



GE Industrial Systems

C70 Capacitor Bank Protection and Control System

UR Series Instruction Manual

C70 Revision: 5.5x

Manual P/N: 1601-9015-**S3** (GEK-113409B)

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UL # A3775



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Please read this chapter to help guide you through the initial setup of your new relay.

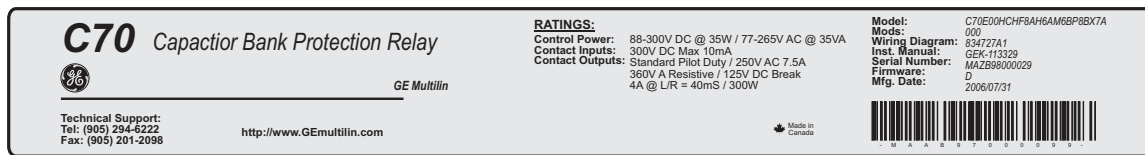
1.1.1 CAUTIONS AND WARNINGS



Before attempting to install or use the relay, it is imperative that all **WARNINGS** and **CAUTIONS** in this manual are reviewed to help prevent personal injury, equipment damage, and/or down-time.

1.1.2 INSPECTION CHECKLIST

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



834726A1.CDR

Figure 1-1: REAR NAMEPLATE (EXAMPLE)

- 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
 - registration card (attached as the last page of the manual)
- Fill out the registration form and return to GE Multilin (include the serial number located on the rear nameplate).
- For product information, instruction manual updates, and the latest software updates, please visit the GE Multilin web-site at <http://www.GEmultilin.com>.



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

1

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.

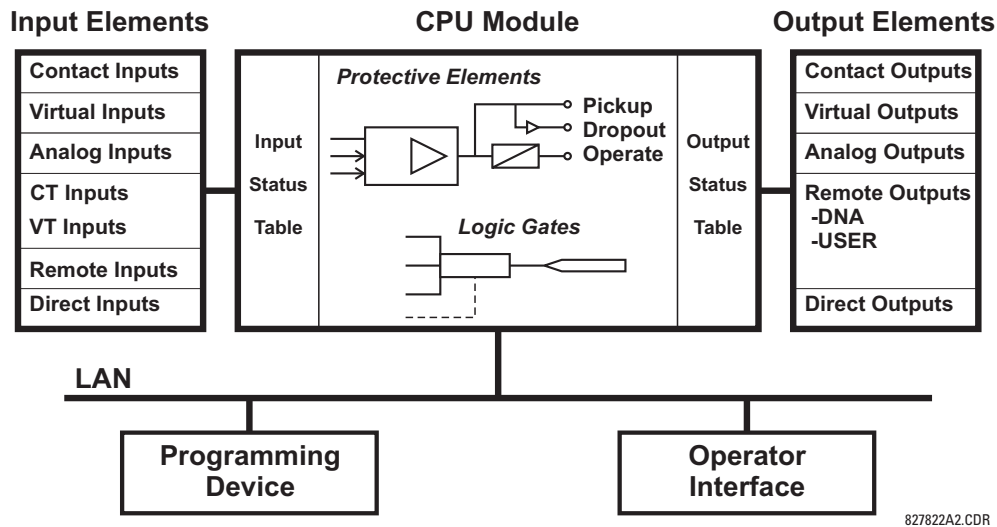


Figure 1-2: UR CONCEPT BLOCK DIAGRAM

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.

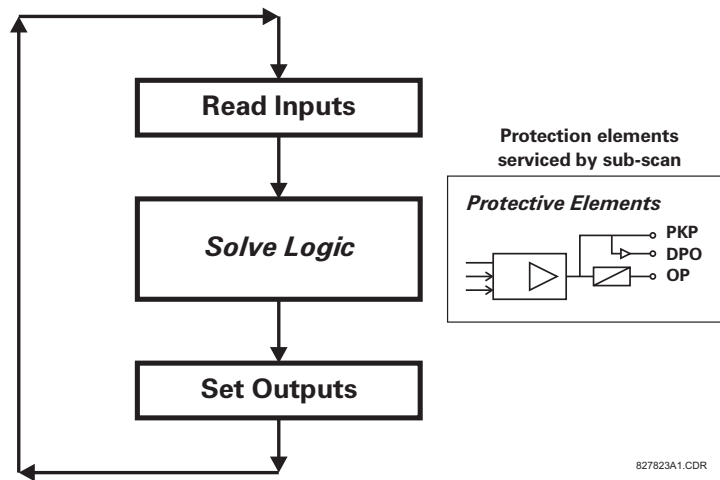


Figure 1-3: UR-SERIES SCAN OPERATION

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

1

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

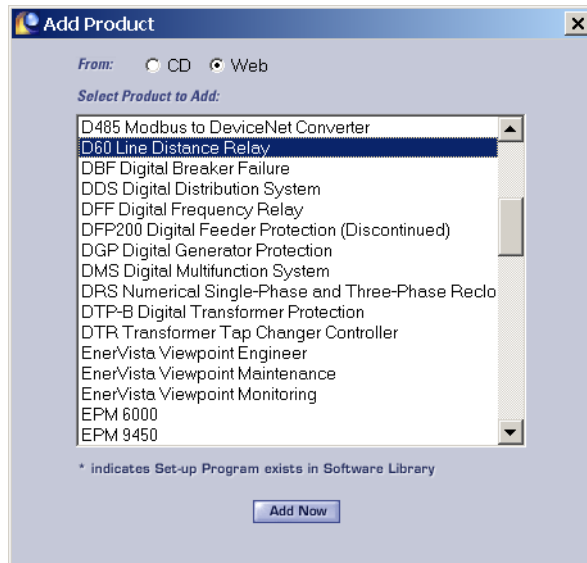
After ensuring the minimum requirements for using EnerVista UR Setup are met (see previous section), use the following procedure to install the EnerVista UR Setup from the enclosed GE EnerVista CD.

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.

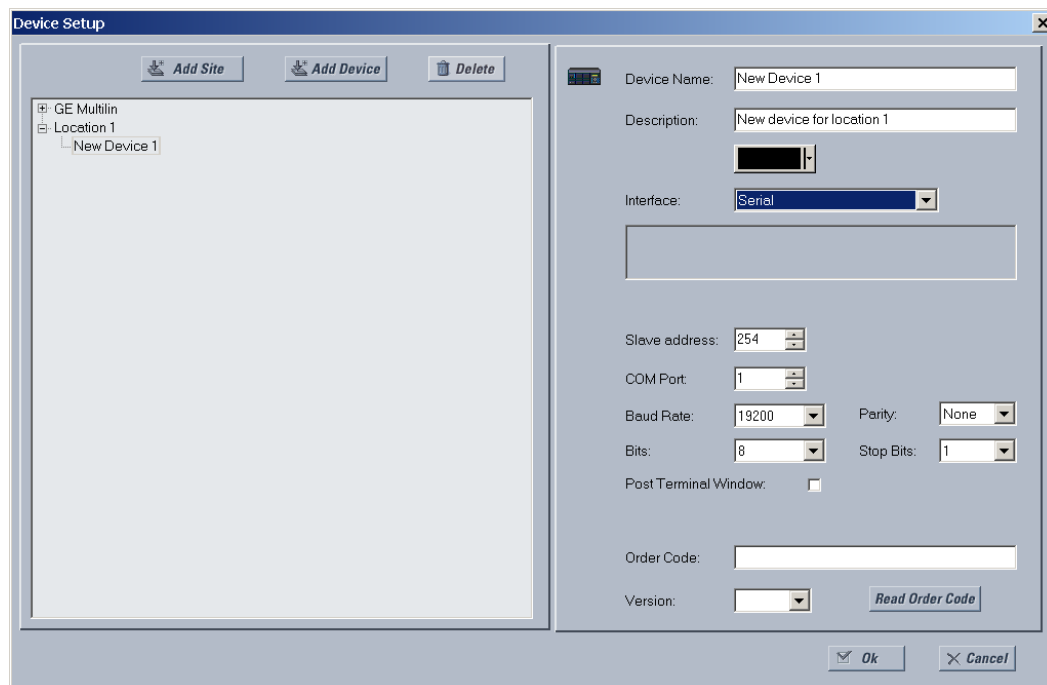


Figure 1–4: CONFIGURING SERIAL COMMUNICATIONS

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.

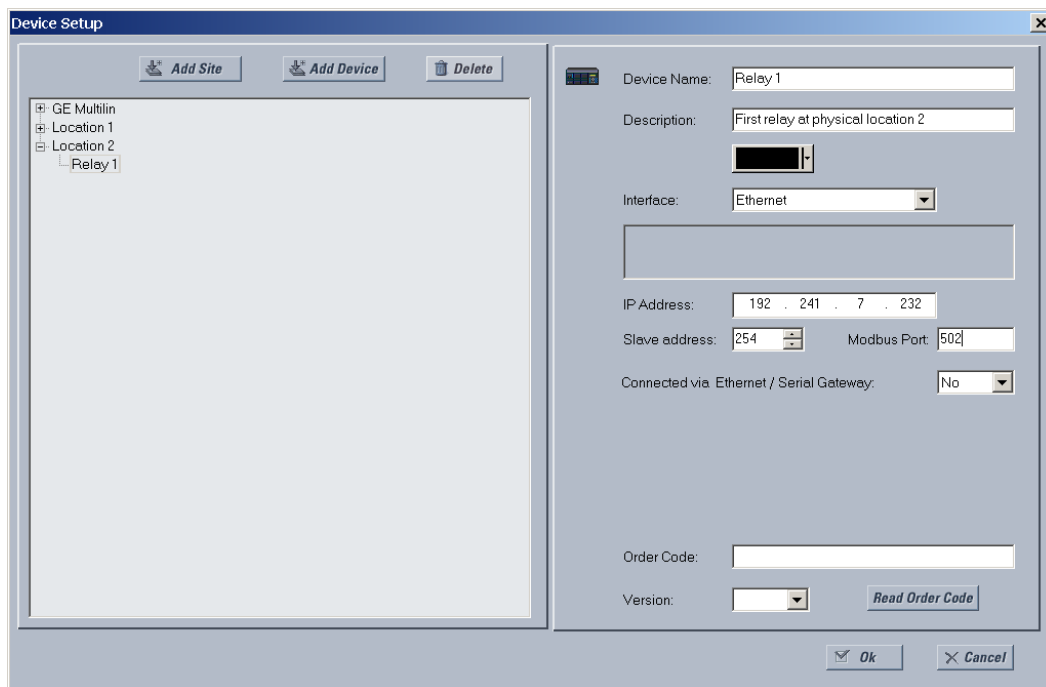


Figure 1–5: CONFIGURING ETHERNET COMMUNICATIONS

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.

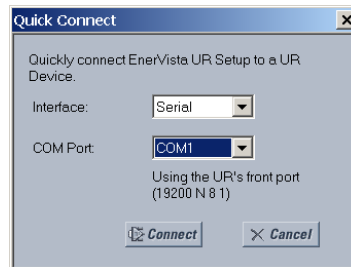
The Site Device has now been configured for Ethernet communications. Proceed to the *Connecting to the C70* section to begin communications.

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.

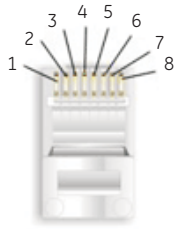
b) USING QUICK CONNECT VIA THE REAR ETHERNET PORTS

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.

1

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 | |

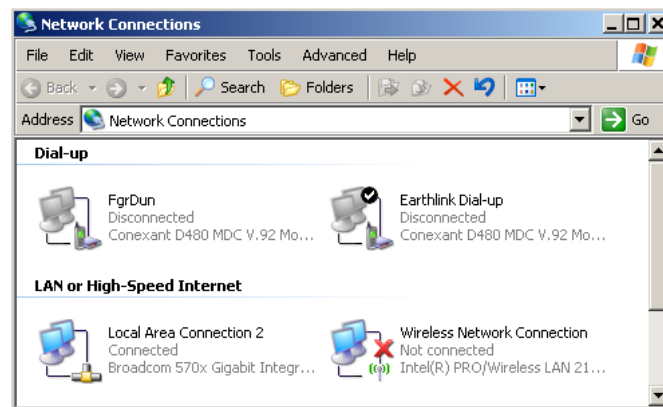
| END 2 | | |
|-------|--------------|---------|
| Pin | Wire color | Diagram |
| 1 | White/green | |
| 2 | Green | |
| 3 | White/orange | |
| 4 | Blue | |
| 5 | White/blue | |
| 6 | Orange | |
| 7 | White/brown | |
| 8 | Brown | |

842799A1.CDR

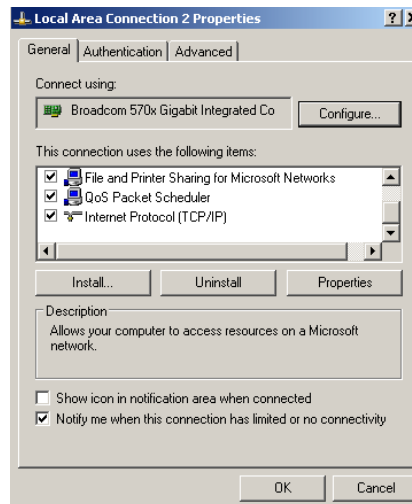
Figure 1–6: ETHERNET CROSS-OVER CABLE PIN LAYOUT

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

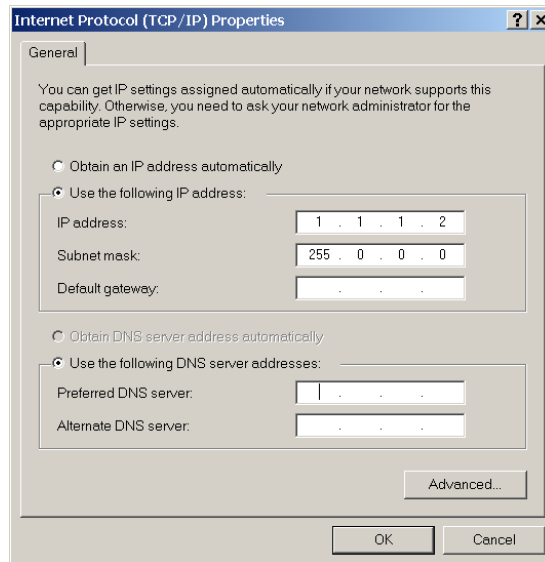
1. From the Windows desktop, right-click the **My Network Places** icon and select **Properties** to open the network connections window.



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:

Ping ing 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

Ping ing 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:

Ping ing 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

Ping ing 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:

Ping ing 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

Ping ing 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

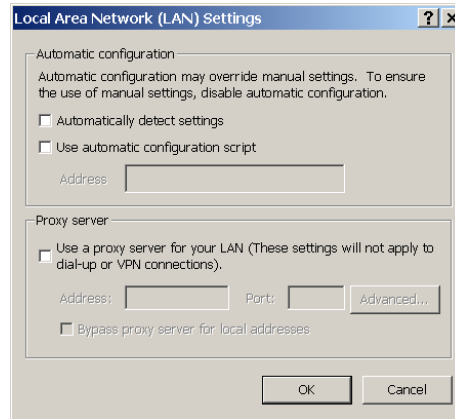
Default Gateway :

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.

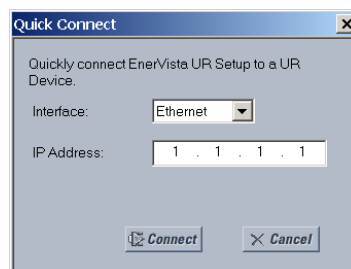
1. Start the Internet Explorer software.
2. Select the **Tools > Internet Options** menu item and click on **Connections** tab.
3. Click on the **LAN Settings** button to open the following window.



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.

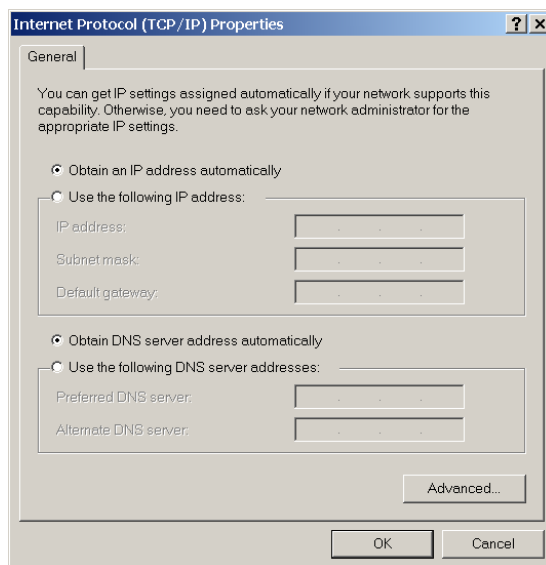
Each time the EnerVista UR Setup software is initialized, click the **Quick Connect** button to establish direct communications to the C70. This ensures that configuration of the EnerVista UR Setup software matches the C70 model number.

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.

1

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

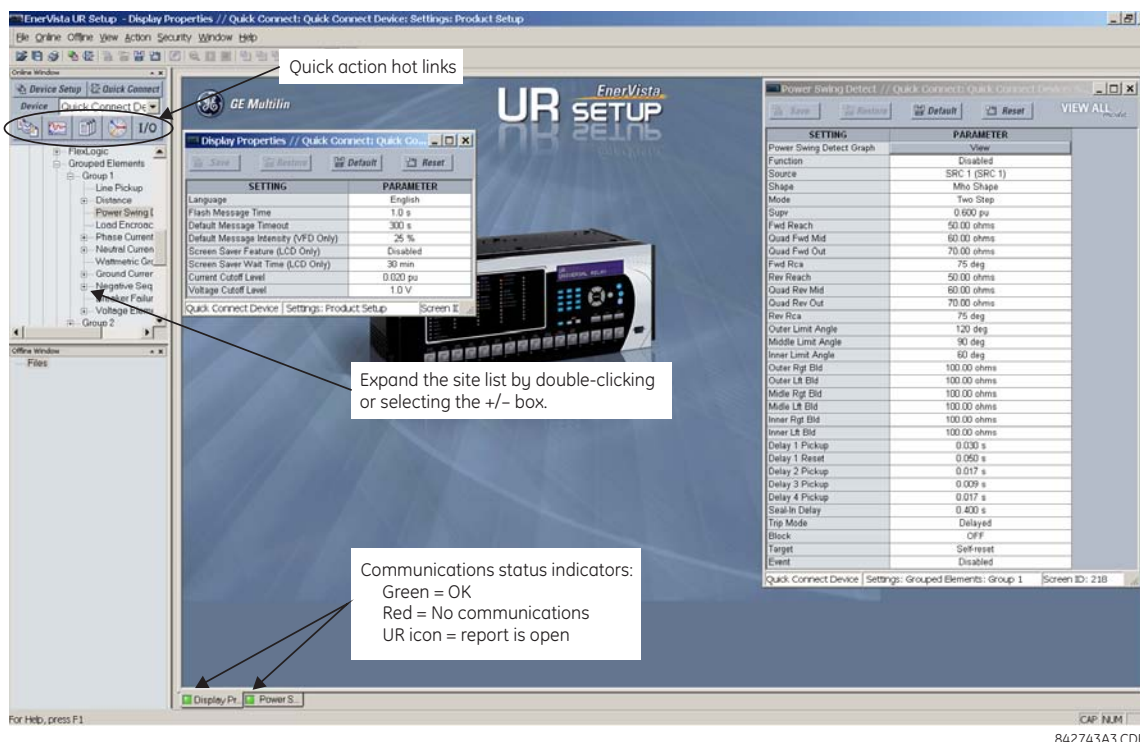
The EnerVista UR Setup software can automatically discover and communicate to all UR-series IEDs located on an Ethernet network.

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

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



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.



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.

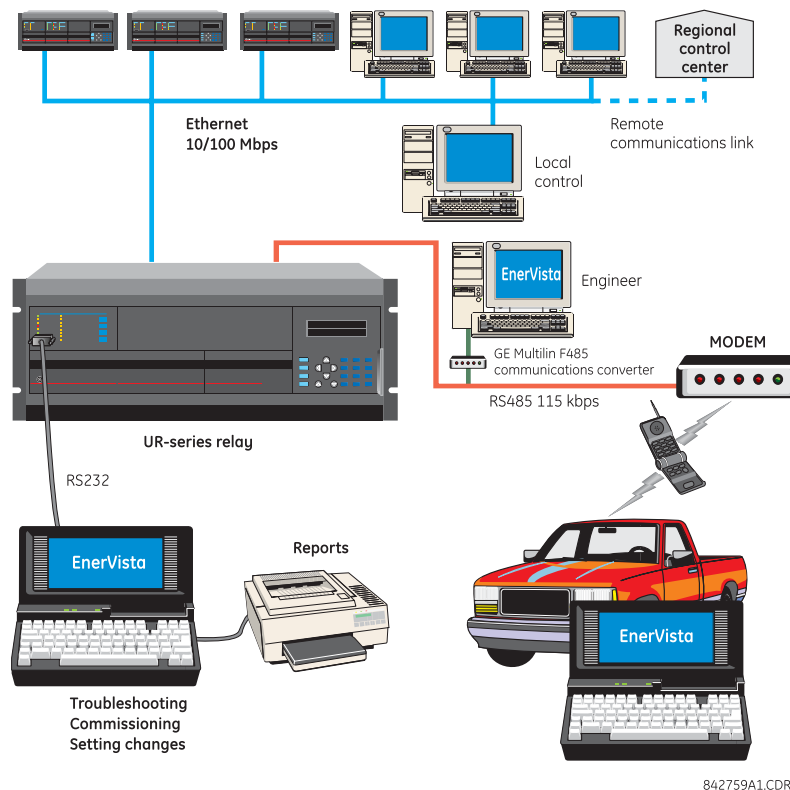


Figure 1-7: RELAY COMMUNICATIONS OPTIONS

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

1

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.

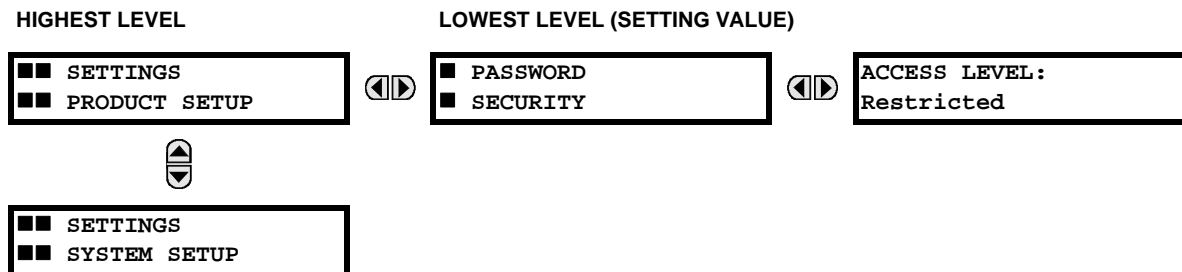
1.5.2 MENU NAVIGATION

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.



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.



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 *Flex-Logic™* section in Chapter 5 for additional details.

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

2

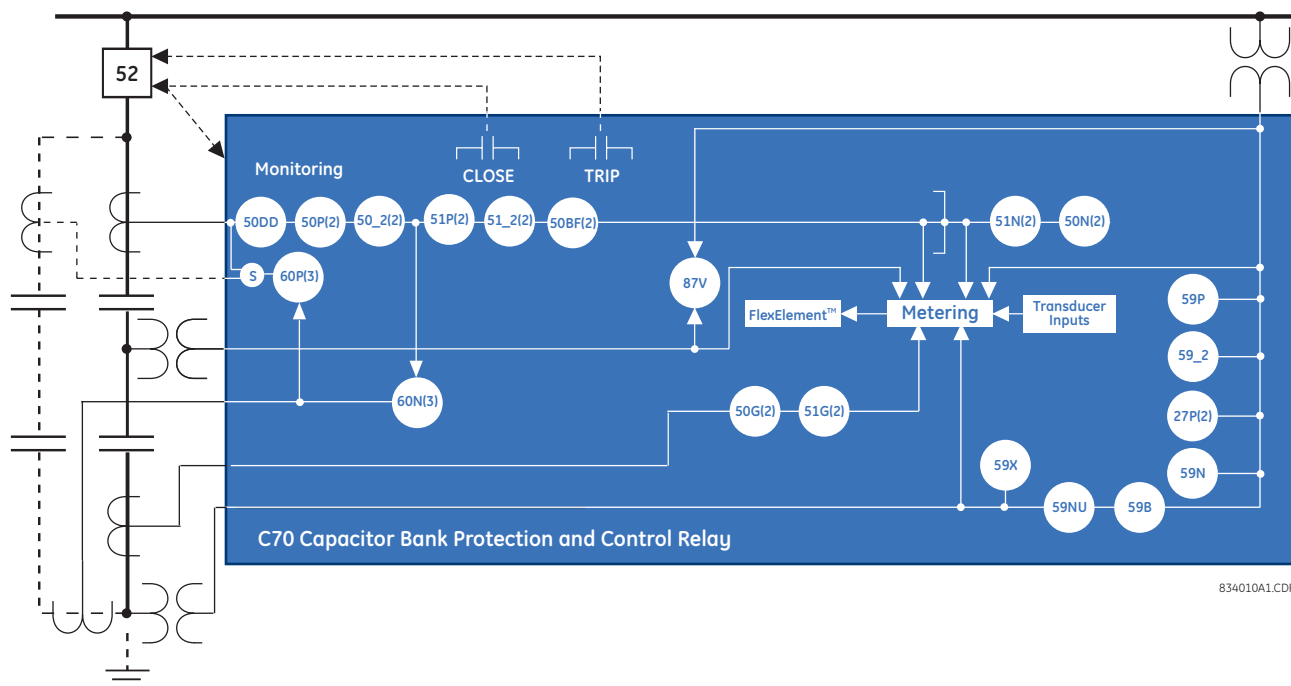


Figure 2-1: SINGLE LINE DIAGRAM

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 |
| Data logger | Non-volatile latches | Virtual inputs (64) |
| Digital counters (8) | Non-volatile selector switch | Virtual outputs (96) |
| Digital elements (48) | Oscillography | Voltage metering: true RMS, phasors, symmetrical |
| Disconnect switches (24) | Power metering | Voltage regulator |
| DNP 3.0 or IEC 60870-5-104 protocol | Power factor metering | VT fuse failure |
| | Setting groups (6) | |

2.1.2 ORDERING

The C70 is available as a 19-inch rack horizontal mount unit and consists of the following modules: CPU, faceplate, power supply, CPU, CTs and VTs, digital input and outputs, 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).



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.

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Table 2–3: C70 ORDER CODES

| BASE UNIT | C70 | F | H | M | P | U | W/X | Full Size Horizontal Mount |
|---|----------------------------|--------|--|--|---|--|--|---|
| CPU | E G H J N S | | | | | | | Base Unit RS485 and RS485 RS485 and multi-mode ST 10Base-F RS485 and multi-mode ST redundant 10Base-F RS485 and multi-mode ST 100Base-FX RS485 and 10/100Base-T RS485 and managed six-port Ethernet switch |
| SOFTWARE | 00 03 12 13 | | | | | | | No software options IEC 61850; not available for type E CPUs Enhanced capacitor bank control (time and date, capacitor control supervision, automatic voltage regulator) Enhanced capacitor bank control and IEC 61850; not available for type E CPUs |
| MOUNT/COATING | | H A | | | | | | Horizontal (19" rack) Horizontal (19" rack) with harsh environmental coating |
| FACEPLATE/ DISPLAY | | | C P K M Q U L N T V | | | | | English display English display with 4 small and 12 large programmable pushbuttons Enhanced front panel with English display Enhanced front panel with French display Enhanced front panel with Russian display Enhanced front panel with Chinese display Enhanced front panel with English display and user-programmable pushbuttons Enhanced front panel with French display and user-programmable pushbuttons Enhanced front panel with Russian display and user-programmable pushbuttons Enhanced front panel with Chinese display and user-programmable pushbuttons |
| POWER SUPPLY | | | H L | | | | | 125 / 250 V AC/DC power supply 24 to 48 V (DC only) power supply |
| CT/VT MODULES | | | | 8L 8N 8V | | 8L 8N 8V | | Standard 4CT/4VT with enhanced diagnostics Standard 8CT with enhanced diagnostics Standard 8VT with enhanced diagnostics |
| DIGITAL INPUTS/OUTPUTS | | | | XX 6A 6B 6C 6D 6E 6F 6G 6H 6K 6L 6M 6N 6P 6R 6S 6T 6U | | XX 6A 6B 6C 6D 6E 6F 6G 6H 6K 6L 6M 6N 6P 6R 6S 6T 6U | 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 4 dcma inputs, 4 dcma outputs (only one 5A module is allowed) | |
| TRANSDUCER INPUTS/OUTPUTS (maximum of 3 per unit) | | | | 5A | | 5A | | 2G 2H 2S 2T 77 7H 7I 7S 7W |
| INTER-RELAY COMMUNICATIONS (select a maximum of 1 per unit) | | | | | | | | 2G 2H 2S 2T 77 7H 7I 7S 7W |

2.1.3 REPLACEMENT MODULES

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



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

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 2–4: ORDER CODES FOR REPLACEMENT MODULES, HORIZONTAL UNITS

| | UR | 11 | 12 |
|--|----|---|----|
| POWER SUPPLY (redundant supply only available in horizontal units; must be same type as main supply) | 1H | 125 / 250 V AC/DC | |
| | 1L | 24 to 48 V (DC only) | |
| | 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 (Ethernet, Modbus TCP/IP, DNP 3.0) | |
| | 9P | RS485 and single mode ST 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0) | |
| | 9R | RS485 and single mode ST redundant 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0) | |
| FACEPLATE/DISPLAY | 9S | RS485 and six-port managed Ethernet switch | |
| | 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 | |
| DIGITAL INPUTS AND OUTPUTS | 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 | |
| | 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 | |
| CT/VT MODULES (NOT AVAILABLE FOR THE C30) | 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 | |
| | 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, 64 kbps, multimode, LED, 1 Channel | |
| | 2H | IEEE C37.94, 820 nm, 64 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 INPUTS/OUTPUTS | 5A | 4 dcmA inputs, 4 dcmA outputs (only one 5A module is allowed) | |
| | 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 | |

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

2.2.1 PROTECTION ELEMENTS



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 0.250 pu of bus voltage in steps of 0.001 |
| Pickup level accuracy: | 0.003 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 ² t; FlexCurves™ (programmable); Definite Time (0.01 s base curve) |
| Curve multiplier: | Time Dial = 0.00 to 600.00 in steps of 0.01 |
| Reset type: | Instantaneous/Timed (per IEEE) |
| 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 × CT rating ±1.5% of reading > 2.0 × CT rating |
| Curve shapes: | IEEE Moderately/Very/Extremely Inverse; IEC (and BS) A/B/C and Short Inverse; GE IAC Inverse, Short/Very/Extremely Inverse; I ² t; FlexCurves™ (programmable); Definite Time (0.01 s base curve) |
| Curve multiplier (Time dial): | 0.00 to 600.00 in steps of 0.01 |
| Reset type: | Instantaneous/Timed (per IEEE) and Linear |
| 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 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 0.250 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 $1.10 \times$ 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 $1.10 \times$ 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 $1.10 \times$ 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 $1.10 \times$ 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 $2.0 \times$ CT rating: | ±0.75% of reading or ±2% of rated (whichever is greater) |
| above $2 \times$ 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 $1.10 \times$ pickup at 60 Hz |

BREAKER RESTRIKE

| | |
|---------------|---|
| Principle: | detection of high-frequency overcurrent condition $\frac{1}{4}$ 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 |

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 |

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 $2.0 \times \text{CT rating}$: $\pm 0.25\%$ of reading or $\pm 0.1\%$ of rated (whichever is greater)> $2.0 \times \text{CT rating}$: $\pm 1.0\%$ of reading**RMS VOLTAGE**Accuracy: $\pm 0.5\%$ of reading from 10 to 208 V**REAL POWER (WATTS)**Accuracy: $\pm 1.0\%$ of reading at $-0.8 < \text{PF} \leq -1.0$ and $0.8 < \text{PF} \leq 1.0$ **REACTIVE POWER (VARs)**Accuracy: $\pm 1.0\%$ of reading at $-0.2 \leq \text{PF} \leq 0.2$ **APPARENT POWER (VA)**Accuracy: $\pm 1.0\%$ of reading**CURRENT HARMONICS**Harmonics: 2nd to 25th harmonic: per phase, displayed as a % of f_1 (fundamental frequency phasor)
THD: per phase, displayed as a % of f_1

Accuracy:

HARMONICS: 1. $f_1 > 0.4\text{pu}$: $(0.20\% + 0.035\% / \text{harmonic})$ of reading or 0.15% of 100%, whichever is greater
2. $f_1 < 0.4\text{pu}$: as above plus %error of f_1 **THD:** 1. $f_1 > 0.4\text{pu}$: $(0.25\% + 0.035\% / \text{harmonic})$ of reading or 0.20% of 100%, whichever is greater
2. $f_1 < 0.4\text{pu}$: as above plus %error of f_1 **VOLTAGE HARMONICS**Harmonics: 2nd to 25th harmonic: per phase, displayed as a % of f_1 (fundamental frequency phasor)
THD: per phase, displayed as a % of f_1

Accuracy:

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

Accuracy at

 $V = 0.8$ to 1.2 pu : $\pm 0.001 \text{ Hz}$ (when voltage signal is used for frequency measurement) $I = 0.1$ to 0.25 pu : $\pm 0.05 \text{ Hz}$ $I > 0.25 \text{ pu}$: $\pm 0.001 \text{ Hz}$ (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 $46 \times \text{CT rating RMS symmetrical}$ Current withstand: 20 ms at 250 times rated
1 sec. at 100 times rated
continuous at 3 times rated**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: $\pm 10\%$

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-BURNISHINGDry contacts: 1000 Ω maximum

Wet contacts: 300 V DC maximum

Selectable thresholds: 17 V, 33 V, 84 V, 166 V

Tolerance: $\pm 10\%$

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: $379\ \Omega \pm 10\%$

Conversion range: -1 to +20 mA DC

Accuracy: $\pm 0.2\%$ of full scale

Type: Passive

IRIG-B INPUT

Amplitude modulation: 1 to 10 V pk-pk

DC shift: TTL

Input impedance: $22\ k\Omega$

Isolation: 2 kV

REMOTE INPUTS (IEC 61850 GSSE/GOOSE)

Number of input points: 32, configured from 64 incoming bit pairs

Number of remote devices: 16

Default states on loss of comms.: On, Off, Latest/Off, Latest/On

DIRECT INPUTS

Number of input points: 32

No. of 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

Min/max DC voltage: 20 / 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

Min/max DC voltage: 88 / 300 V

Nominal AC voltage: 100 to 240 V at 50/60 Hz

Min/max AC voltage: 88 / 265 V at 25 to 100 Hz

Voltage loss hold-up: 200 ms duration at nominal

ALL RANGES

Volt withstand: $2 \times$ 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

FAST FORM-C RELAY

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

Minimum load impedance:

| INPUT VOLTAGE | IMPEDANCE | |
|---------------|---------------|---------------|
| | 2 W RESISTOR | 1 W RESISTOR |
| 250 V DC | 20 K Ω | 50 K Ω |
| 120 V DC | 5 K Ω | 2 K Ω |
| 48 V DC | 2 K Ω | 2 K Ω |
| 24 V DC | 2 K Ω | 2 K Ω |

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

Operate time: < 0.6 ms

Internal Limiting Resistor: 100 Ω , 2 W

SOLID-STATE OUTPUT RELAY

Operate and release time: <100 μ s

Maximum voltage: 265 V DC

Maximum 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 μ s for DC-shift input

Isolation: 2 kV

**CONTROL POWER EXTERNAL OUTPUT
(FOR DRY CONTACT INPUT)**

Capacity: 100 mA DC at 48 V DC

Isolation: \pm 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 k Ω for -1 to 1 mA range

12 k Ω for 0 to 1 mA range

600 Ω for 4 to 20 mA range

Accuracy: \pm 0.75% of full-scale for 0 to 1 mA range

\pm 0.5% of full-scale for -1 to 1 mA range

\pm 0.75% of full-scale for 0 to 20 mA range

99% Settling time to a step change: 100 ms

Isolation: 1.5 kV

Driving signal: any FlexAnalog quantity

Upper and lower limit for the driving signal: -90 to 90 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.

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

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

The worst case optical power budget (OPB_{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:

$$\begin{aligned} OPB_{WORST} &= OPB - 1 \text{ dB (LED aging)} - \text{total insertion loss} \\ 10 \text{ dB} - 1 \text{ dB} - 1 \text{ dB} &= 8 \text{ dB} \end{aligned}$$

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:

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

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.)

2.2.9 INTER-RELAY COMMUNICATIONS

SHIELDED TWISTED-PAIR INTERFACE OPTIONS

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



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

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 |



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



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 |



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: -40 to 80°C

OPERATING TEMPERATURES

Cold: IEC 60068-2-1, 16 h at -40°C

Dry Heat: IEC 60068-2-2, 16 h at +85°C



The LCD contrast may be impaired at temperatures less than -20°C.

