4.2\text{ kA} = 6.3\text{ kA} \quad \textbf{(EQ 5.31)}$$

The base unit for current (refer to the *FlexElements* section in this chapter for additional details) is:

$$I_{BASE} = 5\text{ kA} \quad \textbf{(EQ 5.32)}$$

The minimum and maximum power values to be monitored (in pu) are:

$$\text{minimum current} = \frac{0\text{ kA}}{5\text{ kA}} = 0\text{ pu}, \quad \text{maximum current} = \frac{6.3\text{ kA}}{5\text{ kA}} = 1.26\text{ pu} \quad \textbf{(EQ 5.33)}$$

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.

The minimum and maximum positive-sequence voltages to be monitored are:

$$V_{min} = 0.7 \times \frac{400\text{ kV}}{\sqrt{3}} = 161.66\text{ kV}, \quad V_{max} = 1.1 \times \frac{400\text{ kV}}{\sqrt{3}} = 254.03\text{ kV} \quad \textbf{(EQ 5.34)}$$

The base unit for voltage (refer to the *FlexElements* section in this chapter for additional details) is:

$$V_{BASE} = 0.0664\text{ kV} \times 6024 = 400\text{ kV} \quad \textbf{(EQ 5.35)}$$

The minimum and maximum voltage values to be monitored (in pu) are:

$$\text{minimum voltage} = \frac{161.66\text{ kV}}{400\text{ kV}} = 0.404\text{ pu}, \quad \text{maximum voltage} = \frac{254.03\text{ kV}}{400\text{ kV}} = 0.635\text{ pu} \quad \textbf{(EQ 5.36)}$$

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.

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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 C70 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, C70 operation is normal and all test features are disabled.

In the "Isolated" mode, the C70 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 C70 inputs and outputs operate normally. If the test mode is forcible, and the operand assigned to the **TEST MODE FORCING** setting is "On", the C70 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 C70 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 C70 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 5–28: 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 C70 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
■ INPUTS
```

	Display	Range
	FORCE Cont Ip 1 :Disabled	Range: Disabled, Open, Closed
MESSAGE	FORCE Cont Ip 2 :Disabled	Range: Disabled, Open, Closed
	↓	
MESSAGE	FORCE Cont Ip xx :Disabled	Range: Disabled, Open, Closed

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          FORCE Cont Op 1          Range: Disabled, Energized, De-energized, Freeze
■ OUTPUTS                :Disabled

               MESSAGE   FORCE Cont Op 2          Range: Disabled, Energized, De-energized, Freeze
                         :Disabled
                                ↓
               MESSAGE   FORCE Cont Op xx         Range: Disabled, Energized, De-energized, Freeze
                         :Disabled
```

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.

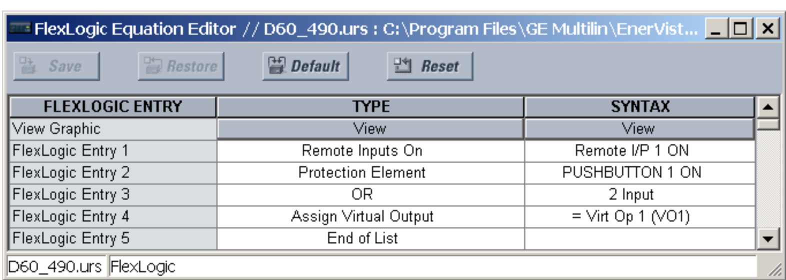
To enable user-programmable pushbutton 1 to initiate the test mode, make the following changes in the **SETTINGS ⇨⇩ TESTING ⇨ TEST MODE** menu: **TEST MODE FUNCTION:** “Enabled” and **TEST MODE INITIATE:** “PUSHBUTTON 1 ON”

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 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	

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”

6.1.1 ACTUAL VALUES MAIN MENU

```
■■ 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.
■ CONTACT OUTPUTS ■	See page 6-4.
■ VIRTUAL OUTPUTS ■	See page 6-4.
■ REMOTE DEVICES ■ STATUS	See page 6-5.
■ REMOTE DEVICES ■ STATISTICS	See page 6-5.
■ DIGITAL COUNTERS ■	See page 6-5.
■ SELECTOR SWITCHES ■	See page 6-6.
■ TIME OF DAY TIMERS ■	See page 6-6.
■ FLEX STATES ■	See page 6-6.
■ ETHERNET ■	See page 6-6.
■ DIRECT INPUTS ■	See page 6-7.
■ DIRECT DEVICES ■ STATUS	See page 6-7.
■ IEC 61850 ■ GOOSE UINTEGERS	See page 6-8.
■ ETHERNET SWITCH ■	See page 6-8.

```
■■ ACTUAL VALUES
■■ METERING
```

■ SOURCE SRC 1 ■	See page 6-12.
■ SOURCE SRC 2 ■	
■ SOURCE SRC 3 ■	
■ SOURCE SRC 4 ■	

Menu	Submenu	Reference
	■ SOURCE SRC 5 ■	
	■ SOURCE SRC 6 ■	
	■ CAPACITOR CONTROL ■	See page 6-16.
	■ CAPACITOR BANK ■	See page 6-17.
	■ TRACKING FREQUENCY ■	See page 6-18.
	■ FLEXELEMENTS ■	See page 6-18.
	■ IEC 61850 ■ GOOSE ANALOGS	See page 6-19.
	■ TRANSDUCER I/O ■ DCMA INPUTS	See page 6-19.
	■ TRANSDUCER I/O ■ RTD INPUTS	See page 6-19.
■■ ACTUAL VALUES ■■ RECORDS	■ USER-PROGRAMMABLE ■ FAULT REPORT	See page 6-20.
	■ EVENT RECORDS ■	See page 6-20.
	■ OSCILLOGRAPHY ■	See page 6-20.
	■ DATA LOGGER ■	See page 6-21.
■■ ACTUAL VALUES ■■ PRODUCT INFO	■ MODEL INFORMATION ■	See page 6-22.
	■ FIRMWARE REVISIONS ■	See page 6-22.

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 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.

6.2.6 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.

6.2.7 REMOTE DEVICES

a) STATUS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE DEVICES STATUS

```
■ REMOTE DEVICES          All REMOTE DEVICES      Range: Yes, No
■ STATUS                  ONLINE: No

              MESSAGE     REMOTE DEVICE  1        Range: Online, Offline
                          STATUS: Offline

              MESSAGE     REMOTE DEVICE  2        Range: Online, Offline
                          STATUS: Offline
                                 ↓
              MESSAGE     REMOTE DEVICE 16        Range: Online, Offline
                          STATUS: 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.

b) STATISTICS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE DEVICES STATISTICS ⇨ REMOTE DEVICE 1(16)

```
■ 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 is incremented whenever a change of state of at least one DNA or UserSt bit occurs. The **SqNum** number is obtained from the indicated remote device and is incremented whenever a GSSE message is sent. This number will rollover to zero when a count of 4 294 967 295 is incremented.

6.2.8 DIGITAL COUNTERS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ DIGITAL COUNTERS ⇨ DIGITAL COUNTERS Counter 1(8)

```
■ DIGITAL COUNTERS        Counter 1      ACCUM:
■ Counter 1                         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.

6.2.9 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.

6.2.10 TIME OF DAY TIMERS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ TIME OF DAY TIMERS

■ TIME OF DAY TIMERS ■	◀▶	TIME OF DAY TIMER 1: Off	Range: On, Off
MESSAGE	▲▼	TIME OF DAY TIMER 2: Off	Range: On, Off
MESSAGE	▲▼	TIME OF DAY TIMER 3: Off	Range: On, Off
MESSAGE	▲▼	TIME OF DAY TIMER 4: Off	Range: On, Off
MESSAGE	▲	TIME OF DAY TIMER 5: Off	Range: On, Off

The current state of each time of day timer is displayed in this menu.

6.2.11 FLEX STATES

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ FLEX STATES

■ 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.

6.2.12 ETHERNET

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ ETHERNET

■ ETHERNET ■	◀▶	ETHERNET PRI LINK STATUS: OK	Range: Fail, OK
MESSAGE	▲	ETHERNET SEC LINK STATUS: OK	Range: Fail, OK

These values indicate the status of the primary and secondary Ethernet links.

6.2.13 DIRECT INPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ DIRECT INPUTS

```
■ DIRECT INPUTS          ◄►   AVG MSG RETURN
■                              TIME CH1:  0 ms

              MESSAGE    ▲▼   UNRETURNED MSG
                               COUNT CH1:  0

              MESSAGE    ▲▼   CRC FAIL COUNT
                               CH1:  0

              MESSAGE    ▲▼   AVG MSG RETURN
                               TIME CH2:  0 ms

              MESSAGE    ▲▼   UNRETURNED MSG
                               COUNT CH2:  0

              MESSAGE    ▲▼   CRC FAIL COUNT
                               CH2:  0

              MESSAGE    ▲▼   DIRECT INPUT  1:
                               On

              MESSAGE    ▲▼   DIRECT INPUT  2:
                               On
                                        ↓
              MESSAGE    ▲    DIRECT INPUT 32:
                               On
```

The **AVERAGE MSG RETURN TIME** is the time taken for direct output messages to return to the sender in a direct input/output ring configuration (this value is not applicable for non-ring configurations). This is a rolling average calculated for the last ten messages. There are two return times for dual-channel communications modules.

The **UNRETURNED MSG COUNT** values (one per communications channel) count the direct output messages that do not make the trip around the communications ring. The **CRC FAIL COUNT** values (one per communications channel) count the direct output messages that have been received but fail the CRC check. High values for either of these counts may indicate on a problem with wiring, the communication channel, or one or more relays. The **UNRETURNED MSG COUNT** and **CRC FAIL COUNT** values can be cleared using the **CLEAR DIRECT I/O COUNTERS** command.

The **DIRECT INPUT 1** to **DIRECT INPUT (32)** values represent the state of each direct input.

6.2.14 DIRECT DEVICES STATUS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ DIRECT DEVICES STATUS

```
■ DIRECT DEVICES         ◄►   DIRECT DEVICE 1        Range:  Offline, Online
■ STATUS                       STATUS: Offline

              MESSAGE    ▲▼   DIRECT DEVICE 2        Range:  Offline, Online
                               STATUS: Offline
                                        ↓
              MESSAGE    ▲    DIRECT DEVICE 16       Range:  Offline, Online
                               STATUS: Offline
```

These actual values represent the state of direct devices 1 through 16.

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6.2.15 IEC 61850 GOOSE INTEGERS

PATH: ACTUAL VALUES ⇨⇩ STATUS ⇨⇩ IEC 61850 GOOSE UINTEGERS

■ IEC 61850 ■ GOOSE UINTEGERS	◀▶	UINT INPUT 1 0	
MESSAGE	▲▼	UINT INPUT 2 0	
		↓	
MESSAGE	▲	UINT INPUT 16 0	

The C70 Capacitor Bank Protection and Control 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 protocol features are not available if CPU type E is ordered.

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.

6.2.16 ETHERNET SWITCH

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ ETHERNET SWITCH

■ ETHERNET SWITCH ■	◀▶	SWITCH 1 PORT STATUS: OK	*Range: FAIL, OK*
MESSAGE	▲▼	SWITCH 2 PORT STATUS: OK	*Range: FAIL, OK*
		↓	
MESSAGE	▲▼	SWITCH 6 PORT STATUS: OK	*Range: FAIL, OK*
MESSAGE	▲	SWITCH MAC ADDRESS: 00A0F40138FA	*Range: standard MAC address format*

These actual values appear only if the C70 is ordered with an Ethernet switch module (type 2S or 2T). The status information for the Ethernet switch is shown in this menu.

- **SWITCH 1 PORT STATUS** to **SWITCH 6 PORT STATUS**: These values represents the receiver status of each port on the Ethernet switch. If the value is “OK”, then data is being received from the remote terminal; If the value is “FAIL”, then data is not being received from the remote terminal or the port is not connected.
- **SWITCH MAC ADDRESS**: This value displays the MAC address assigned to the Ethernet switch module.

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.

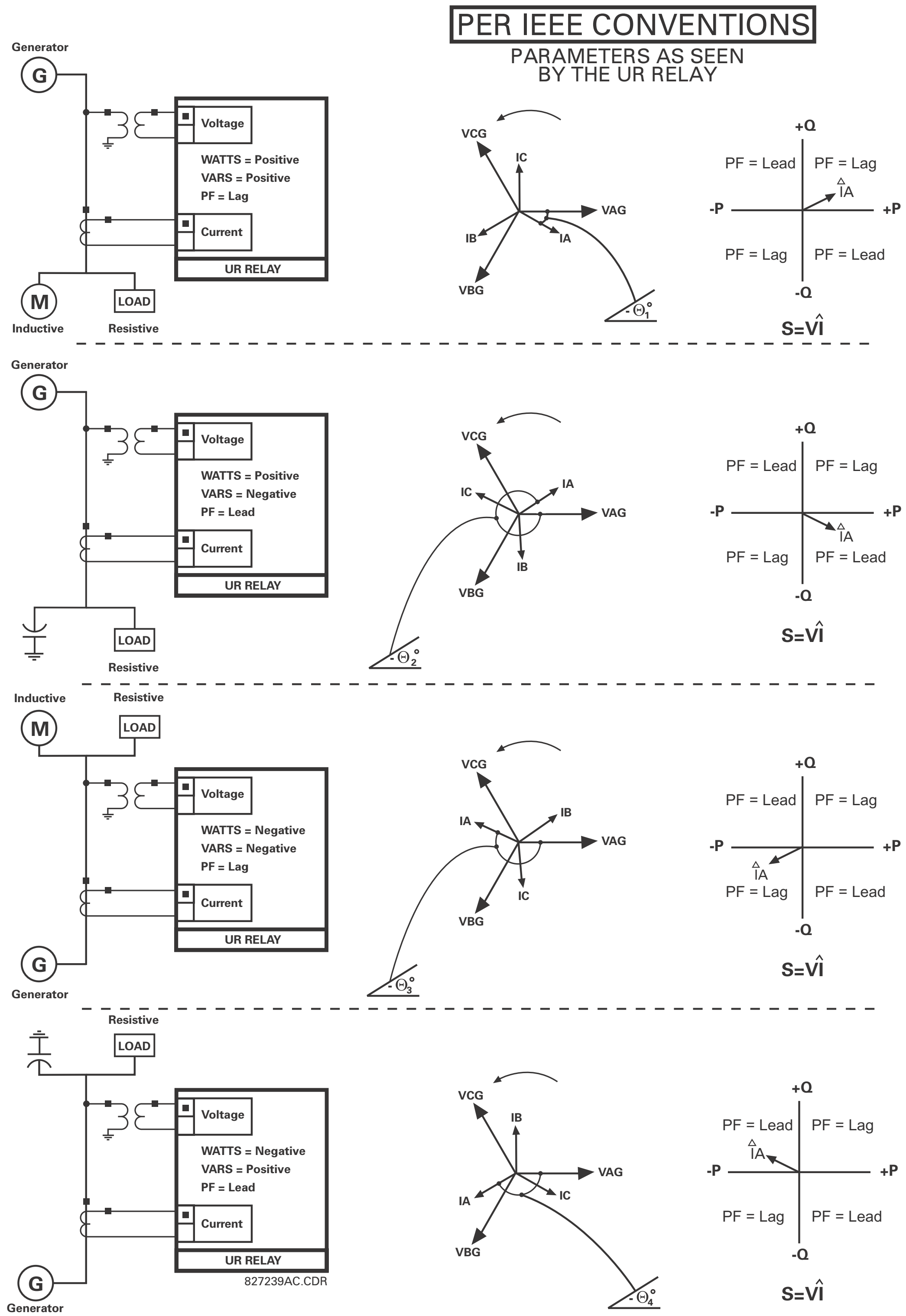

Figure 6–1: FLOW DIRECTION OF SIGNED VALUES FOR WATTS AND VARS

6

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.

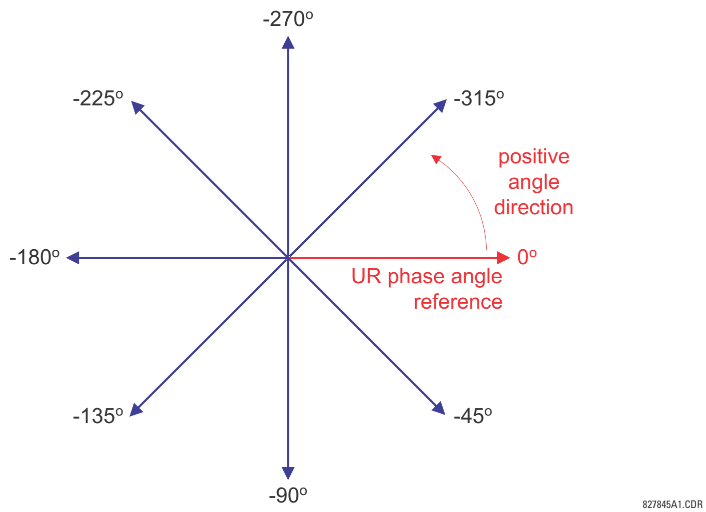

Figure 6–2: UR PHASE ANGLE MEASUREMENT CONVENTION

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 C70 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.

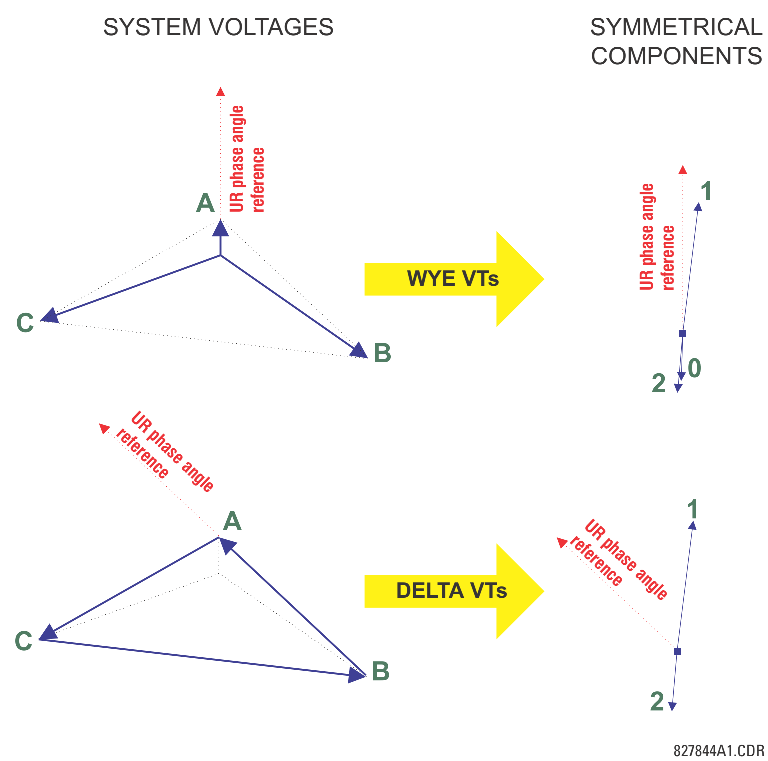

Figure 6–3: MEASUREMENT CONVENTION FOR SYMMETRICAL COMPONENTS

6

6.3.2 SOURCES

a) MAIN MENU

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ SOURCE SRC1

■ SOURCE SRC 1 ■	◀▶	■ PHASE CURRENT ■ SRC 1	See page 6–12.
MESSAGE	▲▼	■ GROUND CURRENT ■ SRC 1	See page 6–13.
MESSAGE	▲▼	■ PHASE VOLTAGE ■ SRC 1	See page 6–13.
MESSAGE	▲▼	■ AUXILIARY VOLTAGE ■ SRC 1	See page 6–14.
MESSAGE	▲▼	■ POWER ■ SRC 1	See page 6–14.
MESSAGE	▲▼	■ FREQUENCY ■ SRC 1	See page 6–15.
MESSAGE	▲▼	■ CURRENT HARMONICS ■ SRC 1	See page 6–15.
MESSAGE	▲	■ VOLTAGE HARMONICS ■ SRC 1	See page 6–16.

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.

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b) PHASE CURRENT METERING

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ SOURCE SRC 1 ⇨ PHASE CURRENT

■ 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
```

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MESSAGE	▲▼	SRC 1 APPARENT PWR φc: 0.000 VA
MESSAGE	▲▼	SRC 1 POWER FACTOR 3φ: 1.000
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	◄►	SRC 1 FREQUENCY: 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.

h) CURRENT HARMONICS AND THD METERING

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ SOURCE SRC 1 ⇨⇩ CURRENT HARMONICS

■ CURRENT HARMONICS ■ SRC 1	◄►	SRC 1 THD Ia: 0.0 Ib: 0.0 Ic: 0.0%
MESSAGE	▲▼	SRC 1 2ND Ia: 0.0 Ib: 0.0 Ic: 0.0%
MESSAGE	▲▼	SRC 1 3RD Ia: 0.0 Ib: 0.0 Ic: 0.0%
		↓
MESSAGE	▲	SRC 1 25TH Ia: 0.0 Ib: 0.0 Ic: 0.0%

The metered current harmonics 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**). Current harmonics are measured for each source for the total harmonic distortion (THD) and 2nd to 25th harmonics per phase.

i) VOLTAGE HARMONICS AND THD METERING

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨ SOURCE SRC 1 ⇨⇩ VOLTAGE HARMONICS

```
■ VOLTAGE HARMONICS          SRC 1   THD Va:  0.0
■ SRC 1                      Vb:  0.0 Vc:  0.0%

                 MESSAGE     SRC 1   2ND Va:  0.0
                             Vb:  0.0 Vc:  0.0%

                 MESSAGE     SRC 1   3RD Va:  0.0
                             Vb:  0.0 Vc:  0.0%
                                     ↓
                 MESSAGE     SRC 1  25TH Va:  0.0
                             Vb:  0.0 Vc:  0.0%
```

The metered current harmonics values are displayed in this menu. The “SRC 1” text will be replaced by the programmed name for the associated source (see the **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES** menu).

To extract the 2nd to 25th voltage harmonics, each harmonic is computed on a per-phase basis, where:

N = 64 is the number of samples per cycle
$\omega_0 = 2\pi f$ is the angular frequency based on the system frequency (50 or 60 Hz)
k = 1, 2,..., N – 1 is the index over one cycle for the Fast Fourier Transform (FFT)
m is the last sample number for the sliding window
h = 1, 2,..., 25 is the harmonic number

The short-time Fourier transform is applied to the unfiltered signal:

$$F_{real}(m, h) = \frac{2}{N}\sum_{k}(f(m-k) \cdot \cos(h \cdot \omega_0 \cdot t(k)))$$
$$F_{imag}(m, h) = \frac{2}{N}\sum_{k}(f(m-k) \cdot \sin(h \cdot \omega_0 \cdot t(k))) \quad \text{(EQ 6.1)}$$
$$F_{ampl}(m, h) = \sqrt{F_{real}(m, h)^2 + F_{imag}(m, h)^2}$$

The harmonics are a percentage of the fundamental signal obtained as a ratio of harmonic amplitude to fundamental amplitude multiplied by 100%. The total harmonic distortion (THD) is the ratio of the total harmonic content to the fundamental:

$$\text{THD} = \sqrt{F_2^2 + F_3^2 + \ldots + F_{25}^2} \quad \text{(EQ 6.2)}$$

NOTE: Voltage harmonics are calculated only for Wye connected phase VTs. Ensure the **SYSTEM SETUP ⇨ AC INPUTS ⇨⇩ VOLTAGE BANK F5 ⇨⇩ PHASE VT XX CONNECTION** setting is “Wye” to enable voltage harmonics metering.

6.3.3 CAPACITOR CONTROL

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ CAPACITOR CONTROL

```
■ CAPACITOR CONTROL          CAP 1 DISCHARGE TIME:
■                            0 s

                 MESSAGE     CAP 2 DISCHARGE TIME:
                             0 s

                 MESSAGE     CAP 3 DISCHARGE TIME:
                             0 s

                 MESSAGE     CAP 4 DISCHARGE TIME:
                             0 s
```

These values indicate the time remaining before the next permissible close operation for each of the four capacitor banks.

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6.3.4 CAPACITOR BANK

a) MAIN MENU

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ CAPACITOR BANK

Menu	Key	Display	Reference
■ CAPACITOR BANK ■	◁▷	■ VOLTAGE ■ DIFFERENTIAL	See page 6-3.
MESSAGE	△▽	■ NEUTRAL VOLTAGE ■ UNBALANCE	See page 6-17.
MESSAGE	△▽	■ PHASE CURRENT ■ UNBALANCE	See page 6-3.
MESSAGE	△	■ NEUTRAL CURRENT ■ UNBALANCE	See page 6-4.

The capacitor bank menu contains the actual values for the voltage differenital, neutral voltage unbalance, phase current unbalance, and neutral current unbalance elements.

b) VOLTAGE DIFFERENTIAL

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ CAPACITOR BANK ⇨ VOLTAGE DIFFERENTIAL ⇨ VOLTAGE DIFFERENTIAL 1(3)

Menu	Key	Display
■ VOLTAGE ■ DIFFERENTIAL 1	◁▷	Bus Va: 0.0000 pu Dif Va: 0.0000 pu
MESSAGE	△▽	Bus Vb: 0.0000 pu Dif Vb: 0.0000 pu
MESSAGE	△	Bus Vc: 0.0000 pu Dif Vc: 0.0000 pu

These actual values display the bus and differential signals in per-unit values of the nominal bus voltage for phases A, B, and C.

c) NEUTRAL VOLTAGE UNBALANCE

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ CAPACITOR BANK ⇨ NEUTRAL VOLTAGE... ⇨ NEUTRAL VOLTAGE UNBALANCE 1(3)

Menu	Key	Display
■ NEUTRAL VOLTAGE ■ UNBALANCE 1	◁▷	NEUTRAL-POINT Vx: 0.0000 pu / 0.0°
MESSAGE	△▽	BUS V0: 0.0000 pu / 0.0°
MESSAGE	△	Vop: 0.0000 pu Vrest: 0.0000 pu

The magnitudes (in pu) and angles of the neutral point and bus V0 voltages for the neutral voltage unbalance elements are displayed in this menu. The magnitudes of the compensating operating voltage and restraining voltage (in pu) are also displayed.

d) PHASE CURRENT UNBALANCE

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ CAPACITOR BANK ⇨ PHASE CURRENT... ⇨ PHASE CURRENT UNBALANCE 1(3)

Menu	Key	Display
■ PHASE CURRENT ■ UNBALANCE 1	◁▷	Raw Id A: 0.0000 pu Cm Iop A: 0.0000 pu
MESSAGE	△▽	Raw Id B: 0.0000 pu Cm Iop B: 0.0000 pu
MESSAGE	△	Raw Id C: 0.0000 pu Cm Iop C: 0.0000 pu

The magnitudes of the raw differential current and compensated operating currents (in per-units of the differential CT) are displayed for each phase.

e) NEUTRAL CURRENT UNBALANCE

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ CAPACITOR BANK ⇨ NEUTRAL CURRENT... ⇨ NEUTRAL CURRENT UNBALANCE 1(3)

```
■ NEUTRAL CURRENT        Raw INsp: 0.0000 pu
■ UNBALANCE 1            Comp Iop: 0.0000 pu
```

The magnitudes of the raw neutral split-phase current and compensated operating current (in per-units of the ground CT input) are displayed in this menu.

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 the selection of the reference source with the **FREQUENCY AND PHASE REFERENCE** setting in the **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ POWER SYSTEM** menu. Refer to the *Power System* section of chapter 5 for additional details.

6.3.6 FLEXELEMENTS™

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ FLEXELEMENTS ⇨ FLEXELEMENT 1(16)

```
■ 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.

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Table 6–2: FLEXELEMENT™ BASE UNITS

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 THD & HARMONICS	BASE = 1%
SOURCE VOLTAGE	V_{BASE} = maximum nominal primary RMS value of 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 C70 Capacitor Bank Protection and Control 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 protocol features are not available if CPU type E is ordered.

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 TRANSDUCER INPUTS/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.

6.4.1 USER-PROGRAMMABLE FAULT REPORTS

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨ USER-PROGRAMMABLE FAULT REPORT

■ USER-PROGRAMMABLE ■ FAULT REPORT	◀▶	NEWEST RECORD NUMBER: 0
MESSAGE	▲▼	LAST CLEARED DATE: 2002/8/11 14:23:57
MESSAGE	▲	LAST REPORT DATE: 2002/10/09 08:25:27

This menu displays the user-programmable fault report actual values. See the *User-Programmable Fault Report* section in chapter 5 for additional information on this feature.

6.4.2 EVENT RECORDS

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*

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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

■ 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

■ 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.

6.5.1 MODEL INFORMATION

PATH: ACTUAL VALUES ⇨⇩ PRODUCT INFO ⇨ MODEL INFORMATION

■ MODEL INFORMATION ■	◁▷	ORDER CODE LINE 1: C60-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	▲▼	CT/ VT ADVANCED DIAG ACTIVE: No	Range: Yes, No
MESSAGE	▲▼	OPERATING TIME: 0:00:00	Range: opearting 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

■ FIRMWARE REVISIONS ■	◁▷	C60 Breaker Relay REVISION: 5.9x	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  ▼  ■■ CAPACITOR BANK
            ■■ AUTO SETTING
MESSAGE  ▼  ■■ COMMANDS
            ■■ VIRTUAL INPUTS
MESSAGE  ▲▼ ■■ COMMANDS
            ■■ CLEAR RECORDS
MESSAGE  ▲▼ ■■ COMMANDS
            ■■ SET DATE AND TIME
MESSAGE  ▲  ■■ COMMANDS
            ■■ RELAY MAINTENANCE
```

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 CAPACITOR BANK AUTOMATIC SETTINGS

a) MAIN MENU

PATH: COMMANDS ⇨ CAPACITOR BANK AUTO SETTING

```
■■ CAPACITOR BANK   ◄►  ■ VOLTAGE               See page 7-2.
■■ AUTO SETTING         ■ DIFFERENTIAL
              MESSAGE ▲▼ ■ NEUTRAL VOLTAGE       See page 7-3.
                         ■ UNBALANCE
              MESSAGE ▲▼ ■ PHASE CURRENT         See page 7-4.
                         ■ UNBALANCE
              MESSAGE ▲  ■ NEUTRAL CURRENT       See page 7-5.
                         ■ UNBALANCE
```

The relay provides for automatic calculations of proper balancing (matching) factors of the sensitive capacitor bank protection functions. The following screens display the suggested values of the balancing factors, and prompt the user to apply them if desired so. If applied from this command level, a given value is placed into the setting file and applied instantaneously in all setting groups of the relay with the same source as the active group during the auto-setting procedure.

b) VOLTAGE DIFFERENTIAL

PATH: COMMANDS ⇨ CAPACITOR BANK AUTO SETTING ⇨ VOLTAGE DIFFERENTIAL ⇨ VOLTAGE DIFFERENTIAL 1(3)

■ VOLTAGE ■ DIFFERENTIAL 1	◄►	VOLTAGE DIF 1 AUTO SETTING: Disabled	Range: Disabled, Manual, Auto
MESSAGE	▲▼	V DIF 1A k=####.#### APPLY IN PHS A? No	Range: Yes, No
MESSAGE	▲▼	V DIF 1A k=####.#### APPLY IN PHS B? No	Range: Yes, No
MESSAGE	▲	V DIF 1A k=####.#### APPLY IN PHS C? No	Range: Yes, No

The automatic setting feature shall be used when the capacitor bank is on-line and the 87V function is enabled. For security reasons one may consider applying less sensitive settings during the auto-setting process. Switching temporarily to a different setting group with less sensitive pickup thresholds is a way to provide for the extra security.

The feature can be used with a manual acceptance of the auto-calculated coefficients (the **VOLTAGE DIF 1 AUTO SETTING** command switched to "Manual"), or with an automatic acceptance of the calculated factors (the **VOLTAGE DIF 1 AUTO SETTING** command switched to "Auto").

The feature is used as follows.

Application with Manual Supervision of the Automatically Calculated Factors:

When the **VOLTAGE DIF 1 AUTO SETTING** command is switched to "Manual", the auto-setting screens, one for each phase, display the values that balance best the function in a given phase and prompt for permission to apply the calculated value as a new setting. When confirmed, the auto-selected value gets applied to all setting groups configured with the same source as the active group during the auto-setting procedure.

After consent to apply the calculated coefficient is received, the **k =?.???? APPLIED** confirmation message is displayed for the duration of the flash message time in the second line of the screen. The time-out period is provided for the field staff to make a note of the newly applied coefficient. However, it is possible to navigate from this screen immediately. The new setting values can be viewed under the setting menu at any time.

After the process if finished, it is recommended to disable the auto-setting feature. If not disabled by the user, the feature disables itself when user-initiated front panel interface activity ceases and the C70 display dims itself.

Certain security conditions are checked during the auto-setting process. This includes deviation from the nominal frequency and verifying that the magnitudes of all three bus voltages are between 0.85 and 1.15 pu. If these conditions are violated. the **SUPV FAIL** message is displayed in the second line.

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If the voltage differential function is disabled or blocked, then the auto-setting process is not functional and the **87V NOT RUNNING** message is displayed in the second line.

Application with Automatic Supervision of the Automatically Calculated Factors:

When the **VOLTAGE DIF 1 AUTO SETTING** command is switched to "Auto", the process of calculating and applying the balancing coefficients is fully automatic. Typical applications require setting this function to "Auto" with the bank de-energized, then energizing the capacitor bank. When the bank is energized and the five-cycle timer of the 87V function expires, the balancing coefficients are calculated and automatically applied. After the new balancing factors are applied, the function switches automatically from "Auto" to "Disabled" and 87V becomes operational. In essence, when in the "Auto" mode, the user confirmation is processed immediately after the balancing values become available. The C70 does not display the applied coefficients in "Auto" mode; rather, they are be viewed under in the **SETTINGS** menu.

If the supervisory conditions are not satisfied in the "Auto" mode within the time specified by the **DEFAULT MESSAGE TIMEOUT** setting, the **AUTO FAIL** message is displayed and the 87V function starts running with the pre-existing settings for the balancing factors.

The advantage of automatically calculating factors is that the bank is immediately protected after energization. However, due to energization inrush and distortion of voltages, the factors may not be accurate enough for the most sensitive stages. Therefore, it is a good practice to block the most sensitive stages on energization, manually adjust the factors to reduce the differential signal, and then enable the most sensitive stages.

c) NEUTRAL VOLTAGE UNBALANCE

PATH: COMMANDS ⇨ CAPACITOR BANK AUTO... ⇨ NEUTRAL VOLTAGE UNBALANCE ⇨ NEUTRAL VOLTAGE UNBALANCE 1(3)

■ NEUTRAL VOLTAGE ■ UNBALANCE 1	◀▶	NTRL VOL UNBAL 1 AUTO SET: Disabled	Range: Disabled, Manual, Auto
MESSAGE	▲▼	XA/XB RATIO k=0.0000 APPLY? No	Range: Yes, No
MESSAGE	▲	XA/XC RATIO k=0.0000 APPLY? No	Range: Yes, No

The auto-setting feature shall be used when the capacitor bank is on-line and the 59NU function is enabled. For security reasons, it may be necessary to consider applying less sensitive settings during the auto-setting process. Switching temporarily to a different setting group with less sensitive pickup thresholds is a method to provide for this extra security.

This feature can be used with a manual acceptance of the auto-calculated coefficients (the **NTRL VOL UNBAL 1 AUTO SET** command switched to “Manual”), or with an automatic acceptance of the calculated factors (the **NTRL VOL UNBAL 1 AUTO SET** command switched to “Auto”).

The feature is used as follows.

MANUAL SUPERVISION OF AUTOMATICALLY CALCULATED FACTORS:

When the **NTRL VOL UNBAL 1 AUTO SET** command is switched to “Manual”, the auto-setting screens (one for each of the two factors) display values that best balance the function and prompt for permission to apply the calculated value as a new setting. When confirmed, the auto-selected value is applied to all setting groups having same source as the active group during auto-setting procedure. Both ratios (X_A / X_B and X_A / X_C) must be set correctly to clear the inherent bank unbalance. After consent to apply the calculated coefficient is received via the keypad, the **k =?.???? APPLIED** confirmation message is displayed for the duration of the flash message time. The time-out period is intended for field staff to make a note of the newly applied coefficient. However, it is possible to immediately navigate from this screen. The new setting values can be viewed in the **SETTING** menu at any time.

After the process if finished, it is recommended to disable the auto-setting feature. If not manually disabled, the feature automatically disables itself when user-initiated front panel interface activity ceases and the C70 display is dimmed.

Certain security conditions are checked during the auto-setting process, such as the deviation from the nominal frequency and the magnitude of the phase voltages within 0.85 pu and 1.15 pu. If any of these conditions are violated, the **SUPV FAIL** message is displayed in the second line.

If the neutral voltage unbalance function is disabled or blocked, the auto-setting process is not functional and the **59NU NOT RUNNING** message is displayed in the second line.

AUTOMATIC SUPERVISION OF AUTOMATICALLY CALCULATED FACTORS:

When the **NTRL VOL UNBAL 1 AUTO SET** command is switched to “Auto”, the process of calculating and applying the balancing coefficients is fully automatic. Typical applications require setting this function to “Auto” with the bank de-energized, then energizing the capacitor bank. After the function is set to “Auto”, it expects to read valid input signals as a result of bank energization within the display flash message time duration to calculate and apply factors; otherwise, the function is returned to “Disabled”. When the bank is energized and the five-cycle timer of the 59NU function expires, the balancing coefficients are calculated and automatically applied. When the new balancing factors are applied, the function switches automatically from “Auto” to “Disabled” and the 59NU function becomes operational. In essence, the when in the “Auto” mode, the confirmation command is automatically executed immediately after the balancing values are available. The C70 does not display the applied coefficients in the “Auto” mode; rather, they are be viewed in the **SETTINGS** menu.

When the supervisory conditions are not satisfied in “Auto” mode, the **AUTO FAIL** message is displayed and the 59NU function starts running with the pre-existing settings for the balancing factors.

d) PHASE CURRENT UNBALANCE

PATH: COMMANDS ⇨ CAPACITOR BANK AUTO SETTINGS ⇨ PHASE CURRENT UNBALANCE ⇨ PHASE CURRENT UNBALANCE 1(3)

■ PHASE CURRENT ■ UNBALANCE 1	◀▶	CUR UNBALACE 1 AUTO SETTINGS: Disabled	*Range: Disabled, Manual, Auto*
MESSAGE	▲▼	CUR UNB 1A k=0.0000 APPLY IN PHS A? No	*Range: Yes, No*
MESSAGE	▲▼	CUR UNB 1A k=0.0000 APPLY IN PHS B? No	*Range: Yes, No*
MESSAGE	▲	CUR UNB 1A k=0.0000 APPLY IN PHS C? No	*Range: Yes, No*

The auto-setting feature shall be used when the capacitor bank is on-line and the 60P function is enabled. For security reasons, it may be necessary to apply less sensitive settings during the auto-setting process. Switching temporarily to an alternate setting group with less sensitive pickup thresholds is a method to provide for this extra security.

The feature can be used with by manual accepting the auto-calculated coefficients (the **CUR UNBALACE 1 AUTO SETTINGS** command switched to "Manual") or by automatic acceptance of the calculated factors (the **CUR UNBALACE 1 AUTO SETTINGS** command switched to "Auto").

The feature is used as follows.

Application with Manual Supervision of the Automatically Calculated Factors:

When the **CUR UNBALACE 1 AUTO SETTINGS** command is switched to "Manual", the auto-setting screens (one for each phase) display values that best balance the function in a given phase and prompt for permission to apply the calculated value as a new setting. When confirmed, the auto-selected value is applied to all setting groups having same source as active group during the auto-setting procedure. Note that the balancing factors can be either positive or negative, depending on which of the two banks has a lower impedance, and on the polarity of the differential CTs connected to the relay.

After user consent to apply the calculated coefficient is received, the **k =?.???? APPLIED** confirmation message is displayed for the duration of the flash message time. The timeout period is meant for field staff to make a note of the newly applied coefficient. However, it is possible to immediately navigate from this screen. The new setting values can be viewed in the **SETTING** menu at any time.

After the process is finished, it is recommended to disable the auto-setting feature. If not disabled, the feature automatically disables itself when user-initiated front panel interface activity ceases and the C70 display is dimmed.

Certain security conditions are checked during the auto-setting process, such as frequency deviation from the nominal and the magnitude of the phase currents above 0.25 pu. If any of these conditions are violated, the **SUPV FAIL** message is displayed in the second line.

If the phase unbalance function is disabled or blocked, the auto-setting process is not functional and the **60P NOT RUNNING** message is displayed in the second line.

Application with Automatic Supervision of the Automatically Calculated Factors:

When the **CUR UNBALACE 1 AUTO SETTINGS** command is switched to "Manual", the process of calculating and applying the balancing coefficients is fully automatic. Typical applications require setting this function to "Auto" with the bank de-energized, then subsequently energizing the capacitor bank. If the function is set to "Auto", it expects to read valid input signals as a result of bank energization within the flash message duration time to calculate and apply factors. Otherwise, the value is switched backed to "Disabled". When the bank is energized and the five-cycle timer of the 60P function expires, the balancing coefficients are calculated and automatically applied. After the new balancing factors are applied, the auto-setting function switches "Auto" to "Disabled" and the 60P element becomes operational. When in the "Auto" mode, the automatic confirmation command is executed immediately after the balancing values are available. The C70 does not display the applied coefficients in "Auto" mode; rather, they can be viewed in the **SETTINGS** menu.

If the supervisory conditions are not satisfied in the "Auto" mode within time defined by the **DEFAULT MESSAGE TIMEOUT** setting, the **AUTO FAIL** message is displayed and the 60P function starts running with the pre-existing settings for the balancing factors.

e) NEUTRAL CURRENT UNBALANCE

PATH: COMMANDS ⇨ CAPACITOR BANK AUTO... ⇨ NEUTRAL CURRENT UNBALANCE ⇨ NEUTRAL CURRENT UNBALANCE 1(3)

```
■ NEUTRAL CURRENT        NTRL CUR UNBALACE 1        Range: Disabled, Manual, Auto
■ UNBALANCE 1            AUTO-SET: Disabled

               MESSAGE   NTRL CUR 1 k=0.0000        Range: Yes, No
                         APPLY MAGNITUDE? No

               MESSAGE   NTRL CUR 1 k=0°            Range: Yes, No
                         APPLY ANGLE? No
```

The auto-setting feature shall be used when the capacitor bank is online and the 60N function is enabled. For security reasons, it may be necessary to apply less sensitive settings during the auto-setting process. Temporarily switching to an alternate setting group with less sensitive pickup thresholds is a method of providing for this extra security.

The feature can be used with manual acceptance of the auto-calculated coefficients (the **NTRL CUR UNBALACE 1 AUTO-SET** command switched to "Manual"), or with automatic acceptance of the calculated factors (the **NTRL CUR UNBALACE 1 AUTO-SET** command switched to "Auto").

The feature is used as follows.

Application with Manual Supervision of the Automatically Calculated Factors

When the **NTRL CUR UNBALACE 1 AUTO-SET** command is switched to "Manual", the auto-setting screens (one for magnitude and one for angle of the compensating factor) display the values that best balance the function and prompt for permission to apply the calculated value as a new setting. When confirmed, the auto-selected value is applied to all setting groups.

After user consent to apply the calculated coefficient is received, the **k =?.???? APPLIED** confirmation message is displayed for the duration of the flash message time. The timeout period is intended for field staff to make a note of the newly applied coefficient. However, it is possible to immediately navigate from this screen. The new setting values can be viewed in the **SETTING** menu at any time.

After the process if finished, it is recommended to disable the auto-setting feature. If not disabled by the user, the feature is automatically disabled when user-initiated front panel interface activity ceases and the C70 display is dimmed.

Certain security conditions are checked during the auto-setting process. If these conditions are violated, the **SUPV FAIL** message is displayed in the second line.

If the neutral voltage unbalance function is disabled or blocked, the auto-setting process is not functional and the **60N NOT RUNNING** message is displayed in the second line.

Application with Automatic Supervision of the Automatically Calculated Factors

When the **NTRL CUR UNBALACE 1 AUTO-SET** command is switched to "Auto", the process of calculating and applying the balancing coefficients is fully automatic. Typical applications require setting this function to "Auto" with the bank de-energized, then subsequently energizing the capacitor bank. After the function is set to "Auto", it expects to read valid input signals as a result of bank energization within the display flash message time duration to calculate and apply factors. Otherwise, the function is switched backed to "Disabled". When the bank is energized and the five-cycle timer of the 60N function expires, the balancing coefficients are calculated and automatically applied. After the new balancing factors are applied, the auto-setting function switches automatically from "Auto" to "Disabled", and the 60N element becomes operational. In essence, the when in the "Auto" mode, the confirmation command is automatically executed immediately after the balancing values become available. The C70 does not display the applied coefficients in the "Auto" mode; instead, they may be viewed in the **SETTINGS** menu.

If the supervisory conditions are not satisfied in the "Auto" mode within time defined by the **DEFAULT MESSAGE TIMEOUT** setting, the **AUTO FAIL** message is displayed and the 60N function starts running with the pre-existing settings for the balancing factors.

7.1.3 VIRTUAL INPUTS

PATH: COMMANDS ⇨ VIRTUAL INPUTS

Menu		Display	Range
■■ COMMANDS ■■ VIRTUAL INPUTS	◀▶	Virt Ip 1 Off	*Range: Off, On*
	▲▼	Virt Ip 2 Off	*Range: Off, On*
		↓	
MESSAGE	▲	Virt Ip 64 Off	*Range: Off, On*

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).

7.1.4 CLEAR RECORDS

PATH: COMMANDS ⇨⇩ CLEAR RECORDS

Menu		Display	Range
■■ COMMANDS ■■ CLEAR RECORDS	◀▶	CLEAR USER 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 UNAUTHORIZED ACCESS? No	*Range: No, Yes*
	▲▼	CLEAR DIRECT I/O COUNTERS? No	*Range: No, Yes. Valid only for units with Direct Input/ Output module.*
	▲	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”.

7.1.5 SET DATE AND TIME

PATH: COMMANDS ⇨⇩ SET DATE AND TIME

Menu		Display	Format
■■ 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 only if the IRIG-B or SNTP signal is not in use. 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 will take effect at the moment the ENTER key is clicked.

7.1.6 RELAY MAINTENANCE

PATH: COMMANDS ⇨⇩ RELAY MAINTENANCE

```
■■ COMMANDS
■■ RELAY MAINTENANCE
```

Display	Range
PERFORM LAMPTEST? No	*Range: No, Yes*
UPDATE ORDER CODE? 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 C70 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 C70 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 C70 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.

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 listed and described below.

```
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 C70 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 C70.
- *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 C70 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".

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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 C70 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 C70. The EnerVista UR Setup software will list the valid items. An IEC61850 client will also show which nodes are available for the C70.

```
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 C70 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 C70. The EnerVista UR Setup software will list the valid items. An IEC61850 client will also show which nodes are available for the C70.

```
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 is displayed after 60 seconds if the problem persists.
- *What to do*: Replace the battery located in the power supply module (1H or 1L).

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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 MODULE OFFLINE
```

- *Latched target message*: No.
- *Description of problem*: The C70 has failed to detect the Ethernet switch.
- *How often the test is performed*: Monitored every five seconds. An error is issued after five consecutive failures.
- *What to do*: Check the C70 device and switch IP configuration settings. Check for incorrect UR port (port 7) settings on the Ethernet switch. Check the power to the switch.

```
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:
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 C70 from service and install in a location that meets operating temperature standards.

```
UNEXPECTED RESTART:
Press “RESET” key
```

- *Latched target message*: Yes.
- *Description of problem*: Abnormal restart from modules being removed or inserted while the C70 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.

8.1.1 OVERVIEW

Two levels of password security are provided via the **ACCESS LEVEL** setting: command and setting. The factory service level is not available and intended for factory use only.

The following operations are under command password supervision:

- Changing the state of virtual inputs.
- Clearing the event records.
- Clearing the oscillography records.
- Changing the date and time.
- 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.

The C70 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 C70, 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.

The appropriate events are also logged in the Event Recorder as well. The FlexLogic™ operands and events are updated every five seconds.

NOTE

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

8.1.2 PASSWORD SECURITY MENU

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ SECURITY

		Display	Range / Reference
■ SECURITY ■	◄►	ACCESS LEVEL: Restricted	Range: Restricted, Command, Setting, Factory Service (for factory use only)
MESSAGE	▲▼	■ CHANGE LOCAL ■ PASSWORDS	See page 8–2.
MESSAGE	▲▼	■ ACCESS ■ SUPERVISION	See page 8–3.
MESSAGE	▲▼	■ DUAL PERMISSION ■ SECURITY ACCESS	See page 8–4.
MESSAGE	▲	PASSWORD ACCESS EVENTS: Disabled	Range: Disabled, Enabled

8.1.3 LOCAL PASSWORDS

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

		Display	Range
■ 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. A password consists of 1 to 10 numerical characters. 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.

If an entered password is lost (or forgotten), consult the factory with the corresponding **ENCRYPTED PASSWORD**.

NOTE

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

8

8.1.4 REMOTE PASSWORDS

The remote password settings are only visible from a remote connection via the EnerVista UR Setup software. Select the **Settings > Product Setup > Password Security** menu item to open the remote password settings window.

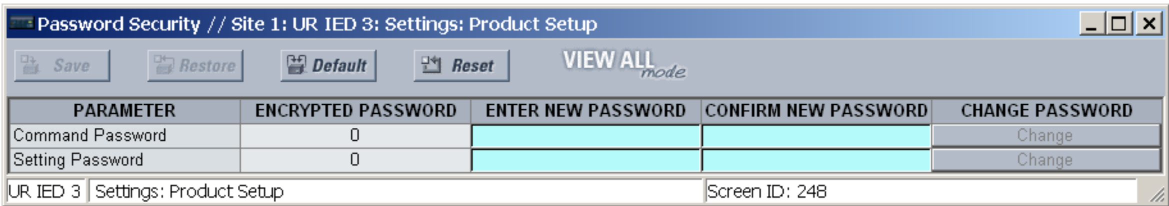
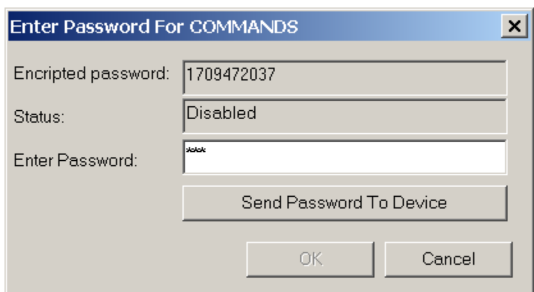


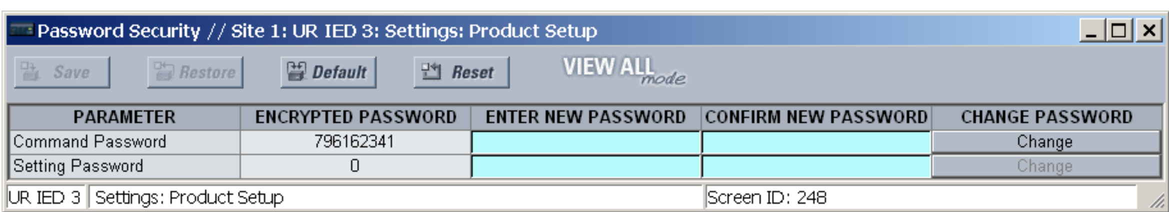
Figure 8–1: REMOTE PASSWORD SETTINGS WINDOW

Proper passwords are required to enable each command or setting level access. A command or setting password consists of 1 to 10 numerical characters and are initially programmed to “0”. The following procedure describes how the set the command or setting password.

1. Enter the new password in the **Enter New Password** field.
2. Re-enter the password in the **Confirm New Password** field.
3. Click the **Change** button. This button will not be active until the new password matches the confirmation password.
4. If the original password is not “0”, then enter the original password in the **Enter Password** field and click the **Send Password to Device** button.



5. The new password is accepted and a value is assigned to the ENCRYPTED PASSWORD item.



If a command or setting password is lost (or forgotten), consult the factory with the corresponding **Encrypted Password** value.

8.1.5 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 C70 will lockout password access after the number of invalid password entries specified by the **INVALID ATTEMPS BEFORE LOCKOUT** setting has occurred.

The C70 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.

If events or targets are required, the UNAUTHORIZED ACCESS operand can be assigned to a digital element programmed with event logs or targets enabled.

The 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.

8.1.6 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.

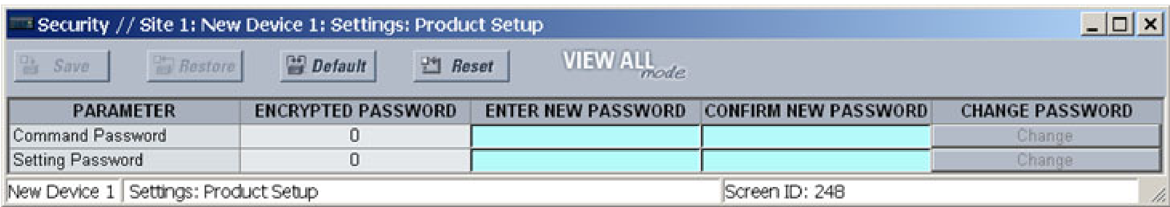
If setting access is *not* authorized for local operation (front panel or RS232 interface) and the user attempts to obtain setting access, then the **UNAUTHORIZED ACCESS** message is displayed on the front panel.

- **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.

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 Authorization** 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.

The **Access Authorization Timeout** setting represents the timeout delay remote setting access. This setting is applicable when the **Remote Settings Authorization** 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 Authorization 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.

8.2.1 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 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 will be settings such as protection element pickup values and CT and VT ratios.

The settings template mode allows the user to define which settings will be 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.

NOTE: The settings template feature requires that *both* the EnerVista UR Setup software and the C70 firmware are at versions 5.40 or higher.

a) ENABLING THE SETTINGS TEMPLATE

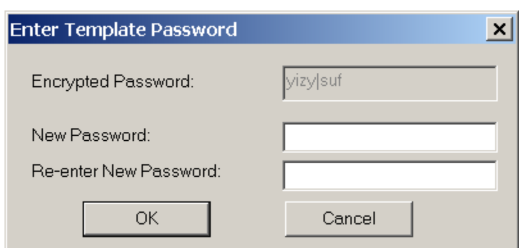
The settings file template feature is disabled by default. The following procedure describes how to enable the settings template for UR-series settings files.

1. Select a settings file from the offline window of the EnerVista UR Setup main screen.
2. Right-click on 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 on the selected device and select the **Template Mode > Create Template** option.



The software will prompt 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 will also indicate that EnerVista UR Setup is in **EDIT mode**. The following example shows the phase time overcurrent settings window in edit mode.

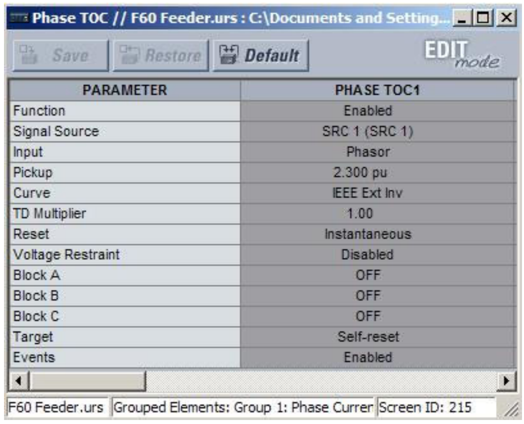


Figure 8–2: SETTINGS TEMPLATE VIEW, ALL SETTINGS SPECIFIED AS LOCKED

5. Specify which settings to make viewable by clicking on them.

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

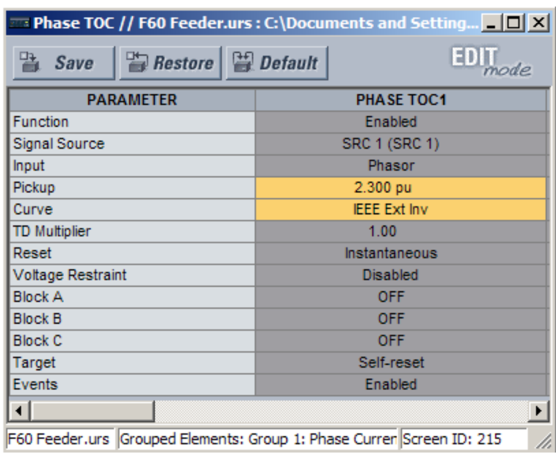


Figure 8–3: SETTINGS TEMPLATE VIEW, TWO SETTINGS SPECIFIED AS EDITABLE

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

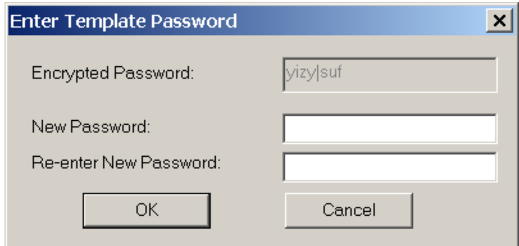
c) ADDING PASSWORD PROTECTION TO A TEMPLATE

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 will prompt 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

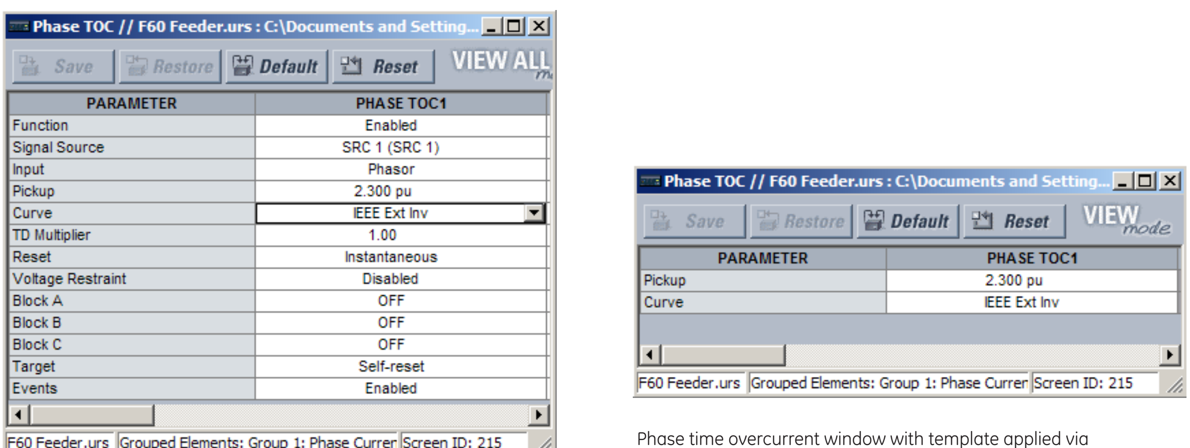
Once all necessary settings are specified for viewing, users are able to view the settings template on the online device or settings file. There are two ways to specify the settings view with the settings template feature:

- 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 will only be able 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.



Phase time overcurrent settings window without template applied.

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

842858A1.CDR

Figure 8–4: 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.

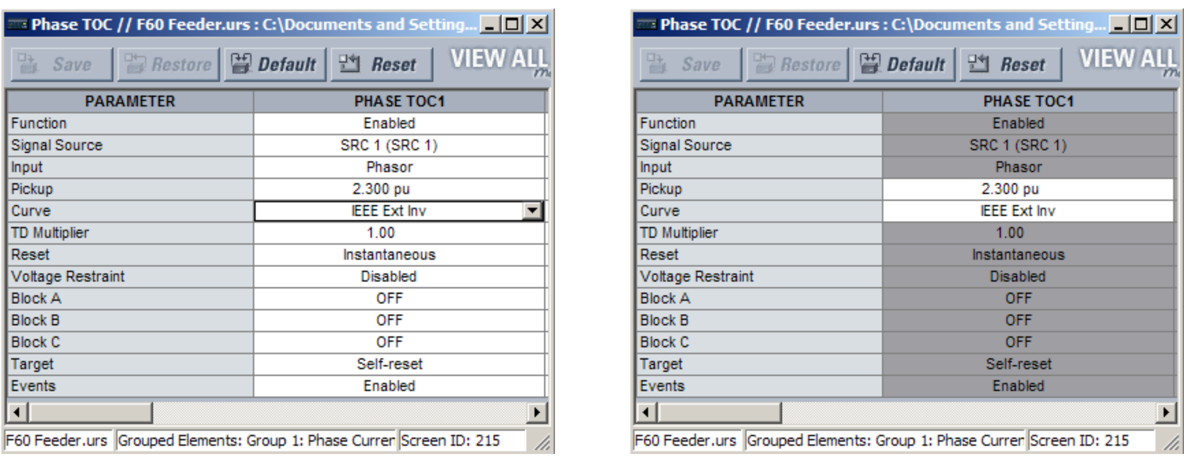
842860A1.CDR

Figure 8–5: 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 will only be able to edit the settings specified by the template, but all settings will be 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

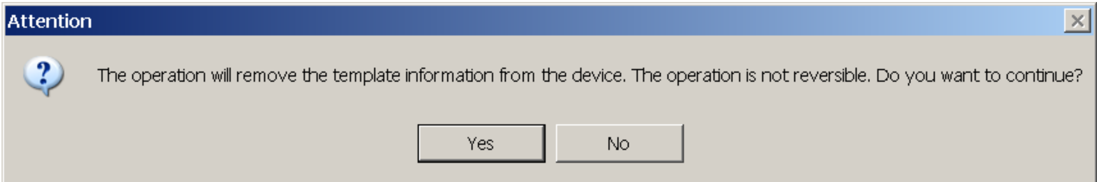
Figure 8–6: APPLYING TEMPLATES VIA THE VIEW ALL SETTINGS COMMAND

e) REMOVING THE SETTINGS TEMPLATE

It may be necessary at some point to remove a settings template. Once a template is removed, it cannot be reapplied and it will be 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. Verify one more time that you wish to remove the template by clicking **Yes**.



The EnerVista software will remove all template information and all settings will be available.

8.2.2 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 will remain secure when files are sent to and retrieved from any UR-series device.

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 will also indicate that EnerVista UR Setup is in **EDIT mode**.
3. Specify which entries to lock by clicking on them.

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

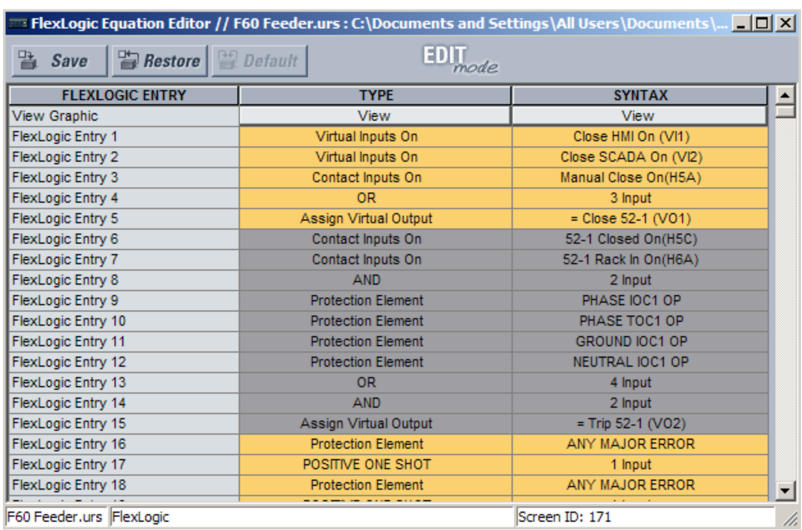
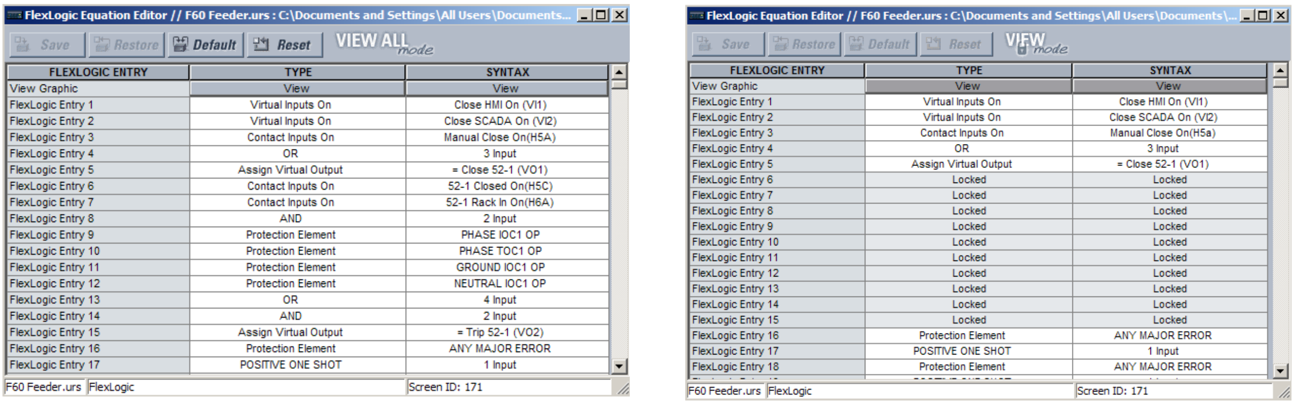


Figure 8–7: LOCKING FLEXLOGIC™ ENTRIES IN EDIT MODE

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 will only be able 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.