OTHER

Humidity (non-condensing): IEC 60068-2-30, 95%, Variant 1, 6 days

Altitude: Up to 2000 m

Installation Category: II

2.2.11 TYPE TESTS

| | |
|----------------------------|--|
| Electrical fast transient: | ANSI/IEEE C37.90.1 IEC 61000-4-4 IEC 60255-22-4 |
| Oscillatory transient: | ANSI/IEEE C37.90.1 IEC 61000-4-12 |
| Insulation resistance: | IEC 60255-5 |
| Dielectric strength: | IEC 60255-6 ANSI/IEEE C37.90 |
| Electrostatic discharge: | EN 61000-4-2 |
| Surge immunity: | EN 61000-4-5 |
| RFI susceptibility: | ANSI/IEEE C37.90.2 IEC 61000-4-3 IEC 60255-22-3 Ontario Hydro C-5047-77 |

| | |
|--|--------------------------------|
| Conducted RFI: | IEC 61000-4-6 |
| Voltage dips/interruptions/variatio | IEC 61000-4-11 IEC 60255-11 |
| Power frequency magnetic field immunity: | IEC 61000-4-8 |
| Pulse magnetic field immunity: | IEC 61000-4-9 |
| Vibration test (sinusoidal): | IEC 60255-21-1 |
| Shock and bump: | IEC 60255-21-2 |
| Seismic: | IEC 60255-21-3 IEEE C37.98 |
| Cold: | IEC 60028-2-1, 16 h at -40°C |
| Dry heat: | IEC 60028-2-2, 16 h at 85°C |



Type test report available upon request.

NOTE

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

UL Listed for the USA and Canada

CE:

| | |
|-----------------|------------------------|
| LVD 73/23/EEC: | IEC 1010-1 |
| EMC 81/336/EEC: | EN 50081-2, EN 50082-2 |

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.



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.

NOTE

3.1.1 PANEL CUTOUT

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.

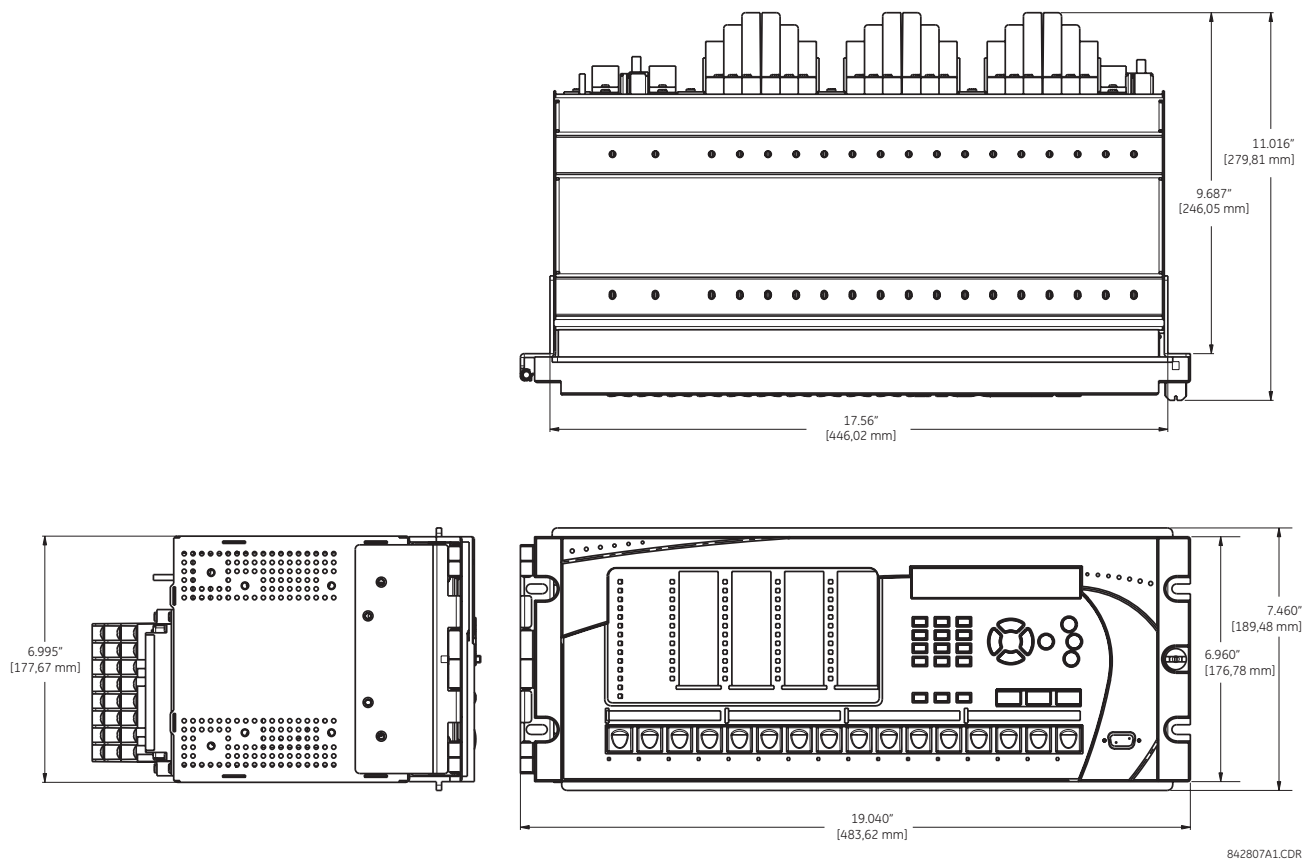


Figure 3-1: C70 HORIZONTAL DIMENSIONS (ENHANCED PANEL)

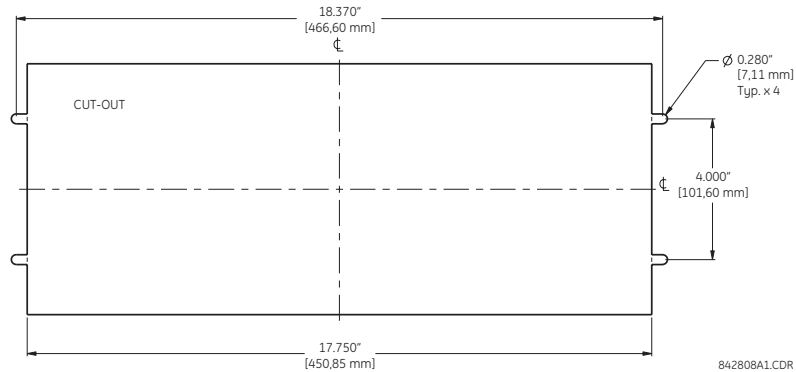


Figure 3-2: C70 HORIZONTAL MOUNTING (ENHANCED PANEL)

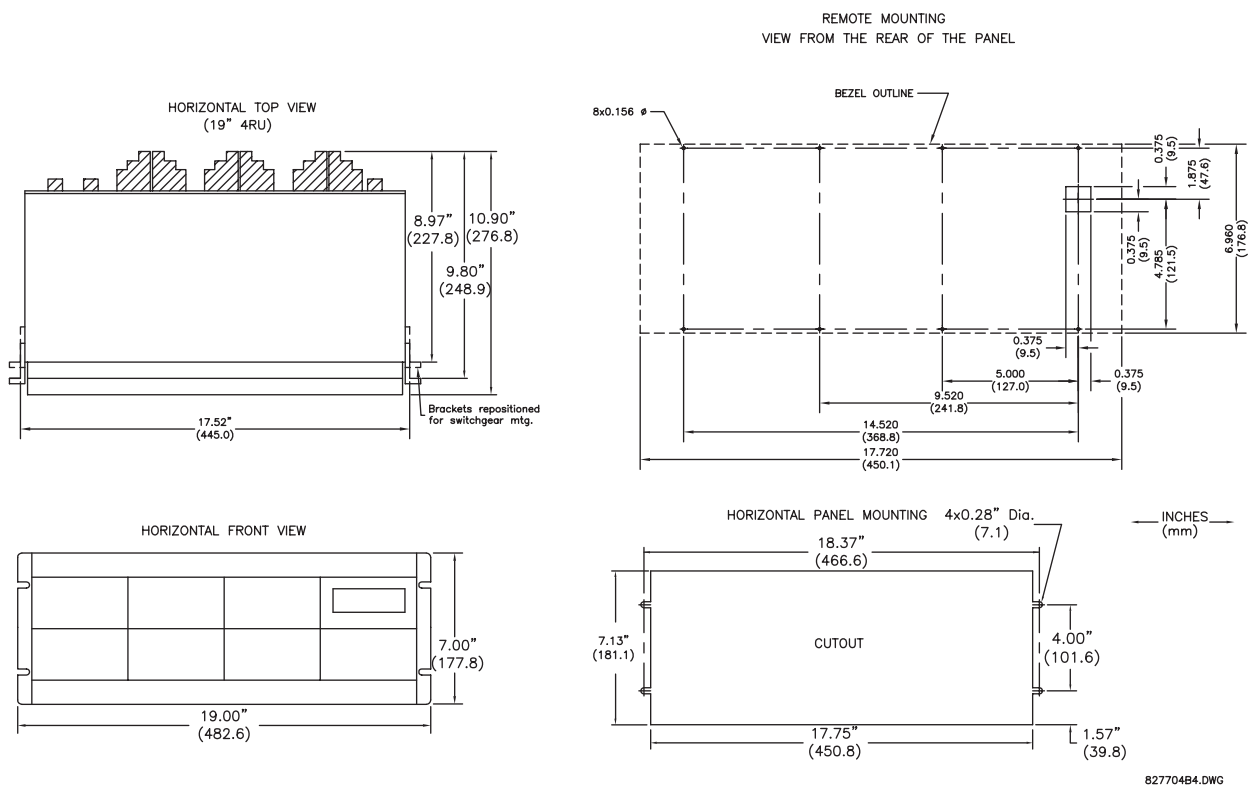


Figure 3-3: C70 HORIZONTAL MOUNTING AND DIMENSIONS (STANDARD PANEL)

3.1.2 MODULE WITHDRAWAL AND INSERTION



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!



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.

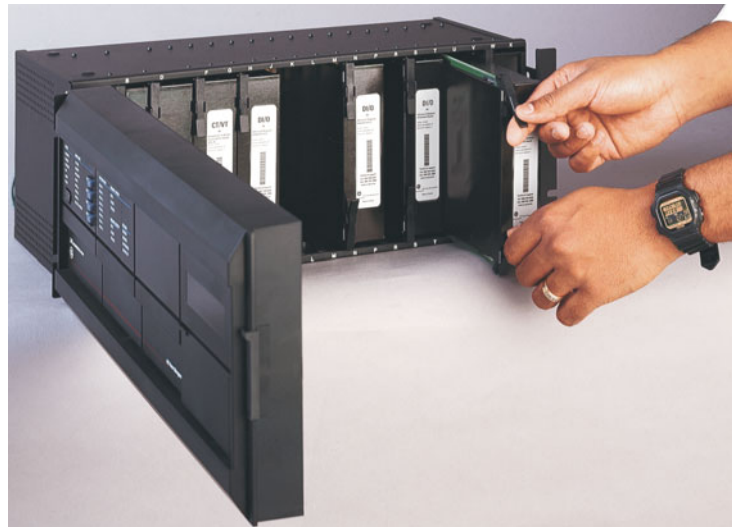
The enhanced faceplate can be opened to the left, once the thumb screw has been removed, as shown below. This allows for easy accessibility of the modules for withdrawal. The new wide-angle hinge assembly in the enhanced front panel opens completely and allows easy access to all modules in the C70.



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Figure 3-4: 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.



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Figure 3-5: 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.



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.

3.1.3 REAR TERMINAL LAYOUT

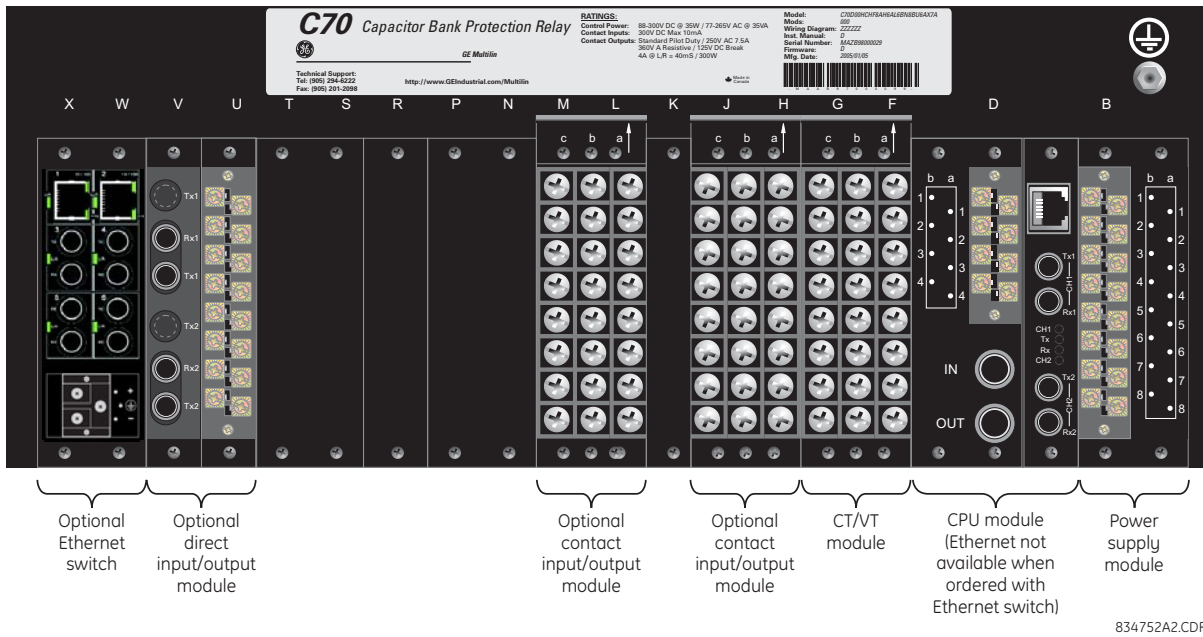


Figure 3-6: REAR TERMINAL VIEW



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

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.

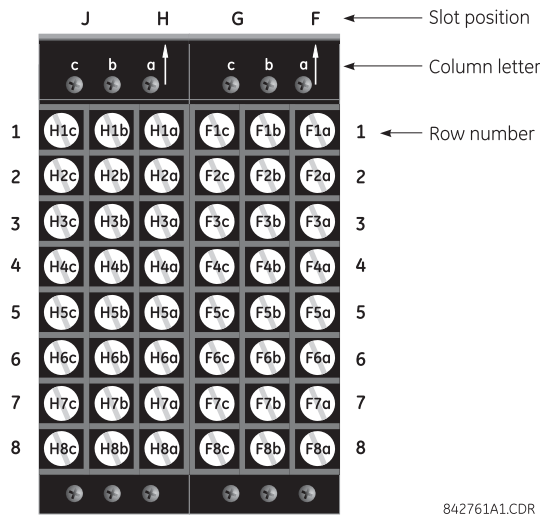


Figure 3-7: EXAMPLE OF MODULES IN F AND H SLOTS

3.2.1 TYPICAL WIRING

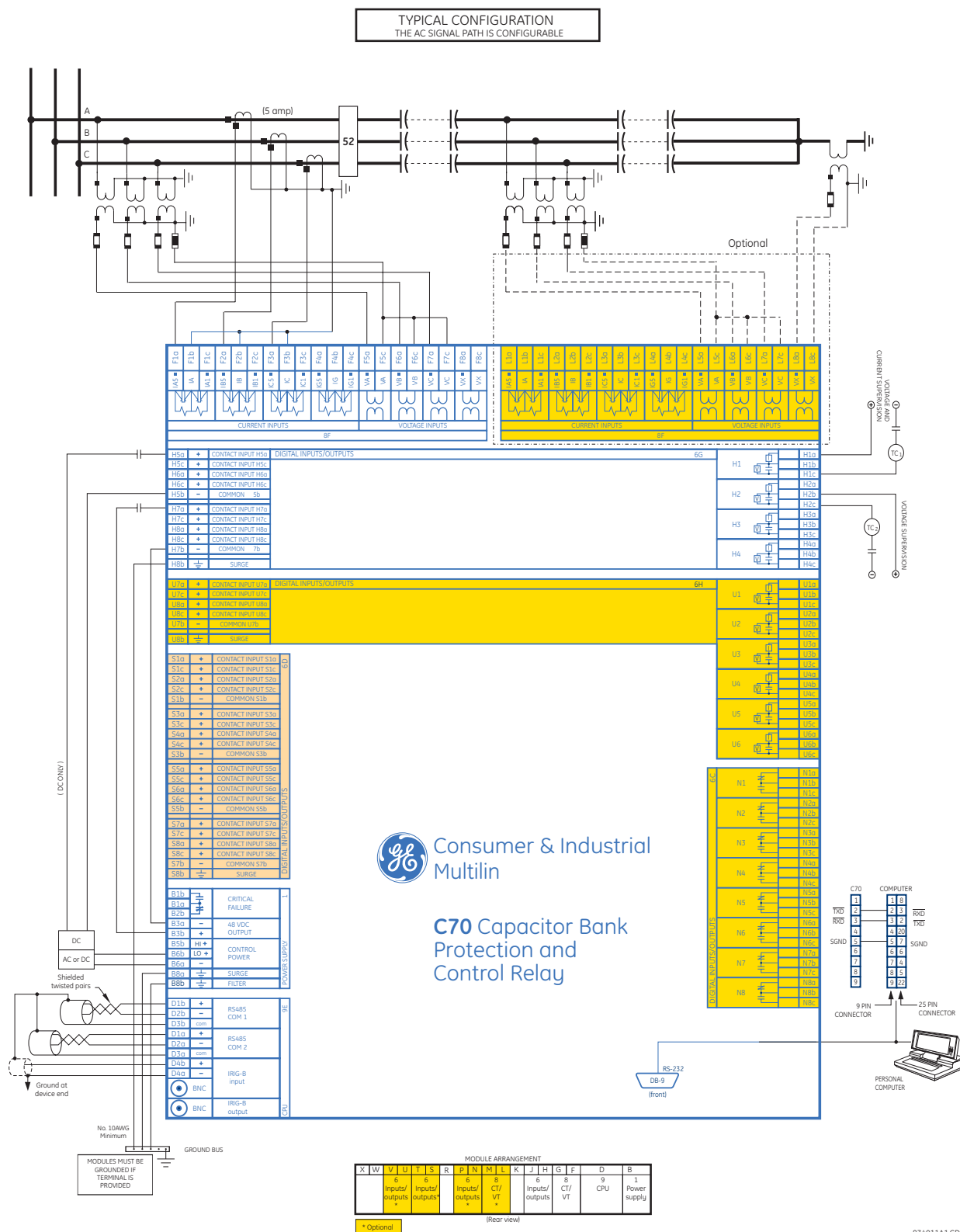


Figure 3-8: TYPICAL WIRING DIAGRAM

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



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!



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 |

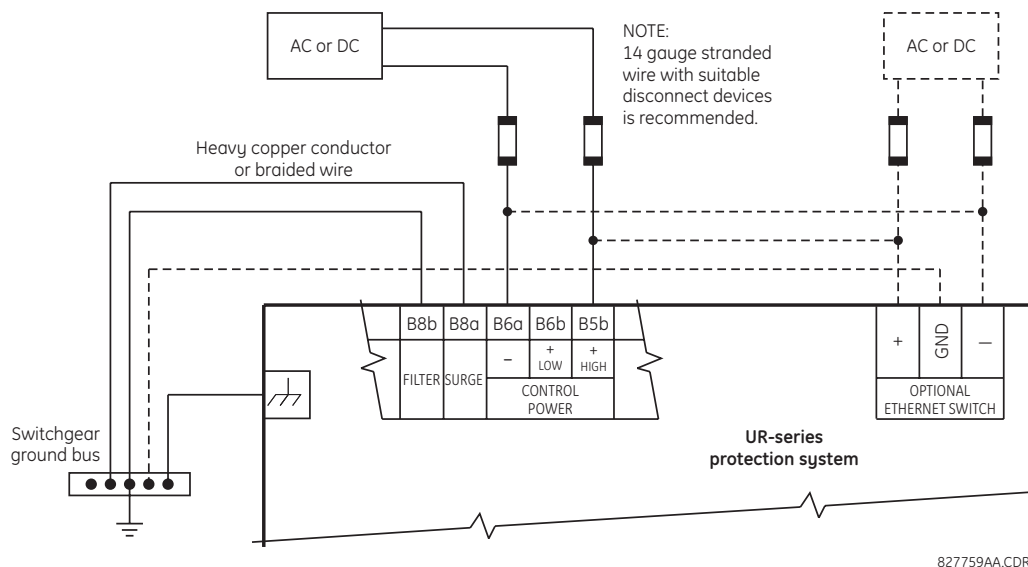


Figure 3-9: CONTROL POWER CONNECTION

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 channels are labeled as auxiliary voltage (VX). For current inputs, these channels are intended for connection to a CT between system neutral and ground, and are labeled as ground current (IG).



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.

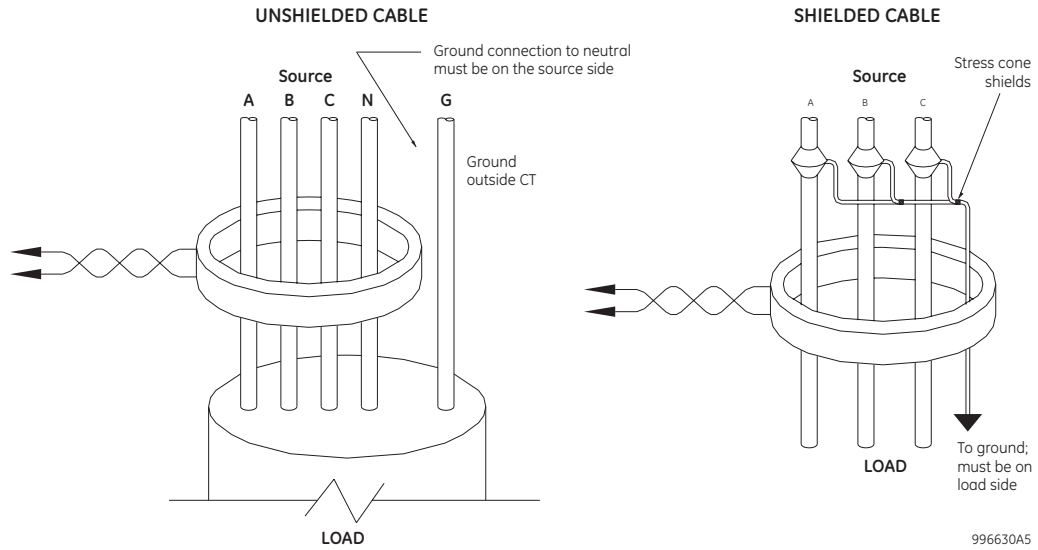


Figure 3-10: ZERO-SEQUENCE CORE BALANCE CT INSTALLATION

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.



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

| | | | | | | | | | | | | | | | | | | | |
|--|------|------|------|------|------|------|------|------|------|------|------|----------------|------|------|------|------|------|------|------|
| ~ 1a | ~ 1b | ~ 1c | ~ 2a | ~ 2b | ~ 2c | ~ 3a | ~ 3b | ~ 3c | ~ 4a | ~ 4b | ~ 4c | ~ 5a | ~ 5c | ~ 6a | ~ 6c | ~ 7a | ~ 7c | ~ 8a | ~ 8c |
| IA5 | IA | IA1 | IB5 | IB | IB1 | IC5 | IC | IC1 | IG5 | IG | IG1 | VA | VA | VB | VB | VC | VC | VX | VX |
| | | | | | | | | | | | | | | | | | | | |
| Current inputs | | | | | | | | | | | | Voltage inputs | | | | | | | |
| 8F, 8G, 8L, and 8M modules (4 CTs and 4 VTs) | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | |
|------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| ~ 1a | ~ 1b | ~ 1c | ~ 2a | ~ 2b | ~ 2c | ~ 3a | ~ 3b | ~ 3c | ~ 4a | ~ 4b | ~ 4c | ~ 5a | ~ 5b | ~ 5c | ~ 6a | ~ 6b | ~ 6c | ~ 7a | ~ 7b | ~ 7c | ~ 8a | ~ 8b | ~ 8c |
| IA5 | IA | IA1 | IB5 | IB | IB1 | IC5 | IC | IC1 | IG5 | IG | IG1 | IA5 | IA | IA1 | IB5 | IB | IB1 | IC5 | IC | IC1 | IG5 | IG | IG1 |
| | | | | | | | | | | | | | | | | | | | | | | | |
| Current inputs | | | | | | | | | | | | | | | | | | | | | | | |
| 8H, 8J, 8N, and 8R modules (8 CTs) | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|--------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| ~ 1a | ~ 1c | ~ 2a | ~ 2c | ~ 3a | ~ 3c | ~ 4a | ~ 4c | ~ 5a | ~ 5c | ~ 6a | ~ 6c | ~ 7a | ~ 7c | ~ 8a | ~ 8c |
| VA | VA | VB | VB | VC | VC | VX | VX | VA | VA | VB | VB | VC | VC | VX | VX |
| | | | | | | | | | | | | | | | |
| Voltage inputs | | | | | | | | | | | | | | | |
| 8V modules (8 VTs) | | | | | | | | | | | | | | | |

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Figure 3-11: CT/VT MODULE WIRING

3.2.5 CONTACT INPUTS/OUTPUTS

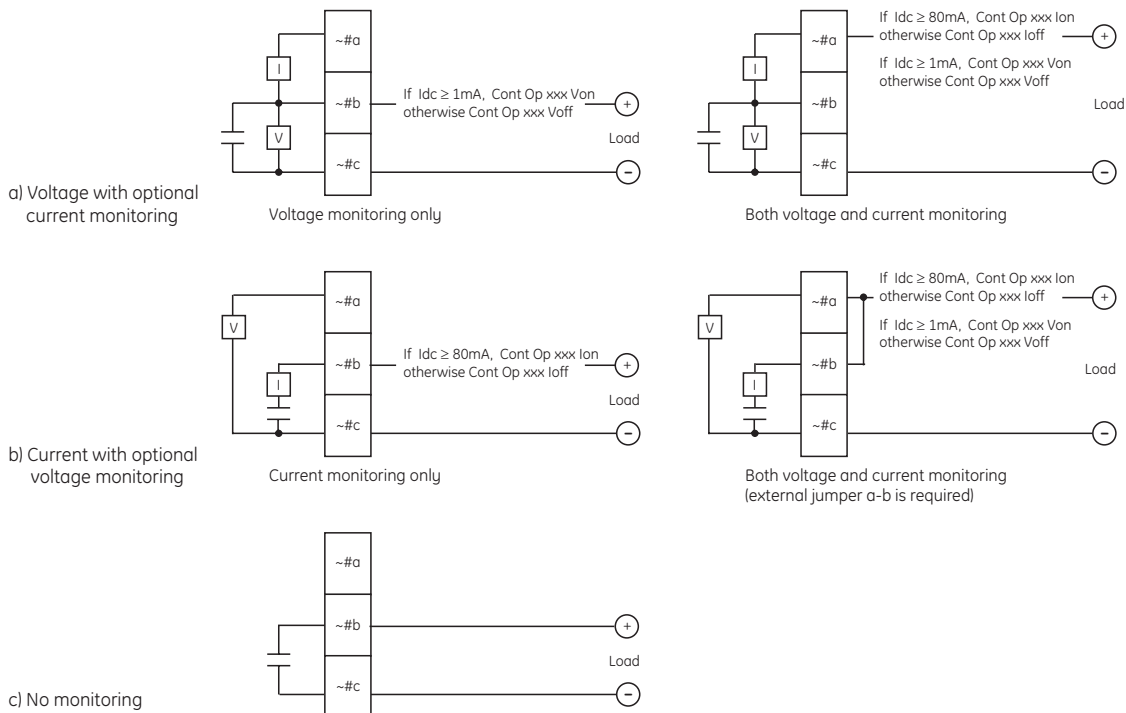
Every digital input/output module has 24 terminal connections. They are arranged as three terminals per row, with eight rows in total. A given row of three terminals may be used for the outputs of one relay. For example, for form-C relay outputs, the terminals connect to the normally open (NO), normally 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 digital 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 digital 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 form-A / solid-state relay outputs with optional voltage monitor, optional current monitor, and with no monitoring



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Figure 3-12: FORM-A CONTACT FUNCTIONS

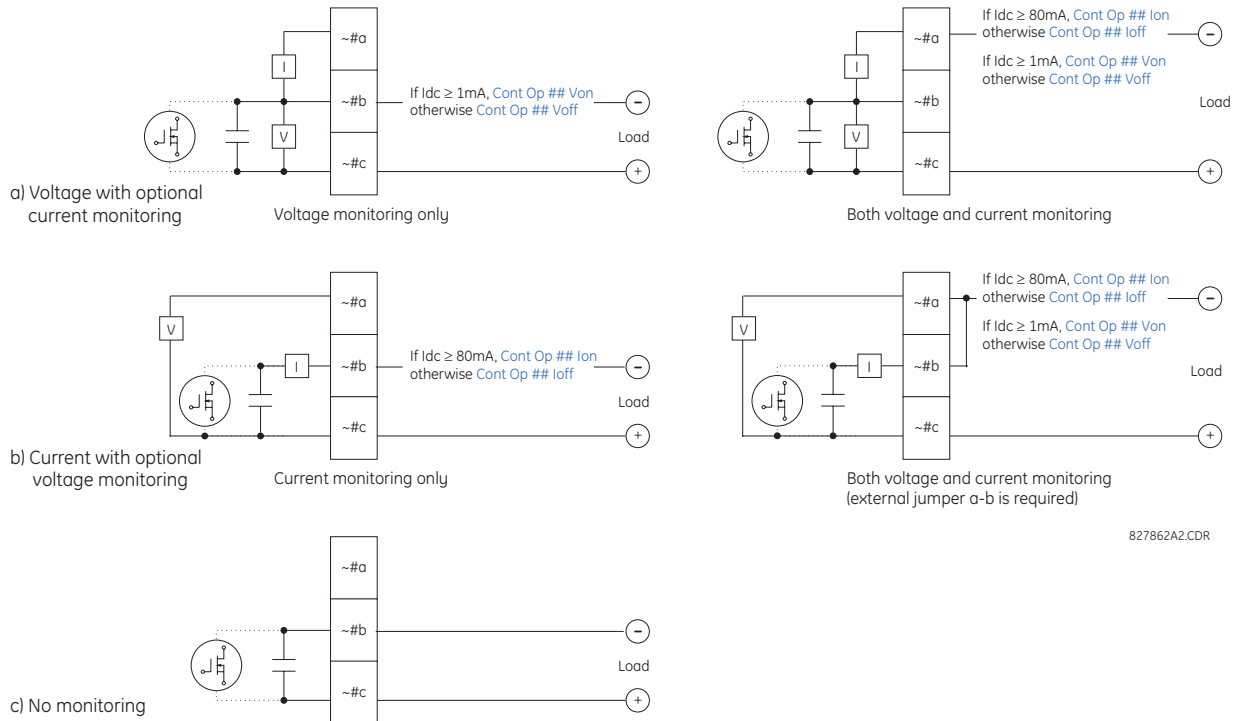


Figure 3-13: FORM-A AND SOLID STATE CONTACT FUNCTIONS

The operation of voltage and current monitors is reflected with the corresponding FlexLogic™ operands (CONT OP # VON, CONT OP # VOFF, CONT OP # ION, and CONT OP # IOFF) 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 circuit across the contact, the circuit has an impedance that can cause a problem when used in conjunction with external high input impedance monitoring equipment such as modern relay test set trigger circuits. These monitoring circuits may continue to read the form-A contact as being closed after it has closed and subsequently opened, when measured as an impedance.

The solution 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: DIGITAL INPUT/OUTPUT MODULE ASSIGNMENTS

| ~6A MODULE | | ~6B MODULE | | ~6C MODULE | | ~6D MODULE | |
|---------------------|-----------------|---------------------|-----------------|---------------------|--------|---------------------|----------|
| TERMINAL ASSIGNMENT | OUTPUT OR INPUT | TERMINAL ASSIGNMENT | OUTPUT OR INPUT | TERMINAL ASSIGNMENT | OUTPUT | TERMINAL ASSIGNMENT | OUTPUT |
| ~1 | Form-A | ~1 | Form-A | ~1 | Form-C | ~1a, ~1c | 2 Inputs |
| ~2 | Form-A | ~2 | Form-A | ~2 | Form-C | ~2a, ~2c | 2 Inputs |
| ~3 | Form-C | ~3 | Form-C | ~3 | Form-C | ~3a, ~3c | 2 Inputs |
| ~4 | Form-C | ~4 | Form-C | ~4 | Form-C | ~4a, ~4c | 2 Inputs |
| ~5a, ~5c | 2 Inputs | ~5 | Form-C | ~5 | Form-C | ~5a, ~5c | 2 Inputs |
| ~6a, ~6c | 2 Inputs | ~6 | Form-C | ~6 | Form-C | ~6a, ~6c | 2 Inputs |
| ~7a, ~7c | 2 Inputs | ~7a, ~7c | 2 Inputs | ~7 | Form-C | ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs | ~8a, ~8c | 2 Inputs | ~8 | Form-C | ~8a, ~8c | 2 Inputs |

| ~6E MODULE | | ~6F MODULE | | ~6G MODULE | | ~6H MODULE | |
|---------------------|-----------------|---------------------|-------------|---------------------|-----------------|---------------------|-----------------|
| TERMINAL ASSIGNMENT | OUTPUT OR INPUT | TERMINAL ASSIGNMENT | OUTPUT | TERMINAL ASSIGNMENT | OUTPUT OR INPUT | TERMINAL ASSIGNMENT | OUTPUT OR INPUT |
| ~1 | Form-C | ~1 | Fast Form-C | ~1 | Form-A | ~1 | Form-A |
| ~2 | Form-C | ~2 | Fast Form-C | ~2 | Form-A | ~2 | Form-A |
| ~3 | Form-C | ~3 | Fast Form-C | ~3 | Form-A | ~3 | Form-A |
| ~4 | Form-C | ~4 | Fast Form-C | ~4 | Form-A | ~4 | Form-A |
| ~5a, ~5c | 2 Inputs | ~5 | Fast Form-C | ~5a, ~5c | 2 Inputs | ~5 | Form-A |
| ~6a, ~6c | 2 Inputs | ~6 | Fast Form-C | ~6a, ~6c | 2 Inputs | ~6 | Form-A |
| ~7a, ~7c | 2 Inputs | ~7 | Fast Form-C | ~7a, ~7c | 2 Inputs | ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs | ~8 | Fast Form-C | ~8a, ~8c | 2 Inputs | ~8a, ~8c | 2 Inputs |

| ~6K MODULE | | ~6L MODULE | | ~6M MODULE | | ~6N MODULE | |
|---------------------|-------------|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|
| TERMINAL ASSIGNMENT | OUTPUT | TERMINAL ASSIGNMENT | OUTPUT OR INPUT | TERMINAL ASSIGNMENT | OUTPUT OR INPUT | TERMINAL ASSIGNMENT | OUTPUT OR INPUT |
| ~1 | Form-C | ~1 | Form-A | ~1 | Form-A | ~1 | Form-A |
| ~2 | Form-C | ~2 | Form-A | ~2 | Form-A | ~2 | Form-A |
| ~3 | Form-C | ~3 | Form-C | ~3 | Form-C | ~3 | Form-A |
| ~4 | Form-C | ~4 | Form-C | ~4 | Form-C | ~4 | Form-A |
| ~5 | Fast Form-C | ~5a, ~5c | 2 Inputs | ~5 | Form-C | ~5a, ~5c | 2 Inputs |
| ~6 | Fast Form-C | ~6a, ~6c | 2 Inputs | ~6 | Form-C | ~6a, ~6c | 2 Inputs |
| ~7 | Fast Form-C | ~7a, ~7c | 2 Inputs | ~7a, ~7c | 2 Inputs | ~7a, ~7c | 2 Inputs |
| ~8 | Fast Form-C | ~8a, ~8c | 2 Inputs | ~8a, ~8c | 2 Inputs | ~8a, ~8c | 2 Inputs |

| ~6P MODULE | | ~6R MODULE | | ~6S MODULE | | ~6T MODULE | |
|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|
| TERMINAL ASSIGNMENT | OUTPUT OR INPUT | TERMINAL ASSIGNMENT | OUTPUT OR INPUT | TERMINAL ASSIGNMENT | OUTPUT OR INPUT | TERMINAL ASSIGNMENT | OUTPUT OR INPUT |
| ~1 | Form-A | ~1 | Form-A | ~1 | Form-A | ~1 | Form-A |
| ~2 | Form-A | ~2 | Form-A | ~2 | Form-A | ~2 | Form-A |
| ~3 | Form-A | ~3 | Form-C | ~3 | Form-C | ~3 | Form-A |
| ~4 | Form-A | ~4 | Form-C | ~4 | Form-C | ~4 | Form-A |
| ~5 | Form-A | ~5a, ~5c | 2 Inputs | ~5 | Form-C | ~5a, ~5c | 2 Inputs |
| ~6 | Form-A | ~6a, ~6c | 2 Inputs | ~6 | Form-C | ~6a, ~6c | 2 Inputs |
| ~7a, ~7c | 2 Inputs | ~7a, ~7c | 2 Inputs | ~7a, ~7c | 2 Inputs | ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs | ~8a, ~8c | 2 Inputs | ~8a, ~8c | 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 |

| ~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 |

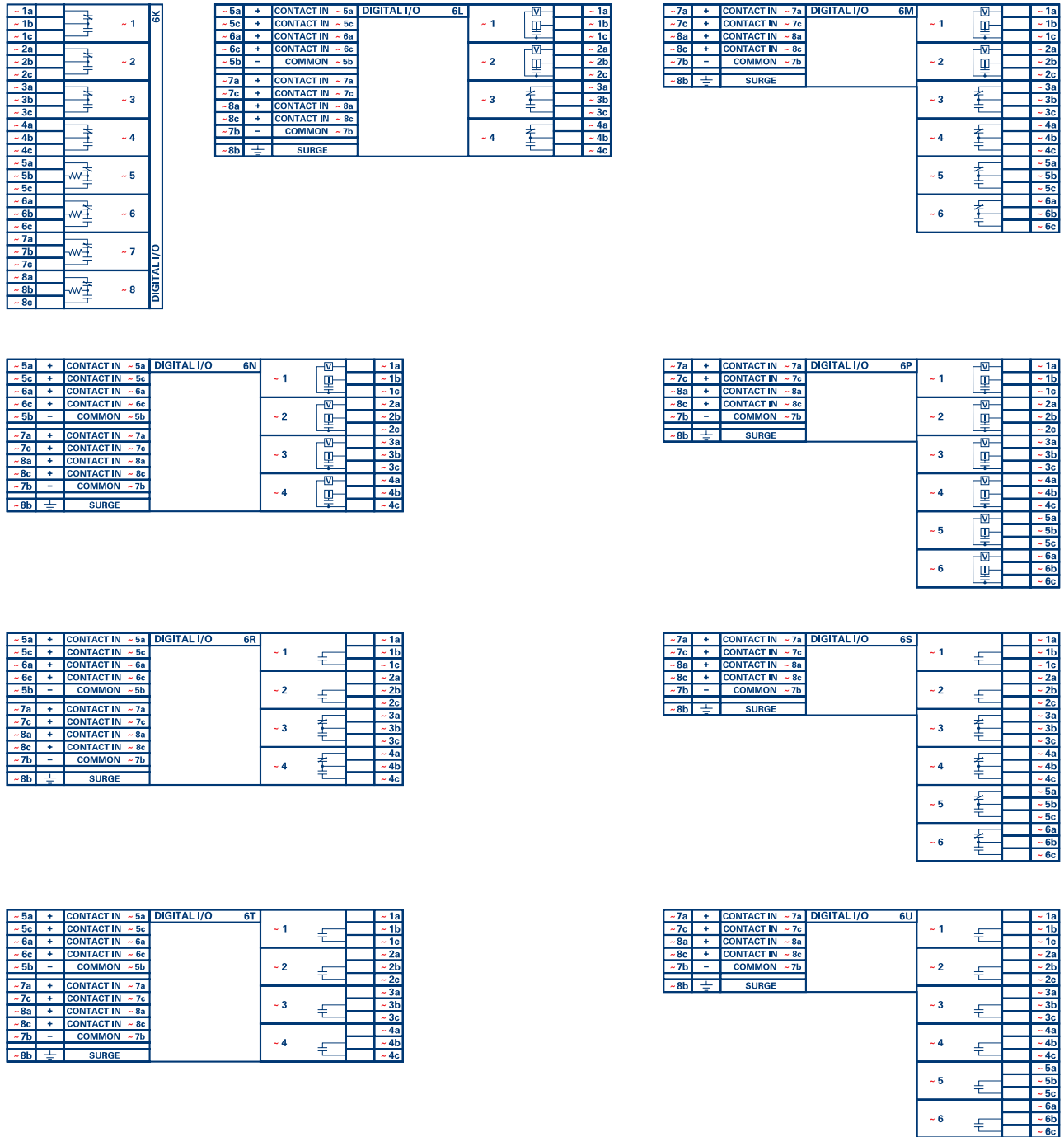
| ~4D MODULE | |
|---------------------|----------|
| TERMINAL ASSIGNMENT | OUTPUT |
| ~1a, ~1c | 2 Inputs |
| ~2a, ~2c | 2 Inputs |
| ~3a, ~3c | 2 Inputs |
| ~4a, ~4c | 2 Inputs |
| ~5a, ~5c | 2 Inputs |
| ~6a, ~6c | 2 Inputs |
| ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs |

| ~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 |



842762A2.CDR

Figure 3-14: DIGITAL INPUT/OUTPUT MODULE WIRING (1 of 2)