842861A1.CDR

Figure 8–8: 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.

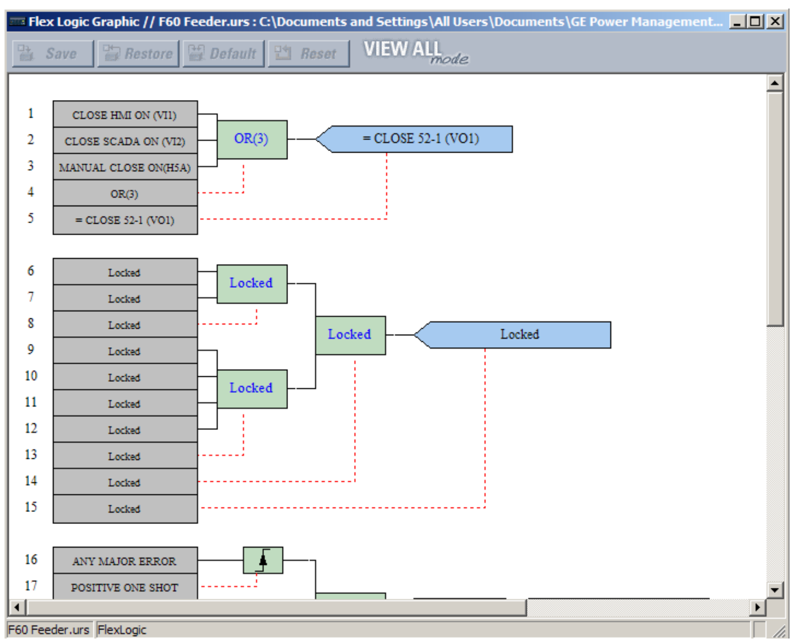


Figure 8–9: SECURED FLEXLOGIC™ IN GRAPHICAL VIEW

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.

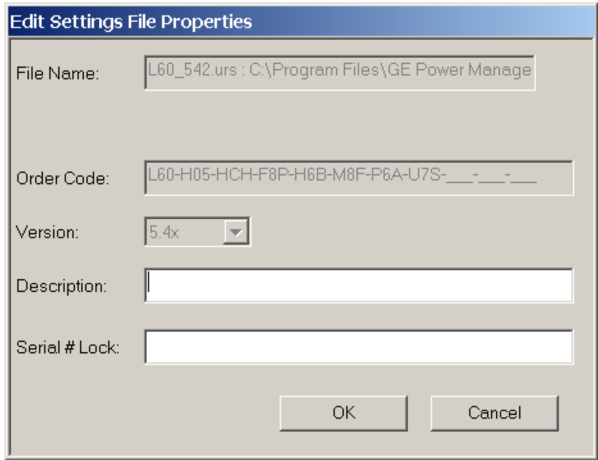


Figure 8–10: TYPICAL SETTINGS FILE PROPERTIES WINDOW

3. Enter the serial number of the C70 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 C70 device specified by the serial number.

8.2.3 SETTINGS FILE TRACEABILITY

A traceability feature for settings files allows the user to quickly determine if the settings in a C70 device have been changed since the time of installation from a settings file. When a settings file is transfered to a C70 device, the date, time, and serial number of the C70 are sent back to EnerVista UR Setup and added to the settings file on the local PC. This information can be compared with the C70 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 C70 device or obtained from the C70 device. Any partial settings transfers by way of drag and drop do not add the traceability information to the settings file.

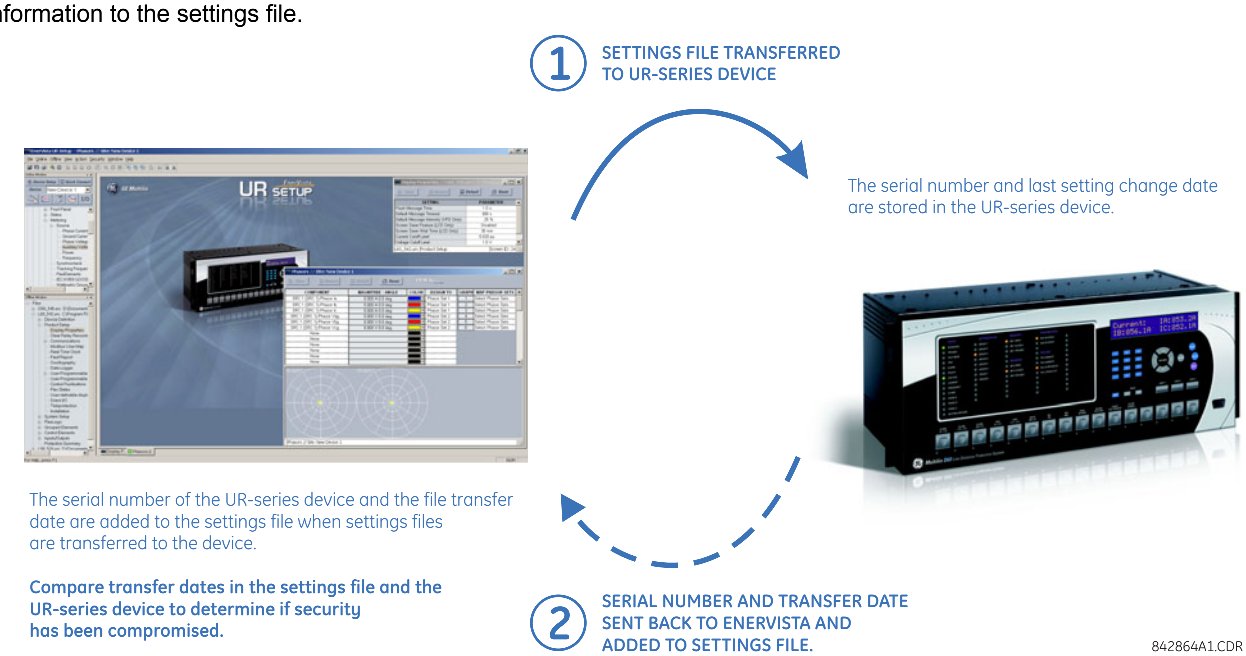


Figure 8–11: SETTINGS FILE TRACEABILITY MECHANISM

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

8

1. The transfer date of a setting file written to a C70 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 will indicate 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 sent to an C70 device.

The C70 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.

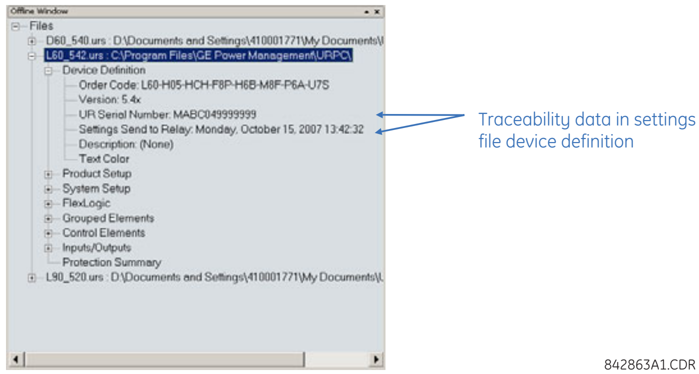


Figure 8–12: DEVICE DEFINITION SHOWING TRACEABILITY DATA

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

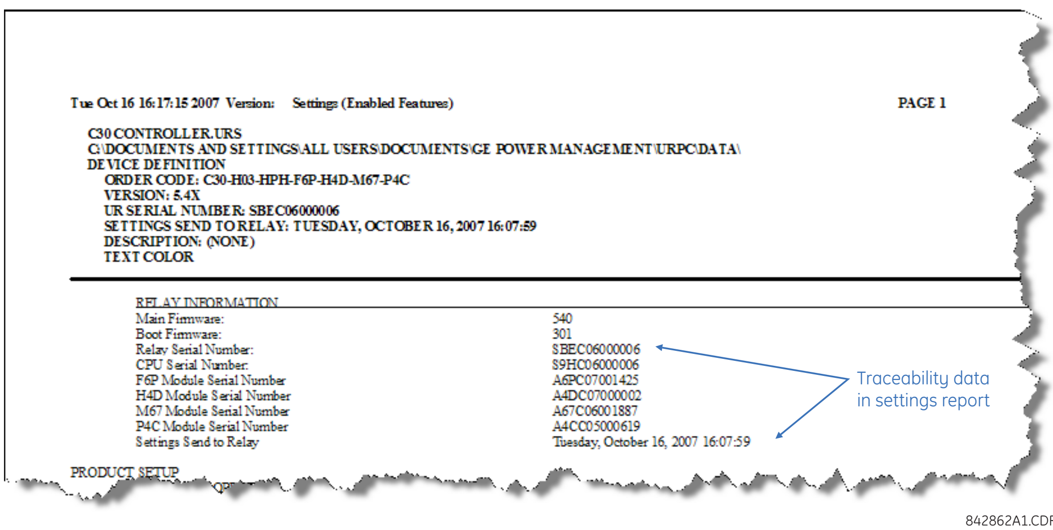


Figure 8–13: SETTINGS FILE REPORT SHOWING TRACEABILITY DATA

b) ONLINE DEVICE TRACEABILITY INFORMATION

The C70 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.

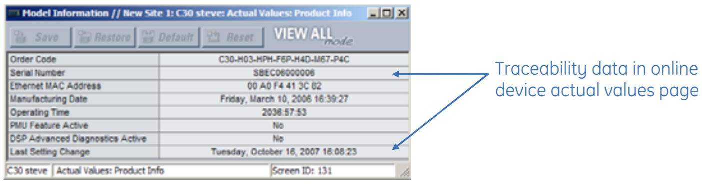


Figure 8–14: TRACEABILITY DATA IN ACTUAL VALUES WINDOW

This infomormation if 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.

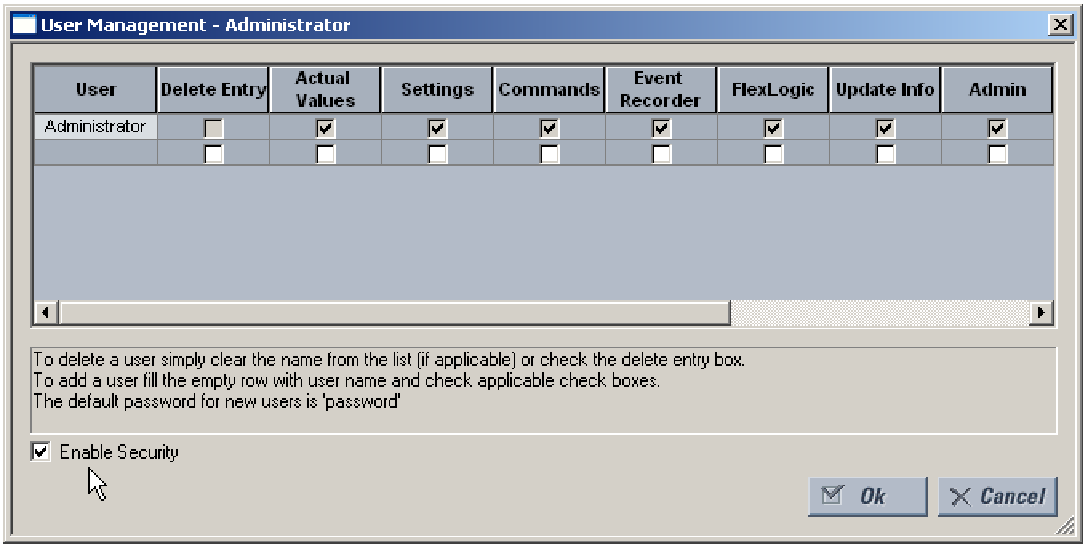
8.3.1 OVERVIEW

The EnerVista security management system is a role-based access control (RBAC) system that allows a security administrator to easily manage the security privileges of multiple users. This allows for access control of URPlus-series 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.

8.3.2 ENABLING THE SECURITY MANAGEMENT SYSTEM

The EnerVista security management system is disabled by default. This allows access to the device immediately after installation. When security is disabled, all users are granted administrator access.

1. Select the **Security > User Management** menu item to open the user management configuration 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. It will now be necessary to enter a username and password upon starting the software.

8.3.3 ADDING A NEW USER

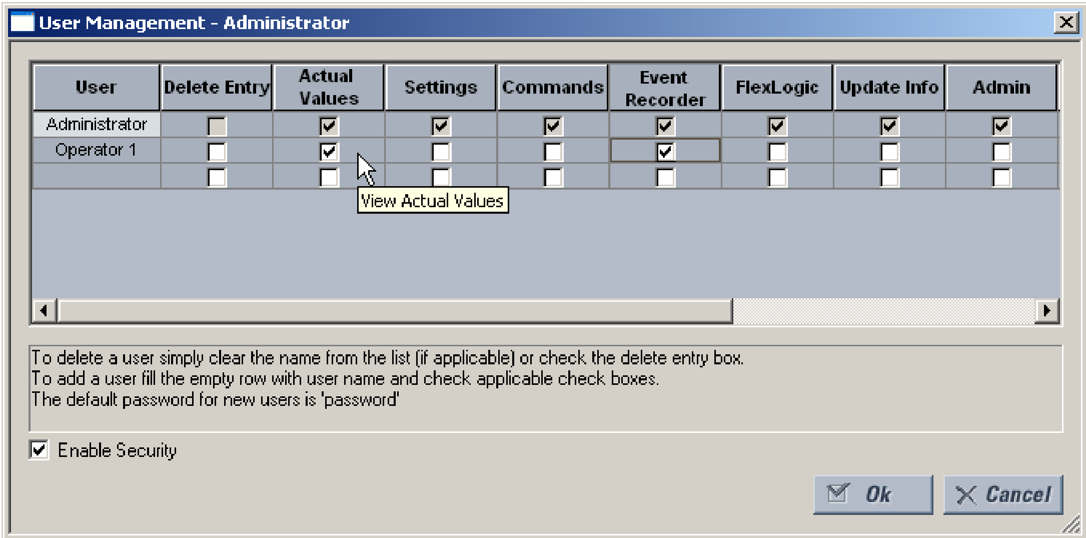
The following pre-requisites are required to add new users to the EnerVista security management system.

- The user adding the new user must have administrator rights.
- The EnerVista security management system must be enabled.

The following procedure describes how to add new users.

1. Select the **Security > User Management** menu item to open the user management configuration window.
2. Enter a username in the **User** field. The username must be between 4 and 20 characters in length.

3. Select the user access rights by checking one or more of the fields shown.



The access rights are described in the following table

Table 8–1: ACCESS RIGHTS SUMMARY

FIELD	DESCRIPTION
Delete Entry	Checking this box will delete the user when exiting the user management configuration window.
Actual Values	Checking this box allows the user to read actual values.
Settings	Checking this box allows the user to read setting values.
Commands	Checking this box allows the user to execute commands.
Event Recorder	Checking this box allows the user to use the digital fault recorder.
FlexLogic	Checking this box allows the user to read FlexLogic™ values.
Update Info	Checking this box allows the user to write to any function to which they have read privileges. When any of the Settings, Event Recorder, and FlexLogic boxes are checked by themselves, the user is granted read access. When any of these are checked in conjunction with the Update Info box, they are granted read and write access. The user will not be granted write access to functions that are not checked, even if the Update Info field is checked.
Admin	When this box is checked, the user will become an EnerVista URPlus Setup administrator, therefore receiving all of the administrative rights. Exercise caution when granting administrator rights.

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

8.3.4 MODIFYING USER PRIVILEGES

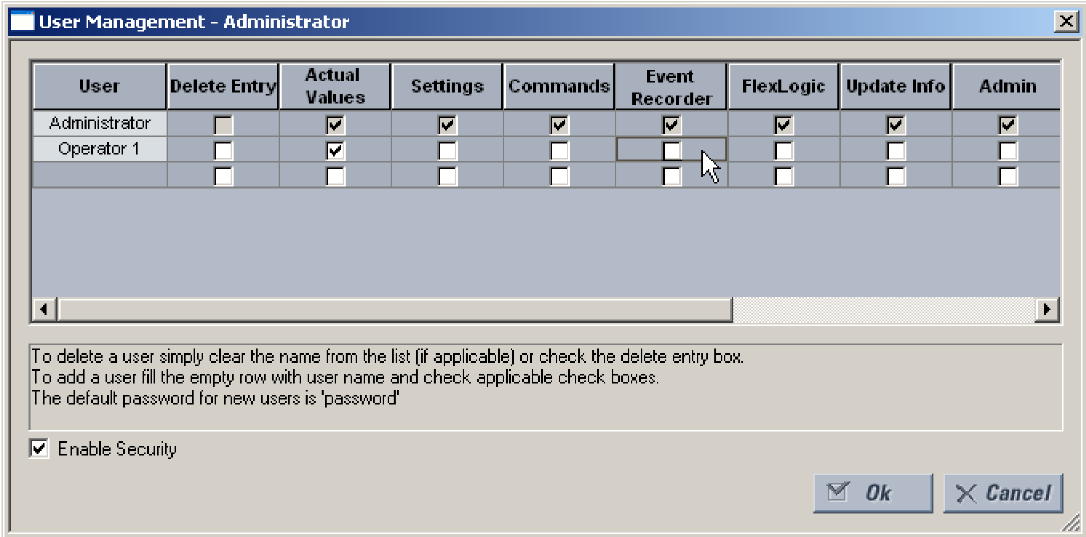
The following pre-requisites are required to modify user privileges in the EnerVista security management system.

- The user modifying the privileges must have administrator rights.
- The EnerVista security management system must be enabled.

The following procedure describes how to modify user privileges.

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

3. Modify the user access rights by checking or clearing one or more of the fields shown.



The access rights are described in the following table

Table 8–2: ACCESS RIGHTS SUMMARY

FIELD	DESCRIPTION
Delete Entry	Checking this box will delete the user when exiting the user management configuration window.
Actual Values	Checking this box allows the user to read actual values.
Settings	Checking this box allows the user to read setting values.
Commands	Checking this box allows the user to execute commands.
Event Recorder	Checking this box allows the user to use the digital fault recorder.
FlexLogic	Checking this box allows the user to read FlexLogic™ values.
Update Info	Checking this box allows the user to write to any function to which they have read privileges. When any of the Settings, Event Recorder, and FlexLogic boxes are checked by themselves, the user is granted read access. When any of these are checked in conjunction with the Update Info box, they are granted read and write access. The user will not be granted write access to functions that are not checked, even if the Update Info field is checked.
Admin	When this box is checked, the user will become an EnerVista URPlus Setup administrator, therefore receiving all of the administrative rights. Exercise caution when granting administrator rights.

4. Click **OK** to save the changes to user to the security management system.

9.1.1 GENERAL OPERATION

Static capacitor banks are constructed with a large number of individual capacitor elements connected in a series/parallel arrangement designed to distribute the system voltage equally among the elements. Equal distribution of voltage is important as the rate of internal insulation degradation is a highly non-linear function of element voltage, with degradation accelerating very rapidly with overvoltage greater than 10%. To obtain balanced voltages in spite of manufacturing tolerances in the capacitance of the elements, the elements are positioned in the bank according to their actual capacitance such that parallel groups have a uniform total capacitance, and a good voltage balance is obtained. However, once in service, individual elements can fail randomly upsetting the balance, increasing the stress on other elements, and causing their early failure. Early failure of an element due to unbalanced voltage predictably further unbalances the bank, leading to cascading failure.

The purpose of capacitor unbalance protection is to detect unbalance caused by element failures as soon as practical, and to either alarm the condition so that repair can be scheduled for a convenient time, or to automatically remove the bank from service to prevent deterioration in the healthy elements pending repair. A brut force method would be to directly measure the voltage across each element, operating on detecting an abnormally high voltage on any element. However, this approach is seldom economic due to the large number of voltage transducers required. Thus, the C70 supports various other methods, the suitability of each dependant on the capacitor bank configuration, and on the VTs and CTs available.

The challenge faced by all capacitor unbalance protections not using the brut force method is the increased sensitivity required due to the less than ideal number of monitoring points, and compensation for the increased effects of inherent unbalance due to manufacturing tolerance and due to system voltage unbalance.

9.1.2 BANK PHASE OVERVOLTAGE (ANSI 59B)

The capacitor unbalance protection functions discussed in the following sections are intended to detect failures in the capacitor bank itself that can result in a few capacitor elements being overstressed. However, these unbalance protection functions do not detect overstressed elements in a healthy bank that can result from external problems. Protection against overstressing elements from system overvoltages is instead provided by the bank phase overvoltage protection.

Ideally, a bank overvoltage protection should measure the voltage across each capacitor string, allowing an accurate inference of the voltage across each element in the string, assuming that the string voltage is equally divided across the elements. This is readily done in grounded wye capacitor banks by simply measuring the three system phase-to-ground voltages. For instance assuming the bank is healthy, the elements shown in the grounded banks of the figure below will each be stressed at one-ninth of system phase-to-ground voltage, allowing the inference that the elements are overstressed when the system phase-to-ground voltage exceeds nine times the element safe operating voltage limit. The true RMS value of these phase-to-ground quantities are what the bank phase overvoltage protection measures when the bus source is set for wye VTs and the bank overvoltage protection ground setpoint is set to grounded.

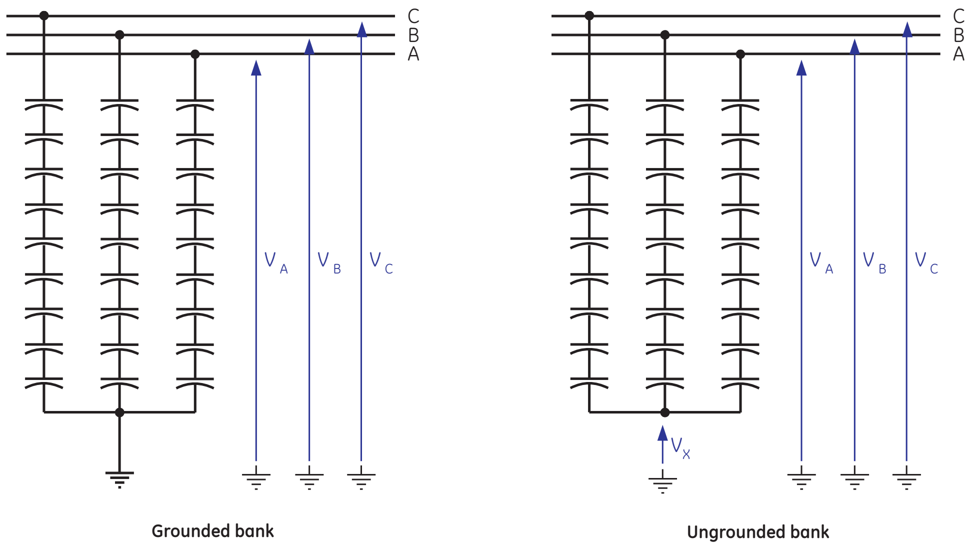


Figure 9–1: BANK OVERVOLTAGE PROTECTION FOR GROUNDED AND UNGROUNDED BANKS

For a capacitor bank that is ungrounded the voltage across the string is equal to the difference between the system phase-to-ground voltage and the bank neutral voltage. For instance elements shown in the ungrounded banks in the above figure will be overstressed when the quantities below exceed nine times the element safe operating voltage limit.

$$|V_A - V_X|_{RMS},\ |V_B - V_X|_{RMS},\ \text{or}\ |V_C - V_X|_{RMS} \quad \textbf{(EQ 9.1)}$$

These quantities are what the bank phase overvoltage protection measures when the bus source is set for wye VTs, the auxiliary channel of the neutral source is set for a neutral voltage, and the bank overvoltage protection ground setpoint is set to ungrounded.

When the neutral voltage of an ungrounded wye capacitor bank is not measured or for some reason it is desired not to use the neutral voltage measurement, the string voltage can still be determined using the assumption that the bank is balanced. For an balanced ungrounded bank the neutral voltage V_X is:

$$V_X = \frac{1}{3}(V_A + V_B + V_C) \quad \textbf{(EQ 9.2)}$$

As such, the A-string voltage is:

$$\begin{aligned} |V_A - V_X|_{RMS} &= \left|V_A - \frac{1}{3}(V_A + V_B + V_C)\right|_{RMS} \\ &= \frac{1}{3}|2V_A - V_B - V_C|_{RMS} \\ &= \frac{1}{3}|V_{AB} - V_{CA}|_{RMS} \end{aligned} \quad \textbf{(EQ 9.3)}$$

Similarly, the B-string and C-string voltages are:

$$\frac{1}{3}|V_{BC} - V_{AB}|_{RMS} \quad \text{and} \quad \frac{1}{3}|V_{CA} - V_{BC}|_{RMS} \quad \textbf{(EQ 9.4)}$$

These quantities are what the bank phase overvoltage protection measures when the bus source is set for wye VTs, and the bank overvoltage protection ground setpoint is set to “Ungrd w/o Vn”.

In applications where the bus VTs are delta connected, the bus phase-to-ground voltages and therefore the bus zero sequence voltage are unknown. However, as shown immediately above, string voltages can be determined for an ungrounded balanced bank using only phase-to-phase bus voltages. In the case of a grounded bank, we can calculate that the A-string voltage is:

$$
\begin{aligned}
|V_A|_{RMS} &= \frac{1}{3}|3V_A + (V_B - V_B) + (V_C - V_C)|_{RMS} \\
&= \frac{1}{3}|V_A - V_B - V_C + V_A + (V_A + V_B + V_C)|_{RMS} \\
&= \frac{1}{3}|V_{AB} - V_{CA} + 3V_0|_{RMS}
\end{aligned}
\quad \text{(EQ 9.5)}
$$

If we make the assumption that the zero-sequence voltage is negligible, which is reasonable when the system is normal (non-faulted), then the string voltages for grounded banks are the same as for the ungrounded balanced banks:

$$\frac{1}{3}|V_{AB} - V_{CA}|_{RMS},\ \frac{1}{3}|V_{BC} - V_{AB}|_{RMS},\ \text{or}\ \frac{1}{3}|V_{CA} - V_{BC}|_{RMS} \quad \text{(EQ 9.6)}$$

These quantities are what the bank phase overvoltage protection measures whenever the bus source is set for delta VTs.

9.1.3 VOLTAGE DIFFERENTIAL (ANSI 87V)

a) OPERATING PRINCIPLE

The voltage differential function is based on a voltage divider principle - a healthy capacitor string has a constant and known match factor between its full tap (typically the bus voltage) and an auxiliary tap used by the protection. Any single element failure will result in a difference between the measured factor and its value when the bank is healthy. The protection can be used on both grounded and ungrounded banks. For ungrounded banks, the neutral point voltage (V_X) must be measured by the relay, and used to derive the voltage across the string.

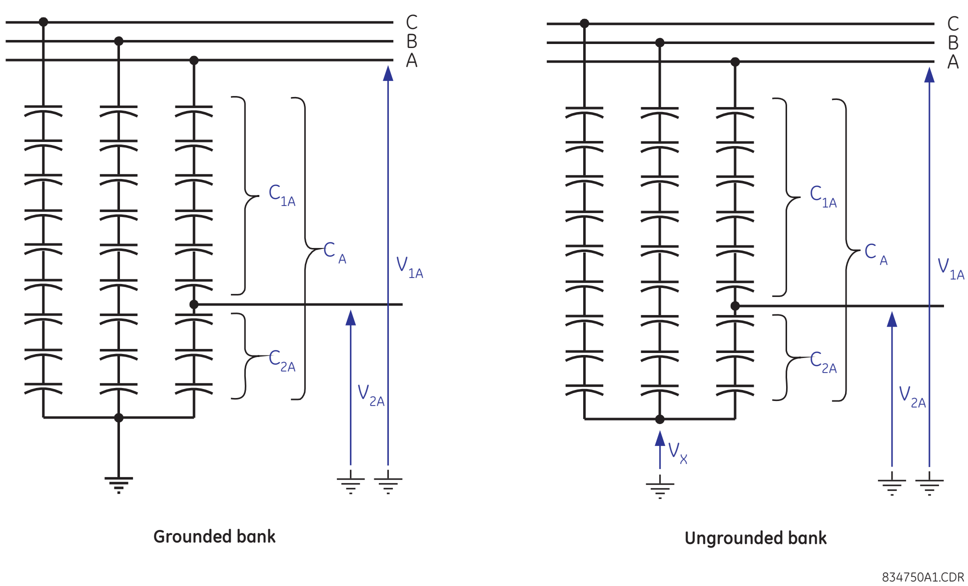


Figure 9–2: VOLTAGE DIFFERENTIAL APPLICATION TO GROUNDED AND UNGROUNDED BANKS

The voltage differential protection uses the following operating signal for grounded banks.

$$V_{OP(A)} = |V_{1A} - k_A V_{2A}| \quad \text{(EQ 9.7)}$$

The voltage differential protection uses the following operating signal for ungrounded banks.

$$V_{OP(A)} = |(V_{1A} - V_X) - k_A(V_{2A} - V_X)| \quad \text{(EQ 9.8)}$$

In the above equations, k_A is a match factor setting for the A-leg of the bank. The voltages are as defined in the figure above, and are in per-unit values on the nominal bus phase-to-ground voltage base. Equation 8.7 is implemented using primary voltage magnitudes, while equation 8.8 is implemented using primary voltage phasors. The protection operates when the operate signal is greater than the set pickup level for the set pickup delay.

Identical relations apply to phases B and C.

Sensitivity is the key performance parameter. The applied comparator uses a simple integration method in addition to the standard hysteresis approach, to deal with chattering of the operating signal at the boundary of operation.

b) BALANCED CASE

To understand how the voltage differential protection works, consider for simplicity the grounded bank operating equation below.

$$V_{OP(A)} = |V_{1A} - k_A V_{2A}| \quad \textbf{(EQ 9.9)}$$

The ungrounded case is similar except that all voltages have V_X subtracted. If the initial factory balanced A-leg string has an initial capacitance of C_A, divided into sub-strings with initial capacitances of C_{1A} and C_{2A}, and the bank is energized with system phase-to-ground voltage V_{Spg}, then the string will form a voltage divider and the initial measured voltages are:

$$V_{1A} = V_{Spg} \quad \textbf{(EQ 9.10)}$$

$$V_{2A} = V_{Spg} \times \frac{C_A}{C_{2A}} \quad \textbf{(EQ 9.11)}$$

Substituting these results into equation 8.9, the initial operating signal is:

$$\begin{aligned} V_{OP(A)} &= |V_{1A} - k_A V_{2A}| \\ &= \left| V_{Spg} - k_A V_{Spg} \times \frac{C_A}{C_{2A}} \right| \\ &= V_{Spg} \times \left| 1 - k_A \times \frac{C_A}{C_{2A}} \right| \end{aligned} \quad \textbf{(EQ 9.12)}$$

The match factor setting k_A is chosen as:

$$k_A = \frac{C_{2A}}{C_A} \quad \textbf{(EQ 9.13)}$$

Therefore, as can be seen from the previous two equations, the initial operating signal will be zero.

c) SENSITIVITY

Now consider the consequences of an element failure in the upper sub-string of leg A, making a small capacitance change in C_{1A}. The effect on the operating signal can be calculated by taking the derivative of equation 8.12 with respect to C_A, holding C_{2A} constant. In the general case, the derivative of the absolute value function is messy, but in our case where the initial value is zero, the derivative of the absolute function is simply the absolute value of the derivative of its argument. The derivative is thus:

$$\begin{aligned} \frac{d}{dC_A} V_{OP(1A)} &= V_{Spg} \times \left| \frac{d}{dC_A}\left(1 - k_A \frac{C_A}{C_{2A}}\right) \right| \\ &= V_{Spg} \times \left| -\frac{k_A}{C_{2A}} \right| \\ &= V_{Spg} \times \frac{k_A}{C_{2A}} \end{aligned} \quad \textbf{(EQ 9.14)}$$

Substituting equation 8.13, we have:

$$\frac{d}{dC_A} V_{OP(1A)} = V_{Spg} \times \frac{1}{C_A} \quad \text{or} \quad dV_{OP(1A)} = V_{Spg} \times \frac{dC_A}{C_A} \quad \textbf{(EQ 9.15)}$$

This can be written as:

$$V_{OP(1A)}(\text{pu}) = V_{Spg}(\text{pu}) \times \Delta C_A(\text{pu}) \quad \textbf{(EQ 9.16)}$$

In the above equation, ΔC_A(pu) is the capacitance change as a per-unit of the leg capacitance, V_{Spg} is the system phase-to-ground voltage, and $V_{OP(1A)}$(pu) is the operating signal resulting from the failure in the upper sub-string. Both voltages are in per-unit of nominal bus phase-to-ground voltage, so V_{Spg} can be taken as 1 when the system is normal (not faulted). Note however that under external fault conditions sensitivity may be much different from the non-fault sensitivity.

Instead of a failure in the upper sub-string, we now suppose a failure in the lower sub-string. The same approach is used, except to make the algebra easier, the initial operating signal is converted to be in terms of C_{1A} using:

$$C_A = \frac{C_{1A}C_{2A}}{C_{1A}+C_{2A}} \quad \text{or} \quad C_{2A} = \frac{C_A C_{1A}}{C_{1A}-C_A} \tag{EQ 9.17}$$

In this case, we have:

$$\begin{aligned} V_{OP(A)} &= V_{Spg} \times \left|1 - k_A \times \frac{C_A}{C_{2A}}\right| \\ &= V_{Spg} \times \left|1 - k_A \times \frac{C_{1A}-C_A}{C_{1A}}\right| \end{aligned} \tag{EQ 9.18}$$

The derivative is thus:

$$\begin{aligned} \frac{d}{dC_A}V_{OP(2A)} &= V_{Spg} \times \left|\frac{d}{dC_A}\left(1 - k_A\frac{C_{1A}-C_A}{C_{1A}}\right)\right| \\ &= V_{Spg} \times \left|\frac{k_A}{C_{1A}}\right| \\ &= V_{Spg} \times \frac{k_A}{C_{1A}} \end{aligned} \tag{EQ 9.19}$$

Substituting equation 8.17 into equation 8.13, we have:

$$k_A = \frac{C_{2A}}{C_A} = \frac{C_{1A}}{C_{1A}-C_A} \quad \text{or} \quad C_{1A} = k_A C_{1A} - k_A C_A \tag{EQ 9.20}$$

Therefore:

$$C_{1A} = \frac{k_A C_A}{k_A - 1} \tag{EQ 9.21}$$

Substituting this value into equation 8.19, we get:

$$\begin{aligned} \frac{d}{dC_A}V_{OP(2A)} &= V_{Spg} \times \frac{k_A}{C_{1A}} \\ &= V_{Spg} \times \frac{k_A - 1}{C_A} \end{aligned} \tag{EQ 9.22}$$

Or alternately,

$$dV_{OP(2A)} = V_{Spg} \times (k_A - 1) \times \frac{dC_A}{C_A} \tag{EQ 9.23}$$

The value can be expressed as:

$$V_{OP(2A)}(\text{pu}) = V_{Spg}(\text{pu}) \times (k_A - 1) \times \Delta C_A(\text{pu}) \tag{EQ 9.24}$$

In the above equation, ΔC_A(pu) is the capacitance change as a per-unit of the leg capacitance, V_{Spg} is the system phase-to-ground voltage, and $V_{OP(2A)}$(pu) is the operating signal resulting from the failure in the lower sub-string. Both voltages are in per-unit of nominal bus phase-to-ground voltage, so V_{Spg} can be taken as 1 when the system is normal (not faulted). Note however that under external fault conditions sensitivity may be much different from the non-fault sensitivity.

In practice, k_A is no less than 2.0 as the tap is no more than half way up the phase string. Comparing equation 8.16 with equation 8.24, it can be seen that $V_{OP(2A)}$(pu) ≥ $V_{OP(1A)}$(pu), and thus that an element failure in the lower substring produces a operating signal no smaller than the same failure in the upper sub-string. Thus $V_{OP(1A)}$(pu) represents the worse case sensitivity. A failure resulting in a 0.01 pu capacitance change in the leg capacitance results in an operating signal of at least 0.01 pu of bus phase-to-ground voltage.

d) AUTO-SETTING

While a capacitor bank may be designed to have a tap at say the mid-point or the one-third point, manufacturing tolerances result in the actual tap ratio being slightly different from the design target. To prevent a spurious component in the operating signal, the match factor settings must correspond to the actual rather than the design tap ratio. As a convenient alternative to manually determining the optimum match factor settings, the relay can automatically calculate these settings from its own measurements while the capacitor is in-service, as described in the *Commands* chapter. The C70 sets the operate signal to zero in equation 8.7 or 8.8 and solves for the match factor k_A using the average of several successive voltage measurements. This technique has the further advantage that it to a large degree compensates for instrumentation error. However, the assumption made here is that when the auto-set command is executed, the capacitor is in an acceptably balanced state, wherein the operating signal ought to be zero. Following the auto-set command, the protection will be measuring changes from the state that existed at the time the auto-set command executed.

9.1.4 COMPENSATED BANK NEUTRAL VOLTAGE UNBALANCE (ANSI 59NU)

a) OPERATING PRINCIPLE

The neutral voltage unbalance function is applicable to ungrounded banks. Fundamentally, this function responds to an overvoltage condition of the neutral-point voltage. If the capacitor bank and the power system voltages are balanced, the neutral-point voltage is zero. Should a capacitor element in the bank fail, the bank will become unbalanced and the neutral voltage will increase.

The operate signal for the neutral voltage unbalance protection is:

$$V_{OP} = \frac{1}{3}\left|V_X(1 + k_{AB} + k_{AC}) - 3V_0 + V_B(1 - k_{AB}) + V_C(1 - k_{AC})\right| \quad \textbf{(EQ 9.25)}$$

The restraint signal for the neutral voltage unbalance protection is:

$$V_{REST} = \left|V_X + V_0\right| \quad \textbf{(EQ 9.26)}$$

In the above equations, k_{AB} and k_{AC} represent capacitor bank unbalance ratio settings. The voltages are as defined by the figure below, and are expressed in per-units of the nominal value of the neutral-point VT.

These equations involve phasors, not magnitudes. That is, the vector sum of the voltages is created by the protection function implementing the method.

The neutral voltage unbalance protection operates when the operate signal is greater than the set pickup level and the operate signal is greater than the set percentage of the restraint signal, all for the set pickup delay.

Sensitivity is the key performance parameter. The applied comparator uses a simple integration method in addition to the standard hysteresis approach to deal with chattering of the operating signal at the boundary of operation. In addition a slope characteristic is used to deal with measuring errors for the involved voltages under large system unbalances such as during a close-in external fault.

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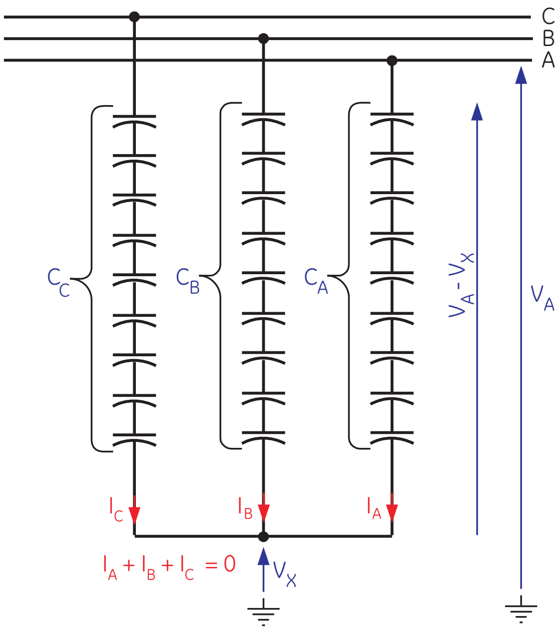

Figure 9–3: COMPENSATED BANK NEUTRAL OVERVOLTAGE APPLICATION

b) BALANCED CASE

To understand neutral voltage unbalance protection, we can start with Kirchhoff's current law for the neutral node of the bank:

$$I_A + I_B + I_C = j\omega C_A(V_A - V_X) + j\omega C_B(V_B - V_X) + j\omega C_C(V_C - V_X) = 0 \quad \textbf{(EQ 9.27)}$$

This expression can be rearranged as follows.

$$\begin{aligned} &-V_X(C_A + C_B + C_C) + V_A C_A + V_B C_B + V_C C_C = 0 \\ &\Rightarrow -V_X(C_A + C_B + C_C) + V_A C_A + V_B C_A + V_C C_A + V_B C_B - V_B C_A + V_C C_C - V_C C_A = 0 \\ &\Rightarrow -V_X(C_A + C_B + C_C) + C_A(V_A + V_B + V_C) + V_B(C_B - C_A) + V_C(C_C - C_A) = 0 \end{aligned} \quad \textbf{(EQ 9.28)}$$

Multiplying both sides by –1 / C_A and substituting the sum of the phase voltages with $3V_0$ yields:

$$V_X\left(1 + \frac{C_B + C_C}{C_A}\right) - 3V_0 + V_B\left(1 - \frac{C_B}{C_A}\right) + V_C\left(1 - \frac{C_C}{C_A}\right) = 0 \quad \textbf{(EQ 9.29)}$$

As the left hand side of this equation is equal to zero, we can subtract it from the expression inside the absolute value brackets in equation 8.25 to get:

$$\begin{aligned} V_{OP} &= \frac{1}{3}\left|V_X(1 + k_{AB} + k_{AC}) - 3V_0 + V_B(1 - k_{AB}) + V_C(1 - k_{AC}) - V_X\left(1 + \frac{C_B + C_C}{C_A}\right) + 3V_0 - V_B\left(1 - \frac{C_B}{C_A}\right) - V_C\left(1 - \frac{C_C}{C_A}\right)\right| \\ &= \frac{1}{3}\left|V_X\left(k_{AB} - \frac{C_B}{C_A} + k_{AC} - \frac{C_C}{C_A}\right) + V_B\left(\frac{C_B}{C_A} - k_{AB}\right) + V_C\left(\frac{C_C}{C_A} - k_{AC}\right)\right| \end{aligned} \quad \textbf{(EQ 9.30)}$$

The unbalance ratio *k*-values that reflect the initial or inherent bank unbalance are chosen as:

$$k_{AB} = \frac{C_B}{C_A}, \; k_{AC} = \frac{C_C}{C_A} \quad \textbf{(EQ 9.31)}$$

Therefore, as seen from the previous two equations, the initial operating signal will be zero.

Note that the ratios of the capacitances between phase A and the two other phases are close to unity, and therefore the correcting factors in equation 8.25 for the B and C-phase voltages are small numbers, while the factor for the V_X voltage is close to 3. If so, equation 8.25 takes a familiar simplified form:

$$V_{OP} = |V_X - V_0| \quad \text{(EQ 9.32)}$$

The V_0 term in the operate equation can be either the neutral component in the bus voltages (one-third of the vectorial sum of the phase voltages calculated by the relay), or directly measured neutral voltage component (open-corner-delta VT voltage).

c) SENSITIVITY

Now consider the consequences of a capacitor element failure in one leg, most conveniently leg C, making a small capacitance change in leg-C capacitance. The effect on the operating signal can be calculated by taking the derivative of equation 8.25 with respect to C_C. In the general case, the derivative of the absolute value function is messy, but in our case where the initial value is zero, the derivative of the absolute function is simply the absolute value of the derivative of its argument. As such, the derivative is:

$$\begin{aligned} \frac{d}{dC_C}V_{OP} &= \frac{1}{3}\frac{d}{dC_C}\left|(V_X(1+k_{AB}+k_{AC}) - 3V_0 + V_B(1-k_{AB}) + V_C(1-k_{AC}))\right| \\ &= \frac{1}{3}\left|(1+k_{AB}+k_{AC})\frac{dV_X}{dC_C}\right| \end{aligned} \quad \text{(EQ 9.33)}$$

Recall equation 8.29.

$$V_X\left(1+\frac{C_B+C_C}{C_A}\right) - 3V_0 + V_B\left(1-\frac{C_B}{C_A}\right) + V_C\left(1-\frac{C_C}{C_A}\right) = 0 \quad \text{(EQ 9.34)}$$

Differentiating this gives:

$$\begin{aligned} &\frac{dV_X}{dC_C}\left(1+\frac{C_B+C_C}{C_A}\right) + V_X\left(\frac{1}{C_A}\right) - V_C\left(\frac{1}{C_A}\right) = 0 \\ &\Rightarrow \frac{d}{dC_C}V_X = -\frac{V_X - V_C}{C_A\left(1+\frac{C_B+C_C}{C_A}\right)} \\ &\Rightarrow \frac{d}{dC_C}V_X = -\frac{V_X - V_C}{C_A(1+k_{AB}+k_{AC})} \end{aligned} \quad \text{(EQ 9.35)}$$

Substituting for V_X from equation 8.34 gives:

$$\frac{d}{dC_C}V_X = \frac{3V_0 - V_B(1-k_{AB}) - V_C(2+k_{AB})}{C_A(1+k_{AB}+k_{AC})^2} \quad \text{(EQ 9.36)}$$

This can be substituted into equation 8.33 to obtain:

$$\begin{aligned} \frac{d}{dC_C}V_{OP} &= \frac{1}{3}\left|(1+k_{AB}+k_{AC})\frac{dV_X}{dC_C}\right| \\ &= \frac{1}{3}\left|\frac{3V_0 - V_B(1-k_{AB}) - V_C(2+k_{AB})}{C_A(1+k_{AB}+k_{AC})}\right| \end{aligned} \quad \text{(EQ 9.37)}$$

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For our purposes, $C_A \cong C_B \cong C_C$, so $k_{AB} \cong 1$ and $k_{AC} \cong 1$. This results in:

$$\begin{aligned} \frac{d}{dC_C}V_{OP} &\cong \frac{1}{3}\left|\frac{V_C - V_0}{C_C}\right| \\ &= \frac{1}{3} \times \frac{1}{C_C} \times |V_C - V_0| \end{aligned} \quad \text{(EQ 9.38)}$$

Under normal system conditions (non-fault), $V_C >> V_0$, and V_C is the system phase-to-ground voltage. The system voltage V_{Spg}, which by convention is on the bus voltage base, converted to the base of nominal value of the neutral-point VT used in these equations, is:

$$\frac{n_{\text{bus\_phs}}}{n_{\text{ntrl\_aux}}} \times V_{Spg} \quad \textbf{(EQ 9.39)}$$

This gives:

$$\frac{d}{dC_C} V_{OP} \cong \frac{1}{3} \times \frac{1}{C_C} \times \frac{n_{\text{bus\_phs}}}{n_{\text{ntrl\_aux}}} \times V_{Spg}$$
$$\Rightarrow dV_{OP} \cong \frac{1}{3} \times \frac{n_{\text{bus\_phs}}}{n_{\text{ntrl\_aux}}} \times V_{Spg} \times \frac{dC_C}{C_C} \quad \textbf{(EQ 9.40)}$$

This can be written as:

$$V_{OP}(\text{pu}) \cong \frac{1}{3} \times \frac{n_{\text{bus\_phs}}}{n_{\text{ntrl\_aux}}} \times V_{Spg} \times \Delta C(\text{pu}) \quad \textbf{(EQ 9.41)}$$

In the above equations, ΔC(pu) is the capacitance change as a per-unit of the leg capacitance, and V_{OP}(pu) is the operating signal resulting from the failure in per-unit of the nominal value of the neutral-point VT. V_{Spg} is the system phase-to-ground voltage in per-unit of the nominal system phase-to-ground voltage, so can be taken as 1 when the system is normal (not faulted). Note however that under external fault conditions sensitivity may be much different from the non-fault sensitivity. $n_{\text{bus\_phs}}$ and $n_{\text{ntrl\_aux}}$ are the VT ratios of the phase VT bank of the bus source and of the auxiliary VT channel of the neutral source, respectively.

Note that under external fault conditions sensitivity may be much different form the non-fault sensitivity. To prevent mis-operation, a restraint and/or coordinating time delay should be used.

d) RESTRAINT

Severe system voltage unbalance, such as can occur during near-by bolted ground faults, can exacerbate measurement error in V_X or V_0, resulting in spurious operating signal. In addition as discussed above the sensitivity can be affected. To prevent operation under these conditions, percent restraint supervision is provided using a restraint signal that is the magnitude of the vector sum of V_X and V_0, as defined below.

$$V_{REST} = |V_X + V_0| \quad \textbf{(EQ 9.42)}$$

During external ground faults, these two voltages are approximately in phase generating a large restraining signal being twice the zero-sequence voltage at the bus. A slope of few percent is typically sufficient to provide good security under large system unbalances.

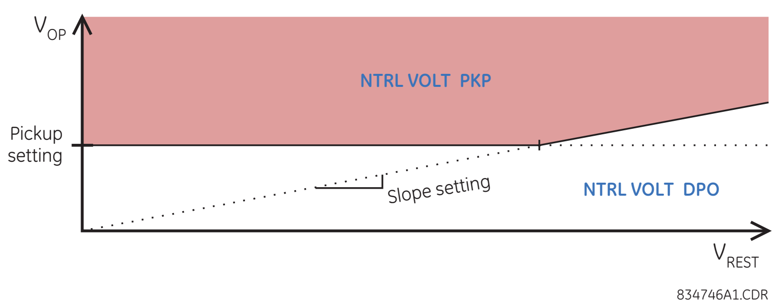

Figure 9–4: NEUTRAL OVERVOLTAGE RESTRAINT

e) AUTO-SETTING COMMAND

As a convenient alternative to manually determining the unbalance ratio settings, the relay can automatically calculate these settings from its own measurements while the capacitor is in-service, as described in the *Commands* chapter. The technique the relay uses is to set the operate signal variable in equation 8.25 to zero and solve for the unbalance ratio *k*-values using the average of several successive measurements of the voltages.

Determination of the two *k*-values using only one equation is possible as the *k*-values are known to be real-valued, so the complex-valued equation above can be separated into real and imaginary parts, with the same two *k*-values in each. A solution exists as long as the cross product of the B and C-phase voltages is non-zero; that is, the capacitor bank is in-service. However, the assumption made here is that when the auto-set command is executed, the capacitor is in an acceptably balanced state, wherein the operating signal ought to be zero. Following the auto-set command, the protection will be measuring changes from the state that existed at the time the auto-set command executed.

9.1.5 PHASE CURRENT UNBALANCE (ANSI 60P)

a) OPERATING PRINCIPLE

The phase current unbalance function is based on the balance between interconnected and nominally identical phase strings, and is applicable to both grounded and ungrounded installations. A window CT measuring the vectorial difference between the two phase currents is required for each phase as shown. While the two phase strings are actually identical, the measured current is be zero. The failure of an element in either string results in a difference current, which is sensed by the relay. However, with the two strings slightly mismatched due to manufacturing tolerances, an inherent difference current may be present. Compensation for this inherent unbalance current is available to increase the sensitivity of the function.

The phase current unbalance function uses the following operate signal.

$$I_{OP(A)} = |I_{DIF(A)} - k_A I_A| \quad \textbf{(EQ 9.43)}$$

In this equation, k_A is the capacitor bank leg-A inherent unbalance factor setting. The currents are as defined in the figure below, and are in per-unit on the nominal current of the differential source. This equation involve phasors, not magnitudes; that is, the vector sum of the currents is created by the protection function implementing the method.

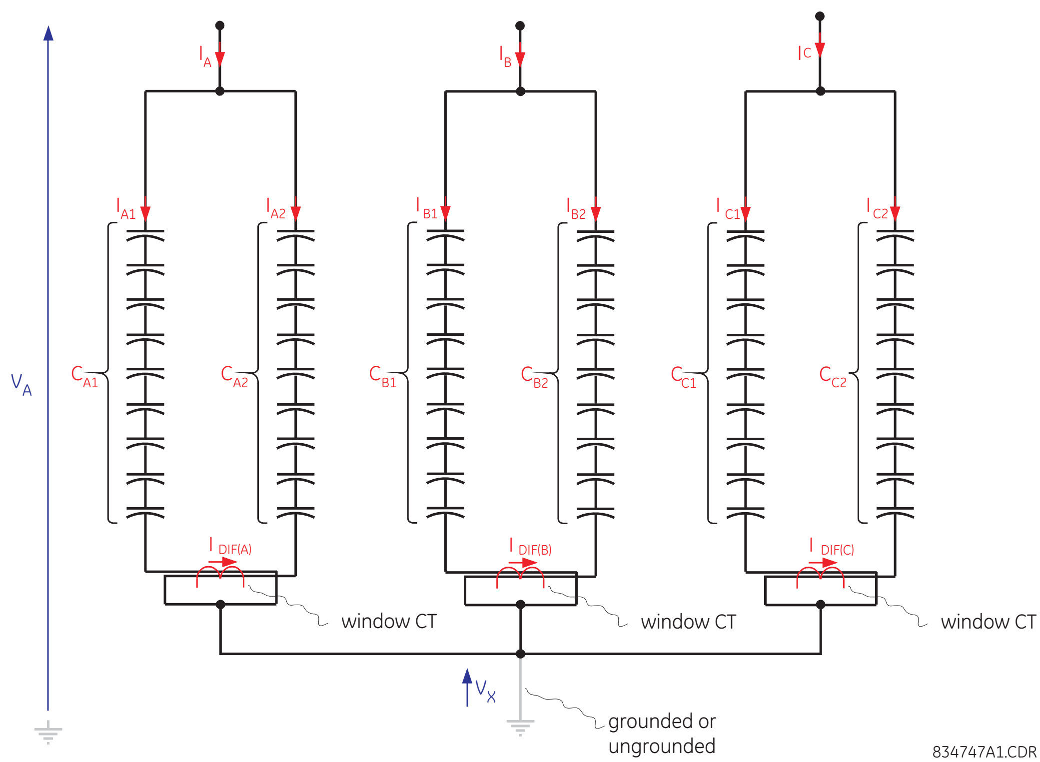

Figure 9–5: PHASE CURRENT UNBALANCE APPLICATION

The protection operates when the operate signal is greater than the set pickup level for the set pickup delay. Identical relations apply to phases B and C.

Sensitivity is the key performance parameter. The applied comparator uses a simple integration method in addition to the standard hysteresis approach, to deal with chattering of the operating signal at the boundary of operation.

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b) BALANCED CASE

To understand phase current unbalance protection, first note that the currents are driven by the individual admittances in each string:

$$I_{A1} = \frac{j\omega C_{A1}(V_A - V_X)}{I_{base}}; \quad I_{A2} = \frac{j\omega C_{A2}(V_A - V_X)}{I_{base}} \tag{EQ 9.44}$$

In the above equations, I_{base} represents the differential CT primary current rating. This places the string currents on the same per-unit base used by the C70. Voltages are expressed in primary volts, capacitances in Farads, and frequency in radians per second.

The differential current is the vector difference between the two currents:

$$\begin{aligned} I_{DIF(A)} &= I_{A1} - I_{A2} \\ &= \frac{j\omega(V_A - V_X)(C_{A1} - C_{A2})}{I_{base}} \end{aligned} \tag{EQ 9.45}$$

The total phase current is the vector sum of the two currents:

$$\begin{aligned} I_A &= I_{A1} + I_{A2} \\ &= \frac{j\omega(V_A - V_X)(C_{A1} + C_{A2})}{I_{base}} \end{aligned} \tag{EQ 9.46}$$

Inserting equation 8.46 into equation 8.45, to eliminate the voltages, we get:

$$I_{DIF(A)} = I_A \times \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} \tag{EQ 9.47}$$

Inserting this value into equation 8.43, we have:

$$\begin{aligned} I_{OP(A)} &= \left| I_{DIF(A)} - k_A I_A \right| \\ &= \left| I_A \times \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} - k_A I_A \right| \end{aligned} \tag{EQ 9.48}$$

The capacitor bank leg-A inherent unbalance factor setting k_A is chosen to be:

$$k_A = \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} \tag{EQ 9.49}$$

As can be seen from the previous two equations, the initial operating signal will be zero.

c) SENSITIVITY

Now consider the consequences of an element failure in a typical string, say string A1, making a small capacitance change in C_{A1} capacitance. The effect on the operating signal can be calculated by taking the derivative of equation 8.48 with respect to C_{A1}.

In the general case, the derivative of the absolute value function is messy, but in our case where the initial value is zero, the derivative of the absolute function is simply the absolute value of the derivative of its argument. We assume here that I_A is constant, which investigation has shown results in negligible error. The derivative is thus:

$$\begin{aligned}\frac{d}{dC_{A1}} I_{OP(A)} &= \left|\frac{d}{dC_{A1}}\left(I_A \times \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} - k_A I_A\right)\right| \\ &= \left|I_A \times \frac{(C_{A1} + C_{A2}) - (C_{A1} - C_{A2})}{(C_{A1} + C_{A2})^2}\right| \\ &= |I_A| \times \frac{2C_{A2}}{(C_{A1} + C_{A2})^2} \\ &\cong \frac{I_A}{2} \times \frac{1}{C_{A1}}\end{aligned} \quad \textbf{(EQ 9.50)}$$

The last step assumes $C_{A1} \cong C_{A2}$, and replaces the phase current vector with its magnitude. This can be written as:

$$\mathrm{d} I_{OP(A)} = \frac{I_A}{2} \times \frac{\mathrm{d}C_{A1}}{C_{A1}} \quad \textbf{(EQ 9.51)}$$

Alternatively, we can say:

$$I_{OP(A)}(\mathrm{pu}) = \frac{I_A}{2} \times \Delta C(\mathrm{pu}) \quad \textbf{(EQ 9.52)}$$

In the above equation, ΔC(pu) represents the capacitance change as a per-unit of the string capacitance, and $I_{OP(A)}$(pu) represents the operating signal resulting from the failure in per-unit of the nominal current of the differential source. I_A is phase A terminal current on the same base. When the system is normal (no fault), I_A may be taken as the capacitor bank rated primary per-phase current I_{rated} converted to the differential source base. For example, $I_A = I_{rated} / I_{base}$, where I_{base} is again the differential CT primary current rating, or:

$$I_{OP(A)}(\mathrm{pu}) = \frac{I_{rated}}{2I_{base}} \times \Delta C(\mathrm{pu}) \quad \textbf{(EQ 9.53)}$$

Note that under external fault conditions, sensitivity may be much different from the non-fault sensitivity.

d) AUTO-SETTING

As a convenient alternative to manually determining inherent unbalance factor settings, the relay can automatically calculate these settings from its own measurements while the capacitor is in-service, as described in the Commands section of this manual. The technique the relay uses is to set the operate signal variable to zero in equation 8.43 and solve for the inherent unbalance factor k_A using the average of several successive measurements of the currents. However, the assumption made here is that when the auto-set command is executed, the capacitor is in an acceptably balanced state, wherein the operating signal ought to be zero. Following the auto-set command, the protection will be measuring changes from the state that existed at the time the auto-set command executed.

9.1.6 NEUTRAL CURRENT UNBALANCE (ANSI 60N)

a) OPERATING PRINCIPLE

The neutral current unbalance function is based on the balance between interconnected neutral currents of two parallel banks, and is applicable to both grounded and ungrounded installations. This text deals first with grounded applications, with a section at the end that discusses the differences with ungrounded applications. A window CT measuring the vector difference between the two neutral currents is required for grounded-wye configurations.

If the two banks were identical, the inter-neutral current would be zero. The failure of an element in either bank would then result in inter-neutral current, which is sensed by the relay. However, with the two banks slightly mis-matched due to manufacturing tolerances, a circulating zero-sequence current may be present. Compensation for this inherent unbalance current is available to increase the sensitivity of the function.

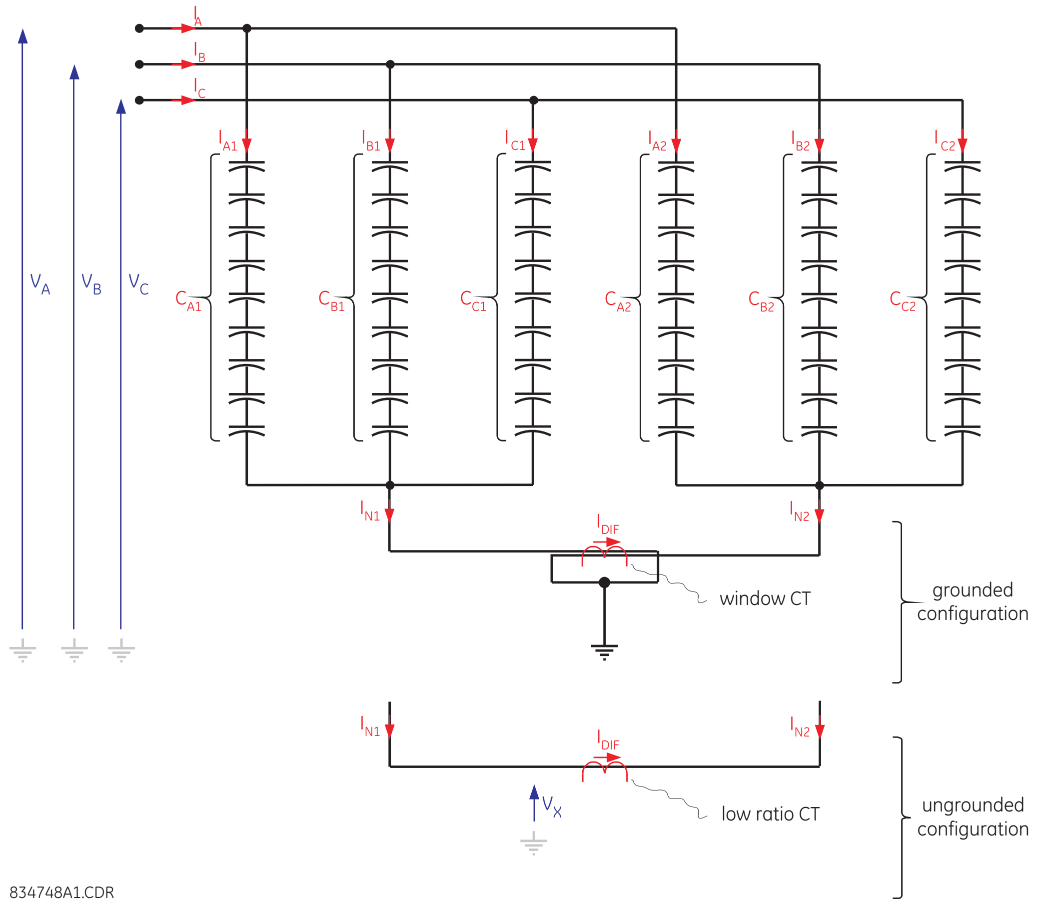

Figure 9–6: NEUTRAL CURRENT UNBALANCE APPLICATION

The neutral current unbalance protection uses the following operate signal.

$$I_{OP} = \left| I_{DIF} - k_1 I_1 - k_1^* I_2 \right| \quad \textbf{(EQ 9.54)}$$

The neutral current unbalance protection uses the following restraint signal.

$$I_{REST} = \left| I_0 \right| \quad \textbf{(EQ 9.55)}$$

In the above equations, k_1 represents the vector capacitor bank positive sequence inherent unbalance factor setting, and k_1* represents the complex conjugate of k_1. The currents are as defined in the figure above, and are in per-unit values of the nominal current of the bank source ground current channel.

These equations involve phasors, not magnitudes; that is, the vector sum of the currents is created by the protection function implementing the method. The protection operates when the operate signal is greater than the set pickup level for the set pickup delay.

Sensitivity is the key performance parameter. The applied comparator uses a simple integration method in addition to the standard hysteresis approach, to deal with chattering of the operating signal at the boundary of operation.

b) BALANCED CASE

The currents in the neutral current unbalance protection are driven by the individual admittances in each string:

$$I_{A1} = \frac{V_A \times j\omega C_{A1}}{I_{base}}; \quad I_{A2} = \frac{V_A \times j\omega C_{A2}}{I_{base}}$$
$$I_{B1} = \frac{V_B \times j\omega C_{B1}}{I_{base}}; \quad I_{B2} = \frac{V_B \times j\omega C_{B2}}{I_{base}} \qquad \text{(EQ 9.56)}$$
$$I_{C1} = \frac{V_C \times j\omega C_{C1}}{I_{base}}; \quad I_{C2} = \frac{V_C \times j\omega C_{C2}}{I_{base}}$$

In the above equations, I_{base} represents the differential CT primary current rating, inserted here to put the string currents on the same per-unit base used by the relay. Voltages are in primary volts, capacitances in Farads, and frequency in radians per second.

The two neutral currents can be derived from the above equations:

$$I_{N1} = I_{A1} + I_{B1} + I_{C1} = \frac{j\omega C_{A1} V_A + j\omega C_{B1} V_B + j\omega C_{C1} V_C}{I_{base}}$$
$$I_{N2} = I_{A2} + I_{B2} + I_{C2} = \frac{j\omega C_{A2} V_A + j\omega C_{B2} V_B + j\omega C_{C2} V_C}{I_{base}} \qquad \text{(EQ 9.57)}$$

The differential current is the vector difference between the two currents. By subtracting I_{N2} from I_{N1}, one obtains:

$$I_{DIF} = I_{N1} - I_{N2} = \frac{j\omega[V_A(C_{A1} - C_{A2}) + V_B(C_{B1} - C_{B2}) + V_C(C_{C1} - C_{C2})]}{I_{base}} \qquad \text{(EQ 9.58)}$$

At the same time the total currents in each phase are driven by the total admittance of the two banks in each phase:

$$I_A = I_{A1} + I_{A2} = \frac{j\omega V_A(C_{A1} + C_{A2})}{I_{base}}$$
$$I_B = I_{B1} + I_{B2} = \frac{j\omega V_B(C_{B1} + C_{B2})}{I_{base}} \qquad \text{(EQ 9.59)}$$
$$I_C = I_{C1} + I_{C2} = \frac{j\omega V_C(C_{C1} + C_{C2})}{I_{base}}$$

Inserting the equations above into equation 8.58 so as to eliminate the voltages:

$$I_{DIF} = \frac{j\omega[V_A(C_{A1} - C_{A2}) + V_B(C_{B1} - C_{B2}) + V_C(C_{C1} - C_{C2})]}{I_{base}} = I_A \times \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} + I_B \times \frac{C_{B1} - C_{B2}}{C_{B1} + C_{B2}} + I_C \times \frac{C_{C1} - C_{C2}}{C_{C1} + C_{C2}} \qquad \text{(EQ 9.60)}$$

Label k_A, k_B, and k_C as follows:

$$k_A = \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}}, \quad k_B = \frac{C_{B1} - C_{B2}}{C_{B1} + C_{B2}}, \quad k_C = \frac{C_{C1} - C_{C2}}{C_{C1} + C_{C2}} \qquad \text{(EQ 9.61)}$$

Also, convert from phase coordinates into sequence components as follows, and equation 8.60 becomes:

$$I_{DIF} = k_A(I_1 + I_2 + I_0) + k_B(\hat{a}^2 I_1 + \hat{a} I_2 + I_0) + k_C(\hat{a} I_1 + \hat{a}^2 I_2 + I_0)$$
$$= I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C) + I_2(k_A + \hat{a} k_B + \hat{a}^2 k_C) + I_0(k_A + k_B + k_C) \qquad \text{(EQ 9.62)}$$

Substituting this into equation 8.54, we get:

$$\begin{aligned} I_{OP} &= \left|I_{DIF} - (k_1 I_1 - k_1^* I_2)\right| \\ &= \left|I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C) + I_2(k_A + \hat{a} k_B + \hat{a}^2 k_C) + I_0(k_A + k_B + k_C) - k_1 I_1 - k_1^* I_2\right| \\ &= \left|I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1) + I_2(k_A + \hat{a} k_B + \hat{a}^2 k_C - k_1^*) + I_0(k_A + k_B + k_C)\right| \\ &= \left|I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1) + I_2(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1)^* + I_0(k_A + k_B + k_C)\right| \end{aligned} \quad \textbf{(EQ 9.63)}$$

The capacitor bank positive sequence inherent unbalance factor setting k_1 is chosen to be:

$$\begin{aligned} k_1 &= k_A + \hat{a}^2 k_B + \hat{a} k_C \\ &= \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} + \hat{a}^2 \frac{C_{B1} - C_{B2}}{C_{B1} + C_{B2}} + \hat{a} \frac{C_{C1} - C_{C2}}{C_{C1} + C_{C2}} \end{aligned} \quad \textbf{(EQ 9.64)}$$

This allows the first and second terms in the I_{OP} equation above to vanish. The last term, being the product of two small numbers, virtually vanishes as well. Under normal system conditions (non-fault), the zero-sequence voltage and thus the zero-sequence current is small. The k_A, k_B, and k_C value involve the difference between two capacitances that are factory matched, and so are also small. In addition, it is very likely that they will be of varying signs, and thus their sum will be doubly small. Thus the initial operating signal under normal operating conditions is seen to be virtually zero.

c) SENSITIVITY

Now consider the consequences of an element failure in a typical string, say string A1, making a small capacitance change in the C_{A1} capacitance. The effect on the operating signal can be calculated by taking the derivative of equation 8.63 with respect to C_{A1}.

In the general case, the derivative of the absolute value function is messy, but in our case where the initial value is zero, the derivative of the absolute function is simply the absolute value of the derivative of its argument. We assume here that the currents remain constant, which investigation has shown results in negligible error. The derivative is thus:

$$\begin{aligned} \frac{d}{dC_{A1}} I_{OP} &= \left|\frac{d}{dC_{A1}}(I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1) + I_2(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1)^* + I_0(k_A + k_B + k_C))\right| \\ &= \left|\frac{dk_A}{dC_{A1}} I_1 + \frac{dk_A}{dC_{A1}} I_2 + \frac{dk_A}{dC_{A1}} I_0\right| \\ &= \left|\frac{dk_A}{dC_{A1}} I_A\right| \\ &= \left|\frac{(C_{A1} + C_{A2}) - (C_{A1} - C_{A2})}{(C_{A1} + C_{A2})^2} I_A\right| \\ &= \frac{2 C_{A2} I_A}{(C_{A1} + C_{A2})^2} \\ &\cong \frac{I_A}{2} \times \frac{1}{C_{A1}} \end{aligned} \quad \textbf{(EQ 9.65)}$$

The final step assumes $C_{A1} \cong C_{A2}$, and replaces the phase current vector with its magnitude. This can be written as:

$$dI_{OP} = \frac{I_A}{2} \times \frac{dC_{A1}}{C_{A1}} \quad \textbf{(EQ 9.66)}$$

Alternately, we can say:

$$I_{OP}(\text{pu}) = \frac{I_A}{2} \times \Delta C(\text{pu}) \quad \textbf{(EQ 9.67)}$$

where ΔC(pu) represents the capacitance change as a per-unit value of the string capacitance, and I_{OP}(pu) represents the operating signal resulting from the failure in per-unit of the nominal current of the differential source. I_A represents the phase A terminal current on the same base. When the system is normal (no fault), I_A may be taken as the capacitor bank's rated primary per-phase current I_{rated} converted to the differential source base. For example, $I_A = I_{rated} / I_{base}$, where I_{base} is again the differential CT primary current rating, or with system normal:

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$$I_{OP}(\text{pu}) = \frac{I_{rated}}{2I_{base}} \times \Delta C(\text{pu})$$ **(EQ 9.68)**

Note that under external fault conditions, sensitivity may be much different from the non-fault sensitivity.

d) RESTRAINT

Severe system voltage unbalance, such as can occur during near-by bolted ground faults, can exacerbate measurement error, resulting in spurious operating signal. To prevent operation under these conditions, percent restraint supervision is applied using a restraint signal that is the magnitude of the zero-sequence current

Typically few percent of slope is enough to ensure security of the function. The factor compensating for the inherent bank unbalance zeroes out the operating signal under relatively balanced bank currents. If the said currents contain a significant zero sequence component, the quality of compensation is lower, hence the need for the restraint, and this slope setting.

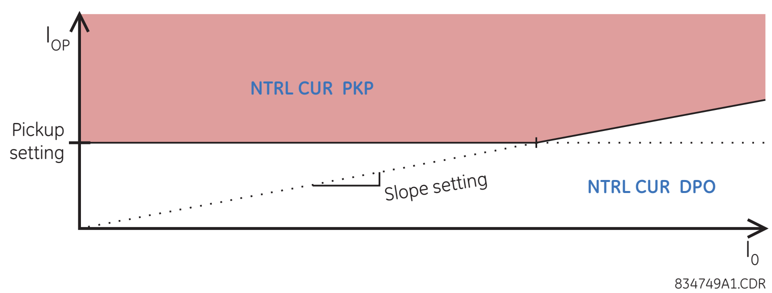

Figure 9–7: NEUTRAL CURRENT UNBALANCE RESTRAINT

e) AUTO-SETTING

As a convenient alternative to manually determining the unbalance *k*-factor settings, the relay can automatically calculate these settings from its own measurements while the capacitor is in-service, as described in the *Commands* chapter. The technique the relay uses is to set the operate signal variable to zero in equation 8.54 and solve for the unbalance factor k_1 using the average of several successive measurements of the currents.

However, the assumption made here is that when the auto-set command is executed, the capacitor is in an acceptably balanced state, wherein the operating signal ought to be zero. Following the auto-set command, the protection will be measuring changes from the state that existed at the time the auto-set command executed.

f) APPLICATION TO UNGROUNDED CAPACITOR BANKS

The forgoing discussion of the neutral current balance protection applied to the ground configuration. When applied to ungrounded configurations, all of the above applies, with the following exceptions:

- The phase voltages in equations 8.54 through 8.59 must have the neutral voltage V_X subtracted. However, as these voltages are eventually eliminated from the calculations, the outcome is unaffected.
- A low ratio CT can be used for ungrounded-wye configurations in place of a window type CT as there is no requirement to form the difference of the primary neutral currents.
- Whereas with the grounded configuration $I_{DIF} = I_{N1} - I_{N2}$, with the ungrounded configuration $I_{DIF} = I_{N1} = -I_{N2}$. This results in the $-C_{A2}$, $-C_{B2}$, and $-C_{C2}$ terms disappearing from equations 8.58 through 8.65. This results in the following changes.

  Equation 8.64 becomes:

$$\begin{aligned} k_1 &= k_A + \hat{a}^2 k_B + \hat{a} k_C \\ &= \frac{C_{A1}}{C_{A1} + C_{A2}} + \hat{a}^2 \frac{C_{B1}}{C_{B1} + C_{B2}} + \hat{a} \frac{C_{C1}}{C_{C1} + C_{C2}} \end{aligned}$$ **(EQ 9.69)**

  Equation 8.65 becomes:

$$\frac{d}{dC_{A1}} I_{OP} = \left| \frac{(C_{A1} + C_{A2}) - C_{A1}}{(C_{A1} + C_{A2})^2} I_A \right|$$
$$= \frac{C_{A2} I_A}{(C_{A1} + C_{A2})^2} \quad \textbf{(EQ 9.70)}$$
$$\cong \frac{I_A}{4} \times \frac{1}{C_{A1}}$$

Equation 8.67 becomes:

$$I_{OP}(\text{pu}) = \frac{I_A}{4} \times \Delta C(\text{pu}) \quad \textbf{(EQ 9.71)}$$

Equation 8.68 becomes:

$$I_{OP}(\text{pu}) = \frac{I_{rated}}{4 I_{base}} \times \Delta C(\text{pu}) \quad \textbf{(EQ 9.72)}$$

Note that in the ungrounded case, the operating signal is half of that for the grounded case.

- With the grounded configuration, the two banks must be nominally identical. With the ungrounded configuration the two banks need not be the identical though each should be balanced. In this situation, the base for ΔC(pu) is the capacitance of the string which has the element failure, so the larger bank will have a lower sensitivity than the smaller bank.

10.1.1 OVERVIEW

The appropriate protection is dependent on the capacitor bank type, configuration, CTs and VTs location and connections. IEEE Standard C37.99-2000: *Guide for Protection of Shunt Capacitor Banks* specifies methods used for protecting different types of banks.

There are four types of arrangements and individual capacitors connections used to form a capacitor bank.

- Externally fused capacitors.
- Internally fused capacitors.
- Fuseless capacitors.
- Unfused capacitors.

These arrangements are described in the following sections.

10.1.2 EXTERNALLY FUSED CAPACITORS

An individual fuse, externally mounted between the capacitor unit and the capacitor bank fuse bus, protects each capacitor unit. The capacitor unit can be designed for a relatively high voltage since the external fuse is capable of interrupting a high-voltage fault. However, the kvar rating of the individual capacitor unit is usually smaller because a minimum number of parallel units are required to limit the voltage rise on remaining units and thus allow the bank to remain in service with a capacitor can out of service. A capacitor bank using fused capacitors is configured using one or more series groups of parallel-connected capacitor units per-phase, as shown below.

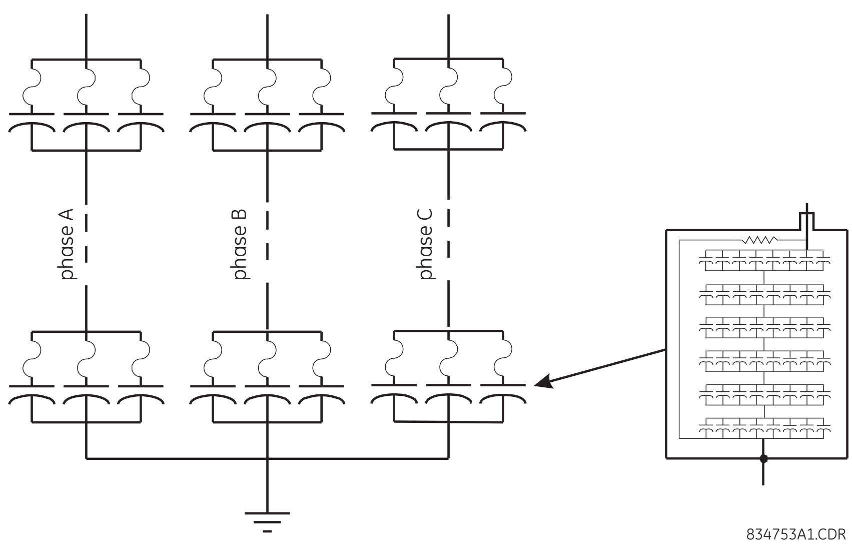

Figure 10–1: EXTERNALLY FUSED SHUNT CAPACITOR BANK AND CAPACITOR UNIT

10.1.3 INTERNALLY FUSED CAPACITORS

Each capacitor element is fused inside the capacitor unit. A *simplified fuse* is a piece of wire sized to melt under the fault current, and encapsulated in a wrapper able to withstand the heat produced by the arc during the current interruption. Upon the capacitor failure, the fuse removes the affected element only. The other elements, connected in parallel in the same group, remain in service but with a slightly higher voltage across them.

The following figure illustrates a typical capacitor bank utilizing internally fused capacitor units. In general, banks employing internally fused capacitor units are configured with fewer capacitor units in parallel, and more series groups of units than are used in banks employing externally fused capacitor units. The capacitor units are built larger because the entire unit is not expected to fail.

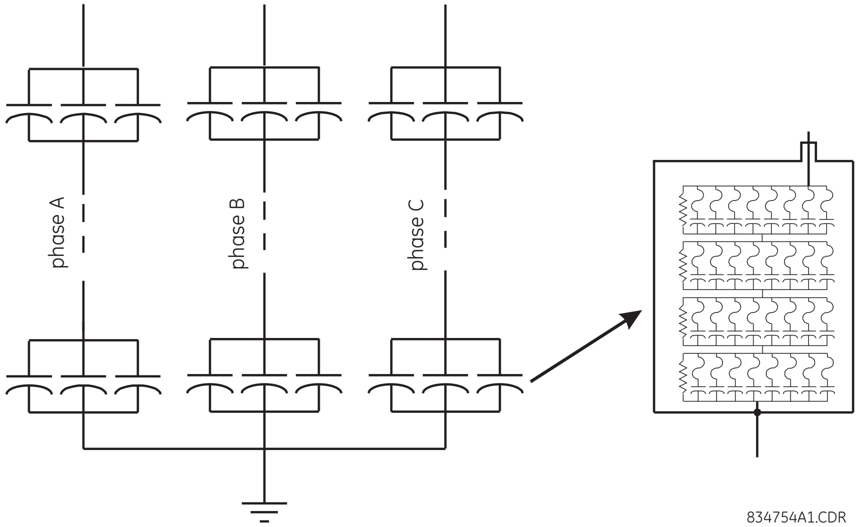

Figure 10–2: INTERNALLY FUSED SHUNT CAPACITOR BANK AND CAPACITOR UNIT

10.1.4 FUSELESS CAPACITORS

Fuseless capacitor bank are typically the most prevalent designs. The capacitor units for fuseless capacitor banks are connected in series strings between phase and neutral. The higher the bank voltage, the more capacitor elements in series.

The expected failure of the capacitor unit element is a short circuit, where the remaining capacitor elements will absorb the additional voltage. For example, if there are 6 capacitor units in series and each unit has 8 element groups in series there is a total of 48 element groups in the string. If one capacitor element fails, this element is shorted and the voltage across the remaining elements is 48 / 47 of the previous value, or about 2% higher. The capacitor bank remains in service; however, successive failures of elements would aggravate the problem and eventually lead to the removal of the bank.

The fuseless design is usually applied for applications at or above 34.5 kV where each string has more than ten elements in series to ensure the remaining elements do not exceed 110% rating if an element in the string shorts.

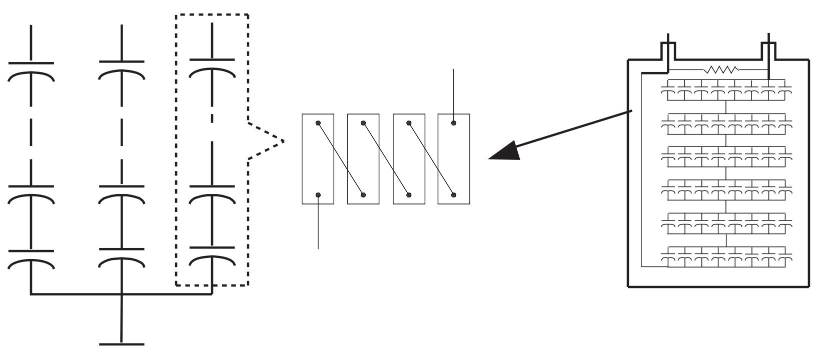

Figure 10–3: FUSELESS SHUNT CAPACITOR BANK AND SERIES STRING

10.1.5 UNFUSED CAPACITORS

Contrary to the fuseless configuration, where the units are connected in series, the unfused shunt capacitor bank uses a series or parallel connection of the capacitor units. The unfused approach would normally be used on banks below 34.5 kV, where series strings of capacitor units are not practical, or on higher voltage banks with modest parallel energy. This design does not require as many capacitor units in parallel as an externally fused bank.

10.2.1 GROUNDED WYE-CONNECTED BANKS

Grounded wye capacitor banks are composed of series and parallel-connected capacitor units per-phase and provide a low impedance path to ground. This offers some protection from surge overvoltages and transient overcurrents.

When a capacitor bank becomes too large, making the parallel energy of a series group too high for the capacitor units or fuses (greater than 4650 kvar), the bank may be split into two wye sections. The characteristics of the grounded double wye are similar to a grounded single wye bank. The two neutrals should be directly connected with a single path to ground.

The double-wye design facilitates better protection methods. Even with inherent unbalances the two banks will respond similarly to system events, and therefore, methods based on comparing one split-phase versus the other are more sensitive and less prone to system events (phase current balance technique, for example).

10.2.2 UNGROUNDED WYE-CONNECTED BANKS

Ungrounded wye banks do not permit zero sequence currents, third harmonic currents, or large capacitor discharge currents during system ground faults (phase-to-phase faults may still occur and will result in large discharge currents). Another advantage is that overvoltages appearing at the CT secondaries are not as high as in the case of grounded banks. However, the neutral should be insulated for full line voltage because it is momentarily at phase potential when the bank is switched or when one capacitor unit fails in a bank configured with a single group of units.

10.2.3 DELTA-CONNECTED BANKS

Delta-connected banks are generally used only at distribution voltages and are configured with a single series group of capacitors rated at line-to-line voltage. With only one series group of units, no overvoltage occurs across the remaining capacitor units from the isolation of a faulted capacitor unit.

10.2.4 H-CONFIGURATION

Some larger banks use an H-configuration in each phase with a current transformer connected between the two legs to compare the current down each leg. As long as all capacitors are balanced, no current will flow through the current transformer. If a capacitor fuse operates or an element shorts, some current will flow through the current transformer. This bridge connection facilitates very sensitive protection. The H-arrangement is used on large banks with many capacitor units in parallel.

10.2.5 TAPPED CONFIGURATION

Some larger banks use a tapped configuration in each phase with voltage transformers connected from the phase to ground and from the tap to ground. As long as no fuses have opened and no elements have shorted, the ratio of these two voltages will remain constant. The ratio changes with any capacitor failure in the phase, providing sensitive protection.

10.2.6 SUMMARY

The following figure summarizes the grounded wye, ungrounded wye, delta, H-bridge, and tapped connection types for capacitor banks.

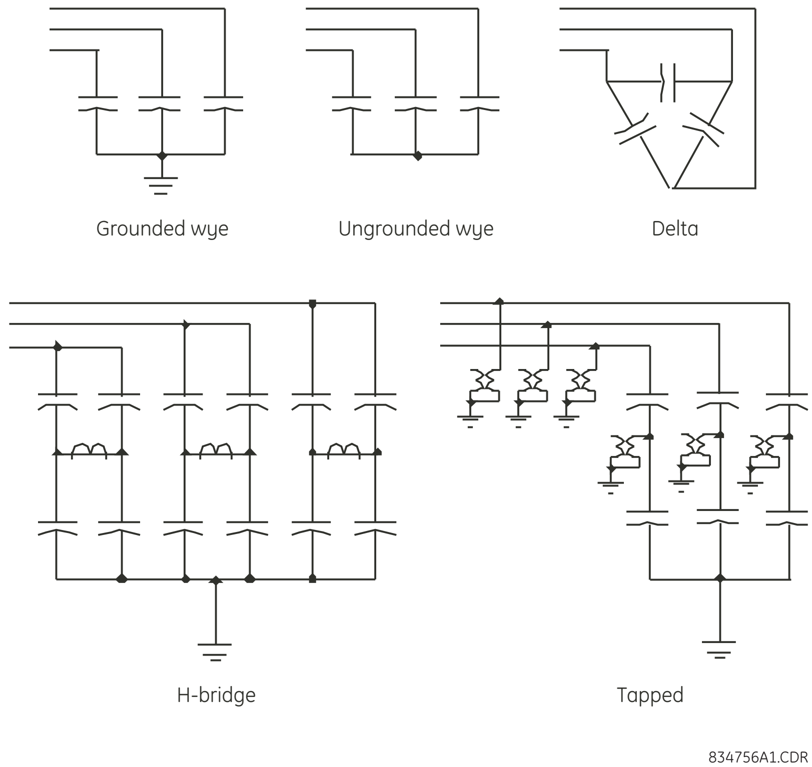

Figure 10–4: CAPACITOR BANK CONNECTIONS

10.3.1 DESCRIPTION

The protection of shunt capacitor banks involves both bank and system protection schemes.

Bank protection schemes are provided for faults within the capacitor bank itself. Bank protection may include items such as a means to disconnect a faulted capacitor unit or capacitor elements, a means to initiate a shutdown of the bank in case of faults that may lead to a catastrophic failure, and alarms to indicate unbalance within the bank.

System protection schemes are provided to protect the capacitor bank from stresses that may be caused by the system and to protect the substation and system from stresses that may be caused by the operation of the capacitor bank. System protection may include items such as a means to limit overvoltage and excessive transient overcurrents, and to disconnect the bank in the event of a major fault within the capacitor installation. System protection may also include alarms and methods to disconnect the entire shunt capacitor bank to prevent further damage to the capacitors due to abnormal system conditions.

In externally fused capacitor banks, several capacitor element breakdowns may occur before the fuse removes the entire unit. The external fuse will operate when a capacitor unit becomes (essentially) short circuited, isolating the faulted unit. Unbalance protection removes the bank from service when the resulting overvoltage becomes excessive on the remaining healthy capacitor units.

Internally fused capacitors have individual capacitor elements within a capacitor unit that are disconnected when an element breakdown occurs. The risk of successive faults is minimized because the fuse will isolate the faulty element within a few cycles. Unbalance protection removes the bank from service when the resulting unbalanced voltage becomes excessive on the remaining healthy capacitor elements or units.

For fuseless or unfused capacitor banks, a failed element is short-circuited by the weld that naturally occurs at the point of failure. Unbalance protection removes the bank from service when the resulting voltage becomes excessive on the remaining healthy capacitor elements or units.

10.3.2 CAPACITOR UNBALANCE PROTECTION

a) CONNECTIONS

Unbalance protection utilizes the unbalance that occurs in a normally balanced capacitor bank to detect an abnormality and initiate appropriate action. The most important function is to promptly remove the bank from service for any fault that may result in further damage. Capacitor unbalance protection is provided in many different ways, depending on the capacitor bank arrangement.

The variety of unbalance protection schemes that may be applied with C70 for internally fused, externally fused, fuseless, or unfused shunt capacitor banks is indicated in *Theory of operation* chapter and is illustrated on the figures below.

The following figure illustrates a single capacitor bank, ungrounded, with no tap available. In this case, a single CT/VT module is required.

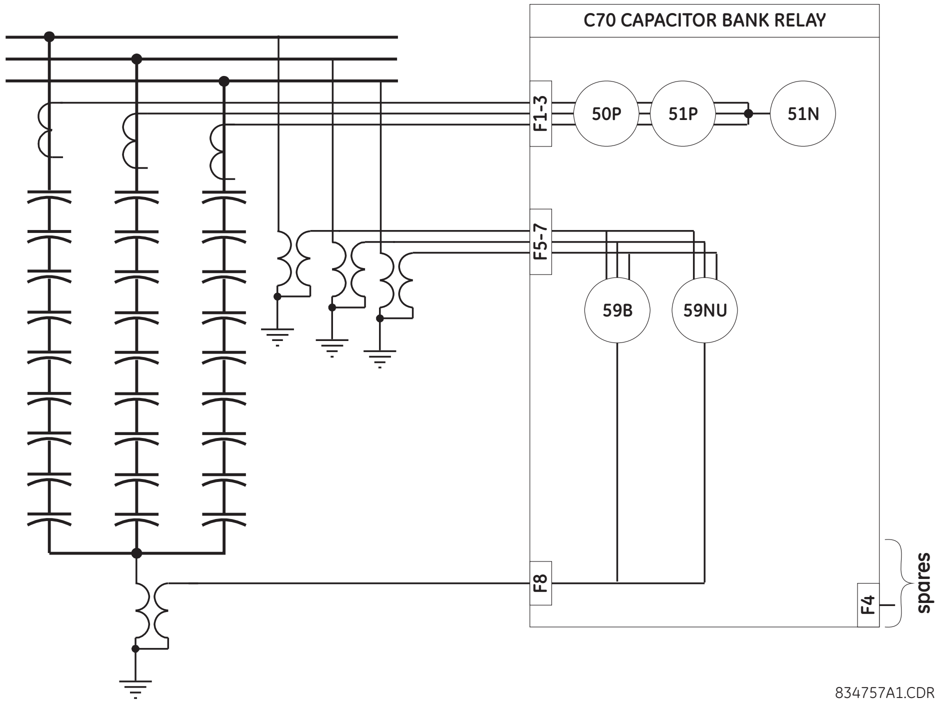

Figure 10–5: SINGLE BANK, UNGROUNDED, NO TAP AVAILABLE

The following figure illustrates a single capacitor bank, ungrounded, with a tap. In this case, two CT/VT modules are required.

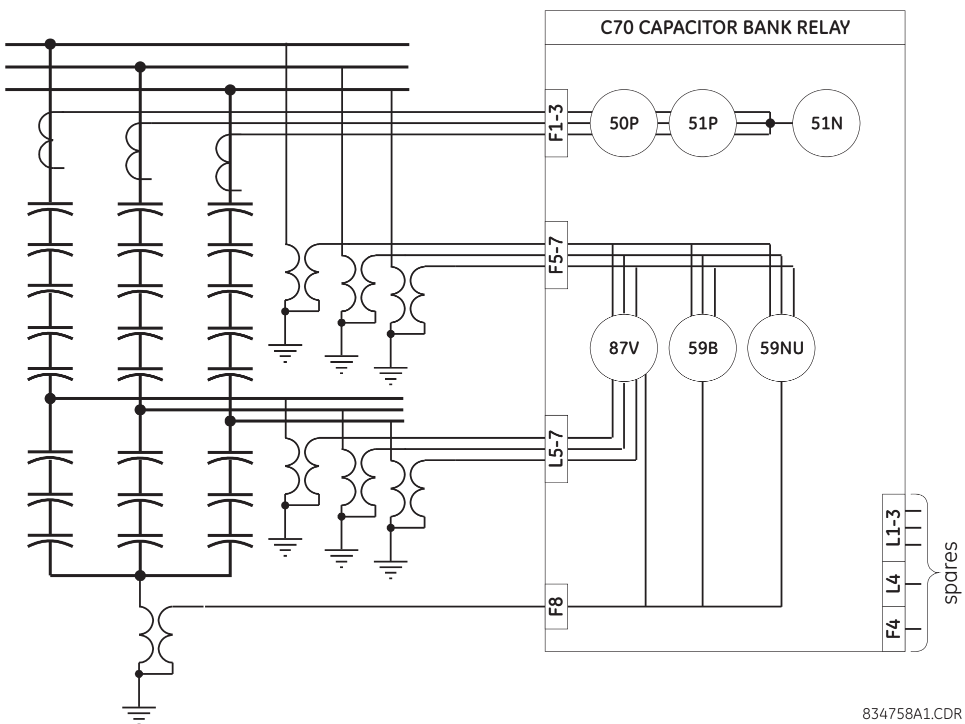

Figure 10–6: SINGLE BANK, UNGROUNDED, WITH A TAP

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The following figure illustrates a single capacitor bank, grounded, with a tap. In this case, two CT/VT modules are required.

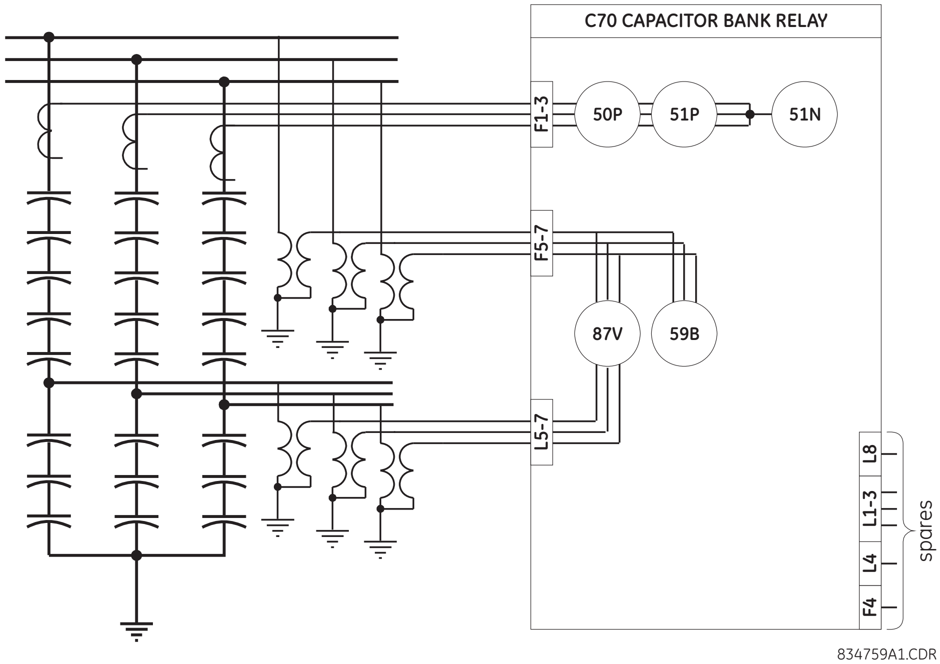


Figure 10–7: SINGLE BANK, GROUNDED, WITH A TAP

The following figure illustrates parallel capacitor banks, ungrounded, no tap available, and with current unbalance protection. In this case, two CT/VT modules are required.

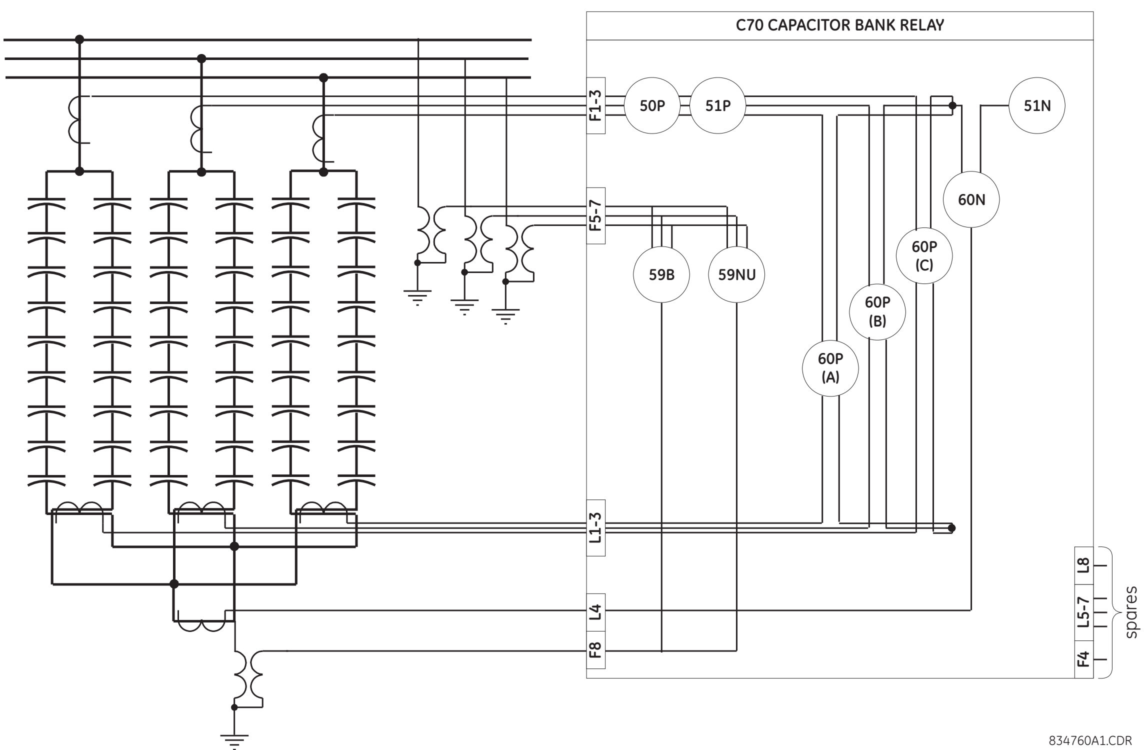


Figure 10–8: PARALLEL BANKS, UNGROUNDED, NO TAP AVAILABLE, CURRENT UNBALANCE PROTECTION

The following figure illustrates parallel capacitor banks, grounded, no tap available, and with current unbalance protection. In this case, two CT/VT modules are required.

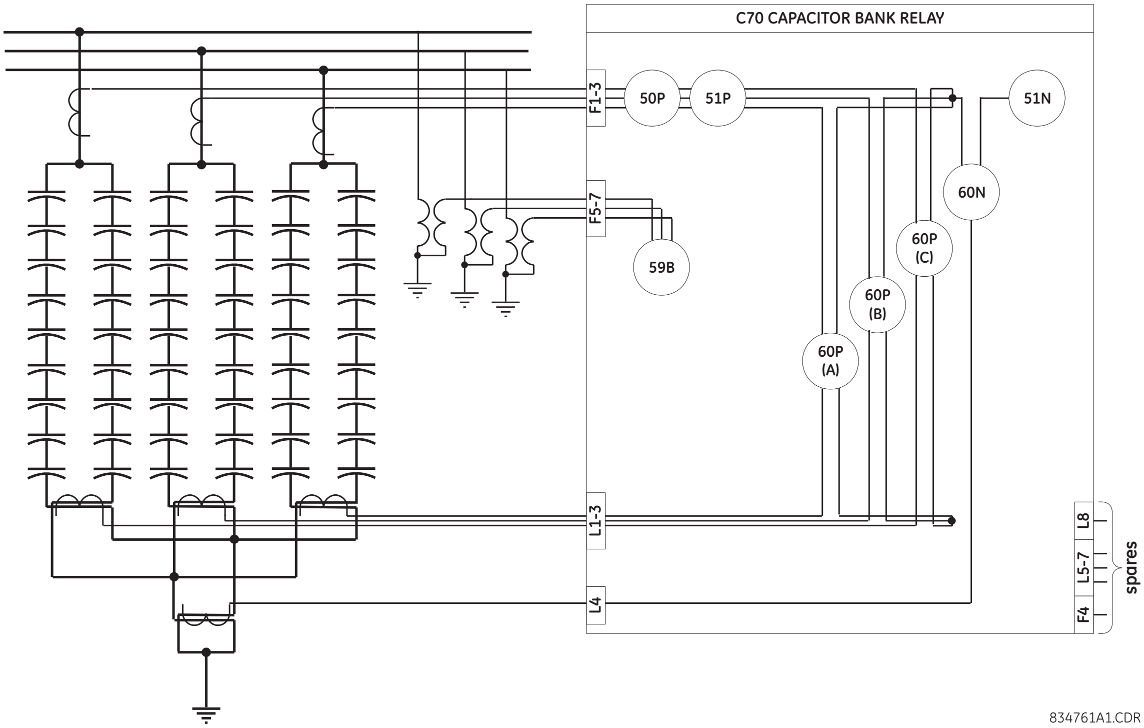


Figure 10–9: PARALLEL BANKS, GROUNDED, NO TAP AVAILABLE, CURRENT BALANCE PROTECTION

The following figure illustrates parallel capacitor banks, grounded, no tap available, with current unbalance protection and high-side CTs for each bank. In this case, two CT/VT modules are required.

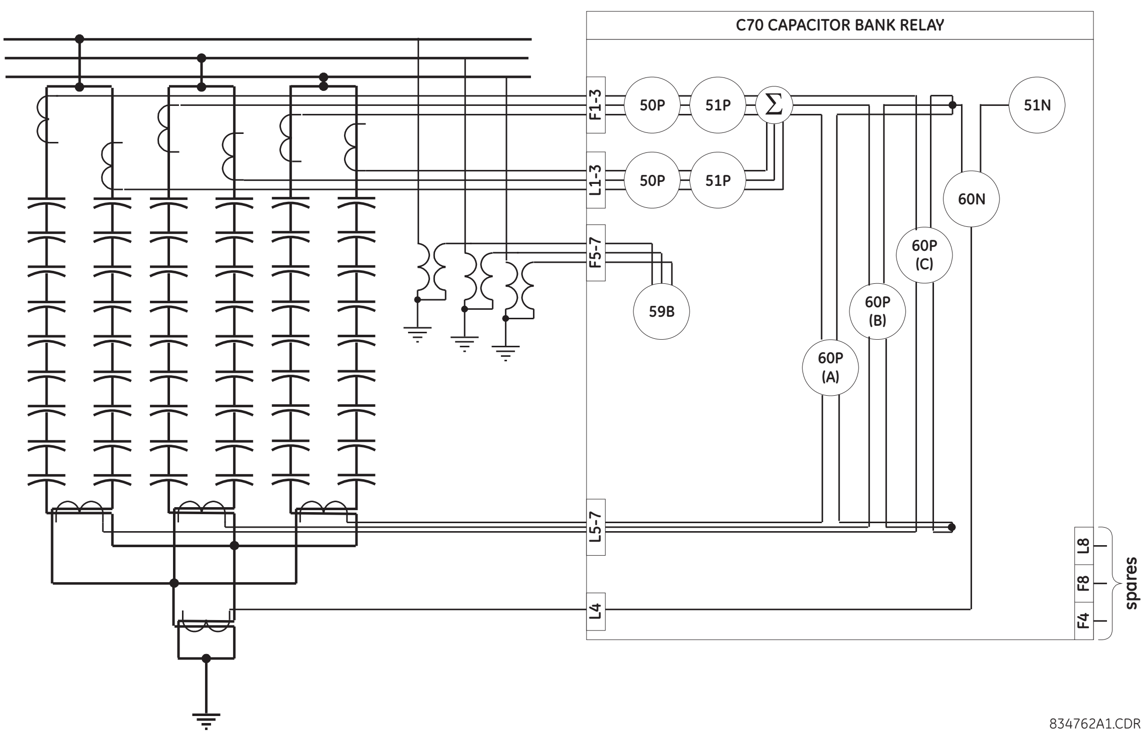


Figure 10–10: PARALLEL BANKS, GROUNDED, NO TAP, WITH CURRENT BALANCE PROTECTION AND HIGH-SIDE CTS

The following figure illustrates parallel capacitor banks, grounded, with taps and current unbalance protection. In this case, three CT/VT modules are required.

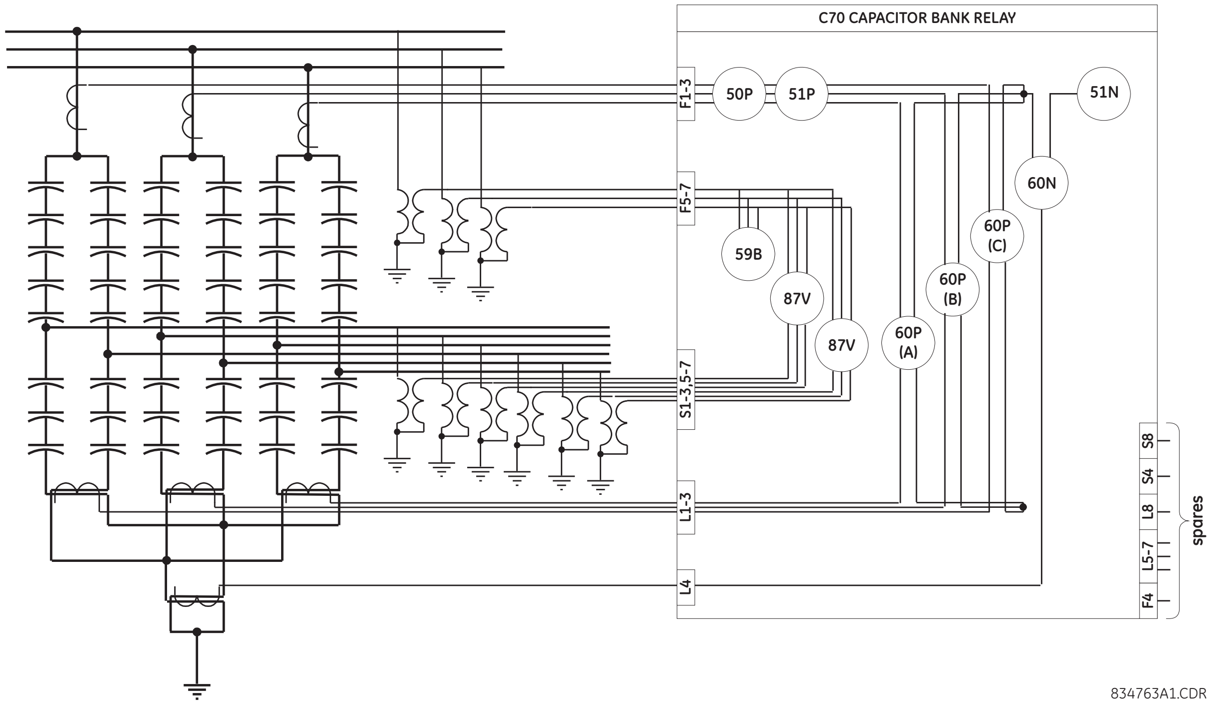


Figure 10–11: PARALLEL BANKS, GROUNDED, WITH TAPS AND CURRENT UNBALANCE PROTECTION

The normal functions of unbalance relaying are listed below.

- Trip the bank promptly if an unbalance indicates the possible presence of external arcing or a cascading fault within the capacitor bank.
- Provide early unbalance alarm signal(s) to indicate the operation of fuses (internally or externally fused capacitors) or failure of capacitor elements (fuseless or unfused capacitors).
- Trip the bank for unbalances that are large enough to indicate that continuing operation may result in the following.
  - Damage to remaining good capacitor units or elements from overvoltage.
  - Fuse malfunction.
  - Inappropriate filter operation (for capacitor banks that are a part of a harmonic filter).
  - Other undesirable consequences.

Note that there may be undetectable failure modes for each type of unbalance protection. These will need to be backed up by other types of protection.

b) UNBALANCE TRIP ELEMENT CONSIDERATIONS

The following points should be noted when using the unbalance trip element.

- The unbalance trip element time delay should be minimized to reduce damage from an arcing fault within the bank structure and prevent exposure of the remaining capacitor units to overvoltage conditions beyond their permissible limits. For a single-phase or an open-phase condition, the time delay should also be short enough to avoid damage to the current transformer or voltage transformer and to the relay system.
- The unbalance trip element should have enough time delay to avoid false operations due to inrush, system ground faults, switching of nearby equipment, and non-simultaneous pole operation of the energizing switch. For most applications, 0.1 seconds should be adequate. For unbalance relaying systems that operate on a system voltage unbalance (ground fault), a delay slightly longer than the upstream protection fault clearing time is required to avoid tripping due to a system fault. Longer delays increase the probability of catastrophic bank failure.

- With grounded capacitor banks, the failure of one pole of the switching device or the single phasing from a blown bank fuse will allow zero sequence currents to flow in system ground relays. Capacitor bank relaying, including the operating time of the switching device, should be coordinated with the operation of the system ground relays to avoid tripping system load.
- The unbalance trip element may need to be delayed to account for the settling time of the protection system on initial energization and for the transient response of certain capacitor voltage transformers, etc., which may be a part of the unbalance protection system.
- The unbalance trip scheme may include a lockout feature to prevent inadvertent closing of the capacitor bank switching device if an unbalance trip has occurred.
- To allow for the effects of inherent unbalance, the unbalance element trip should be set to operate at a signal level halfway between the critical step and the next lower step. The critical step is the number of fuse operations or shorted elements that will cause an overvoltage on healthy capacitor units in excess of 110% of the capacitor unit rated voltage or the capacitor unit manufacturer's recommended maximum continuous operating voltage. In addition, for internally fused capacitor units, the critical step may be the number of internal fuse operations at which tripping should occur as recommended by the capacitor manufacturer.
- If switch failure or single phasing due to a blown main fuse could result in the continuous voltage exceeding the relay or VT rating, additional elements in the relay should be configured to trip the bank for this condition.
- The unbalance element detects only the unbalance in the capacitor bank and in supply voltage and will not respond to capacitor overvoltage due to a balanced system voltage above nominal. The bank phase overvoltage should be configured to trip the bank for this condition.
- The maximum system operating voltage, with capacitor bank energized, should be used for setting unbalance relays.

c) UNBALANCE ALARM ELEMENT CONSIDERATIONS

To allow for the effects of inherent unbalance within the bank, the unbalance relay alarm should be set to operate at about one-half the level of the unbalance signal determined by the calculated alarm condition based on an idealized bank. The alarm should have sufficient time delay to override external disturbances.

10.3.3 PROTECTION FOR RACK FAULTS (ARC-OVER WITHIN CAPACITOR BANK)

The most effective protection for an arc-over within the capacitor bank is provided by a fast unbalance element. A short time delay for the unbalance elements minimizes the damage caused by rack faults. Intentional delays as short as 0.05 seconds have been used. This short unbalance time delay, however, should not be less than the maximum clearing time of the capacitor-unit or element fuse. Although the unbalance trip element is the most effective protection for arc detection of a series section, the neutral voltage type of unbalance element should not be relied upon for rack fault protection on capacitor banks where all three phases are not well separated.

Negative sequence elements can be used for inter-phase fault detection as they can be set to be more sensitive than phase overcurrent relays, but tripping should be delayed to coordinate with the other relays in the system. A setting of 10% of the rated capacitor current, taking into consideration the maximum system voltage unbalance and the maximum capacitance variation together with a time delay setting of 15 to 25 cycles, may provide adequate coordination for faults external to the bank. However, it may not prevent damage due to arcing faults within the bank structure.

10.3.4 OVERVOLTAGE

The capacitor bank and other equipment in the vicinity may be subjected to overvoltages resulting from abnormal system operating conditions. If the system voltage exceeds the capacitor or equipment capability with the capacitor bank on line, the bank should be removed with minimum time delay. Removing the capacitor bank from the system lowers the system voltage in the vicinity of the capacitor, reducing the overvoltage on other system elements.

Especially for very large EHV capacitor banks, it is advisable to install three-phase overvoltage protection (ANSI 59B) to trip the bank quickly for extreme overvoltage conditions. To avoid nuisance tripping during transient overvoltage conditions, in some cases, tripping is delayed by a timer. The C70 relay provides inverse time overvoltage characteristics required to decrease tripping time for large overvoltages.

Because this tripping is not due to a fault within the capacitor bank, the capacitor bank is not locked out.

10.3.5 OVERCURRENT

Phase and neutral time overcurrent elements can be applied with normal settings without encountering false operations due to inrush currents. The desirable minimum pickup is 135% of nominal phase current for grounded wye banks or 125% for ungrounded banks. Instantaneous elements (if used) should be set high to override inrush or outrush transients.

For effectively grounded systems with grounded wye capacitor banks, the high-frequency outrush current into an external ground fault will not normally operate the 51N ground element. The unbalanced capacitor bank load current caused by an external ground fault may be sufficient to cause the element to pick up and trip the capacitor bank if the 51N is set too low. To prevent this inadvertent tripping, the trip of the 51N element is normally set above the capacitor phase current.

10.3.6 LOSS OF BUS VOLTAGE

In some cases, it may be necessary to trip a shunt capacitor bank if the supply bus voltage is lost. Two conditions that may need to be considered are:

- Re-energizing a bank with a trapped charge.
- Energizing a capacitor bank without parallel load through a previously unenergized transformer.

The undervoltage element (ANSI device 27B) will detect loss of system voltage and trip the capacitor bank after a time delay. This delay prevents tripping of the bank for system faults external to the bank. The undervoltage element should be set so the element will not operate for voltages that require the capacitor bank to remain in service. Because this tripping is also not due to a fault within the capacitor bank (like system overvoltage tripping), the bank is not locked out.

10.4.1 DESCRIPTION

Consider protection of a capacitor bank with the following characteristics:

- V_{LL} = 138 kV fuseless.
- Q_B = 21 Mvar.
- Two parallel strings (S = 2) in each phase with N = 7 capacitor units rated Q_C = 500 kvar, V_C = 11.62 kV.
- Each capacitor unit consisting of n = 6 series capacitors.

Refer to the diagram below for details. Phase capacitors are connected to ground through a neutral capacitor rated Q_{CN} = 167 kvar, V_{CN} = 0.825 kV.

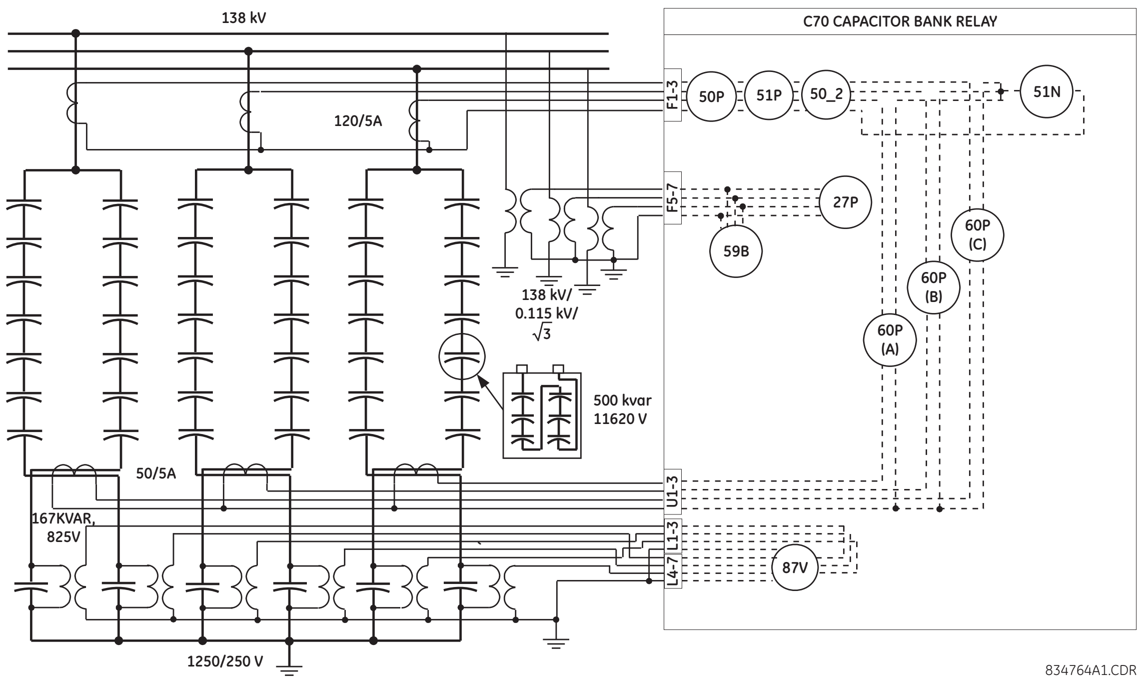


Figure 10–12: SAMPLE CAPACITOR BANK CONFIGURATION

Based on the bank configuration, CT connections, and VTs connections, a C70 model is chosen with three CT/VT modules: two type 8L modules (in slots F and U) and one type 8V module (in slot M) to provide following protection functionality.

- Negative-sequence instantaneous overcurrent (ANSI 50_2) to provide fast backup protection against arcing within capacitor bank.
- Phase overvoltage (ANSI 59B) to provide protection against overvoltages.
- Bank overcurrent protection, phase instantaneous overcurrent (ANSI 50P), neutral instantaneous overcurrent (ANSI 50N) and phase time overcurrent (ANSI 51P) to provide protection against major faults within the capacitor bank.
- Bank undervoltage (ANSI 27P) to detect loss of bus voltage and trip the bank.
- Voltage differential (ANSI 87V) to detect failure of one or more capacitor elements in a given string. Three voltage differential elements can be set for this application: one between two tap voltages (ANSI 87V-1) and two between the bus voltage and tap voltage in both strings (ANSI 87V-2 and 87V-3).
- Phase current unbalance (ANSI 60P) to detect failure of one or more capacitor elements in a given string.

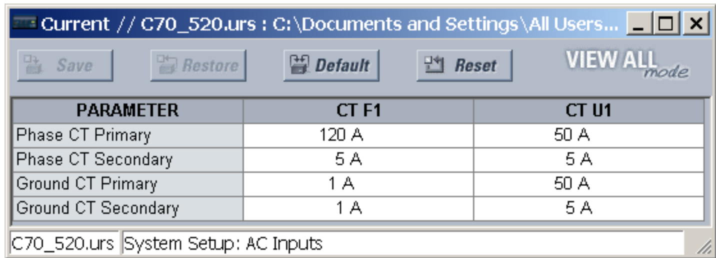
10.4.2 VT AND CT SETUP

The CT and VT connections are shown in the figure above. The CT channels are connected as follows.

- The type 8L CT/VT module F1 to F3 three-phase CT channels are connected to the bus side three-phase CTs with a 120 / 5 A ratio.

- The type 8L CT/VT module U1 to U3 three-phase CT channels are connected to the neutral side window CTs with a 50 / 5 A ratio.

The following settings are applied in the EnerVista UR Setup software.



PARAMETER	CT F1	CT U1
Phase CT Primary	120 A	50 A
Phase CT Secondary	5 A	5 A
Ground CT Primary	1 A	50 A
Ground CT Secondary	1 A	5 A

The VT channels are connected as follows.

- The type 8L CT/VT module F5 to F7 three-phase VT channels are connected to the bus side three-phase VTs with a 138 / 0.115 kV ratio.
- The type 8V CT/VT module M1 to M3 and M5 to M7 three-phase VT channels are connected to two tap VTs with a 1.25 / 0.25 kV ratio. The nominal voltage is calculated below for normal bank conditions and a nominal system voltage of 138 kV (see impedance calculations the following sub-section).

The nominal bus phase VT voltage is:

$$V_{tap(bus)} = \frac{13800}{\sqrt{3}} = 79674.34\text{ V} \qquad \textbf{(EQ 10.1)}$$

The nominal tap VT voltage is:

$$V_{tap(nominal)} = \frac{138000 \times Z_C^b}{\sqrt{3} \times Z_C^t} = \frac{13800 \times 4.08}{\sqrt{3} \times 1894.42} = 171.41\text{ V} \qquad \textbf{(EQ 10.2)}$$

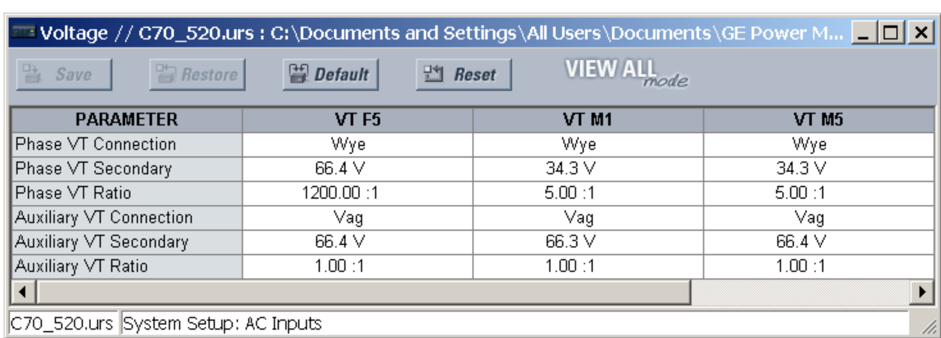
Therefore, the tap VT secondary voltage is set as:

$$V_{tap(secondary)} = \frac{V_{tap(nominal)}}{N_{tap(VT)}} = \frac{171.41\text{ V}}{5} = 34.28\text{ V} \qquad \textbf{(EQ 10.3)}$$

Where the VT ratio $N_{tap(VT)}$ is calculated as:

$$N_{tap(VT)} = \frac{125\text{ kV}}{0.25\text{ kV}} = 5 \qquad \textbf{(EQ 10.4)}$$

The following settings are applied in the EnerVista UR Setup software.



PARAMETER	VT F5	VT M1	VT M5
Phase VT Connection	Wye	Wye	Wye
Phase VT Secondary	66.4 V	34.3 V	34.3 V
Phase VT Ratio	1200.00 :1	5.00 :1	5.00 :1
Auxiliary VT Connection	Vag	Vag	Vag
Auxiliary VT Secondary	66.4 V	66.3 V	66.4 V
Auxiliary VT Ratio	1.00 :1	1.00 :1	1.00 :1

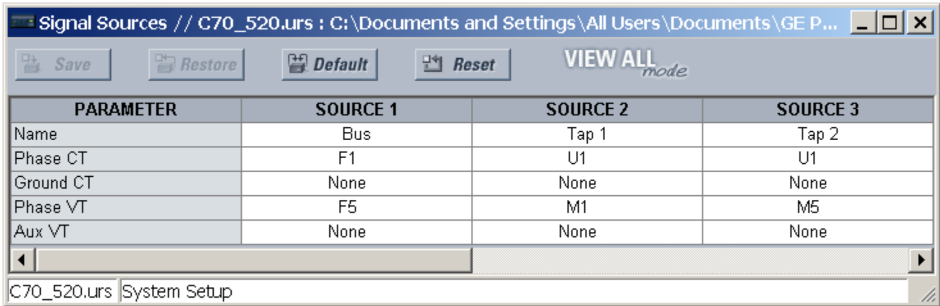
10.4.3 SOURCE ASSIGNMENT

The following sources must be assigned for the protection functions indicated.

- Source 1 (bus) is assigned with CT and VT banks connected to the bus, providing a signal source for overcurrent, phase current unbalance, overvoltage, and undervoltage functions.

- Source 2 (tap 1) and source 3 (tap 2) are assigned with the VT banks and split window CT bank connected to the tap point of two strings of the bank, providing a signal source for the voltage differential and phase unbalance functions.

The CT and VT connections shown in the figure above are assigned the following values in EnerVista UR Setup.



PARAMETER	SOURCE 1	SOURCE 2	SOURCE 3
Name	Bus	Tap 1	Tap 2
Phase CT	F1	U1	U1
Ground CT	None	None	None
Phase VT	F5	M1	M5
Aux VT	None	None	None

10.4.4 BANK UNBALANCE CALCULATIONS

The following values are used in unbalance calculations.