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Figure 3-15: DIGITAL INPUT/OUTPUT MODULE WIRING (2 of 2)



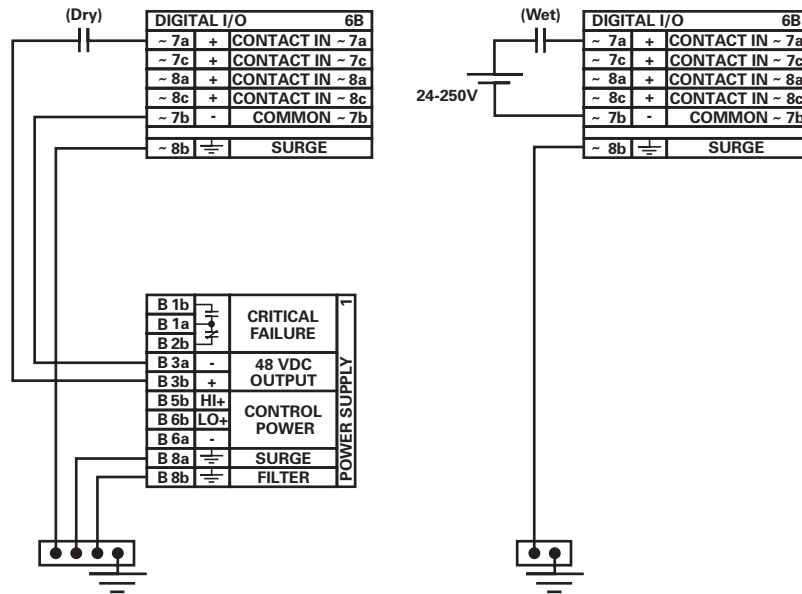
CORRECT POLARITY MUST BE OBSERVED FOR ALL CONTACT INPUT AND SOLID STATE OUTPUT CONNECTIONS FOR PROPER FUNCTIONALITY.

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.



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Figure 3-16: DRY AND WET CONTACT INPUT CONNECTIONS

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.



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 contaminants 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.

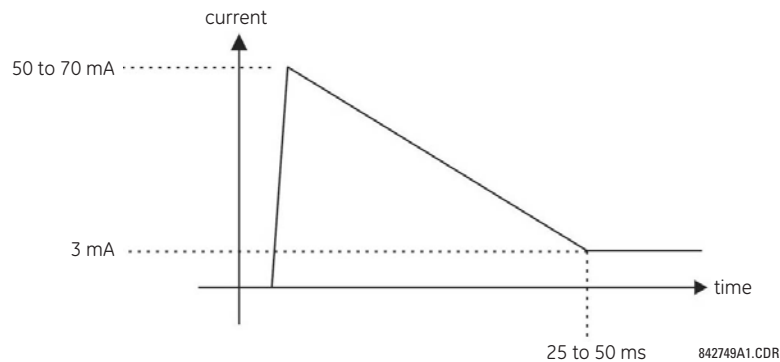


Figure 3-17: CURRENT THROUGH CONTACT INPUTS WITH AUTO-BURNISHING

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 *Digital Input/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.

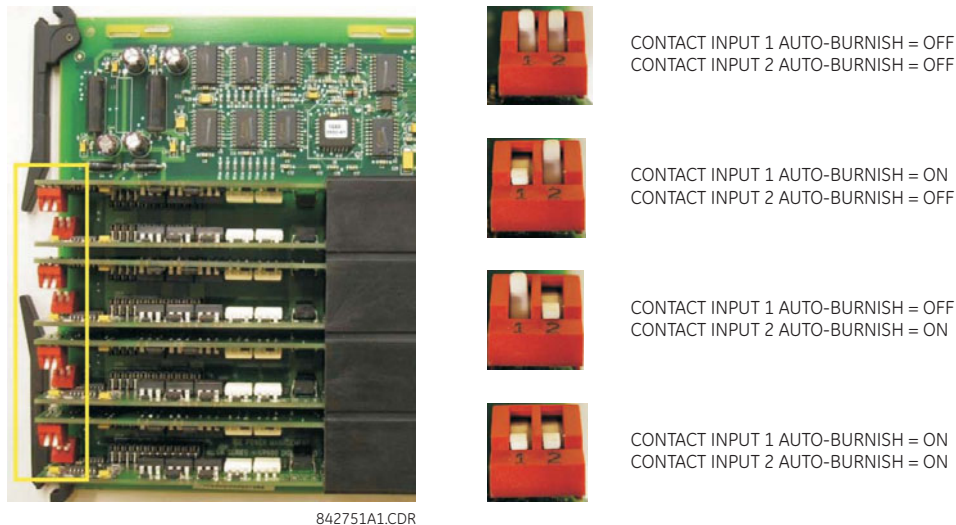


Figure 3-18: AUTO-BURNISH DIP SWITCHES



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

3.2.6 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.



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

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

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

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

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

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

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Figure 3-19: TRANSDUCER INPUT/OUTPUT MODULE WIRING

3.2.7 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.



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

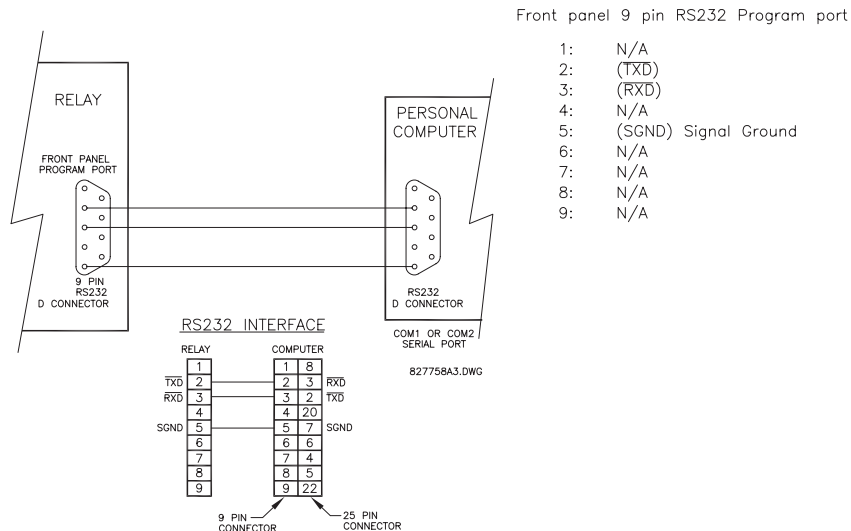


Figure 3–20: RS232 FACEPLATE PORT CONNECTION

3.2.8 CPU COMMUNICATION PORTS

a) OPTIONS

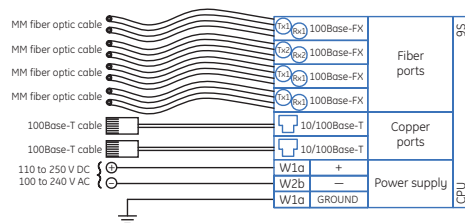
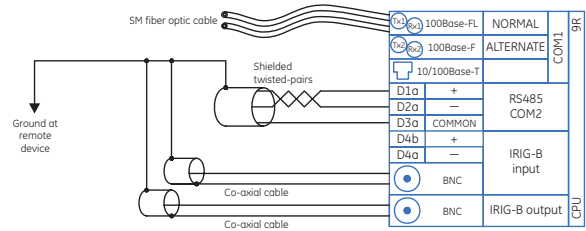
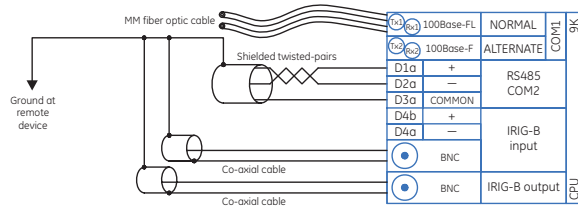
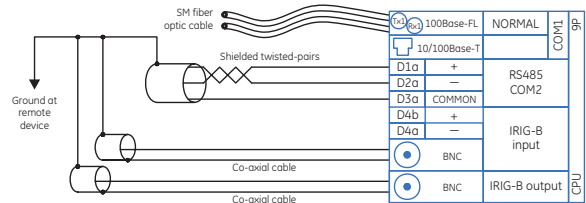
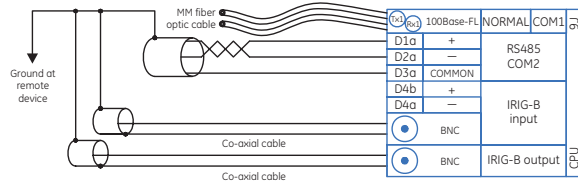
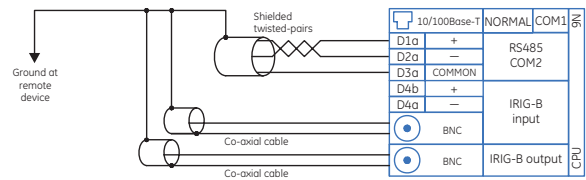
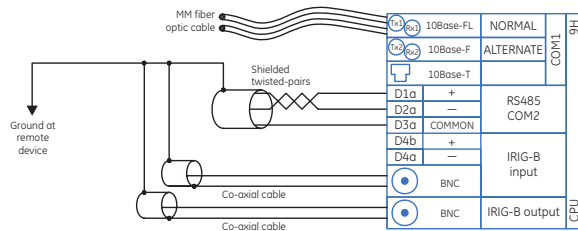
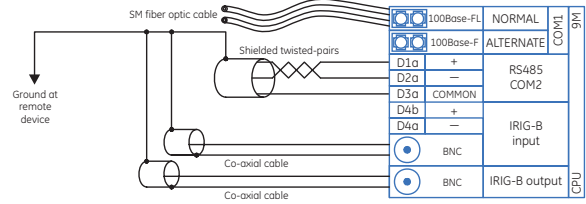
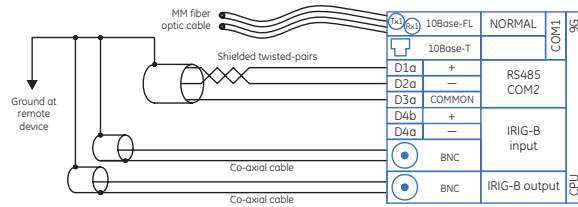
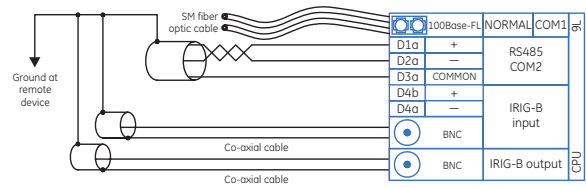
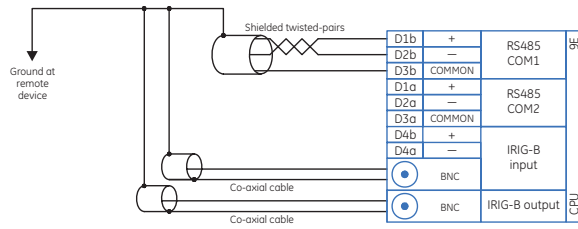
In addition to the faceplate RS232 port, the C70 provides two additional communication ports or a managed six-port Ethernet switch, depending on the installed CPU module.



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 |
| 9N | 10/100Base-T | RS485 |
| 9P | 100Base-FX | RS485 |
| 9R | Redundant 100Base-FX | RS485 |
| 9S | Ethernet switch module with two 10/100Base-T and four 100Base-FX ports | RS485 |



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Figure 3-21: 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. The COM terminal should be connected to the common wire inside the shield, when provided. To avoid loop currents, the shield should be grounded at one point only. 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 increase the number of relays on a single channel to more than 32. 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.

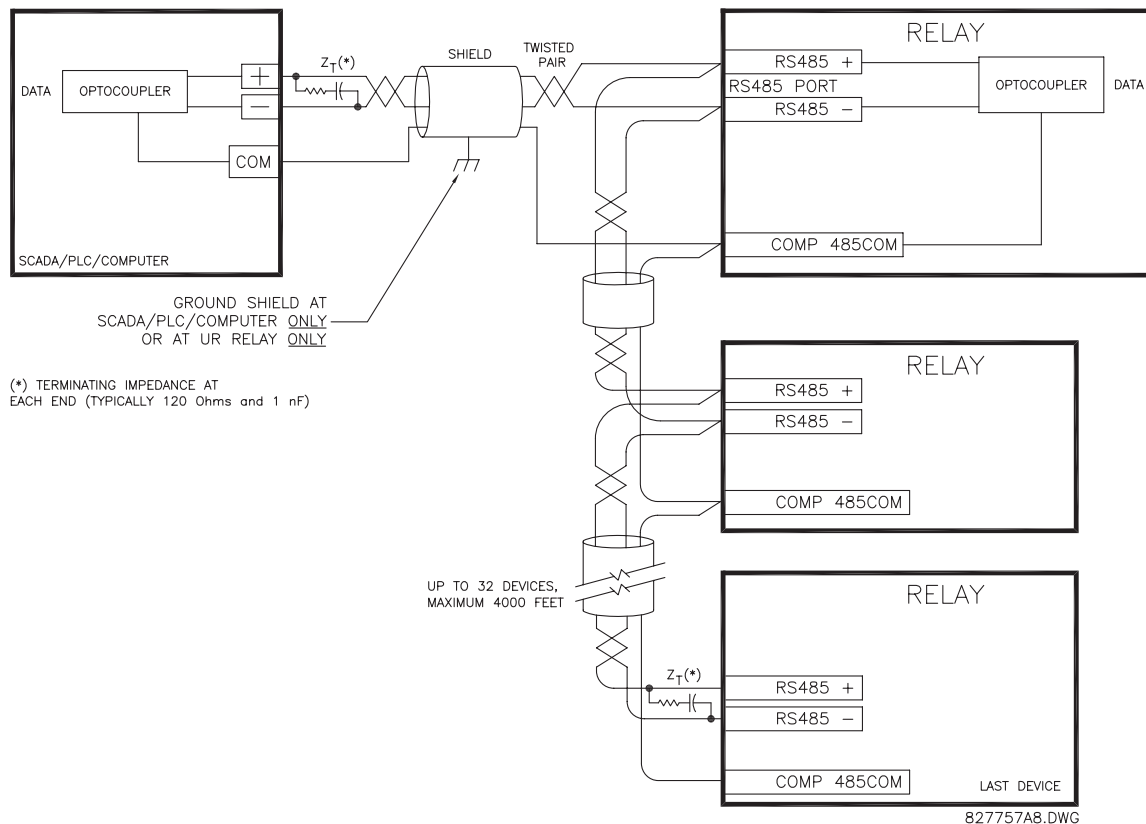


Figure 3–22: RS485 SERIAL CONNECTION

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

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.



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.

3

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.

3.2.9 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.

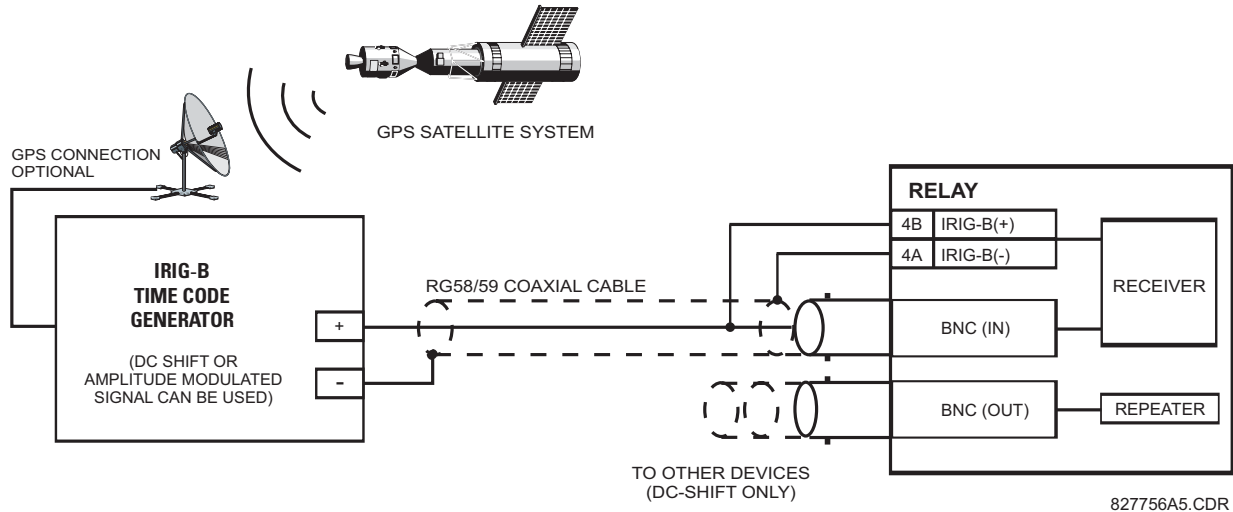


Figure 3–23: IRIG-B CONNECTION

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.

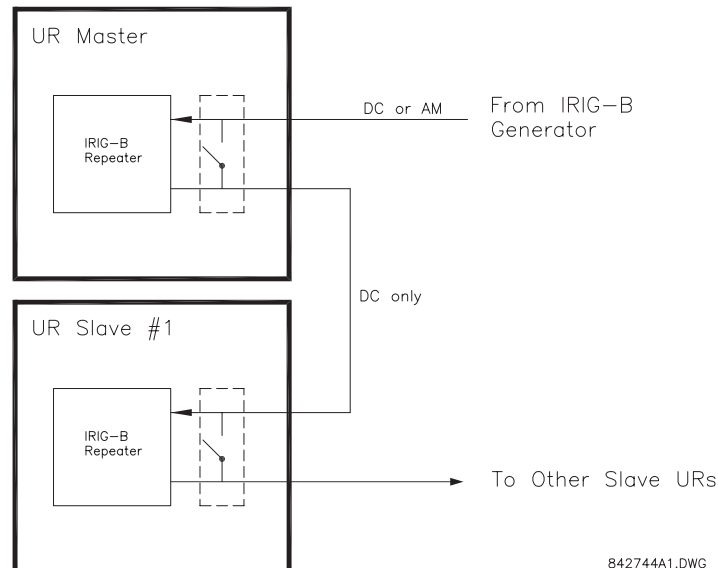


Figure 3–24: IRIG-B REPEATER



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

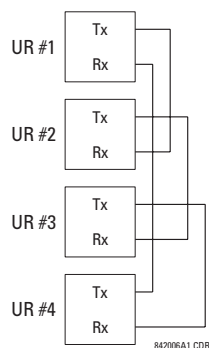


Figure 3–25: DIRECT INPUT AND OUTPUT SINGLE CHANNEL CONNECTION

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.

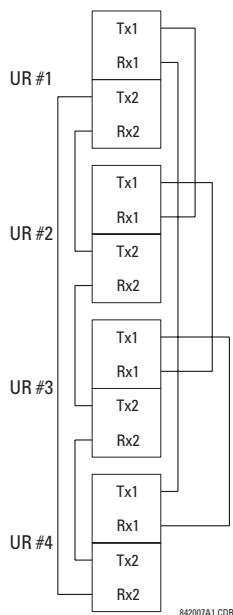


Figure 3–26: DIRECT INPUT AND OUTPUT DUAL CHANNEL CONNECTION

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.

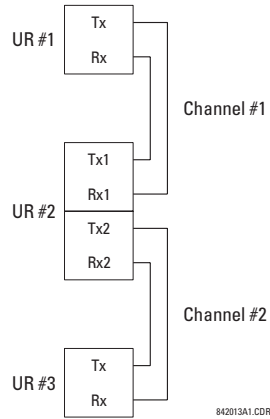


Figure 3–27: DIRECT INPUT AND OUTPUT SINGLE/DUAL CHANNEL COMBINATION CONNECTION

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.



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 |

3



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.

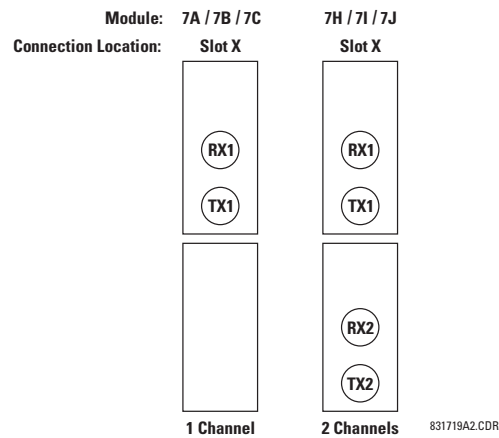


Figure 3–28: LED AND ELED FIBER MODULES

3.3.3 G.703 INTERFACE

a) DESCRIPTION

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



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.

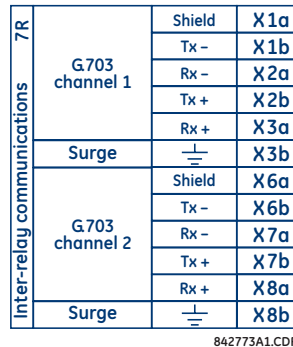


Figure 3-29: G.703 INTERFACE CONFIGURATION

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.

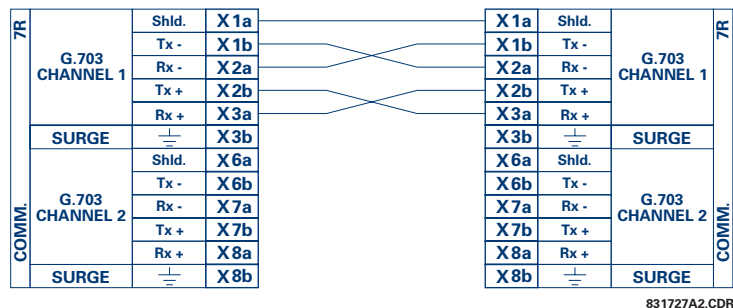


Figure 3-30: TYPICAL PIN INTERCONNECTION BETWEEN TWO G.703 INTERFACES



Pin nomenclature may differ from one manufacturer to another. Therefore, it is not uncommon to see pin-outs 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/insert 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/insertor clips located at the top and at the bottom of each module must be in the disengaged position as the module is smoothly inserted into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module will be fully inserted.

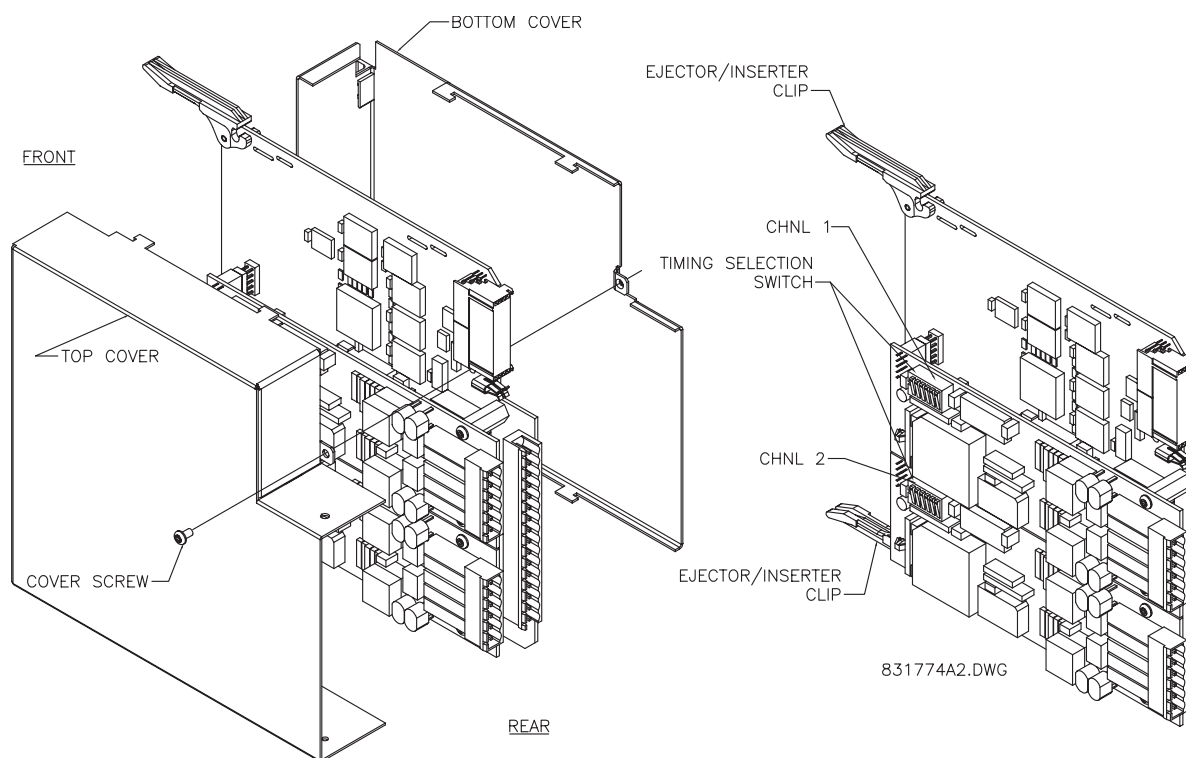


Figure 3-31: G.703 TIMING SELECTION SWITCH SETTING

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

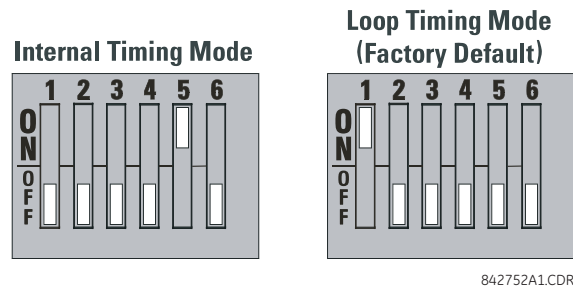
If octet timing is enabled (on), this 8 kHz signal will be asserted during the violation of bit 8 (LSB) necessary for connecting to higher order systems. When C70s are connected back to back, octet timing should be disabled (off).

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

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.

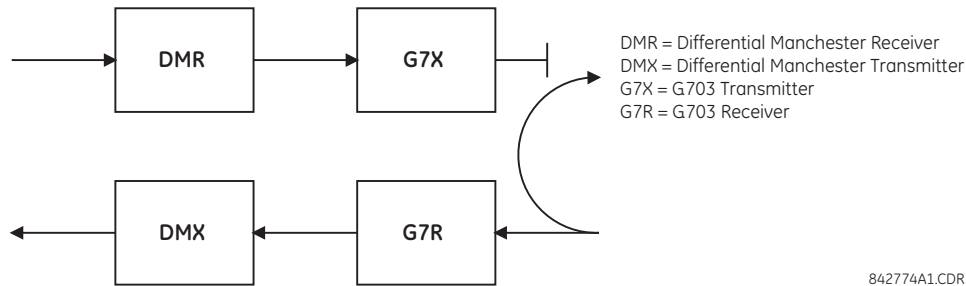


Figure 3-32: G.703 MINIMUM REMOTE LOOPBACK MODE

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.

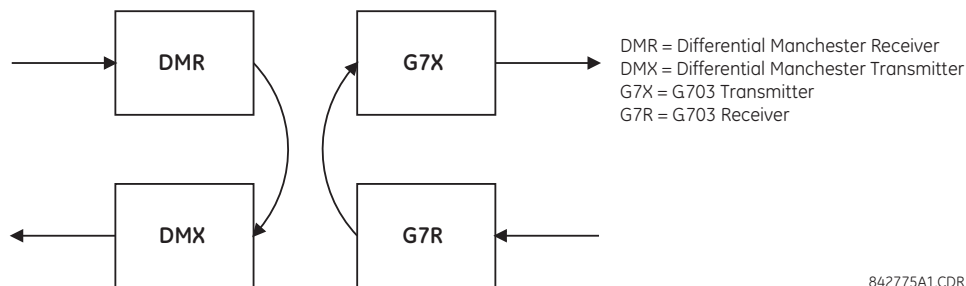


Figure 3-33: G.703 DUAL LOOPBACK MODE

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.

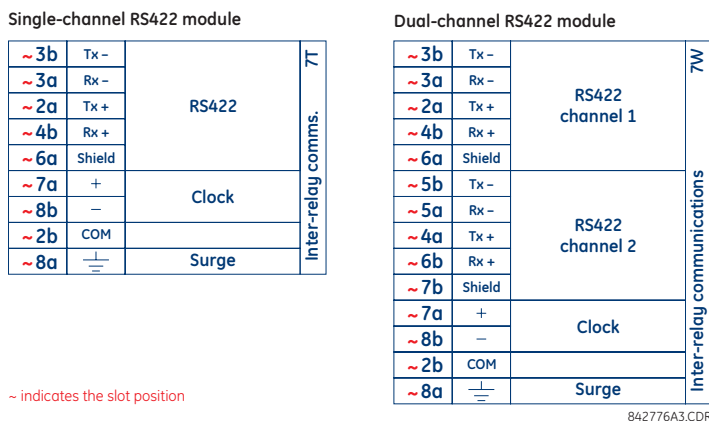


Figure 3-34: RS422 INTERFACE CONNECTIONS

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.

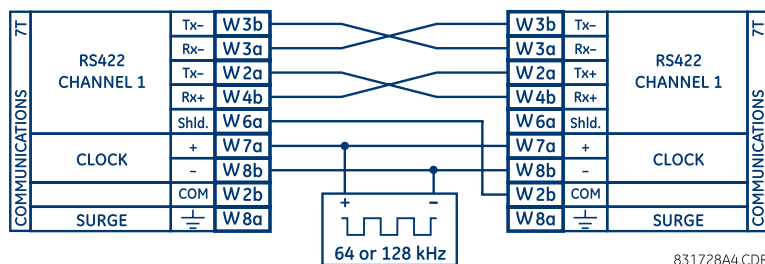


Figure 3-35: TYPICAL PIN INTERCONNECTION BETWEEN TWO RS422 INTERFACES

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.

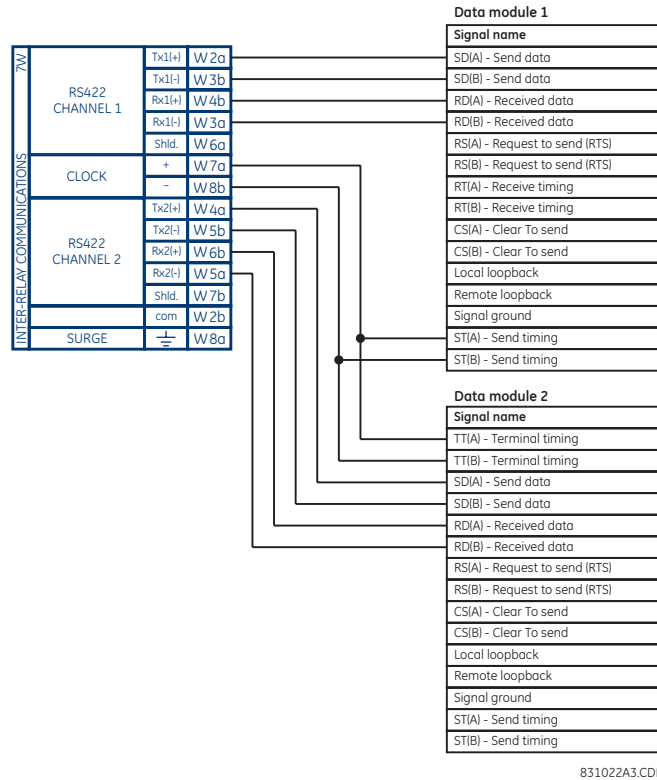


Figure 3-36: TIMING CONFIGURATION FOR RS422 TWO-CHANNEL, 3-TERMINAL APPLICATION

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.

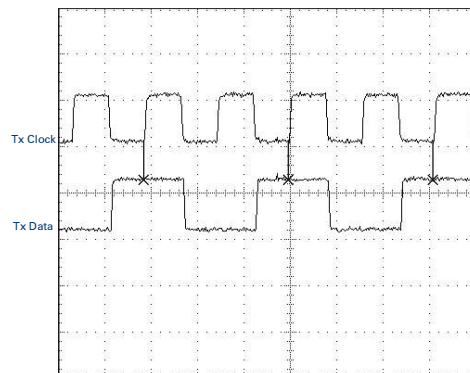


Figure 3-37: CLOCK AND DATA TRANSITIONS

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.

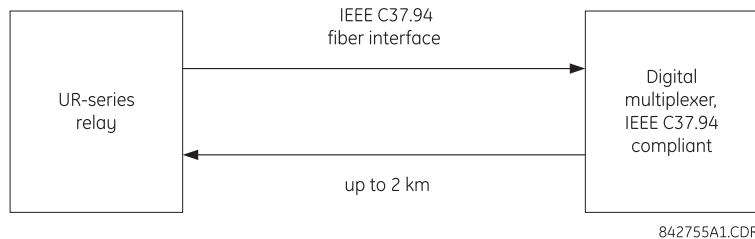
3.3.5 IEEE C37.94 INTERFACE

The UR-series IEEE C37.94 communication modules (modules types 2G, 2H, 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 $64n$ kbps, where $n = 1, 2, \dots, 12$. 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.