The impedance of one capacitor can:

$$Z_C^c = \frac{V_C^2}{Q_C} = \frac{(11.62\text{ V})^2}{500 \times 10^{-3}\text{ vars}} = 270.05\Omega \quad \textbf{(EQ 10.5)}$$

The impedance of one capacitor element, with n = 6 capacitor elements per can:

$$Z_C^e = \frac{Z_C^c}{n} = \frac{270.05\Omega}{6} = 45.01\Omega \quad \textbf{(EQ 10.6)}$$

The impedance of the top healthy capacitor string:

$$Z_C^s = Z_C^c \times N = 270.05\Omega \times 7 = 1890.34\Omega \quad \textbf{(EQ 10.7)}$$

The impedance of the bottom capacitor can:

$$Z_C^b = \frac{V_{CN}^2}{Q_{CN}} = \frac{(0.825\text{ V})^2}{0.167\text{ var}} = 4.08\ \Omega \quad \textbf{(EQ 10.8)}$$

The total impedance of the healthy capacitor string:

$$Z_C^t = Z_C^s + Z_C^b = 1890.34\Omega + 4.08\Omega = 1894.42\Omega \quad \textbf{(EQ 10.9)}$$

The maximum rated line-to-neutral system voltage:

$$V_{max} = V_C \times N + \frac{V_C \times N}{Z_C^s} \times Z_C^b = 11620\text{ V} \times 7 + \frac{11620\text{ V} \times 7}{1890.34\Omega} \times 4.08\ \Omega = 81515.37\text{ V} \quad \textbf{(EQ 10.10)}$$

The maximum rated phase current of the healthy bank:

$$I_{max} = \frac{V_{max}}{Z_C^t/2} = \frac{81515.37\text{ V}}{1894.92\Omega/2} = 86.06\text{ A} \quad \textbf{(EQ 10.11)}$$

The maximum rated voltage across the healthy top section:

$$V_{top} = \frac{V_{max} \times Z_C^s}{Z_C^t} = \frac{81515.37\text{ V} \times 1890.34\Omega}{1894.92\Omega} = 81340.40\text{ V} \quad \textbf{(EQ 10.12)}$$

The maximum rated voltage across the healthy bottom section:

$$V_{bottom} = \frac{V_{max} \times Z_C^b}{Z_C^t} = \frac{81515.37\ \text{V} \times 4.08\ \Omega}{1894.92\Omega} = 175.37\ \text{V} \quad \text{(EQ 10.13)}$$

The voltage distribution factor for the healthy perfectly balanced bank for the 87V-2 and 87V-3 elements:

$$K_{tap} = \frac{V_{top}}{V_{bottom}} = \frac{81340.40\ \text{V}}{175.37\ \text{V}} = 463.8194 \quad \text{(EQ 10.14)}$$

The impedance of the string for the failed capacitors elements (for one failed element, $n_f = 1$:

$$Z_C^{sf} = Z_C^e(N \times n - n_f) + Z_C^b = 45.01\Omega \times (7 \times 6 - 1) + 4.08\ \Omega = 1849.41\Omega \quad \text{(EQ 10.15)}$$

The voltage at the tap in the section with one failed capacitor element in the string:

$$V_{tap2} = \frac{V_{max} \times Z_C^b}{Z_C^{sf}} = \frac{81515.37\ \text{V} \times 4.08\ \Omega}{1849.91\ \Omega} = 179.64\ \text{V} \quad \text{(EQ 10.16)}$$

The voltage of the top section with one capacitor element failed:

$$V_{top} = V_{max} - V_{tap2} \quad \text{(EQ 10.17)}$$

The overvoltage at the affected capacitors with one capacitor element failed:

$$\text{OV} = \frac{V_{f(top)} \times N \times n}{V_{top} \times (N \times n - n_f)} = \frac{81335.74\ \text{V} \times 7 \times 6}{81340.40\ \text{V} \times (7 \times 6 - 1)} = 1.024\ \text{pu} \quad \text{(EQ 10.18)}$$

The differential voltage between two taps with one failed capacitor element in the upper string, assuming $K = 1$ for 87V-1, in per-unit values is:

$$V_{diff(tap)} = \left|\frac{V_{tap1} - 1 \times V_{tap2}}{\text{VT}_{nom(tap)}}\right| = \left|\frac{175.374\ \text{V} - 1 \times 179.64\ \text{V}}{171.59\ \text{V}}\right| = 0.0249\ \text{pu} \quad \text{(EQ 10.19)}$$

The differential voltage between the bus voltage and the tap with one failed capacitor element in the upper string, assuming $K = 1$, for 87V-3 in per-unit values is:

$$V_{diff(string)} = \left|\frac{V_{f(top)} - K_{tap} \times V_{tap2}}{\text{VT}_{nom(bus)}}\right| = \left|\frac{175.374\ \text{V} - 463.8194 \times 179.64\ \text{V}}{79674.34\ \text{V}}\right| = 0.0249\ \text{pu} \quad \text{(EQ 10.20)}$$

The unbalance current in the window type CT between two strings with one failed capacitor element in the upper string:

$$I_{unbal} = \left|\frac{V_{max}}{Z_C^{sf} \times \text{CT}_{tap}} - \frac{V_{max}}{Z_C^s \times \text{CT}_{tap}}\right| = \left|\frac{81515.37\ \text{V}}{1845.33\Omega \times 50} - \frac{81515.37\ \text{V}}{1890.34\Omega \times 50}\right| = 0.0209\ \text{pu} \quad \text{(EQ 10.21)}$$

The following table summarizes the calculated values for the number of failed capacitors used to set the protection elements.

Table 10–1: UNBALANCE VALUES FOR MAXIMUM SYSTEM CONDITIONS

n_f	Z_C^s	Z_C^{sf}	V_{tap1}	V_{tap2}	V_{top}	OV	$V_{diff(tap)}$	$V_{diff(string)}$	I_{unbal}
0	1894.42 Ω	1894.42 Ω	175.37 V	175.37 V	81340.00 V	1.000 pu	0.0000 pu	0.0000 pu	0.0000 pu
1	1894.42 Ω	1849.41 Ω	175.37 V	179.64 V	81335.73 V	1.024 pu	0.0249 pu	0.0249 pu	0.0209 pu
2	1894.42 Ω	1804.40 Ω	175.37 V	184.12 V	81331.25 V	1.050 pu	0.0510 pu	0.0510 pu	0.0429 pu
3	1894.42 Ω	1759.39 Ω	175.37 V	188.83 V	81326.54 V	1.077 pu	0.0785 pu	0.0785 pu	0.0660 pu
4	1894.42 Ω	1714.38 Ω	175.37 V	193.79 V	81321.58 V	1.105 pu	0.1074 pu	0.1074 pu	0.0904 pu
5	1894.42 Ω	1669.38 Ω	175.37 V	199.01 V	81316.36 V	1.135 pu	0.1379 pu	0.1379 pu	0.1160 pu
6	1894.42 Ω	1624.37 Ω	175.37 V	204.52 V	81310.85 V	1.167 pu	0.1701 pu	0.1701 pu	0.1431 pu
7	1894.42 Ω	1579.36 Ω	175.37 V	210.35 V	81305.02 V	1.200 pu	0.2041 pu	0.2041 pu	0.1717 pu
8	1894.42 Ω	1534.35 Ω	175.37 V	216.52 V	81298.85 V	1.235 pu	0.2401 pu	0.2401 pu	0.2020 pu
9	1894.42 Ω	1489.34 Ω	175.37 V	223.07 V	81292.30 V	1.273 pu	0.2783 pu	0.2783 pu	0.2341 pu
10	1894.42 Ω	1444.34 Ω	175.37 V	230.02 V	81285.35 V	1.313 pu	0.3188 pu	0.3188 pu	0.2682 pu

To check the limits of protection sensitivity, the same calculations are repeated for the minimum system conditions, which are considered to be 0.85 pu of nominal system voltage.

The minimum line to neutral system voltage is:

$$V_{min} = \frac{0.85 \times V_{nom}}{\sqrt{3}} = \frac{0.85 \times 138000\text{ V}}{\sqrt{3}} = 67723\text{ V} \quad \textbf{(EQ 10.22)}$$

The following table summarizes the unbalance values during minimum system conditions.

Table 10–2: UNBALANCE VALUES FOR MINIMUM SYSTEM CONDITIONS

n_f	Z_C^s	Z_C^{sf}	V_{tap1}	V_{tap2}	V_{top}	OV	$V_{diff(tap)}$	$V_{diff(string)}$	I_{unbal}
0	1894.42 Ω	1894.42 Ω	145.70 V	145.70 V	67577.30 V	1.000 pu	0.0000 pu	0.0000 pu	0.0000 pu
1	1894.42 Ω	1849.41 Ω	145.70 V	149.24 V	67573.76 V	1.024 pu	0.0207 pu	0.0207 pu	0.0174 pu
2	1894.42 Ω	1804.40 Ω	145.70 V	152.97 V	67570.03 V	1.050 pu	0.0424 pu	0.0424 pu	0.0357 pu
3	1894.42 Ω	1759.39 Ω	145.70 V	156.88 V	67566.12 V	1.077 pu	0.0652 pu	0.0652 pu	0.0549 pu
4	1894.42 Ω	1714.38 Ω	145.70 V	161.00 V	67562.00 V	1.105 pu	0.0893 pu	0.0893 pu	0.0751 pu
5	1894.42 Ω	1669.38 Ω	145.70 V	165.34 V	67557.66 V	1.135 pu	0.1146 pu	0.1146 pu	0.0964 pu
6	1894.42 Ω	1624.37 Ω	145.70 V	169.92 V	67553.08 V	1.167 pu	0.1413 pu	0.1413 pu	0.1189 pu
7	1894.42 Ω	1579.36 Ω	145.70 V	174.76 V	67548.24 V	1.200 pu	0.1696 pu	0.1696 pu	0.1426 pu
8	1894.42 Ω	1534.35 Ω	145.70 V	179.89 V	67543.11 V	1.235 pu	0.1995 pu	0.1995 pu	0.1678 pu
9	1894.42 Ω	1489.34 Ω	145.70 V	185.32 V	67537.68 V	1.273 pu	0.2312 pu	0.2312 pu	0.1945 pu
10	1894.42 Ω	1444.34 Ω	145.70 V	191.10 V	67531.90 V	1.313 pu	0.2649 pu	0.2649 pu	0.2228 pu

The balance values during minimum operating conditions may be used to check sensitivity.

10.4.5 BANK VOLTAGE DIFFERENTIAL SETTINGS

The bank configuration, CT location, and VT locations allow applying three voltage differential elements:

- An 87V-1 differential element measuring the differential voltage between the two bottom taps.
- An 87V-2 differential element measuring the differential voltage between the upper capacitor string and bottom capacitor can for string 1.
- An 87V-3 differential element measuring the differential voltage between the upper capacitor string and bottom capacitor can for string 2.

Two voltage differential (87V) stages provide trip and alarm levels during capacitor unit failures in each differential element. The capacitor units are subject to overvoltage if one or more capacitors units are shorted out. The voltage differential trip pickup setting is programmed for value of 110% of capacitor rated voltage. As seen from the *Unbalance values for maximum system conditions* table above, a failure of four capacitor elements causes a 10.5% overvoltage.

The pickup setting for the stage 1 differential alarm element is chosen for one element failure.

$$\text{87V alarm} = 0.9V_{diff(f1\_max)} = 0.9 \times 0.0249 \text{ pu} = 0.0224 \text{ pu} \quad \textbf{(EQ 10.23)}$$

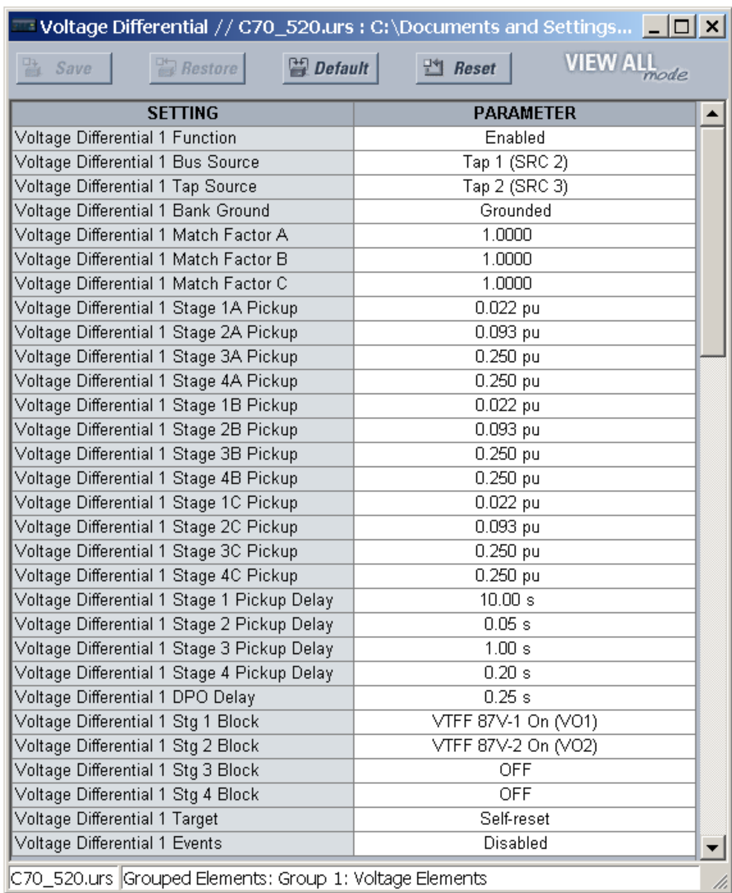
The alarm delay is set to 10 seconds to avoid alarming during transient conditions.

The pickup setting for the stage 2 differential trip element is programmed as the differential voltage during maximum system conditions midway between the third and fourth capacitor element failure differential voltages.

$$\text{87V trip} = \frac{V_{diff(f4\_max)} + V_{diff(f3\_max)}}{2} = \frac{0.1074 \text{ pu} + 0.0785 \text{ pu}}{2} = 0.093 \text{ pu} \quad \textbf{(EQ 10.24)}$$

Therefore, the trip delay is set to 50 ms.

The following setting values for the voltage differential 1 element between two tap voltages are programmed in the EnerVista UR Setup software.



SETTING	PARAMETER
Voltage Differential 1 Function	Enabled
Voltage Differential 1 Bus Source	Tap 1 (SRC 2)
Voltage Differential 1 Tap Source	Tap 2 (SRC 3)
Voltage Differential 1 Bank Ground	Grounded
Voltage Differential 1 Match Factor A	1.0000
Voltage Differential 1 Match Factor B	1.0000
Voltage Differential 1 Match Factor C	1.0000
Voltage Differential 1 Stage 1A Pickup	0.022 pu
Voltage Differential 1 Stage 2A Pickup	0.093 pu
Voltage Differential 1 Stage 3A Pickup	0.250 pu
Voltage Differential 1 Stage 4A Pickup	0.250 pu
Voltage Differential 1 Stage 1B Pickup	0.022 pu
Voltage Differential 1 Stage 2B Pickup	0.093 pu
Voltage Differential 1 Stage 3B Pickup	0.250 pu
Voltage Differential 1 Stage 4B Pickup	0.250 pu
Voltage Differential 1 Stage 1C Pickup	0.022 pu
Voltage Differential 1 Stage 2C Pickup	0.093 pu
Voltage Differential 1 Stage 3C Pickup	0.250 pu
Voltage Differential 1 Stage 4C Pickup	0.250 pu
Voltage Differential 1 Stage 1 Pickup Delay	10.00 s
Voltage Differential 1 Stage 2 Pickup Delay	0.05 s
Voltage Differential 1 Stage 3 Pickup Delay	1.00 s
Voltage Differential 1 Stage 4 Pickup Delay	0.20 s
Voltage Differential 1 DPO Delay	0.25 s
Voltage Differential 1 Stg 1 Block	VTFF 87V-1 On (VO1)
Voltage Differential 1 Stg 2 Block	VTFF 87V-2 On (VO2)
Voltage Differential 1 Stg 3 Block	OFF
Voltage Differential 1 Stg 4 Block	OFF
Voltage Differential 1 Target	Self-reset
Voltage Differential 1 Events	Disabled

Note that match factor shown above assumes perfect bank balance. This must be adjusted when the bank is energized during the differential function auto-setting procedure tune up.

The voltage differential element must be blocked during a VT fuse failure at any tap. The voltage differential element is dependent on both source VTs. These VTs must be blocked if one or both of them has a VT fuse failure condition. Therefore, as shown in the following figure, a blocking input for each element is created with FlexLogic™.

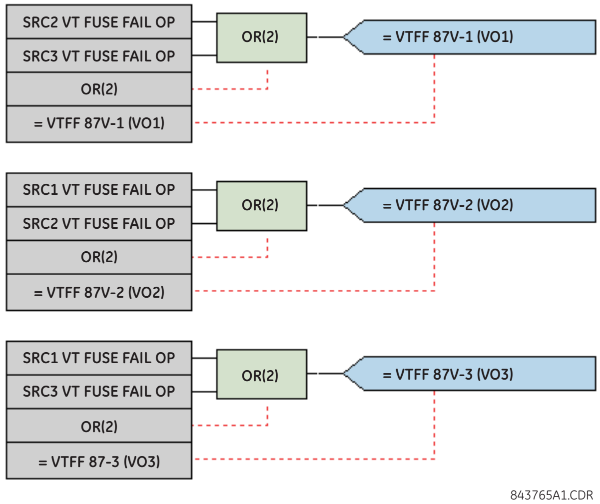


Figure 10–13: VOLTAGE DIFFERENTIAL BLOCKING DURING VT FUSE FAILURE

The 87V-2 and 87V-3 differential elements for the strings against tap voltage are created in a similar manner. In these cases, the *K* factor will be different, reflecting the voltage division of *K* = 463.8194 between the string and tap capacitor voltages.

10.4.6 BANK PHASE CURRENT UNBALANCE SETTINGS

Two phase current unbalance (ANSI 60P) stages are used to provide trip and alarm levels during capacitor unit failures in each differential element.

The pickup setting for the stage 1 phase current unbalance alarm element is programmed for one element failure.

$$\text{60P alarm} = 0.9 I_{unbal(f1\_max)} = 0.9 \times 0.0209 \text{ pu} = 0.019 \text{ pu} \quad \textbf{(EQ 10.25)}$$

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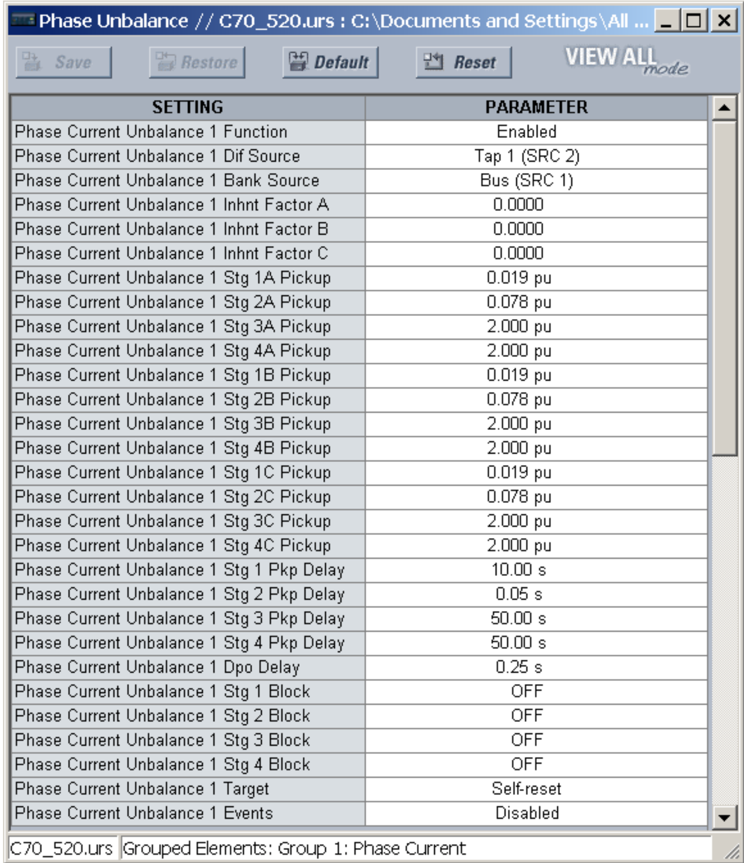
Therefore, the alarm delay is specified as 10 seconds. The following setting values are programmed in the EnerVista UR Setup software.



SETTING	PARAMETER
Phase Current Unbalance 1 Function	Enabled
Phase Current Unbalance 1 Dif Source	Tap 1 (SRC 2)
Phase Current Unbalance 1 Bank Source	Bus (SRC 1)
Phase Current Unbalance 1 Inhnt Factor A	0.0000
Phase Current Unbalance 1 Inhnt Factor B	0.0000
Phase Current Unbalance 1 Inhnt Factor C	0.0000
Phase Current Unbalance 1 Stg 1A Pickup	0.019 pu
Phase Current Unbalance 1 Stg 2A Pickup	0.078 pu
Phase Current Unbalance 1 Stg 3A Pickup	2.000 pu
Phase Current Unbalance 1 Stg 4A Pickup	2.000 pu
Phase Current Unbalance 1 Stg 1B Pickup	0.019 pu
Phase Current Unbalance 1 Stg 2B Pickup	0.078 pu
Phase Current Unbalance 1 Stg 3B Pickup	2.000 pu
Phase Current Unbalance 1 Stg 4B Pickup	2.000 pu
Phase Current Unbalance 1 Stg 1C Pickup	0.019 pu
Phase Current Unbalance 1 Stg 2C Pickup	0.078 pu
Phase Current Unbalance 1 Stg 3C Pickup	2.000 pu
Phase Current Unbalance 1 Stg 4C Pickup	2.000 pu
Phase Current Unbalance 1 Stg 1 Pkp Delay	10.00 s
Phase Current Unbalance 1 Stg 2 Pkp Delay	0.05 s
Phase Current Unbalance 1 Stg 3 Pkp Delay	50.00 s
Phase Current Unbalance 1 Stg 4 Pkp Delay	50.00 s
Phase Current Unbalance 1 Dpo Delay	0.25 s
Phase Current Unbalance 1 Stg 1 Block	OFF
Phase Current Unbalance 1 Stg 2 Block	OFF
Phase Current Unbalance 1 Stg 3 Block	OFF
Phase Current Unbalance 1 Stg 4 Block	OFF
Phase Current Unbalance 1 Target	Self-reset
Phase Current Unbalance 1 Events	Disabled

The pickup setting for the stage 2 current unbalance trip element is specified as the unbalance current during maximum system conditions midway between the third and fourth capacitor element failure unbalance currents.

$$\text{60P trip} = \frac{I_{unbal(f4\_max)} + I_{unbal(f3\_max)}}{2} = \frac{0.0904\text{ pu} + 0.0660\text{ pu}}{2} = 0.078\text{ pu} \quad \textbf{(EQ 10.26)}$$

Therefore, the trip delay is chosen 50 ms.

10.4.7 BANK PHASE OVERVOLTAGE SETTINGS

To protect the capacitor bank from overvoltage resulting from abnormal system conditions, the capability of the bank to withstand transient overvoltages must be evaluated according to the IEEE 1036-1992 standard or to manufacturer specifications. For example, consider the following manufacturer overvoltage data:

- 2 pu overvoltage toleration for 0.25 second.
- 1.5 pu overvoltage toleration for 15 seconds.
- 1.25 pu overvoltage toleration for 5 minutes.

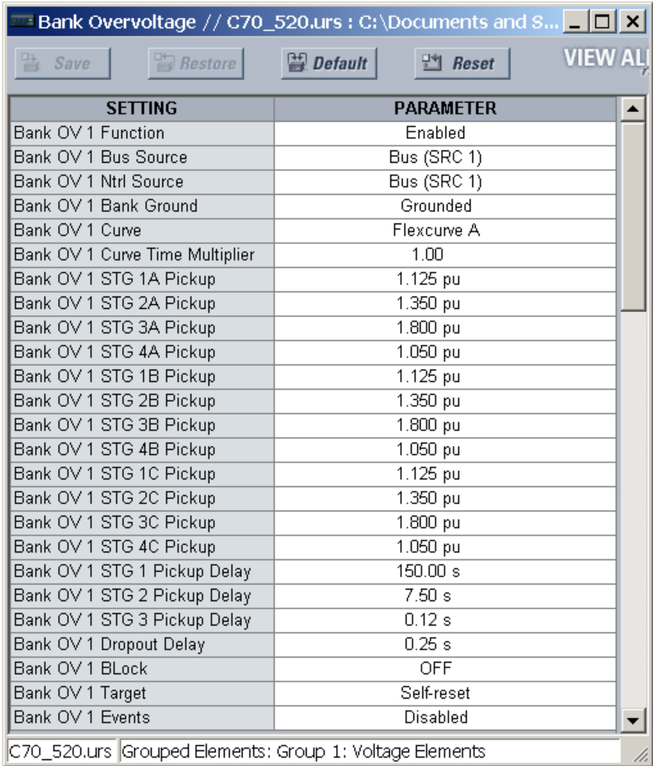
When the relay settings are calculated, the number of prospective overvoltage transients stressing the capacitor insulation during the bank lifetime must be taken into account. As such, it is preferable to set the relay conservatively.

Based on the manufacturer overvoltage data above, three overvoltage trip stages are applied using a factor of 0.9 for the stage pickup overvoltage levels and half of the allowable time indicated above.

$$\begin{aligned} \text{59B pickup (stage 1)} &= 0.9 \times 1.25 = 1.125\text{ pu} \\ \text{59B pickup (stage 2)} &= 0.9 \times 1.5 = 1.35\text{ pu} \\ \text{59B pickup (stage 3)} &= 0.9 \times 2 = 1.80\text{ pu} \end{aligned} \quad \textbf{(EQ 10.27)}$$

$$\begin{aligned} \text{59B delay (stage 1)} &= 0.5 \times 5 \times 60 = 150 \text{ seconds} \\ \text{59B delay (stage 2)} &= 0.5 \times 15 = 7.5 \text{ seconds} \\ \text{59B delay (stage 3)} &= 0.5 \times 0.25 = 0.125 \text{ seconds} \end{aligned} \quad \textbf{(EQ 10.28)}$$

The following setting values are programmed in the EnerVista UR Setup software.

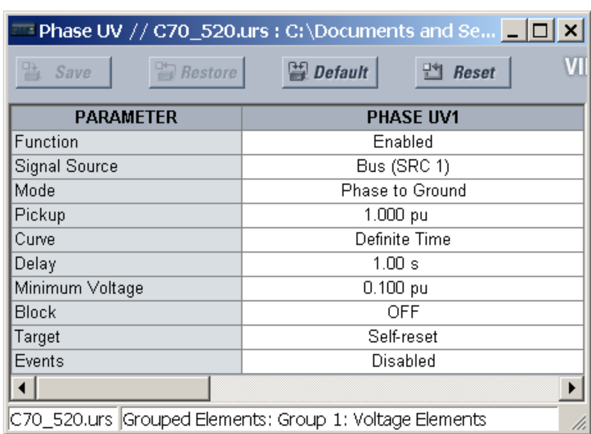


SETTING	PARAMETER
Bank OV 1 Function	Enabled
Bank OV 1 Bus Source	Bus (SRC 1)
Bank OV 1 Ntrl Source	Bus (SRC 1)
Bank OV 1 Bank Ground	Grounded
Bank OV 1 Curve	Flexcurve A
Bank OV 1 Curve Time Multiplier	1.00
Bank OV 1 STG 1A Pickup	1.125 pu
Bank OV 1 STG 2A Pickup	1.350 pu
Bank OV 1 STG 3A Pickup	1.800 pu
Bank OV 1 STG 4A Pickup	1.050 pu
Bank OV 1 STG 1B Pickup	1.125 pu
Bank OV 1 STG 2B Pickup	1.350 pu
Bank OV 1 STG 3B Pickup	1.800 pu
Bank OV 1 STG 4B Pickup	1.050 pu
Bank OV 1 STG 1C Pickup	1.125 pu
Bank OV 1 STG 2C Pickup	1.350 pu
Bank OV 1 STG 3C Pickup	1.800 pu
Bank OV 1 STG 4C Pickup	1.050 pu
Bank OV 1 STG 1 Pickup Delay	150.00 s
Bank OV 1 STG 2 Pickup Delay	7.50 s
Bank OV 1 STG 3 Pickup Delay	0.12 s
Bank OV 1 Dropout Delay	0.25 s
Bank OV 1 BLock	OFF
Bank OV 1 Target	Self-reset
Bank OV 1 Events	Disabled

10.4.8 BANK PHASE UNDERVOLTAGE SETTINGS

Bank undervoltage protection is required to take bank out-of-service when the supply bus voltage is lost. The pickup setting is specified as 0.7 pu with a time delay of 1 second, based on maximum fault clearing time. The bank undervoltage element is blocked during VT fuse fail conditions.

The following setting values are programmed in the EnerVista UR Setup software.



PARAMETER	PHASE UV1
Function	Enabled
Signal Source	Bus (SRC 1)
Mode	Phase to Ground
Pickup	1.000 pu
Curve	Definite Time
Delay	1.00 s
Minimum Voltage	0.100 pu
Block	OFF
Target	Self-reset
Events	Disabled

10.4.9 BANK OVERCURRENT PROTECTION

Bank overcurrent protection is required to protect capacitor banks against major faults, such as line-to-line or line-to-ground faults. It is desirable to set overcurrent protection to be as low and as fast as possible, with only enough delay to avoid tripping on external system disturbances.

During bank energization, the capacitor charge current inrush may cause significant neutral currents approaching the bank phase current levels. Also, during a system SLG fault, unbalanced bank neutral currents can be as high as bank phase currents. Because of these considerations, the neutral time overcurrent pickup is programmed equal to the phase time overcurrent pickup and is set to 1.25 pu. The delay for these elements should be specified longer than the maximum system fault clearing time (for example 0.5 second).

The phase instantaneous overcurrent element can be set to a value three to four times the capacitor bank rated current to override back-to-back bank switching.

Negative-sequence instantaneous overcurrent protection is required to provide backup protection for phase current unbalance during rack faults in the banks where phase capacitors are not well separated. Programming the negative-sequence instantaneous overcurrent pickup at 10% of the nominal bank phase current with a delay of 250 to 400 ms typically provides adequate coordination for faults external to the bank and protection for internal rack faults.

A.1.1 FLEXANALOG ITEMS

Table A–1: FLEXANALOG DATA ITEMS (Sheet 1 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
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
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

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 2 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
6244	SRC 2 Igd Angle	Amps	Source 2 differential ground current angle
6272	SRC 3 Ia RMS	Amps	Source 3 phase A current RMS
6274	SRC 3 Ib RMS	Amps	Source 3 phase B current RMS
6276	SRC 3 Ic RMS	Amps	Source 3 phase C current RMS
6278	SRC 3 In RMS	Amps	Source 3 neutral current RMS
6280	SRC 3 Ia Mag	Amps	Source 3 phase A current magnitude
6282	SRC 3 Ia Angle	Degrees	Source 3 phase A current angle
6283	SRC 3 Ib Mag	Amps	Source 3 phase B current magnitude
6285	SRC 3 Ib Angle	Degrees	Source 3 phase B current angle
6286	SRC 3 Ic Mag	Amps	Source 3 phase C current magnitude
6288	SRC 3 Ic Angle	Degrees	Source 3 phase C current angle
6289	SRC 3 In Mag	Amps	Source 3 neutral current magnitude
6291	SRC 3 In Angle	Degrees	Source 3 neutral current angle
6292	SRC 3 Ig RMS	Amps	Source 3 ground current RMS
6294	SRC 3 Ig Mag	Degrees	Source 3 ground current magnitude
6296	SRC 3 Ig Angle	Amps	Source 3 ground current angle
6297	SRC 3 I_0 Mag	Degrees	Source 3 zero-sequence current magnitude
6299	SRC 3 I_0 Angle	Amps	Source 3 zero-sequence current angle
6300	SRC 3 I_1 Mag	Degrees	Source 3 positive-sequence current magnitude
6302	SRC 3 I_1 Angle	Amps	Source 3 positive-sequence current angle
6303	SRC 3 I_2 Mag	Degrees	Source 3 negative-sequence current magnitude
6305	SRC 3 I_2 Angle	Amps	Source 3 negative-sequence current angle
6306	SRC 3 Igd Mag	Degrees	Source 3 differential ground current magnitude
6308	SRC 3 Igd Angle	Amps	Source 3 differential ground current angle
6336	SRC 4 Ia RMS	Amps	Source 4 phase A current RMS
6338	SRC 4 Ib RMS	Amps	Source 4 phase B current RMS
6340	SRC 4 Ic RMS	Amps	Source 4 phase C current RMS
6342	SRC 4 In RMS	Amps	Source 4 neutral current RMS
6344	SRC 4 Ia Mag	Amps	Source 4 phase A current magnitude
6346	SRC 4 Ia Angle	Degrees	Source 4 phase A current angle
6347	SRC 4 Ib Mag	Amps	Source 4 phase B current magnitude
6349	SRC 4 Ib Angle	Degrees	Source 4 phase B current angle
6350	SRC 4 Ic Mag	Amps	Source 4 phase C current magnitude
6352	SRC 4 Ic Angle	Degrees	Source 4 phase C current angle
6353	SRC 4 In Mag	Amps	Source 4 neutral current magnitude
6355	SRC 4 In Angle	Degrees	Source 4 neutral current angle
6356	SRC 4 Ig RMS	Amps	Source 4 ground current RMS
6358	SRC 4 Ig Mag	Degrees	Source 4 ground current magnitude
6360	SRC 4 Ig Angle	Amps	Source 4 ground current angle
6361	SRC 4 I_0 Mag	Degrees	Source 4 zero-sequence current magnitude
6363	SRC 4 I_0 Angle	Amps	Source 4 zero-sequence current angle
6364	SRC 4 I_1 Mag	Degrees	Source 4 positive-sequence current magnitude
6366	SRC 4 I_1 Angle	Amps	Source 4 positive-sequence current angle
6367	SRC 4 I_2 Mag	Degrees	Source 4 negative-sequence current magnitude
6369	SRC 4 I_2 Angle	Amps	Source 4 negative-sequence current angle
6370	SRC 4 Igd Mag	Degrees	Source 4 differential ground current magnitude
6372	SRC 4 Igd Angle	Amps	Source 4 differential ground current angle

Table A–1: FLEXANALOG DATA ITEMS (Sheet 3 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
6400	SRC 5 Ia RMS	Amps	Source 5 phase A current RMS
6402	SRC 5 Ib RMS	Amps	Source 5 phase B current RMS
6404	SRC 5 Ic RMS	Amps	Source 5 phase C current RMS
6406	SRC 5 In RMS	Amps	Source 5 neutral current RMS
6408	SRC 5 Ia Mag	Amps	Source 5 phase A current magnitude
6410	SRC 5 Ia Angle	Degrees	Source 5 phase A current angle
6411	SRC 5 Ib Mag	Amps	Source 5 phase B current magnitude
6413	SRC 5 Ib Angle	Degrees	Source 5 phase B current angle
6414	SRC 5 Ic Mag	Amps	Source 5 phase C current magnitude
6416	SRC 5 Ic Angle	Degrees	Source 5 phase C current angle
6417	SRC 5 In Mag	Amps	Source 5 neutral current magnitude
6419	SRC 5 In Angle	Degrees	Source 5 neutral current angle
6420	SRC 5 Ig RMS	Amps	Source 5 ground current RMS
6422	SRC 5 Ig Mag	Degrees	Source 5 ground current magnitude
6424	SRC 5 Ig Angle	Amps	Source 5 ground current angle
6425	SRC 5 I_0 Mag	Degrees	Source 5 zero-sequence current magnitude
6427	SRC 5 I_0 Angle	Amps	Source 5 zero-sequence current angle
6428	SRC 5 I_1 Mag	Degrees	Source 5 positive-sequence current magnitude
6430	SRC 5 I_1 Angle	Amps	Source 5 positive-sequence current angle
6431	SRC 5 I_2 Mag	Degrees	Source 5 negative-sequence current magnitude
6433	SRC 5 I_2 Angle	Amps	Source 5 negative-sequence current angle
6434	SRC 5 Igd Mag	Degrees	Source 5 differential ground current magnitude
6436	SRC 5 Igd Angle	Amps	Source 5 differential ground current angle
6464	SRC 6 Ia RMS	Amps	Source 6 phase A current RMS
6466	SRC 6 Ib RMS	Amps	Source 6 phase B current RMS
6468	SRC 6 Ic RMS	Amps	Source 6 phase C current RMS
6470	SRC 6 In RMS	Amps	Source 6 neutral current RMS
6472	SRC 6 Ia Mag	Amps	Source 6 phase A current magnitude
6474	SRC 6 Ia Angle	Degrees	Source 6 phase A current angle
6475	SRC 6 Ib Mag	Amps	Source 6 phase B current magnitude
6477	SRC 6 Ib Angle	Degrees	Source 6 phase B current angle
6478	SRC 6 Ic Mag	Amps	Source 6 phase C current magnitude
6480	SRC 6 Ic Angle	Degrees	Source 6 phase C current angle
6481	SRC 6 In Mag	Amps	Source 6 neutral current magnitude
6483	SRC 6 In Angle	Degrees	Source 6 neutral current angle
6484	SRC 6 Ig RMS	Amps	Source 6 ground current RMS
6486	SRC 6 Ig Mag	Degrees	Source 6 ground current magnitude
6488	SRC 6 Ig Angle	Amps	Source 6 ground current angle
6489	SRC 6 I_0 Mag	Degrees	Source 6 zero-sequence current magnitude
6491	SRC 6 I_0 Angle	Amps	Source 6 zero-sequence current angle
6492	SRC 6 I_1 Mag	Degrees	Source 6 positive-sequence current magnitude
6494	SRC 6 I_1 Angle	Amps	Source 6 positive-sequence current angle
6495	SRC 6 I_2 Mag	Degrees	Source 6 negative-sequence current magnitude
6497	SRC 6 I_2 Angle	Amps	Source 6 negative-sequence current angle
6498	SRC 6 Igd Mag	Degrees	Source 6 differential ground current magnitude
6500	SRC 6 Igd Angle	Amps	Source 6 differential ground current angle
6656	SRC 1 Vag RMS	Volts	Source 1 phase AG voltage RMS

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 4 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
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
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

Table A–1: FLEXANALOG DATA ITEMS (Sheet 5 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
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
6784	SRC 3 Vag RMS	Volts	Source 3 phase AG voltage RMS
6786	SRC 3 Vbg RMS	Volts	Source 3 phase BG voltage RMS
6788	SRC 3 Vcg RMS	Volts	Source 3 phase CG voltage RMS
6790	SRC 3 Vag Mag	Volts	Source 3 phase AG voltage magnitude
6792	SRC 3 Vag Angle	Degrees	Source 3 phase AG voltage angle
6793	SRC 3 Vbg Mag	Volts	Source 3 phase BG voltage magnitude
6795	SRC 3 Vbg Angle	Degrees	Source 3 phase BG voltage angle
6796	SRC 3 Vcg Mag	Volts	Source 3 phase CG voltage magnitude
6798	SRC 3 Vcg Angle	Degrees	Source 3 phase CG voltage angle
6799	SRC 3 Vab RMS	Volts	Source 3 phase AB voltage RMS
6801	SRC 3 Vbc RMS	Volts	Source 3 phase BC voltage RMS
6803	SRC 3 Vca RMS	Volts	Source 3 phase CA voltage RMS
6805	SRC 3 Vab Mag	Volts	Source 3 phase AB voltage magnitude
6807	SRC 3 Vab Angle	Degrees	Source 3 phase AB voltage angle
6808	SRC 3 Vbc Mag	Volts	Source 3 phase BC voltage magnitude
6810	SRC 3 Vbc Angle	Degrees	Source 3 phase BC voltage angle
6811	SRC 3 Vca Mag	Volts	Source 3 phase CA voltage magnitude
6813	SRC 3 Vca Angle	Degrees	Source 3 phase CA voltage angle
6814	SRC 3 Vx RMS	Volts	Source 3 auxiliary voltage RMS
6816	SRC 3 Vx Mag	Volts	Source 3 auxiliary voltage magnitude
6818	SRC 3 Vx Angle	Degrees	Source 3 auxiliary voltage angle
6819	SRC 3 V_0 Mag	Volts	Source 3 zero-sequence voltage magnitude
6821	SRC 3 V_0 Angle	Degrees	Source 3 zero-sequence voltage angle
6822	SRC 3 V_1 Mag	Volts	Source 3 positive-sequence voltage magnitude
6824	SRC 3 V_1 Angle	Degrees	Source 3 positive-sequence voltage angle
6825	SRC 3 V_2 Mag	Volts	Source 3 negative-sequence voltage magnitude
6827	SRC 3 V_2 Angle	Degrees	Source 3 negative-sequence voltage angle
6848	SRC 4 Vag RMS	Volts	Source 4 phase AG voltage RMS
6850	SRC 4 Vbg RMS	Volts	Source 4 phase BG voltage RMS
6852	SRC 4 Vcg RMS	Volts	Source 4 phase CG voltage RMS
6854	SRC 4 Vag Mag	Volts	Source 4 phase AG voltage magnitude
6856	SRC 4 Vag Angle	Degrees	Source 4 phase AG voltage angle
6857	SRC 4 Vbg Mag	Volts	Source 4 phase BG voltage magnitude
6859	SRC 4 Vbg Angle	Degrees	Source 4 phase BG voltage angle
6860	SRC 4 Vcg Mag	Volts	Source 4 phase CG voltage magnitude
6862	SRC 4 Vcg Angle	Degrees	Source 4 phase CG voltage angle
6863	SRC 4 Vab RMS	Volts	Source 4 phase AB voltage RMS
6865	SRC 4 Vbc RMS	Volts	Source 4 phase BC voltage RMS
6867	SRC 4 Vca RMS	Volts	Source 4 phase CA voltage RMS
6869	SRC 4 Vab Mag	Volts	Source 4 phase AB voltage magnitude
6871	SRC 4 Vab Angle	Degrees	Source 4 phase AB voltage angle

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 6 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
6872	SRC 4 Vbc Mag	Volts	Source 4 phase BC voltage magnitude
6874	SRC 4 Vbc Angle	Degrees	Source 4 phase BC voltage angle
6875	SRC 4 Vca Mag	Volts	Source 4 phase CA voltage magnitude
6877	SRC 4 Vca Angle	Degrees	Source 4 phase CA voltage angle
6878	SRC 4 Vx RMS	Volts	Source 4 auxiliary voltage RMS
6880	SRC 4 Vx Mag	Volts	Source 4 auxiliary voltage magnitude
6882	SRC 4 Vx Angle	Degrees	Source 4 auxiliary voltage angle
6883	SRC 4 V_0 Mag	Volts	Source 4 zero-sequence voltage magnitude
6885	SRC 4 V_0 Angle	Degrees	Source 4 zero-sequence voltage angle
6886	SRC 4 V_1 Mag	Volts	Source 4 positive-sequence voltage magnitude
6888	SRC 4 V_1 Angle	Degrees	Source 4 positive-sequence voltage angle
6889	SRC 4 V_2 Mag	Volts	Source 4 negative-sequence voltage magnitude
6891	SRC 4 V_2 Angle	Degrees	Source 4 negative-sequence voltage angle
6912	SRC 5 Vag RMS	Volts	Source 5 phase AG voltage RMS
6914	SRC 5 Vbg RMS	Volts	Source 5 phase BG voltage RMS
6916	SRC 5 Vcg RMS	Volts	Source 5 phase CG voltage RMS
6918	SRC 5 Vag Mag	Volts	Source 5 phase AG voltage magnitude
6920	SRC 5 Vag Angle	Degrees	Source 5 phase AG voltage angle
6921	SRC 5 Vbg Mag	Volts	Source 5 phase BG voltage magnitude
6923	SRC 5 Vbg Angle	Degrees	Source 5 phase BG voltage angle
6924	SRC 5 Vcg Mag	Volts	Source 5 phase CG voltage magnitude
6926	SRC 5 Vcg Angle	Degrees	Source 5 phase CG voltage angle
6927	SRC 5 Vab RMS	Volts	Source 5 phase AB voltage RMS
6929	SRC 5 Vbc RMS	Volts	Source 5 phase BC voltage RMS
6931	SRC 5 Vca RMS	Volts	Source 5 phase CA voltage RMS
6933	SRC 5 Vab Mag	Volts	Source 5 phase AB voltage magnitude
6935	SRC 5 Vab Angle	Degrees	Source 5 phase AB voltage angle
6936	SRC 5 Vbc Mag	Volts	Source 5 phase BC voltage magnitude
6938	SRC 5 Vbc Angle	Degrees	Source 5 phase BC voltage angle
6939	SRC 5 Vca Mag	Volts	Source 5 phase CA voltage magnitude
6941	SRC 5 Vca Angle	Degrees	Source 5 phase CA voltage angle
6942	SRC 5 Vx RMS	Volts	Source 5 auxiliary voltage RMS
6944	SRC 5 Vx Mag	Volts	Source 5 auxiliary voltage magnitude
6946	SRC 5 Vx Angle	Degrees	Source 5 auxiliary voltage angle
6947	SRC 5 V_0 Mag	Volts	Source 5 zero-sequence voltage magnitude
6949	SRC 5 V_0 Angle	Degrees	Source 5 zero-sequence voltage angle
6950	SRC 5 V_1 Mag	Volts	Source 5 positive-sequence voltage magnitude
6952	SRC 5 V_1 Angle	Degrees	Source 5 positive-sequence voltage angle
6953	SRC 5 V_2 Mag	Volts	Source 5 negative-sequence voltage magnitude
6955	SRC 5 V_2 Angle	Degrees	Source 5 negative-sequence voltage angle
6976	SRC 6 Vag RMS	Volts	Source 6 phase AG voltage RMS
6978	SRC 6 Vbg RMS	Volts	Source 6 phase BG voltage RMS
6980	SRC 6 Vcg RMS	Volts	Source 6 phase CG voltage RMS
6982	SRC 6 Vag Mag	Volts	Source 6 phase AG voltage magnitude
6984	SRC 6 Vag Angle	Degrees	Source 6 phase AG voltage angle
6985	SRC 6 Vbg Mag	Volts	Source 6 phase BG voltage magnitude
6987	SRC 6 Vbg Angle	Degrees	Source 6 phase BG voltage angle

Table A–1: FLEXANALOG DATA ITEMS (Sheet 7 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
6988	SRC 6 Vcg Mag	Volts	Source 6 phase CG voltage magnitude
6990	SRC 6 Vcg Angle	Degrees	Source 6 phase CG voltage angle
6991	SRC 6 Vab RMS	Volts	Source 6 phase AB voltage RMS
6993	SRC 6 Vbc RMS	Volts	Source 6 phase BC voltage RMS
6995	SRC 6 Vca RMS	Volts	Source 6 phase CA voltage RMS
6997	SRC 6 Vab Mag	Volts	Source 6 phase AB voltage magnitude
6999	SRC 6 Vab Angle	Degrees	Source 6 phase AB voltage angle
7000	SRC 6 Vbc Mag	Volts	Source 6 phase BC voltage magnitude
7002	SRC 6 Vbc Angle	Degrees	Source 6 phase BC voltage angle
7003	SRC 6 Vca Mag	Volts	Source 6 phase CA voltage magnitude
7005	SRC 6 Vca Angle	Degrees	Source 6 phase CA voltage angle
7006	SRC 6 Vx RMS	Volts	Source 6 auxiliary voltage RMS
7008	SRC 6 Vx Mag	Volts	Source 6 auxiliary voltage magnitude
7010	SRC 6 Vx Angle	Degrees	Source 6 auxiliary voltage angle
7011	SRC 6 V_0 Mag	Volts	Source 6 zero-sequence voltage magnitude
7013	SRC 6 V_0 Angle	Degrees	Source 6 zero-sequence voltage angle
7014	SRC 6 V_1 Mag	Volts	Source 6 positive-sequence voltage magnitude
7016	SRC 6 V_1 Angle	Degrees	Source 6 positive-sequence voltage angle
7017	SRC 6 V_2 Mag	Volts	Source 6 negative-sequence voltage magnitude
7019	SRC 6 V_2 Angle	Degrees	Source 6 negative-sequence voltage angle
7168	SRC 1 P	Watts	Source 1 three-phase real power
7170	SRC 1 Pa	Watts	Source 1 phase A real power
7172	SRC 1 Pb	Watts	Source 1 phase B real power
7174	SRC 1 Pc	Watts	Source 1 phase C real power
7176	SRC 1 Q	Vars	Source 1 three-phase reactive power
7178	SRC 1 Qa	Vars	Source 1 phase A reactive power
7180	SRC 1 Qb	Vars	Source 1 phase B reactive power
7182	SRC 1 Qc	Vars	Source 1 phase C reactive power
7184	SRC 1 S	VA	Source 1 three-phase apparent power
7186	SRC 1 Sa	VA	Source 1 phase A apparent power
7188	SRC 1 Sb	VA	Source 1 phase B apparent power
7190	SRC 1 Sc	VA	Source 1 phase C apparent power
7192	SRC 1 PF	---	Source 1 three-phase power factor
7193	SRC 1 Phase A PF	---	Source 1 phase A power factor
7194	SRC 1 Phase B PF	---	Source 1 phase B power factor
7195	SRC 1 Phase C PF	---	Source 1 phase C power factor
7200	SRC 2 P	Watts	Source 2 three-phase real power
7202	SRC 2 Pa	Watts	Source 2 phase A real power
7204	SRC 2 Pb	Watts	Source 2 phase B real power
7206	SRC 2 Pc	Watts	Source 2 phase C real power
7208	SRC 2 Q	Vars	Source 2 three-phase reactive power
7210	SRC 2 Qa	Vars	Source 2 phase A reactive power
7212	SRC 2 Qb	Vars	Source 2 phase B reactive power
7214	SRC 2 Qc	Vars	Source 2 phase C reactive power
7216	SRC 2 S	VA	Source 2 three-phase apparent power
7218	SRC 2 Sa	VA	Source 2 phase A apparent power
7220	SRC 2 Sb	VA	Source 2 phase B apparent power

Table A–1: FLEXANALOG DATA ITEMS (Sheet 8 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
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
7232	SRC 3 P	Watts	Source 3 three-phase real power
7234	SRC 3 Pa	Watts	Source 3 phase A real power
7236	SRC 3 Pb	Watts	Source 3 phase B real power
7238	SRC 3 Pc	Watts	Source 3 phase C real power
7240	SRC 3 Q	Vars	Source 3 three-phase reactive power
7242	SRC 3 Qa	Vars	Source 3 phase A reactive power
7244	SRC 3 Qb	Vars	Source 3 phase B reactive power
7246	SRC 3 Qc	Vars	Source 3 phase C reactive power
7248	SRC 3 S	VA	Source 3 three-phase apparent power
7250	SRC 3 Sa	VA	Source 3 phase A apparent power
7252	SRC 3 Sb	VA	Source 3 phase B apparent power
7254	SRC 3 Sc	VA	Source 3 phase C apparent power
7256	SRC 3 PF	---	Source 3 three-phase power factor
7257	SRC 3 Phase A PF	---	Source 3 phase A power factor
7258	SRC 3 Phase B PF	---	Source 3 phase B power factor
7259	SRC 3 Phase C PF	---	Source 3 phase C power factor
7264	SRC 4 P	Watts	Source 4 three-phase real power
7266	SRC 4 Pa	Watts	Source 4 phase A real power
7268	SRC 4 Pb	Watts	Source 4 phase B real power
7270	SRC 4 Pc	Watts	Source 4 phase C real power
7272	SRC 4 Q	Vars	Source 4 three-phase reactive power
7274	SRC 4 Qa	Vars	Source 4 phase A reactive power
7276	SRC 4 Qb	Vars	Source 4 phase B reactive power
7278	SRC 4 Qc	Vars	Source 4 phase C reactive power
7280	SRC 4 S	VA	Source 4 three-phase apparent power
7282	SRC 4 Sa	VA	Source 4 phase A apparent power
7284	SRC 4 Sb	VA	Source 4 phase B apparent power
7286	SRC 4 Sc	VA	Source 4 phase C apparent power
7288	SRC 4 PF	---	Source 4 three-phase power factor
7289	SRC 4 Phase A PF	---	Source 4 phase A power factor
7290	SRC 4 Phase B PF	---	Source 4 phase B power factor
7291	SRC 4 Phase C PF	---	Source 4 phase C power factor
7296	SRC 5 P	Watts	Source 5 three-phase real power
7298	SRC 5 Pa	Watts	Source 5 phase A real power
7300	SRC 5 Pb	Watts	Source 5 phase B real power
7302	SRC 5 Pc	Watts	Source 5 phase C real power
7304	SRC 5 Q	Vars	Source 5 three-phase reactive power
7306	SRC 5 Qa	Vars	Source 5 phase A reactive power
7308	SRC 5 Qb	Vars	Source 5 phase B reactive power
7310	SRC 5 Qc	Vars	Source 5 phase C reactive power
7312	SRC 5 S	VA	Source 5 three-phase apparent power
7314	SRC 5 Sa	VA	Source 5 phase A apparent power

Table A–1: FLEXANALOG DATA ITEMS (Sheet 9 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
7316	SRC 5 Sb	VA	Source 5 phase B apparent power
7318	SRC 5 Sc	VA	Source 5 phase C apparent power
7320	SRC 5 PF	---	Source 5 three-phase power factor
7321	SRC 5 Phase A PF	---	Source 5 phase A power factor
7322	SRC 5 Phase B PF	---	Source 5 phase B power factor
7323	SRC 5 Phase C PF	---	Source 5 phase C power factor
7328	SRC 6 P	Watts	Source 6 three-phase real power
7330	SRC 6 Pa	Watts	Source 6 phase A real power
7332	SRC 6 Pb	Watts	Source 6 phase B real power
7334	SRC 6 Pc	Watts	Source 6 phase C real power
7336	SRC 6 Q	Vars	Source 6 three-phase reactive power
7338	SRC 6 Qa	Vars	Source 6 phase A reactive power
7340	SRC 6 Qb	Vars	Source 6 phase B reactive power
7342	SRC 6 Qc	Vars	Source 6 phase C reactive power
7344	SRC 6 S	VA	Source 6 three-phase apparent power
7346	SRC 6 Sa	VA	Source 6 phase A apparent power
7348	SRC 6 Sb	VA	Source 6 phase B apparent power
7350	SRC 6 Sc	VA	Source 6 phase C apparent power
7352	SRC 6 PF	---	Source 6 three-phase power factor
7353	SRC 6 Phase A PF	---	Source 6 phase A power factor
7354	SRC 6 Phase B PF	---	Source 6 phase B power factor
7355	SRC 6 Phase C PF	---	Source 6 phase C power factor
7552	SRC 1 Frequency	Hz	Source 1 frequency
7553	SRC 2 Frequency	Hz	Source 2 frequency
7554	SRC 3 Frequency	Hz	Source 3 frequency
7555	SRC 4 Frequency	Hz	Source 4 frequency
7556	SRC 5 Frequency	Hz	Source 5 frequency
7557	SRC 6 Frequency	Hz	Source 6 frequency
8064	SRC 1 Va THD	---	Source 1 phase A voltage total harmonic distortion (THD)
8065	SRC 1 Va Harm[0]	Volts	Source 1 phase A voltage second harmonic
8066	SRC 1 Va Harm[1]	Volts	Source 1 phase A voltage third harmonic
8067	SRC 1 Va Harm[2]	Volts	Source 1 phase A voltage fourth harmonic
8068	SRC 1 Va Harm[3]	Volts	Source 1 phase A voltage fifth harmonic
8069	SRC 1 Va Harm[4]	Volts	Source 1 phase A voltage sixth harmonic
8070	SRC 1 Va Harm[5]	Volts	Source 1 phase A voltage seventh harmonic
8071	SRC 1 Va Harm[6]	Volts	Source 1 phase A voltage eighth harmonic
8072	SRC 1 Va Harm[7]	Volts	Source 1 phase A voltage ninth harmonic
8073	SRC 1 Va Harm[8]	Volts	Source 1 phase A voltage tenth harmonic
8074	SRC 1 Va Harm[9]	Volts	Source 1 phase A voltage eleventh harmonic
8075	SRC 1 Va Harm[10]	Volts	Source 1 phase A voltage twelfth harmonic
8076	SRC 1 Va Harm[11]	Volts	Source 1 phase A voltage thirteenth harmonic
8077	SRC 1 Va Harm[12]	Volts	Source 1 phase A voltage fourteenth harmonic
8078	SRC 1 Va Harm[13]	Volts	Source 1 phase A voltage fifteenth harmonic
8079	SRC 1 Va Harm[14]	Volts	Source 1 phase A voltage sixteenth harmonic
8080	SRC 1 Va Harm[15]	Volts	Source 1 phase A voltage seventeenth harmonic
8081	SRC 1 Va Harm[16]	Volts	Source 1 phase A voltage eighteenth harmonic
8082	SRC 1 Va Harm[17]	Volts	Source 1 phase A voltage nineteenth harmonic

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 10 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8083	SRC 1 Va Harm[18]	Volts	Source 1 phase A voltage twentieth harmonic
8084	SRC 1 Va Harm[19]	Volts	Source 1 phase A voltage twenty-first harmonic
8085	SRC 1 Va Harm[20]	Volts	Source 1 phase A voltage twenty-second harmonic
8086	SRC 1 Va Harm[21]	Volts	Source 1 phase A voltage twenty-third harmonic
8087	SRC 1 Va Harm[22]	Volts	Source 1 phase A voltage twenty-fourth harmonic
8088	SRC 1 Va Harm[23]	Volts	Source 1 phase A voltage twenty-fifth harmonic
8089	SRC 1 Vb THD	---	Source 1 phase B voltage total harmonic distortion (THD)
8090	SRC 1 Vb Harm[0]	Volts	Source 1 phase B voltage second harmonic
8091	SRC 1 Vb Harm[1]	Volts	Source 1 phase B voltage third harmonic
8092	SRC 1 Vb Harm[2]	Volts	Source 1 phase B voltage fourth harmonic
8093	SRC 1 Vb Harm[3]	Volts	Source 1 phase B voltage fifth harmonic
8094	SRC 1 Vb Harm[4]	Volts	Source 1 phase B voltage sixth harmonic
8095	SRC 1 Vb Harm[5]	Volts	Source 1 phase B voltage seventh harmonic
8096	SRC 1 Vb Harm[6]	Volts	Source 1 phase B voltage eighth harmonic
8097	SRC 1 Vb Harm[7]	Volts	Source 1 phase B voltage ninth harmonic
8098	SRC 1 Vb Harm[8]	Volts	Source 1 phase B voltage tenth harmonic
8099	SRC 1 Vb Harm[9]	Volts	Source 1 phase B voltage eleventh harmonic
8100	SRC 1 Vb Harm[10]	Volts	Source 1 phase B voltage twelfth harmonic
8101	SRC 1 Vb Harm[11]	Volts	Source 1 phase B voltage thirteenth harmonic
8102	SRC 1 Vb Harm[12]	Volts	Source 1 phase B voltage fourteenth harmonic
8103	SRC 1 Vb Harm[13]	Volts	Source 1 phase B voltage fifteenth harmonic
8104	SRC 1 Vb Harm[14]	Volts	Source 1 phase B voltage sixteenth harmonic
8105	SRC 1 Vb Harm[15]	Volts	Source 1 phase B voltage seventeenth harmonic
8106	SRC 1 Vb Harm[16]	Volts	Source 1 phase B voltage eighteenth harmonic
8107	SRC 1 Vb Harm[17]	Volts	Source 1 phase B voltage nineteenth harmonic
8108	SRC 1 Vb Harm[18]	Volts	Source 1 phase B voltage twentieth harmonic
8109	SRC 1 Vb Harm[19]	Volts	Source 1 phase B voltage twenty-first harmonic
8110	SRC 1 Vb Harm[20]	Volts	Source 1 phase B voltage twenty-second harmonic
8111	SRC 1 Vb Harm[21]	Volts	Source 1 phase B voltage twenty-third harmonic
8112	SRC 1 Vb Harm[22]	Volts	Source 1 phase B voltage twenty-fourth harmonic
8113	SRC 1 Vb Harm[23]	Volts	Source 1 phase B voltage twenty-fifth harmonic
8114	SRC 1 Vc THD	---	Source 1 phase C voltage total harmonic distortion (THD)
8115	SRC 1 Vc Harm[0]	Volts	Source 1 phase C voltage second harmonic
8116	SRC 1 Vc Harm[1]	Volts	Source 1 phase C voltage third harmonic
8117	SRC 1 Vc Harm[2]	Volts	Source 1 phase C voltage fourth harmonic
8118	SRC 1 Vc Harm[3]	Volts	Source 1 phase C voltage fifth harmonic
8119	SRC 1 Vc Harm[4]	Volts	Source 1 phase C voltage sixth harmonic
8120	SRC 1 Vc Harm[5]	Volts	Source 1 phase C voltage seventh harmonic
8121	SRC 1 Vc Harm[6]	Volts	Source 1 phase C voltage eighth harmonic
8122	SRC 1 Vc Harm[7]	Volts	Source 1 phase C voltage ninth harmonic
8123	SRC 1 Vc Harm[8]	Volts	Source 1 phase C voltage tenth harmonic
8124	SRC 1 Vc Harm[9]	Volts	Source 1 phase C voltage eleventh harmonic
8125	SRC 1 Vc Harm[10]	Volts	Source 1 phase C voltage twelfth harmonic
8126	SRC 1 Vc Harm[11]	Volts	Source 1 phase C voltage thirteenth harmonic
8127	SRC 1 Vc Harm[12]	Volts	Source 1 phase C voltage fourteenth harmonic
8128	SRC 1 Vc Harm[13]	Volts	Source 1 phase C voltage fifteenth harmonic
8129	SRC 1 Vc Harm[14]	Volts	Source 1 phase C voltage sixteenth harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 11 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8130	SRC 1 Vc Harm[15]	Volts	Source 1 phase C voltage seventeenth harmonic
8131	SRC 1 Vc Harm[16]	Volts	Source 1 phase C voltage eighteenth harmonic
8132	SRC 1 Vc Harm[17]	Volts	Source 1 phase C voltage nineteenth harmonic
8133	SRC 1 Vc Harm[18]	Volts	Source 1 phase C voltage twentieth harmonic
8134	SRC 1 Vc Harm[19]	Volts	Source 1 phase C voltage twenty-first harmonic
8135	SRC 1 Vc Harm[20]	Volts	Source 1 phase C voltage twenty-second harmonic
8136	SRC 1 Vc Harm[21]	Volts	Source 1 phase C voltage twenty-third harmonic
8137	SRC 1 Vc Harm[22]	Volts	Source 1 phase C voltage twenty-fourth harmonic
8138	SRC 1 Vc Harm[23]	Volts	Source 1 phase C voltage twenty-fifth harmonic
8139	SRC 2 Va THD	---	Source 2 phase A voltage total harmonic distortion (THD)
8140	SRC 2 Va Harm[0]	Volts	Source 2 phase A voltage second harmonic
8141	SRC 2 Va Harm[1]	Volts	Source 2 phase A voltage third harmonic
8142	SRC 2 Va Harm[2]	Volts	Source 2 phase A voltage fourth harmonic
8143	SRC 2 Va Harm[3]	Volts	Source 2 phase A voltage fifth harmonic
8144	SRC 2 Va Harm[4]	Volts	Source 2 phase A voltage sixth harmonic
8145	SRC 2 Va Harm[5]	Volts	Source 2 phase A voltage seventh harmonic
8146	SRC 2 Va Harm[6]	Volts	Source 2 phase A voltage eighth harmonic
8147	SRC 2 Va Harm[7]	Volts	Source 2 phase A voltage ninth harmonic
8148	SRC 2 Va Harm[8]	Volts	Source 2 phase A voltage tenth harmonic
8149	SRC 2 Va Harm[9]	Volts	Source 2 phase A voltage eleventh harmonic
8150	SRC 2 Va Harm[10]	Volts	Source 2 phase A voltage twelfth harmonic
8151	SRC 2 Va Harm[11]	Volts	Source 2 phase A voltage thirteenth harmonic
8152	SRC 2 Va Harm[12]	Volts	Source 2 phase A voltage fourteenth harmonic
8153	SRC 2 Va Harm[13]	Volts	Source 2 phase A voltage fifteenth harmonic
8154	SRC 2 Va Harm[14]	Volts	Source 2 phase A voltage sixteenth harmonic
8155	SRC 2 Va Harm[15]	Volts	Source 2 phase A voltage seventeenth harmonic
8156	SRC 2 Va Harm[16]	Volts	Source 2 phase A voltage eighteenth harmonic
8157	SRC 2 Va Harm[17]	Volts	Source 2 phase A voltage nineteenth harmonic
8158	SRC 2 Va Harm[18]	Volts	Source 2 phase A voltage twentieth harmonic
8159	SRC 2 Va Harm[19]	Volts	Source 2 phase A voltage twenty-first harmonic
8160	SRC 2 Va Harm[20]	Volts	Source 2 phase A voltage twenty-second harmonic
8161	SRC 2 Va Harm[21]	Volts	Source 2 phase A voltage twenty-third harmonic
8162	SRC 2 Va Harm[22]	Volts	Source 2 phase A voltage twenty-fourth harmonic
8163	SRC 2 Va Harm[23]	Volts	Source 2 phase A voltage twenty-fifth harmonic
8164	SRC 2 Vb THD	---	Source 2 phase B voltage total harmonic distortion (THD)
8165	SRC 2 Vb Harm[0]	Volts	Source 2 phase B voltage second harmonic
8166	SRC 2 Vb Harm[1]	Volts	Source 2 phase B voltage third harmonic
8167	SRC 2 Vb Harm[2]	Volts	Source 2 phase B voltage fourth harmonic
8168	SRC 2 Vb Harm[3]	Volts	Source 2 phase B voltage fifth harmonic
8169	SRC 2 Vb Harm[4]	Volts	Source 2 phase B voltage sixth harmonic
8170	SRC 2 Vb Harm[5]	Volts	Source 2 phase B voltage seventh harmonic
8171	SRC 2 Vb Harm[6]	Volts	Source 2 phase B voltage eighth harmonic
8172	SRC 2 Vb Harm[7]	Volts	Source 2 phase B voltage ninth harmonic
8173	SRC 2 Vb Harm[8]	Volts	Source 2 phase B voltage tenth harmonic
8174	SRC 2 Vb Harm[9]	Volts	Source 2 phase B voltage eleventh harmonic
8175	SRC 2 Vb Harm[10]	Volts	Source 2 phase B voltage twelfth harmonic
8176	SRC 2 Vb Harm[11]	Volts	Source 2 phase B voltage thirteenth harmonic

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 12 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8177	SRC 2 Vb Harm[12]	Volts	Source 2 phase B voltage fourteenth harmonic
8178	SRC 2 Vb Harm[13]	Volts	Source 2 phase B voltage fifteenth harmonic
8179	SRC 2 Vb Harm[14]	Volts	Source 2 phase B voltage sixteenth harmonic
8180	SRC 2 Vb Harm[15]	Volts	Source 2 phase B voltage seventeenth harmonic
8181	SRC 2 Vb Harm[16]	Volts	Source 2 phase B voltage eighteenth harmonic
8182	SRC 2 Vb Harm[17]	Volts	Source 2 phase B voltage nineteenth harmonic
8183	SRC 2 Vb Harm[18]	Volts	Source 2 phase B voltage twentieth harmonic
8184	SRC 2 Vb Harm[19]	Volts	Source 2 phase B voltage twenty-first harmonic
8185	SRC 2 Vb Harm[20]	Volts	Source 2 phase B voltage twenty-second harmonic
8186	SRC 2 Vb Harm[21]	Volts	Source 2 phase B voltage twenty-third harmonic
8187	SRC 2 Vb Harm[22]	Volts	Source 2 phase B voltage twenty-fourth harmonic
8188	SRC 2 Vb Harm[23]	Volts	Source 2 phase B voltage twenty-fifth harmonic
8189	SRC 2 Vc THD	---	Source 2 phase C voltage total harmonic distortion (THD)
8190	SRC 2 Vc Harm[0]	Volts	Source 2 phase C voltage second harmonic
8191	SRC 2 Vc Harm[1]	Volts	Source 2 phase C voltage third harmonic
8192	SRC 2 Vc Harm[2]	Volts	Source 2 phase C voltage fourth harmonic
8193	SRC 2 Vc Harm[3]	Volts	Source 2 phase C voltage fifth harmonic
8194	SRC 2 Vc Harm[4]	Volts	Source 2 phase C voltage sixth harmonic
8195	SRC 2 Vc Harm[5]	Volts	Source 2 phase C voltage seventh harmonic
8196	SRC 2 Vc Harm[6]	Volts	Source 2 phase C voltage eighth harmonic
8197	SRC 2 Vc Harm[7]	Volts	Source 2 phase C voltage ninth harmonic
8198	SRC 2 Vc Harm[8]	Volts	Source 2 phase C voltage tenth harmonic
8199	SRC 2 Vc Harm[9]	Volts	Source 2 phase C voltage eleventh harmonic
8200	SRC 2 Vc Harm[10]	Volts	Source 2 phase C voltage twelfth harmonic
8201	SRC 2 Vc Harm[11]	Volts	Source 2 phase C voltage thirteenth harmonic
8202	SRC 2 Vc Harm[12]	Volts	Source 2 phase C voltage fourteenth harmonic
8203	SRC 2 Vc Harm[13]	Volts	Source 2 phase C voltage fifteenth harmonic
8204	SRC 2 Vc Harm[14]	Volts	Source 2 phase C voltage sixteenth harmonic
8205	SRC 2 Vc Harm[15]	Volts	Source 2 phase C voltage seventeenth harmonic
8206	SRC 2 Vc Harm[16]	Volts	Source 2 phase C voltage eighteenth harmonic
8207	SRC 2 Vc Harm[17]	Volts	Source 2 phase C voltage nineteenth harmonic
8208	SRC 2 Vc Harm[18]	Volts	Source 2 phase C voltage twentieth harmonic
8209	SRC 2 Vc Harm[19]	Volts	Source 2 phase C voltage twenty-first harmonic
8210	SRC 2 Vc Harm[20]	Volts	Source 2 phase C voltage twenty-second harmonic
8211	SRC 2 Vc Harm[21]	Volts	Source 2 phase C voltage twenty-third harmonic
8212	SRC 2 Vc Harm[22]	Volts	Source 2 phase C voltage twenty-fourth harmonic
8213	SRC 2 Vc Harm[23]	Volts	Source 2 phase C voltage twenty-fifth harmonic
8214	SRC 3 Va THD	---	Source 3 phase A voltage total harmonic distortion (THD)
8215	SRC 3 Va Harm[0]	Volts	Source 3 phase A voltage second harmonic
8216	SRC 3 Va Harm[1]	Volts	Source 3 phase A voltage third harmonic
8217	SRC 3 Va Harm[2]	Volts	Source 3 phase A voltage fourth harmonic
8218	SRC 3 Va Harm[3]	Volts	Source 3 phase A voltage fifth harmonic
8219	SRC 3 Va Harm[4]	Volts	Source 3 phase A voltage sixth harmonic
8220	SRC 3 Va Harm[5]	Volts	Source 3 phase A voltage seventh harmonic
8221	SRC 3 Va Harm[6]	Volts	Source 3 phase A voltage eighth harmonic
8222	SRC 3 Va Harm[7]	Volts	Source 3 phase A voltage ninth harmonic
8223	SRC 3 Va Harm[8]	Volts	Source 3 phase A voltage tenth harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 13 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8224	SRC 3 Va Harm[9]	Volts	Source 3 phase A voltage eleventh harmonic
8225	SRC 3 Va Harm[10]	Volts	Source 3 phase A voltage twelfth harmonic
8226	SRC 3 Va Harm[11]	Volts	Source 3 phase A voltage thirteenth harmonic
8227	SRC 3 Va Harm[12]	Volts	Source 3 phase A voltage fourteenth harmonic
8228	SRC 3 Va Harm[13]	Volts	Source 3 phase A voltage fifteenth harmonic
8229	SRC 3 Va Harm[14]	Volts	Source 3 phase A voltage sixteenth harmonic
8230	SRC 3 Va Harm[15]	Volts	Source 3 phase A voltage seventeenth harmonic
8231	SRC 3 Va Harm[16]	Volts	Source 3 phase A voltage eighteenth harmonic
8232	SRC 3 Va Harm[17]	Volts	Source 3 phase A voltage nineteenth harmonic
8233	SRC 3 Va Harm[18]	Volts	Source 3 phase A voltage twentieth harmonic
8234	SRC 3 Va Harm[19]	Volts	Source 3 phase A voltage twenty-first harmonic
8235	SRC 3 Va Harm[20]	Volts	Source 3 phase A voltage twenty-second harmonic
8236	SRC 3 Va Harm[21]	Volts	Source 3 phase A voltage twenty-third harmonic
8237	SRC 3 Va Harm[22]	Volts	Source 3 phase A voltage twenty-fourth harmonic
8238	SRC 3 Va Harm[23]	Volts	Source 3 phase A voltage twenty-fifth harmonic
8239	SRC 3 Vb THD	---	Source 3 phase B voltage total harmonic distortion (THD)
8240	SRC 3 Vb Harm[0]	Volts	Source 3 phase B voltage second harmonic
8241	SRC 3 Vb Harm[1]	Volts	Source 3 phase B voltage third harmonic
8242	SRC 3 Vb Harm[2]	Volts	Source 3 phase B voltage fourth harmonic
8243	SRC 3 Vb Harm[3]	Volts	Source 3 phase B voltage fifth harmonic
8244	SRC 3 Vb Harm[4]	Volts	Source 3 phase B voltage sixth harmonic
8245	SRC 3 Vb Harm[5]	Volts	Source 3 phase B voltage seventh harmonic
8246	SRC 3 Vb Harm[6]	Volts	Source 3 phase B voltage eighth harmonic
8247	SRC 3 Vb Harm[7]	Volts	Source 3 phase B voltage ninth harmonic
8248	SRC 3 Vb Harm[8]	Volts	Source 3 phase B voltage tenth harmonic
8249	SRC 3 Vb Harm[9]	Volts	Source 3 phase B voltage eleventh harmonic
8250	SRC 3 Vb Harm[10]	Volts	Source 3 phase B voltage twelfth harmonic
8251	SRC 3 Vb Harm[11]	Volts	Source 3 phase B voltage thirteenth harmonic
8252	SRC 3 Vb Harm[12]	Volts	Source 3 phase B voltage fourteenth harmonic
8253	SRC 3 Vb Harm[13]	Volts	Source 3 phase B voltage fifteenth harmonic
8254	SRC 3 Vb Harm[14]	Volts	Source 3 phase B voltage sixteenth harmonic
8255	SRC 3 Vb Harm[15]	Volts	Source 3 phase B voltage seventeenth harmonic
8256	SRC 3 Vb Harm[16]	Volts	Source 3 phase B voltage eighteenth harmonic
8257	SRC 3 Vb Harm[17]	Volts	Source 3 phase B voltage nineteenth harmonic
8258	SRC 3 Vb Harm[18]	Volts	Source 3 phase B voltage twentieth harmonic
8259	SRC 3 Vb Harm[19]	Volts	Source 3 phase B voltage twenty-first harmonic
8260	SRC 3 Vb Harm[20]	Volts	Source 3 phase B voltage twenty-second harmonic
8261	SRC 3 Vb Harm[21]	Volts	Source 3 phase B voltage twenty-third harmonic
8262	SRC 3 Vb Harm[22]	Volts	Source 3 phase B voltage twenty-fourth harmonic
8263	SRC 3 Vb Harm[23]	Volts	Source 3 phase B voltage twenty-fifth harmonic
8264	SRC 3 Vc THD	---	Source 3 phase C voltage total harmonic distortion (THD)
8265	SRC 3 Vc Harm[0]	Volts	Source 3 phase C voltage second harmonic
8266	SRC 3 Vc Harm[1]	Volts	Source 3 phase C voltage third harmonic
8267	SRC 3 Vc Harm[2]	Volts	Source 3 phase C voltage fourth harmonic
8268	SRC 3 Vc Harm[3]	Volts	Source 3 phase C voltage fifth harmonic
8269	SRC 3 Vc Harm[4]	Volts	Source 3 phase C voltage sixth harmonic
8270	SRC 3 Vc Harm[5]	Volts	Source 3 phase C voltage seventh harmonic

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 14 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8271	SRC 3 Vc Harm[6]	Volts	Source 3 phase C voltage eighth harmonic
8272	SRC 3 Vc Harm[7]	Volts	Source 3 phase C voltage ninth harmonic
8273	SRC 3 Vc Harm[8]	Volts	Source 3 phase C voltage tenth harmonic
8274	SRC 3 Vc Harm[9]	Volts	Source 3 phase C voltage eleventh harmonic
8275	SRC 3 Vc Harm[10]	Volts	Source 3 phase C voltage twelfth harmonic
8276	SRC 3 Vc Harm[11]	Volts	Source 3 phase C voltage thirteenth harmonic
8277	SRC 3 Vc Harm[12]	Volts	Source 3 phase C voltage fourteenth harmonic
8278	SRC 3 Vc Harm[13]	Volts	Source 3 phase C voltage fifteenth harmonic
8279	SRC 3 Vc Harm[14]	Volts	Source 3 phase C voltage sixteenth harmonic
8280	SRC 3 Vc Harm[15]	Volts	Source 3 phase C voltage seventeenth harmonic
8281	SRC 3 Vc Harm[16]	Volts	Source 3 phase C voltage eighteenth harmonic
8282	SRC 3 Vc Harm[17]	Volts	Source 3 phase C voltage nineteenth harmonic
8283	SRC 3 Vc Harm[18]	Volts	Source 3 phase C voltage twentieth harmonic
8284	SRC 3 Vc Harm[19]	Volts	Source 3 phase C voltage twenty-first harmonic
8285	SRC 3 Vc Harm[20]	Volts	Source 3 phase C voltage twenty-second harmonic
8286	SRC 3 Vc Harm[21]	Volts	Source 3 phase C voltage twenty-third harmonic
8287	SRC 3 Vc Harm[22]	Volts	Source 3 phase C voltage twenty-fourth harmonic
8288	SRC 3 Vc Harm[23]	Volts	Source 3 phase C voltage twenty-fifth harmonic
8289	SRC 4 Va THD	---	Source 4 phase A voltage total harmonic distortion (THD)
8290	SRC 4 Va Harm[0]	Volts	Source 4 phase A voltage second harmonic
8291	SRC 4 Va Harm[1]	Volts	Source 4 phase A voltage third harmonic
8292	SRC 4 Va Harm[2]	Volts	Source 4 phase A voltage fourth harmonic
8293	SRC 4 Va Harm[3]	Volts	Source 4 phase A voltage fifth harmonic
8294	SRC 4 Va Harm[4]	Volts	Source 4 phase A voltage sixth harmonic
8295	SRC 4 Va Harm[5]	Volts	Source 4 phase A voltage seventh harmonic
8296	SRC 4 Va Harm[6]	Volts	Source 4 phase A voltage eighth harmonic
8297	SRC 4 Va Harm[7]	Volts	Source 4 phase A voltage ninth harmonic
8298	SRC 4 Va Harm[8]	Volts	Source 4 phase A voltage tenth harmonic
8299	SRC 4 Va Harm[9]	Volts	Source 4 phase A voltage eleventh harmonic
8300	SRC 4 Va Harm[10]	Volts	Source 4 phase A voltage twelfth harmonic
8301	SRC 4 Va Harm[11]	Volts	Source 4 phase A voltage thirteenth harmonic
8302	SRC 4 Va Harm[12]	Volts	Source 4 phase A voltage fourteenth harmonic
8303	SRC 4 Va Harm[13]	Volts	Source 4 phase A voltage fifteenth harmonic
8304	SRC 4 Va Harm[14]	Volts	Source 4 phase A voltage sixteenth harmonic
8305	SRC 4 Va Harm[15]	Volts	Source 4 phase A voltage seventeenth harmonic
8306	SRC 4 Va Harm[16]	Volts	Source 4 phase A voltage eighteenth harmonic
8307	SRC 4 Va Harm[17]	Volts	Source 4 phase A voltage nineteenth harmonic
8308	SRC 4 Va Harm[18]	Volts	Source 4 phase A voltage twentieth harmonic
8309	SRC 4 Va Harm[19]	Volts	Source 4 phase A voltage twenty-first harmonic
8310	SRC 4 Va Harm[20]	Volts	Source 4 phase A voltage twenty-second harmonic
8311	SRC 4 Va Harm[21]	Volts	Source 4 phase A voltage twenty-third harmonic
8312	SRC 4 Va Harm[22]	Volts	Source 4 phase A voltage twenty-fourth harmonic
8313	SRC 4 Va Harm[23]	Volts	Source 4 phase A voltage twenty-fifth harmonic
8314	SRC 4 Vb THD	---	Source 4 phase B voltage total harmonic distortion (THD)
8315	SRC 4 Vb Harm[0]	Volts	Source 4 phase B voltage second harmonic
8316	SRC 4 Vb Harm[1]	Volts	Source 4 phase B voltage third harmonic
8317	SRC 4 Vb Harm[2]	Volts	Source 4 phase B voltage fourth harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 15 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8318	SRC 4 Vb Harm[3]	Volts	Source 4 phase B voltage fifth harmonic
8319	SRC 4 Vb Harm[4]	Volts	Source 4 phase B voltage sixth harmonic
8320	SRC 4 Vb Harm[5]	Volts	Source 4 phase B voltage seventh harmonic
8321	SRC 4 Vb Harm[6]	Volts	Source 4 phase B voltage eighth harmonic
8322	SRC 4 Vb Harm[7]	Volts	Source 4 phase B voltage ninth harmonic
8323	SRC 4 Vb Harm[8]	Volts	Source 4 phase B voltage tenth harmonic
8324	SRC 4 Vb Harm[9]	Volts	Source 4 phase B voltage eleventh harmonic
8325	SRC 4 Vb Harm[10]	Volts	Source 4 phase B voltage twelfth harmonic
8326	SRC 4 Vb Harm[11]	Volts	Source 4 phase B voltage thirteenth harmonic
8327	SRC 4 Vb Harm[12]	Volts	Source 4 phase B voltage fourteenth harmonic
8328	SRC 4 Vb Harm[13]	Volts	Source 4 phase B voltage fifteenth harmonic
8329	SRC 4 Vb Harm[14]	Volts	Source 4 phase B voltage sixteenth harmonic
8330	SRC 4 Vb Harm[15]	Volts	Source 4 phase B voltage seventeenth harmonic
8331	SRC 4 Vb Harm[16]	Volts	Source 4 phase B voltage eighteenth harmonic
8332	SRC 4 Vb Harm[17]	Volts	Source 4 phase B voltage nineteenth harmonic
8333	SRC 4 Vb Harm[18]	Volts	Source 4 phase B voltage twentieth harmonic
8334	SRC 4 Vb Harm[19]	Volts	Source 4 phase B voltage twenty-first harmonic
8335	SRC 4 Vb Harm[20]	Volts	Source 4 phase B voltage twenty-second harmonic
8336	SRC 4 Vb Harm[21]	Volts	Source 4 phase B voltage twenty-third harmonic
8337	SRC 4 Vb Harm[22]	Volts	Source 4 phase B voltage twenty-fourth harmonic
8338	SRC 4 Vb Harm[23]	Volts	Source 4 phase B voltage twenty-fifth harmonic
8339	SRC 4 Vc THD	---	Source 4 phase C voltage total harmonic distortion (THD)
8340	SRC 4 Vc Harm[0]	Volts	Source 4 phase C voltage second harmonic
8341	SRC 4 Vc Harm[1]	Volts	Source 4 phase C voltage third harmonic
8342	SRC 4 Vc Harm[2]	Volts	Source 4 phase C voltage fourth harmonic
8343	SRC 4 Vc Harm[3]	Volts	Source 4 phase C voltage fifth harmonic
8344	SRC 4 Vc Harm[4]	Volts	Source 4 phase C voltage sixth harmonic
8345	SRC 4 Vc Harm[5]	Volts	Source 4 phase C voltage seventh harmonic
8346	SRC 4 Vc Harm[6]	Volts	Source 4 phase C voltage eighth harmonic
8347	SRC 4 Vc Harm[7]	Volts	Source 4 phase C voltage ninth harmonic
8348	SRC 4 Vc Harm[8]	Volts	Source 4 phase C voltage tenth harmonic
8349	SRC 4 Vc Harm[9]	Volts	Source 4 phase C voltage eleventh harmonic
8350	SRC 4 Vc Harm[10]	Volts	Source 4 phase C voltage twelfth harmonic
8351	SRC 4 Vc Harm[11]	Volts	Source 4 phase C voltage thirteenth harmonic
8352	SRC 4 Vc Harm[12]	Volts	Source 4 phase C voltage fourteenth harmonic
8353	SRC 4 Vc Harm[13]	Volts	Source 4 phase C voltage fifteenth harmonic
8354	SRC 4 Vc Harm[14]	Volts	Source 4 phase C voltage sixteenth harmonic
8355	SRC 4 Vc Harm[15]	Volts	Source 4 phase C voltage seventeenth harmonic
8356	SRC 4 Vc Harm[16]	Volts	Source 4 phase C voltage eighteenth harmonic
8357	SRC 4 Vc Harm[17]	Volts	Source 4 phase C voltage nineteenth harmonic
8358	SRC 4 Vc Harm[18]	Volts	Source 4 phase C voltage twentieth harmonic
8359	SRC 4 Vc Harm[19]	Volts	Source 4 phase C voltage twenty-first harmonic
8360	SRC 4 Vc Harm[20]	Volts	Source 4 phase C voltage twenty-second harmonic
8361	SRC 4 Vc Harm[21]	Volts	Source 4 phase C voltage twenty-third harmonic
8362	SRC 4 Vc Harm[22]	Volts	Source 4 phase C voltage twenty-fourth harmonic
8363	SRC 4 Vc Harm[23]	Volts	Source 4 phase C voltage twenty-fifth harmonic
8364	SRC 5 Va THD	---	Source 5 phase A voltage total harmonic distortion (THD)

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 16 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8365	SRC 5 Va Harm[0]	Volts	Source 5 phase A voltage second harmonic
8366	SRC 5 Va Harm[1]	Volts	Source 5 phase A voltage third harmonic
8367	SRC 5 Va Harm[2]	Volts	Source 5 phase A voltage fourth harmonic
8368	SRC 5 Va Harm[3]	Volts	Source 5 phase A voltage fifth harmonic
8369	SRC 5 Va Harm[4]	Volts	Source 5 phase A voltage sixth harmonic
8370	SRC 5 Va Harm[5]	Volts	Source 5 phase A voltage seventh harmonic
8371	SRC 5 Va Harm[6]	Volts	Source 5 phase A voltage eighth harmonic
8372	SRC 5 Va Harm[7]	Volts	Source 5 phase A voltage ninth harmonic
8373	SRC 5 Va Harm[8]	Volts	Source 5 phase A voltage tenth harmonic
8374	SRC 5 Va Harm[9]	Volts	Source 5 phase A voltage eleventh harmonic
8375	SRC 5 Va Harm[10]	Volts	Source 5 phase A voltage twelfth harmonic
8376	SRC 5 Va Harm[11]	Volts	Source 5 phase A voltage thirteenth harmonic
8377	SRC 5 Va Harm[12]	Volts	Source 5 phase A voltage fourteenth harmonic
8378	SRC 5 Va Harm[13]	Volts	Source 5 phase A voltage fifteenth harmonic
8379	SRC 5 Va Harm[14]	Volts	Source 5 phase A voltage sixteenth harmonic
8380	SRC 5 Va Harm[15]	Volts	Source 5 phase A voltage seventeenth harmonic
8381	SRC 5 Va Harm[16]	Volts	Source 5 phase A voltage eighteenth harmonic
8382	SRC 5 Va Harm[17]	Volts	Source 5 phase A voltage nineteenth harmonic
8383	SRC 5 Va Harm[18]	Volts	Source 5 phase A voltage twentieth harmonic
8384	SRC 5 Va Harm[19]	Volts	Source 5 phase A voltage twenty-first harmonic
8385	SRC 5 Va Harm[20]	Volts	Source 5 phase A voltage twenty-second harmonic
8386	SRC 5 Va Harm[21]	Volts	Source 5 phase A voltage twenty-third harmonic
8387	SRC 5 Va Harm[22]	Volts	Source 5 phase A voltage twenty-fourth harmonic
8388	SRC 5 Va Harm[23]	Volts	Source 5 phase A voltage twenty-fifth harmonic
8389	SRC 5 Vb THD	---	Source 5 phase B voltage total harmonic distortion (THD)
8390	SRC 5 Vb Harm[0]	Volts	Source 5 phase B voltage second harmonic
8391	SRC 5 Vb Harm[1]	Volts	Source 5 phase B voltage third harmonic
8392	SRC 5 Vb Harm[2]	Volts	Source 5 phase B voltage fourth harmonic
8393	SRC 5 Vb Harm[3]	Volts	Source 5 phase B voltage fifth harmonic
8394	SRC 5 Vb Harm[4]	Volts	Source 5 phase B voltage sixth harmonic
8395	SRC 5 Vb Harm[5]	Volts	Source 5 phase B voltage seventh harmonic
8396	SRC 5 Vb Harm[6]	Volts	Source 5 phase B voltage eighth harmonic
8397	SRC 5 Vb Harm[7]	Volts	Source 5 phase B voltage ninth harmonic
8398	SRC 5 Vb Harm[8]	Volts	Source 5 phase B voltage tenth harmonic
8399	SRC 5 Vb Harm[9]	Volts	Source 5 phase B voltage eleventh harmonic
8400	SRC 5 Vb Harm[10]	Volts	Source 5 phase B voltage twelfth harmonic
8401	SRC 5 Vb Harm[11]	Volts	Source 5 phase B voltage thirteenth harmonic
8402	SRC 5 Vb Harm[12]	Volts	Source 5 phase B voltage fourteenth harmonic
8403	SRC 5 Vb Harm[13]	Volts	Source 5 phase B voltage fifteenth harmonic
8404	SRC 5 Vb Harm[14]	Volts	Source 5 phase B voltage sixteenth harmonic
8405	SRC 5 Vb Harm[15]	Volts	Source 5 phase B voltage seventeenth harmonic
8406	SRC 5 Vb Harm[16]	Volts	Source 5 phase B voltage eighteenth harmonic
8407	SRC 5 Vb Harm[17]	Volts	Source 5 phase B voltage nineteenth harmonic
8408	SRC 5 Vb Harm[18]	Volts	Source 5 phase B voltage twentieth harmonic
8409	SRC 5 Vb Harm[19]	Volts	Source 5 phase B voltage twenty-first harmonic
8410	SRC 5 Vb Harm[20]	Volts	Source 5 phase B voltage twenty-second harmonic
8411	SRC 5 Vb Harm[21]	Volts	Source 5 phase B voltage twenty-third harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 17 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8412	SRC 5 Vb Harm[22]	Volts	Source 5 phase B voltage twenty-fourth harmonic
8413	SRC 5 Vb Harm[23]	Volts	Source 5 phase B voltage twenty-fifth harmonic
8414	SRC 5 Vc THD	---	Source 5 phase C voltage total harmonic distortion (THD)
8415	SRC 5 Vc Harm[0]	Volts	Source 5 phase C voltage second harmonic
8416	SRC 5 Vc Harm[1]	Volts	Source 5 phase C voltage third harmonic
8417	SRC 5 Vc Harm[2]	Volts	Source 5 phase C voltage fourth harmonic
8418	SRC 5 Vc Harm[3]	Volts	Source 5 phase C voltage fifth harmonic
8419	SRC 5 Vc Harm[4]	Volts	Source 5 phase C voltage sixth harmonic
8420	SRC 5 Vc Harm[5]	Volts	Source 5 phase C voltage seventh harmonic
8421	SRC 5 Vc Harm[6]	Volts	Source 5 phase C voltage eighth harmonic
8422	SRC 5 Vc Harm[7]	Volts	Source 5 phase C voltage ninth harmonic
8423	SRC 5 Vc Harm[8]	Volts	Source 5 phase C voltage tenth harmonic
8424	SRC 5 Vc Harm[9]	Volts	Source 5 phase C voltage eleventh harmonic
8425	SRC 5 Vc Harm[10]	Volts	Source 5 phase C voltage twelfth harmonic
8426	SRC 5 Vc Harm[11]	Volts	Source 5 phase C voltage thirteenth harmonic
8427	SRC 5 Vc Harm[12]	Volts	Source 5 phase C voltage fourteenth harmonic
8428	SRC 5 Vc Harm[13]	Volts	Source 5 phase C voltage fifteenth harmonic
8429	SRC 5 Vc Harm[14]	Volts	Source 5 phase C voltage sixteenth harmonic
8430	SRC 5 Vc Harm[15]	Volts	Source 5 phase C voltage seventeenth harmonic
8431	SRC 5 Vc Harm[16]	Volts	Source 5 phase C voltage eighteenth harmonic
8432	SRC 5 Vc Harm[17]	Volts	Source 5 phase C voltage nineteenth harmonic
8433	SRC 5 Vc Harm[18]	Volts	Source 5 phase C voltage twentieth harmonic
8434	SRC 5 Vc Harm[19]	Volts	Source 5 phase C voltage twenty-first harmonic
8435	SRC 5 Vc Harm[20]	Volts	Source 5 phase C voltage twenty-second harmonic
8436	SRC 5 Vc Harm[21]	Volts	Source 5 phase C voltage twenty-third harmonic
8437	SRC 5 Vc Harm[22]	Volts	Source 5 phase C voltage twenty-fourth harmonic
8438	SRC 5 Vc Harm[23]	Volts	Source 5 phase C voltage twenty-fifth harmonic
8439	SRC 6 Va THD	---	Source 6 phase A voltage total harmonic distortion (THD)
8440	SRC 6 Va Harm[0]	Volts	Source 6 phase A voltage second harmonic
8441	SRC 6 Va Harm[1]	Volts	Source 6 phase A voltage third harmonic
8442	SRC 6 Va Harm[2]	Volts	Source 6 phase A voltage fourth harmonic
8443	SRC 6 Va Harm[3]	Volts	Source 6 phase A voltage fifth harmonic
8444	SRC 6 Va Harm[4]	Volts	Source 6 phase A voltage sixth harmonic
8445	SRC 6 Va Harm[5]	Volts	Source 6 phase A voltage seventh harmonic
8446	SRC 6 Va Harm[6]	Volts	Source 6 phase A voltage eighth harmonic
8447	SRC 6 Va Harm[7]	Volts	Source 6 phase A voltage ninth harmonic
8448	SRC 6 Va Harm[8]	Volts	Source 6 phase A voltage tenth harmonic
8449	SRC 6 Va Harm[9]	Volts	Source 6 phase A voltage eleventh harmonic
8450	SRC 6 Va Harm[10]	Volts	Source 6 phase A voltage twelfth harmonic
8451	SRC 6 Va Harm[11]	Volts	Source 6 phase A voltage thirteenth harmonic
8452	SRC 6 Va Harm[12]	Volts	Source 6 phase A voltage fourteenth harmonic
8453	SRC 6 Va Harm[13]	Volts	Source 6 phase A voltage fifteenth harmonic
8454	SRC 6 Va Harm[14]	Volts	Source 6 phase A voltage sixteenth harmonic
8455	SRC 6 Va Harm[15]	Volts	Source 6 phase A voltage seventeenth harmonic
8456	SRC 6 Va Harm[16]	Volts	Source 6 phase A voltage eighteenth harmonic
8457	SRC 6 Va Harm[17]	Volts	Source 6 phase A voltage nineteenth harmonic
8458	SRC 6 Va Harm[18]	Volts	Source 6 phase A voltage twentieth harmonic

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 18 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8459	SRC 6 Va Harm[19]	Volts	Source 6 phase A voltage twenty-first harmonic
8460	SRC 6 Va Harm[20]	Volts	Source 6 phase A voltage twenty-second harmonic
8461	SRC 6 Va Harm[21]	Volts	Source 6 phase A voltage twenty-third harmonic
8462	SRC 6 Va Harm[22]	Volts	Source 6 phase A voltage twenty-fourth harmonic
8463	SRC 6 Va Harm[23]	Volts	Source 6 phase A voltage twenty-fifth harmonic
8464	SRC 6 Vb THD	---	Source 6 phase B voltage total harmonic distortion (THD)
8465	SRC 6 Vb Harm[0]	Volts	Source 6 phase B voltage second harmonic
8466	SRC 6 Vb Harm[1]	Volts	Source 6 phase B voltage third harmonic
8467	SRC 6 Vb Harm[2]	Volts	Source 6 phase B voltage fourth harmonic
8468	SRC 6 Vb Harm[3]	Volts	Source 6 phase B voltage fifth harmonic
8469	SRC 6 Vb Harm[4]	Volts	Source 6 phase B voltage sixth harmonic
8470	SRC 6 Vb Harm[5]	Volts	Source 6 phase B voltage seventh harmonic
8471	SRC 6 Vb Harm[6]	Volts	Source 6 phase B voltage eighth harmonic
8472	SRC 6 Vb Harm[7]	Volts	Source 6 phase B voltage ninth harmonic
8473	SRC 6 Vb Harm[8]	Volts	Source 6 phase B voltage tenth harmonic
8474	SRC 6 Vb Harm[9]	Volts	Source 6 phase B voltage eleventh harmonic
8475	SRC 6 Vb Harm[10]	Volts	Source 6 phase B voltage twelfth harmonic
8476	SRC 6 Vb Harm[11]	Volts	Source 6 phase B voltage thirteenth harmonic
8477	SRC 6 Vb Harm[12]	Volts	Source 6 phase B voltage fourteenth harmonic
8478	SRC 6 Vb Harm[13]	Volts	Source 6 phase B voltage fifteenth harmonic
8479	SRC 6 Vb Harm[14]	Volts	Source 6 phase B voltage sixteenth harmonic
8480	SRC 6 Vb Harm[15]	Volts	Source 6 phase B voltage seventeenth harmonic
8481	SRC 6 Vb Harm[16]	Volts	Source 6 phase B voltage eighteenth harmonic
8482	SRC 6 Vb Harm[17]	Volts	Source 6 phase B voltage nineteenth harmonic
8483	SRC 6 Vb Harm[18]	Volts	Source 6 phase B voltage twentieth harmonic
8484	SRC 6 Vb Harm[19]	Volts	Source 6 phase B voltage twenty-first harmonic
8485	SRC 6 Vb Harm[20]	Volts	Source 6 phase B voltage twenty-second harmonic
8486	SRC 6 Vb Harm[21]	Volts	Source 6 phase B voltage twenty-third harmonic
8487	SRC 6 Vb Harm[22]	Volts	Source 6 phase B voltage twenty-fourth harmonic
8488	SRC 6 Vb Harm[23]	Volts	Source 6 phase B voltage twenty-fifth harmonic
8489	SRC 6 Vc THD	---	Source 6 phase C voltage total harmonic distortion (THD)
8490	SRC 6 Vc Harm[0]	Volts	Source 6 phase C voltage second harmonic
8491	SRC 6 Vc Harm[1]	Volts	Source 6 phase C voltage third harmonic
8492	SRC 6 Vc Harm[2]	Volts	Source 6 phase C voltage fourth harmonic
8493	SRC 6 Vc Harm[3]	Volts	Source 6 phase C voltage fifth harmonic
8494	SRC 6 Vc Harm[4]	Volts	Source 6 phase C voltage sixth harmonic
8495	SRC 6 Vc Harm[5]	Volts	Source 6 phase C voltage seventh harmonic
8496	SRC 6 Vc Harm[6]	Volts	Source 6 phase C voltage eighth harmonic
8497	SRC 6 Vc Harm[7]	Volts	Source 6 phase C voltage ninth harmonic
8498	SRC 6 Vc Harm[8]	Volts	Source 6 phase C voltage tenth harmonic
8499	SRC 6 Vc Harm[9]	Volts	Source 6 phase C voltage eleventh harmonic
8500	SRC 6 Vc Harm[10]	Volts	Source 6 phase C voltage twelfth harmonic
8501	SRC 6 Vc Harm[11]	Volts	Source 6 phase C voltage thirteenth harmonic
8502	SRC 6 Vc Harm[12]	Volts	Source 6 phase C voltage fourteenth harmonic
8503	SRC 6 Vc Harm[13]	Volts	Source 6 phase C voltage fifteenth harmonic
8504	SRC 6 Vc Harm[14]	Volts	Source 6 phase C voltage sixteenth harmonic
8505	SRC 6 Vc Harm[15]	Volts	Source 6 phase C voltage seventeenth harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 19 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
8506	SRC 6 Vc Harm[16]	Volts	Source 6 phase C voltage eighteenth harmonic
8507	SRC 6 Vc Harm[17]	Volts	Source 6 phase C voltage nineteenth harmonic
8508	SRC 6 Vc Harm[18]	Volts	Source 6 phase C voltage twentieth harmonic
8509	SRC 6 Vc Harm[19]	Volts	Source 6 phase C voltage twenty-first harmonic
8510	SRC 6 Vc Harm[20]	Volts	Source 6 phase C voltage twenty-second harmonic
8511	SRC 6 Vc Harm[21]	Volts	Source 6 phase C voltage twenty-third harmonic
8512	SRC 6 Vc Harm[22]	Volts	Source 6 phase C voltage twenty-fourth harmonic
8513	SRC 6 Vc Harm[23]	Volts	Source 6 phase C voltage twenty-fifth harmonic
10240	SRC 1 Ia THD	---	Source 1 phase A current total harmonic distortion
10241	SRC 1 Ia Harm[0]	Amps	Source 1 phase A current second harmonic
10242	SRC 1 Ia Harm[1]	Amps	Source 1 phase A current third harmonic
10243	SRC 1 Ia Harm[2]	Amps	Source 1 phase A current fourth harmonic
10244	SRC 1 Ia Harm[3]	Amps	Source 1 phase A current fifth harmonic
10245	SRC 1 Ia Harm[4]	Amps	Source 1 phase A current sixth harmonic
10246	SRC 1 Ia Harm[5]	Amps	Source 1 phase A current seventh harmonic
10247	SRC 1 Ia Harm[6]	Amps	Source 1 phase A current eighth harmonic
10248	SRC 1 Ia Harm[7]	Amps	Source 1 phase A current ninth harmonic
10249	SRC 1 Ia Harm[8]	Amps	Source 1 phase A current tenth harmonic
10250	SRC 1 Ia Harm[9]	Amps	Source 1 phase A current eleventh harmonic
10251	SRC 1 Ia Harm[10]	Amps	Source 1 phase A current twelfth harmonic
10252	SRC 1 Ia Harm[11]	Amps	Source 1 phase A current thirteenth harmonic
10253	SRC 1 Ia Harm[12]	Amps	Source 1 phase A current fourteenth harmonic
10254	SRC 1 Ia Harm[13]	Amps	Source 1 phase A current fifteenth harmonic
10255	SRC 1 Ia Harm[14]	Amps	Source 1 phase A current sixteenth harmonic
10256	SRC 1 Ia Harm[15]	Amps	Source 1 phase A current seventeenth harmonic
10257	SRC 1 Ia Harm[16]	Amps	Source 1 phase A current eighteenth harmonic
10258	SRC 1 Ia Harm[17]	Amps	Source 1 phase A current nineteenth harmonic
10259	SRC 1 Ia Harm[18]	Amps	Source 1 phase A current twentieth harmonic
10260	SRC 1 Ia Harm[19]	Amps	Source 1 phase A current twenty-first harmonic
10261	SRC 1 Ia Harm[20]	Amps	Source 1 phase A current twenty-second harmonic
10262	SRC 1 Ia Harm[21]	Amps	Source 1 phase A current twenty-third harmonic
10263	SRC 1 Ia Harm[22]	Amps	Source 1 phase A current twenty-fourth harmonic
10264	SRC 1 Ia Harm[23]	Amps	Source 1 phase A current twenty-fifth harmonic
10273	SRC 1 Ib THD	---	Source 1 phase B current total harmonic distortion
10274	SRC 1 Ib Harm[0]	Amps	Source 1 phase B current second harmonic
10275	SRC 1 Ib Harm[1]	Amps	Source 1 phase B current third harmonic
10276	SRC 1 Ib Harm[2]	Amps	Source 1 phase B current fourth harmonic
10277	SRC 1 Ib Harm[3]	Amps	Source 1 phase B current fifth harmonic
10278	SRC 1 Ib Harm[4]	Amps	Source 1 phase B current sixth harmonic
10279	SRC 1 Ib Harm[5]	Amps	Source 1 phase B current seventh harmonic
10280	SRC 1 Ib Harm[6]	Amps	Source 1 phase B current eighth harmonic
10281	SRC 1 Ib Harm[7]	Amps	Source 1 phase B current ninth harmonic
10282	SRC 1 Ib Harm[8]	Amps	Source 1 phase B current tenth harmonic
10283	SRC 1 Ib Harm[9]	Amps	Source 1 phase B current eleventh harmonic
10284	SRC 1 Ib Harm[10]	Amps	Source 1 phase B current twelfth harmonic
10285	SRC 1 Ib Harm[11]	Amps	Source 1 phase B current thirteenth harmonic
10286	SRC 1 Ib Harm[12]	Amps	Source 1 phase B current fourteenth harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 20 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
10287	SRC 1 Ib Harm[13]	Amps	Source 1 phase B current fifteenth harmonic
10288	SRC 1 Ib Harm[14]	Amps	Source 1 phase B current sixteenth harmonic
10289	SRC 1 Ib Harm[15]	Amps	Source 1 phase B current seventeenth harmonic
10290	SRC 1 Ib Harm[16]	Amps	Source 1 phase B current eighteenth harmonic
10291	SRC 1 Ib Harm[17]	Amps	Source 1 phase B current nineteenth harmonic
10292	SRC 1 Ib Harm[18]	Amps	Source 1 phase B current twentieth harmonic
10293	SRC 1 Ib Harm[19]	Amps	Source 1 phase B current twenty-first harmonic
10294	SRC 1 Ib Harm[20]	Amps	Source 1 phase B current twenty-second harmonic
10295	SRC 1 Ib Harm[21]	Amps	Source 1 phase B current twenty-third harmonic
10296	SRC 1 Ib Harm[22]	Amps	Source 1 phase B current twenty-fourth harmonic
10297	SRC 1 Ib Harm[23]	Amps	Source 1 phase B current twenty-fifth harmonic
10306	SRC 1 Ic THD	---	Source 1 phase C current total harmonic distortion
10307	SRC 1 Ic Harm[0]	Amps	Source 1 phase C current second harmonic
10308	SRC 1 Ic Harm[1]	Amps	Source 1 phase C current third harmonic
10309	SRC 1 Ic Harm[2]	Amps	Source 1 phase C current fourth harmonic
10310	SRC 1 Ic Harm[3]	Amps	Source 1 phase C current fifth harmonic
10311	SRC 1 Ic Harm[4]	Amps	Source 1 phase C current sixth harmonic
10312	SRC 1 Ic Harm[5]	Amps	Source 1 phase C current seventh harmonic
10313	SRC 1 Ic Harm[6]	Amps	Source 1 phase C current eighth harmonic
10314	SRC 1 Ic Harm[7]	Amps	Source 1 phase C current ninth harmonic
10315	SRC 1 Ic Harm[8]	Amps	Source 1 phase C current tenth harmonic
10316	SRC 1 Ic Harm[9]	Amps	Source 1 phase C current eleventh harmonic
10317	SRC 1 Ic Harm[10]	Amps	Source 1 phase C current twelfth harmonic
10318	SRC 1 Ic Harm[11]	Amps	Source 1 phase C current thirteenth harmonic
10319	SRC 1 Ic Harm[12]	Amps	Source 1 phase C current fourteenth harmonic
10320	SRC 1 Ic Harm[13]	Amps	Source 1 phase C current fifteenth harmonic
10321	SRC 1 Ic Harm[14]	Amps	Source 1 phase C current sixteenth harmonic
10322	SRC 1 Ic Harm[15]	Amps	Source 1 phase C current seventeenth harmonic
10323	SRC 1 Ic Harm[16]	Amps	Source 1 phase C current eighteenth harmonic
10324	SRC 1 Ic Harm[17]	Amps	Source 1 phase C current nineteenth harmonic
10325	SRC 1 Ic Harm[18]	Amps	Source 1 phase C current twentieth harmonic
10326	SRC 1 Ic Harm[19]	Amps	Source 1 phase C current twenty-first harmonic
10327	SRC 1 Ic Harm[20]	Amps	Source 1 phase C current twenty-second harmonic
10328	SRC 1 Ic Harm[21]	Amps	Source 1 phase C current twenty-third harmonic
10329	SRC 1 Ic Harm[22]	Amps	Source 1 phase C current twenty-fourth harmonic
10330	SRC 1 Ic Harm[23]	Amps	Source 1 phase C current twenty-fifth harmonic
10339	SRC 2 Ia THD	---	Source 2 phase A current total harmonic distortion
10340	SRC 2 Ia Harm[0]	Amps	Source 2 phase A current second harmonic
10341	SRC 2 Ia Harm[1]	Amps	Source 2 phase A current third harmonic
10342	SRC 2 Ia Harm[2]	Amps	Source 2 phase A current fourth harmonic
10343	SRC 2 Ia Harm[3]	Amps	Source 2 phase A current fifth harmonic
10344	SRC 2 Ia Harm[4]	Amps	Source 2 phase A current sixth harmonic
10345	SRC 2 Ia Harm[5]	Amps	Source 2 phase A current seventh harmonic
10346	SRC 2 Ia Harm[6]	Amps	Source 2 phase A current eighth harmonic
10347	SRC 2 Ia Harm[7]	Amps	Source 2 phase A current ninth harmonic
10348	SRC 2 Ia Harm[8]	Amps	Source 2 phase A current tenth harmonic
10349	SRC 2 Ia Harm[9]	Amps	Source 2 phase A current eleventh harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 21 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
10350	SRC 2 Ia Harm[10]	Amps	Source 2 phase A current twelfth harmonic
10351	SRC 2 Ia Harm[11]	Amps	Source 2 phase A current thirteenth harmonic
10352	SRC 2 Ia Harm[12]	Amps	Source 2 phase A current fourteenth harmonic
10353	SRC 2 Ia Harm[13]	Amps	Source 2 phase A current fifteenth harmonic
10354	SRC 2 Ia Harm[14]	Amps	Source 2 phase A current sixteenth harmonic
10355	SRC 2 Ia Harm[15]	Amps	Source 2 phase A current seventeenth harmonic
10356	SRC 2 Ia Harm[16]	Amps	Source 2 phase A current eighteenth harmonic
10357	SRC 2 Ia Harm[17]	Amps	Source 2 phase A current nineteenth harmonic
10358	SRC 2 Ia Harm[18]	Amps	Source 2 phase A current twentieth harmonic
10359	SRC 2 Ia Harm[19]	Amps	Source 2 phase A current twenty-first harmonic
10360	SRC 2 Ia Harm[20]	Amps	Source 2 phase A current twenty-second harmonic
10361	SRC 2 Ia Harm[21]	Amps	Source 2 phase A current twenty-third harmonic
10362	SRC 2 Ia Harm[22]	Amps	Source 2 phase A current twenty-fourth harmonic
10363	SRC 2 Ia Harm[23]	Amps	Source 2 phase A current twenty-fifth harmonic
10372	SRC 2 Ib THD	---	Source 2 phase B current total harmonic distortion
10373	SRC 2 Ib Harm[0]	Amps	Source 2 phase B current second harmonic
10374	SRC 2 Ib Harm[1]	Amps	Source 2 phase B current third harmonic
10375	SRC 2 Ib Harm[2]	Amps	Source 2 phase B current fourth harmonic
10376	SRC 2 Ib Harm[3]	Amps	Source 2 phase B current fifth harmonic
10377	SRC 2 Ib Harm[4]	Amps	Source 2 phase B current sixth harmonic
10378	SRC 2 Ib Harm[5]	Amps	Source 2 phase B current seventh harmonic
10379	SRC 2 Ib Harm[6]	Amps	Source 2 phase B current eighth harmonic
10380	SRC 2 Ib Harm[7]	Amps	Source 2 phase B current ninth harmonic
10381	SRC 2 Ib Harm[8]	Amps	Source 2 phase B current tenth harmonic
10382	SRC 2 Ib Harm[9]	Amps	Source 2 phase B current eleventh harmonic
10383	SRC 2 Ib Harm[10]	Amps	Source 2 phase B current twelfth harmonic
10384	SRC 2 Ib Harm[11]	Amps	Source 2 phase B current thirteenth harmonic
10385	SRC 2 Ib Harm[12]	Amps	Source 2 phase B current fourteenth harmonic
10386	SRC 2 Ib Harm[13]	Amps	Source 2 phase B current fifteenth harmonic
10387	SRC 2 Ib Harm[14]	Amps	Source 2 phase B current sixteenth harmonic
10388	SRC 2 Ib Harm[15]	Amps	Source 2 phase B current seventeenth harmonic
10389	SRC 2 Ib Harm[16]	Amps	Source 2 phase B current eighteenth harmonic
10390	SRC 2 Ib Harm[17]	Amps	Source 2 phase B current nineteenth harmonic
10391	SRC 2 Ib Harm[18]	Amps	Source 2 phase B current twentieth harmonic
10392	SRC 2 Ib Harm[19]	Amps	Source 2 phase B current twenty-first harmonic
10393	SRC 2 Ib Harm[20]	Amps	Source 2 phase B current twenty-second harmonic
10394	SRC 2 Ib Harm[21]	Amps	Source 2 phase B current twenty-third harmonic
10395	SRC 2 Ib Harm[22]	Amps	Source 2 phase B current twenty-fourth harmonic
10396	SRC 2 Ib Harm[23]	Amps	Source 2 phase B current twenty-fifth harmonic
10405	SRC 2 Ic THD	---	Source 2 phase C current total harmonic distortion
10406	SRC 2 Ic Harm[0]	Amps	Source 2 phase C current second harmonic
10407	SRC 2 Ic Harm[1]	Amps	Source 2 phase C current third harmonic
10408	SRC 2 Ic Harm[2]	Amps	Source 2 phase C current fourth harmonic
10409	SRC 2 Ic Harm[3]	Amps	Source 2 phase C current fifth harmonic
10410	SRC 2 Ic Harm[4]	Amps	Source 2 phase C current sixth harmonic
10411	SRC 2 Ic Harm[5]	Amps	Source 2 phase C current seventh harmonic
10412	SRC 2 Ic Harm[6]	Amps	Source 2 phase C current eighth harmonic

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 22 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
10413	SRC 2 Ic Harm[7]	Amps	Source 2 phase C current ninth harmonic
10414	SRC 2 Ic Harm[8]	Amps	Source 2 phase C current tenth harmonic
10415	SRC 2 Ic Harm[9]	Amps	Source 2 phase C current eleventh harmonic
10416	SRC 2 Ic Harm[10]	Amps	Source 2 phase C current twelfth harmonic
10417	SRC 2 Ic Harm[11]	Amps	Source 2 phase C current thirteenth harmonic
10418	SRC 2 Ic Harm[12]	Amps	Source 2 phase C current fourteenth harmonic
10419	SRC 2 Ic Harm[13]	Amps	Source 2 phase C current fifteenth harmonic
10420	SRC 2 Ic Harm[14]	Amps	Source 2 phase C current sixteenth harmonic
10421	SRC 2 Ic Harm[15]	Amps	Source 2 phase C current seventeenth harmonic
10422	SRC 2 Ic Harm[16]	Amps	Source 2 phase C current eighteenth harmonic
10423	SRC 2 Ic Harm[17]	Amps	Source 2 phase C current nineteenth harmonic
10424	SRC 2 Ic Harm[18]	Amps	Source 2 phase C current twentieth harmonic
10425	SRC 2 Ic Harm[19]	Amps	Source 2 phase C current twenty-first harmonic
10426	SRC 2 Ic Harm[20]	Amps	Source 2 phase C current twenty-second harmonic
10427	SRC 2 Ic Harm[21]	Amps	Source 2 phase C current twenty-third harmonic
10428	SRC 2 Ic Harm[22]	Amps	Source 2 phase C current twenty-fourth harmonic
10429	SRC 2 Ic Harm[23]	Amps	Source 2 phase C current twenty-fifth harmonic
10438	SRC 3 Ia THD	---	Source 3 phase A current total harmonic distortion
10439	SRC 3 Ia Harm[0]	Amps	Source 3 phase A current second harmonic
10440	SRC 3 Ia Harm[1]	Amps	Source 3 phase A current third harmonic
10441	SRC 3 Ia Harm[2]	Amps	Source 3 phase A current fourth harmonic
10442	SRC 3 Ia Harm[3]	Amps	Source 3 phase A current fifth harmonic
10443	SRC 3 Ia Harm[4]	Amps	Source 3 phase A current sixth harmonic
10444	SRC 3 Ia Harm[5]	Amps	Source 3 phase A current seventh harmonic
10445	SRC 3 Ia Harm[6]	Amps	Source 3 phase A current eighth harmonic
10446	SRC 3 Ia Harm[7]	Amps	Source 3 phase A current ninth harmonic
10447	SRC 3 Ia Harm[8]	Amps	Source 3 phase A current tenth harmonic
10448	SRC 3 Ia Harm[9]	Amps	Source 3 phase A current eleventh harmonic
10449	SRC 3 Ia Harm[10]	Amps	Source 3 phase A current twelfth harmonic
10450	SRC 3 Ia Harm[11]	Amps	Source 3 phase A current thirteenth harmonic
10451	SRC 3 Ia Harm[12]	Amps	Source 3 phase A current fourteenth harmonic
10452	SRC 3 Ia Harm[13]	Amps	Source 3 phase A current fifteenth harmonic
10453	SRC 3 Ia Harm[14]	Amps	Source 3 phase A current sixteenth harmonic
10454	SRC 3 Ia Harm[15]	Amps	Source 3 phase A current seventeenth harmonic
10455	SRC 3 Ia Harm[16]	Amps	Source 3 phase A current eighteenth harmonic
10456	SRC 3 Ia Harm[17]	Amps	Source 3 phase A current nineteenth harmonic
10457	SRC 3 Ia Harm[18]	Amps	Source 3 phase A current twentieth harmonic
10458	SRC 3 Ia Harm[19]	Amps	Source 3 phase A current twenty-first harmonic
10459	SRC 3 Ia Harm[20]	Amps	Source 3 phase A current twenty-second harmonic
10460	SRC 3 Ia Harm[21]	Amps	Source 3 phase A current twenty-third harmonic
10461	SRC 3 Ia Harm[22]	Amps	Source 3 phase A current twenty-fourth harmonic
10462	SRC 3 Ia Harm[23]	Amps	Source 3 phase A current twenty-fifth harmonic
10471	SRC 3 Ib THD	---	Source 3 phase B current total harmonic distortion
10472	SRC 3 Ib Harm[0]	Amps	Source 3 phase B current second harmonic
10473	SRC 3 Ib Harm[1]	Amps	Source 3 phase B current third harmonic
10474	SRC 3 Ib Harm[2]	Amps	Source 3 phase B current fourth harmonic
10475	SRC 3 Ib Harm[3]	Amps	Source 3 phase B current fifth harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 23 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
10476	SRC 3 Ib Harm[4]	Amps	Source 3 phase B current sixth harmonic
10477	SRC 3 Ib Harm[5]	Amps	Source 3 phase B current seventh harmonic
10478	SRC 3 Ib Harm[6]	Amps	Source 3 phase B current eighth harmonic
10479	SRC 3 Ib Harm[7]	Amps	Source 3 phase B current ninth harmonic
10480	SRC 3 Ib Harm[8]	Amps	Source 3 phase B current tenth harmonic
10481	SRC 3 Ib Harm[9]	Amps	Source 3 phase B current eleventh harmonic
10482	SRC 3 Ib Harm[10]	Amps	Source 3 phase B current twelfth harmonic
10483	SRC 3 Ib Harm[11]	Amps	Source 3 phase B current thirteenth harmonic
10484	SRC 3 Ib Harm[12]	Amps	Source 3 phase B current fourteenth harmonic
10485	SRC 3 Ib Harm[13]	Amps	Source 3 phase B current fifteenth harmonic
10486	SRC 3 Ib Harm[14]	Amps	Source 3 phase B current sixteenth harmonic
10487	SRC 3 Ib Harm[15]	Amps	Source 3 phase B current seventeenth harmonic
10488	SRC 3 Ib Harm[16]	Amps	Source 3 phase B current eighteenth harmonic
10489	SRC 3 Ib Harm[17]	Amps	Source 3 phase B current nineteenth harmonic
10490	SRC 3 Ib Harm[18]	Amps	Source 3 phase B current twentieth harmonic
10491	SRC 3 Ib Harm[19]	Amps	Source 3 phase B current twenty-first harmonic
10492	SRC 3 Ib Harm[20]	Amps	Source 3 phase B current twenty-second harmonic
10493	SRC 3 Ib Harm[21]	Amps	Source 3 phase B current twenty-third harmonic
10494	SRC 3 Ib Harm[22]	Amps	Source 3 phase B current twenty-fourth harmonic
10495	SRC 3 Ib Harm[23]	Amps	Source 3 phase B current twenty-fifth harmonic
10504	SRC 3 Ic THD	---	Source 3 phase C current total harmonic distortion
10505	SRC 3 Ic Harm[0]	Amps	Source 3 phase C current second harmonic
10506	SRC 3 Ic Harm[1]	Amps	Source 3 phase C current third harmonic
10507	SRC 3 Ic Harm[2]	Amps	Source 3 phase C current fourth harmonic
10508	SRC 3 Ic Harm[3]	Amps	Source 3 phase C current fifth harmonic
10509	SRC 3 Ic Harm[4]	Amps	Source 3 phase C current sixth harmonic
10510	SRC 3 Ic Harm[5]	Amps	Source 3 phase C current seventh harmonic
10511	SRC 3 Ic Harm[6]	Amps	Source 3 phase C current eighth harmonic
10512	SRC 3 Ic Harm[7]	Amps	Source 3 phase C current ninth harmonic
10513	SRC 3 Ic Harm[8]	Amps	Source 3 phase C current tenth harmonic
10514	SRC 3 Ic Harm[9]	Amps	Source 3 phase C current eleventh harmonic
10515	SRC 3 Ic Harm[10]	Amps	Source 3 phase C current twelfth harmonic
10516	SRC 3 Ic Harm[11]	Amps	Source 3 phase C current thirteenth harmonic
10517	SRC 3 Ic Harm[12]	Amps	Source 3 phase C current fourteenth harmonic
10518	SRC 3 Ic Harm[13]	Amps	Source 3 phase C current fifteenth harmonic
10519	SRC 3 Ic Harm[14]	Amps	Source 3 phase C current sixteenth harmonic
10520	SRC 3 Ic Harm[15]	Amps	Source 3 phase C current seventeenth harmonic
10521	SRC 3 Ic Harm[16]	Amps	Source 3 phase C current eighteenth harmonic
10522	SRC 3 Ic Harm[17]	Amps	Source 3 phase C current nineteenth harmonic
10523	SRC 3 Ic Harm[18]	Amps	Source 3 phase C current twentieth harmonic
10524	SRC 3 Ic Harm[19]	Amps	Source 3 phase C current twenty-first harmonic
10525	SRC 3 Ic Harm[20]	Amps	Source 3 phase C current twenty-second harmonic
10526	SRC 3 Ic Harm[21]	Amps	Source 3 phase C current twenty-third harmonic
10527	SRC 3 Ic Harm[22]	Amps	Source 3 phase C current twenty-fourth harmonic
10528	SRC 3 Ic Harm[23]	Amps	Source 3 phase C current twenty-fifth harmonic
10537	SRC 4 Ia THD	---	Source 4 phase A current total harmonic distortion
10538	SRC 4 Ia Harm[0]	Amps	Source 4 phase A current second harmonic

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 24 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
10539	SRC 4 Ia Harm[1]	Amps	Source 4 phase A current third harmonic
10540	SRC 4 Ia Harm[2]	Amps	Source 4 phase A current fourth harmonic
10541	SRC 4 Ia Harm[3]	Amps	Source 4 phase A current fifth harmonic
10542	SRC 4 Ia Harm[4]	Amps	Source 4 phase A current sixth harmonic
10543	SRC 4 Ia Harm[5]	Amps	Source 4 phase A current seventh harmonic
10544	SRC 4 Ia Harm[6]	Amps	Source 4 phase A current eighth harmonic
10545	SRC 4 Ia Harm[7]	Amps	Source 4 phase A current ninth harmonic
10546	SRC 4 Ia Harm[8]	Amps	Source 4 phase A current tenth harmonic
10547	SRC 4 Ia Harm[9]	Amps	Source 4 phase A current eleventh harmonic
10548	SRC 4 Ia Harm[10]	Amps	Source 4 phase A current twelfth harmonic
10549	SRC 4 Ia Harm[11]	Amps	Source 4 phase A current thirteenth harmonic
10550	SRC 4 Ia Harm[12]	Amps	Source 4 phase A current fourteenth harmonic
10551	SRC 4 Ia Harm[13]	Amps	Source 4 phase A current fifteenth harmonic
10552	SRC 4 Ia Harm[14]	Amps	Source 4 phase A current sixteenth harmonic
10553	SRC 4 Ia Harm[15]	Amps	Source 4 phase A current seventeenth harmonic
10554	SRC 4 Ia Harm[16]	Amps	Source 4 phase A current eighteenth harmonic
10555	SRC 4 Ia Harm[17]	Amps	Source 4 phase A current nineteenth harmonic
10556	SRC 4 Ia Harm[18]	Amps	Source 4 phase A current twentieth harmonic
10557	SRC 4 Ia Harm[19]	Amps	Source 4 phase A current twenty-first harmonic
10558	SRC 4 Ia Harm[20]	Amps	Source 4 phase A current twenty-second harmonic
10559	SRC 4 Ia Harm[21]	Amps	Source 4 phase A current twenty-third harmonic
10560	SRC 4 Ia Harm[22]	Amps	Source 4 phase A current twenty-fourth harmonic
10561	SRC 4 Ia Harm[23]	Amps	Source 4 phase A current twenty-fifth harmonic
10570	SRC 4 Ib THD	---	Source 4 phase B current total harmonic distortion
10571	SRC 4 Ib Harm[0]	Amps	Source 4 phase B current second harmonic
10572	SRC 4 Ib Harm[1]	Amps	Source 4 phase B current third harmonic
10573	SRC 4 Ib Harm[2]	Amps	Source 4 phase B current fourth harmonic
10574	SRC 4 Ib Harm[3]	Amps	Source 4 phase B current fifth harmonic
10575	SRC 4 Ib Harm[4]	Amps	Source 4 phase B current sixth harmonic
10576	SRC 4 Ib Harm[5]	Amps	Source 4 phase B current seventh harmonic
10577	SRC 4 Ib Harm[6]	Amps	Source 4 phase B current eighth harmonic
10578	SRC 4 Ib Harm[7]	Amps	Source 4 phase B current ninth harmonic
10579	SRC 4 Ib Harm[8]	Amps	Source 4 phase B current tenth harmonic
10580	SRC 4 Ib Harm[9]	Amps	Source 4 phase B current eleventh harmonic
10581	SRC 4 Ib Harm[10]	Amps	Source 4 phase B current twelfth harmonic
10582	SRC 4 Ib Harm[11]	Amps	Source 4 phase B current thirteenth harmonic
10583	SRC 4 Ib Harm[12]	Amps	Source 4 phase B current fourteenth harmonic
10584	SRC 4 Ib Harm[13]	Amps	Source 4 phase B current fifteenth harmonic
10585	SRC 4 Ib Harm[14]	Amps	Source 4 phase B current sixteenth harmonic
10586	SRC 4 Ib Harm[15]	Amps	Source 4 phase B current seventeenth harmonic
10587	SRC 4 Ib Harm[16]	Amps	Source 4 phase B current eighteenth harmonic
10588	SRC 4 Ib Harm[17]	Amps	Source 4 phase B current nineteenth harmonic
10589	SRC 4 Ib Harm[18]	Amps	Source 4 phase B current twentieth harmonic
10590	SRC 4 Ib Harm[19]	Amps	Source 4 phase B current twenty-first harmonic
10591	SRC 4 Ib Harm[20]	Amps	Source 4 phase B current twenty-second harmonic
10592	SRC 4 Ib Harm[21]	Amps	Source 4 phase B current twenty-third harmonic
10593	SRC 4 Ib Harm[22]	Amps	Source 4 phase B current twenty-fourth harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 25 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
10594	SRC 4 Ib Harm[23]	Amps	Source 4 phase B current twenty-fifth harmonic
10603	SRC 4 Ic THD	---	Source 4 phase C current total harmonic distortion
10604	SRC 4 Ic Harm[0]	Amps	Source 4 phase C current second harmonic
10605	SRC 4 Ic Harm[1]	Amps	Source 4 phase C current third harmonic
10606	SRC 4 Ic Harm[2]	Amps	Source 4 phase C current fourth harmonic
10607	SRC 4 Ic Harm[3]	Amps	Source 4 phase C current fifth harmonic
10608	SRC 4 Ic Harm[4]	Amps	Source 4 phase C current sixth harmonic
10609	SRC 4 Ic Harm[5]	Amps	Source 4 phase C current seventh harmonic
10610	SRC 4 Ic Harm[6]	Amps	Source 4 phase C current eighth harmonic
10611	SRC 4 Ic Harm[7]	Amps	Source 4 phase C current ninth harmonic
10612	SRC 4 Ic Harm[8]	Amps	Source 4 phase C current tenth harmonic
10613	SRC 4 Ic Harm[9]	Amps	Source 4 phase C current eleventh harmonic
10614	SRC 4 Ic Harm[10]	Amps	Source 4 phase C current twelfth harmonic
10615	SRC 4 Ic Harm[11]	Amps	Source 4 phase C current thirteenth harmonic
10616	SRC 4 Ic Harm[12]	Amps	Source 4 phase C current fourteenth harmonic
10617	SRC 4 Ic Harm[13]	Amps	Source 4 phase C current fifteenth harmonic
10618	SRC 4 Ic Harm[14]	Amps	Source 4 phase C current sixteenth harmonic
10619	SRC 4 Ic Harm[15]	Amps	Source 4 phase C current seventeenth harmonic
10620	SRC 4 Ic Harm[16]	Amps	Source 4 phase C current eighteenth harmonic
10621	SRC 4 Ic Harm[17]	Amps	Source 4 phase C current nineteenth harmonic
10622	SRC 4 Ic Harm[18]	Amps	Source 4 phase C current twentieth harmonic
10623	SRC 4 Ic Harm[19]	Amps	Source 4 phase C current twenty-first harmonic
10624	SRC 4 Ic Harm[20]	Amps	Source 4 phase C current twenty-second harmonic
10625	SRC 4 Ic Harm[21]	Amps	Source 4 phase C current twenty-third harmonic
10626	SRC 4 Ic Harm[22]	Amps	Source 4 phase C current twenty-fourth harmonic
10627	SRC 4 Ic Harm[23]	Amps	Source 4 phase C current twenty-fifth harmonic
10628	SRC 5 Ia THD	---	Source 5 phase A current total harmonic distortion
10629	SRC 5 Ia Harm[0]	Amps	Source 5 phase A current second harmonic
10630	SRC 5 Ia Harm[1]	Amps	Source 5 phase A current third harmonic
10631	SRC 5 Ia Harm[2]	Amps	Source 5 phase A current fourth harmonic
10632	SRC 5 Ia Harm[3]	Amps	Source 5 phase A current fifth harmonic
10633	SRC 5 Ia Harm[4]	Amps	Source 5 phase A current sixth harmonic
10634	SRC 5 Ia Harm[5]	Amps	Source 5 phase A current seventh harmonic
10635	SRC 5 Ia Harm[6]	Amps	Source 5 phase A current eighth harmonic
10636	SRC 5 Ia Harm[7]	Amps	Source 5 phase A current ninth harmonic
10637	SRC 5 Ia Harm[8]	Amps	Source 5 phase A current tenth harmonic
10638	SRC 5 Ia Harm[9]	Amps	Source 5 phase A current eleventh harmonic
10639	SRC 5 Ia Harm[10]	Amps	Source 5 phase A current twelfth harmonic
10640	SRC 5 Ia Harm[11]	Amps	Source 5 phase A current thirteenth harmonic
10641	SRC 5 Ia Harm[12]	Amps	Source 5 phase A current fourteenth harmonic
10642	SRC 5 Ia Harm[13]	Amps	Source 5 phase A current fifteenth harmonic
10643	SRC 5 Ia Harm[14]	Amps	Source 5 phase A current sixteenth harmonic
10644	SRC 5 Ia Harm[15]	Amps	Source 5 phase A current seventeenth harmonic
10645	SRC 5 Ia Harm[16]	Amps	Source 5 phase A current eighteenth harmonic
10646	SRC 5 Ia Harm[17]	Amps	Source 5 phase A current nineteenth harmonic
10647	SRC 5 Ia Harm[18]	Amps	Source 5 phase A current twentieth harmonic
10648	SRC 5 Ia Harm[19]	Amps	Source 5 phase A current twenty-first harmonic