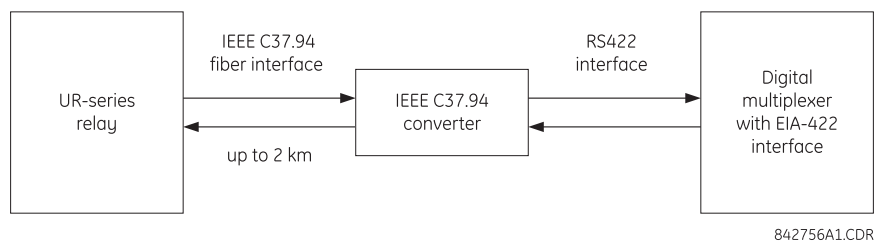
The specifications for the module are as follows:

- IEEE standard: C37.94 for 1×64 kbps optical fiber interface (for 2G and 2H modules) or 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.

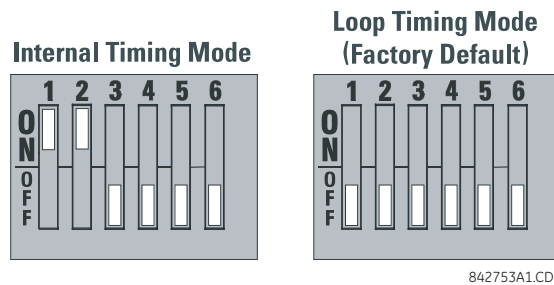
The UR-series C37.94 communication module can be connected directly to any compliant digital multiplexer that supports the IEEE C37.94 standard as shown below.



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 2G, 2H, 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/inserters 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.

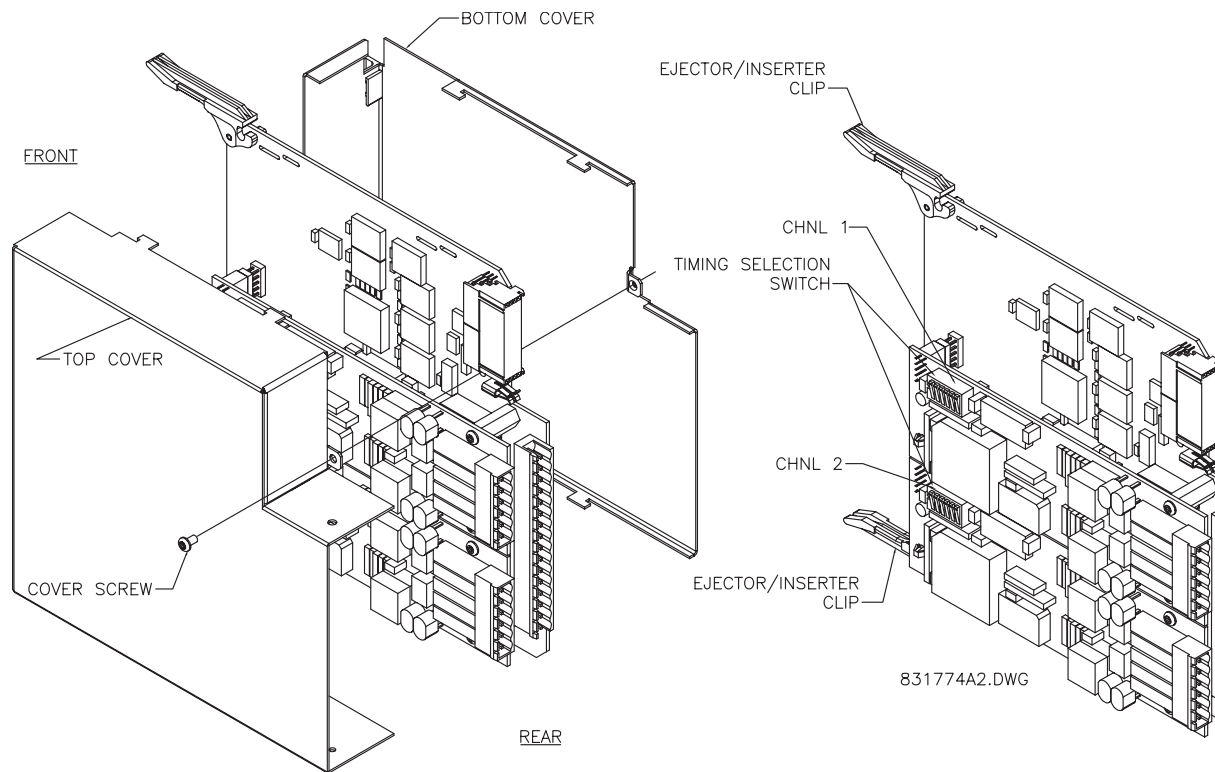


Figure 3–38: IEEE C37.94 TIMING SELECTION SWITCH SETTING

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.



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 |

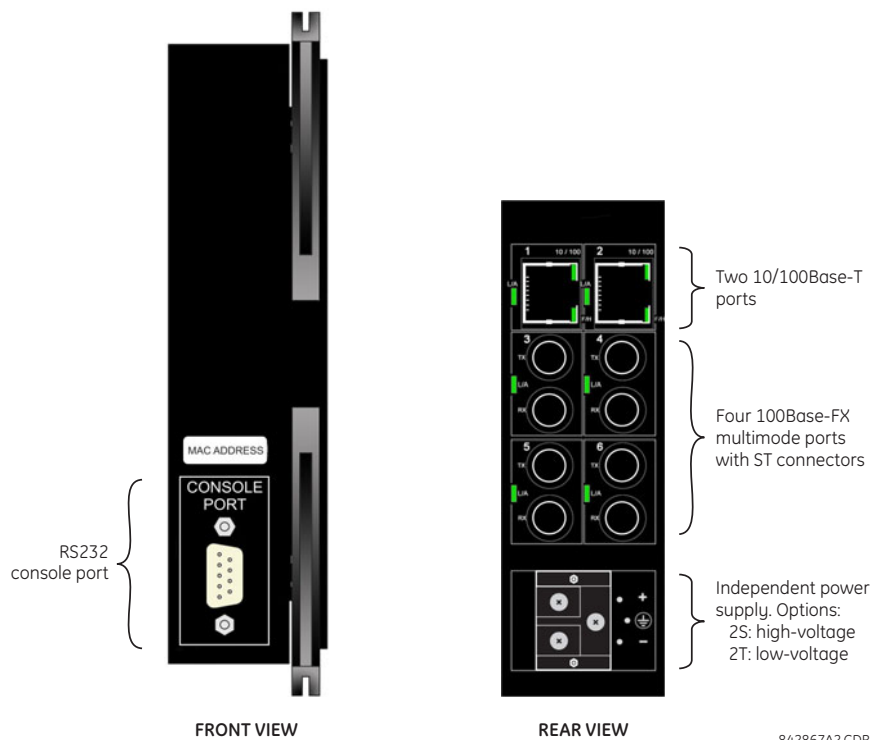
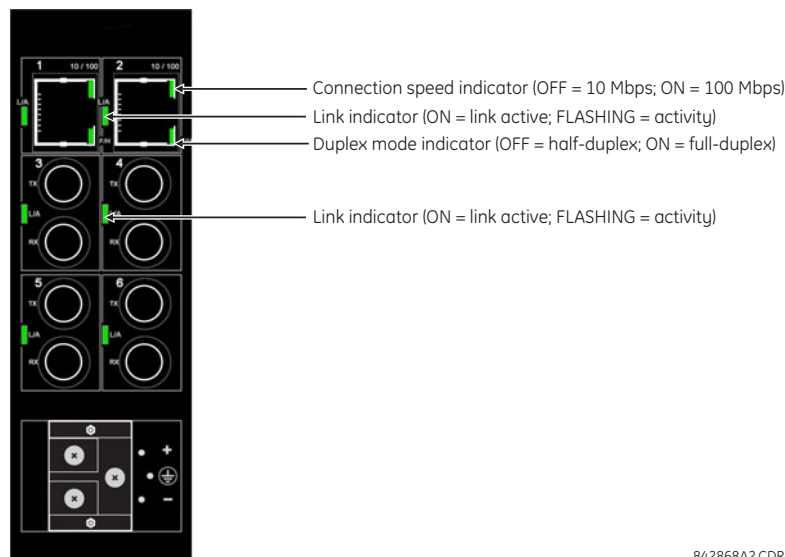


Figure 3–39: MANAGED ETHERNET SWITCHES HARDWARE

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.



842868A2.CDR

Figure 3-40: ETHERNET SWITCH LED INDICATORS

3.4.4 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.



Do not connect to network while configuring the switch module.

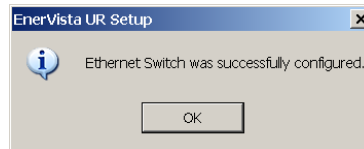
a) CONFIGURING THE SWITCH MODULE IP SETTINGS

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

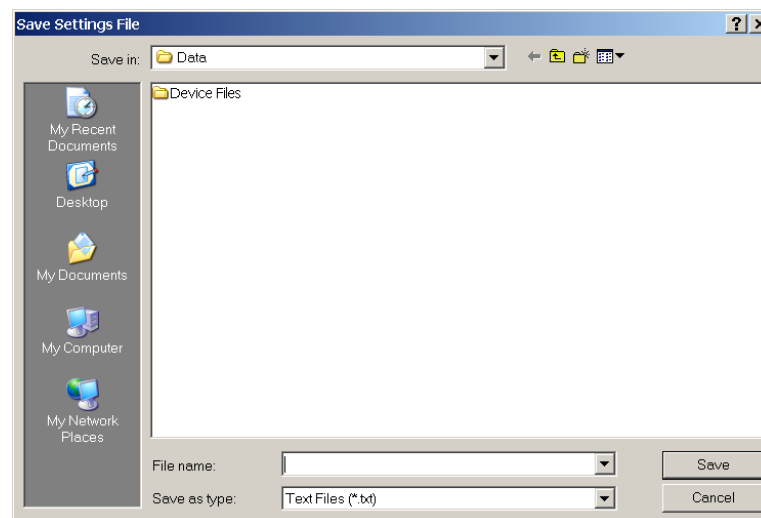
The C70 allows the settings information for the Ethernet switch module to be saved locally as a settings file. This file contains the advanced configuration details for the switch not contained within the standard C70 settings file.

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 > Retrieve Settings File** item from the device settings tree.

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

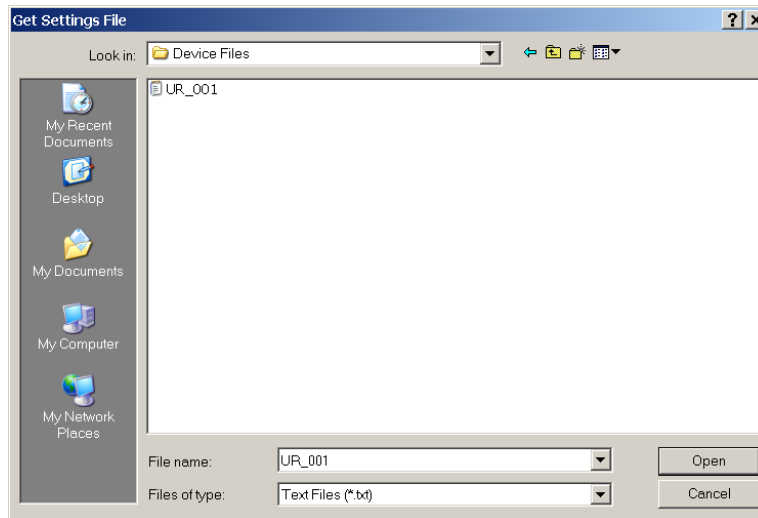
The following procedure describes how to upload local settings files to the Ethernet switch module. It is highly recommended that the current settings are saved to a settings file before uploading a new settings file.



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.

3.4.5 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.



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

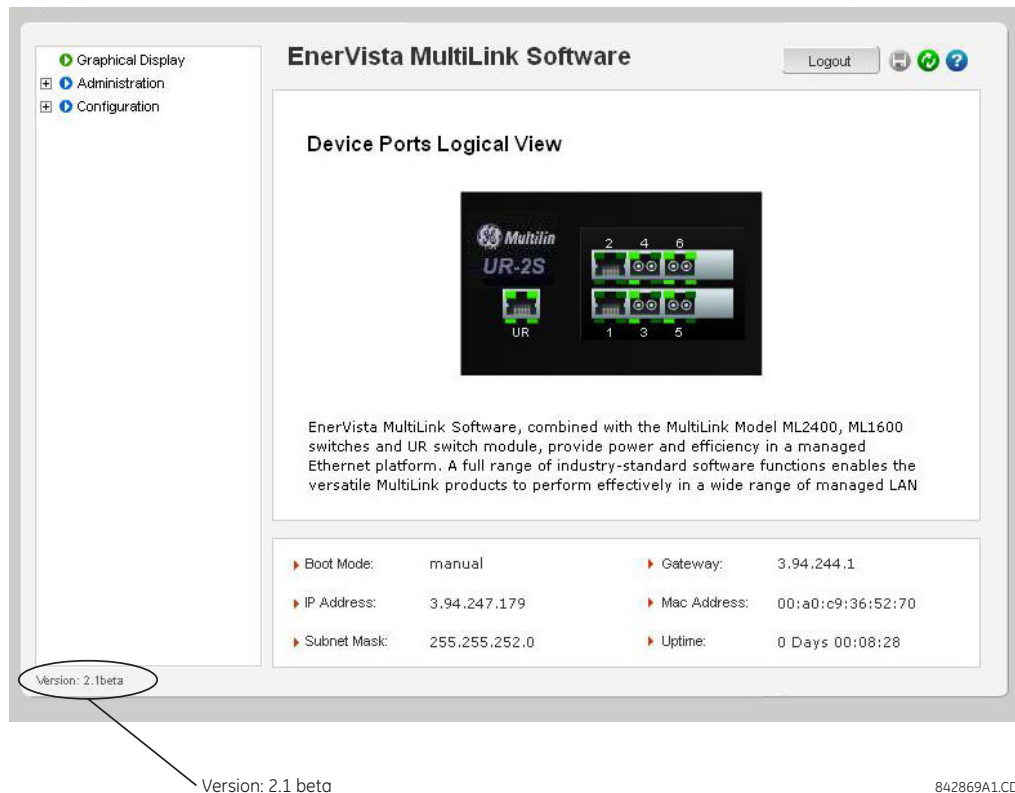
The latest switch module firmware is available as a download from the GE Multilin web site. Use the following procedure to determine the version of firmware currently installed on your switch

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



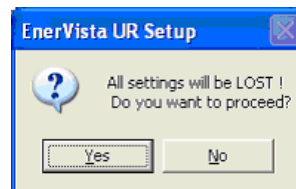
The default switch login ID is “manager” and the default password is “manager”.

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



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

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

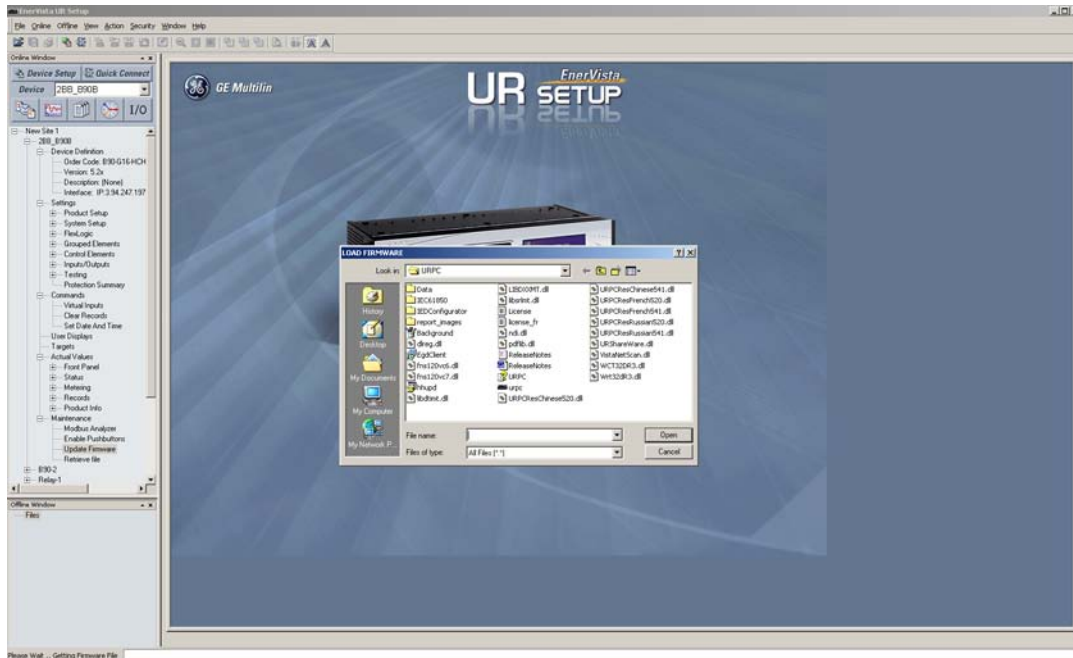


It is highly recommended that you save the switch settings before upgrading the firmware.

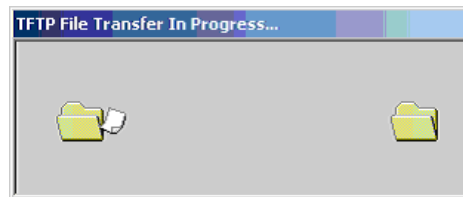
NOTE

- 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.

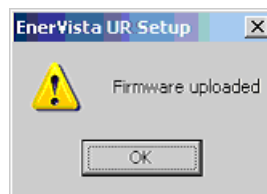
4. Select the firmware file to be loaded on to the Switch, and select the **Open** option.



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:



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

NOTE

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

3.4.6 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. | <ul style="list-style-type: none"> 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. | <ul style="list-style-type: none"> 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. |

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.

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 facility:** The event recorder captures contextual data associated with the last 1024 events, listed in chronological order from most recent to oldest.
- **Oscillography facility:** 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”.



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.

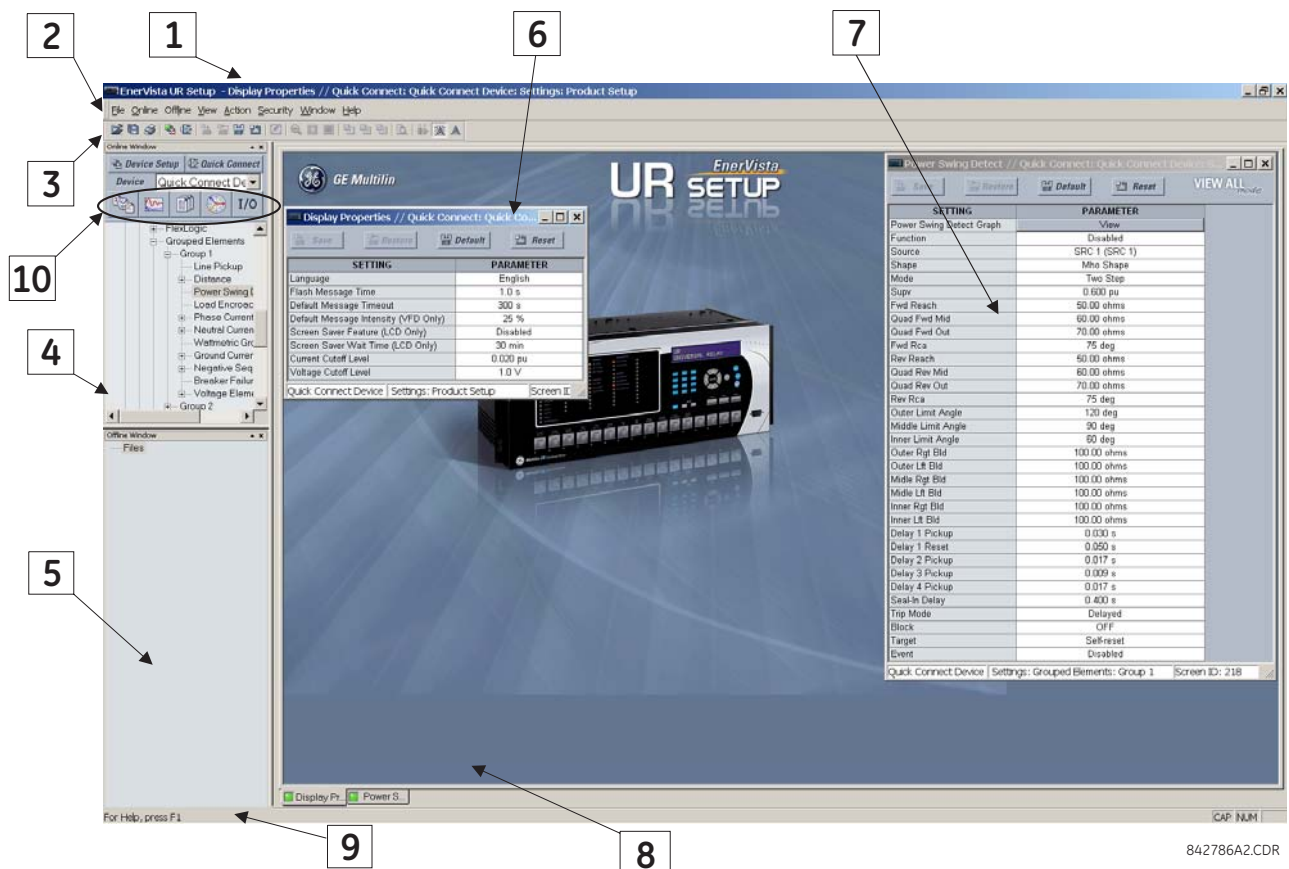


Figure 4-1: ENERVISTA UR SETUP SOFTWARE MAIN WINDOW

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.



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

4

a) ENABLING THE SETTINGS TEMPLATE

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

1. Select a settings file from the offline window of the EnerVista UR Setup main screen.
2. Right-click 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.

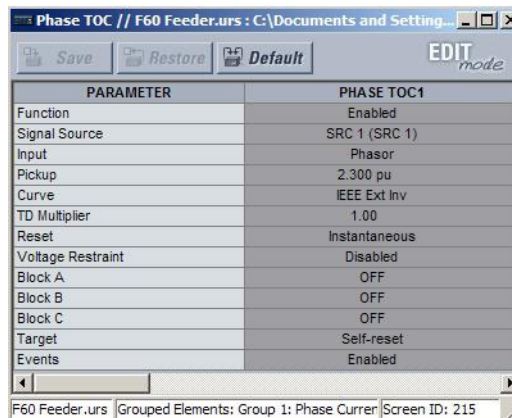


Figure 4-2: SETTINGS TEMPLATE VIEW, ALL SETTINGS SPECIFIED AS LOCKED

- 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.

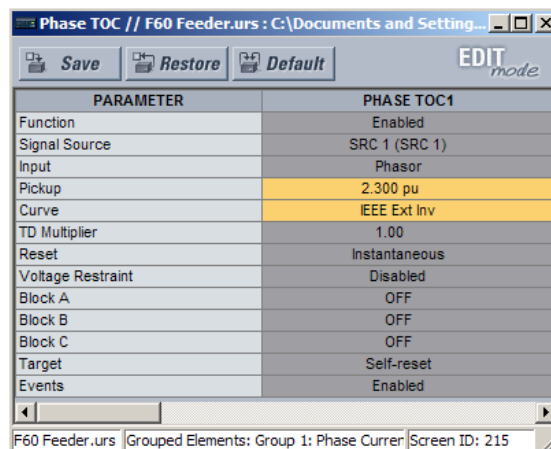


Figure 4-3: SETTINGS TEMPLATE VIEW, TWO SETTINGS SPECIFIED AS EDITABLE

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

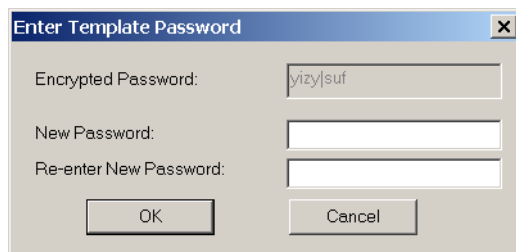
c) ADDING PASSWORD PROTECTION TO A TEMPLATE

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.

- Select a settings file from the offline window on the left of the EnerVista UR Setup main screen.
- 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.



Enter Template Password dialog box with fields for Encrypted Password (yizy|suf), New Password, and Re-enter New Password, with OK and Cancel buttons.

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

The settings file template is now secured with password protection.



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

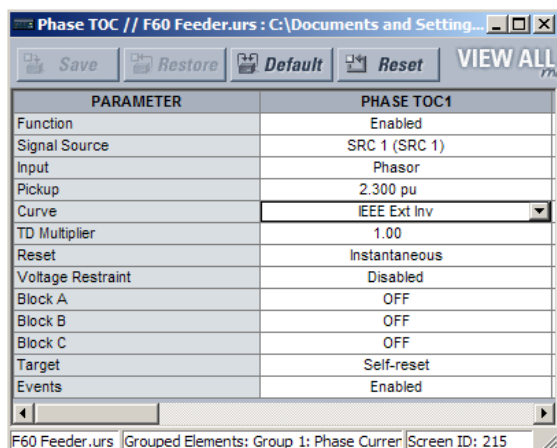
Once all necessary settings are specified for viewing, users are able to view the settings template on the online device or settings file. There are two ways to specify the settings view with the settings template feature:

- 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.

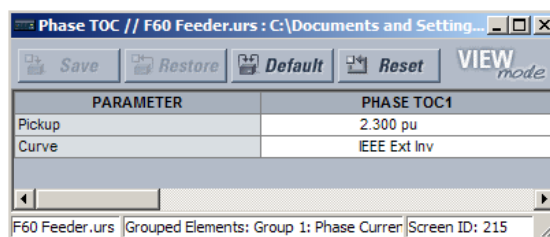


Phase TOC settings window showing parameters for PHASE TOC1. The window includes buttons for Save, Restore, Default, and Reset, and a VIEW ALL button. The parameters listed are:

| 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 |

The status bar shows: F60 Feeder.urs | Grouped Elements: Group 1: Phase Currer | Screen ID: 215

Phase time overcurrent settings window without template applied.



Phase TOC settings window showing parameters for PHASE TOC1. The window includes buttons for Save, Restore, Default, and Reset, and a VIEW mode button. The parameters listed are:

| PARAMETER | PHASE TOC1 |
|-----------|--------------|
| Pickup | 2.300 pu |
| Curve | IEEE Ext Inv |

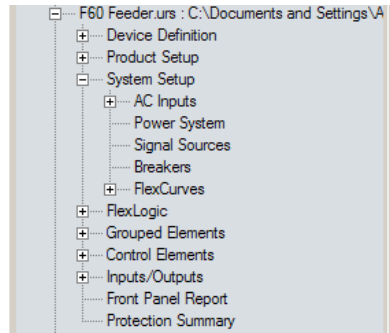
The status bar shows: F60 Feeder.urs | Grouped Elements: Group 1: Phase Currer | Screen ID: 215

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

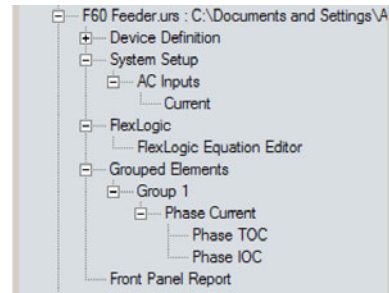
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Figure 4–4: APPLYING TEMPLATES VIA THE VIEW IN TEMPLATE MODE COMMAND

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.

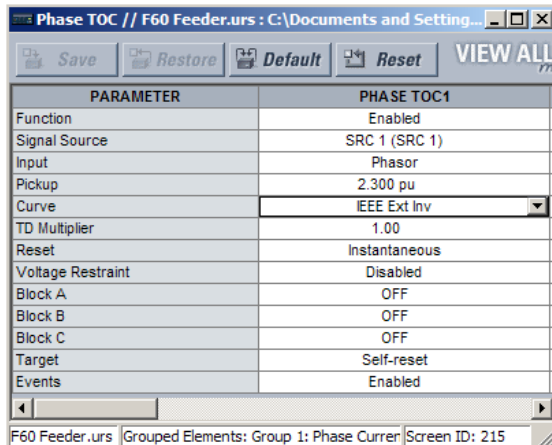
842860A1.CDR

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

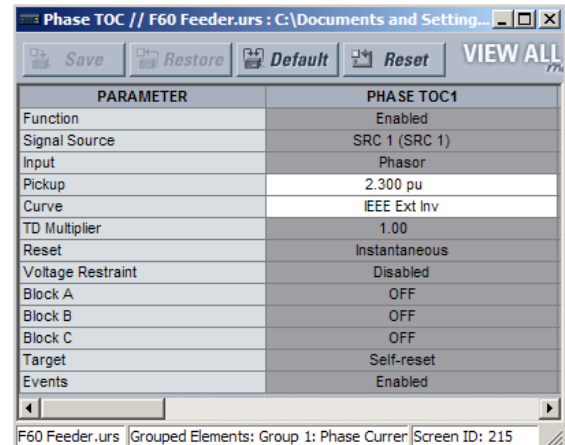
Use the following procedure to display settings available for editing and settings locked by the template.

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.

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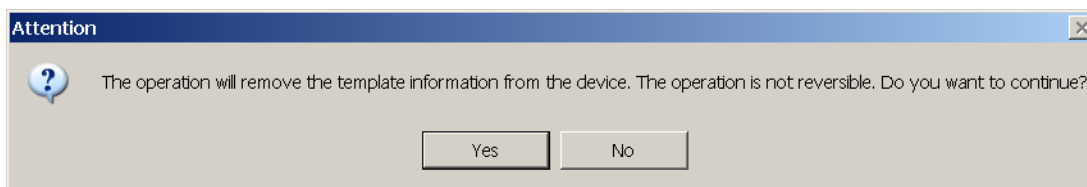
Figure 4-6: APPLYING TEMPLATES VIA THE VIEW ALL SETTINGS COMMAND

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.

- 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.

- Right-click the settings file or online device and select the **Template Mode > Create Template** item to enable the settings template feature.
- 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**.

- 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.

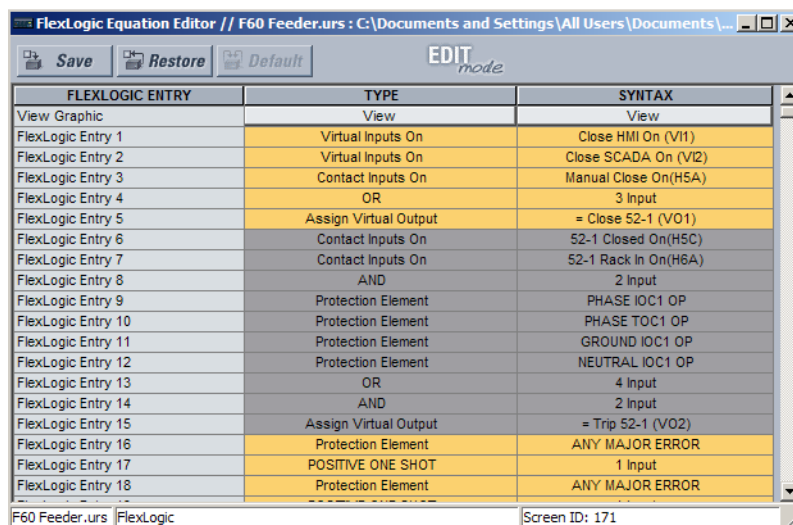


Figure 4-7: LOCKING FLEXLOGIC™ ENTRIES IN EDIT MODE

- Click on **Save** to save and apply changes to the settings template.
- Select the **Template Mode > View In Template Mode** option to view the template.
- 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 (V11) |
| FlexLogic Entry 2 | Virtual Inputs On | Close SCADA On (V12) |
| FlexLogic Entry 3 | Contact Inputs On | Manual Close On(H5A) |
| FlexLogic Entry 4 | OR | 3 Input |
| FlexLogic Entry 5 | Assign Virtual Output | = Close 52-1 (VO1) |
| FlexLogic Entry 6 | Contact Inputs On | 52-1 Closed On(H5C) |
| FlexLogic Entry 7 | Contact Inputs On | 52-1 Rack In On(H6A) |
| FlexLogic Entry 8 | AND | 2 Input |
| FlexLogic Entry 9 | Protection Element | PHASE IOC1 OP |
| FlexLogic Entry 10 | Protection Element | PHASE TOC1 OP |
| FlexLogic Entry 11 | Protection Element | GROUND IOC1 OP |
| FlexLogic Entry 12 | Protection Element | NEUTRAL IOC1 OP |
| FlexLogic Entry 13 | OR | 4 Input |
| FlexLogic Entry 14 | AND | 2 Input |
| FlexLogic Entry 15 | Assign Virtual Output | = Trip 52-1 (VO2) |
| FlexLogic Entry 16 | Protection Element | ANY MAJOR ERROR |
| FlexLogic Entry 17 | POSITIVE ONE SHOT | 1 Input |

Typical FlexLogic™ entries without template applied.

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

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

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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.

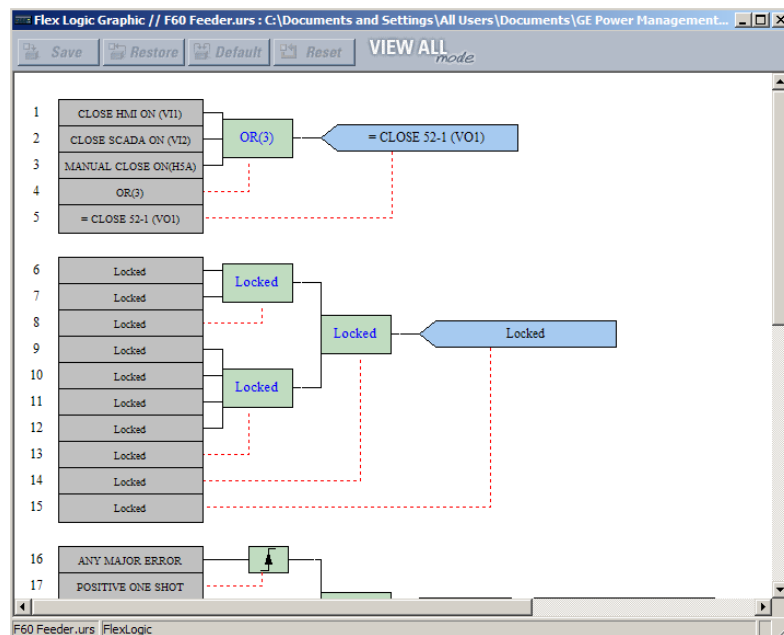


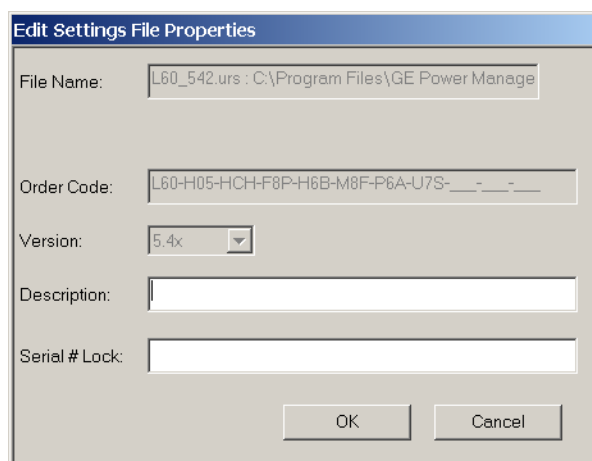
Figure 4-9: SECURED FLEXLOGIC™ IN GRAPHICAL VIEW

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.



The dialog box titled "Edit Settings File Properties" contains the following fields:

- File Name:** L60_542.urs : C:\Program Files\GE Power Manage
- Order Code:** L60-H05-HCH-F8P-H6B-M8F-P6A-U7S-__-__-__
- Version:** 5.4x (dropdown menu)
- Description:** (empty text box)
- Serial # Lock:** (empty text box)

At the bottom are "OK" and "Cancel" buttons.

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 transferred 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.

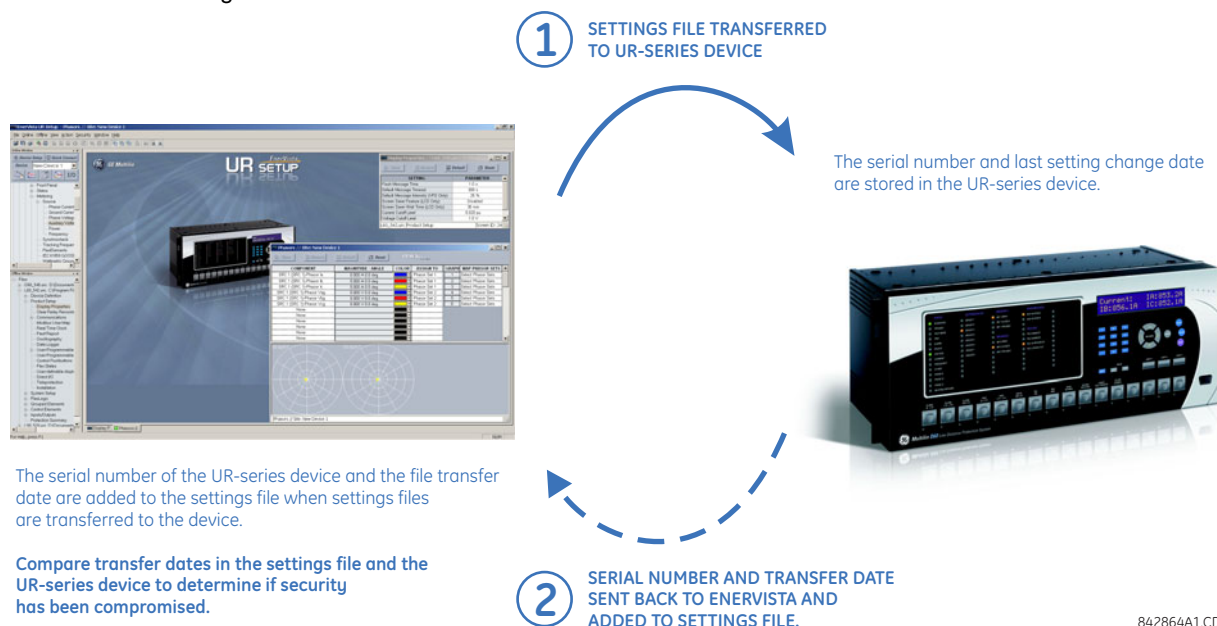


Figure 4–11: SETTINGS FILE TRACEABILITY MECHANISM

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 are 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.

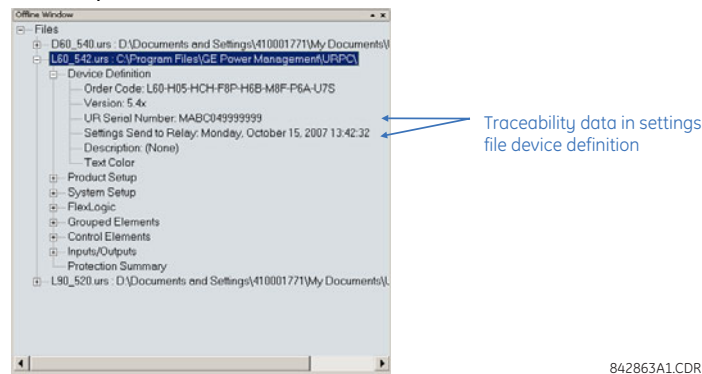


Figure 4-12: DEVICE DEFINITION SHOWING TRACEABILITY DATA

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

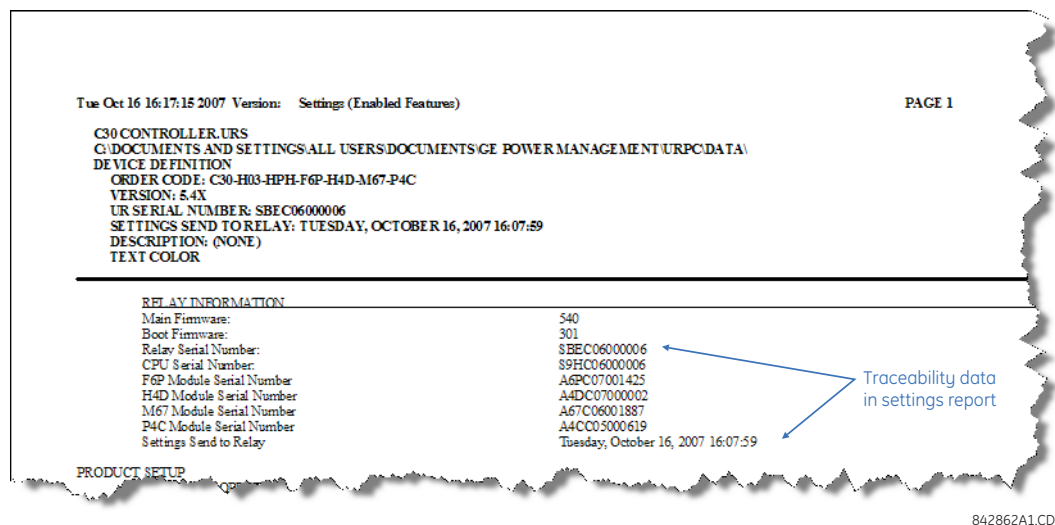
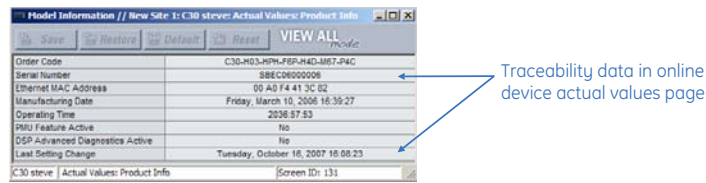


Figure 4-13: SETTINGS FILE REPORT SHOWING TRACEABILITY DATA

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.



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Figure 4-14: TRACEABILITY DATA IN ACTUAL VALUES WINDOW

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

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

c) ADDITIONAL TRACEABILITY RULES

The following additional rules apply for the traceability feature

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

4.3.1 FACEPLATE

a) ENHANCED FACEPLATE

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

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



Figure 4-15: UR-SERIES ENHANCED FACEPLATE

b) STANDARD FACEPLATE

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.

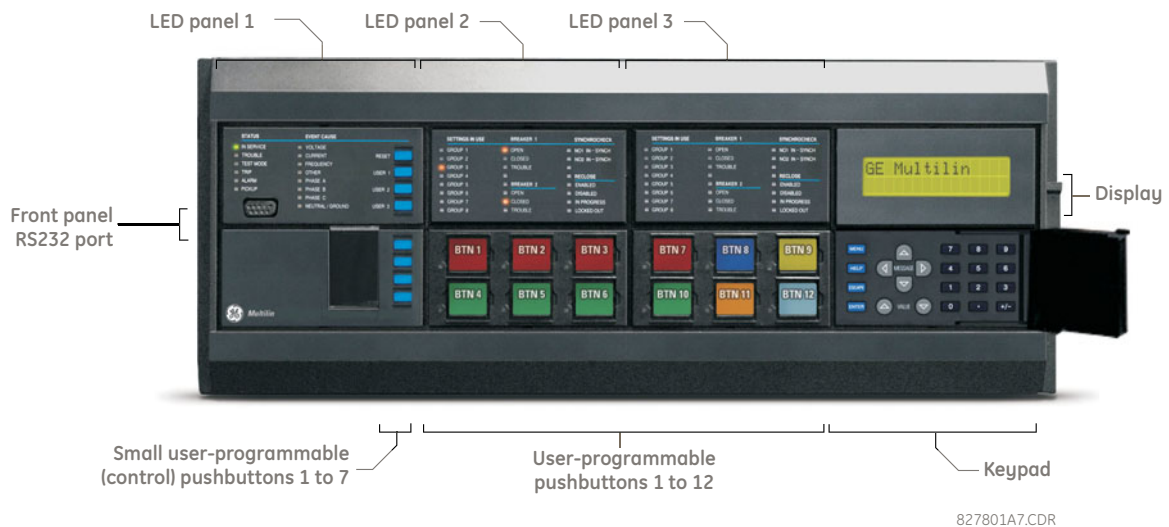


Figure 4-16: UR-SERIES STANDARD HORIZONTAL FACEPLATE PANELS

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.



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Figure 4-17: 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. These indicate the input type that was involved in a condition detected by an element that is operated or has a latched flag waiting to be reset.

- **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.

b) STANDARD FACEPLATE

The standar 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.

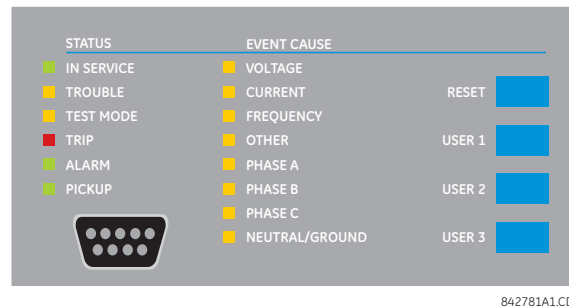


Figure 4–18: LED PANEL 1

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:

These indicate the input type that was involved in a condition detected by an element that is operated or has a latched flag waiting to be reset.

- **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.

| USER-PROGRAMMABLE LEDS | | |
|------------------------|--------|--------|
| ■ (1) | ■ (9) | ■ (17) |
| ■ (2) | ■ (10) | ■ (18) |
| ■ (3) | ■ (11) | ■ (19) |
| ■ (4) | ■ (12) | ■ (20) |
| ■ (5) | ■ (13) | ■ (21) |
| ■ (6) | ■ (14) | ■ (22) |
| ■ (7) | ■ (15) | ■ (23) |
| ■ (8) | ■ (16) | ■ (24) |

| USER-PROGRAMMABLE LEDS | | |
|------------------------|--------|--------|
| ■ (25) | ■ (33) | ■ (41) |
| ■ (26) | ■ (34) | ■ (42) |
| ■ (27) | ■ (35) | ■ (43) |
| ■ (28) | ■ (36) | ■ (44) |
| ■ (29) | ■ (37) | ■ (45) |
| ■ (30) | ■ (38) | ■ (46) |
| ■ (31) | ■ (39) | ■ (47) |
| ■ (32) | ■ (40) | ■ (48) |

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Figure 4–19: 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.

| SETTINGS IN USE | |
|-----------------|---------|
| ■ | GROUP 1 |
| ■ | GROUP 2 |
| ■ | GROUP 3 |
| ■ | GROUP 4 |
| ■ | GROUP 5 |
| ■ | GROUP 6 |
| ■ | GROUP 7 |
| ■ | GROUP 8 |

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Figure 4–20: 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.

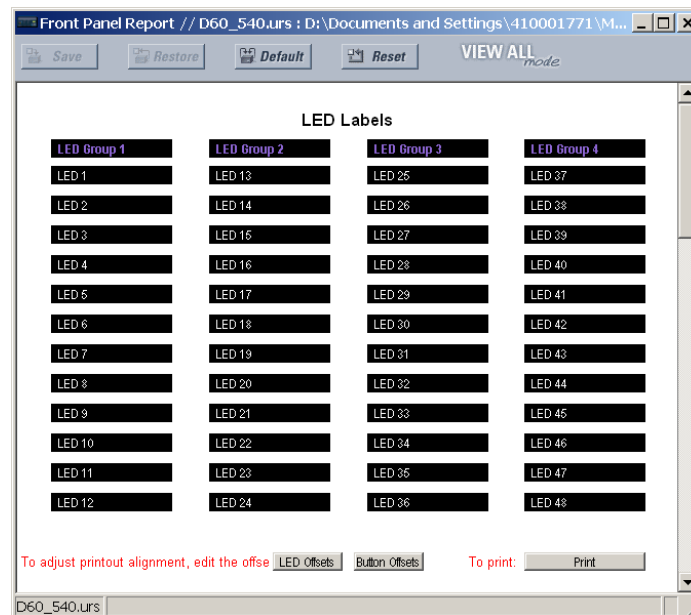


Figure 4-21: FRONT PANEL REPORT WINDOW

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.



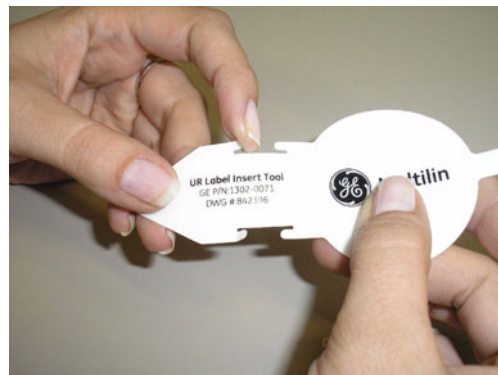
It is important that the tool be used EXACTLY as shown below, with the printed side containing the GE part number facing the user.

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

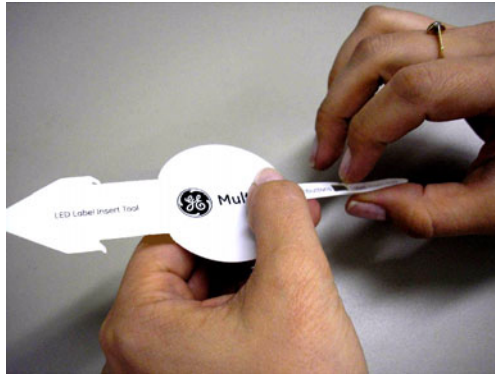
If the default labels are suitable for your application, insert them in the appropriate slots and program the LEDs to match them. If you require custom labels, follow the procedures below to remove the original labels and insert the new ones.

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.

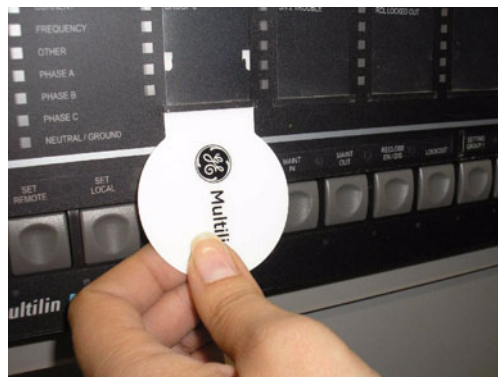


The following procedure describes how to remove the LED labels from the C70 enhanced front panel and insert the custom labels.

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.



- 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.



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



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



4

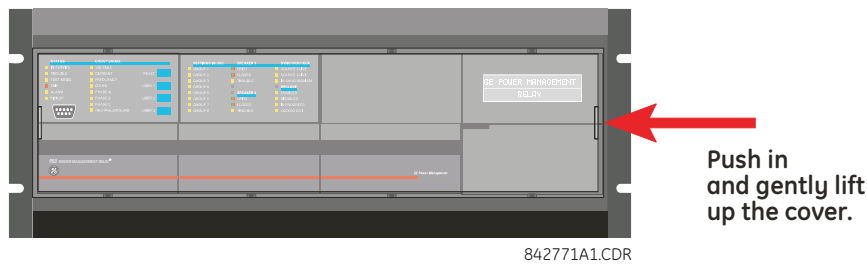
b) STANDARD FACEPLATE

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

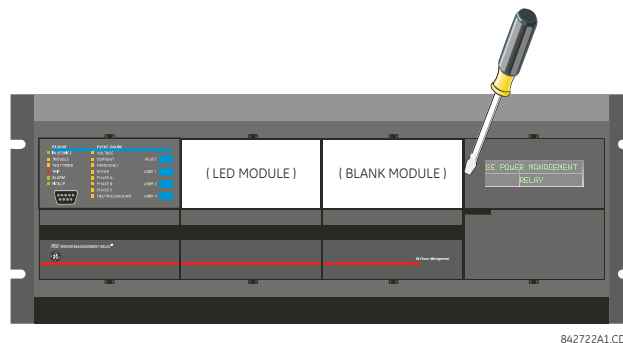
<http://www.GEindustrial.com/multilin/support/ur/>

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.

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



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



- Place the left side of the customized module back to the front panel frame, then snap back the right side.
- 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.

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.

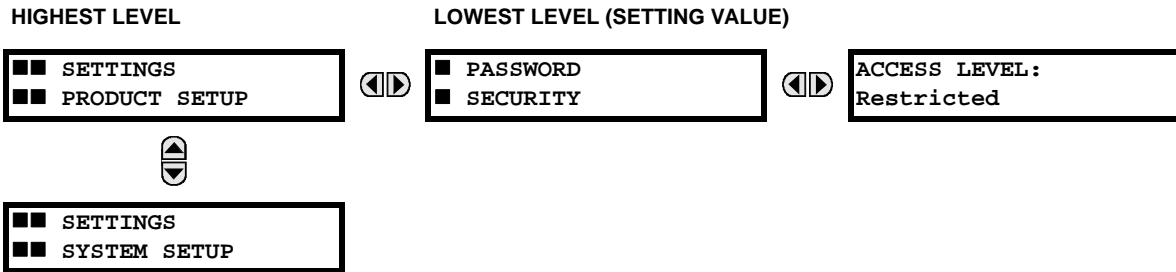
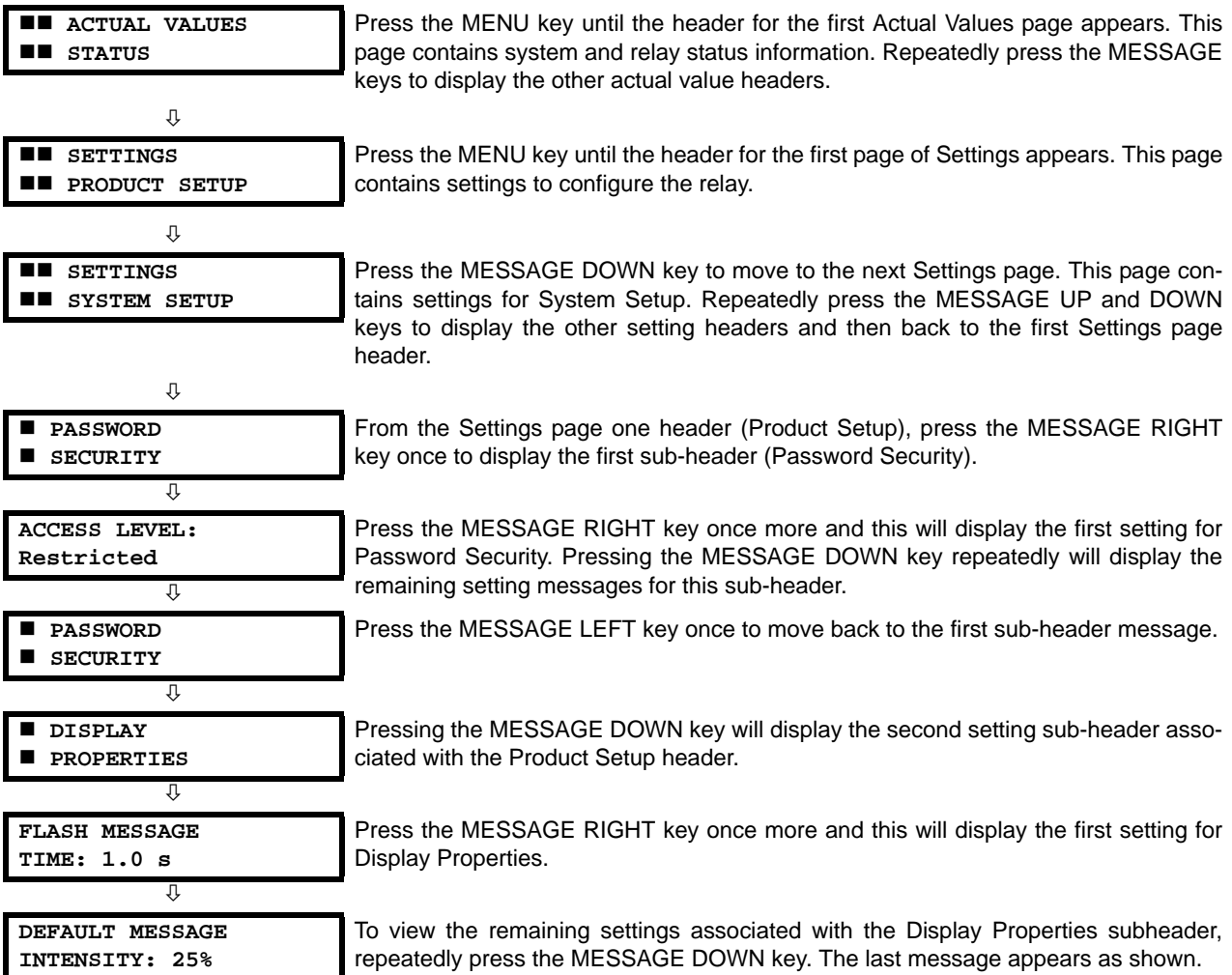
4.3.7 MENUS**a) NAVIGATION**

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.

**c) EXAMPLE MENU NAVIGATION**

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 MESSAGES 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.

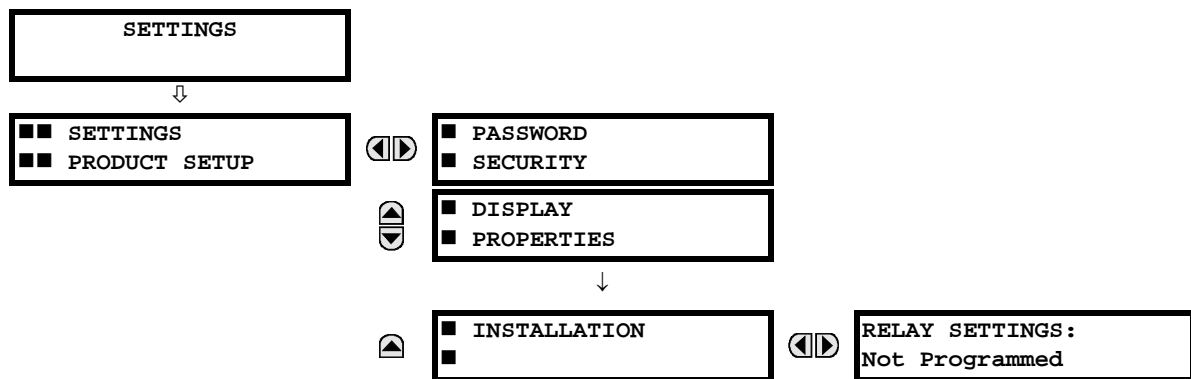
d) ACTIVATING THE RELAY

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.



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:
Not Programmed

RELAY SETTINGS:
Programmed

NEW SETTING
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.

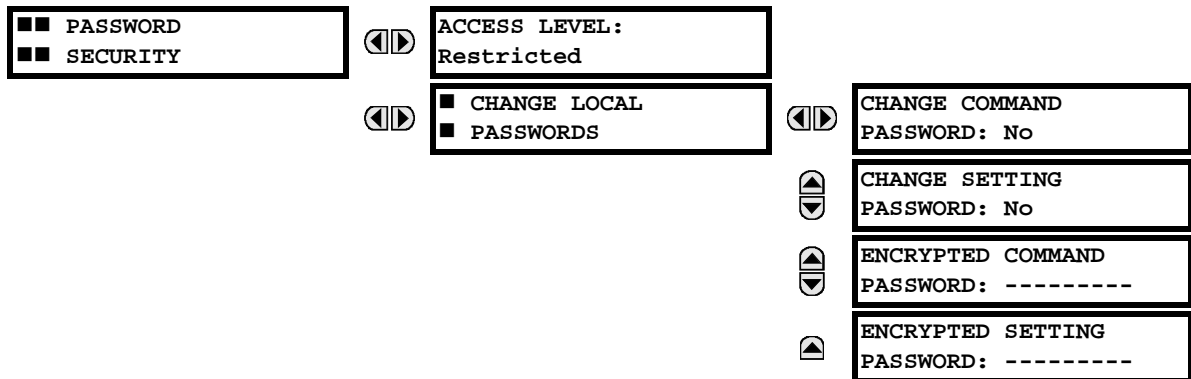
e) ENTERING INITIAL PASSWORDS

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

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.



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.



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

In the event that an incorrect Command or Setting password has been entered via the faceplate interface three times within a three-minute time span, the LOCAL ACCESS DENIED FlexLogic™ operand will be set to "On" and the C70 will not allow Settings or Command access via the faceplate interface for the next ten minutes. The **TOO MANY ATTEMPTS – BLOCKED**

FOR 10 MIN! flash message will appear upon activation of the ten minute timeout or any other time a user attempts any change to the defined tier during the ten minute timeout. The LOCAL ACCESS DENIED FlexLogic™ operand will be set to “Off” after the expiration of the ten-minute timeout.

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

| | | | |
|---|----|--|----------------|
| <div> <div>■ ■ SETTINGS</div> <div>■ ■ PRODUCT SETUP</div> </div> | ◀▶ | <div>■ SECURITY</div> | See page 5-8. |
| ▼ | ▲▼ | <div>■ DISPLAY</div> <div>■ PROPERTIES</div> | See page 5-11. |
| | ▲▼ | <div>■ CLEAR RELAY</div> <div>■ RECORDS</div> | See page 5-13. |
| | ▲▼ | <div>■ COMMUNICATIONS</div> | See page 5-14. |
| | ▲▼ | <div>■ MODBUS USER MAP</div> | See page 5-32. |
| | ▲▼ | <div>■ REAL TIME</div> <div>■ CLOCK</div> | See page 5-33. |
| | ▲▼ | <div>■ USER-PROGRAMMABLE</div> <div>■ FAULT REPORT</div> | See page 5-34. |
| | ▲▼ | <div>■ OSCILLOGRAPHY</div> | See page 5-35. |
| | ▲▼ | <div>■ DATA LOGGER</div> | See page 5-37. |
| | ▲▼ | <div>■ USER-PROGRAMMABLE</div> <div>■ LEDS</div> | See page 5-39. |
| | ▲▼ | <div>■ USER-PROGRAMMABLE</div> <div>■ SELF TESTS</div> | See page 5-42. |
| | ▲▼ | <div>■ CONTROL</div> <div>■ PUSHBUTTONS</div> | See page 5-43. |
| | ▲▼ | <div>■ USER-PROGRAMMABLE</div> <div>■ PUSHBUTTONS</div> | See page 5-44. |
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| | ▲▼ | <div>■ USER-DEFINABLE</div> <div>■ DISPLAYS</div> | See page 5-50. |
| | ▲▼ | <div>■ DIRECT I/O</div> | See page 5-52. |
| | ▲ | <div>■ INSTALLATION</div> | See page 5-59. |
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| <div> <div>■ ■ SETTINGS</div> <div>■ ■ SYSTEM SETUP</div> </div> | ◀▶ | <div>■ AC INPUTS</div> | See page 5-61. |
| ▼ | ▲▼ | <div>■ POWER SYSTEM</div> | See page 5-62. |
| | ▲▼ | <div>■ SIGNAL SOURCES</div> | See page 5-64. |
| | ▲▼ | <div>■ BREAKERS</div> | See page 5-66. |

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|---|----|------------------------------------|-----------------|
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| | ▲ | ■ FLEXCURVES ■ | See page 5-73. |
| <div> <div>▲</div> <div>■ ■ SETTINGS ■ ■ GROUPED ELEMENTS</div> <div>▼</div> </div> | ◀▶ | ■ FLEXLOGIC ■ EQUATION EDITOR | See page 5-95. |
| | ▲ | ■ FLEXLOGIC ■ TIMERS | See page 5-95. |
| | ▲ | ■ FLEXELEMENTS ■ | See page 5-96. |
| | ▲ | ■ NON-VOLATILE ■ LATCHES | See page 5-100. |
| <div> <div>▲</div> <div>■ ■ SETTINGS ■ ■ CONTROL ELEMENTS</div> <div>▼</div> </div> | ◀▶ | ■ SETTING GROUP 1 ■ | See page 5-101. |
| | ▲ | ■ SETTING GROUP 2 ■ | |
| | | ↓ | |
| | ▲ | ■ SETTING GROUP 6 ■ | |
| | ◀▶ | ■ SETTING GROUPS ■ | See page 5-152. |
| | ▲ | ■ SELECTOR SWITCH ■ | See page 5-153. |
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| | ▲ | ■ CAPACITOR CONTROL ■ | See page 5-160. |
| | ▲ | ■ AUTOMATIC VOLTAGE ■ REGULATOR | See page 5-165. |
| | ▲ | ■ DIGITAL ELEMENTS ■ | See page 5-170. |
| <div> <div>▲</div> <div>■ ■ SETTINGS ■ ■ INPUTS / OUTPUTS</div> <div>▼</div> </div> | ▲ | ■ DIGITAL COUNTERS ■ | See page 5-173. |
| | ▲ | ■ MONITORING ■ ELEMENTS | See page 5-175. |
| | ▲ | ■ TRIP BUS ■ | See page 5-175. |
| | ◀▶ | ■ CONTACT INPUTS ■ | See page 5-186. |
| | ▲ | ■ VIRTUAL INPUTS ■ | See page 5-188. |

| | | | |
|---|---------------------------|---|-----------------|
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| | <div>▲</div> | <div>■ DIRECT OUTPUTS</div> <div>■</div> | See page 5-196. |
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| | <div>▲</div> <div>▼</div> | <div>■ RTD INPUTS</div> <div>■</div> | See page 5-200. |
| | <div>▲</div> | <div>■ DCMA OUTPUTS</div> <div>■</div> | See page 5-201. |
| <div>▲</div> <div>■ ■ SETTINGS</div> <div>■ ■ TESTING</div> | <div>◀▶</div> | <div>TEST MODE</div> <div>FUNCTION: Disabled</div> | See page 5-205. |
| | <div>▲</div> <div>▼</div> | <div>TEST MODE INITIATE:</div> <div>On</div> | See page 5-205. |
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| | <div>▲</div> | <div>■ FORCE CONTACT</div> <div>■ OUTPUTS</div> | See page 5-206. |

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 values as the input.



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:

$$\text{pu quantity} = (\text{actual quantity}) / (\text{base quantity})$$

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:

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

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

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

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 3I₀ 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, 3I₀, and ground current, current from CTs with different ratios are adjusted to a single ratio before summation.

A mechanism called a “Source” configures the routing of CT and VT input channels to measurement sub-systems. Sources, in the context of 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.

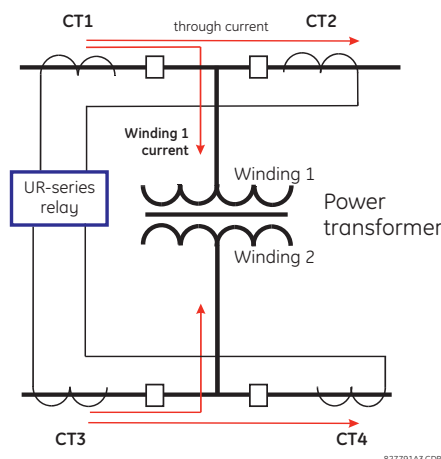


Figure 5-1: BREAKER-AND-A-HALF SCHEME

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.

5

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 configures one Source to be the sum of CT1 and CT2 and can name this Source as "Wdg 1 Current".

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.

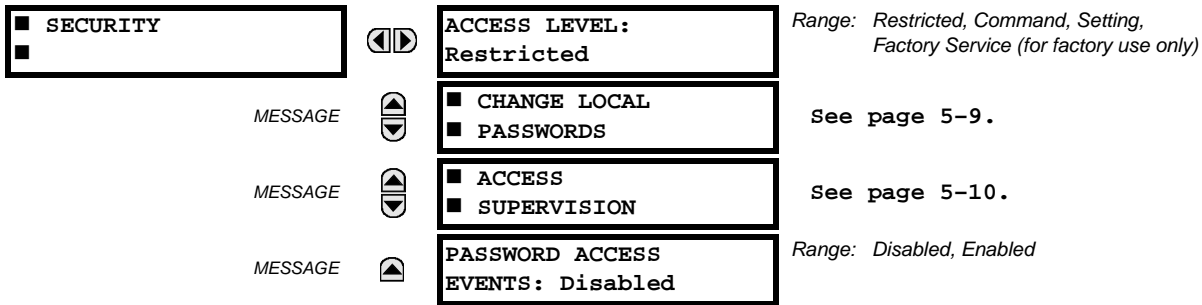
The above section explains how the input channels are identified and configured to the specific application instrument transformers and the connections of these transformers. The specific parameters to be used by each measuring element and comparator, and some actual values are controlled by selecting 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



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.

b) LOCAL PASSWORDS

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ CHANGE LOCAL PASSWORDS

| | | | |
|---|---|---|---|
| <input checked="" type="checkbox"/> CHANGE LOCAL <input checked="" type="checkbox"/> PASSWORDS | <div>◀▶</div> <div>▲▼</div> <div>MESSAGE</div> <div>▲▼</div> <div>MESSAGE</div> <div>▲▼</div> <div>MESSAGE</div> <div>▲</div> | <div>CHANGE COMMAND PASSWORD: No</div> <div>CHANGE SETTING PASSWORD: No</div> <div>ENCRYPTED COMMAND PASSWORD: -----</div> <div>ENCRYPTED SETTING PASSWORD: -----</div> | <div>Range: No, Yes</div> <div>Range: No, Yes</div> <div>Range: 0 to 9999999999 Note: ----- indicates no password</div> <div>Range: 0 to 9999999999 Note: ----- indicates no password</div> |
|---|---|---|---|

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**.



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.

| PARAMETER | ENCRYPTED PASSWORD | ENTER NEW PASSWORD | CONFIRM NEW PASSWORD | CHANGE PASSWORD |
|------------------|--------------------|--------------------|----------------------|-----------------|
| Command Password | 0 | | | Change |
| Setting Password | 0 | | | Change |

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 to 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.

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d) ACCESS SUPERVISION

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ACCESS SUPERVISION

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 and 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 ATTEMPTS 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

| | | | |
|--|---|--|---------------------------------------|
| <div> <div>■ ACCESS LEVEL</div> <div>■ TIMEOUTS</div> </div> | <div> <div>◀▶</div> <div>MESSAGE ▲</div> </div> | <div>COMMAND LEVEL ACCESS</div> <div>TIMEOUT: 5 min</div> | Range: 5 to 480 minutes in steps of 1 |
| | | <div>SETTING LEVEL ACCESS</div> <div>TIMEOUT: 30 min</div> | 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.

5.2.2 DISPLAY PROPERTIES

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ DISPLAY PROPERTIES

| | | | |
|---|--|---|--|
| <div> <div>■ DISPLAY</div> <div>■ PROPERTIES</div> </div> | <div> <div>◀▶</div> <div>MESSAGE ▲</div> <div>MESSAGE ▲</div> <div>MESSAGE ▲</div> <div>MESSAGE ▲</div> <div>MESSAGE ▲</div> <div>MESSAGE ▲</div> </div> | <div>LANGUAGE:</div> <div>English</div> | Range: English; English, French; English, Russian; English, Chinese (range dependent on order code) |
| | | <div>FLASH MESSAGE</div> <div>TIME: 1.0 s</div> | Range: 0.5 to 10.0 s in steps of 0.1 |
| | | <div>DEFAULT MESSAGE</div> <div>TIMEOUT: 300 s</div> | Range: 10 to 900 s in steps of 1 |
| | | <div>DEFAULT MESSAGE</div> <div>INTENSITY: 25 %</div> | Range: 25%, 50%, 75%, 100% Visible only if a VFD is installed |
| | | <div>SCREEN SAVER</div> <div>FEATURE: Disabled</div> | Range: Disabled, Enabled Visible only if an LCD is installed |
| | | <div>SCREEN SAVER WAIT</div> <div>TIME: 30 min</div> | Range: 1 to 65535 min. in steps of 1 Visible only if an LCD is installed |
| | | <div>CURRENT CUT-OFF</div> <div>LEVEL: 0.020 pu</div> | Range: 0.002 to 0.020 pu in steps of 0.001 |
| | | <div>VOLTAGE CUT-OFF</div> <div>LEVEL: 1.0 V</div> | 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 than 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:

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

For Wye connections:

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

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

where VT primary = VT secondary × VT ratio and CT primary = CT secondary × CT ratio.

For example, given the following settings:

CURRENT CUT-OFF LEVEL: "0.02 pu"
VOLTAGE CUT-OFF LEVEL: "1.0 V"
PHASE CT PRIMARY: "100 A"
PHASE VT SECONDARY: "66.4 V"
PHASE VT RATIO: "208.00 : 1"
PHASE VT CONNECTION: "Delta".

We have:

CT primary = "100 A", and
 VT primary = PHASE VT SECONDARY × PHASE VT RATIO = 66.4 V × 208 = 13811.2 V

The power cut-off is therefore:

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

Any calculated power value below this cut-off 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.



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

| | | | |
|--|---------------|--|--|
| <div> <div>■ CLEAR RELAY</div> <div>■ RECORDS</div> </div> | <div>◀▶</div> | <div>CLEAR USER REPORTS:</div> <div>Off</div> | Range: FlexLogic™ operand |
| MESSAGE | <div>▲▼</div> | <div>CLEAR EVENT RECORDS:</div> <div>Off</div> | Range: FlexLogic™ operand |
| MESSAGE | <div>▲▼</div> | <div>CLEAR OSCILLOGRAPHY?</div> <div>No</div> | Range: FlexLogic™ operand |
| MESSAGE | <div>▲▼</div> | <div>CLEAR DATA LOGGER:</div> <div>Off</div> | Range: FlexLogic™ operand |
| MESSAGE | <div>▲▼</div> | <div>RESET UNAUTH ACCESS:</div> <div>Off</div> | Range: FlexLogic™ operand |
| MESSAGE | <div>▲▼</div> | <div>CLEAR DIR I/O STATS:</div> <div>Off</div> | 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.

- 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"
- 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 5-15. |
| MESSAGE | ▲▼ | ■ MODBUS PROTOCOL | See page 5-15. |
| MESSAGE | ▲▼ | ■ DNP PROTOCOL | See page 5-16. |
| MESSAGE | ▲▼ | ■ DNP / IEC 104 ■ POINT LISTS | See page 5-19. |
| MESSAGE | ▲▼ | ■ IEC 61850 PROTOCOL | See page 5-20. |
| MESSAGE | ▲▼ | ■ WEB SERVER ■ HTTP PROTOCOL | See page 5-29. |
| MESSAGE | ▲▼ | ■ TFTP PROTOCOL | See page 5-29. |
| MESSAGE | ▲▼ | ■ IEC 60870-5-104 ■ PROTOCOL | See page 5-29. |
| MESSAGE | ▲▼ | ■ SNTP PROTOCOL | See page 5-30. |
| MESSAGE | ▲▼ | ■ EGD PROTOCOL | See page 5-30. |
| MESSAGE | ▲ | ■ ETHERNET SWITCH | See page 5-32. |

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

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.