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 26 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
10649	SRC 5 Ia Harm[20]	Amps	Source 5 phase A current twenty-second harmonic
10650	SRC 5 Ia Harm[21]	Amps	Source 5 phase A current twenty-third harmonic
10651	SRC 5 Ia Harm[22]	Amps	Source 5 phase A current twenty-fourth harmonic
10652	SRC 5 Ia Harm[23]	Amps	Source 5 phase A current twenty-fifth harmonic
10653	SRC 5 Ib THD	---	Source 5 phase B current total harmonic distortion
10654	SRC 5 Ib Harm[0]	Amps	Source 5 phase B current second harmonic
10655	SRC 5 Ib Harm[1]	Amps	Source 5 phase B current third harmonic
10656	SRC 5 Ib Harm[2]	Amps	Source 5 phase B current fourth harmonic
10657	SRC 5 Ib Harm[3]	Amps	Source 5 phase B current fifth harmonic
10658	SRC 5 Ib Harm[4]	Amps	Source 5 phase B current sixth harmonic
10659	SRC 5 Ib Harm[5]	Amps	Source 5 phase B current seventh harmonic
10660	SRC 5 Ib Harm[6]	Amps	Source 5 phase B current eighth harmonic
10661	SRC 5 Ib Harm[7]	Amps	Source 5 phase B current ninth harmonic
10662	SRC 5 Ib Harm[8]	Amps	Source 5 phase B current tenth harmonic
10663	SRC 5 Ib Harm[9]	Amps	Source 5 phase B current eleventh harmonic
10664	SRC 5 Ib Harm[10]	Amps	Source 5 phase B current twelfth harmonic
10665	SRC 5 Ib Harm[11]	Amps	Source 5 phase B current thirteenth harmonic
10666	SRC 5 Ib Harm[12]	Amps	Source 5 phase B current fourteenth harmonic
10667	SRC 5 Ib Harm[13]	Amps	Source 5 phase B current fifteenth harmonic
10668	SRC 5 Ib Harm[14]	Amps	Source 5 phase B current sixteenth harmonic
10669	SRC 5 Ib Harm[15]	Amps	Source 5 phase B current seventeenth harmonic
10670	SRC 5 Ib Harm[16]	Amps	Source 5 phase B current eighteenth harmonic
10671	SRC 5 Ib Harm[17]	Amps	Source 5 phase B current nineteenth harmonic
10672	SRC 5 Ib Harm[18]	Amps	Source 5 phase B current twentieth harmonic
10673	SRC 5 Ib Harm[19]	Amps	Source 5 phase B current twenty-first harmonic
10674	SRC 5 Ib Harm[20]	Amps	Source 5 phase B current twenty-second harmonic
10675	SRC 5 Ib Harm[21]	Amps	Source 5 phase B current twenty-third harmonic
10676	SRC 5 Ib Harm[22]	Amps	Source 5 phase B current twenty-fourth harmonic
10677	SRC 5 Ib Harm[23]	Amps	Source 5 phase B current twenty-fifth harmonic
10678	SRC 5 Ic THD	---	Source 5 phase C current total harmonic distortion
10679	SRC 5 Ic Harm[0]	Amps	Source 5 phase C current second harmonic
10680	SRC 5 Ic Harm[1]	Amps	Source 5 phase C current third harmonic
10681	SRC 5 Ic Harm[2]	Amps	Source 5 phase C current fourth harmonic
10682	SRC 5 Ic Harm[3]	Amps	Source 5 phase C current fifth harmonic
10683	SRC 5 Ic Harm[4]	Amps	Source 5 phase C current sixth harmonic
10684	SRC 5 Ic Harm[5]	Amps	Source 5 phase C current seventh harmonic
10685	SRC 5 Ic Harm[6]	Amps	Source 5 phase C current eighth harmonic
10686	SRC 5 Ic Harm[7]	Amps	Source 5 phase C current ninth harmonic
10687	SRC 5 Ic Harm[8]	Amps	Source 5 phase C current tenth harmonic
10688	SRC 5 Ic Harm[9]	Amps	Source 5 phase C current eleventh harmonic
10689	SRC 5 Ic Harm[10]	Amps	Source 5 phase C current twelfth harmonic
10690	SRC 5 Ic Harm[11]	Amps	Source 5 phase C current thirteenth harmonic
10691	SRC 5 Ic Harm[12]	Amps	Source 5 phase C current fourteenth harmonic
10692	SRC 5 Ic Harm[13]	Amps	Source 5 phase C current fifteenth harmonic
10693	SRC 5 Ic Harm[14]	Amps	Source 5 phase C current sixteenth harmonic
10694	SRC 5 Ic Harm[15]	Amps	Source 5 phase C current seventeenth harmonic
10695	SRC 5 Ic Harm[16]	Amps	Source 5 phase C current eighteenth harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 27 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
10696	SRC 5 Ic Harm[17]	Amps	Source 5 phase C current nineteenth harmonic
10697	SRC 5 Ic Harm[18]	Amps	Source 5 phase C current twentieth harmonic
10698	SRC 5 Ic Harm[19]	Amps	Source 5 phase C current twenty-first harmonic
10699	SRC 5 Ic Harm[20]	Amps	Source 5 phase C current twenty-second harmonic
10700	SRC 5 Ic Harm[21]	Amps	Source 5 phase C current twenty-third harmonic
10701	SRC 5 Ic Harm[22]	Amps	Source 5 phase C current twenty-fourth harmonic
10702	SRC 5 Ic Harm[23]	Amps	Source 5 phase C current twenty-fifth harmonic
10703	SRC 6 Ia THD	---	Source 6 phase A current total harmonic distortion
10704	SRC 6 Ia Harm[0]	Amps	Source 6 phase A current second harmonic
10705	SRC 6 Ia Harm[1]	Amps	Source 6 phase A current third harmonic
10706	SRC 6 Ia Harm[2]	Amps	Source 6 phase A current fourth harmonic
10707	SRC 6 Ia Harm[3]	Amps	Source 6 phase A current fifth harmonic
10708	SRC 6 Ia Harm[4]	Amps	Source 6 phase A current sixth harmonic
10709	SRC 6 Ia Harm[5]	Amps	Source 6 phase A current seventh harmonic
10710	SRC 6 Ia Harm[6]	Amps	Source 6 phase A current eighth harmonic
10711	SRC 6 Ia Harm[7]	Amps	Source 6 phase A current ninth harmonic
10712	SRC 6 Ia Harm[8]	Amps	Source 6 phase A current tenth harmonic
10713	SRC 6 Ia Harm[9]	Amps	Source 6 phase A current eleventh harmonic
10714	SRC 6 Ia Harm[10]	Amps	Source 6 phase A current twelfth harmonic
10715	SRC 6 Ia Harm[11]	Amps	Source 6 phase A current thirteenth harmonic
10716	SRC 6 Ia Harm[12]	Amps	Source 6 phase A current fourteenth harmonic
10717	SRC 6 Ia Harm[13]	Amps	Source 6 phase A current fifteenth harmonic
10718	SRC 6 Ia Harm[14]	Amps	Source 6 phase A current sixteenth harmonic
10719	SRC 6 Ia Harm[15]	Amps	Source 6 phase A current seventeenth harmonic
10720	SRC 6 Ia Harm[16]	Amps	Source 6 phase A current eighteenth harmonic
10721	SRC 6 Ia Harm[17]	Amps	Source 6 phase A current nineteenth harmonic
10722	SRC 6 Ia Harm[18]	Amps	Source 6 phase A current twentieth harmonic
10723	SRC 6 Ia Harm[19]	Amps	Source 6 phase A current twenty-first harmonic
10724	SRC 6 Ia Harm[20]	Amps	Source 6 phase A current twenty-second harmonic
10725	SRC 6 Ia Harm[21]	Amps	Source 6 phase A current twenty-third harmonic
10726	SRC 6 Ia Harm[22]	Amps	Source 6 phase A current twenty-fourth harmonic
10727	SRC 6 Ia Harm[23]	Amps	Source 6 phase A current twenty-fifth harmonic
10728	SRC 6 Ib THD	---	Source 6 phase B current total harmonic distortion
10729	SRC 6 Ib Harm[0]	Amps	Source 6 phase B current second harmonic
10730	SRC 6 Ib Harm[1]	Amps	Source 6 phase B current third harmonic
10731	SRC 6 Ib Harm[2]	Amps	Source 6 phase B current fourth harmonic
10732	SRC 6 Ib Harm[3]	Amps	Source 6 phase B current fifth harmonic
10733	SRC 6 Ib Harm[4]	Amps	Source 6 phase B current sixth harmonic
10734	SRC 6 Ib Harm[5]	Amps	Source 6 phase B current seventh harmonic
10735	SRC 6 Ib Harm[6]	Amps	Source 6 phase B current eighth harmonic
10736	SRC 6 Ib Harm[7]	Amps	Source 6 phase B current ninth harmonic
10737	SRC 6 Ib Harm[8]	Amps	Source 6 phase B current tenth harmonic
10738	SRC 6 Ib Harm[9]	Amps	Source 6 phase B current eleventh harmonic
10739	SRC 6 Ib Harm[10]	Amps	Source 6 phase B current twelfth harmonic
10740	SRC 6 Ib Harm[11]	Amps	Source 6 phase B current thirteenth harmonic
10741	SRC 6 Ib Harm[12]	Amps	Source 6 phase B current fourteenth harmonic
10742	SRC 6 Ib Harm[13]	Amps	Source 6 phase B current fifteenth harmonic

Table A–1: FLEXANALOG DATA ITEMS (Sheet 28 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
10743	SRC 6 Ib Harm[14]	Amps	Source 6 phase B current sixteenth harmonic
10744	SRC 6 Ib Harm[15]	Amps	Source 6 phase B current seventeenth harmonic
10745	SRC 6 Ib Harm[16]	Amps	Source 6 phase B current eighteenth harmonic
10746	SRC 6 Ib Harm[17]	Amps	Source 6 phase B current nineteenth harmonic
10747	SRC 6 Ib Harm[18]	Amps	Source 6 phase B current twentieth harmonic
10748	SRC 6 Ib Harm[19]	Amps	Source 6 phase B current twenty-first harmonic
10749	SRC 6 Ib Harm[20]	Amps	Source 6 phase B current twenty-second harmonic
10750	SRC 6 Ib Harm[21]	Amps	Source 6 phase B current twenty-third harmonic
10751	SRC 6 Ib Harm[22]	Amps	Source 6 phase B current twenty-fourth harmonic
10752	SRC 6 Ib Harm[23]	Amps	Source 6 phase B current twenty-fifth harmonic
10753	SRC 6 Ic THD	---	Source 6 phase C current total harmonic distortion
10754	SRC 6 Ic Harm[0]	Amps	Source 6 phase C current second harmonic
10755	SRC 6 Ic Harm[1]	Amps	Source 6 phase C current third harmonic
10756	SRC 6 Ic Harm[2]	Amps	Source 6 phase C current fourth harmonic
10757	SRC 6 Ic Harm[3]	Amps	Source 6 phase C current fifth harmonic
10758	SRC 6 Ic Harm[4]	Amps	Source 6 phase C current sixth harmonic
10759	SRC 6 Ic Harm[5]	Amps	Source 6 phase C current seventh harmonic
10760	SRC 6 Ic Harm[6]	Amps	Source 6 phase C current eighth harmonic
10761	SRC 6 Ic Harm[7]	Amps	Source 6 phase C current ninth harmonic
10762	SRC 6 Ic Harm[8]	Amps	Source 6 phase C current tenth harmonic
10763	SRC 6 Ic Harm[9]	Amps	Source 6 phase C current eleventh harmonic
10764	SRC 6 Ic Harm[10]	Amps	Source 6 phase C current twelfth harmonic
10765	SRC 6 Ic Harm[11]	Amps	Source 6 phase C current thirteenth harmonic
10766	SRC 6 Ic Harm[12]	Amps	Source 6 phase C current fourteenth harmonic
10767	SRC 6 Ic Harm[13]	Amps	Source 6 phase C current fifteenth harmonic
10768	SRC 6 Ic Harm[14]	Amps	Source 6 phase C current sixteenth harmonic
10769	SRC 6 Ic Harm[15]	Amps	Source 6 phase C current seventeenth harmonic
10770	SRC 6 Ic Harm[16]	Amps	Source 6 phase C current eighteenth harmonic
10771	SRC 6 Ic Harm[17]	Amps	Source 6 phase C current nineteenth harmonic
10772	SRC 6 Ic Harm[18]	Amps	Source 6 phase C current twentieth harmonic
10773	SRC 6 Ic Harm[19]	Amps	Source 6 phase C current twenty-first harmonic
10774	SRC 6 Ic Harm[20]	Amps	Source 6 phase C current twenty-second harmonic
10775	SRC 6 Ic Harm[21]	Amps	Source 6 phase C current twenty-third harmonic
10776	SRC 6 Ic Harm[22]	Amps	Source 6 phase C current twenty-fourth harmonic
10777	SRC 6 Ic Harm[23]	Amps	Source 6 phase C current twenty-fifth harmonic
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 29 of 31)

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

A

Table A–1: FLEXANALOG DATA ITEMS (Sheet 30 of 31)

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
13824	60P 1 Raw Idiff A	Amps	Phase current balance raw phase A differential current actual value
13826	60P 1 Raw Idiff B	Amps	Phase current balance raw phase B differential current actual value
13828	60P 1 Raw Idiff C	Amps	Phase current balance raw phase C differential current actual value
13830	60P 1 Comp Iop A	Amps	Phase current balance composite phase A operating current actual value
13832	60P 1 Comp Iop B	Amps	Phase current balance composite phase B operating current actual value
13834	60P 1 Comp Iop C	Amps	Phase current balance composite phase C operating current actual value
14020	60N 1 Raw INsp	Amps	Neutral current unbalance INsp actual value
14022	60N 1 Comp Iop	Amps	Neutral current unbalance Iop actual value
14064	59NU1Ntrl-p Vx Ang	Angle	Neutral voltage unbalance neutral-point Vx angle
14066	59NU1Bus V0 Ang	Angle	Neutral voltage unbalance neutral-point Vx bus V0 angle
14068	59NU1Bus V0 Mag	Volts	Neutral voltage unbalance neutral-point Vx bus V0 magnitude
14070	59NU1Ntrl-p Vx Mag	Volts	Neutral voltage unbalance neutral-point Vx magnitude
14072	59NU1Vop	Volts	Neutral voltage unbalance neutral-point Vx operating voltage
14074	59NU1Vrest	Volts	Neutral voltage unbalance neutral-point Vx restraining voltage
14112	SecondOfDay	---	Integer number of seconds past midnight (1000 seconds = 1 pu)
14114	DayOfMonth	---	Day of the current month (1 day = 1 pu)
14115	DayOfYear	---	Integer number of day of year (Julian date. 5 days = 1 pu)
14116	Year	---	Time of day, year (100 years = 1 pu)
14432	CAP 1 DISCHRG TIME	seconds	Capacitor control discharge time in seconds
24459	Active Setting Group	---	Current setting group
25451	59B 1 Vop A	Volts	Bank overvoltage 1 Vop phase A
25452	59B 1 Vop B	Volts	Bank overvoltage 1 Vop phase B
25453	59B 1 Vop C	Volts	Bank overvoltage 1 Vop phase C
25454	59B 2 Vop A	Volts	Bank overvoltage 2 Vop phase A
25455	59B 2 Vop B	Volts	Bank overvoltage 2 Vop phase B
25456	59B 2 Vop C	Volts	Bank overvoltage 2 Vop phase C
25457	59B 3 Vop A	Volts	Bank overvoltage 3 Vop phase A
25458	59B 3 Vop B	Volts	Bank overvoltage 3 Vop phase B
25459	59B 3 Vop C	Volts	Bank overvoltage 3 Vop phase C
32768	Tracking Frequency	Hz	Tracking frequency
39425	FlexElement 1 Value	---	FlexElement™ 1 actual value
39427	FlexElement 2 Value	---	FlexElement™ 2 actual value
39429	FlexElement 3 Value	---	FlexElement™ 3 actual value

Table A–1: FLEXANALOG DATA ITEMS (Sheet 31 of 31)

ADDRESS	FLEXANALOG NAME	UNITS	DESCRIPTION
39431	FlexElement 4 Value	---	FlexElement™ 4 actual value
39433	FlexElement 5 Value	---	FlexElement™ 5 actual value
39435	FlexElement 6 Value	---	FlexElement™ 6 actual value
39437	FlexElement 7 Value	---	FlexElement™ 7 actual value
39439	FlexElement 8 Value	---	FlexElement™ 8 actual value
39441	FlexElement 9 Value	---	FlexElement™ 9 actual value
39443	FlexElement 10 Value	---	FlexElement™ 10 actual value
39445	FlexElement 11 Value	---	FlexElement™ 11 actual value
39447	FlexElement 12 Value	---	FlexElement™ 12 actual value
39449	FlexElement 13 Value	---	FlexElement™ 13 actual value
39451	FlexElement 14 Value	---	FlexElement™ 14 actual value
39453	FlexElement 15 Value	---	FlexElement™ 15 actual value
39455	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
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

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A.1.2 FLEXINTEGER ITEMS

Table A–2: FLEXINTEGER DATA ITEMS

ADDRESS	FLEXINTEGER NAME	UNITS	DESCRIPTION
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 C70 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

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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.

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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	**EXMAPLE (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 PC37.111 Draft 7c (02 September 1997). The files may 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)

B.3.2 MODBUS PASSWORD OPERATION

The C70 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 C70, 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. Storing a value of “0” removes command password protection. When reading the password setting, the encrypted value (zero if no password is set) is returned. 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 and encrypted values 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.

Table B–9: MODBUS MEMORY MAP (Sheet 1 of 53)

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
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)
Self Test Targets (Read Only)						
0200	Self Test States (2 items)	0 to 4294967295	0	1	F143	0
Front Panel (Read Only)						
0204	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 42	---	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)
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)

Table B–9: MODBUS MEMORY MAP (Sheet 2 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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					
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

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Table B–9: MODBUS MEMORY MAP (Sheet 3 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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)						
14C0	Target Sequence	0 to 65535	---	1	F001	0
14C1	Number of Targets	0 to 65535	---	1	F001	0
Element Targets (Read/Write)						
14C2	Target to Read	0 to 65535	---	1	F001	0
Element Targets (Read Only)						
14C3	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
Remote Input/Output States (Read Only)						
1540	Remote Device States	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)
Platform Direct Input/Output States (Read Only)						
15C0	Direct input states (6 items)	0 to 65535	---	1	F500	0
15C8	Direct outputs average message return time 1	0 to 65535	ms	1	F001	0
15C9	Direct outputs average message return time 2	0 to 65535	ms	1	F001	0
15CA	Direct inputs/outputs unreturned message count - Ch. 1	0 to 65535	---	1	F001	0
15CB	Direct inputs/outputs unreturned message count - Ch. 2	0 to 65535	---	1	F001	0
15D0	Direct device states	0 to 65535	---	1	F500	0
15D1	Reserved	0 to 65535	---	1	F001	0
15D2	Direct inputs/outputs CRC fail count 1	0 to 65535	---	1	F001	0
15D3	Direct inputs/outputs CRC fail count 2	0 to 65535	---	1	F001	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)
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
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

Table B–9: MODBUS MEMORY MAP (Sheet 4 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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
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		V		F060	0
1A02	Source 1 Phase BG Voltage RMS		V		F060	0
1A04	Source 1 Phase CG Voltage RMS		V		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					

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Table B–9: MODBUS MEMORY MAP (Sheet 5 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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
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	---	Hz	---	F003	0
1D82	Frequency for Source 2	---	Hz	---	F003	0
1D84	Frequency for Source 3	---	Hz	---	F003	0
1D86	Frequency for Source 4	---	Hz	---	F003	0
1D88	Frequency for Source 5	---	Hz	---	F003	0
1D8A	Frequency for Source 6	---	Hz	---	F003	0
Source Voltage THD And Harmonics (Read Only) (6 modules)						
1F80	Source 1 Va THD	0 to 99.9	---	0.1	F001	0
1F81	Source 1 Va Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
1F99	Source 1 Vb THD	0 to 99.9	---	0.1	F001	0
1F9A	Source 1 Vb Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
1FB2	Source 1 Vc THD	0 to 99.9	---	0.1	F001	0
1FB3	Source 1 Vc Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
1FCB	...Repeated for Source 2					
2016	...Repeated for Source 3					
2061	...Repeated for Source 4					
20AC	...Repeated for Source 5					
20F7	...Repeated for Source 6					
Breaker flashover (read/write setting) (2 modules)						
21A6	Breaker flashover 1 function	0 to 1	---	1	F102	0 (Disabled)

Table B–9: MODBUS MEMORY MAP (Sheet 6 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
21A7	Breaker flashover 1 side 1 source	0 to 5	---	1	F167	0 (SRC 1)
21A8	Breaker flashover 1 side 2 source	0 to 6	---	1	F211	0 (None)
21A9	Breaker flashover 1 status closed A	0 to 65535	---	1	F300	0
21AA	Breaker flashover 1 status closed B	0 to 65535	---	1	F300	0
21AB	Breaker flashover 1 status closed C	0 to 65535	---	1	F300	0
21AC	Breaker flashover 1 voltage pickup level	0 to 1.5	pu	0.001	F001	850
21AD	Breaker flashover 1 voltage difference pickup level	0 to 100000	V	1	F060	1000
21AF	Breaker flashover 1 current pickup level	0 to 1.5	pu	0.001	F001	600
21B0	Breaker flashover 1 pickup delay	0 to 65.535	s	0.001	F001	100
21B1	Breaker flashover 1 supervision phase A	0 to 65535	---	1	F300	0
21B2	Breaker flashover 1 supervision phase B	0 to 65535	---	1	F300	0
21B3	Breaker flashover 1 supervision phase C	0 to 65535	---	1	F300	0
21B4	Breaker flashover 1 block	0 to 65535	---	1	F300	0
21B5	Breaker flashover 1 events	0 to 1	---	1	F102	0 (Disabled)
21B6	Breaker flashover 1 target	0 to 2	---	1	F109	0 (Self-Reset)
21B7	Reserved (4 items)	---	---	---	F001	0
21BB	...Repeated for breaker flashover 2	0 to 99999999	kA^2-cyc	1	F060	0
Passwords Unauthorized Access (Read/Write Command)						
2230	Reset Unauthorized Access	0 to 1	---	1	F126	0 (No)
Remote double-point status inputs (read/write setting registers)						
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					
IEC 61850 GGIO5 configuration (read/write setting registers)						
26B0	IEC 61850 GGIO5 uinteger input 1 operand	---	---	---	F612	0
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

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Table B–9: MODBUS MEMORY MAP (Sheet 7 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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
Source Current THD And Harmonics (Read Only) (6 modules)						
2800	Ia THD for Source 1	0 to 99.9	---	0.1	F001	0
2801	Ia Harmonics for Source 1 - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
2821	Ib THD for Source 1	0 to 99.9	---	0.1	F001	0
2822	Ib Harmonics for Source 1 - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
283A	Reserved (8 items)	0 to 0.1	---	0.1	F001	0
2842	Ic THD for Source 1	0 to 99.9	---	0.1	F001	0
2843	Ic Harmonics for Source 1 - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
285B	Reserved (8 items)	0 to 0.1	---	0.1	F001	0
2863	...Repeated for Source 2					
28C6	...Repeated for Source 3					
2929	...Repeated for Source 4					
298C	...Repeated for Source 5					
29EF	...Repeated for Source 6					
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
User Programmable Fault Report Commands (Read/Write Command)						
3060	User Fault Report Clear	0 to 1	---	1	F126	0 (No)
User Programmable Fault Report Actuals (Read Only)						
3070	Newest Record Number	0 to 65535	---	1	F001	0
3071	Cleared Date	0 to 4294967295	---	1	F050	0
3073	Report Date (10 items)	0 to 4294967295	---	1	F050	0
User Programmable Fault Report (Read/Write Setting) (2 modules)						
3090	Fault Report 1 Fault Trigger	0 to 65535	---	1	F300	0
3091	Fault Report 1 Function	0 to 1	---	1	F102	0 (Disabled)
3092	Fault Report 1 Prefault Trigger	0 to 65535	---	1	F300	0
3093	Fault Report Analog Channel 1 (32 items)	0 to 65536	---	1	F600	0
30B3	Fault Report 1 Reserved (5 items)	---	---	---	F001	0
30B8	...Repeated for Fault Report 2					

Table B–9: MODBUS MEMORY MAP (Sheet 8 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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
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)
Neutral current unbalance commands and actual values (read/write unless noted, 3 modules)						
3410	Neutral current unbalance automatic setting function	0 to 2	---	1	F092	0 (Disabled)
3411	Neutral current unbalance apply magnitude	0 to 1	---	1	F126	0 (No)
3412	Neutral current unbalance apply angle	0 to 1	---	1	F126	0 (No)
3413	60N apply magnitude actual value (read only)	0 to 0.1500	---	0.0001	F003	0
3415	60N apply angle actual value (read only)	0 to 359	°	1	F003	0
3417	...Repeated for neutral current unbalance 2					
341E	...Repeated for neutral current unbalance 3					
Neutral voltage unbalance commands and actual values (read/write unless noted, 3 modules)						
3430	Neutral voltage unbalance automatic setting function	0 to 2	---	1	F092	0 (Disabled)
3431	59NU XA/XB ratio actual value (read only)	0 to 9.9999	---	0.0001	F003	0
3433	Neutral voltage unbalance auto-set XA/XB ratio	0 to 1	---	1	F126	0 (No)
3434	59NU XA/XC ratio actual value (read only)	0 to 9.9999	---	0.0001	F003	0
3436	Neutral voltage unbalance auto-set XA/XC ratio	0 to 1	---	1	F126	0 (No)
3437	...Repeated for neutral voltage unbalance 2					
343E	...Repeated for neutral voltage unbalance 3					
Phase current unbalance commands and actual values (read/write unless noted, 3 modules)						
3450	Phase current unbalance automatic setting function	0 to 2	---	1	F092	0 (Disabled)
3451	Phase current unbalance Ka actual value (read only)	–0.1000 to 0.1000	---	0.0001	F004	0
3453	Phase current unbalance auto-set Ka	0 to 1	---	1	F126	0 (No)
3454	Phase current unbalance Kb actual value (read only)	–0.1000 to 0.1000	---	0.0001	F004	0
3456	Phase current unbalance auto-set Kb	0 to 1	---	1	F126	0 (No)
3457	Phase current unbalance Kc actual value (read only)	–0.1000 to 0.1000	---	0.0001	F004	0
3459	Phase current unbalance auto-set Kc	0 to 1	---	1	F126	0 (No)
345A	...Repeated for phase current unbalance 2					
3464	...Repeated for phase current unbalance 3					
Voltage differential commands and actual values (read/write unless noted, 3 modules)						
3470	Voltage differential automatic setting function	0 to 2	---	1	F092	0 (Disabled)
3471	Voltage differential Ka actual value (read only)	0 to 99.9999	---	0.0001	F003	0
3473	Voltage differential auto-set Ka	0 to 1	---	1	F126	0 (No)
3474	Voltage differential Kb actual value (read only)	0 to 99.9999	---	0.0001	F003	0
3476	Voltage differential auto-set Kb	0 to 1	---	1	F126	0 (No)
3477	Voltage differential Kc actual value (read only)	0 to 99.9999	---	0.0001	F003	0
3479	Voltage differential auto-set Kc	0 to 1	---	1	F126	0 (No)
347A	...Repeated for voltage differential 2					
3484	...Repeated for voltage differential 3					
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

Table B–9: MODBUS MEMORY MAP (Sheet 9 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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
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

Table B–9: MODBUS MEMORY MAP (Sheet 10 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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
Expanded Direct Input/Output Status (Read Only)						
3560	Direct Device States, one per register (8 items)	0 to 1	---	1	F155	0 (Offline)
3570	Direct Input States, one per register (96 items)	0 to 1	---	1	F108	0 (Off)
Phase current unbalance actual values (read only, 3 modules)						
3600	Phase current unbalance 1 raw Idiff A	0 to 99.9999	pu	0.0001	F004	0
3602	Phase current unbalance 1 raw Idiff B	0 to 99.9999	pu	0.0001	F004	0
3604	Phase current unbalance 1 raw Idiff C	0 to 99.9999	pu	0.0001	F004	0
3606	Phase current unbalance 1 comp Iop A	0 to 99.9999	pu	0.0001	F004	0
3608	Phase current unbalance 1 comp Iop B	0 to 99.9999	pu	0.0001	F004	0
360A	Phase current unbalance 1 comp Iop C	0 to 99.9999	pu	0.0001	F004	0
360C	...Repeated for phase current unbalance 2					
3618	...Repeated for phase current unbalance 3					
Voltage differential actual values (read only, 3 modules)						
3640	Voltage differential 1 bus phase A voltage	0 to 99.9999	pu	0.0001	F003	0
3642	Voltage differential 1 differential phase A voltage	0 to 99.9999	pu	0.0001	F003	0
3644	Voltage differential 1 bus phase B voltage	0 to 99.9999	pu	0.0001	F003	0
3646	Voltage differential 1 differential phase B voltage	0 to 99.9999	pu	0.0001	F003	0
3648	Voltage differential 1 bus phase C voltage	0 to 99.9999	pu	0.0001	F003	0
364A	Voltage differential 1 differential phase C voltage	0 to 99.9999	pu	0.0001	F003	0
364C	...Repeated for voltage differential 2					
3658	...Repeated for voltage differential 3					
Neutral current unbalance actual values (read only, 3 modules)						
36C4	Neutral current unbalance 1 raw INsp	0 to 9.9999	pu	0.0001	F003	0
36C6	Neutral current unbalance 1 comp Iop	0 to 9.9999	pu	0.0001	F003	0
36C8	...Repeated for neutral current unbalance 2					
36CC	...Repeated for neutral current unbalance 3					
Neutral voltage unbalance actual values (read only, 3 modules)						
36F0	Neutral voltage unbalance 1 neutral point Vx angle	0 to 99.9999	°	0.0001	F004	0
36F2	Neutral voltage unbalance 1 V0 angle	0 to 99.9999	°	0.0001	F004	0
36F4	Neutral voltage unbalance 1 V0 magnitude	0 to 99.9999	pu	0.0001	F004	0
36F6	Neutral voltage unbalance 1 neutral point Vx magnitude	0 to 99.9999	pu	0.0001	F004	0
36F8	Neutral voltage unbalance 1 Vop	0 to 99.9999	pu	0.0001	F004	0
36FA	Neutral voltage unbalance 1 Vrest	0 to 99.9999	pu	0.0001	F004	0
36FC	...Repeated for neutral voltage unbalance 2					
3708	...Repeated for neutral voltage unbalance 3					
Time of day timer actual values (read only)						
3720	Seconds of day	1 to 86400	---	1	F003	0
3722	Day of month	1 to 31	---	1	F001	0
3723	Day of year	1 to 366	---	1	F001	0
3724	Year	1970 to 3000	---	1	F001	0

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Table B–9: MODBUS MEMORY MAP (Sheet 11 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
3730	Time of day timer 1 state	0 to 1	---	1	F108	0 (Off)
3731	Time of day timer 2 state	0 to 1	---	1	F108	0 (Off)
3732	Time of day timer 3 state	0 to 1	---	1	F108	0 (Off)
3733	Time of day timer 4 state	0 to 1	---	1	F108	0 (Off)
3734	Time of day timer 5 state	0 to 1	---	1	F108	0 (Off)
Capacitor control actual values (read only)						
3780	Capacitor control 1 discharge time	0 to 3600	s	1	F001	0
3781	Capacitor control 2 discharge time	0 to 3600	s	1	F001	0
3782	Capacitor control 3 discharge time	0 to 3600	s	1	F001	0
3783	Capacitor control 4 discharge time	0 to 3600	s	1	F001	0
Passwords (Read/Write Command)						
4000	Command Password Setting	0 to 4294967295	---	1	F003	0
Passwords (Read/Write Setting)						
4002	Setting Password Setting	0 to 4294967295	---	1	F003	0
Passwords (Read/Write)						
4008	Command Password Entry	0 to 4294967295	---	1	F003	0
400A	Setting Password Entry	0 to 4294967295	---	1	F003	0
Passwords (read only actual values)						
4010	Command password status	0 to 1	---	1	F102	0 (Disabled)
4011	Setting password status	0 to 1	---	1	F102	0 (Disabled)
Passwords (read/write settings)						
4012	Control password access timeout	5 to 480	minutes	1	F001	5
4013	Setting password access timeout	5 to 480	minutes	1	F001	30
4014	Invalid password attempts	2 to 5	---	1	F001	3
4015	Password lockout duration	5 to 60	minutes	1	F001	5
4016	Password access events	0 to 1	---	1	F102	0 (Disabled)
4017	Local setting authorization	1 to 65535	---	1	F300	1
4018	Remote setting authorization	0 to 65535	---	1	F300	1
4019	Access authorization timeout	5 to 480	minutes	1	F001	30
User Display Invoke (Read/Write Setting)						
4040	Invoke and Scroll Through User Display Menu Operand	0 to 65535	---	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 65535	---	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
Communications (Read/Write Setting)						
407E	COM1 minimum response time	0 to 1000	ms	10	F001	0
407F	COM2 minimum response time	0 to 1000	ms	10	F001	0
4080	Modbus Slave Address	1 to 254	---	1	F001	254
4083	RS485 Com1 Baud Rate	0 to 11	---	1	F112	8 (115200)
4084	RS485 Com1 Parity	0 to 2	---	1	F113	0 (None)
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	Gateway IP Address	0 to 4294967295	---	1	F003	56554497

Table B–9: MODBUS MEMORY MAP (Sheet 12 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
408D	Network Address NSAP	---	---	---	F074	0
409A	DNP Channel 1 Port	0 to 4	---	1	F177	0 (None)
409B	DNP Channel 2 Port	0 to 4	---	1	F177	0 (None)
409C	DNP Address	0 to 65519	---	1	F001	1
409D	Reserved	0 to 1	---	1	F001	0
409E	DNP Client Addresses (2 items)	0 to 4294967295	---	1	F003	0
40A3	TCP Port Number for the Modbus protocol	1 to 65535	---	1	F001	502
40A4	TCP/UDP Port Number for the DNP Protocol	1 to 65535	---	1	F001	20000
40A5	TCP Port Number for the HTTP (Web Server) Protocol	1 to 65535	---	1	F001	80
40A6	Main UDP Port Number for the TFTP Protocol	1 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	0 (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 65535	---	1	F001	30000
40B6	DNP voltage default deadband	0 to 65535	---	1	F001	30000
40B8	DNP power default deadband	0 to 65535	---	1	F001	30000
40BA	DNP energy default deadband	0 to 65535	---	1	F001	30000
40BE	DNP other default deadband	0 to 65535	---	1	F001	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	Reserved (22 items)	0 to 1	---	1	F001	0
40E0	TCP port number for the IEC 60870-5-104 protocol	1 to 65535	---	1	F001	2404
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 65535	---	1	F001	30000
40E6	IEC 60870-5-104 voltage default threshold	0 to 65535	---	1	F001	30000
40E8	IEC 60870-5-104 power default threshold	0 to 65535	---	1	F001	30000
40EA	IEC 60870-5-104 energy default threshold	0 to 65535	---	1	F001	30000
40EC	IEC 60870-5-104 power default threshold	0 to 65535	---	1	F001	30000
40EE	IEC 60870-5-104 other default threshold	0 to 65535	---	1	F001	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)
4005	Reserved (59 items)	0 to 1	---	1	F001	0
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)

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Table B–9: MODBUS MEMORY MAP (Sheet 13 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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)
Ethernet switch (Read/Write Setting)						
4148	Ethernet switch IP address	0 to 4294967295	---	1	F003	3232235778
414A	Ethernet switch Modbus IP port number	1 to 65535	---	1	F001	502
414B	Ethernet switch Port 1 Events	0 to 1	---	1	F102	0 (Disabled)
414C	Ethernet switch Port 2 Events	0 to 1	---	1	F102	0 (Disabled)
414D	Ethernet switch Port 3 Events	0 to 1	---	1	F102	0 (Disabled)
414E	Ethernet switch Port 4 Events	0 to 1	---	1	F102	0 (Disabled)
414F	Ethernet switch Port 5 Events	0 to 1	---	1	F102	0 (Disabled)
4150	Ethernet switch Port 6 Events	0 to 1	---	1	F102	0 (Disabled)
Ethernet switch (Read Only Actual Values)						
4151	Ethernet switch MAC address	---	---	1	F072	0
4154	Ethernet switch Port 1 Status	0 to 2	---	1	F134	0 (Fail)
4155	Ethernet switch Port 2 Status	0 to 2	---	1	F134	0 (Fail)
4156	Ethernet switch Port 3 Status	0 to 2	---	1	F134	0 (Fail)
4157	Ethernet switch Port 4 Status	0 to 2	---	1	F134	0 (Fail)
4158	Ethernet switch Port 5 Status	0 to 2	---	1	F134	0 (Fail)
4159	Ethernet switch Port 6 Status	0 to 2	---	1	F134	0 (Fail)
415A	Switch Firmware Version	0.00 to 99.99	---	0.01	F001	0
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 65535	---	1	F300	0
4193	Data Logger Rate	15 to 3600000	ms	1	F003	60000
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
Oscillography (Read/Write Setting)						
41C0	Oscillography Number of Records	1 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 65535	---	1	F300	0

Table B–9: MODBUS MEMORY MAP (Sheet 14 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
41C4	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 65535	---	1	F300	0
Trip and Alarm LEDs (Read/Write Setting)						
4260	Trip LED Input FlexLogic Operand	0 to 65535	---	1	F300	0
4261	Alarm LED Input FlexLogic Operand	0 to 65535	---	1	F300	0
User Programmable LEDs (Read/Write Setting) (48 modules)						
4280	FlexLogic™ Operand to Activate LED	0 to 65535	---	1	F300	0
4281	User LED type (latched or self-resetting)	0 to 1	---	1	F127	1 (Self-Reset)
4282	...Repeated for User-Programmable LED 2					
4284	...Repeated for User-Programmable LED 3					
4286	...Repeated for User-Programmable LED 4					
4288	...Repeated for User-Programmable LED 5					
428A	...Repeated for User-Programmable LED 6					
428C	...Repeated for User-Programmable LED 7					
428E	...Repeated for User-Programmable LED 8					
4290	...Repeated for User-Programmable LED 9					
4292	...Repeated for User-Programmable LED 10					
4294	...Repeated for User-Programmable LED 11					
4296	...Repeated for User-Programmable LED 12					
4298	...Repeated for User-Programmable LED 13					
429A	...Repeated for User-Programmable LED 14					
429C	...Repeated for User-Programmable LED 15					
429E	...Repeated for User-Programmable LED 16					
42A0	...Repeated for User-Programmable LED 17					
42A2	...Repeated for User-Programmable LED 18					
42A4	...Repeated for User-Programmable LED 19					
42A6	...Repeated for User-Programmable LED 20					
42A8	...Repeated for User-Programmable LED 21					
42AA	...Repeated for User-Programmable LED 22					
42AC	...Repeated for User-Programmable LED 23					
42AE	...Repeated for User-Programmable LED 24					
42B0	...Repeated for User-Programmable LED 25					
42B2	...Repeated for User-Programmable LED 26					
42B4	...Repeated for User-Programmable LED 27					
42B6	...Repeated for User-Programmable LED 28					
42B8	...Repeated for User-Programmable LED 29					
42BA	...Repeated for User-Programmable LED 30					
42BC	...Repeated for User-Programmable LED 31					
42BE	...Repeated for User-Programmable LED 32					
42C0	...Repeated for User-Programmable LED 33					
42C2	...Repeated for User-Programmable LED 34					
42C4	...Repeated for User-Programmable LED 35					
42C6	...Repeated for User-Programmable LED 36					
42C8	...Repeated for User-Programmable LED 37					
42CA	...Repeated for User-Programmable LED 38					
42CC	...Repeated for User-Programmable LED 39					
42CE	...Repeated for User-Programmable LED 40					
42D0	...Repeated for User-Programmable LED 41					
42D2	...Repeated for User-Programmable LED 42					
42D4	...Repeated for User-Programmable LED 43					
42D6	...Repeated for User-Programmable LED 44					
42D8	...Repeated for User-Programmable LED 45					
42DA	...Repeated for User-Programmable LED 46					

Table B–9: MODBUS MEMORY MAP (Sheet 15 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
42DC	...Repeated for User-Programmable LED 47					
42DE	...Repeated for User-Programmable LED 48					
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 Primary 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)
4448	User Programmable IRIG-B Fail Function	0 to 1	---	1	F102	1 (Enabled)
4449	User Programmable Ethernet Switch 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	50 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	50 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					
Source Settings (Read/Write Setting) (6 modules)						
4580	Source 1 Name	---	---	---	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)
Breaker control (read/write settings)						
4700	Breaker 1 function	0 to 1	---	1	F102	0 (Disabled)
4701	Breaker 1 name	---	---	---	F206	“Bkr 1"
4704	Breaker 1 mode	0 to 1	---	1	F157	0 (3-Pole)

Table B–9: MODBUS MEMORY MAP (Sheet 16 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
4705	Breaker 1 open	0 to 65535	---	1	F300	0
4706	Breaker 1 close	0 to 65535	---	1	F300	0
4707	Breaker 1 phase A / three-pole closed	0 to 65535	---	1	F300	0
4708	Breaker 1 phase B closed	0 to 65535	---	1	F300	0
4709	Breaker 1 phase C closed	0 to 65535	---	1	F300	0
470A	Breaker 1 external alarm	0 to 65535	---	1	F300	0
470B	Breaker 1 alarm delay	0 to 65535	s	0.001	F003	0
470D	Breaker 1 pushbutton control	0 to 1	---	1	F102	0 (Disabled)
470E	Breaker 1 manual close recall time	0 to 65535	s	0.001	F003	0
4710	Breaker 1 out of service	0 to 65535	---	1	F300	0
4711	Breaker 1 block open	0 to 65535	---	1	F300	0
4712	Breaker 1 block close	0 to 65535	---	1	F300	0
4713	Breaker 1 phase A / three-pole opened	0 to 65535	---	1	F300	0
4714	Breaker 1 phase B opened	0 to 65535	---	1	F300	0
4715	Breaker 1 phase C opened	0 to 65535	---	1	F300	0
4716	Breaker 1 operate time	0 to 65535	s	0.001	F001	70
4717	Breaker 1 events	0 to 1	---	1	F102	0 (Disabled)
4718	Reserved	---	---	---	---	---
4719	...Repeated for breaker 2					
4732	...Repeated for breaker 3					
474B	...Repeated for breaker 4					
4764	...Repeated for breaker 5					
477D	...Repeated for breaker 6					
Flexcurves A and B (Read/Write Settings)						
4800	FlexCurve A (120 items)	0 to 65535	ms	1	F011	0
48F0	FlexCurve B (120 items)	0 to 65535	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					
User Programmable Pushbuttons (Read/Write Setting) (12 modules)						
4E00	User Programmable Pushbutton 1 Function	0 to 2	---	1	F109	2 (Disabled)
4E01	User Programmable Pushbutton 1 Top Line	---	---	---	F202	(none)
4E0B	User Programmable Pushbutton 1 On Text	---	---	---	F202	(none)
4E15	User Programmable Pushbutton 1 Off Text	---	---	---	F202	(none)
4E1F	User Programmable Pushbutton 1 Drop-Out Time	0 to 60	s	0.05	F001	0

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Table B–9: MODBUS MEMORY MAP (Sheet 17 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
4E20	User Programmable Pushbutton 1 Target	0 to 2	---	1	F109	0 (Self-reset)
4E21	User Programmable Pushbutton 1 Events	0 to 1	---	1	F102	0 (Disabled)
4E22	User Programmable Pushbutton 1 LED Operand	0 to 65535	---	1	F300	0
4E23	User Programmable Pushbutton 1 Autoreset Delay	0 to 600	s	0.05	F001	0
4E24	User Programmable Pushbutton 1 Autoreset Function	0 to 1	---	1	F102	0 (Disabled)
4E25	User Programmable Pushbutton 1 Local Lock	0 to 65535	---	1	F300	0
4E26	User Programmable Pushbutton 1 Message Priority	0 to 2	---	1	F220	0 (Disabled)
4E27	User Programmable Pushbutton 1 Remote Lock	0 to 65535	---	1	F300	0
4E28	User Programmable Pushbutton 1 Reset	0 to 65535	---	1	F300	0
4E29	User Programmable Pushbutton 1 Set	0 to 65535	---	1	F300	0
4E2A	...Repeated for User Programmable Pushbutton 2					
4E54	...Repeated for User Programmable Pushbutton 3					
4E7E	...Repeated for User Programmable Pushbutton 4					
4EA8	...Repeated for User Programmable Pushbutton 5					
4ED2	...Repeated for User Programmable Pushbutton 6					
4EFC	...Repeated for User Programmable Pushbutton 7					
4F26	...Repeated for User Programmable Pushbutton 8					
4F50	...Repeated for User Programmable Pushbutton 9					
4F7A	...Repeated for User Programmable Pushbutton 10					
4FA4	...Repeated for User Programmable Pushbutton 11					
4FCE	...Repeated for User Programmable Pushbutton 12					
Flexlogic (Read/Write Setting)						
5000	FlexLogic™ Entry (512 items)	0 to 65535	---	1	F300	16384
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)
5413	...Repeated for RTD Input 2					
5426	...Repeated for RTD Input 3					
5439	...Repeated for RTD Input 4					
544C	...Repeated for RTD Input 5					
545F	...Repeated for RTD Input 6					
5472	...Repeated for RTD Input 7					
5485	...Repeated for RTD Input 8					
5498	...Repeated for RTD Input 9					
54AB	...Repeated for RTD Input 10					
54BE	...Repeated for RTD Input 11					
54D1	...Repeated for RTD Input 12					
54E4	...Repeated for RTD Input 13					
54F7	...Repeated for RTD Input 14					
550A	...Repeated for RTD Input 15					
551D	...Repeated for RTD Input 16					
5530	...Repeated for RTD Input 17					
5543	...Repeated for RTD Input 18					
5556	...Repeated for RTD Input 19					
5569	...Repeated for RTD Input 20					
557C	...Repeated for RTD Input 21					
558F	...Repeated for RTD Input 22					
55A2	...Repeated for RTD Input 23					
55B5	...Repeated for RTD Input 24					
55C8	...Repeated for RTD Input 25					
55DB	...Repeated for RTD Input 26					
55EE	...Repeated for RTD Input 27					
5601	...Repeated for RTD Input 28					

Table B–9: MODBUS MEMORY MAP (Sheet 18 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5614	...Repeated for RTD Input 29					
5627	...Repeated for RTD Input 30					
563A	...Repeated for RTD Input 31					
564D	...Repeated for RTD Input 32					
5660	...Repeated for RTD Input 33					
5673	...Repeated for RTD Input 34					
5686	...Repeated for RTD Input 35					
5699	...Repeated for RTD Input 36					
56AC	...Repeated for RTD Input 37					
56BF	...Repeated for RTD Input 38					
56D2	...Repeated for RTD Input 39					
56E5	...Repeated for RTD Input 40					
56F8	...Repeated for RTD Input 41					
570B	...Repeated for RTD Input 42					
571E	...Repeated for RTD Input 43					
5731	...Repeated for RTD Input 44					
5744	...Repeated for RTD Input 45					
5757	...Repeated for RTD Input 46					
576A	...Repeated for RTD Input 47					
577D	...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					
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					

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Table B–9: MODBUS MEMORY MAP (Sheet 19 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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 65535	---	1	F300	0
590B	Phase Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
590C	Phase Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
590D	Reserved (3 items)	0 to 1	---	1	F001	0
5910	...Repeated for Phase Time Overcurrent 2					
5920	...Repeated for Phase Time Overcurrent 3					
5930	...Repeated for Phase Time Overcurrent 4					
5940	...Repeated for Phase Time Overcurrent 5					
5950	...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 Phase A	0 to 65535	---	1	F300	0
5A06	Phase IOC1 Block For Phase B	0 to 65535	---	1	F300	0
5A07	Phase IOC1 Block For Phase C	0 to 65535	---	1	F300	0
5A08	Phase Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5A09	Phase Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5A0A	Reserved (6 items)	0 to 1	---	1	F001	0
5A10	...Repeated for Phase Instantaneous Overcurrent 2					
5A20	...Repeated for Phase Instantaneous Overcurrent 3					
5A30	...Repeated for Phase Instantaneous Overcurrent 4					
5A40	...Repeated for Phase Instantaneous Overcurrent 5					
5A50	...Repeated for Phase Instantaneous Overcurrent 6					
5A60	...Repeated for Phase Instantaneous Overcurrent 7					
5A70	...Repeated for Phase Instantaneous Overcurrent 8					
5A80	...Repeated for Phase Instantaneous Overcurrent 9					
5A90	...Repeated for Phase Instantaneous Overcurrent 10					
5AA0	...Repeated for Phase Instantaneous Overcurrent 11					
5AB0	...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)
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 65535	---	1	F300	0
5B08	Neutral Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5B09	Neutral Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)

Table B–9: MODBUS MEMORY MAP (Sheet 20 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5B0A	Reserved (6 items)	0 to 1	---	1	F001	0
5B10	...Repeated for Neutral Time Overcurrent 2					
5B20	...Repeated for Neutral Time Overcurrent 3					
5B30	...Repeated for Neutral Time Overcurrent 4					
5B40	...Repeated for Neutral Time Overcurrent 5					
5B50	...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 65535	---	1	F300	0
5C06	Neutral Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5C07	Neutral Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5C08	Reserved (8 items)	0 to 1	---	1	F001	0
5C10	...Repeated for Neutral Instantaneous Overcurrent 2					
5C20	...Repeated for Neutral Instantaneous Overcurrent 3					
5C30	...Repeated for Neutral Instantaneous Overcurrent 4					
5C40	...Repeated for Neutral Instantaneous Overcurrent 5					
5C50	...Repeated for Neutral Instantaneous Overcurrent 6					
5C60	...Repeated for Neutral Instantaneous Overcurrent 7					
5C70	...Repeated for Neutral Instantaneous Overcurrent 8					
5C80	...Repeated for Neutral Instantaneous Overcurrent 9					
5C90	...Repeated for Neutral Instantaneous Overcurrent 10					
5CA0	...Repeated for Neutral Instantaneous Overcurrent 11					
5CB0	...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 65535	---	1	F300	0
5D08	Ground Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5D09	Ground Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5D0A	Reserved (6 items)	0 to 1	---	1	F001	0
5D10	...Repeated for Ground Time Overcurrent 2					
5D20	...Repeated for Ground Time Overcurrent 3					
5D30	...Repeated for Ground Time Overcurrent 4					
5D40	...Repeated for Ground Time Overcurrent 5					
5D50	...Repeated for Ground Time Overcurrent 6					
Ground Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)						
5E00	Ground Instantaneous Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5E01	Ground Instantaneous Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5E02	Ground Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5E03	Ground Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
5E04	Ground Instantaneous Overcurrent 1 Reset Delay	0 to 600	s	0.01	F001	0
5E05	Ground Instantaneous Overcurrent 1 Block	0 to 65535	---	1	F300	0
5E06	Ground Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5E07	Ground Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5E08	Reserved (8 items)	0 to 1	---	1	F001	0

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Table B–9: MODBUS MEMORY MAP (Sheet 21 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5E10	...Repeated for Ground Instantaneous Overcurrent 2					
5E20	...Repeated for Ground Instantaneous Overcurrent 3					
5E30	...Repeated for Ground Instantaneous Overcurrent 4					
5E40	...Repeated for Ground Instantaneous Overcurrent 5					
5E50	...Repeated for Ground Instantaneous Overcurrent 6					
5E60	...Repeated for Ground Instantaneous Overcurrent 7					
5E70	...Repeated for Ground Instantaneous Overcurrent 8					
5E80	...Repeated for Ground Instantaneous Overcurrent 9					
5E90	...Repeated for Ground Instantaneous Overcurrent 10					
5EA0	...Repeated for Ground Instantaneous Overcurrent 11					
5EB0	...Repeated for Ground Instantaneous Overcurrent 12					
Setting Groups (Read/Write Setting)						
5F80	Setting Group for Modbus Comms (0 means group 1)	0 to 5	---	1	F001	0
5F81	Setting Groups Block	0 to 65535	---	1	F300	0
5F82	FlexLogic to Activate Groups 2 through 6 (5 items)	0 to 65535	---	1	F300	0
5F89	Setting Group Function	0 to 1	---	1	F102	0 (Disabled)
5F8A	Setting Group Events	0 to 1	---	1	F102	0 (Disabled)
Setting Groups (Read Only)						
5F8B	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)
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 65535	---	1	F300	0
6307	Negative Sequence Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
6308	Negative Sequence Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
6309	Reserved (7 items)	0 to 1	---	1	F001	0
6310	...Repeated for Negative Sequence Time Overcurrent 2					
Capacitor bank overvoltage settings (read/write, grouped, 3 modules)						
6320	Bank phase overvoltage 1 function	0 to 1	---	1	F102	0 (Disabled)
6321	Bank phase overvoltage 1 bus source	0 to 5	---	1	F167	0 (SRC 1)
6322	Bank phase overvoltage 1 neutral source	0 to 5	---	1	F167	0 (SRC 1)
6323	Bank phase overvoltage 1 bank ground	0 to 2	---	1	F093	0 (Grounded)
6324	Bank phase overvoltage 1 curve	0 to 3	---	1	F094	0 (FlexCurve A)
6325	Bank phase overvoltage 1 curve time multiplier	1.00 to 10.00	---	0.01	F001	100
6326	Bank phase overvoltage 1 stage 1A pickup	0.800 to 2.000	pu	0.001	F001	1050
6327	Bank phase overvoltage 1 stage 2A pickup	0.800 to 2.000	pu	0.001	F001	1100
6328	Bank phase overvoltage 1 stage 3A pickup	0.800 to 2.000	pu	0.001	F001	1200
6329	Bank phase overvoltage 1 stage 4A pickup	0.800 to 2.000	pu	0.001	F001	1050
632A	Bank phase overvoltage 1 stage 1B pickup	0.800 to 2.000	pu	0.001	F001	1050
632B	Bank phase overvoltage 1 stage 2B pickup	0.800 to 2.000	pu	0.001	F001	1100
632C	Bank phase overvoltage 1 stage 3B pickup	0.800 to 2.000	pu	0.001	F001	1200
632D	Bank phase overvoltage 1 stage 4B pickup	0.800 to 2.000	pu	0.001	F001	1050
632E	Bank phase overvoltage 1 stage 1C pickup	0.800 to 2.000	pu	0.001	F001	1050

Table B–9: MODBUS MEMORY MAP (Sheet 22 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
632F	Bank phase overvoltage 1 stage 2C pickup	0.800 to 2.000	pu	0.001	F001	1100
6330	Bank phase overvoltage 1 stage 3C pickup	0.800 to 2.000	pu	0.001	F001	1200
6331	Bank phase overvoltage 1 stage 4C pickup	0.800 to 2.000	pu	0.001	F001	1050
6332	Bank phase overvoltage 1 stage 1 pickup delay	0 to 600.00	s	0.01	F001	6000
6333	Bank phase overvoltage 1 stage 2 pickup delay	0 to 600.00	s	0.01	F001	1000
6334	Bank phase overvoltage 1 stage 3 pickup delay	0 to 600.00	s	0.01	F001	200
6335	Bank phase overvoltage 1 dropout delay	0 to 600.00	s	0.01	F001	25
6336	Bank phase overvoltage 1 block	0 to 65535	---	1	F300	0
6337	Bank phase overvoltage 1 target	0 to 2	---	1	F109	0 (Self-reset)
6338	Bank phase overvoltage 1 events	0 to 1	---	1	F102	0 (Disabled)
6339	...Repeated for bank phase overvoltage 2					
6352	...Repeated for bank phase overvoltage 3					
Capacitor bank overvoltage actual values (read only, 3 modules)						
636B	Bank overvoltage 1 phase A operate voltage	0 to 65.535	pu	0.001	F001	0
636C	Bank overvoltage 1 phase B operate voltage	0 to 65.535	pu	0.001	F001	0
636D	Bank overvoltage 1 phase C operate voltage	0 to 65.535	pu	0.001	F001	0
636E	...Repeated for bank phase overvoltage 2					
6371	...Repeated for bank phase overvoltage 3					
Negative Sequence Instantaneous Overcurrent (Read/Write Grouped Setting) (2 modules)						
6400	Negative Sequence Instantaneous OC 1 Function	0 to 1	---	1	F102	0 (Disabled)
6401	Negative Sequence Instantaneous OC 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
6402	Negative Sequence Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
6403	Negative Sequence Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
6404	Negative Sequence Instantaneous OC 1 Reset Delay	0 to 600	s	0.01	F001	0
6405	Negative Sequence Instantaneous Overcurrent 1 Block	0 to 65535	---	1	F300	0
6406	Negative Sequence Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
6407	Negative Sequence Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
6408	Reserved (8 items)	0 to 1	---	1	F001	0
6410	...Repeated for Negative Sequence Instantaneous OC 2					
Negative Sequence Overvoltage (Read/Write Grouped Setting)						
64A0	Negative Sequence Overvoltage Function	0 to 1	---	1	F102	0 (Disabled)
64A1	Negative Sequence Overvoltage Source	0 to 5	---	1	F167	0 (SRC 1)
64A2	Negative Sequence Overvoltage Pickup	0 to 1.25	pu	0.001	F001	300
64A3	Negative Sequence Overvoltage Pickup Delay	0 to 600	s	0.01	F001	50
64A4	Negative Sequence Overvoltage Reset Delay	0 to 600	s	0.01	F001	50
64A5	Negative Sequence Overvoltage Block	0 to 65535	---	1	F300	0
64A6	Negative Sequence Overvoltage Target	0 to 2	---	1	F109	0 (Self-reset)
64A7	Negative Sequence Overvoltage Events	0 to 1	---	1	F102	0 (Disabled)
Time of day timer settings (read/write, grouped, 5 modules)						
6570	Time of day timer 1 function	0 to 1	---	1	F102	0 (Disabled)
6571	Time of day timer 1 start time	0 to 2359	---	1	F050	0
6573	Time of day timer 1 stop time	0 to 2359	---	1	F001	2359
6575	Time of day timer 1 targets	0 to 2	---	1	F109	0 (Self-reset)
6576	Time of day timer 1 events	0 to 1	---	1	F102	0 (Disabled)
6577	...Repeated for time of day timer 2					
657E	...Repeated for time of day timer 3					
6585	...Repeated for time of day timer 4					
658C	...Repeated for time of day timer 5					
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

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Table B–9: MODBUS MEMORY MAP (Sheet 23 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7005	Phase Undervoltage 1 Minimum Voltage	0 to 3	pu	0.001	F001	100
7006	Phase Undervoltage 1 Block	0 to 65535	---	1	F300	0
7007	Phase Undervoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7008	Phase Undervoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7009	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					
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 65535	---	1	F300	0
7046	Phase Overvoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7047	Phase Overvoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7048	Reserved (8 items)	0 to 1	---	1	F001	0
Phase Directional Overcurrent (Read/Write Grouped Setting) (2 modules)						
7260	Phase Directional Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
7261	Phase Directional Overcurrent 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7262	Phase Directional Overcurrent 1 Block	0 to 65535	---	1	F300	0
7263	Phase Directional Overcurrent 1 ECA	0 to 359	---	1	F001	30
7264	Phase Directional Overcurrent 1 Pol V Threshold	0 to 3	pu	0.001	F001	700
7265	Phase Directional Overcurrent 1 Block Overcurrent	0 to 1	---	1	F126	0 (No)
7266	Phase Directional Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7267	Phase Directional Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
7268	Reserved (8 items)	0 to 1	---	1	F001	0
7270	...Repeated for Phase Directional Overcurrent 2					
Neutral Directional Overcurrent (Read/Write Grouped Setting) (2 modules)						
7280	Neutral Directional Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
7281	Neutral Directional Overcurrent 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7282	Neutral Directional Overcurrent 1 Polarizing	0 to 2	---	1	F230	0 (Voltage)
7283	Neutral Directional Overcurrent 1 Forward ECA	-90 to 90	° Lag	1	F002	75
7284	Neutral Directional Overcurrent 1 Forward Limit Angle	40 to 90	degrees	1	F001	90
7285	Neutral Directional Overcurrent 1 Forward Pickup	0.002 to 30	pu	0.001	F001	50
7286	Neutral Directional Overcurrent 1 Reverse Limit Angle	40 to 90	degrees	1	F001	90
7287	Neutral Directional Overcurrent 1 Reverse Pickup	0.002 to 30	pu	0.001	F001	50
7288	Neutral Directional Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7289	Neutral Directional Overcurrent 1 Block	0 to 65535	---	1	F300	0
728A	Neutral Directional Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
728B	Neutral Directional Overcurrent 1 Polarizing Voltage	0 to 1	---	1	F231	0 (Calculated V0)
728C	Neutral Directional Overcurrent 1 Op Current	0 to 1	---	1	F196	0 (Calculated 3I0)
728D	Neutral Directional Overcurrent 1 Offset	0 to 250	ohms	0.01	F001	0
728E	Neutral Directional Overcurrent 1 Pos Seq Restraint	0 to 0.5	---	0.001	F001	63
728F	Reserved	0 to 1	---	1	F001	0
Negative-sequence directional overcurrent (read/write grouped settings) (2 modules)						
72A0	Negative Sequence Directional Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
72A1	Negative Sequence Directional Overcurrent 1 Source	0 to 5	---	1	F167	0 (SRC 1)
72A2	Negative Sequence Directional Overcurrent 1 Type	0 to 1	---	1	F179	0 (Neg Sequence)
72A3	Neg Sequence Directional Overcurrent 1 Forward ECA	0 to 90	° Lag	1	F002	75
72A4	Neg Seq Directional Overcurrent 1 Forward Limit Angle	40 to 90	degrees	1	F001	90
72A5	Neg Sequence Directional Overcurrent 1 Forward Pickup	0.015 to 30	pu	0.05	F001	5
72A6	Neg Seq Directional Overcurrent 1 Reverse Limit Angle	40 to 90	degrees	1	F001	90
72A7	Neg Sequence Directional Overcurrent 1 Reverse Pickup	0.015 to 30	pu	0.05	F001	5