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

| | | | |
|--|--|---|--|
| <input checked="" type="checkbox"/> NETWORK MESSAGE MESSAGE MESSAGE MESSAGE | | IP ADDRESS: 0.0.0.0 | Range: Standard IP address format Not shown if CPU Type E is ordered. |
| | | SUBNET IP MASK: 0.0.0.0 | Range: Standard IP address format Not shown if CPU Type E is ordered. |
| | | GATEWAY IP ADDRESS: 0.0.0.0 | Range: Standard IP address format Not shown if CPU Type E is ordered. |
| | | <input checked="" type="checkbox"/> OSI NETWORK ADDRESS (NSAP) | Range: Select to enter the OSI NETWORK ADDRESS . Not shown if CPU Type E is ordered. |
| | | 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.



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).



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

| | | | |
|---|--|------------------------------------|---------------------------------|
| <input checked="" type="checkbox"/> MODBUS PROTOCOL MESSAGE | | MODBUS SLAVE ADDRESS: 254 | Range: 1 to 254 in steps of 1 |
| | | 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.



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

| | | | | |
|----------------|---------|----|--|--|
| ■ DNP PROTOCOL | | ◀▶ | ■ DNP CHANNELS | Range: see sub-menu below |
| | MESSAGE | ▲▼ | DNP ADDRESS: 65519 | Range: 0 to 65519 in steps of 1 |
| ■ DNP NETWORK | MESSAGE | ▲▼ | ■ 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 |

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.



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 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.



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

| | | | | |
|---|---------|----|------------------------------|----------------------------|
| <input checked="" type="checkbox"/> DNP NETWORK <input checked="" type="checkbox"/> 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.



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.



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.



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 ■ POINT LISTS | ◀▶ | ■ BINARY INPUT / MSP ■ POINTS | Range: see sub-menu below |
| MESSAGE ▲ | | ■ ANALOG INPUT / MME ■ POINTS | Range: see sub-menu below |

The binary and analog inputs points for the DNP protocol, or the MSP and MME points for IEC 60870-5-104 protocol, can be configured to a maximum of 256 points. The value for each point is user-programmable and can be configured by assigning FlexLogic™ operands for binary inputs / MSP points or FlexAnalog parameters for analog inputs / MME points.

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

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

| | | | |
|----------------------------------|----|-------------------|---------------------------|
| ■ BINARY INPUT / MSP ■ POINTS | ◀▶ | Point: 0 Off | Range: FlexLogic™ operand |
| MESSAGE ▲ | | Point: 1 Off | Range: FlexLogic™ operand |
| | | ↓ | |
| MESSAGE ▲ | | Point: 255 Off | Range: FlexLogic™ operand |

Up to 256 binary input points can be configured for the DNP or IEC 60870-5-104 protocols. The points are configured by assigning an appropriate FlexLogic™ operand. Refer to the *Introduction to FlexLogic™* section in this chapter for the full range of assignable operands.

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

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

| | | | |
|----------------------------------|----|-------------------|---------------------------------|
| ■ ANALOG INPUT / MME ■ POINTS | ◀▶ | Point: 0 Off | Range: any FlexAnalog parameter |
| MESSAGE ▲ | | Point: 1 Off | Range: any FlexAnalog parameter |
| | | ↓ | |
| MESSAGE ▲ | | Point: 255 Off | Range: any FlexAnalog parameter |

Up to 256 analog input points can be configured for the DNP or IEC 60870-5-104 protocols. The analog point list is configured by assigning an appropriate FlexAnalog parameter to each point. Refer to Appendix A: *FlexAnalog Parameters* for the full range of assignable parameters.



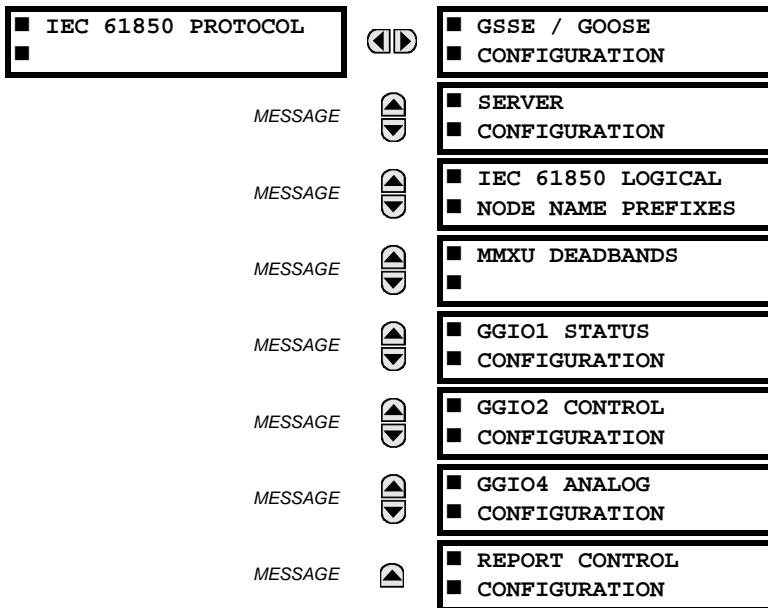
The DNP / IEC 60870-5-104 point lists always begin with point 0 and end at the first “Off” value. Since DNP / IEC 60870-5-104 point lists must be in one continuous block, any points assigned after the first “Off” point are ignored.



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

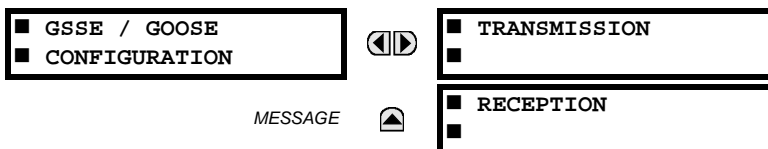


The C70 Capacitor Bank Protection and Control System is provided with optional IEC 61850 communications capability. This feature is specified as a software option at the time of ordering. Refer to the *Ordering* section of chapter 2 for additional details. The IEC 61850 protocol features are not available 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



The main transmission menu is shown below:

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 61850 PROTOCOL ⇒ GSSE/GOOSE... ⇒ 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... ⇒ GSSE/GOOSE... ⇒ 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.

The GSSE settings are shown below:

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 61850... ⇒ GSSE/GOOSE... ⇒ 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... ⇒ COMMUNICATIONS ⇒ IEC 61850... ⇒ GSSE/GOOSE... ⇒ 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... ⇒ COMMUNICATIONS ⇒ IEC 61850... ⇒ GSSE... ⇒ TRANSMISSION ⇒ CONFIGURABLE GOOSE 1(8)

| | | | |
|---|---------|---|--|
| <div> <div>■ CONFIGURABLE</div> <div>■ GOOSE 1</div> </div> | | <div> <div>CONFIG GSE 1</div> <div>FUNCTION: Enabled</div> </div> | Range: Enabled, Disabled |
| | MESSAGE | <div> <div>CONFIG GSE 1 ID:</div> <div>GOOSEOut_1</div> </div> | Range: 65-character ASCII string |
| | MESSAGE | <div> <div>CONFIG GSE 1 DST MAC:</div> <div>010CDC010000</div> </div> | Range: standard MAC address |
| | MESSAGE | <div> <div>CONFIG GSE 1</div> <div>VLAN PRIORITY: 4</div> </div> | Range: 0 to 7 in steps of 1 |
| | MESSAGE | <div> <div>CONFIG GSE 1</div> <div>VLAN ID: 0</div> </div> | Range: 0 to 4095 in steps of 1 |
| | MESSAGE | <div> <div>CONFIG GSE 1</div> <div>ETYPE APPID: 0</div> </div> | Range: 0 to 16383 in steps of 1 |
| | MESSAGE | <div> <div>CONFIG GSE 1</div> <div>CONFREV: 1</div> </div> | Range: 0 to 4294967295 in steps of 1 |
| | MESSAGE | <div> <div>■ CONFIG GSE 1</div> <div>■ DATASET ITEMS</div> </div> | Range: 64 data items; each can be set to all valid MMS data item references for transmitted data |

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 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 2 through 8 will have changes in their status transmitted at a maximum rate of every 100 ms. Datasets 2 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.

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

PATH: ...RECEPTION ⇌ CONFIGURABLE GOOSE 1(8) ⇌ CONFIG GSE 1(64) DATA ITEMS

| | | | |
|---|---------------|---|---|
| <div> <div>■ CONFIG GSE 1</div> <div>■ DATASET ITEMS</div> </div> | <div>◀▶</div> | <div>ITEM 1:</div> <div>GGIO1.ST.Ind1.stVal</div> | <div>Range: all valid MMS data item references for transmitted data</div> |
|---|---------------|---|---|

The configurable GOOSE settings allow the C70 to be configured to receive a number of different datasets within IEC 61850 GOOSE messages. Up to eight 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.

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.XM.AnIn1 and higher items. Received values are also available as FlexAnalog parameters (GOOSE analog In1 and up).

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

PATH: SETTINGS ⇌ PRODUCT SETUP ⇌ COMMUNICATIONS ⇌ IEC 61850 PROTOCOL ⇌ SERVER CONFIGURATION

| | | | |
|---|---------------|--|--|
| <div> <div>■ SERVER</div> <div>■ CONFIGURATION</div> </div> | <div>◀▶</div> | <div>IED NAME: IECDevice</div> | <div>Range: up to 32 alphanumeric characters</div> |
| MESSAGE | <div>▲▼</div> | <div>LD INST: LDInst</div> | <div>Range: up to 32 alphanumeric characters</div> |
| MESSAGE | <div>▲▼</div> | <div>LOCATION: Location</div> | <div>Range: up to 80 alphanumeric characters</div> |
| MESSAGE | <div>▲▼</div> | <div>IEC/MMS TCP PORT NUMBER: 102</div> | <div>Range: 1 to 65535 in steps of 1</div> |
| MESSAGE | <div>▲▼</div> | <div>INCLUDE NON-IEC DATA: Enabled</div> | <div>Range: Disabled, Enabled</div> |
| MESSAGE | <div>▲</div> | <div>SERVER SCANNING: Disabled</div> | <div>Range: Disabled, Enabled</div> |

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".

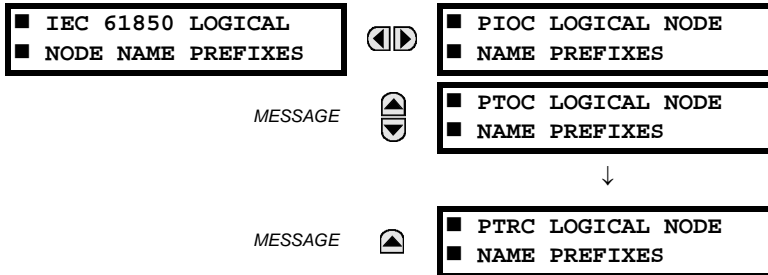
The **SERVER SCANNING** feature should be set to "Disabled" when IEC 61850 client/server functionality is not required. IEC 61850 has two modes of functionality: GOOSE/GSSE inter-device communication and client/server communication. If the GOOSE/GSSE functionality is required without the IEC 61850 client 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.



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... ⇒ IEC 61850 LOGICAL NODE NAME PREFIXES

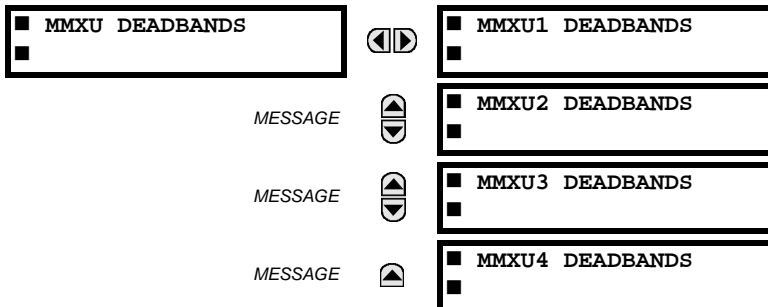


The IEC 61850 logical node name prefix settings are used to create name prefixes to uniquely identify each logical node. For example, the logical node “PTOC1” may have the name prefix “abc”. The full logical node name will then be “abcMMXU1”. Valid characters for the logical node name prefixes are upper 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



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

The GGIO1 status configuration points are shown below:

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 61850... ⇒ GGIO1 STATUS CONFIGURATION

| | | | |
|---|---------|--|-------------------------------|
| <input checked="" type="checkbox"/> GGIO1 STATUS <input checked="" type="checkbox"/> 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 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... ⇒ GGIO2 CONTROL... ⇒ GGIO2 CF SPCSO 1(64)

| | | | |
|---|--|---|-------------------|
| <input checked="" type="checkbox"/> GGIO2 CF SPCSO 1 <input checked="" type="checkbox"/> | | 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... ⇒ GGIO4 ANALOG CONFIGURATION

| | | | |
|---|---------|---|------------------------------|
| <input checked="" type="checkbox"/> GGIO4 ANALOG <input checked="" type="checkbox"/> CONFIGURATION | | NUMBER OF ANALOG POINTS IN GGIO4: 8 | Range: 4 to 32 in steps of 4 |
| | MESSAGE | <input checked="" type="checkbox"/> GGIO4 ANALOG 1 <input checked="" type="checkbox"/> MEASURED VALUE | |
| | MESSAGE | <input checked="" type="checkbox"/> GGIO4 ANALOG 2 <input checked="" type="checkbox"/> MEASURED VALUE | |
| ↓ | | | |
| MESSAGE | | <input checked="" type="checkbox"/> GGIO4 ANALOG 32 <input checked="" type="checkbox"/> 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... ⇒ GGIO4... ⇒ GGIO4 ANALOG 1(32) MEASURED VALUE

| | | | |
|--|---------|--|--|
| <div> <div>GGIO4 ANALOG 1</div> <div>MEASURED VALUE</div> </div> | | <div>ANALOG IN 1 VALUE:</div> <div>Off</div> | Range: any FlexAnalog value |
| | MESSAGE | <div>ANALOG IN 1 DB:</div> <div>0.000</div> | Range: 0.000 to 100.000 in steps of 0.001 |
| | MESSAGE | <div>ANALOG IN 1 MIN:</div> <div>0.000</div> | Range: -1000000000.000 to 1000000000.000 in steps of 0.001 |
| | MESSAGE | <div>ANALOG IN 1 MAX:</div> <div>0.000</div> | 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 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 report control configuration settings are shown below:

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 61850... ⇒ REPORT... ⇒ REPORT 1(6) CONFIGURATION

| | | | |
|---|---------|---|---|
| <div> <div>REPORT 1</div> <div>CONFIGURATION</div> </div> | | <div>REPORT 1</div> <div>RptID:</div> | Range: up to 66 alphanumeric characters |
| | MESSAGE | <div>REPORT 1</div> <div>OptFlds: 0</div> | Range: 0 to 65535 in steps of 1 |
| | MESSAGE | <div>REPORT 1</div> <div>BufTm: 0</div> | Range: 0 to 4294967295 in steps of 1 |
| | MESSAGE | <div>REPORT 1</div> <div>TrgOps: 0</div> | Range: 0 to 65535 in steps of 1 |
| | MESSAGE | <div>REPORT 1</div> <div>IntgPd: 0</div> | Range: 0 to 4294967295 in steps of 1 |

Changes to the report configuration will not take effect until the C70 is restarted.



Please disconnect any IEC 61850 client connection to the C70 prior to making setting changes to the report configuration. Disconnecting the rear Ethernet connection from the C70 will disconnect the IEC 61850 client connection.



Since GSSE/GOOSE messages are multicast Ethernet by specification, they will not usually be forwarded by network routers. However, GOOSE messages may be forwarded 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

| | | | |
|---|--|-----------------------------|---------------------------------|
| <input type="checkbox"/> WEB SERVER <input type="checkbox"/> 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

| | | | |
|--|--|-----------------------------------|---------------------------------|
| <input type="checkbox"/> 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

| | | | |
|---|--|---|-----------------------------------|
| <input type="checkbox"/> IEC 60870-5-104 <input type="checkbox"/> 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 | | <input type="checkbox"/> IEC NETWORK <input type="checkbox"/> 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.



The C70 relay does not support energy metering. As such, the IEC **ENERGY DEFAULT THRESHOLD** setting is not applicable.



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

| | | |
|---|--|-----------------------------------|
| <div>5</div> <div>SNTP PROTOCOL</div> <div>MESSAGE</div> <div>MESSAGE</div> | <div>SNTP FUNCTION:</div> <div>Disabled</div> | Range: Enabled, Disabled |
| | <div>SNTP SERVER IP ADDR:</div> <div>0.0.0.0</div> | Range: Standard IP address format |
| | <div>SNTP UDP PORT NUMBER:</div> <div>123</div> | 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

| | |
|---|--|
| <div>EGD PROTOCOL</div> <div>MESSAGE</div> <div>MESSAGE</div> | <div>FAST PROD EXCH 1</div> <div>CONFIGURATION</div> |
| | <div>SLOW PROD EXCH 1</div> <div>CONFIGURATION</div> |
| | <div>SLOW PROD EXCH 2</div> <div>CONFIGURATION</div> |



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

| | | | |
|---|----|---|--|
| <input checked="" type="checkbox"/> FAST PROD EXCH 1 <input checked="" type="checkbox"/> CONFIGURATION | | <div>◀▶</div> <div>EXCH 1 FUNCTION: Disable</div> | Range: Disable, Enable |
| MESSAGE | ▲▼ | <div>EXCH 1 DESTINATION: 0.0.0.0</div> | Range: standard IP address |
| MESSAGE | ▲▼ | <div>EXCH 1 DATA RATE: 1000 ms</div> | Range: 50 to 1000 ms in steps of 1 |
| MESSAGE | ▲▼ | <div>EXCH 1 DATA ITEM 1: 0</div> | Range: 0 to 65535 in steps of 1 (Modbus register address range) |
| ↓ | | | |
| MESSAGE | ▲ | <div>EXCH 1 DATA ITEM 20: 0</div> | 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 (Exchanges 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

| | | | |
|---|----|---|---|
| <input checked="" type="checkbox"/> SLOW PROD EXCH 1 <input checked="" type="checkbox"/> CONFIGURATION | | <div>◀▶</div> <div>EXCH 1 FUNCTION: Disable</div> | Range: Disable, Enable |
| MESSAGE | ▲▼ | <div>EXCH 1 DESTINATION: 0.0.0.0</div> | Range: standard IP address |
| MESSAGE | ▲▼ | <div>EXCH 1 DATA RATE: 1000 ms</div> | Range: 500 to 1000 ms in steps of 1 |
| MESSAGE | ▲▼ | <div>EXCH 1 DATA ITEM 1: 0</div> | Range: 0 to 65535 in steps of 1 (Modbus register address range in decimal) |
| ↓ | | | |
| MESSAGE | ▲ | <div>EXCH 1 DATA ITEM 50: 0</div> | 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

| | | | |
|--------------|----------------------------|---|-----------------------------------|
| <div>5</div> | <div>ETHERNET SWITCH</div> | <div>SWITCH IP ADDRESS: 127.0.0.1</div> | Range: standard IP address format |
| | MESSAGE | <div>SWITCH MODBUS TCP PORT NUMBER: 502</div> | Range: 1 to 65535 in steps of 1 |
| | MESSAGE | <div>PORT 1 EVENTS: Disabled</div> | Range: Enabled, Disabled |
| | MESSAGE | <div>PORT 2 EVENTS: Disabled</div> | Range: Enabled, Disabled |
| | MESSAGE | <div>PORT 6 EVENTS: Disabled</div> | 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

| | | |
|----------------------------|--|---------------------------------|
| <div>MODBUS USER MAP</div> | <div>ADDRESS 1: 0 VALUE: 0</div> | Range: 0 to 65535 in steps of 1 |
| | <div>ADDRESS 2: 0 VALUE: 0</div> | Range: 0 to 65535 in steps of 1 |
| | <div>ADDRESS 256: 0 VALUE: 0</div> | 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

| | | | |
|-------------|----|---------------------|--|
| ■ REAL TIME | ◀▶ | IRIG-B SIGNAL TYPE: | Range: None, DC Shift, Amplitude Modulated |
| ■ CLOCK | | None | |
| MESSAGE | ▲▼ | REAL TIME CLOCK | Range: Disabled, Enabled |
| | | EVENTS: Disabled | |
| MESSAGE | ▲▼ | LOCAL TIME OFFSET | Range: -24.0 to 24.0 hrs in steps of 0.5 |
| | | FROM UTC: 0.0 hrs | |
| MESSAGE | ▲▼ | DAYLIGHT SAVINGS | Range: Disabled, Enabled |
| | | TIME: Disabled | |
| MESSAGE | ▲▼ | DST START MONTH: | Range: January to December (all months) |
| | | April | |
| MESSAGE | ▲▼ | DST START DAY: | Range: Sunday to Saturday (all days of the week) |
| | | Sunday | |
| MESSAGE | ▲▼ | DST START DAY | Range: First, Second, Third, Fourth, Last |
| | | INSTANCE: First | |
| MESSAGE | ▲▼ | DST START HOUR: | Range: 0:00 to 23:00 |
| | | 2:00 | |
| MESSAGE | ▲▼ | DST STOP MONTH: | Range: January to December (all months) |
| | | April | |
| MESSAGE | ▲▼ | DST STOP DAY: | Range: Sunday to Saturday (all days of the week) |
| | | Sunday | |
| MESSAGE | ▲▼ | DST STOP DAY | Range: First, Second, Third, Fourth, Last |
| | | INSTANCE: First | |
| MESSAGE | ▲▼ | DST STOP HOUR: | Range: 0:00 to 23:00 |
| | | 2:00 | |

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.



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)

| | | | |
|---|----|---|---|
| <input checked="" type="checkbox"/> USER-PROGRAMMABLE <input checked="" type="checkbox"/> FAULT REPORT 1 | | <div>◀▶</div> <div>FAULT REPORT 1</div> <div>FUNCTION: Disabled</div> | Range: Disabled, Enabled |
| MESSAGE | ▲▼ | <div>PRE-FAULT 1 TRIGGER:</div> <div>Off</div> | Range: FlexLogic™ operand |
| MESSAGE | ▲▼ | <div>FAULT 1 TRIGGER:</div> <div>Off</div> | Range: FlexLogic™ operand |
| MESSAGE | ▲▼ | <div>FAULT REPORT 1 #1:</div> <div>Off</div> | Range: Off, any actual value analog parameter |
| MESSAGE | ▲▼ | <div>FAULT REPORT 1 #2:</div> <div>Off</div> | Range: Off, any actual value analog parameter |
| ↓ | | | |
| MESSAGE | ▲ | <div>FAULT REPORT 1 #32:</div> <div>Off</div> | 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 (5.5x, 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 5–1: 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 | 64 | 16 | 93.5 |
| 8 | 2 | 32 | 64 | 16 | 57.6 |
| 8 | 2 | 64 | 64 | 16 | 32.3 |
| 32 | 2 | 64 | 64 | 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.



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

| | | | |
|--|----|----------------------------|---------------------------|
| <input checked="" type="checkbox"/> DIGITAL CHANNELS <input type="checkbox"/> MESSAGE | ◀▶ | DIGITAL CHANNEL 1: Off | Range: FlexLogic™ operand |
| | ▲▼ | DIGITAL CHANNEL 2: 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

| | | | |
|---|----|---------------------------|---|
| <input checked="" type="checkbox"/> ANALOG CHANNELS <input type="checkbox"/> MESSAGE | ◀▶ | ANALOG CHANNEL 1: Off | Range: Off, any FlexAnalog parameter See Appendix A for complete list. |
| | ▲▼ | ANALOG CHANNEL 2: 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, et
- 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.



The source harmonic indices appear as oscillography analog channels numbered from 0 to 23. These correspond directly 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 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 5–2: 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 |



Changing any setting affecting data logger operation will clear any data that is currently in the log.

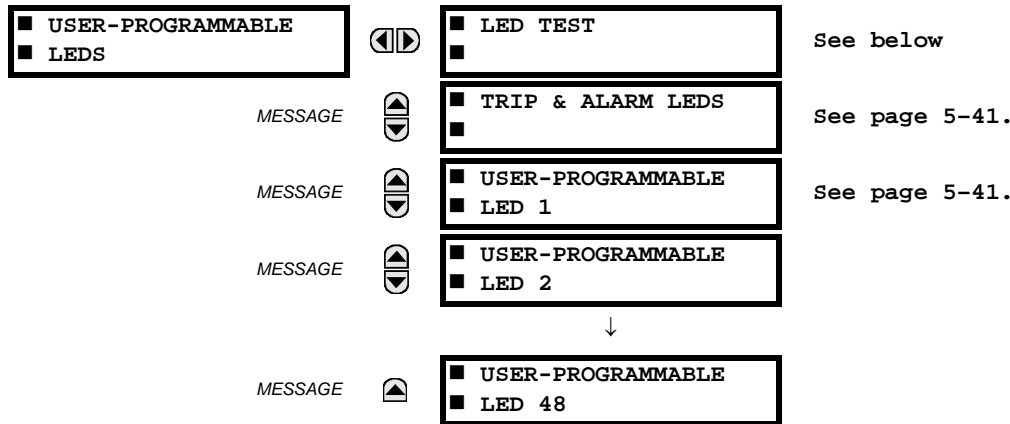
5

- **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

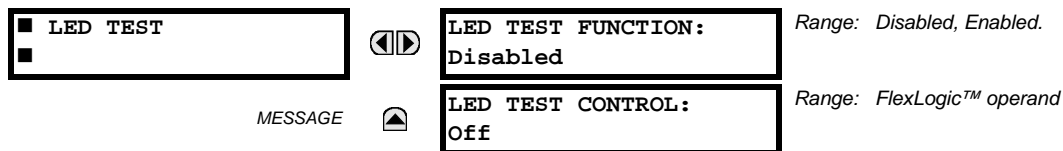
a) MAIN MENU

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE LEDS



b) LED TEST

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE LEDS ⇒ LED TEST



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.

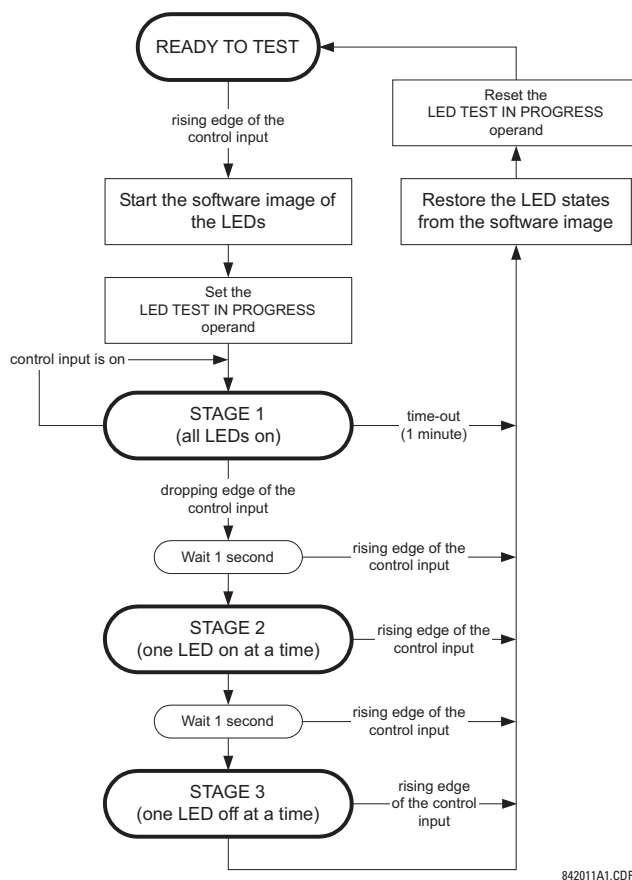
The test consists of three stages.

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.



842011A1.CDR

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

| | | |
|--|---|---------------------------|
| <div> <div>TRIP & ALARM LEDS</div> <div>MESSAGE</div> </div> | <div> <div>TRIP LED INPUT:</div> <div>Off</div> </div> | Range: FlexLogic™ operand |
| | <div> <div>ALARM LED INPUT:</div> <div>Off</div> </div> | 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)

| | | |
|--|---|----------------------------|
| <div> <div>USER-PROGRAMMABLE</div> <div>LED 1</div> </div> | <div> <div>LED 1 OPERAND:</div> <div>Off</div> </div> | Range: FlexLogic™ operand |
| | <div> <div>LED 1 TYPE:</div> <div>Self-Reset</div> </div> | 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 5–3: 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

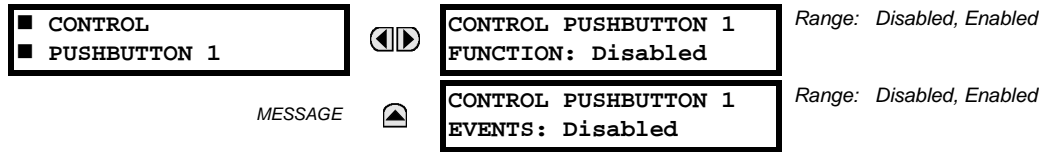
| | | | | |
|--|---------|--|--|---|
| <div> <div> <div>■ USER-PROGRAMMABLE</div> <div>■ SELF TESTS</div> </div> </div> | | | DIRECT RING BREAK FUNCTION: Enabled | Range: Disabled, Enabled. Valid for units equipped with Direct Input/Output module. |
| | MESSAGE | | DIRECT DEVICE OFF FUNCTION: Enabled | 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)



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 through 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.

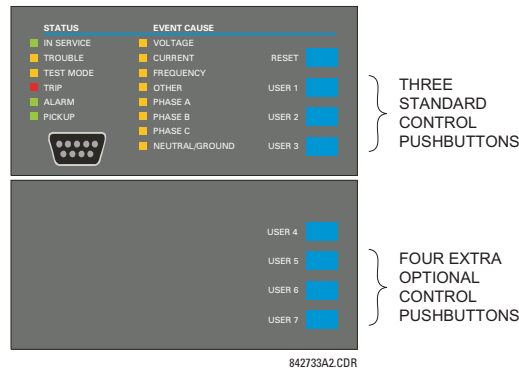


Figure 5-5: CONTROL PUSHBUTTONS (STANDARD FACEPLATE)

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.

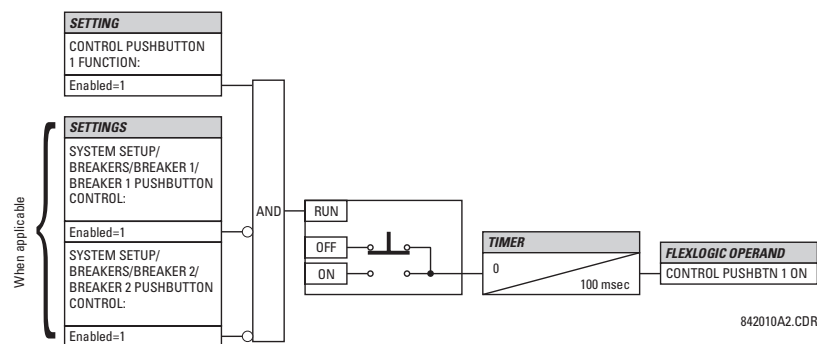


Figure 5-6: CONTROL PUSHBUTTON LOGIC

5.2.13 USER-PROGRAMMABLE PUSHBUTTONS

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

| | | | | |
|---|---------------------|----|------------------------------------|---|
| 5 | ■ USER PUSHBUTTON 1 | ◀▶ | PUSHBUTTON 1 FUNCTION: Disabled | Range: Self-Reset, Latched, Disabled |
| | MESSAGE | ▲▼ | PUSHBTN 1 ID TEXT: | Range: Up to 20 alphanumeric characters |
| | MESSAGE | ▲▼ | PUSHBTN 1 ON TEXT: | Range: Up to 20 alphanumeric characters |
| | MESSAGE | ▲▼ | PUSHBTN 1 OFF TEXT: | Range: Up to 20 alphanumeric characters |
| | MESSAGE | ▲▼ | PUSHBTN 1 HOLD: 0.0 s | Range: 0.0 to 10.0 s in steps of 0.1 |
| | MESSAGE | ▲▼ | PUSHBTN 1 SET: Off | Range: FlexLogic™ operand |
| | MESSAGE | ▲▼ | PUSHBTN 1 RESET: Off | Range: FlexLogic™ operand |
| | MESSAGE | ▲▼ | PUSHBTN 1 AUTORST: Disabled | Range: Disabled, Enabled |
| | MESSAGE | ▲▼ | PUSHBTN 1 AUTORST DELAY: 1.0 s | Range: 0.2 to 600.0 s in steps of 0.1 |
| | MESSAGE | ▲▼ | PUSHBTN 1 REMOTE: Off | Range: FlexLogic™ operand |
| | MESSAGE | ▲▼ | PUSHBTN 1 LOCAL: Off | Range: FlexLogic™ operand |
| | MESSAGE | ▲▼ | PUSHBTN 1 DROP-OUT TIME: 0.00 s | Range: 0 to 60.00 s in steps of 0.05 |
| | MESSAGE | ▲▼ | PUSHBTN 1 LED CTL: Off | Range: FlexLogic™ operand |
| | MESSAGE | ▲▼ | PUSHBTN 1 MESSAGE: Disabled | Range: Disabled, Normal, High Priority |
| | MESSAGE | ▲ | PUSHBUTTON 1 EVENTS: Disabled | Range: Disabled, Enabled |

The optional user-programmable pushbuttons (specified in the order code) provide an easy and error-free method of entering digital state (on, off) information. The number of available pushbuttons is dependent on the faceplate module ordered with the relay.

- Type P faceplate: standard horizontal faceplate with 12 user-programmable pushbuttons.
- Type Q faceplate: enhanced horizontal faceplate with 16 user-programmable pushbuttons.

The digital state can be entered locally (by directly pressing the front panel pushbutton) or remotely (via FlexLogic™ operands) into FlexLogic™ equations, protection elements, and control elements. Typical applications include breaker control, autorecloser blocking, and setting groups changes. The user-programmable pushbuttons are under the control level of password protection.

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

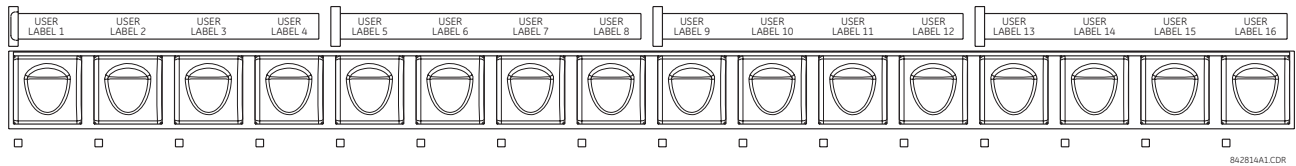


Figure 5-7: USER-PROGRAMMABLE PUSHBUTTONS (ENHANCED FACEPLATE)

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

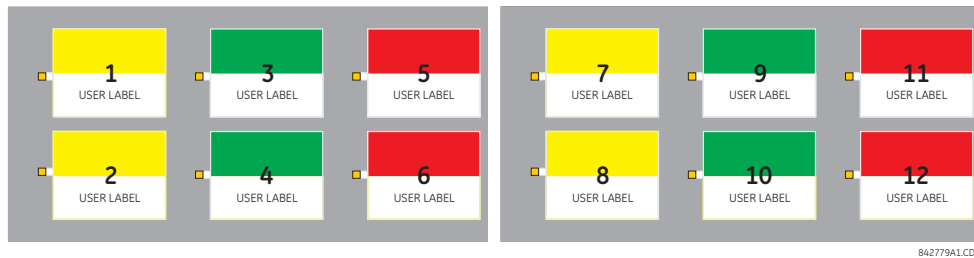


Figure 5-8: USER-PROGRAMMABLE PUSHBUTTONS (STANDARD FACEPLATE)

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.



The pulse duration of the remote set, remote reset, or local pushbutton must be at least 50 ms to operate the pushbutton. This allows the user-programmable pushbuttons to properly operate during power cycling events and various system disturbances that may cause transient assertion of the operating signals.

The local and remote operation of each user-programmable pushbutton can be inhibited through the **PUSHBTN 1 LOCAL** and **PUSHBTN 1 REMOTE** settings, respectively. If local locking is applied, the pushbutton will ignore set and reset commands executed through the front panel pushbuttons. If remote locking is applied, the pushbutton will ignore set and reset commands executed through FlexLogic™ operands.

The locking functions are not applied to the autorestart feature. In this case, the inhibit function can be used in SBO control operations to prevent the pushbutton function from being activated and ensuring “one-at-a-time” select operation.

The locking functions can also be used to prevent the accidental pressing of the front panel pushbuttons. The separate inhibit of the local and remote operation simplifies the implementation of local/remote control supervision.

Pushbutton states can be logged by the event recorder and displayed as target messages. In latched mode, user-defined messages can also be associated with each pushbutton and displayed when the pushbutton is on or changing to off.

- **PUSHBUTTON 1 FUNCTION:** This setting selects the characteristic of the pushbutton. If set to “Disabled”, the pushbutton is not active and the corresponding FlexLogic™ operands (both “On” and “Off”) are de-asserted. If set to “Self-Reset”, the control logic is activated by the pulse (longer than 100 ms) issued when the pushbutton is being physically pressed or virtually pressed via a FlexLogic™ operand assigned to the **PUSHBTN 1 SET** setting.

When in “Self-Reset” mode and activated locally, the pushbutton control logic asserts the “On” corresponding FlexLogic™ operand as long as the pushbutton is being physically pressed, and after being released the deactivation of the operand is delayed by the drop out timer. The “Off” operand is asserted when the pushbutton element is deactivated. If the pushbutton is activated remotely, the control logic of the pushbutton asserts the corresponding “On” FlexLogic™ operand only for the time period specified by the **PUSHBTN 1 DROP-OUT TIME** setting.

If set to “Latched”, the control logic alternates the state of the corresponding FlexLogic™ operand between “On” and “Off” on each button press or by virtually activating the pushbutton (assigning set and reset operands). When in the “Latched” mode, the states of the FlexLogic™ operands are stored in a non-volatile memory. Should the power supply be lost, the correct state of the pushbutton is retained upon subsequent power up of the relay.

- **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.

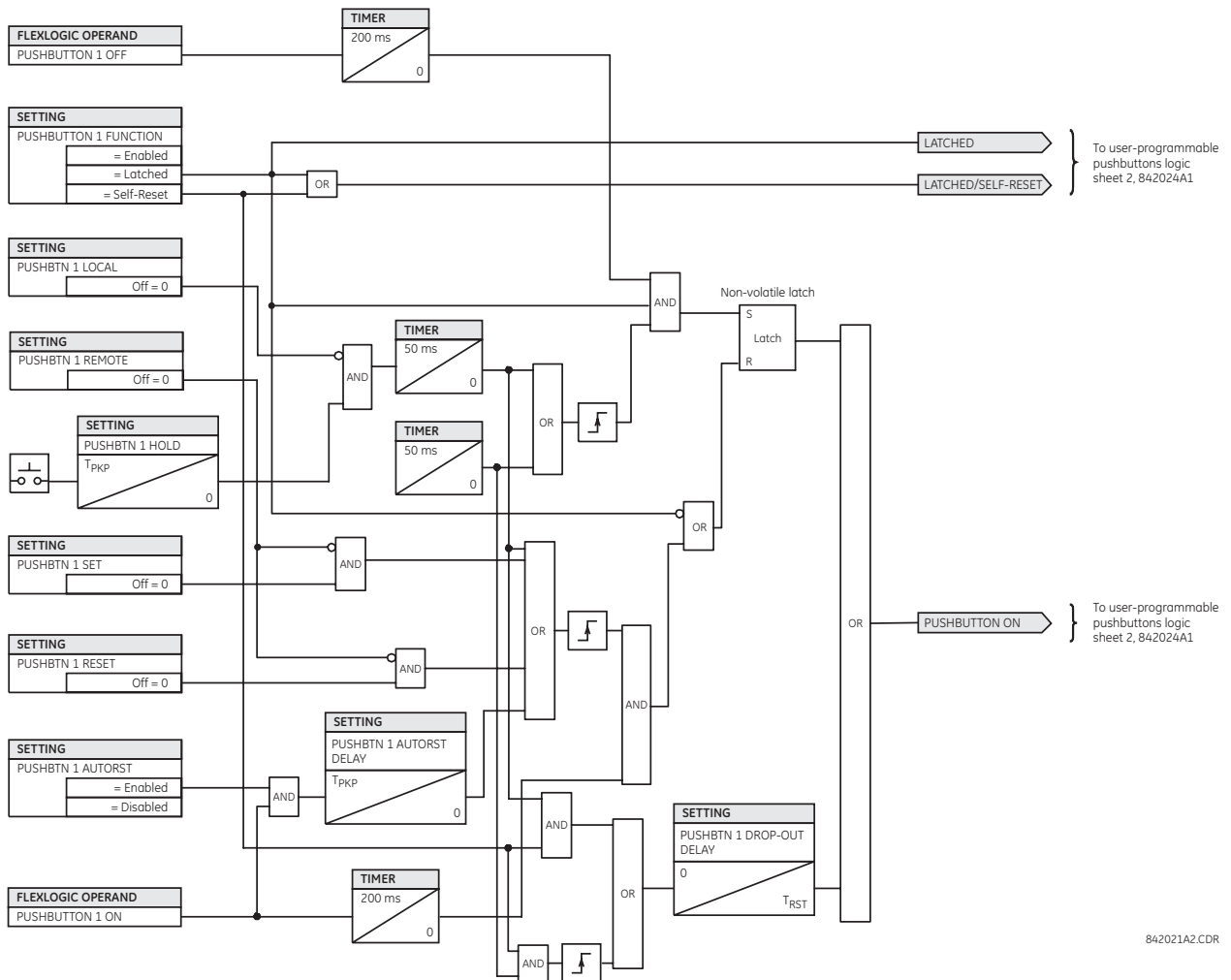


Figure 5-9: USER-PROGRAMMABLE PUSHBUTTON LOGIC (Sheet 1 of 2)

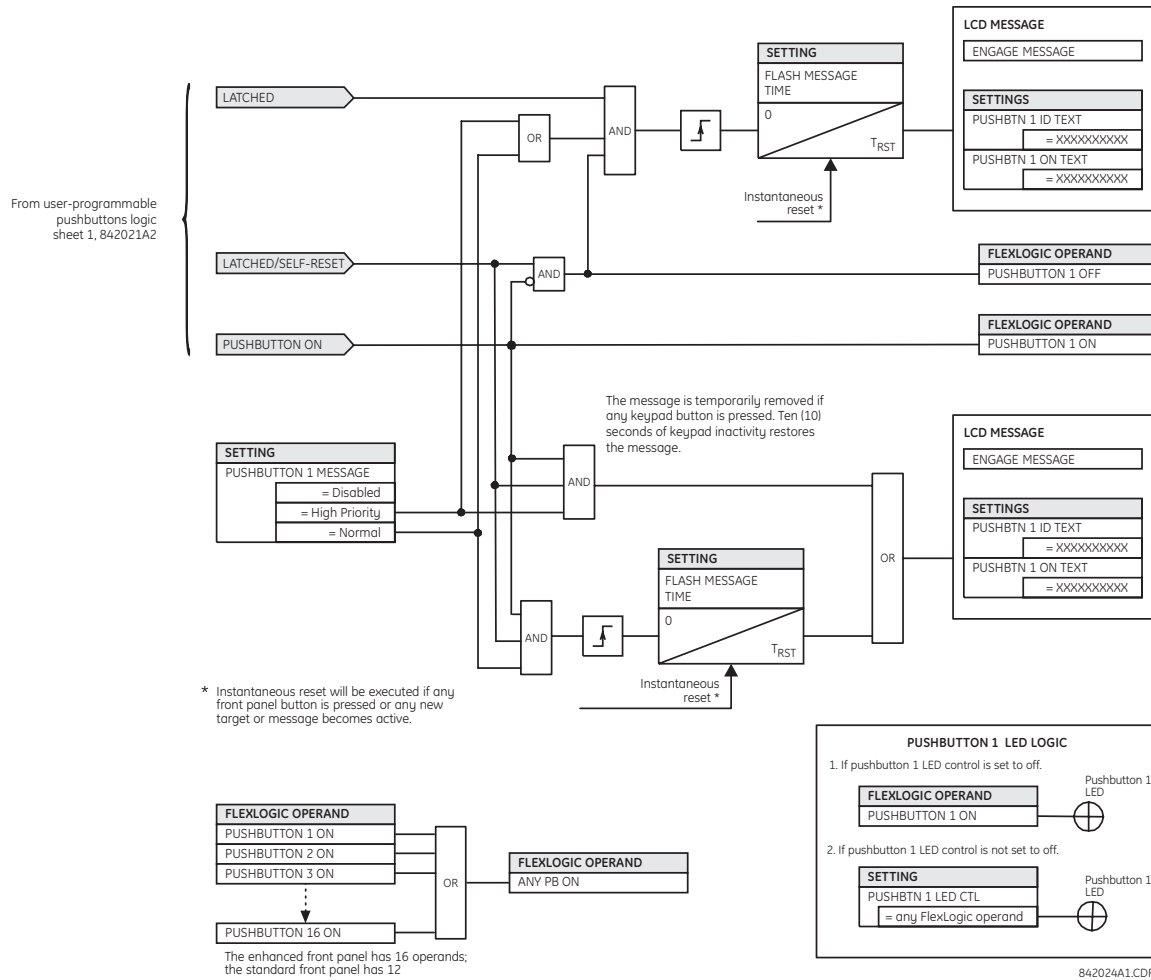


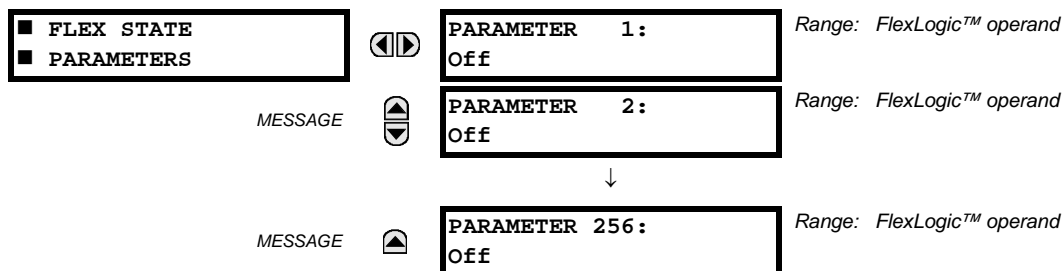
Figure 5-10: USER-PROGRAMMABLE PUSHBUTTON LOGIC (Sheet 2 of 2)



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



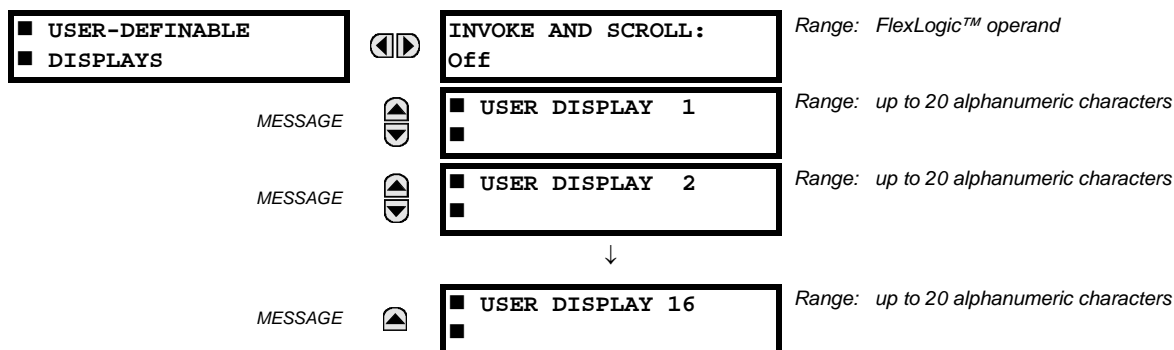
This feature provides a mechanism where any of 256 selected FlexLogic™ operand states can be used for efficient monitoring. The feature allows user-customized access to the FlexLogic™ operand states in the relay. The state bits are packed so that 16 states may be read out in a single Modbus register. 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



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 **INVOLVE 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 **INVOLVE 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 **INVOLVE AND SCROLL** input stops the cycling at the currently displayed user display, not at the first user-defined display. The **INVOLVE 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 4 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:

| | | | |
|--|---|--|---|
| <div> <div>■ USER DISPLAY 1</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div> | <div> <div>◀▶</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲</div> </div> | <div>DISP 1 TOP LINE: Current X ~ A</div> | Shows user-defined text with first Tilde marker. |
| | | <div>DISP 1 BOTTOM LINE: Current Y ~ A</div> | Shows user-defined text with second Tilde marker. |
| | | <div>DISP 1 ITEM 1: 6016</div> | Shows decimal form of user-selected Modbus Register Address, corresponding to first Tilde marker. |
| | | <div>DISP 1 ITEM 2: 6357</div> | Shows decimal form of user-selected Modbus Register Address, corresponding to 2nd Tilde marker. |
| | | <div>DISP 1 ITEM 3: 0</div> | This item is not being used - there is no corresponding Tilde marker in Top or Bottom lines. |
| | | <div>DISP 1 ITEM 4: 0</div> | This item is not being used - there is no corresponding Tilde marker in Top or Bottom lines. |
| <div> <div>USER DISPLAYS</div> <div>→</div> </div> | | <div>Current X 0.850 A Current Y 0.327 A</div> | Shows the resultant display content. |

a) MAIN MENU

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ DIRECT I/O

| | | | |
|--|---|---|--------------------------|
| <div> <div>■ DIRECT I/O</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div> | <div> <div>◀▶</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲</div> </div> | <div>DIRECT OUTPUT DEVICE ID: 1</div> | Range: 1 to 16 |
| | | <div>DIRECT I/O CH1 RING CONFIGURATION: Yes</div> | Range: Yes, No |
| | | <div>DIRECT I/O CH2 RING CONFIGURATION: Yes</div> | Range: Yes, No |
| | | <div>DIRECT I/O DATA RATE: 64 kbps</div> | Range: 64 kbps, 128 kbps |
| | | <div>DIRECT I/O CHANNEL CROSSOVER: Disabled</div> | Range: Disabled, Enabled |
| | | <div>■ CRC ALARM CH1</div> | See page 5-58. |
| | | <div>■ CRC ALARM CH2</div> | See page 5-58. |
| | | <div>■ UNRETURNED ■ MESSAGES ALARM CH1</div> | See page 5-59. |
| | | <div>■ UNRETURNED ■ MESSAGES ALARM CH2</div> | See page 5-59. |

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 5–4: 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 |



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

NOTE

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.

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.

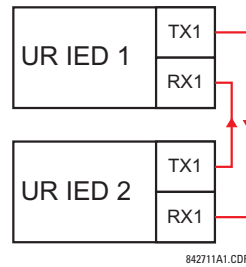


Figure 5–11: INPUT AND OUTPUT EXTENSION VIA DIRECT INPUTS AND OUTPUTS

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.

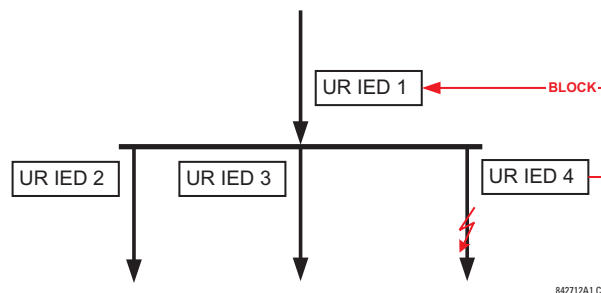


Figure 5–12: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME

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

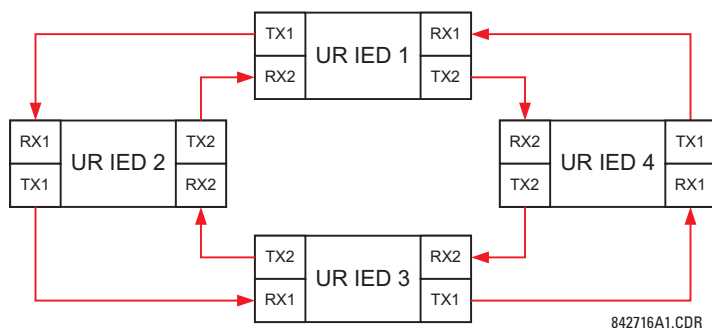


Figure 5-13: INTERLOCKING BUS PROTECTION SCHEME VIA DIRECT INPUTS/OUTPUTS

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:

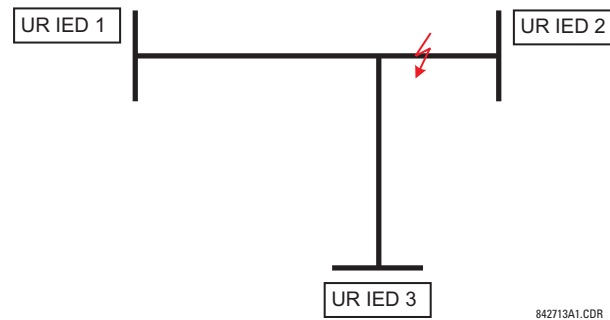


Figure 5-14: THREE-TERMINAL LINE APPLICATION

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):

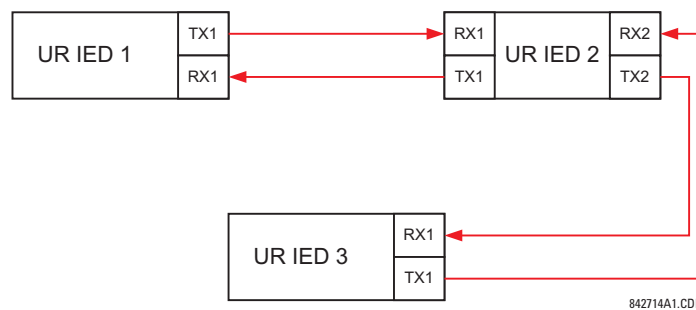


Figure 5-15: SINGLE-CHANNEL OPEN LOOP CONFIGURATION

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.

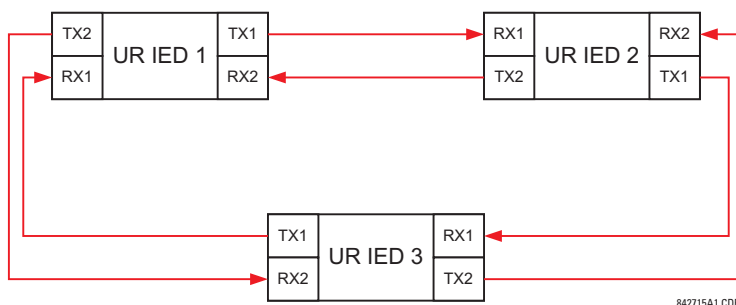


Figure 5-16: DUAL-CHANNEL CLOSED LOOP (DUAL-RING) CONFIGURATION

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)

| | | | |
|--|--|---|-----------------------------------|
| <input checked="" type="checkbox"/> 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 $10 \times 60 \times 1 = 600$.
- **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)**

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

5.2.17 INSTALLATION

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ **INSTALLATION**

| | | |
|---|--|-----------------------------------|
| <div> <div>■ INSTALLATION</div> <div>■</div> </div> | <div> <div>◀▶</div> <div>RELAY SETTINGS: Not Programmed</div> </div> | 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 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 ($I_A + I_B + I_C = \text{neutral current} = 3I_o$) 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:

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

1 pu is the highest primary current. In this case, 1000 is entered and the secondary current from the 500:1 ratio CT 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)

| | | | |
|-------------------|------------|--------------------------------------|--|
| ■ 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”.



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, $(13800 / 14400) \times 120$. 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, $14400 / 120$.



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

5.3.2 POWER SYSTEM

PATH: SETTINGS ⇒ SYSTEM SETUP ⇒ POWER SYSTEM

| | | | |
|----------------|------------|---|---|
| ■ POWER SYSTEM | ◀▶ | NOMINAL FREQUENCY: 60 Hz | Range: 25 to 60 Hz in steps of 1 |
| | MESSAGE ▲▼ | PHASE ROTATION: ABC | Range: ABC, ACB |
| MESSAGE ▲▼ | ▲▼ | FREQUENCY AND PHASE REFERENCE: SRC 1 | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| | 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.



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

5.3.3 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, F1, F5, M1, M5, U1, U5 Only phase voltage inputs will be displayed. |
| MESSAGE | ▲ | SOURCE 1 AUX VT: None | Range: None, F1, F5, M1, M5, U1, 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:

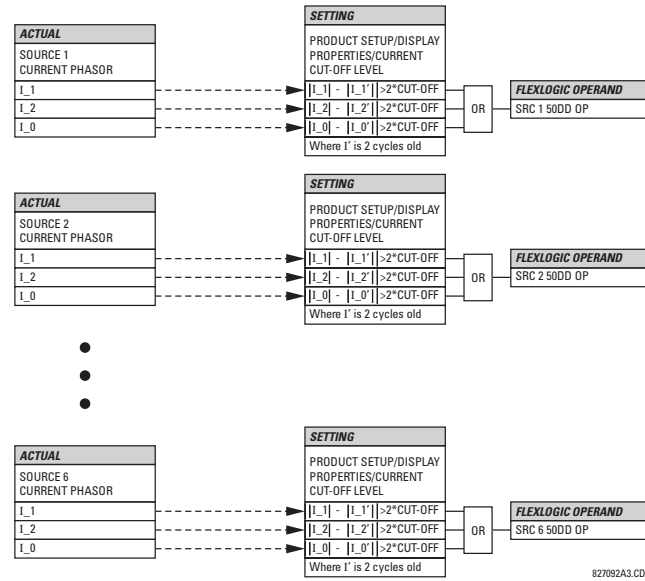


Figure 5-17: DISTURBANCE DETECTOR LOGIC DIAGRAM

The disturbance detector responds to the change in currents of twice the current cut-off level. The default cut-off threshold is 0.02 pu; thus by default the disturbance detector responds to a change of 0.04 pu. The metering sensitivity setting (**PRODUCT SETUP** ⇒ **DISPLAY PROPERTIES** ⇒ **CURRENT CUT-OFF LEVEL**) controls the sensitivity of the disturbance detector accordingly.

Example use of sources:

An example of the use of sources is shown in the diagram below. A relay could have the following hardware configuration:

| INCREASING SLOT POSITION LETTER --> | | |
|-------------------------------------|----------------|----------------|
| CT/VT MODULE 1 | CT/VT MODULE 2 | CT/VT MODULE 3 |
| CTs | 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.

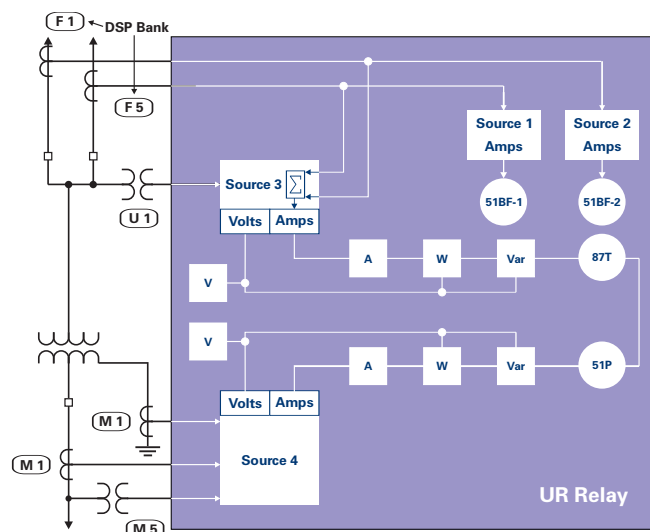


Figure 5-18: EXAMPLE USE OF SOURCES

5.3.4 BREAKERS

PATH: SETTINGS ⇒ SYSTEM SETUP ⇒ BREAKERS ⇒ BREAKER 1

| | | | |
|-------------|----|--|---|
| ■ BREAKER 1 | | BREAKER 1 | Range: Disabled, Enabled |
| | | FUNCTION: Disabled | |
| 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 2.000 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 1 000 000.000 s in steps of 0.001 |
| MESSAGE | ▲▼ | MANUAL CLOSE RECAL1 TIME: 0.000 s | Range: 0.000 to 1 000 000.000 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 Φ A/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 Φ B** and **BREAKER 1 Φ C** settings select operands to track phases B and C, respectively.
- **BREAKER 1 Φ A/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 Φ B CLOSED:** If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the breaker phase B closed position as above for phase A.
- **BREAKER 1 Φ B OPENED:** If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the breaker phase B opened position as above for phase A.
- **BREAKER 1 Φ C CLOSED:** If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the breaker phase C closed position as above for phase A.
- **BREAKER 1 Φ C OPENED:** If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the breaker phase C opened position as 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.

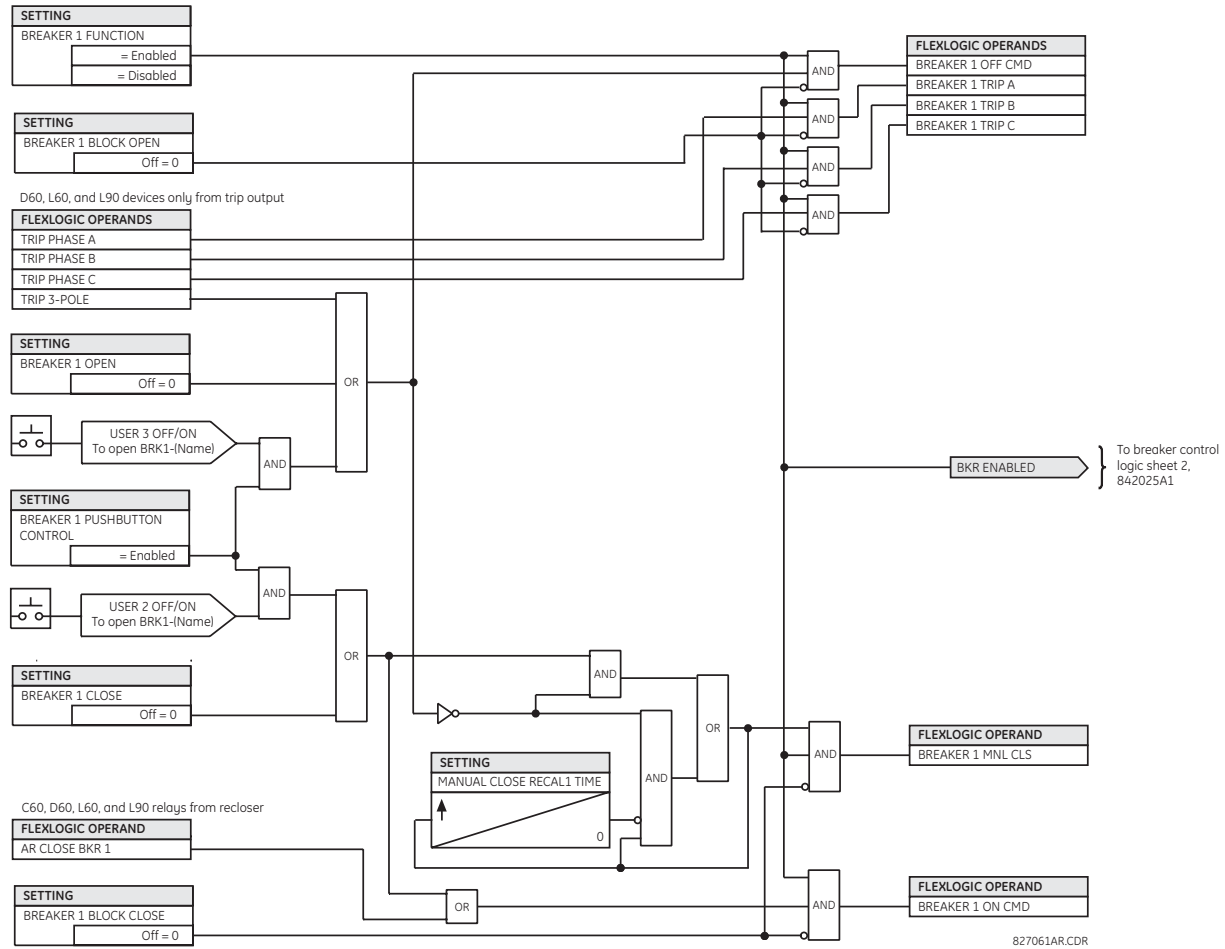


Figure 5-19: DUAL BREAKER CONTROL SCHEME LOGIC (Sheet 1 of 2)

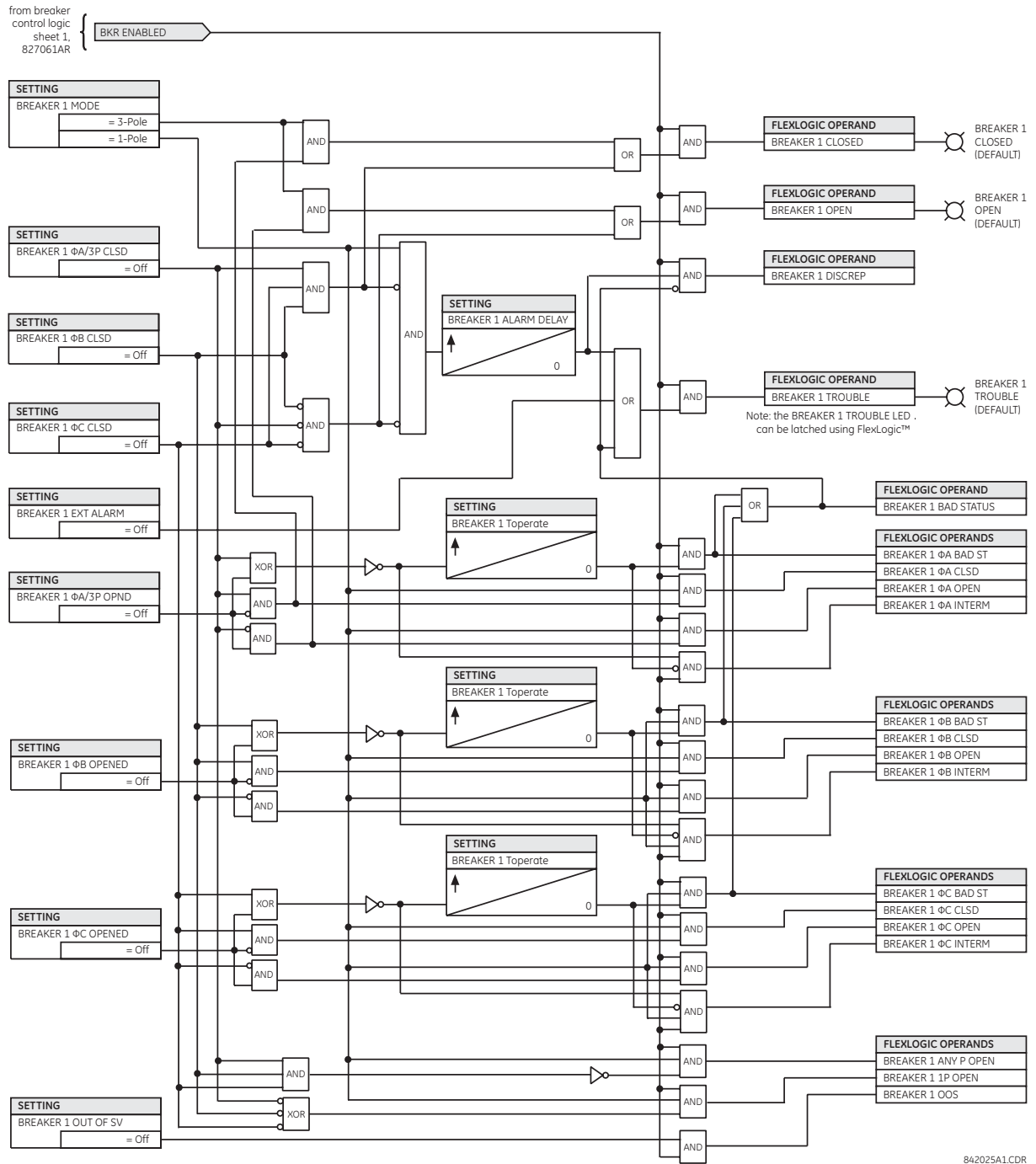


Figure 5-20: DUAL BREAKER CONTROL SCHEME LOGIC (Sheet 2 of 2)

5.3.5 DISCONNECT SWITCHES

PATH: SETTINGS ⇒ SYSTEM SETUP ⇒ SWITCHES ⇒ SWITCH 1

| | |
|--|--|
| <div> <div>■ SWITCH 1</div> <div> <div>◀▶</div> <div> <div>SWITCH 1</div> <div>FUNCTION: Disabled</div> </div> </div> </div> <div>Range: Disabled, Enabled</div> | |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 NAME:</div> <div>SW 1</div> </div> </div> <div>Range: up to 6 alphanumeric characters</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 MODE:</div> <div>3-Pole</div> </div> </div> <div>Range: 3-Pole, 1-Pole</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 OPEN:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 BLK OPEN:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 CLOSE:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 BLK CLOSE:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 ΦA/3P CLSD:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 ΦA/3P OPND:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 ΦB CLOSED:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 ΦB OPENED:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 ΦC CLOSED:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 ΦC OPENED:</div> <div>Off</div> </div> </div> <div>Range: FlexLogic™ operand</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 Toperate:</div> <div>0.070 s</div> </div> </div> <div>Range: 0.000 to 2.000 s in steps of 0.001</div> |
| MESSAGE | <div> <div>▲▼</div> <div> <div>SWITCH 1 ALARM</div> <div>DELAY: 0.000 s</div> </div> </div> <div>Range: 0.000 to 1 000 000.000 s in steps of 0.001</div> |
| MESSAGE | <div> <div>▲</div> <div> <div>SWITCH 1 EVENTS:</div> <div>Disabled</div> </div> </div> <div>Range: Disabled, Enabled</div> |

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.
- **SWITCH 1 Φ A/3P CLSD:** This setting selects an operand, usually a contact input connected to a disconnect switch auxiliary position tracking mechanism. This input 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 Φ B** and **SWITCH 1 Φ C** settings select operands to track phases B and C, respectively.
- **SWITCH 1 Φ A/3P OPND:** This setting selects an operand, usually a contact input, that 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 Φ B CLOSED:** If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the disconnect switch phase B closed position as above for phase A.
- **SWITCH 1 Φ B OPENED:** If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the disconnect switch phase B opened position as above for phase A.
- **SWITCH 1 Φ C CLOSED:** If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the disconnect switch phase C closed position as above for phase A.
- **SWITCH 1 Φ C OPENED:** If the mode is selected as three-pole, this setting has no function. If the mode is selected as single-pole, this input is used to track the disconnect switch phase C opened position as 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.

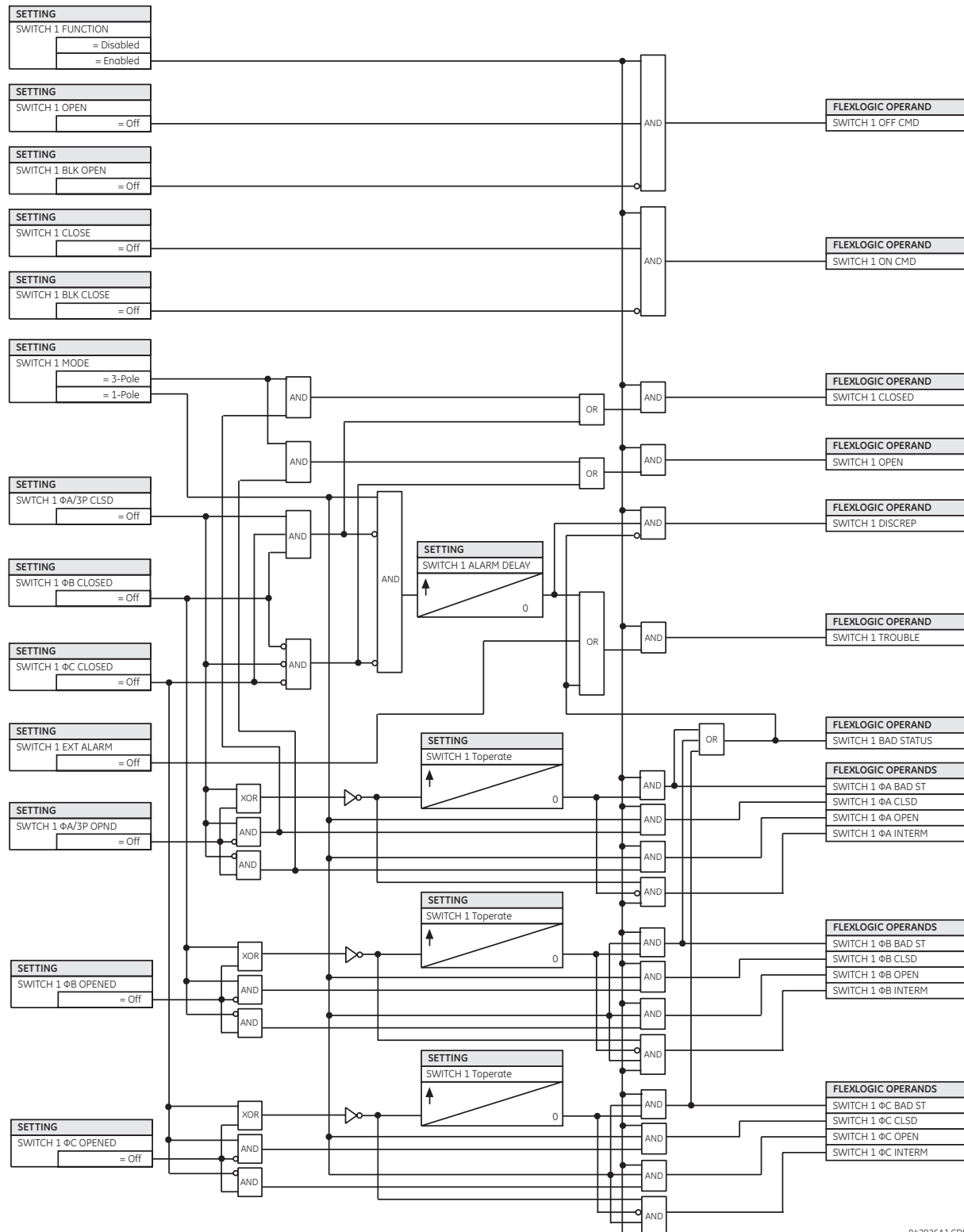


Figure 5-21: DISCONNECT SWITCH SCHEME LOGIC

5.3.6 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 5–5: FLEXCURVE™ TABLE

| RESET | TIME MS | RESET | TIME MS | OPERATE | TIME MS | OPERATE | TIME MS | OPERATE | TIME MS | OPERATE | TIME MS |
|-------|---------|-------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 0.00 | | 0.68 | | 1.03 | | 2.9 | | 4.9 | | 10.5 | |
| 0.05 | | 0.70 | | 1.05 | | 3.0 | | 5.0 | | 11.0 | |
| 0.10 | | 0.72 | | 1.1 | | 3.1 | | 5.1 | | 11.5 | |
| 0.15 | | 0.74 | | 1.2 | | 3.2 | | 5.2 | | 12.0 | |
| 0.20 | | 0.76 | | 1.3 | | 3.3 | | 5.3 | | 12.5 | |
| 0.25 | | 0.78 | | 1.4 | | 3.4 | | 5.4 | | 13.0 | |
| 0.30 | | 0.80 | | 1.5 | | 3.5 | | 5.5 | | 13.5 | |
| 0.35 | | 0.82 | | 1.6 | | 3.6 | | 5.6 | | 14.0 | |
| 0.40 | | 0.84 | | 1.7 | | 3.7 | | 5.7 | | 14.5 | |
| 0.45 | | 0.86 | | 1.8 | | 3.8 | | 5.8 | | 15.0 | |
| 0.48 | | 0.88 | | 1.9 | | 3.9 | | 5.9 | | 15.5 | |
| 0.50 | | 0.90 | | 2.0 | | 4.0 | | 6.0 | | 16.0 | |
| 0.52 | | 0.91 | | 2.1 | | 4.1 | | 6.5 | | 16.5 | |
| 0.54 | | 0.92 | | 2.2 | | 4.2 | | 7.0 | | 17.0 | |
| 0.56 | | 0.93 | | 2.3 | | 4.3 | | 7.5 | | 17.5 | |
| 0.58 | | 0.94 | | 2.4 | | 4.4 | | 8.0 | | 18.0 | |
| 0.60 | | 0.95 | | 2.5 | | 4.5 | | 8.5 | | 18.5 | |
| 0.62 | | 0.96 | | 2.6 | | 4.6 | | 9.0 | | 19.0 | |
| 0.64 | | 0.97 | | 2.7 | | 4.7 | | 9.5 | | 19.5 | |
| 0.66 | | 0.98 | | 2.8 | | 4.8 | | 10.0 | | 20.0 | |



The relay using a given FlexCurve™ applies linear approximation for times between the user-entered points. 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.