Table B–9: MODBUS MEMORY MAP (Sheet 24 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
72A8	Negative Sequence Directional Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
72A9	Negative Sequence Directional Overcurrent 1 Block	0 to 65535	---	1	F300	0
72AA	Negative Sequence Directional Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
72AB	Negative Sequence Directional Overcurrent 1 Offset	0 to 250	ohms	0.01	F001	0
72AC	Neg Seq Directional Overcurrent 1 Pos Seq Restraint	0 to 0.5	---	0.001	F001	63
72AD	Reserved (3 items)	0 to 1	---	1	F001	0
72B0	...Repeated for Neg Seq Directional Overcurrent 2					
dcmA Inputs (Read/Write Setting) (24 modules)						
7300	dcmA Inputs 1 Function	0 to 1	---	1	F102	0 (Disabled)
7301	dcmA Inputs 1 ID	---	---	---	F205	“DCMA I 1"
7307	Reserved 1 (4 items)	0 to 65535	---	1	F001	0
730B	dcmA Inputs 1 Units	---	---	---	F206	“mA”
730E	dcmA Inputs 1 Range	0 to 6	---	1	F173	6 (4 to 20 mA)
730F	dcmA Inputs 1 Minimum Value	-9999.999 to 9999.999	---	0.001	F004	4000
7311	dcmA Inputs 1 Maximum Value	-9999.999 to 9999.999	---	0.001	F004	20000
7313	Reserved (5 items)	0 to 65535	---	1	F001	0
7318	...Repeated for dcmA Inputs 2					
7330	...Repeated for dcmA Inputs 3					
7348	...Repeated for dcmA Inputs 4					
7360	...Repeated for dcmA Inputs 5					
7378	...Repeated for dcmA Inputs 6					
7390	...Repeated for dcmA Inputs 7					
73A8	...Repeated for dcmA Inputs 8					
73C0	...Repeated for dcmA Inputs 9					
73D8	...Repeated for dcmA Inputs 10					
73F0	...Repeated for dcmA Inputs 11					
7408	...Repeated for dcmA Inputs 12					
7420	...Repeated for dcmA Inputs 13					
7438	...Repeated for dcmA Inputs 14					
7450	...Repeated for dcmA Inputs 15					
7468	...Repeated for dcmA Inputs 16					
7480	...Repeated for dcmA Inputs 17					
7498	...Repeated for dcmA Inputs 18					
74B0	...Repeated for dcmA Inputs 19					
74C8	...Repeated for dcmA Inputs 20					
74E0	...Repeated for dcmA Inputs 21					
74F8	...Repeated for dcmA Inputs 22					
7510	...Repeated for dcmA Inputs 23					
7528	...Repeated for dcmA Inputs 24					
Disconnect switches (read/write settings)						
7540	Disconnect switch 1 function	0 to 1	---	1	F102	0 (Disabled)
7541	Disconnect switch 1 name	---	---	---	F206	“SW 1"
7544	Disconnect switch 1 mode	0 to 1	---	1	F157	0 (3-Pole)
7545	Disconnect switch 1 open	0 to 65535	---	1	F300	0
7546	Disconnect switch 1 block open	0 to 65535	---	1	F300	0
7547	Disconnect switch 1 close	0 to 65535	---	1	F300	0
7548	Disconnect switch 1 block close	0 to 65535	---	1	F300	0
7549	Disconnect switch 1 phase A / three-pole closed	0 to 65535	---	1	F300	0
754A	Disconnect switch 1 phase A / three-pole opened	0 to 65535	---	1	F300	0
754B	Disconnect switch 1 phase B closed	0 to 65535	---	1	F300	0
754C	Disconnect switch 1 phase B opened	0 to 65535	---	1	F300	0
754D	Disconnect switch 1 phase C closed	0 to 65535	---	1	F300	0
754E	Disconnect switch 1 phase C opened	0 to 65535	---	1	F300	0
754F	Disconnect switch 1 operate time	0 to 65535	s	0.001	F001	70

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Table B–9: MODBUS MEMORY MAP (Sheet 25 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7550	Disconnect switch 1 alarm delay	0 to 65535	s	0.001	F003	0
7552	Disconnect switch 1 events	0 to 1	---	1	F102	0 (Disabled)
7553	Reserved (2 items)	---	---	---	---	---
7555	...Repeated for disconnect switch 2					
756A	...Repeated for disconnect switch 3					
757F	...Repeated for disconnect switch 4					
7594	...Repeated for disconnect switch 5					
75A9	...Repeated for disconnect switch 6					
75BE	...Repeated for disconnect switch 7					
75D3	...Repeated for disconnect switch 8					
75E8	...Repeated for disconnect switch 9					
75FD	...Repeated for disconnect switch 10					
7612	...Repeated for disconnect switch 11					
7627	...Repeated for disconnect switch 12					
763C	...Repeated for disconnect switch 13					
7651	...Repeated for disconnect switch 14					
7666	...Repeated for disconnect switch 15					
767B	...Repeated for disconnect switch 16					
7690	...Repeated for disconnect switch 17					
76A5	...Repeated for disconnect switch 18					
76BA	...Repeated for disconnect switch 19					
76CF	...Repeated for disconnect switch 20					
76E4	...Repeated for disconnect switch 21					
76F9	...Repeated for disconnect switch 22					
770E	...Repeated for disconnect switch 23					
7723	...Repeated for disconnect switch 24					
Thermal Overload Protecttion (Read/Write Settings)						
7738	Thermal Protection 1 Function	0 to 1	---	1	F102	0 (Disabled)
7739	Thermal Protection 1 Source	0 to 5	---	1	F167	0 (SRC 1)
773A	Thermal Protection 1 Base Current	0.2 to 3	pu	0.01	F001	80
773B	Thermal Protection 1 K Factor	1 to 1.2	---	0.05	F001	110
773C	Thermal Protection 1 Trip Time Constant	0 to 1000	min.	1	F001	45
773D	Thermal Protection 1 Reset Time Constant	0 to 1000	min.	1	F001	45
773E	Thermal Protection 1 Minimum Reset Time	0 to 1000	min.	1	F001	20
773F	Thermal Protection 1 Reset	0 to 65535	---	1	F300	0
7740	Thermal Protection 1 Block	0 to 65535	---	1	F300	0
7741	Thermal Protection 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7742	Thermal Protection 1 Events	0 to 1	---	1	F102	0 (Disabled)
7743	Reserved (2 items)	---	---	---	F001	0
7745	Repeated for Thermal Protection 2					
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 65535	---	1	F300	0
7B83	User Programmable Pushbutton 1 Autoreset Delay	0 to 600	s	0.05	F001	0
7B84	User Programmable Pushbutton 1 Autoreset Function	0 to 1	---	1	F102	0 (Disabled)
7B85	User Programmable Pushbutton 1 Local Lock	0 to 65535	---	1	F300	0
7B86	User Programmable Pushbutton 1 Message Priority	0 to 2	---	1	F220	0 (Disabled)
7B87	User Programmable Pushbutton 1 Remote Lock	0 to 65535	---	1	F300	0

Table B–9: MODBUS MEMORY MAP (Sheet 26 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7B88	User Programmable Pushbutton 1 Reset	0 to 65535	---	1	F300	0
7B89	User Programmable Pushbutton 1 Set	0 to 65535	---	1	F300	0
7B8A	User Programmable Pushbutton 1 Hold	0 to 10	s	0.1	F001	1
7B8B	...Repeated for User Programmable Pushbutton 2					
7BB6	...Repeated for User Programmable Pushbutton 3					
7BE1	...Repeated for User Programmable Pushbutton 4					
7C0C	...Repeated for User Programmable Pushbutton 5					
7C37	...Repeated for User Programmable Pushbutton 6					
7C62	...Repeated for User Programmable Pushbutton 7					
7C8D	...Repeated for User Programmable Pushbutton 8					
7CB8	...Repeated for User Programmable Pushbutton 9					
7CE3	...Repeated for User Programmable Pushbutton 10					
7D0E	...Repeated for User Programmable Pushbutton 11					
7D39	...Repeated for User Programmable Pushbutton 12					
7D64	...Repeated for User Programmable Pushbutton 13					
7D8F	...Repeated for User Programmable Pushbutton 14					
7DBA	...Repeated for User Programmable Pushbutton 15					
7DE5	...Repeated for User Programmable Pushbutton 16					
Neutral Overvoltage (Read/Write Grouped Setting) (3 modules)						
7F00	Neutral Overvoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7F01	Neutral Overvoltage 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7F02	Neutral Overvoltage 1 Pickup	0 to 3.00	pu	0.001	F001	300
7F03	Neutral Overvoltage 1 Pickup Delay	0 to 600	s	0.01	F001	100
7F04	Neutral Overvoltage 1 Reset Delay	0 to 600	s	0.01	F001	100
7F05	Neutral Overvoltage 1 Block	0 to 65535	---	1	F300	0
7F06	Neutral Overvoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7F07	Neutral Overvoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7F08	Neutral Overvoltage 1 Curves	0 to 3	---	1	F116	0 (Definite Time)
7F09	Reserved (8 items)	0 to 65535	---	1	F001	0
7F10	...Repeated for Neutral Overvoltage 2					
7F20	...Repeated for Neutral Overvoltage 3					
Auxiliary Overvoltage (Read/Write Grouped Setting) (3 modules)						
7F30	Auxiliary Overvoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7F31	Auxiliary Overvoltage 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7F32	Auxiliary Overvoltage 1 Pickup	0 to 3	pu	0.001	F001	300
7F33	Auxiliary Overvoltage 1 Pickup Delay	0 to 600	s	0.01	F001	100
7F34	Auxiliary Overvoltage 1 Reset Delay	0 to 600	s	0.01	F001	100
7F35	Auxiliary Overvoltage 1 Block	0 to 65535	---	1	F300	0
7F36	Auxiliary Overvoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7F37	Auxiliary Overvoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7F38	Reserved (8 items)	0 to 65535	---	1	F001	0
7F40	...Repeated for Auxiliary Overvoltage 2					
7F50	...Repeated for Auxiliary Overvoltage 3					
Frequency (Read Only)						
8000	Tracking Frequency	---	Hz	---	F001	0
Breaker Failure (Read/Write Grouped Setting) (2 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 65535	---	1	F300	0
8606	Breaker Failure 1 Block	0 to 65535	---	1	F300	0
8607	Breaker Failure 1 Phase Amp Supv Pickup	0.001 to 30	pu	0.001	F001	1050

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Table B–9: MODBUS MEMORY MAP (Sheet 27 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
8608	Breaker Failure 1 Neutral Amp Supv Pickup	0.001 to 30	pu	0.001	F001	1050
8609	Breaker Failure 1 Use Timer 1	0 to 1	---	1	F126	1 (Yes)
860A	Breaker Failure 1 Timer 1 Pickup	0 to 65.535	s	0.001	F001	0
860B	Breaker Failure 1 Use Timer 2	0 to 1	---	1	F126	1 (Yes)
860C	Breaker Failure 1 Timer 2 Pickup	0 to 65.535	s	0.001	F001	0
860D	Breaker Failure 1 Use Timer 3	0 to 1	---	1	F126	1 (Yes)
860E	Breaker Failure 1 Timer 3 Pickup	0 to 65.535	s	0.001	F001	0
860F	Breaker Failure 1 Breaker Status 1 Phase A/3P	0 to 65535	---	1	F300	0
8610	Breaker Failure 1 Breaker Status 2 Phase A/3P	0 to 65535	---	1	F300	0
8611	Breaker Failure 1 Breaker Test On	0 to 65535	---	1	F300	0
8612	Breaker Failure 1 Phase Amp Hiset Pickup	0.001 to 30	pu	0.001	F001	1050
8613	Breaker Failure 1 Neutral Amp Hiset Pickup	0.001 to 30	pu	0.001	F001	1050
8614	Breaker Failure 1 Phase Amp Loset Pickup	0.001 to 30	pu	0.001	F001	1050
8615	Breaker Failure 1 Neutral Amp Loset Pickup	0.001 to 30	pu	0.001	F001	1050
8616	Breaker Failure 1 Loset Time	0 to 65.535	s	0.001	F001	0
8617	Breaker Failure 1 Trip Dropout Delay	0 to 65.535	s	0.001	F001	0
8618	Breaker Failure 1 Target	0 to 2	---	1	F109	0 (Self-reset)
8619	Breaker Failure 1 Events	0 to 1	---	1	F102	0 (Disabled)
861A	Breaker Failure 1 Phase A Initiate	0 to 65535	---	1	F300	0
861B	Breaker Failure 1 Phase B Initiate	0 to 65535	---	1	F300	0
861C	Breaker Failure 1 Phase C Initiate	0 to 65535	---	1	F300	0
861D	Breaker Failure 1 Breaker Status 1 Phase B	0 to 65535	---	1	F300	0
861E	Breaker Failure 1 Breaker Status 1 Phase C	0 to 65535	---	1	F300	0
861F	Breaker Failure 1 Breaker Status 2 Phase B	0 to 65535	---	1	F300	0
8620	Breaker Failure 1 Breaker Status 2 Phase C	0 to 65535	---	1	F300	0
8621	...Repeated for Breaker Failure 2					
8642	...Repeated for Breaker Failure 3					
8663	...Repeated for Breaker Failure 4					
8684	...Repeated for Breaker Failure 5					
86A5	...Repeated for Breaker Failure 6					
FlexState Settings (Read/Write Setting)						
8800	FlexState Parameters (256 items)	---	---	---	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 65535	---	1	F300	0
8A0A	Digital Element 1 Pickup Delay	0 to 999999.999	s	0.001	F003	0
8A0C	Digital Element 1 Reset Delay	0 to 999999.999	s	0.001	F003	0
8A0E	Digital Element 1 Block	0 to 65535	---	1	F300	0
8A0F	Digital Element 1 Target	0 to 2	---	1	F109	0 (Self-reset)
8A10	Digital Element 1 Events	0 to 1	---	1	F102	0 (Disabled)
8A11	Digital Element 1 Pickup LED	0 to 1	---	1	F102	1 (Enabled)
8A12	Reserved (2 items)	---	---	---	F001	0
8A14	...Repeated for Digital Element 2					
8A28	...Repeated for Digital Element 3					
8A3C	...Repeated for Digital Element 4					
8A50	...Repeated for Digital Element 5					
8A64	...Repeated for Digital Element 6					
8A78	...Repeated for Digital Element 7					
8A8C	...Repeated for Digital Element 8					
8AA0	...Repeated for Digital Element 9					
8AB4	...Repeated for Digital Element 10					
8AC8	...Repeated for Digital Element 11					
8ADC	...Repeated for Digital Element 12					

Table B–9: MODBUS MEMORY MAP (Sheet 28 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
8AF0	...Repeated for Digital Element 13					
8B04	...Repeated for Digital Element 14					
8B18	...Repeated for Digital Element 15					
8B2C	...Repeated for Digital Element 16					
8B40	...Repeated for Digital Element 17					
8B54	...Repeated for Digital Element 18					
8B68	...Repeated for Digital Element 19					
8B7C	...Repeated for Digital Element 20					
8B90	...Repeated for Digital Element 21					
8BA4	...Repeated for Digital Element 22					
8BB8	...Repeated for Digital Element 23					
8BCC	...Repeated for Digital Element 24					
8BE0	...Repeated for Digital Element 25					
8BF4	...Repeated for Digital Element 26					
8C08	...Repeated for Digital Element 27					
8C1C	...Repeated for Digital Element 28					
8C30	...Repeated for Digital Element 29					
8C44	...Repeated for Digital Element 30					
8C58	...Repeated for Digital Element 31					
8C6C	...Repeated for Digital Element 32					
8C80	...Repeated for Digital Element 33					
8C94	...Repeated for Digital Element 34					
8CA8	...Repeated for Digital Element 35					
8CBC	...Repeated for Digital Element 36					
8CD0	...Repeated for Digital Element 37					
8CE4	...Repeated for Digital Element 38					
8CF8	...Repeated for Digital Element 39					
8D0C	...Repeated for Digital Element 40					
8D20	...Repeated for Digital Element 41					
8D34	...Repeated for Digital Element 42					
8D48	...Repeated for Digital Element 43					
8D5C	...Repeated for Digital Element 44					
8D70	...Repeated for Digital Element 45					
8D84	...Repeated for Digital Element 46					
8D98	...Repeated for Digital Element 47					
8DAC	...Repeated for Digital Element 48					
Trip Bus (Read/Write Setting)						
8E00	Trip Bus 1 Function	0 to 1	---	1	F102	0 (Disabled)
8E01	Trip Bus 1 Block	---	---	---	F300	0
8E02	Trip Bus 1 Pickup Delay	0 to 600	s	0.01	F001	0
8E03	Trip Bus 1 Reset Delay	0 to 600	s	0.01	F001	0
8E04	Trip Bus 1 Input 1	0 to 65535	---	1	F300	0
8E05	Trip Bus 1 Input 2	0 to 65535	---	1	F300	0
8E06	Trip Bus 1 Input 3	0 to 65535	---	1	F300	0
8E07	Trip Bus 1 Input 4	0 to 65535	---	1	F300	0
8E08	Trip Bus 1 Input 5	0 to 65535	---	1	F300	0
8E09	Trip Bus 1 Input 6	0 to 65535	---	1	F300	0
8E0A	Trip Bus 1 Input 7	0 to 65535	---	1	F300	0
8E0B	Trip Bus 1 Input 8	0 to 65535	---	1	F300	0
8E0C	Trip Bus 1 Input 9	0 to 65535	---	1	F300	0
8E0D	Trip Bus 1 Input 10	0 to 65535	---	1	F300	0
8E0E	Trip Bus 1 Input 11	0 to 65535	---	1	F300	0
8E0F	Trip Bus 1 Input 12	0 to 65535	---	1	F300	0
8E10	Trip Bus 1 Input 13	0 to 65535	---	1	F300	0

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Table B–9: MODBUS MEMORY MAP (Sheet 29 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
8E11	Trip Bus 1 Input 14	0 to 65535	---	1	F300	0
8E12	Trip Bus 1 Input 15	0 to 65535	---	1	F300	0
8E13	Trip Bus 1 Input 16	0 to 65535	---	1	F300	0
8E14	Trip Bus 1 Latching	0 to 1	---	1	F102	0 (Disabled)
8E15	Trip Bus 1 Reset	0 to 65535	---	1	F300	0
8E16	Trip Bus 1 Target	0 to 2	---	1	F109	0 (Self-reset)
8E16	Trip Bus 1 Events	0 to 1	---	1	F102	0 (Disabled)
8E18	Reserved (8 items)	---	---	---	F001	0
8E20	...Repeated for Trip Bus 2					
8E40	...Repeated for Trip Bus 3					
8E60	...Repeated for Trip Bus 4					
8E80	...Repeated for Trip Bus 5					
8EA0	...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
9012	FlexElement™ 1 Target	0 to 2	---	1	F109	0 (Self-reset)
9013	FlexElement™ 1 Events	0 to 1	---	1	F102	0 (Disabled)
9014	...Repeated for FlexElement™ 2					
9028	...Repeated for FlexElement™ 3					
903C	...Repeated for FlexElement™ 4					
9050	...Repeated for FlexElement™ 5					
9064	...Repeated for FlexElement™ 6					
9078	...Repeated for FlexElement™ 7					
908C	...Repeated for FlexElement™ 8					
90A0	...Repeated for FlexElement™ 9					
90B4	...Repeated for FlexElement™ 10					
90C8	...Repeated for FlexElement™ 11					
90DC	...Repeated for FlexElement™ 12					
90F0	...Repeated for FlexElement™ 13					
9104	...Repeated for FlexElement™ 14					
9118	...Repeated for FlexElement™ 15					
912C	...Repeated for FlexElement™ 16					
dcmA Outputs (Read/Write Setting) (24 modules)						
9300	dcmA Output 1 Source	0 to 65535	---	1	F600	0
9301	dcmA Output 1 Range	0 to 2	---	1	F522	0 (–1 to 1 mA)
9302	dcmA Output 1 Minimum	–90 to 90	pu	0.001	F004	0
9304	dcmA Output 1 Maximum	–90 to 90	pu	0.001	F004	1000
9306	...Repeated for dcmA Output 2					
930C	...Repeated for dcmA Output 3					
9312	...Repeated for dcmA Output 4					
9318	...Repeated for dcmA Output 5					

Table B–9: MODBUS MEMORY MAP (Sheet 30 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
931E	...Repeated for dcmA Output 6					
9324	...Repeated for dcmA Output 7					
932A	...Repeated for dcmA Output 8					
9330	...Repeated for dcmA Output 9					
9336	...Repeated for dcmA Output 10					
933C	...Repeated for dcmA Output 11					
9342	...Repeated for dcmA Output 12					
9348	...Repeated for dcmA Output 13					
934E	...Repeated for dcmA Output 14					
9354	...Repeated for dcmA Output 15					
935A	...Repeated for dcmA Output 16					
9360	...Repeated for dcmA Output 17					
9366	...Repeated for dcmA Output 18					
936C	...Repeated for dcmA Output 19					
9372	...Repeated for dcmA Output 20					
9378	...Repeated for dcmA Output 21					
937E	...Repeated for dcmA Output 22					
9384	...Repeated for dcmA Output 23					
938A	...Repeated for dcmA Output 24					
Direct Input/Output Names (Read/Write Setting) (96 modules)						
9400	Direct Input 1 Name	0 to 96	---	1	F205	“Dir Ip 1”
9406	Direct Output 1 Name	1 to 96	---	1	F205	“Dir Out 1”
940C	...Repeated for Direct Input/Output 2					
9418	...Repeated for Direct Input/Output 3					
9424	...Repeated for Direct Input/Output 4					
9430	...Repeated for Direct Input/Output 5					
943C	...Repeated for Direct Input/Output 6					
9448	...Repeated for Direct Input/Output 7					
9454	...Repeated for Direct Input/Output 8					
9460	...Repeated for Direct Input/Output 9					
946C	...Repeated for Direct Input/Output 10					
9478	...Repeated for Direct Input/Output 11					
9484	...Repeated for Direct Input/Output 12					
9490	...Repeated for Direct Input/Output 13					
949C	...Repeated for Direct Input/Output 14					
94A8	...Repeated for Direct Input/Output 15					
94B4	...Repeated for Direct Input/Output 16					
94C0	...Repeated for Direct Input/Output 17					
94CC	...Repeated for Direct Input/Output 18					
94D8	...Repeated for Direct Input/Output 19					
94E4	...Repeated for Direct Input/Output 20					
94F0	...Repeated for Direct Input/Output 21					
94FC	...Repeated for Direct Input/Output 22					
9508	...Repeated for Direct Input/Output 23					
9514	...Repeated for Direct Input/Output 24					
9520	...Repeated for Direct Input/Output 25					
952C	...Repeated for Direct Input/Output 26					
9538	...Repeated for Direct Input/Output 27					
9544	...Repeated for Direct Input/Output 28					
9550	...Repeated for Direct Input/Output 29					
955C	...Repeated for Direct Input/Output 30					
9568	...Repeated for Direct Input/Output 31					
9574	...Repeated for Direct Input/Output 32					

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Table B–9: MODBUS MEMORY MAP (Sheet 31 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
IEC 61850 received integers (read/write setting registers)						
9910	IEC61850 GOOSE UInteger 1 default value	0 to 429496295	---	1	F003	1000
9912	IEC61850 GOOSE UInteger input 1 mode	0 to 1	---	1	F491	0 (Default Value)
9913	...Repeated for IEC61850 GOOSE UInteger 2					
9916	...Repeated for IEC61850 GOOSE UInteger 3					
9919	...Repeated for IEC61850 GOOSE UInteger 4					
991C	...Repeated for IEC61850 GOOSE UInteger 5					
991F	...Repeated for IEC61850 GOOSE UInteger 6					
9922	...Repeated for IEC61850 GOOSE UInteger 7					
9925	...Repeated for IEC61850 GOOSE UInteger 8					
9928	...Repeated for IEC61850 GOOSE UInteger 9					
992B	...Repeated for IEC61850 GOOSE UInteger 10					
992E	...Repeated for IEC61850 GOOSE UInteger 11					
9931	...Repeated for IEC61850 GOOSE UInteger 12					
9934	...Repeated for IEC61850 GOOSE UInteger 13					
9937	...Repeated for IEC61850 GOOSE UInteger 14					
993A	...Repeated for IEC61850 GOOSE UInteger 15					
993D	...Repeated for IEC61850 GOOSE UInteger 16					
FlexElement Actuals (Read Only) (16 modules)						
9A01	FlexElement™ 1 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A03	FlexElement™ 2 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A05	FlexElement™ 3 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A07	FlexElement™ 4 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A09	FlexElement™ 5 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A0B	FlexElement™ 6 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A0D	FlexElement™ 7 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A0F	FlexElement™ 8 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A11	FlexElement™ 9 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A13	FlexElement™ 10 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A15	FlexElement™ 11 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A17	FlexElement™ 12 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A19	FlexElement™ 13 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A1B	FlexElement™ 14 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A1D	FlexElement™ 15 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A1F	FlexElement™ 16 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
Breaker restrike (read/write settings)						
9AD9	Breaker restrike 1 function	0 to 1	---	1	F102	0 (Disabled)
9ADA	Breaker restrike 1 block	0 to 65535	---	1	F300	0
9ADB	Breaker restrike 1 signal source	0 to 5	---	1	F167	0 (SRC 1)
9ADC	Breaker restrike 1 pickup	0.10 to 2.00	pu	0.01	F001	500
9ADD	Breaker restrike 1 reset delay	0 to 65.535	s	0.001	F001	100
9ADE	Breaker restrike 1 HF detect	0 to 1	---	1	F102	1 (Enabled)
9ADF	Breaker restrike 1 breaker open	0 to 65535	---	1	F300	0
9AE0	Breaker restrike 1 open command	0 to 65535	---	1	F300	0
9AE1	Breaker restrike 1 close command	0 to 65535	---	1	F300	0
9AE2	Breaker restrike 1 target	0 to 2	---	1	F109	0 (Self-reset)
9AE3	Breaker restrike 1 events	0 to 1	---	1	F102	0 (Disabled)
9AE4	Reserved (2 items)	0 to 1	---	1	F001	0
9AE6	...Repeated for breaker restrike 2					
9AF3	...Repeated for breaker restrike 3					
Capacitor control settings (read/write, 4 modules)						
9C00	Capacitor control 1 function	0 to 1	---	1	F102	0 (Disabled)
9C01	Capacitor control 1 set remote 1	0 to 65535	---	1	F300	0
9C02	Capacitor control 1 set remote 2	0 to 65535	---	1	F300	0

Table B–9: MODBUS MEMORY MAP (Sheet 32 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
9C03	Capacitor control 1 set local 1	0 to 65535	---	1	F300	0
9C04	Capacitor control 1 set local 2	0 to 65535	---	1	F300	0
9C05	Capacitor control 1 remote control enable	0 to 65535	---	1	F300	0
9C06	Capacitor control 1 local control enable	0 to 65535	---	1	F300	0
9C07	Capacitor control 1 remote set automatic	0 to 65535	---	1	F300	0
9C08	Capacitor control 1 local set automatic	0 to 65535	---	1	F300	0
9C09	Capacitor control 1 remote set manual	0 to 65535	---	1	F300	0
9C0A	Capacitor control 1 local set manual	0 to 65535	---	1	F300	0
9C0B	Capacitor control 1 trip 1	0 to 65535	---	1	F300	0
9C0C	Capacitor control 1 trip 2	0 to 65535	---	1	F300	0
9C0D	Capacitor control 1 trip 3	0 to 65535	---	1	F300	0
9C0E	Capacitor control 1 trip 4	0 to 65535	---	1	F300	0
9C0F	Capacitor control 1 trip 5	0 to 65535	---	1	F300	0
9C10	Capacitor control 1 trip 6	0 to 65535	---	1	F300	0
9C11	Reserved	---	---	---	---	---
9C12	Capacitor control 1 automatic control enable	0 to 65535	---	1	F300	0
9C13	Capacitor control 1 manual control enable	0 to 65535	---	1	F300	0
9C14	Capacitor control 1 remote open	0 to 65535	---	1	F300	0
9C15	Capacitor control 1 local open	0 to 65535	---	1	F300	0
9C16	Capacitor control 1 automatic open	0 to 65535	---	1	F300	0
9C17	Capacitor control 1 breaker open 52b	0 to 65535	---	1	F300	0
9C18	Capacitor control 1 trip seal-in delay	0 to 60.000	s	0.001	F001	400
9C19	Capacitor control 1 remote close	0 to 65535	---	1	F300	0
9C1A	Capacitor control 1 local close	0 to 65535	---	1	F300	0
9C1B	Capacitor control 1 automatic close	0 to 65535	---	1	F300	0
9C1C	Capacitor control 1 breaker closed 52a	0 to 65535	---	1	F300	0
9C1D	Capacitor control 1 close discharge time	0 to 3600	s	1	F001	300
9C1F	Capacitor control 1 close seal-in delay	0 to 60.000	s	0.001	F001	400
9C20	Capacitor control 1 breaker close block	0 to 65535	---	1	F300	0
9C21	Reserved	---	---	---	---	---
9C22	Capacitor control 1 targets	0 to 2	---	1	F109	0 (Self-Reset)
9C23	Capacitor control 1 events	0 to 1	---	1	F102	0 (Disabled)
9C24	...Repeated for capacitor control element 2					
9C48	...Repeated for capacitor control element 3					
9C6C	...Repeated for capacitor control element 4					
Automatic voltage regulator settings (read/write, 3 modules)						
9C90	Automatic voltage regulator 1 function	0 to 1	---	1	F102	0 (Disabled)
9C91	Automatic voltage regulator 1 source	0 to 5	---	1	F167	0 (SRC 1)
9C92	Automatic voltage regulator 1 minimum voltage	0.500 to 15.000	pu	0.001	F001	500
9C93	Automatic voltage regulator 1 control mode	0 to 1	---	1	F536	0 (Voltage)
9C94	Automatic voltage regulator 1 voltage operating signal	0 to 5	---	1	F535	4 (V1)
9C95	Automatic voltage regulator 1 voltage level to close	0.750 to 1.500	pu	0.001	F001	950
9C96	Automatic voltage regulator 1 voltage level to open	0.750 to 1.500	pu	0.001	F001	1050
9C97	AVR 1 voltage drop compensation impedance	0 to 250	ohms	0.01	F001	0
9C98	AVR 1 voltage drop compensation RCA	30 to 90	°	1	F001	75
9C99	Automatic voltage regulator 1 var level to close	–1.500 to 1.500	pu	0.001	F002	950
9C9A	Automatic voltage regulator 1 var level to open	–1.500 to 1.500	pu	0.001	F002	1050
9C9B	Automatic voltage regulator 1 power factor limit	0.50 to 1.00	---	0.01	F001	100
9C9C	Automatic voltage regulator 1 var open mode	0 to 1	---	1	F537	1 (Minimize no. of ops.)
9C9D	Automatic voltage regulator 1 delay before close	0 to 65.535	s	0.001	F001	1000
9C9E	Automatic voltage regulator 1 delay before open	0 to 65.535	s	0.001	F001	1000
9C9F	Automatic voltage regulator 1 block	0 to 65.535	---	1	F300	0
9CA0	Automatic voltage regulator 1 events	0 to 1	---	1	F102	0 (Disabled)
9CA1	Automatic voltage regulator 1 target	0 to 2	---	1	F109	0 (Self-Reset)

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Table B–9: MODBUS MEMORY MAP (Sheet 33 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
9CA2	Automatic voltage regulator 1 reserved	---	---	---	---	---
9CA3	...Repeated for automatic voltage regulator 2					
9CB6	...Repeated for automatic voltage regulator 3					
Neutral current unbalance settings (read/write, 3 modules)						
9CE0	Neutral current unbalance 1 function	0 to 1	---	1	F102	0 (Disabled)
9CE1	Neutral current unbalance 1 bank source	0 to 5	---	1	F167	0 (SRC 1)
9CE2	Neutral current unbalance 1 *k* magnitude	0 to 0.1500	---	0.0001	F001	0
9CE3	Neutral current unbalance 1 *k* angle	0 to 359	°	1	F001	0
9CE4	Neutral current unbalance 1 stage 1 pickup	0 to 5.000	pu	0.001	F001	20
9CE5	Neutral current unbalance 1 stage 1 slope	0 to 10.0	%	0.1	F001	20
9CE6	Neutral current unbalance 1 stage 2 pickup	0 to 5.000	pu	0.001	F001	30
9CE7	Neutral current unbalance 1 stage 2 slope	0 to 10.0	%	0.1	F001	20
9CE8	Neutral current unbalance 1 stage 3 pickup	0 to 5.000	pu	0.001	F001	40
9CE9	Neutral current unbalance 1 stage 3 slope	0 to 10.0	%	0.1	F001	20
9CEA	Neutral current unbalance 1 stage 4 pickup	0 to 5.000	pu	0.001	F001	50
9CEB	Neutral current unbalance 1 stage 4 slope	0 to 10.0	%	0.1	F001	50
9CEC	Neutral current unbalance 1 stage 1 pickup delay	0 to 600.00	s	0.01	F001	3000
9CED	Neutral current unbalance 1 stage 2 pickup delay	0 to 600.00	s	0.01	F001	1000
9CEE	Neutral current unbalance 1 stage 3 pickup delay	0 to 600.00	s	0.01	F001	100
9CEF	Neutral current unbalance 1 stage 4 pickup delay	0 to 600.00	s	0.01	F001	20
9CF0	Neutral current unbalance 1 dropout delay	0 to 600.00	s	0.01	F001	25
9CF1	Neutral current unbalance 1 stage 1 block	0 to 65.535	---	1	F300	0
9CF2	Neutral current unbalance 1 stage 2 block	0 to 65.535	---	1	F300	0
9CF3	Neutral current unbalance 1 stage 3 block	0 to 65.535	---	1	F300	0
9CF4	Neutral current unbalance 1 stage 4 block	0 to 65.535	---	1	F300	0
9CF5	Neutral current unbalance 1 target	0 to 2	---	1	F109	0 (Self-Reset)
9CF6	Neutral current unbalance 1 events	0 to 1	---	1	F102	0 (Disabled)
9CF7	...Repeated for neutral current unbalance 2					
9D0E	...Repeated for neutral current unbalance 3					
Neutral voltage unbalance settings (read/write, 3 modules)						
9D50	Neutral voltage unbalance 1 function	0 to 1	---	1	F102	0 (Disabled)
9D51	Neutral voltage unbalance 1 bank source	0 to 5	---	1	F167	0 (SRC 1)
9D52	Neutral voltage unbalance 1 bus source	0 to 5	---	1	F167	0 (SRC 1)
9D53	Neutral voltage unbalance 1 bus 3V0	0 to 1	---	1	F241	0 (Calculated)
9D54	Neutral voltage unbalance 1 ground	0 to 1	---	1	F255	0 (VT (ungrnd))
9D55	Neutral voltage unbalance 1 AB ratio	0.7500 to 1.2500	---	0.0001	F001	10000
9D56	Neutral voltage unbalance 1 AC ratio	0.7500 to 1.2500	---	0.0001	F001	10000
9D57	Neutral voltage unbalance 1 stage 1 pickup	0.001 to 1.000	pu	0.001	F001	10
9D58	Neutral voltage unbalance 1 stage 1 slope	0 to 10.0	%	0.1	F001	0
9D59	Neutral voltage unbalance 1 stage 2 pickup	0.001 to 1.000	pu	0.001	F001	20
9D5A	Neutral voltage unbalance 1 stage 2 slope	0 to 10.0	%	0.1	F001	0
9D5B	Neutral voltage unbalance 1 stage 3 pickup	0.001 to 1.000	pu	0.001	F001	20
9D5C	Neutral voltage unbalance 1 stage 3 slope	0 to 10.0	%	0.1	F001	50
9D5D	Neutral voltage unbalance 1 stage 4 pickup	0.001 to 1.000	pu	0.001	F001	30
9D5E	Neutral voltage unbalance 1 stage 4 slope	0 to 10.0	%	0.1	F001	30
9D5F	Neutral voltage unbalance 1 stage 1 pickup delay	0 to 600.00	s	0.01	F001	3000
9D60	Neutral voltage unbalance 1 stage 1 pickup delay	0 to 600.00	s	0.01	F001	1000
9D61	Neutral voltage unbalance 1 stage 1 pickup delay	0 to 600.00	s	0.01	F001	100
9D62	Neutral voltage unbalance 1 stage 1 pickup delay	0 to 600.00	s	0.01	F001	20
9D63	Neutral voltage unbalance 1 dropout delay	0 to 600.00	s	0.01	F001	25
9D64	Neutral voltage unbalance 1 stage 1 block	0 to 65.535	---	1	F300	0
9D65	Neutral voltage unbalance 1 stage 2 block	0 to 65.535	---	1	F300	0
9D66	Neutral voltage unbalance 1 stage 3 block	0 to 65.535	---	1	F300	0
9D67	Neutral voltage unbalance 1 stage 4 block	0 to 65.535	---	1	F300	0

Table B–9: MODBUS MEMORY MAP (Sheet 34 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
9D68	Neutral voltage unbalance 1 target	0 to 2	---	1	F109	0 (Self-Reset)
9D69	Neutral voltage unbalance 1 events	0 to 1	---	1	F102	0 (Disabled)
9D6A	...Repeated for neutral voltage unbalance 2					
9D84	...Repeated for neutral voltage unbalance 3					
Phase current unbalance settings (read/write, 3 modules)						
9DC0	Phase current unbalance 1 function	0 to 1	---	1	F102	0 (Disabled)
9DC1	Phase current unbalance 1 differential source	0 to 5	---	1	F167	0 (SRC 1)
9DC2	Phase current unbalance 1 bank source	0 to 5	---	1	F167	0 (SRC 1)
9DC3	Phase current unbalance 1 inherent factor A	–0.1000 to 0.1000	---	0.0001	F002	0
9DC4	Phase current unbalance 1 inherent factor B	–0.1000 to 0.1000	---	0.0001	F002	0
9DC5	Phase current unbalance 1 inherent factor C	–0.1000 to 0.1000	---	0.0001	F002	0
9DC6	Phase current unbalance 1 stage 1A pickup	0.001 to 5.000	pu	0.001	F001	20
9DC7	Phase current unbalance 1 stage 2A pickup	0.001 to 5.000	pu	0.001	F001	30
9DC8	Phase current unbalance 1 stage 3A pickup	0.001 to 5.000	pu	0.001	F001	40
9DC9	Phase current unbalance 1 stage 4A pickup	0.001 to 5.000	pu	0.001	F001	50
9DCA	Phase current unbalance 1 stage 1B pickup	0.001 to 5.000	pu	0.001	F001	20
9DCB	Phase current unbalance 1 stage 2B pickup	0.001 to 5.000	pu	0.001	F001	30
9DCC	Phase current unbalance 1 stage 3B pickup	0.001 to 5.000	pu	0.001	F001	40
9DCD	Phase current unbalance 1 stage 4B pickup	0.001 to 5.000	pu	0.001	F001	50
9DCE	Phase current unbalance 1 stage 1C pickup	0.001 to 5.000	pu	0.001	F001	20
9DCF	Phase current unbalance 1 stage 2C pickup	0.001 to 5.000	pu	0.001	F001	30
9DD0	Phase current unbalance 1 stage 3C pickup	0.001 to 5.000	pu	0.001	F001	40
9DD1	Phase current unbalance 1 stage 4C pickup	0.001 to 5.000	pu	0.001	F001	50
9DD2	Phase current unbalance 1 stage 1 pickup delay	0 to 600.00	s	0.01	F001	3000
9DD3	Phase current unbalance 1 stage 2 pickup delay	0 to 600.00	s	0.01	F001	1000
9DD4	Phase current unbalance 1 stage 3 pickup delay	0 to 600.00	s	0.01	F001	100
9DD5	Phase current unbalance 1 stage 4 pickup delay	0 to 600.00	s	0.01	F001	20
9DD6	Phase current unbalance 1 dropout delay	0 to 600.00	s	0.01	F001	25
9DD7	Phase current unbalance 1 stage 1 block	0 to 65.535	---	1	F300	0
9DD8	Phase current unbalance 1 stage 2 block	0 to 65.535	---	1	F300	0
9DD9	Phase current unbalance 1 stage 3 block	0 to 65.535	---	1	F300	0
9DDA	Phase current unbalance 1 stage 4 block	0 to 65.535	---	1	F300	0
9DDB	Phase current unbalance 1 target	0 to 2	---	1	F109	0 (Self-Reset)
9DDC	Phase current unbalance 1 events	0 to 1	---	1	F102	0 (Disabled)
9DDD	...Repeated for phase current unbalance 2					
9DFA	...Repeated for phase current unbalance 3					
Voltage differential settings (read/write, 3 modules)						
9E40	Voltage differential 1 function	0 to 1	---	1	F102	0 (Disabled)
9E41	Voltage differential 1 bus source	0 to 5	---	1	F167	0 (SRC 1)
9E42	Voltage differential 1 tap source	0 to 5	---	1	F167	0 (SRC 1)
9E43	Voltage differential 1 bank ground	0 to 1	---	1	F091	0 (Grounded)
9E44	Voltage differential 1 match factor A	0.5000 to 2000.0000	---	0.0001	F003	20000
9E46	Voltage differential 1 match factor B	0.5000 to 2000.0000	---	0.0001	F003	20000
9E48	Voltage differential 1 match factor C	0.5000 to 2000.0000	---	0.0001	F003	20000
9E4A	Voltage differential 1 stage 1A pickup	0.001 to 1.000	pu	0.001	F001	10
9E4B	Voltage differential 1 stage 2A pickup	0.001 to 1.000	pu	0.001	F001	20
9E4C	Voltage differential 1 stage 3A pickup	0.001 to 1.000	pu	0.001	F001	30
9E4D	Voltage differential 1 stage 4A pickup	0.001 to 1.000	pu	0.001	F001	40
9E4E	Voltage differential 1 stage 1B pickup	0.001 to 1.000	pu	0.001	F001	10
9E5F	Voltage differential 1 stage 2B pickup	0.001 to 1.000	pu	0.001	F001	20
9E50	Voltage differential 1 stage 3B pickup	0.001 to 1.000	pu	0.001	F001	30
9E51	Voltage differential 1 stage 4B pickup	0.001 to 1.000	pu	0.001	F001	40
9E52	Voltage differential 1 stage 1C pickup	0.001 to 1.000	pu	0.001	F001	10
9E53	Voltage differential 1 stage 2C pickup	0.001 to 1.000	pu	0.001	F001	20

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Table B–9: MODBUS MEMORY MAP (Sheet 35 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
9E54	Voltage differential 1 stage 3C pickup	0.001 to 1.000	pu	0.001	F001	30
9E55	Voltage differential 1 stage 4C pickup	0.001 to 1.000	pu	0.001	F001	40
9E56	Voltage differential 1 stage 1 pickup delay	0 to 600.00	s	0.01	F001	3000
9E57	Voltage differential 1 stage 2 pickup delay	0 to 600.00	s	0.01	F001	1000
9E58	Voltage differential 1 stage 3 pickup delay	0 to 600.00	s	0.01	F001	100
9E59	Voltage differential 1 stage 4 pickup delay	0 to 600.00	s	0.01	F001	20
9E5A	Voltage differential 1 dropout delay	0 to 600.00	s	0.01	F001	25
9E5B	Voltage differential 1 stage 1 block	0 to 65.535	---	1	F300	0
9E5C	Voltage differential 1 stage 2 block	0 to 65.535	---	1	F300	0
9E5D	Voltage differential 1 stage 3 block	0 to 65.535	---	1	F300	0
9E5E	Voltage differential 1 stage 4 block	0 to 65.535	---	1	F300	0
9E5F	Voltage differential 1 target	0 to 2	---	1	F109	0 (Self-Reset)
9E60	Voltage differential 1 events	0 to 1	---	1	F102	0 (Disabled)
9E61	...Repeated for voltage differential 2					
9E82	...Repeated for voltage differential 3					
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
A041	...Repeated for module number 2					
A042	...Repeated for module number 3					
A043	...Repeated for module number 4					
A044	...Repeated for module number 5					
A045	...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 65535	---	1	F300	0
A284	Selector 1 Step Mode	0 to 1	---	1	F083	0 (Time-out)
A285	Selector 1 Acknowledge	0 to 65535	---	1	F300	0
A286	Selector 1 Bit0	0 to 65535	---	1	F300	0
A287	Selector 1 Bit1	0 to 65535	---	1	F300	0
A288	Selector 1 Bit2	0 to 65535	---	1	F300	0
A289	Selector 1 Bit Mode	0 to 1	---	1	F083	0 (Time-out)
A28A	Selector 1 Bit Acknowledge	0 to 65535	---	1	F300	0
A28B	Selector 1 Power Up Mode	0 to 2	---	1	F084	0 (Restore)
A28C	Selector 1 Target	0 to 2	---	1	F109	0 (Self-reset)
A28D	Selector 1 Events	0 to 1	---	1	F102	0 (Disabled)
A28E	Reserved (10 items)	---	---	1	F001	0
A298	...Repeated for Selector 2					
DNP/IEC Points (Read/Write Setting)						
A300	DNP/IEC 60870-5-104 Binary Input Points (256 items)	0 to 65535	---	1	F300	0
A400	DNP/IEC 60870-5-104 Analog Input Points (256 items)	0 to 65535	---	1	F300	0
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)

Table B–9: MODBUS MEMORY MAP (Sheet 36 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
A702	Non-Volatile Latch 1 Set	0 to 65535	---	1	F300	0
A703	Non-Volatile Latch 1 Reset	0 to 65535	---	1	F300	0
A704	Non-Volatile Latch 1 Target	0 to 2	---	1	F109	0 (Self-reset)
A705	Non-Volatile Latch 1 Events	0 to 1	---	1	F102	0 (Disabled)
A706	Reserved (4 items)	---	---	---	F001	0
A70A	...Repeated for Non-Volatile Latch 2					
A714	...Repeated for Non-Volatile Latch 3					
A71E	...Repeated for Non-Volatile Latch 4					
A728	...Repeated for Non-Volatile Latch 5					
A732	...Repeated for Non-Volatile Latch 6					
A73C	...Repeated for Non-Volatile Latch 7					
A746	...Repeated for Non-Volatile Latch 8					
A750	...Repeated for Non-Volatile Latch 9					
A75A	...Repeated for Non-Volatile Latch 10					
A764	...Repeated for Non-Volatile Latch 11					
A76E	...Repeated for Non-Volatile Latch 12					
A778	...Repeated for Non-Volatile Latch 13					
A782	...Repeated for Non-Volatile Latch 14					
A78C	...Repeated for Non-Volatile Latch 15					
A796	...Repeated for Non-Volatile Latch 16					
Digital Counter (Read/Write Setting) (8 modules)						
A800	Digital Counter 1 Function	0 to 1	---	1	F102	0 (Disabled)
A801	Digital Counter 1 Name	---	---	---	F205	"Counter 1"
A807	Digital Counter 1 Units	---	---	---	F206	(none)
A80A	Digital Counter 1 Block	0 to 65535	---	1	F300	0
A80B	Digital Counter 1 Up	0 to 65535	---	1	F300	0
A80C	Digital Counter 1 Down	0 to 65535	---	1	F300	0
A80D	Digital Counter 1 Preset	–2147483647 to 2147483647	---	1	F004	0
A80F	Digital Counter 1 Compare	–2147483647 to 2147483647	---	1	F004	0
A811	Digital Counter 1 Reset	0 to 65535	---	1	F300	0
A812	Digital Counter 1 Freeze/Reset	0 to 65535	---	1	F300	0
A813	Digital Counter 1 Freeze/Count	0 to 65535	---	1	F300	0
A814	Digital Counter 1 Set To Preset	0 to 65535	---	1	F300	0
A815	Reserved (11 items)	---	---	---	F001	0
A820	...Repeated for Digital Counter 2					
A840	...Repeated for Digital Counter 3					
A860	...Repeated for Digital Counter 4					
A880	...Repeated for Digital Counter 5					
A8A0	...Repeated for Digital Counter 6					
A8C0	...Repeated for Digital Counter 7					
A8E0	...Repeated for Digital Counter 8					
IEC 61850 received analog settings (read/write)						
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					

Table B–9: MODBUS MEMORY MAP (Sheet 37 of 53)

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					
IEC 61850 XCBR configuration (read/write settings)						
AB24	Operand for IEC 61850 XCBR1.ST.Loc status	0 to 65535	---	1	F300	0
AB25	Command to clear XCBR1 OpCnt (operation counter)	0 to 1	---	1	F126	0 (No)
AB26	Operand for IEC 61850 XCBR2.ST.Loc status	0 to 65535	---	1	F300	0
AB27	Command to clear XCBR2 OpCnt (operation counter)	0 to 1	---	1	F126	0 (No)
AB28	Operand for IEC 61850 XCBR3.ST.Loc status	0 to 65535	---	1	F300	0
AB29	Command to clear XCBR3 OpCnt (operation counter)	0 to 1	---	1	F126	0 (No)
AB2A	Operand for IEC 61850 XCBR4.ST.Loc status	0 to 65535	---	1	F300	0
AB2B	Command to clear XCBR4 OpCnt (operation counter)	0 to 1	---	1	F126	0 (No)
AB2C	Operand for IEC 61850 XCBR5.ST.Loc status	0 to 65535	---	1	F300	0
AB2D	Command to clear XCBR5 OpCnt (operation counter)	0 to 1	---	1	F126	0 (No)
AB2E	Operand for IEC 61850 XCBR6.ST.Loc status	0 to 65535	---	1	F300	0
AB2F	Command to clear XCBR6 OpCnt (operation counter)	0 to 1	---	1	F126	0 (No)
IEC 61850 LN name prefixes (read/write settings)						
AB30	IEC 61850 logical node LPHD1 name prefix	0 to 65534	---	1	F206	(none)
AB33	IEC 61850 logical node PIOCx name prefix (72 items)	0 to 65534	---	1	F206	(none)
AC0B	IEC 61850 logical node PTOCx name prefix (24 items)	0 to 65534	---	1	F206	(none)
AC53	IEC 61850 logical node PTUVx name prefix (13 items)	0 to 65534	---	1	F206	(none)
AC7A	IEC 61850 logical node PTOVx name prefix (10 items)	0 to 65534	---	1	F206	(none)
AC98	IEC 61850 logical node PDISx name prefix (10 items)	0 to 65534	---	1	F206	(none)
ACB6	IEC 61850 logical node RBRFx name prefix (24 items)	0 to 65534	---	1	F206	(none)
ACFE	IEC 61850 logical node RPSBx name prefix	0 to 65534	---	1	F206	(none)
AD01	IEC 61850 logical node RRECx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AD13	IEC 61850 logical node MMXUx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AD25	IEC 61850 logical node GGIOx name prefix (5 items)	0 to 65534	---	1	F206	(none)
AD34	IEC 61850 logical node RFLOx name prefix (5 items)	0 to 65534	---	1	F206	(none)
AD43	IEC 61850 logical node XCBRx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AD55	IEC 61850 logical node PTRCx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AD67	IEC 61850 logical node PDIFx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AD73	IEC 61850 logical node MMXNx name prefix (6 items)	0 to 65534	---	1	F206	(none)
ADE2	IEC 61850 logical node CSWIx name prefix (6 items)	0 to 65534	---	1	F206	(none)
AE3C	IEC 61850 logical node XSWIx name prefix (6 items)	0 to 65534	---	1	F206	(none)
IEC 61850 XSWI configuration (read/write settings)						
AECF	Operand for IEC 61850 XSWI1.ST.Loc status	0 to 65535	---	1	F300	0
AED0	Command to clear XSWI1 OpCnt (operation counter)	0 to 1	---	1	F126	0 (No)
AED1	Repeated for IEC 61850 XSWI2					
AED3	Repeated for IEC 61850 XSWI3					
AED5	Repeated for IEC 61850 XSWI4					
AED7	Repeated for IEC 61850 XSWI5					
AED9	Repeated for IEC 61850 XSWI6					
AEDB	Repeated for IEC 61850 XSWI7					
AEDD	Repeated for IEC 61850 XSWI8					
AEDF	Repeated for IEC 61850 XSWI9					
AEE1	Repeated for IEC 61850 XSWI10					
AEE3	Repeated for IEC 61850 XSWI11					
AEE5	Repeated for IEC 61850 XSWI12					

Table B–9: MODBUS MEMORY MAP (Sheet 38 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
AEE7	Repeated for IEC 61850 XSWI13					
AEE9	Repeated for IEC 61850 XSWI14					
AEEB	Repeated for IEC 61850 XSWI15					
AEED	Repeated for IEC 61850 XSWI16					
AEEF	Repeated for IEC 61850 XSWI17					
AEF1	Repeated for IEC 61850 XSWI18					
AEF3	Repeated for IEC 61850 XSWI19					
AEF5	Repeated for IEC 61850 XSWI20					
AEF7	Repeated for IEC 61850 XSWI21					
AEF9	Repeated for IEC 61850 XSWI22					
AEFB	Repeated for IEC 61850 XSWI23					
AEFD	Repeated for IEC 61850 XSWI24					
IEC 61850 GGIO4 general analog configuration settings (read/write)						
AF00	Number of analog points in GGIO4	4 to 32	---	4	F001	4
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 Logical Node Name Prefixes (Read/Write Setting)						
AB30	IEC 61850 Logical Node LPHD1 Name Prefix	0 to 65534	---	1	F206	(None)
AB33	IEC 61850 Logical Node PIOCx Name Prefix (72 items)	0 to 65534	---	1	F206	(None)

Table B–9: MODBUS MEMORY MAP (Sheet 39 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
AC0B	IEC 61850 Logical Node PTOCx Name Prefix (24 items)	0 to 65534	---	1	F206	(None)
AC53	IEC 61850 Logical Node PTUVx Name Prefix (12 items)	0 to 65534	---	1	F206	(None)
AC77	IEC 61850 Logical Node PTOVx Name Prefix (8 items)	0 to 65534	---	1	F206	(None)
AC8F	IEC 61850 Logical Node PDISx Name Prefix (10 items)	0 to 65534	---	1	F206	(None)
ACAD	IEC 61850 Logical Node RRBFx Name Prefix (24 items)	0 to 65534	---	1	F206	(None)
ACF5	IEC 61850 Logical Node RPSBx Name Prefix	0 to 65534	---	1	F206	(None)
ACF8	IEC 61850 Logical Node RRECx Name Prefix (6 items)	0 to 65534	---	1	F206	(None)
AD0A	IEC 61850 Logical Node MMXUx Name Prefix (6 items)	0 to 65534	---	1	F206	(None)
AD1C	IEC 61850 Logical Node GGIOx Name Prefix (4 items)	0 to 65534	---	1	F206	(None)
AD28	IEC 61850 Logical Node RFLOx Name Prefix (5 items)	0 to 65534	---	1	F206	(None)
AD37	IEC 61850 Logical Node XCBRx Name Prefix (2 items)	0 to 65534	---	1	F206	(None)
AD3D	IEC 61850 Logical Node PTRCx Name Prefix (2 items)	0 to 65534	---	1	F206	(None)
AD43	IEC 61850 Logical Node PDIFx Name Prefix (4 items)	0 to 65534	---	1	F206	(None)
AD4F	IEC 61850 Logical Node MMXNx Name Prefix (37 items)	0 to 65534	---	1	F206	(None)
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
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	1 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)
B06B	IEC 61850 Server Data Scanning Function	0 to 1	---	1	F102	0 (Disabled)
B0B7	Reserved (15 items)					
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

Table B–9: MODBUS MEMORY MAP (Sheet 40 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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 Configurable Report Settings (Read/Write Setting)						
B290	IEC 61850 configurable reports dataset items (64 items)	0 to 848	---	1	F615	0 (None)
IEC 61850 GGIO1 Configuration Settings (Read/Write Setting)						
B500	Number of Status Indications in GGIO1	8 to 128	---	8	F001	8
B501	IEC 61850 GGIO1 Indication operands (128 items)	---	---	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					
IEC 61850 Configurable GOOSE Reception (Read/Write Setting) (8 modules)						
B900	Configurable GOOSE dataset items for reception (32 items)	0 to 32	---	1	F233	0 (None)
B940	...Repeated for Module 2					
B980	...Repeated for Module 3					
B9C0	...Repeated for Module 4					
BA00	...Repeated for Module 5					
BA40	...Repeated for Module 6					
BA80	...Repeated for Module 7					
BAC0	...Repeated for Module 8					
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					

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Table B–9: MODBUS MEMORY MAP (Sheet 41 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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					
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					

Table B–9: MODBUS MEMORY MAP (Sheet 42 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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					
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 24 (24 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					

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Table B–9: MODBUS MEMORY MAP (Sheet 43 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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					
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					

Table B–9: MODBUS MEMORY MAP (Sheet 44 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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					
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					

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Table B–9: MODBUS MEMORY MAP (Sheet 45 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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					
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 1	---	1	F245	0 (Disabled)
C431	Force VFD and LED	0 to 1	---	1	F126	0 (No)
C432	Test Mode Forcing	0 to 65535	---	1	F300	1
C436	Relay Reboot Command	0 to 1	---	1	F126	0 (No)
Clear commands (read/write)						
C433	Clear All Relay Records Command	0 to 1	---	1	F126	0 (No)
Advanced diagnostics actual values (read only)						
C434	CT/VT module advanced diagnostics active	0 to 1	---	1	F126	0 (No)

Table B–9: MODBUS MEMORY MAP (Sheet 46 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Contact Outputs (Read/Write Setting) (64 modules)						
C440	Contact Output 1 Name	---	---	---	F205	“Cont Op 1"
C446	Contact Output 1 Operation	0 to 65535	---	1	F300	0
C447	Contact Output 1 Seal In	0 to 65535	---	1	F300	0
C448	Latching Output 1 Reset	0 to 65535	---	1	F300	0
C449	Contact Output 1 Events	0 to 1	---	1	F102	1 (Enabled)
C44A	Latching Output 1 Type	0 to 1	---	1	F090	0 (Operate-dominant)
C44B	Reserved	---	---	---	F001	0
C44C	...Repeated for Contact Output 2					
C458	...Repeated for Contact Output 3					
C464	...Repeated for Contact Output 4					
C470	...Repeated for Contact Output 5					
C47C	...Repeated for Contact Output 6					
C488	...Repeated for Contact Output 7					
C494	...Repeated for Contact Output 8					
C4A0	...Repeated for Contact Output 9					
C4AC	...Repeated for Contact Output 10					
C4B8	...Repeated for Contact Output 11					
C4C4	...Repeated for Contact Output 12					
C4D0	...Repeated for Contact Output 13					
C4DC	...Repeated for Contact Output 14					
C4E8	...Repeated for Contact Output 15					
C4F4	...Repeated for Contact Output 16					
C500	...Repeated for Contact Output 17					
C50C	...Repeated for Contact Output 18					
C518	...Repeated for Contact Output 19					
C524	...Repeated for Contact Output 20					
C530	...Repeated for Contact Output 21					
C53C	...Repeated for Contact Output 22					
C548	...Repeated for Contact Output 23					
C554	...Repeated for Contact Output 24					
C560	...Repeated for Contact Output 25					
C56C	...Repeated for Contact Output 26					
C578	...Repeated for Contact Output 27					
C584	...Repeated for Contact Output 28					
C590	...Repeated for Contact Output 29					
C59C	...Repeated for Contact Output 30					
C5A8	...Repeated for Contact Output 31					
C5B4	...Repeated for Contact Output 32					
C5C0	...Repeated for Contact Output 33					
C5CC	...Repeated for Contact Output 34					
C5D8	...Repeated for Contact Output 35					
C5E4	...Repeated for Contact Output 36					
C5F0	...Repeated for Contact Output 37					
C5FC	...Repeated for Contact Output 38					
C608	...Repeated for Contact Output 39					
C614	...Repeated for Contact Output 40					
C620	...Repeated for Contact Output 41					
C62C	...Repeated for Contact Output 42					
C638	...Repeated for Contact Output 43					
C644	...Repeated for Contact Output 44					
C650	...Repeated for Contact Output 45					
C65C	...Repeated for Contact Output 46					
C668	...Repeated for Contact Output 47					

Table B–9: MODBUS MEMORY MAP (Sheet 47 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C674	...Repeated for Contact Output 48					
C680	...Repeated for Contact Output 49					
C68C	...Repeated for Contact Output 50					
C698	...Repeated for Contact Output 51					
C6A4	...Repeated for Contact Output 52					
C6B0	...Repeated for Contact Output 53					
C6BC	...Repeated for Contact Output 54					
C6C8	...Repeated for Contact Output 55					
C6D4	...Repeated for Contact Output 56					
C6E0	...Repeated for Contact Output 57					
C6EC	...Repeated for Contact Output 58					
C6F8	...Repeated for Contact Output 59					
C704	...Repeated for Contact Output 60					
C710	...Repeated for Contact Output 61					
C71C	...Repeated for Contact Output 62					
C728	...Repeated for Contact Output 63					
C734	...Repeated for Contact Output 64					
Reset (Read/Write Setting)						
C750	FlexLogic™ operand which initiates a reset	0 to 65535	---	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					
C768	...Repeated for Control Pushbutton 5					
C76A	...Repeated for Control Pushbutton 6					
C76C	...Repeated for Control Pushbutton 7					
Clear Records (Read/Write Setting)						
C771	Clear User Fault Reports operand	0 to 65535	---	1	F300	0
C772	Clear Event Records operand	0 to 65535	---	1	F300	0
C773	Clear Oscillography operand	0 to 65535	---	1	F300	0
C774	Clear Data Logger operand	0 to 65535	---	1	F300	0
C77F	Clear Unauthorized Access operand	0 to 65535	---	1	F300	0
C781	Clear Platform Direct Input/Output Statistics operand	0 to 65535	---	1	F300	0
C782	Reserved (13 items)	---	---	---	F001	0
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)
Direct Inputs/Outputs (Read/Write Setting)						
C880	Direct Device ID	1 to 16	---	1	F001	1
C881	Direct I/O Channel 1 Ring Configuration Function	0 to 1	---	1	F126	0 (No)
C882	Platform Direct I/O Data Rate	64 to 128	kbps	64	F001	64
C883	Direct I/O Channel 2 Ring Configuration Function	0 to 1	---	1	F126	0 (No)
C884	Platform Direct I/O Crossover Function	0 to 1	---	1	F102	0 (Disabled)
Direct input/output commands (Read/Write Command)						
C888	Direct input/output clear counters command	0 to 1	---	1	F126	0 (No)
Direct inputs (Read/Write Setting) (96 modules)						
C890	Direct Input 1 Device Number	0 to 16	---	1	F001	0
C891	Direct Input 1 Number	0 to 96	---	1	F001	0
C892	Direct Input 1 Default State	0 to 3	---	1	F086	0 (Off)
C893	Direct Input 1 Events	0 to 1	---	1	F102	0 (Disabled)
C894	...Repeated for Direct Input 2					
C898	...Repeated for Direct Input 3					

Table B–9: MODBUS MEMORY MAP (Sheet 48 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C89C	...Repeated for Direct Input 4					
C8A0	...Repeated for Direct Input 5					
C8A4	...Repeated for Direct Input 6					
C8A8	...Repeated for Direct Input 7					
C8AC	...Repeated for Direct Input 8					
C8B0	...Repeated for Direct Input 9					
C8B4	...Repeated for Direct Input 10					
C8B8	...Repeated for Direct Input 11					
C8BC	...Repeated for Direct Input 12					
C8C0	...Repeated for Direct Input 13					
C8C4	...Repeated for Direct Input 14					
C8C8	...Repeated for Direct Input 15					
C8CC	...Repeated for Direct Input 16					
C8D0	...Repeated for Direct Input 17					
C8D4	...Repeated for Direct Input 18					
C8D8	...Repeated for Direct Input 19					
C8DC	...Repeated for Direct Input 20					
C8E0	...Repeated for Direct Input 21					
C8E4	...Repeated for Direct Input 22					
C8E8	...Repeated for Direct Input 23					
C8EC	...Repeated for Direct Input 24					
C8F0	...Repeated for Direct Input 25					
C8F4	...Repeated for Direct Input 26					
C8F8	...Repeated for Direct Input 27					
C8FC	...Repeated for Direct Input 28					
C900	...Repeated for Direct Input 29					
C904	...Repeated for Direct Input 30					
C908	...Repeated for Direct Input 31					
C90C	...Repeated for Direct Input 32					
Platform Direct Outputs (Read/Write Setting) (96 modules)						
CA10	Direct Output 1 Operand	0 to 65535	---	1	F300	0
CA11	Direct Output 1 Events	0 to 1	---	1	F102	0 (Disabled)
CA12	...Repeated for Direct Output 2					
CA14	...Repeated for Direct Output 3					
CA16	...Repeated for Direct Output 4					
CA18	...Repeated for Direct Output 5					
CA1A	...Repeated for Direct Output 6					
CA1C	...Repeated for Direct Output 7					
CA1E	...Repeated for Direct Output 8					
CA20	...Repeated for Direct Output 9					
CA22	...Repeated for Direct Output 10					
CA24	...Repeated for Direct Output 11					
CA26	...Repeated for Direct Output 12					
CA28	...Repeated for Direct Output 13					
CA2A	...Repeated for Direct Output 14					
CA2C	...Repeated for Direct Output 15					
CA2E	...Repeated for Direct Output 16					
CA30	...Repeated for Direct Output 17					
CA32	...Repeated for Direct Output 18					
CA34	...Repeated for Direct Output 19					
CA36	...Repeated for Direct Output 20					
CA38	...Repeated for Direct Output 21					
CA3A	...Repeated for Direct Output 22					
CA3C	...Repeated for Direct Output 23					

Table B–9: MODBUS MEMORY MAP (Sheet 49 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
CA3E	...Repeated for Direct Output 24					
CA40	...Repeated for Direct Output 25					
CA42	...Repeated for Direct Output 26					
CA44	...Repeated for Direct Output 27					
CA46	...Repeated for Direct Output 28					
CA48	...Repeated for Direct Output 29					
CA4A	...Repeated for Direct Output 30					
CA4C	...Repeated for Direct Output 31					
CA4E	...Repeated for Direct Output 32					
Direct Input/Output Alarms (Read/Write Setting)						
CAD0	Direct Input/Output Channel 1 CRC Alarm Function	0 to 1	---	1	F102	0 (Disabled)
CAD1	Direct I/O Channel 1 CRC Alarm Message Count	100 to 10000	---	1	F001	600
CAD2	Direct Input/Output Channel 1 CRC Alarm Threshold	1 to 1000	---	1	F001	10
CAD3	Direct Input/Output Channel 1 CRC Alarm Events	0 to 1	---	1	F102	0 (Disabled)
CAD4	Reserved (4 items)	1 to 1000	---	1	F001	10
CAD8	Direct Input/Output Channel 2 CRC Alarm Function	0 to 1	---	1	F102	0 (Disabled)
CAD9	Direct I/O Channel 2 CRC Alarm Message Count	100 to 10000	---	1	F001	600
CADA	Direct Input/Output Channel 2 CRC Alarm Threshold	1 to 1000	---	1	F001	10
CADB	Direct Input/Output Channel 2 CRC Alarm Events	0 to 1	---	1	F102	0 (Disabled)
CADC	Reserved (4 items)	1 to 1000	---	1	F001	10
CAE0	Direct I/O Ch 1 Unreturned Messages Alarm Function	0 to 1	---	1	F102	0 (Disabled)
CAE1	Direct I/O Ch 1 Unreturned Messages Alarm Msg Count	100 to 10000	---	1	F001	600
CAE2	Direct I/O Ch 1 Unreturned Messages Alarm Threshold	1 to 1000	---	1	F001	10
CAE3	Direct I/O Ch 1 Unreturned Messages Alarm Events	0 to 1	---	1	F102	0 (Disabled)
CAE4	Reserved (4 items)	1 to 1000	---	1	F001	10
CAE8	Direct IO Ch 2 Unreturned Messages Alarm Function	0 to 1	---	1	F102	0 (Disabled)
CAE9	Direct I/O Ch 2 Unreturned Messages Alarm Msg Count	100 to 10000	---	1	F001	600
CAEA	Direct I/O Ch 2 Unreturned Messages Alarm Threshold	1 to 1000	---	1	F001	10
CAEB	Direct I/O Channel 2 Unreturned Messages Alarm Events	0 to 1	---	1	F102	0 (Disabled)
CAEC	Reserved (4 items)	---	---	1	F001	10
Remote Devices (Read/Write Setting) (16 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)
CB23	Remote Device 1 in PMU Scheme	0 to 1	---	1	F126	0 (No)
CB24	...Repeated for Device 2					
CB48	...Repeated for Device 3					
CB6C	...Repeated for Device 4					
CB90	...Repeated for Device 5					
CBB4	...Repeated for Device 6					
CBD8	...Repeated for Device 7					
CBFC	...Repeated for Device 8					
CC20	...Repeated for Device 9					
CC44	...Repeated for Device 10					
CC68	...Repeated for Device 11					
CC8C	...Repeated for Device 12					
CCB0	...Repeated for Device 13					
CCD4	...Repeated for Device 14					
CCF8	...Repeated for Device 15					
CD1C	...Repeated for Device 16					
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)

Table B–9: MODBUS MEMORY MAP (Sheet 50 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
CFA3	Remote Input 1 Events	0 to 1	---	1	F102	0 (Disabled)
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					
Remote Output DNA Pairs (Read/Write Setting) (32 modules)						
D220	Remote Output DNA 1 Operand	0 to 65535	---	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					

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Table B–9: MODBUS MEMORY MAP (Sheet 51 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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 65535	---	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					
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

Table B–9: MODBUS MEMORY MAP (Sheet 52 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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
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

Table B–9: MODBUS MEMORY MAP (Sheet 53 of 53)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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
Remote Device Status (Read Only) (16 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					
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					
Setting file template values (read only)						
ED00	FlexLogic™ displays active	0 to 1	---	1	F102	1 (Enabled)
ED01	Reserved (6 items)	---	---	---	---	---
ED07	Last settings change date	0 to 4294967295	---	1	F050	0
ED09	Template bitmask (750 items)	0 to 65535	---	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

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

F091
ENUMERATION: VOLTAGE DIFFERENTIAL BANK GROUND TYPE

0 = Grounded, 1 = Ungrounded

F092
ENUMERATION: AUTOMATIC SETTING FUNCTION

0 = Disabled, 1 = Manual, 2 = Auto

F093
ENUMERATION: BANK OVERVOLTAGE GROUND TYPE

0 = Grounded, 1 = Ungrounded, 2 = Ungrounded without Vn

F094
ENUMERATION: BANK OVERVOLTAGE CURVE TYPE

0 = FlexCurve™ A, 1 = FlexCurve™ B, 2 = FlexCurve™ C,
3 = FlexCurve™ D

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

F112
ENUMERATION: RS485 BAUD RATES

bitmask	value
0	300
1	1200
2	2400
3	4800
4	9600
5	19200
6	38400
7	57600
8	115200
9	14400
10	28800
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

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bitmask	element
5	Phase Instantaneous Overcurrent 6
6	Phase Instantaneous Overcurrent 7
7	Phase Instantaneous Overcurrent 8
8	Phase Instantaneous Overcurrent 9
9	Phase Instantaneous Overcurrent 10
10	Phase Instantaneous Overcurrent 11
11	Phase Instantaneous Overcurrent 12
16	Phase Time Overcurrent 1
17	Phase Time Overcurrent 2
18	Phase Time Overcurrent 3
19	Phase Time Overcurrent 4
20	Phase Time Overcurrent 5
21	Phase Time Overcurrent 6
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
40	Neutral Instantaneous Overcurrent 9
41	Neutral Instantaneous Overcurrent 10
42	Neutral Instantaneous Overcurrent 11
43	Neutral Instantaneous Overcurrent 12
48	Neutral Time Overcurrent 1
49	Neutral Time Overcurrent 2
50	Neutral Time Overcurrent 3
51	Neutral Time Overcurrent 4
52	Neutral Time Overcurrent 5
53	Neutral Time Overcurrent 6
56	Neutral Directional Overcurrent 1
60	Negative Sequence Directional Overcurrent 1
61	Negative Sequence 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
72	Ground Instantaneous Overcurrent 9
73	Ground Instantaneous Overcurrent 10
74	Ground Instantaneous Overcurrent 11
75	Ground Instantaneous Overcurrent 12
80	Ground Time Overcurrent 1
81	Ground Time Overcurrent 2
82	Ground Time Overcurrent 3
83	Ground Time Overcurrent 4
84	Ground Time Overcurrent 5

bitmask	element
85	Ground Time Overcurrent 6
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
144	Phase Undervoltage 1
145	Phase Undervoltage 2
148	Auxiliary Overvoltage 1
152	Phase Overvoltage 1
154	Compensated Overvoltage 1
156	Neutral Overvoltage 1
224	SRC1 VT Fuse Failure
225	SRC2 VT Fuse Failure
226	SRC3 VT Fuse Failure
227	SRC4 VT Fuse Failure
228	SRC5 VT Fuse Failure
229	SRC6 VT Fuse Failure
232	SRC1 50DD (Disturbance Detection)
233	SRC2 50DD (Disturbance Detection)
234	SRC3 50DD (Disturbance Detection)
235	SRC4 50DD (Disturbance Detection)
236	SRC5 50DD (Disturbance Detection)
237	SRC6 50DD (Disturbance Detection)
280	Breaker Failure 1
281	Breaker Failure 2
282	Breaker Failure 3
283	Breaker Failure 4
284	Breaker Failure 5
285	Breaker Failure 6
294	Breaker 1 Flashover
295	Breaker 2 Flashover
336	Setting Group
337	Reset
340	Neutral voltage unbalance 1
341	Neutral voltage unbalance 2
342	Neutral voltage unbalance 3
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	FlexElement™ 7

bitmask	element
407	FlexElement™ 8
408	FlexElement™ 9
409	FlexElement™ 10
410	FlexElement™ 11
411	FlexElement™ 12
412	FlexElement™ 13
413	FlexElement™ 14
414	FlexElement™ 15
415	FlexElement™ 16
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
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

bitmask	element
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
781	Time of day timer 1
782	Time of day timer 2
783	Time of day timer 3
784	Time of day timer 4
785	Time of day timer 5
787	Automatic voltage regulator 1
788	Automatic voltage regulator 2
789	Automatic voltage regulator 3
790	Phase current unbalance 1 phase A
791	Phase current unbalance 1 phase B
792	Phase current unbalance 1 phase C
793	Phase current unbalance 2 phase A
794	Phase current unbalance 2 phase B
795	Phase current unbalance 2 phase C
796	Phase current unbalance 3 phase A
797	Phase current unbalance 3 phase B
798	Phase current unbalance 3 phase C
803	Voltage differential 1 phase A
804	Voltage differential 1 phase B
805	Voltage differential 1 phase C
806	Voltage differential 2 phase A
807	Voltage differential 2 phase B
808	Voltage differential 2 phase C
809	Voltage differential 3 phase A
810	Voltage differential 3 phase B

bitmask	element
811	Voltage differential 3 phase C
813	Capacitor control 1
814	Capacitor control 2
815	Capacitor control 3
816	Capacitor control 4
820	Neutral current unbalance 1
821	Neutral current unbalance 2
822	Neutral current unbalance 3
830	Bank phase overvoltage 1 phase A
831	Bank phase overvoltage 1 phase A
832	Bank phase overvoltage 1 phase A
833	Bank phase overvoltage 1 phase B
834	Bank phase overvoltage 1 phase B
835	Bank phase overvoltage 1 phase B
842	Trip Bus 1
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

bitmask	element
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
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
936	Disconnect switch 17
937	Disconnect switch 18
938	Disconnect switch 19
939	Disconnect switch 20
940	Disconnect switch 21
941	Disconnect switch 22

bitmask	element
942	Disconnect switch 23
943	Disconnect switch 24
968	Breaker 1
969	Breaker 2
970	Breaker 3
971	Breaker 4
972	Breaker 5
973	Breaker 6
980	Breaker restrike 1
981	Breaker restrike 2
982	Breaker restrike 3
1012	Thermal overload protection 1
1013	Thermal overload protection 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 Communcations 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
16	Ethernet Switch Fail
17	Maintenance Alert 01

Bitmask	Error
18	SNTP Failure
19	---
20	Primary Ethernet Fail
21	Secondary Ethernet Fail
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	Direct Input/Output Ring Break
30	Any Minor Error
31	Any Major Error
32	IEC 61850 Data Set
33	Aggregator Error
34	---
35	---
36	Watchdog Error
37	Low On Memory
38	---
43	Module Failure 01
44	Module Failure 02
45	Module Failure 03
46	Module Failure 04
47	Module Failure 05
48	Module Failure 06
49	Module Failure 07
50	Module Failure 08
51	Module Failure 09
52	Incompatible Hardware
53	Module Failure 10
54	Module Failure 11
55	Module Failure 12

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

F145
ENUMERATION: ALPHABET LETTER

bitmask	type	bitmask	type	bitmask	type	bitmask	type
0	null	7	G	14	N	21	U
1	A	8	H	15	O	22	V
2	B	9	I	16	P	23	W
3	C	10	J	17	Q	24	X
4	D	11	K	18	R	25	Y
5	E	12	L	19	S	26	Z
6	F	13	M	20	T		

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

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

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

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

B

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

F177
ENUMERATION: COMMUNICATION PORT

0 = None, 1 = COM1-RS485, 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

F179
ENUMERATION: NEGATIVE SEQUENCE DIRECTIONAL OVERCURRENT TYPE

0 = Neg Sequence, 1 = Zero Sequence

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

value	GOOSE dataset
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
0	--- use between real keys
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	0
11	Decimal Point
12	Plus/Minus
13	Value Up
14	Value Down
15	Message Up
16	Message Down
17	Message Left
18	Message Right
19	Menu
20	Help
21	Escape
22	---

bitmsk	keypress
23	Reset
24	User 1
25	User 2
26	User 3
27	User-programmable key 1
28	User-programmable key 2
29	User-programmable key 3
30	User-programmable key 4
31	User-programmable key 5
32	User-programmable key 6
33	User-programmable key 7
34	User-programmable key 8
35	User-programmable key 9
36	User-programmable key 10
37	User-programmable key 11
38	User-programmable key 12
43	User-programmable key 13
44	User-programmable key 14
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

B

B

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

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

F230
ENUMERATION: DIRECTIONAL POLARIZING

0 = Voltage, 1 = Current, 2 = Dual

F231
ENUMERATION: POLARIZING VOLTAGE

0 = Calculated V0, 1 = Measured VX

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

value	GOOSE dataset item
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

value	GOOSE dataset item
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

value	GOOSE dataset item
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
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

B

value	GOOSE dataset item
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
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

value	GOOSE dataset item
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

value	GOOSE dataset item
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
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

value	GOOSE dataset item
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

F237
ENUMERATION: REAL TIME CLOCK MONTH

value	month
0	January
1	February

B

value	month
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

F241
ENUMERATION: NEUTRAL VOLTAGE UNBALANCE BUS 3V0

0 = Calculated, 1 = Measured

F254
ENUMERATION: TEST MODE FUNCTION

Value	Function
0	Disabled
1	Isolated
2	Forcible

F255
ENUMERATION: CAPACITOR BANK GROUNDING

Value	Description
0	VT (ungrounded)
1	CTxR (grounded

F260
ENUMERATION: DATA LOGGER MODE

0 = Continuous, 1 = Trigger

F300
UR_UINT16: FLEXLOGIC™ BASE TYPE (6-bit type)

The FlexLogic™ BASE type is 6 bits and is combined with a 9 bit descriptor and 1 bit for protection element to form a 16 bit value. The combined bits are of the form: PTTTTTTDDDDDDDDD, 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 [PTTTTTT] and the values in round brackets indicate the descriptor range.

[0] Off(0) – this is boolean FALSE value
[0] 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 64)
[6] VIRTUAL OUTPUTS (1 to 96)
[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)
[28] INSERT (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 96)
[52] SELF-TEST ERROR (see F141 for range)
[56] ACTIVE SETTING GROUP (1 to 6)
[62] MISCELLANEOUS EVENTS (see F146 for range)
[64 to 127] ELEMENT STATES

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

F511
BITFIELD: 3-PHASE SIMPLE ELEMENT STATE

0 = Operate, 1 = Operate A, 2 = Operate B, 3 = Operate C

F512
ENUMERATION: HARMONIC NUMBER

bitmask	harmonic	bitmask	harmonic
0	2ND	12	14TH
1	3RD	13	15TH
2	4TH	14	16TH
3	5TH	15	17TH
4	6TH	16	18TH
5	7TH	17	19TH
6	8TH	18	20TH
7	9TH	19	21ST
8	10TH	20	22ND
9	11TH	21	23RD
10	12TH	22	24TH
11	13TH	23	25TH

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

B

B

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	value	keypress	value	keypress
0	None	15	3	33	User PB 3
1	Menu	16	Enter	34	User PB 4
2	Message Up	17	Message Down	35	User PB 5
3	7	18	0	36	User PB 6
4	8	19	Decimal	37	User PB 7
5	9	20	+/–	38	User PB 8
6	Help	21	Value Up	39	User PB 9
7	Message Left	22	Value Down	40	User PB 10
8	4	23	Reset	41	User PB 11
9	5	24	User 1	42	User PB 12
10	6	25	User 2	44	User 4
11	Escape	26	User 3	45	User 5
12	Message Right	31	User PB 1	46	User 6
13	1	32	User PB 2	47	User 7
14	2				

F531
ENUMERATION: LANGUAGE

0 = English, 1 = French, 2 = Chinese, 3 = Russian

F535
ENUMERATION: AUTOMATIC VOLTAGE REGULATOR OPERATING SIGNAL

0 = Vab, 1 = Vbc, 2 = Vca, 3 = Vavg, 4 = V1, 5 = Vaux

F536
ENUMERATION: AUTOMATIC VOLTAGE REGULATOR CONTROL MODE

0 = Voltage, 1 = Var

F537
ENUMERATION: AUTOMATIC VOLTAGE REGULATOR VAR OPEN MODE

0 = Minimize uptime, 1 = Minimize number of operations

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 Flex-Analogs (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 paramter. 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

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

Enumeration	GOOSE dataset items
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

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

Enumeration	GOOSE dataset items
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

B

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

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
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

Enumeration	GOOSE dataset items
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

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 C70 relay supports IEC 61850 server services over both TCP/IP and TP4/CLNP (OSI) communication protocol stacks. The TP4/CLNP profile requires the C70 to have a network address or Network Service Access Point (NSAP) to establish a communication link. The TCP/IP profile requires the C70 to have an IP address to establish communications. These addresses are located in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK** menu. Note that the C70 supports IEC 61850 over the TP4/CLNP or TCP/IP stacks, and also operation over both stacks simultaneously. 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 C70 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 C70 IED physical device. The logical node LLN0 contains information about the C70 IED logical device.

C.2.2 GGIO1: DIGITAL STATUS VALUES

The GGIO1 logical node is available in the C70 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 C70. 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 C70 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 C70 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 RECEIVED 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 C70. 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 C70 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 C70 source 1, and MMXU2 provides data from C70 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 C70 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 C70 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

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 C70 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 C70:
  - Bit 1: data-change
  - Bit 4: integrity
  - Bit 5: general interrogation
- **OptFlds**: Option Fields. The following bits are supported by the C70:
  - 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 C70 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 C70. 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 C70. 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 C70.

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 C70 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 C70. 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 C70 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 C70 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 C70 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 C70, 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 C70 will use the source Ethernet MAC address as the destination, with the multicast bit set.

C.4.3 FIXED GOOSE

The C70 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 C70 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 C70. The C70 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.

The C70 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 C70 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 C70 will continue to block transmission of the dataset. The C70 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 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.

   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.

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 C70 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 C70 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 C70 is configured to use an automated multicast MAC scheme. If the C70 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 C70; no settings are required.

C.5.1 OVERVIEW

The C70 can be configured for IEC 61850 via the EnerVista UR Setup software as follows.

1. An ICD file is generated for the C70 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.

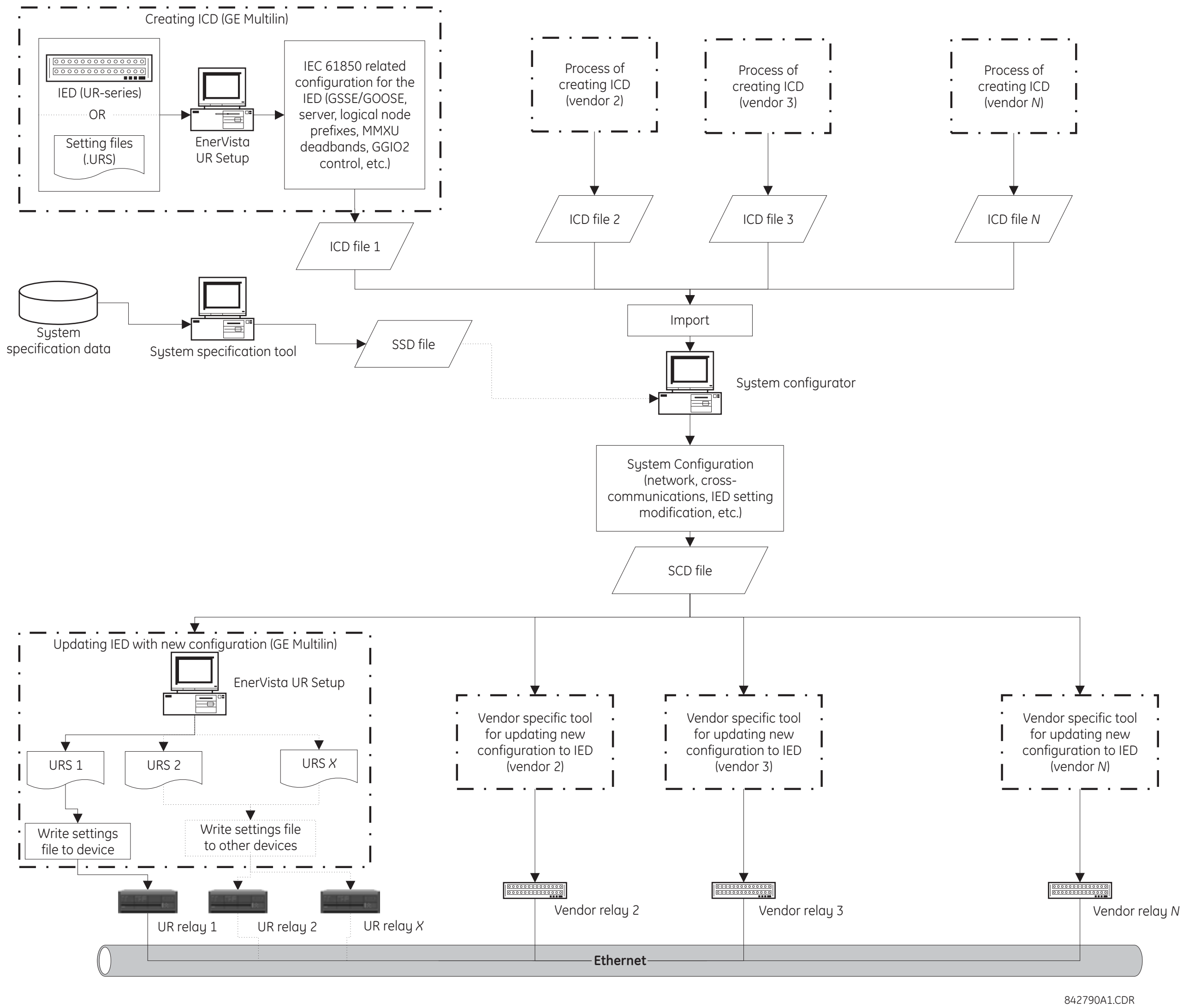


Figure 0–1: IED CONFIGURATION PROCESS

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 C70 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 5.9x, 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.

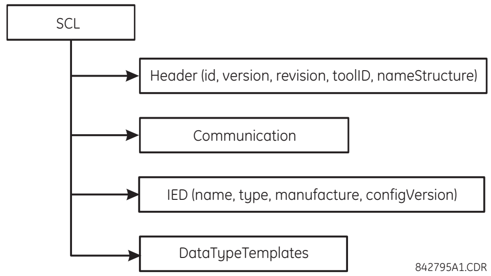


Figure 0–2: ICD FILE STRUCTURE, SCL (ROOT) NODE

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.

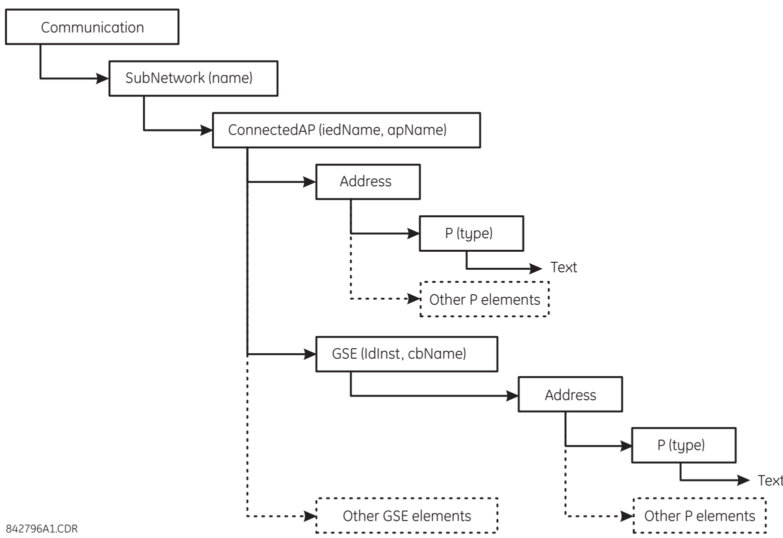


Figure 0–3: ICD FILE STRUCTURE, COMMUNICATIONS NODE

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.

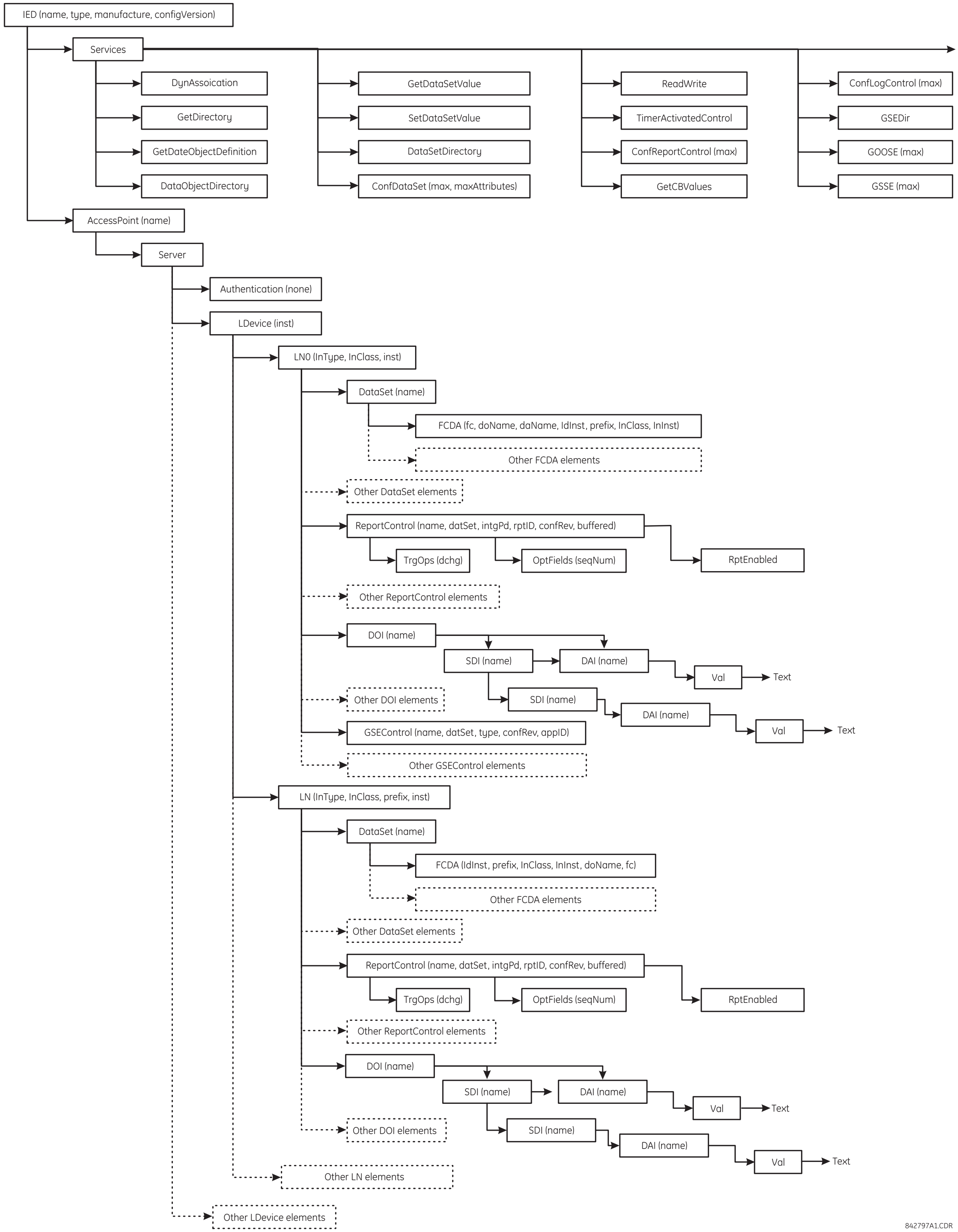


Figure 0–4: ICD FILE STRUCTURE, IED NODE

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.

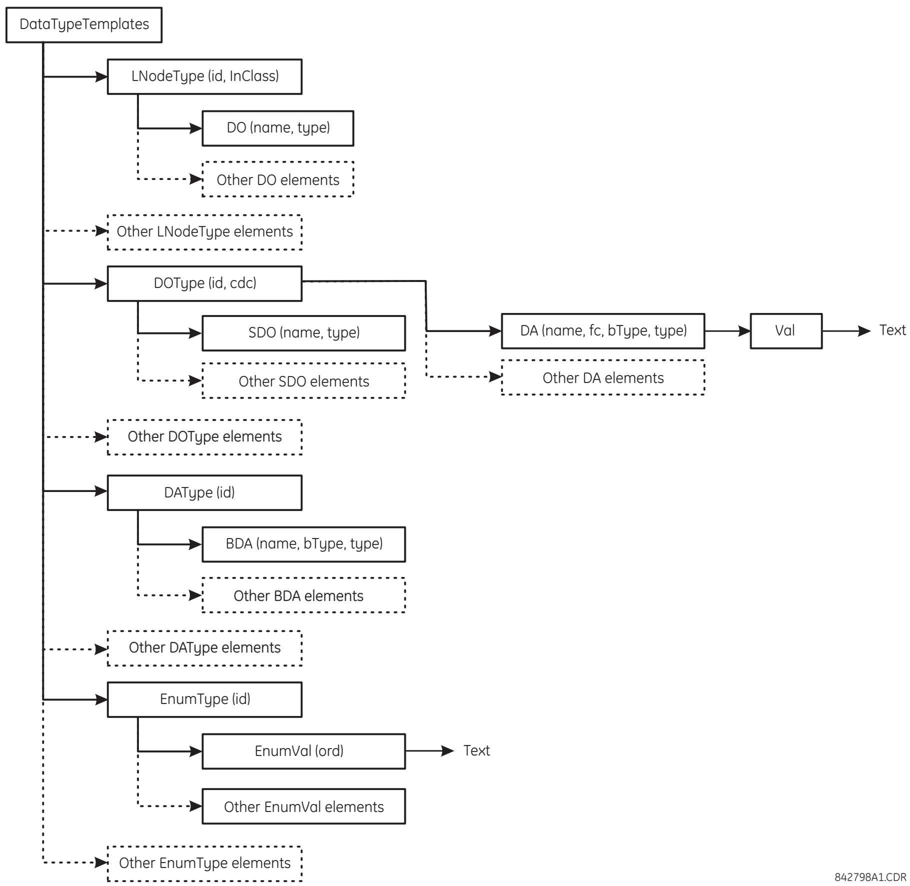
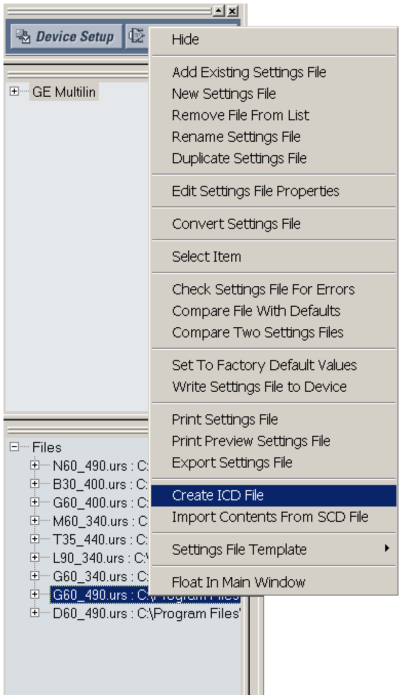


Figure 0–5: ICD FILE STRUCTURE, DATATYPETEMPLATES NODE

C.5.4 CREATING AN ICD FILE WITH ENERVISTA UR SETUP

An ICD file can be created directly from a connected C70 IED or from an offline C70 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 C70 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.

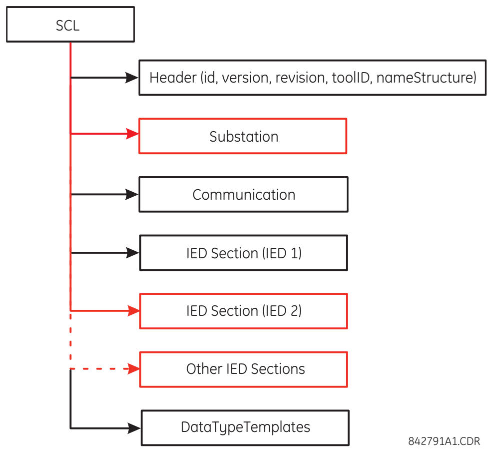


Figure 0–6: SCD FILE STRUCTURE, SCL (ROOT) NODE

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:

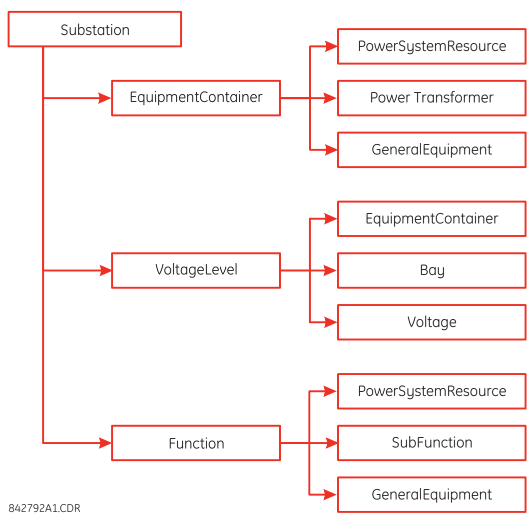


Figure 0–7: SCD FILE STRUCTURE, SUBSTATION NODE

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.

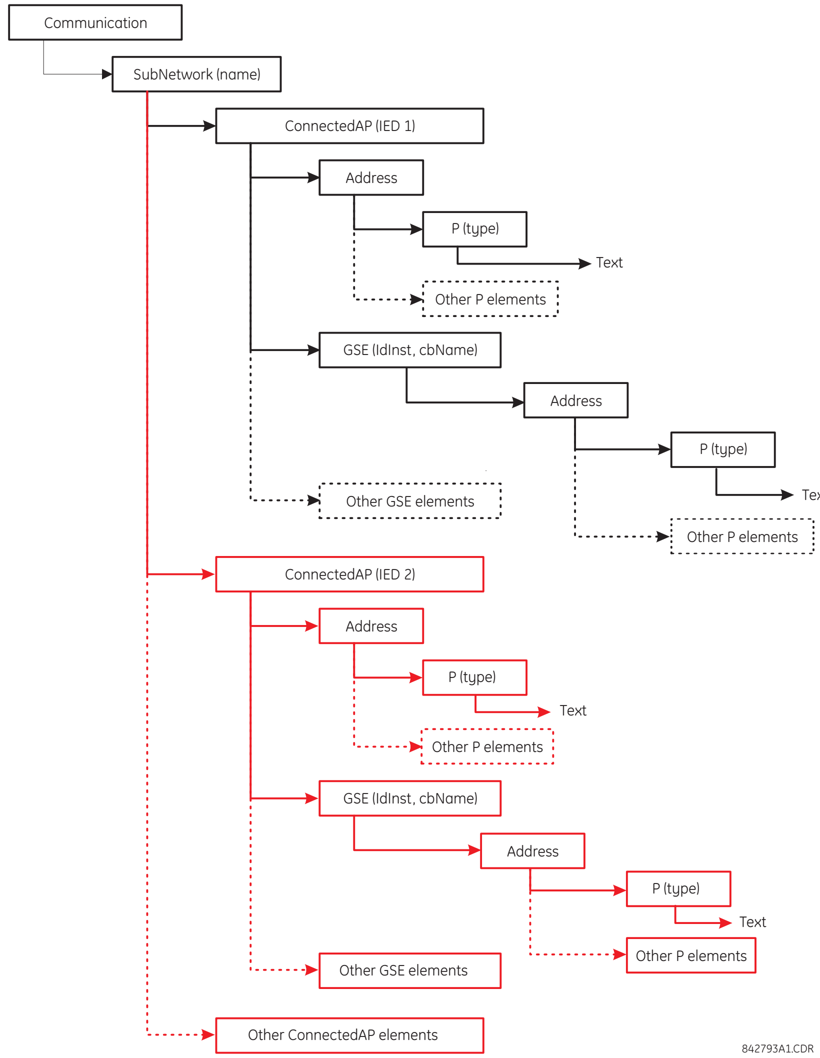


Figure 0–8: SCD FILE STRUCTURE, COMMUNICATIONS NODE

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.

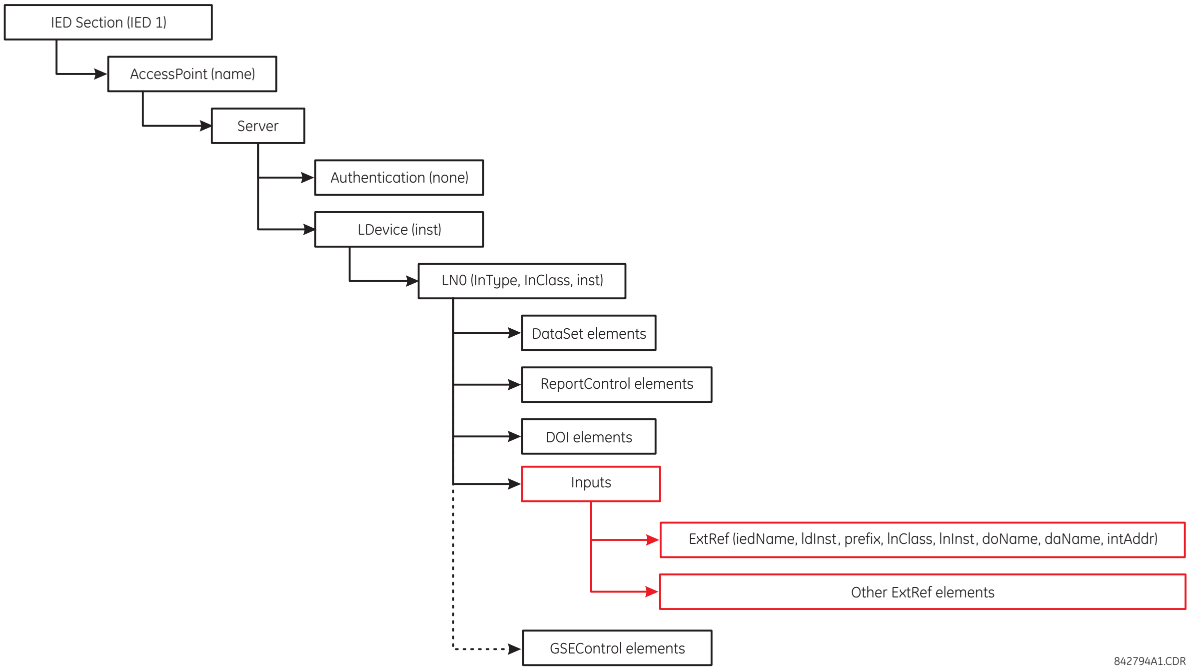
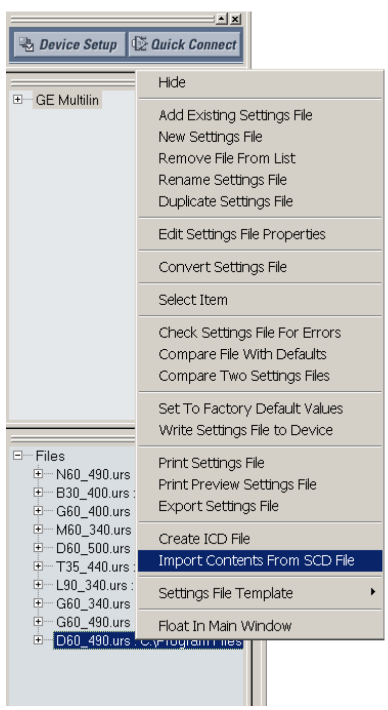


Figure 0–9: SCD FILE STRUCTURE, IED NODE

C.5.6 IMPORTING AN SCD FILE WITH ENERVISTA UR SETUP

The following procedure describes how to update the C70 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.

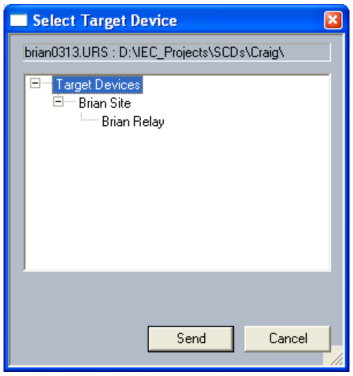


2. Select the saved SCD file and click **Open**.

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 6)				
S1	ServerDirectory	TP	M	Yes
APPLICATION ASSOCIATION (CLAUSE 7)				
S2	Associate		M	Yes
S3	Abort		M	Yes
S4	Release		M	Yes
LOGICAL DEVICE (CLAUSE 8)				
S5	LogicalDeviceDirectory	TP	M	Yes
LOGICAL NODE (CLAUSE 9)				
S6	LogicalNodeDirectory	TP	M	Yes
S7	GetAllDataValues	TP	M	Yes
DATA (CLAUSE 10)				
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 11)				
S12	GetDataSetValues	TP	M	Yes
S13	SetDataSetValues	TP	O	
S14	CreateDataSet	TP	O	
S15	DeleteDataSet	TP	O	
S16	GetDataSetDirectory	TP	O	Yes
SUBSTITUTION (CLAUSE 12)				
S17	SetDataValues	TP	M	
SETTING GROUP CONTROL (CLAUSE 13)				
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 14)				
	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 14)				
	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 14.3.5.3.4)				
	GOOSE-CONTROL-BLOCK			
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			
S40	SendGSSEMessage	MC	c8	Yes
S41	GetReference	TP	c9	

SERVICES		AA: TP/MC	SERVER/ PUBLISHER	UR FAMILY
S42	GetGSSEElementNumber	TP	c9	
S43	GetGsCBValues	TP	O	Yes
S44	SetGsCBValues	TP	O	Yes
TRANSMISSION OF SAMPLE VALUE MODEL (SVC) (CLAUSE 16)				
	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 16.4.8)				
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 20)				
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			
T3	supported TimeStamp resolution (nearest value of 2^{-n} in seconds, accoridng to 5.5.3.7.3.3)			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

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 3)

NODES	UR-FAMILY
L: SYSTEM LOGICAL NODES	
LPHD: Physical device information	Yes
LLN0: Logical node zero	Yes
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	---
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	Yes
PTUC: Undercurrent	---
PTUV: Undervoltage	Yes
PUPF: Underpower factor	---
PTUF: Underfrequency	---
PVOC: Voltage controlled time overcurrent	---
PVPH: Volts per Hz	---
PZSU: Zero speed or underspeed	---
R: LOGICAL NODES FOR PROTECTION RELATED FUNCTIONS	
RDRE: Disturbance recorder function	---
RADR: Disturbance recorder channel analogue	---
RBDR: Disturbance recorder channel binary	---
RDRS: Disturbance record handling	---
RBRF: Breaker failure	Yes
RDIR: Directional element	---
RFLO: Fault locator	Yes
RPSB: Power swing detection/blocking	Yes
RREC: Autoreclosing	Yes

Table C–1: IEC 61850 LOGICAL NODES (Sheet 2 of 3)

NODES	UR-FAMILY
RSYN: Synchronism-check or synchronizing	---
C: LOGICAL NODES FOR CONTROL	
CALH: Alarm handling	---
CCGR: Cooling group control	---
CILO: Interlocking	---
CPOW: Point-on-wave switching	---
CSWI: Switch controller	**Yes**
G: LOGICAL NODES FOR GENERIC REFERENCES	
GAPC: Generic automatic process control	---
GGIO: Generic process I/O	**Yes**
GSAL: Generic security application	---
I: LOGICAL NODES FOR INTERFACING AND ARCHIVING	
IARC: Archiving	---
IHMI: Human machine interface	---
ITCI: Telecontrol interface	---
ITMI: Telemonitoring interface	---
A: LOGICAL NODES FOR AUTOMATIC CONTROL	
ANCR: Neutral current regulator	---
ARCO: Reactive power control	---
ATCC: Automatic tap changer controller	---
AVCO: Voltage control	---
M: LOGICAL NODES FOR METERING AND MEASUREMENT	
MDIF: Differential measurements	---
MHAI: Harmonics or interharmonics	---
MHAN: Non phase related harmonics or interharmonic	---
MMTR: Metering	---
MMXN: Non phase related measurement	**Yes**
MMXU: Measurement	**Yes**
MSQI: Sequence and imbalance	---
MSTA: Metering statistics	---
S: LOGICAL NODES FOR SENSORS AND MONITORING	
SARC: Monitoring and diagnostics for arcs	---
SIMG: Insulation medium supervision (gas)	---
SIML: Insulation medium supervision (liquid)	---
SPDC: Monitoring and diagnostics for partial discharges	---
X: LOGICAL NODES FOR SWITCHGEAR	
XCBR: Circuit breaker	**Yes**
XSWI: Circuit switch	**Yes**
T: LOGICAL NODES FOR INSTRUMENT TRANSFORMERS	
TCTR: Current transformer	---
TVTR: Voltage transformer	---
Y: LOGICAL NODES FOR POWER TRANSFORMERS	
YEFN: Earth fault neutralizer (Peterson coil)	---
YLTC: Tap changer	---
YPSH: Power shunt	---
YPTR: Power transformer	---

C

Table C–1: IEC 61850 LOGICAL NODES (Sheet 3 of 3)

NODES	UR-FAMILY
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	---
ZRRC: Rotating reactive component	---
ZSAR: Surge arrestor	---
ZTCF: Thyristor controlled frequency converter	---
ZTRC: Thyristor controlled reactive component	---

D.1.1 INTEROPERABILITY DOCUMENT

This document is adapted from the IEC 60870-5-104 standard. For ths 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~~

■ ~~Multiple Point-to-Point~~

■ ~~Multipoint~~

■ ~~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 Transmision~~	■ ~~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	

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 stanadard.

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 wiht 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.

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

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

☒ 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 acknowlegements 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	

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.

E

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 C70 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 C70 is not restarted, but the DNP process is restarted.

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 C70 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 C70 is not restarted, but the DNP process is restarted.

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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 C70 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**

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. C70 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 REVISION HISTORY

Table F–1: REVISION HISTORY

MANUAL P/N	C70 REVISION	RELEASE DATE	ECO
1601-9015-P1	5.2x	23 October 2006	URX-230
1601-9015-P2	5.2x	24 January 2007	URX-232
1601-9015-R1	5.4x	26 June 2007	URX-242
1601-9015-R2	5.4x	31 August 2007	URX-246
1601-9015-R3	5.4x	17 October 2007	URX-251
1601-9015-S1	5.5x	7 December 2007	URX-253
1601-9015-S2	5.5x	22 February 2008	URX-258
1601-9015-S3	5.5x	12 March 2008	URX-260
1601-9015-T1	5.6x	27 June 2008	08-0390
1601-9015-U1	5.7x	29 May 2009	09-0938
1601-9015-U2	5.7x	30 September 2009	09-1165
1601-9015-V1	5.8x	29 May 2010	09-1457
1601-9015-V2	5.8x	04 January 2011	11-2237
1601-9015-W1	5.9x	12 January 2011	11-2227
1601-9015-W2	5.9x		

F.1.2 CHANGES TO THE C70 MANUAL

Table F–2: MAJOR UPDATES FOR C70 MANUAL REVISION W2

PAGE (W1)	PAGE (W2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-W2
3-23	3-23	Update	Updated RS485 PORTS section

Table F–3: MAJOR UPDATES FOR C70 MANUAL REVISION W1

PAGE (V2)	PAGE (W1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-W1
2-9	2-9	Update	Updated PROTECTION ELEMENTS specifications section
---	3-39	Update	Added INITIAL SETUP OF THE ETHERNET SWITCH MODULE section
4-3	4-3	Update	Updated USING SETTING FILES section
5-21	5-21	Update	Updated IEC 61850 PROTOCOL section
5-38	5-40	Update	Updated OSCILLOGRAPHY section
5-53	5-55	Update	Updated USER-DEFINABLE DISPLAYS section
5-70	5-72	Update	Updated BREAKERS section
5-74	5-76	Update	Updated DISCONNECT SWITCHES section
5-86	5-88	Update	Updated FLEXLOGIC™ OPERANDS table
---	5-206	Add	Added THERMAL OVERLOAD PROTECTION section
5-203	5-216	Update	Updated REMOTE INPUTS section
B-8	B-8	Update	Updated MODBUS MEMORY MAP section
C-3	C-3	Update	Updated PROTECTION AND OTHER LOGICAL NODES section

Table F–4: MAJOR UPDATES FOR C70 MANUAL REVISION V2

PAGE (V1)	PAGE (V2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-V2
2-1	2-1	Update	Updated OVERVIEW section
2-3	2-3	Update	Updated ORDERING section
2-9	2-9	Update	Updated PROTECTION ELEMENTS specifications section
3-23	3-23	Update	Updated RS485 PORTS section
10-14	10-14	Update	Updated BANK UNBALANCE CALCULATIONS section

Table F–5: MAJOR UPDATES FOR C70 MANUAL REVISION V1

PAGE (U2)	PAGE (V1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-V1
2-1	2-1	Update	Updated OVERVIEW section
2-3	2-3	Update	Updated ORDERING section
2-6	2-6	Update	Updated REPLACEMENT MODULES section
2-9	2-9	Update	Updated PROTECTION ELEMENTS specifications section
3-21	3-22	Update	Updated CPU COMMUNICATION PORTS section
3-37	3-37	Update	Updated MANAGED ETHERNET SWITCH MODULE HARDWARE section
4-28	4-28	Update	Updated INVALID PASSWORD ENTRY section
5-10	5-10	Update	Updated ACCESS SUPERVISION section
5-21	5-21	Update	Updated IEC 61850 PROTOCOL section
5-86	5-87	Update	Updated FLEXLOGIC OPERANDS table
5-106	5-108	Update	Updated BREAKER FAILURE section
---	5-127	Add	Added PHASE DIRECTIONAL OVERCURRENT section
---	5-147	Add	Added NEGATIVE-SEQUENCE CURRENT section
10-14	10-14	Update	Updated BANK UNBALANCE CALCULATIONS section
B-8	B-8	Update	Updated MODBUS MEMORY MAP section
B-61	B-61	Update	Updated DATA FORMATS section
C-3	C-3	Update	Updated PROTECTION AND OTHER LOGICAL NODES section

Table F–6: MAJOR UPDATES FOR C70 MANUAL REVISION U2 (Sheet 1 of 2)

PAGE (U1)	PAGE (U2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-U2
1-1	1-1	Update	Updated INSPECTION CHECKLIST section
2-12	2-12	Update	Updated USER-PROGRAMMABLE ELEMENTS specifications section
2-18	2-18	Update	Updated ENVIRONMENTAL specifications section
2-19	2-19	Update	Updated TYPE TESTS specifications section
2-19	2-20	Update	Updated APPROVALS specifications section
4-14	4-14	Update	Updated LED INDICATORS section

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Table F–6: MAJOR UPDATES FOR C70 MANUAL REVISION U2 (Sheet 2 of 2)

PAGE (U1)	PAGE (U2)	CHANGE	DESCRIPTION
5-21	5-21	Update	Updated IEC 61850 PROTOCOL section
5-74	5-74	Update	Updated DISCONNECT SWITCHES section
5-194	5-194	Update	Updated VT FUSE FAILURE section
C-7	C-7	Update	Updated CONFIGURABLE GOOSE section

Table F–7: MAJOR UPDATES FOR C70 MANUAL REVISION U1

PAGE (T1)	PAGE (U1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-U1
2-2	2-2	Update	Updated ORDERING section
2-5	2-6	Update	Updated REPLACEMENT MODULES section
2-12	2-14	Update	Updated INPUTS specifications section
2-16	2-18	Update	Updated ENVIRONMENTAL specifications section
2-17	2-19	Update	Updated TYPE TESTS specifications section
---	3-2	Add	Added VERTICAL UNITS section
3-10	3-12	Update	Updated CONTACT INPUTS AND OUTPUTS section
4-1	4-1	Update	Updated USING SETTINGS FILES section
4-12	4-12	Update	Updated FACEPLATE section
5-8	5-8	Update	Updated SECURITY section
5-21	5-21	Update	Updated IEC 61850 PROTOCOL sub-section
5-65	5-67	Update	Updated POWER SYSTEM section
5-69	5-71	Update	Updated BREAKERS section
5-73	5-75	Update	Updated DISCONNECT SWITCHES section
5-85	5-87	Update	Updated FLEXLOGIC OPERANDS table
5-122	5-124	Update	Updated PHASE INSTANTANEOUS OVERCURRENT section
5-129	5-131	Update	Updated NEUTRAL DIRECTIONAL OVERCURRENT section
5-144	5-146	Update	Updated PHASE OVERVOLTAGE section
5-155	5-157	Update	Updated NEUTRAL VOLTAGE UNBALANCE section
5-169	5-170	Update	Updated TIME OF DAY TIMERS section
5-180	5-182	Update	Updated DIGITAL ELEMENTS section
5-186	5-188	Update	Updated BREAKER FLASHOVER section
5-192	5-194	Update	Updated VT FUSE FAILURE section
5-197	5-199	Update	Updated CONTACT OUTPUTS section
---	5-209	Add	Added IEC 61850 GOOSE ANALOGS section
---	5-210	Add	Added IEC 61850 GOOSE INTEGERS section
---	6-8	Add	Added IEC 61850 GOOSE INTEGERS section
7-7	7-7	Update	Updated RELAY MAINTENANCE section
7-10	7-10	Update	Updated MINOR SELF-TEST ERRORS section
---	8-1	Add	Added SECURITY chapter
---	A-32	Add	Added FLEXINTEGER ITEMS section
B-8	B-8	Update	Updated MODBUS MEMORY MAP section
B-60	B-61	Update	Updated DATA FORMATS section

Table F–8: MAJOR UPDATES FOR C70 MANUAL REVISION T1

PAGE (S3)	PAGE (T1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-T1
2-3	2-3	Update	Updated ORDERING section
---	3-10	Add	Added PROCESS BUS MODULES section
---	5-11	Add	Added DUAL PERMISSION SECURITY ACCESS section
5-20	5-21	Update	Updated IEC 61850 PROTOCOL section
---	5-63	Add	Added REMOTE RESOURCES section
5-82	5-85	Update	Updated FLEXLOGIC OPERANDS table
5-140	5-148	Update	Updated VOLTAGE DIFFERENTIAL section
5-147	5-155	Update	Updated NEUTRAL VOLTAGE UNBALANCE section
---	5-202	Add	Added REMOTE DOUBLE-POINT STATUS INPUTS section
5-205	5-214	Update	Updated TEST MODE section
---	6-4	Add	Added REMOTE DOUBLE-POINT STATUS INPUTS section
B-8	B-8	Update	Updated MODBUS MEMORY MAP section

Table F–9: MAJOR UPDATES FOR C70 MANUAL REVISION S3

PAGE (S2)	PAGE (S3)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-S3
2-12	2-12	Update	Updated COMMUNICATIONS specifications section
2-13	2-13	Update	Updated INTER-RELAY COMMUNICATIONS specifications section
3-5	3-5	Update	Updated REAR TERMINAL LAYOUT section
---	3-41	Add	Added ETHERNET SWITCH SELF-TEST ERRORS section
7-9	7-10	Update	Updated MINOR SELF-TEST ERROR MESSAGES section
B-8	B-8	Update	Update MODBUS MEMORY MAP section

Table F–10: MAJOR UPDATES FOR C70 MANUAL REVISION S2

PAGE (S1)	PAGE (S2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-S2
3-35	3-35	Update	Updated MANAGED ETHERNET SWITCH OVERVIEW section
3-35	3-35	Update	Updated MANAGED ETHERNET SWITCH MODULE HARDWARE section
---	3-38	Add	Added UPLOADING C70 SWITCH MODULE FIRMWARE sub-section
---	3-38	Add	Added SELECTING THE PROPER SWITCH FIRMWARE VERSION sub-section

Table F–11: MAJOR UPDATES FOR C70 MANUAL REVISION S1 (Sheet 1 of 2)

PAGE (R3)	PAGE (S1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-S1
2-3	2-3	Update	Updated ORDERING section
2-4	2-3	Update	Updated REPLACEMENT MODULES section
2-5	2-5	Update	Updated PROTECTION ELEMENTS specifications section

Table F–11: MAJOR UPDATES FOR C70 MANUAL REVISION S1 (Sheet 2 of 2)

PAGE (R3)	PAGE (S1)	CHANGE	DESCRIPTION
2-10	2-10	Update	Updated OUTPUTS specifications section
2-12	2-12	Update	Updated COMMUNICATIONS specifications section
3-30	3-32	Update	Updated IEEE C37.94 INTERFACE section
---	3-35	Add	Added MANAGED ETHERNET SWITCH MODULES section
---	4-22	Add	Added BREAKER CONTROL section
5-8	5-8	Update	Updated PASSWORD SECURITY section (now titled SECURITY)
---	5-32	Add	Added ETHERNET SWITCH sub-section
5-43	5-44	Update	Updated USER-PROGRAMMABLE PUSHBUTTONS section
5-63	5-66	Update	Updated BREAKERS section
---	5-70	Add	Added DISCONNECT SWITCHES section
5-75	5-82	Update	Updated FLEXLOGIC OPERANDS table
5-139	5-147	Update	Updated NEUTRAL VOLTAGE UNBALANCE section
---	5-180	Add	Added BREAKER RESTRIKE sub-section
---	6-8	Add	Added ETHERNET SWITCH section
B-8	B-8	Update	Update MODBUS MEMORY MAP section for revision 5.5x

Table F–12: MAJOR UPDATES FOR C70 MANUAL REVISION R3

PAGE (R2)	PAGE (R3)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-R3
---	4-4	Add	Added EXTENDED ENERVISTA UR SETUP FEATURES section
6-21	6-21	Update	Updated MODEL INFORMATION section

Table F–13: MAJOR UPDATES FOR C70 MANUAL REVISION R2

PAGE (R1)	PAGE (R2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-R2

Table F–14: MAJOR UPDATES FOR C70 MANUAL REVISION R1 (Sheet 1 of 2)

PAGE (P2)	PAGE (R1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-R1
2-3	2-3	Update	Updated ORDERING section
2-5	2-5	Update	Updated PROTECTION ELEMENTS specifications section
3-1	3-1	Update	Updated PANEL CUTOUT section
3-2	3-3	Update	Updated MODULE WITHDRAWAL AND INSERTION section
4-4	4-4	Update	Updated FACEPLATE section
4-4	4-5	Update	Updated LED INDICATORS section
4-6	4-7	Update	Updated CUSTOM LABELING OF LEDS section
4-11	4-18	Update	Updated ENTERING INITIAL PASSWORDS section

Table F–14: MAJOR UPDATES FOR C70 MANUAL REVISION R1 (Sheet 2 of 2)

PAGE (P2)	PAGE (R1)	CHANGE	DESCRIPTION
5-8	5-8	Update	Updated PASSWORD SECURITY section
5-33	5-35	Update	Updated USER-PROGRAMMABLE LEDS section
5-37	5-39	Update	Updated CONTROL PUSHBUTTONS section
5-38	5-40	Update	Updated USER-PROGRAMMABLE PUSHBUTTONS section
5-44	5-47	Update	Updated DIRECT INPUTS AND OUTPUTS section
5-68	5-71	Update	Updated FLEXLOGIC™ OPERANDS table
5-105	5-110	Update	Updated PHASE CURRENT UNBALANCE sub-section
---	5-170	Add	Added TRIP BUS section
7-8	7-8	Update	Updated RELAY SELF-TESTS section
A-1	A-2	Update	Updated FLEXANALOG DATA ITEMS table
B-7	B-7	Update	Updated MODBUS PASSWORD OPERATION section
B-8	B-8	Update	Updated MODBUS MEMORY MAP section
---	C-2	Add	Added GGIO4: GENERIC ANALOG MEASURED VALUES section
C-7	C-7	Update	Updated CONFIGURABLE GOOSE section

Table F–15: MAJOR UPDATES FOR C70 MANUAL REVISION P2

PAGE (P1)	PAGE (P2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-9015-P2
2-5	2-5	Update	Updated PROTECTION ELEMENTS specifications section
2-9	2-9	Update	Updated INPUTS specifications section
3-18	3-18	Update	Updated CPU MODULE COMMUNICATIONS WIRING diagram to 842765A2
5-112	5-114	Update	Updated NEUTRAL CURRENT UNBALANCE SCHEME LOGIC diagram to 834736A2
---	5-122	Add	Added NEGATIVE-SEQUENCE OVERVOLTAGE sub-section
5-146	5-149	Update	Updated AUTOMATIC VOLTAGE REGULATOR section
6-17	6-17	Update	Updated TRACKING FREQUENCY section
---	6-18	Add	Added IEC 61850 GOOSE ANALOG VALUES section
7-4	7-4	Update	Updated SELF-TEST ERROR MESSAGES table
9-14	9-14	Update	Updated BANK UNBALANCE CALCULATIONS section
A-1	A-1	Update	Updated FLEXANALOG PARAMETERS table

F

F.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

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)
MVA_C...........MegaVolt-Ampere (phase C)

F

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
NSAP .... Network Service Access Protocol
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

F

F.3.1 GE MULTILIN WARRANTY

GE MULTILIN RELAY WARRANTY

General Electric Multilin Inc. (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.

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