The dialog box titled "Recloser Curve Initialization" contains the following fields and controls:

- Standard Recloser Curve:** A dropdown menu showing "GE_101".
- Multiplier:** A text field containing "1".
- Adder (seconds):** A text field containing "0".
- Minimum Response Time:** A section with a checkbox "Use MRT" (unchecked) and a text field "MRT (seconds)" containing "0.013".
- High Current Time:** A section with a checkbox "Use HCT" (unchecked), a text field "HCT Ratio (Multiple of Pickup)" containing "20", and a text field "HCT (seconds)" containing "0.016".
- Buttons:** "Defaults", "OK", "Apply", and "Cancel".

Annotations on the right side of the dialog box:

- Multiplier:** Scales (multiplies) the curve operating times
- Addr:** Adds the time specified in this field (in ms) to each curve operating time value.
- Minimum Response Time (MRT):** If enabled, the MRT setting defines the shortest operating time even if the curve suggests a shorter time at higher current multiples. A composite operating characteristic is effectively defined. For current multiples lower than the intersection point, the curve dictates the operating time; otherwise, the MRT does. An information message appears when attempting to apply an MRT shorter than the minimum curve time.
- High Current Time:** Allows the user to set a pickup multiple from which point onwards the operating time is fixed. This is normally only required at higher current levels. The **HCT Ratio** defines the high current pickup multiple; the **HCT** defines the operating time.

842721A1.CDR

Figure 5-22: 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).

Recloser Curve Initialization

Standard Recloser Curve: GE_111

Multiplier: 1 Adder (seconds): 0

Minimum Response Time

☒ Use MRT

MRT (seconds): 0.2

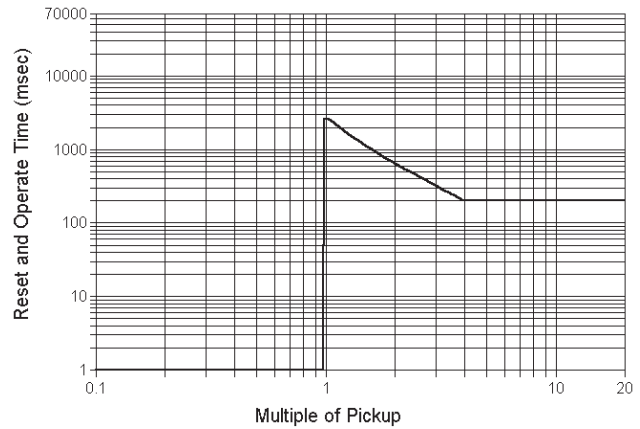
High Current Time

☐ Use HCT

HCT Ratio (Multiple of Pickup): 20

HCT (seconds): 0.016

Defaults OK Apply Cancel



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Figure 5-23: 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.

Recloser Curve Initialization

Standard Recloser Curve: GE_111

Multiplier: 1 Adder (seconds): 0

Minimum Response Time

☒ Use MRT

MRT (seconds): 0.2

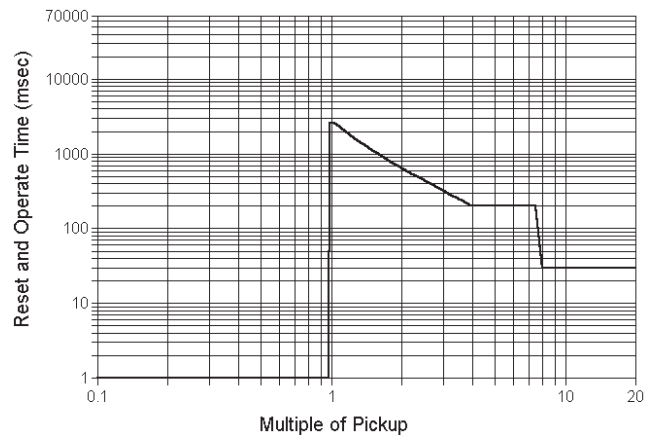
High Current Time

☒ Use HCT

HCT Ratio (Multiple of Pickup): 8

HCT (seconds): 0.03

Defaults OK Apply Cancel



842720A1.CDR

Figure 5-24: COMPOSITE RECLOSER CURVE WITH HCT ENABLED

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.

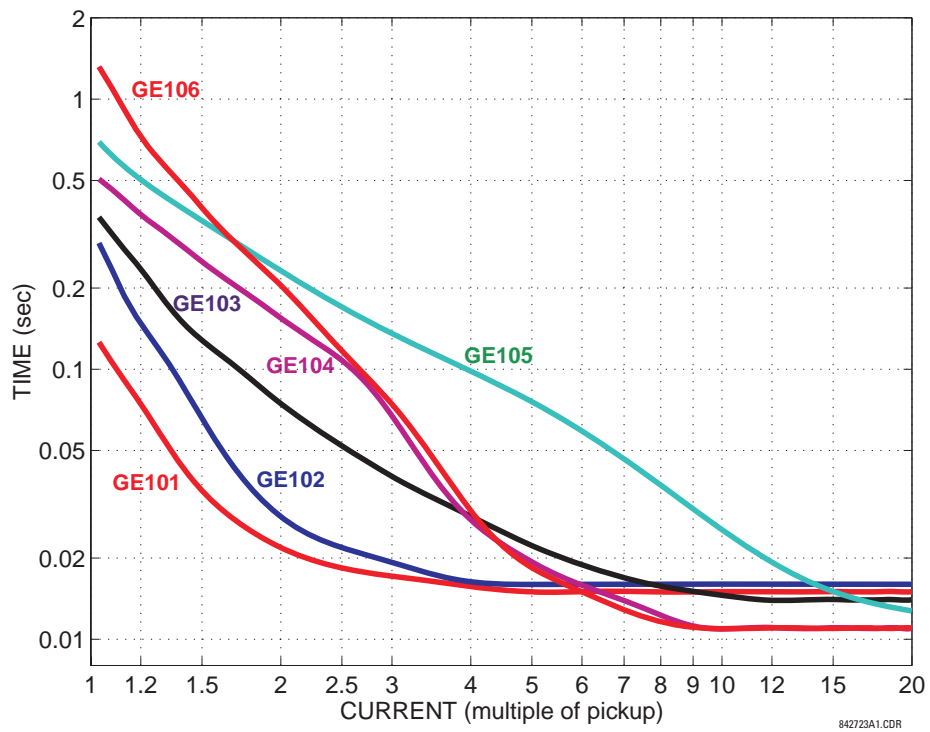


Figure 5-25: RECLOSER CURVES GE101 TO GE106

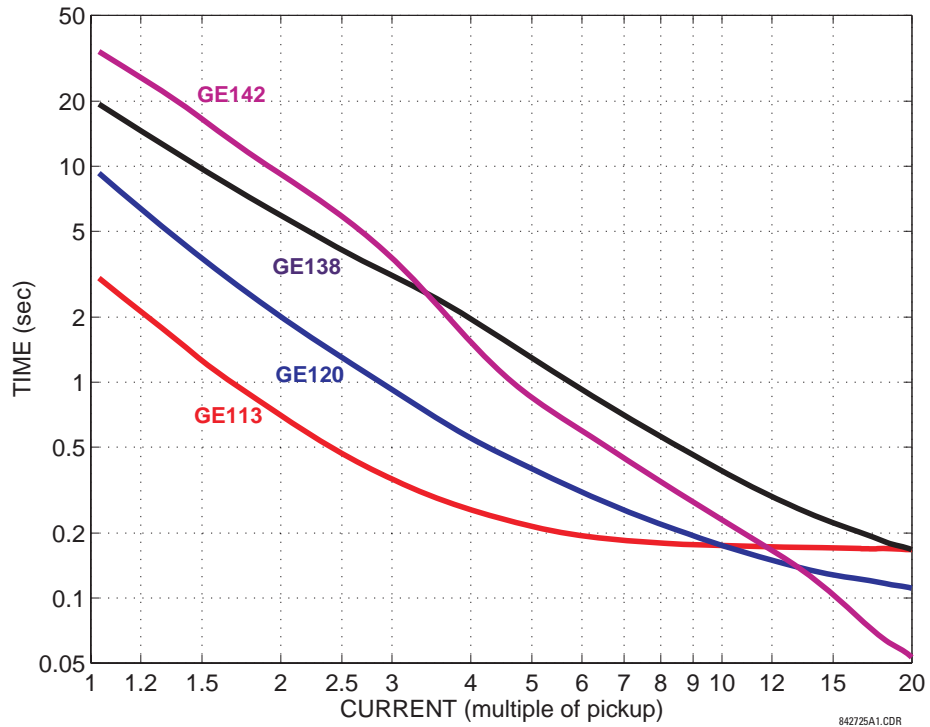


Figure 5-26: RECLOSER CURVES GE113, GE120, GE138 AND GE142

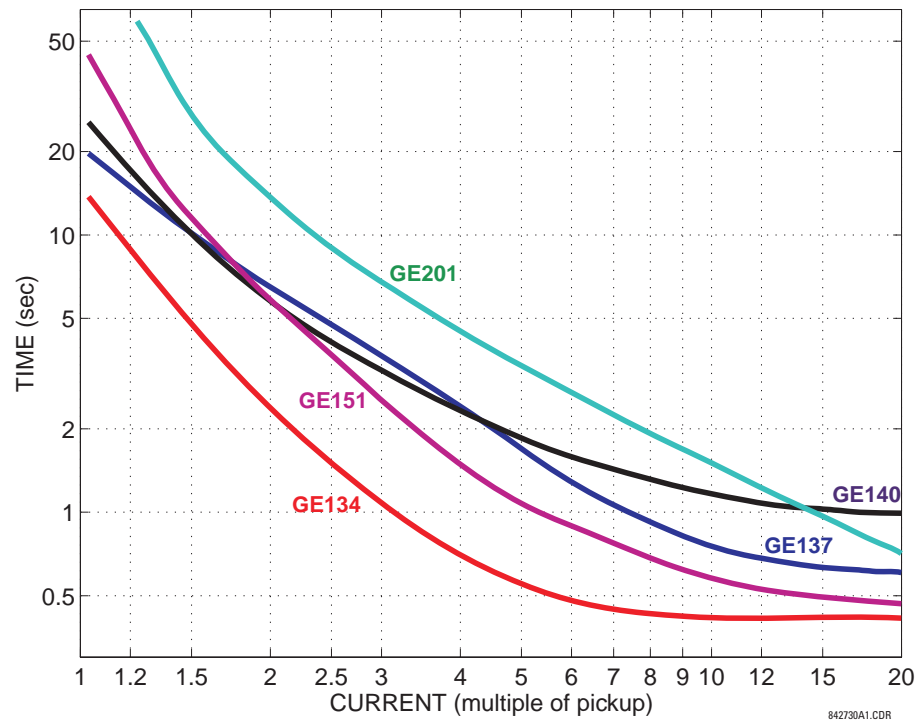


Figure 5-27: RECLOSER CURVES GE134, GE137, GE140, GE151 AND GE201

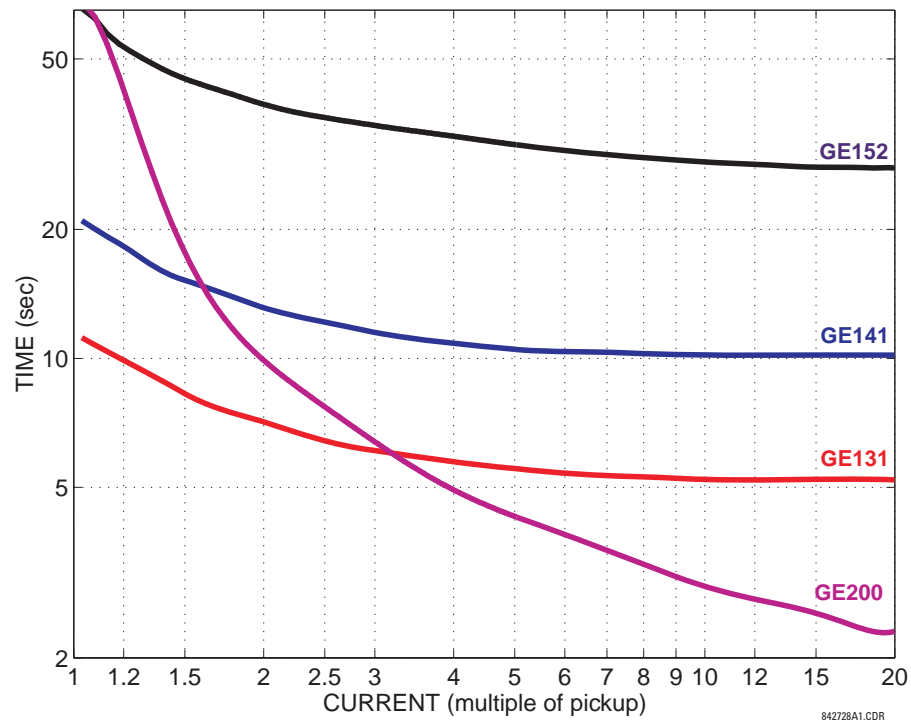


Figure 5-28: RECLOSER CURVES GE131, GE141, GE152, AND GE200

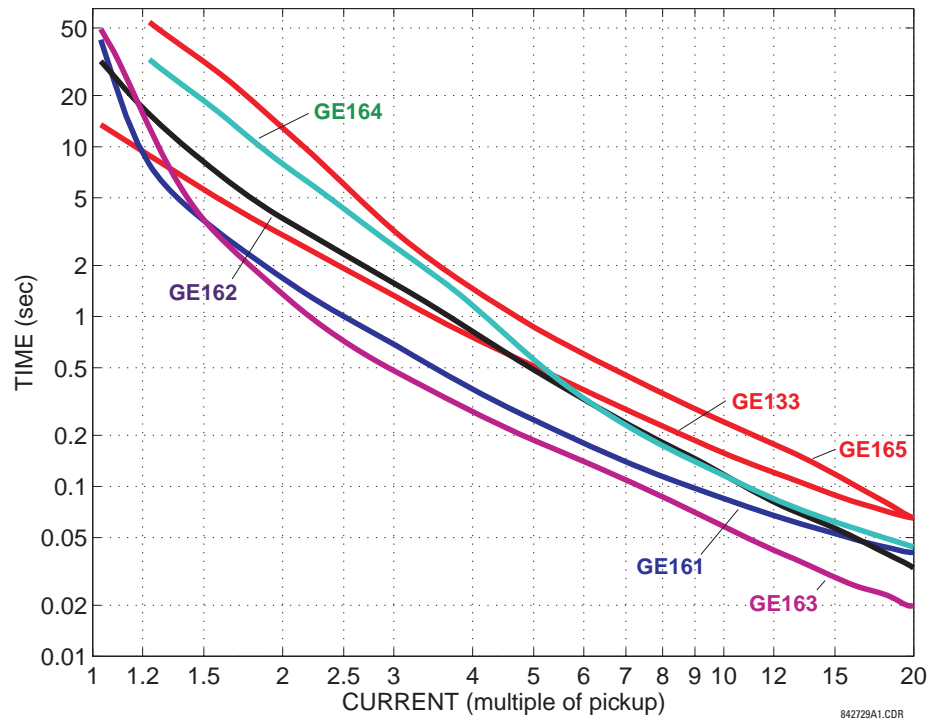


Figure 5-29: RECLOSER CURVES GE133, GE161, GE162, GE163, GE164 AND GE165

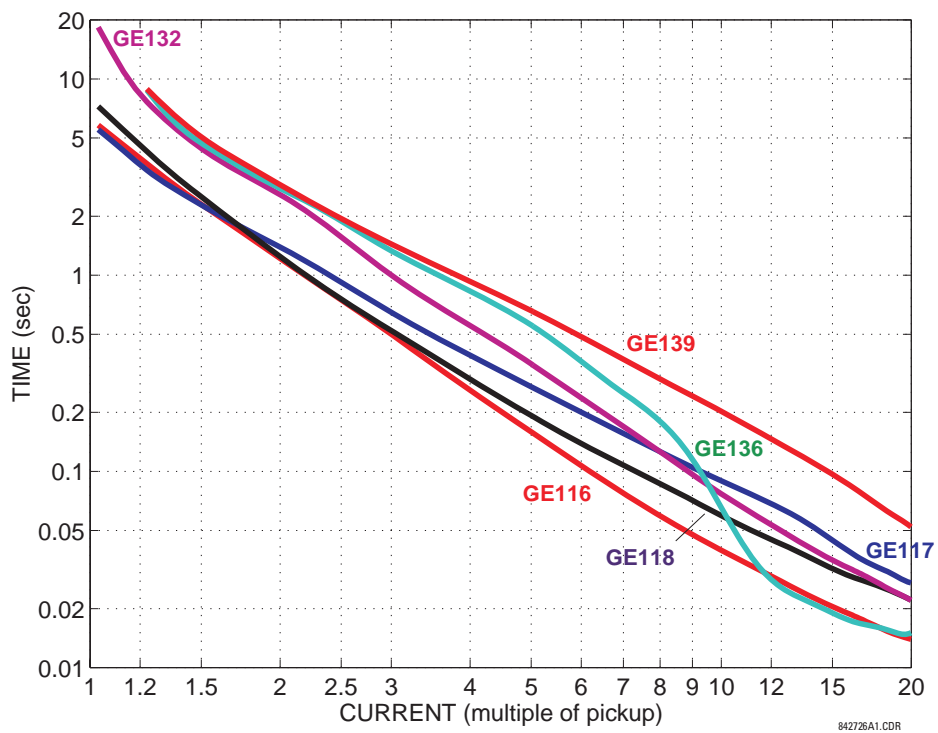


Figure 5-30: RECLOSER CURVES GE116, GE117, GE118, GE132, GE136, AND GE139

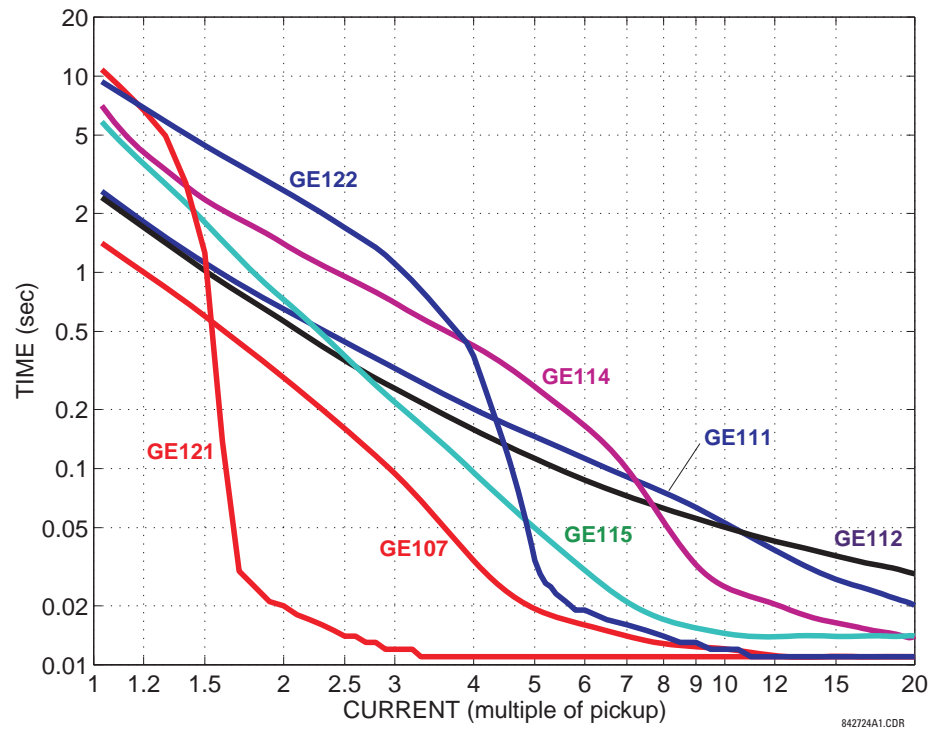


Figure 5-31: RECLOSER CURVES GE107, GE111, GE112, GE114, GE115, GE121, AND GE122

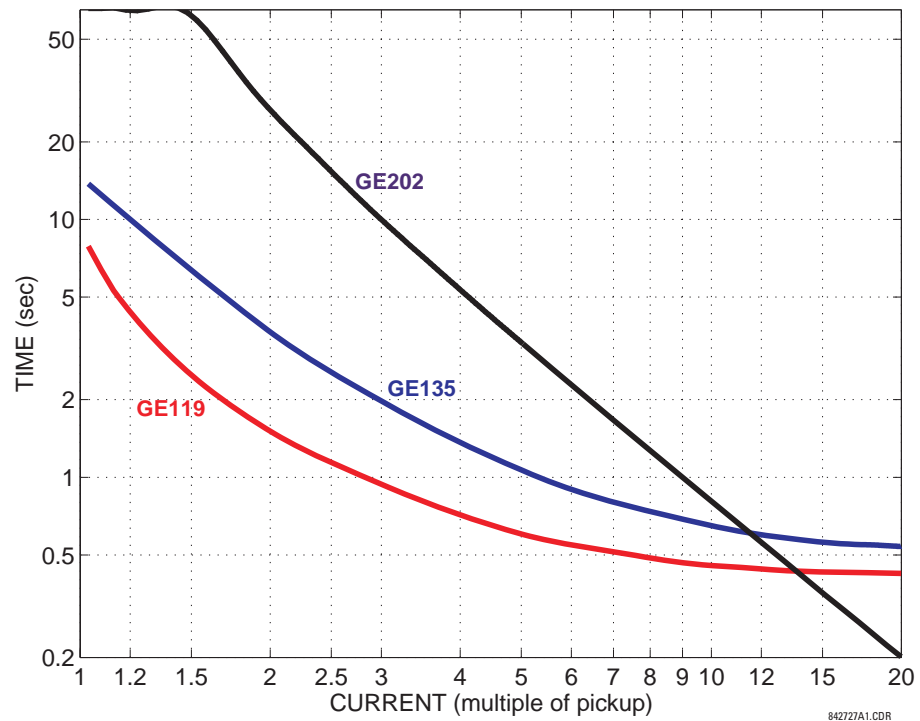


Figure 5-32: RECLOSER CURVES GE119, GE135, AND GE202

5.4.1 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.

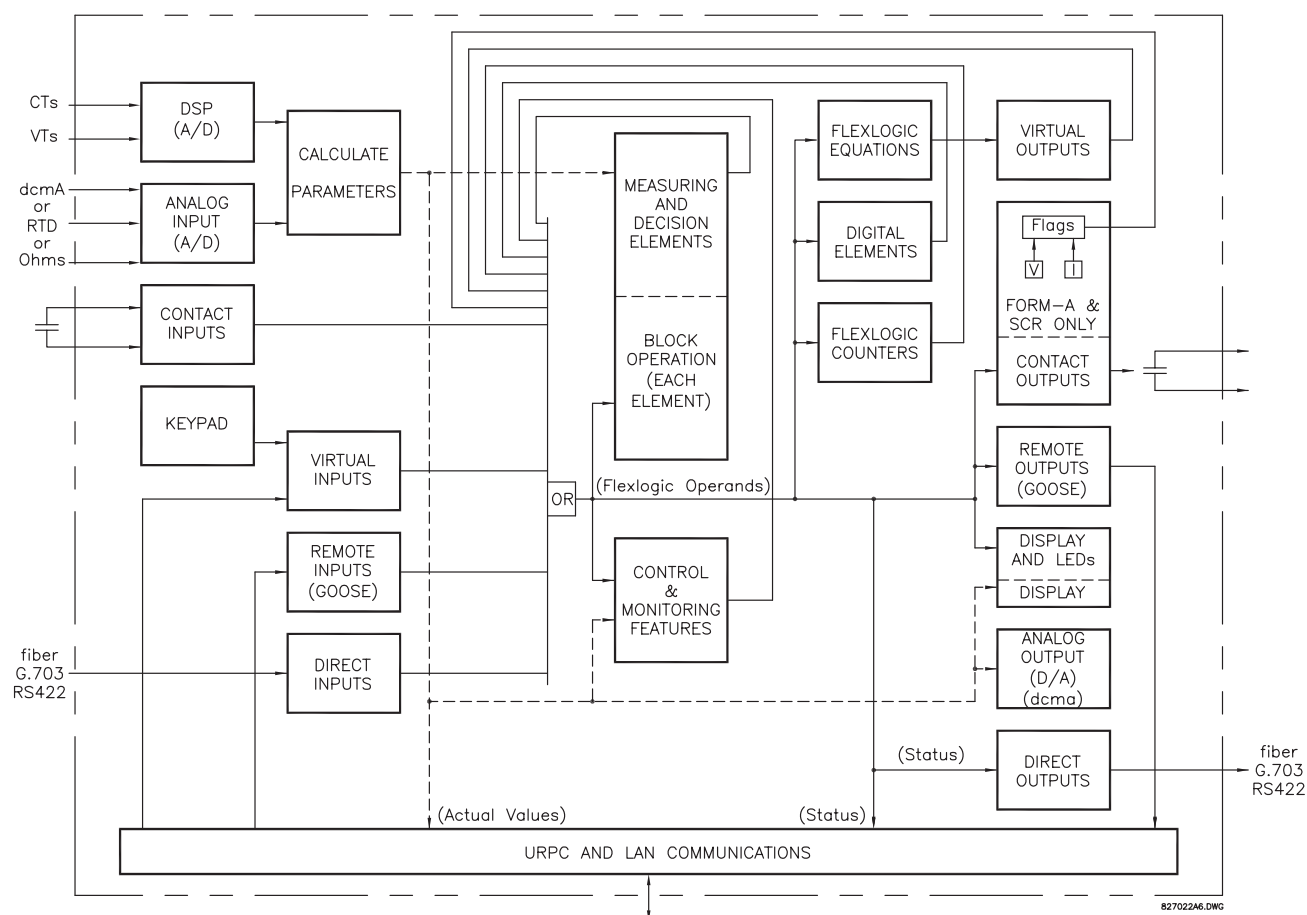


Figure 5-33: UR ARCHITECTURE OVERVIEW

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 5–6: 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) | Voltage On | Cont Op 1 VOn | Voltage exists across the contact. |
| | Voltage Off | Cont Op 1 VOff | Voltage does not exist across the contact. |
| | Current On | Cont Op 1 IOOn | Current is flowing through the contact. |
| | Current Off | Cont Op 1 IOOff | Current is not flowing through 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 5–7: C70 FLEXLOGIC™ OPERANDS (Sheet 1 of 8)

| 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 DIR IO CH2 CRC ALARM DIR IO CRC ALARM DIR IO CH1 UNRET ALM DIR IO CH2 UNRET ALM DIR IO UNRET ALM | The rate of direct input messages received on channel 1 and failing the CRC exceeded the user-specified level. The rate of direct input messages received on channel 2 and failing the CRC exceeded the user-specified level. The rate of direct input messages failing the CRC exceeded the user-specified level on channel 1 or 2. The rate of returned direct input/output messages on channel 1 exceeded the user-specified level (ring configurations only). The rate of returned direct input/output messages on channel 2 exceeded the user-specified level (ring configurations only). The rate of returned direct input/output messages exceeded the user-specified level on channel 1 or 2 (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 5–7: C70 FLEXLOGIC™ OPERANDS (Sheet 2 of 8)

| 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 RETRIP A BKR FAIL 1 RETRIP B BKR FAIL 1 RETRIP C 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 A of the breaker control 1 element. Breaker restrike detected in phase A 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 5–7: C70 FLEXLOGIC™ OPERANDS (Sheet 3 of 8)

| 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-voltage latch 1 is OFF (Logic = 0) |
| | LATCH 2 to LATCH 16 | Same set of operands as shown for LATCH 1 |

Table 5–7: C70 FLEXLOGIC™ OPERANDS (Sheet 4 of 8)

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

| OPERAND TYPE | OPERAND SYNTAX | OPERAND DESCRIPTION |
|---|--|---|
| 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 At least one phase of phase instantaneous overcurrent 1 has 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 | 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 At least one phase of overvoltage 1 has dropped out Phase A of overvoltage 1 has picked up Phase B of overvoltage 1 has picked up Phase C of overvoltage 1 has picked up Phase A of overvoltage 1 has operated Phase B of overvoltage 1 has operated Phase C of overvoltage 1 has operated Phase A of overvoltage 1 has dropped out Phase B of overvoltage 1 has dropped out Phase C of overvoltage 1 has dropped out |
| | PHASE 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 At least one phase of phase time overcurrent 1 has 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 |
| ELEMENT: Phase time overcurrent | PHASE TOC2 to TOC6 | Same set of operands as shown for PHASE TOC1 |
| | 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 At least one phase of phase undervoltage 1 has 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 |
| ELEMENT: Phase undervoltage | PHASE UV2 | Same set of operands as shown for PHASE UV1 |
| | SETTING GROUP ACT 1 SETTING GROUP ACT 2 SETTING GROUP ACT 3 SETTING GROUP ACT 4 SETTING GROUP ACT 5 SETTING GROUP ACT 6 | Setting group 1 is active Setting group 2 is active Setting group 3 is active Setting group 4 is active Setting group 5 is active Setting group 6 is active |
| ELEMENT: Disturbance detector | SRC1 50DD OP SRC2 50DD OP 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 |
| | 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) |
| ELEMENT: VTFF (Voltage transformer fuse failure) | SRC2 VT FUSE FAIL to SRC6 VT FUSE FAIL | Same set of operands as shown for SRC1 VT FUSE FAIL |

Table 5–7: C70 FLEXLOGIC™ OPERANDS (Sheet 6 of 8)

| OPERAND TYPE | OPERAND SYNTAX | OPERAND DESCRIPTION |
|----------------------------------|--------------------------|--|
| ELEMENT: Disconnect switch | SWITCH 1 OFF CMD | Disconnect switch 1 open command initiated |
| | SWITCH 1 ON CMD | Disconnect switch 1 close command initiated |
| | SWITCH 1 Φ A BAD ST | Disconnect switch 1 phase A bad status is detected (discrepancy between the 52/a and 52/b contacts) |
| | SWITCH 1 Φ A INTERM | Disconnect switch 1 phase A intermediate status is detected (transition from one position to another) |
| | SWITCH 1 Φ A CLSD | Disconnect switch 1 phase A is closed |
| | SWITCH 1 Φ A OPEN | Disconnect switch 1 phase A is open |
| | SWITCH 1 Φ B BAD ST | Disconnect switch 1 phase B bad status is detected (discrepancy between the 52/a and 52/b contacts) |
| | SWITCH 1 Φ A INTERM | Disconnect switch 1 phase A intermediate status is detected (transition from one position to another) |
| | SWITCH 1 Φ B CLSD | Disconnect switch 1 phase B is closed |
| | SWITCH 1 Φ B OPEN | Disconnect switch 1 phase B is open |
| ELEMENT: Time of day timer | SWITCH 1 Φ C BAD ST | Disconnect switch 1 phase C bad status is detected (discrepancy between the 52/a and 52/b contacts) |
| | SWITCH 1 Φ A INTERM | Disconnect switch 1 phase A intermediate status is detected (transition from one position to another) |
| | SWITCH 1 Φ C CLSD | Disconnect switch 1 phase C is closed |
| | SWITCH 1 Φ C OPEN | Disconnect switch 1 phase C is open |
| | SWITCH 1 BAD STATUS | Disconnect switch 1 bad status is detected on any pole |
| | SWITCH 1 CLOSED | Disconnect switch 1 is closed |
| | SWITCH 1 OPEN | Disconnect switch 1 is open |
| | SWITCH 1 DISCREP | Disconnect switch 1 has discrepancy |
| | SWITCH 1 TROUBLE | Disconnect switch 1 trouble alarm |
| | SWITCH 2... | Same set of operands as shown for SWITCH 1 |
| ELEMENT: Trip bus | TRIP BUS 1 PKP | Asserted when the trip bus 1 element picks up. |
| | TRIP BUS 1 OP | Asserted when the trip bus 1 element operates. |
| ELEMENT: Voltage differential | TRIP BUS 2... | Same set of operands as shown for TRIP BUS 1 |
| | VOLT DIF 1 STG1A PKP | Voltage differential element 1 picked up in phase A of stage 1 |
| | VOLT DIF 1 STG1B PKP | Voltage differential element 1 picked up in phase B of stage 1 |
| | VOLT DIF 1 STG1C PKP | Voltage differential element 1 picked up in phase C of stage 1 |
| | VOLT DIF 1 STG2A PKP | Voltage differential element 1 picked up in phase A of stage 2 |
| | VOLT DIF 1 STG2B PKP | Voltage differential element 1 picked up in phase B of stage 2 |
| | VOLT DIF 1 STG2C PKP | Voltage differential element 1 picked up in phase C of stage 2 |
| | VOLT DIF 1 STG3A PKP | Voltage differential element 1 picked up in phase A of stage 3 |
| | VOLT DIF 1 STG3B PKP | Voltage differential element 1 picked up in phase B of stage 3 |
| | VOLT DIF 1 STG3C PKP | Voltage differential element 1 picked up in phase C of stage 3 |
| FIXED OPERANDS | VOLT DIF 1 STG4A PKP | Voltage differential element 1 picked up in phase A of stage 4 |
| | VOLT DIF 1 STG4B PKP | Voltage differential element 1 picked up in phase B of stage 4 |
| | VOLT DIF 1 STG4C PKP | Voltage differential element 1 picked up in phase C of stage 4 |
| | VOLT DIF 1 PKP A | Voltage differential element 1 picked up in phase A |
| | VOLT DIF 1 PKP B | Voltage differential element 1 picked up in phase B |
| | VOLT DIF 1 PKP C | Voltage differential element 1 picked up in phase C |
| | VOLT DIF 1 PKP | Voltage differential element 1 picked up |
| | VOLT DIF 1 DPO | Voltage differential element 1 dropped out |
| | VOLT DIF 1 STG1A OP | Voltage differential element 1 operated in phase A of stage 1 |
| | VOLT DIF 1 STG1B OP | Voltage differential element 1 operated in phase B of stage 1 |
| FIXED OPERANDS | VOLT DIF 1 STG1C OP | Voltage differential element 1 operated in phase C of stage 1 |
| | VOLT DIF 1 STG2A OP | Voltage differential element 1 operated in phase A of stage 2 |
| | VOLT DIF 1 STG2B OP | Voltage differential element 1 operated in phase B of stage 2 |
| | VOLT DIF 1 STG2C OP | Voltage differential element 1 operated in phase C of stage 2 |
| | VOLT DIF 1 STG3A OP | Voltage differential element 1 operated in phase A of stage 3 |
| | VOLT DIF 1 STG3B OP | Voltage differential element 1 operated in phase B of stage 3 |
| | VOLT DIF 1 STG3C OP | Voltage differential element 1 operated in phase C of stage 3 |
| | VOLT DIF 1 STG4A OP | Voltage differential element 1 operated in phase A of stage 4 |
| | VOLT DIF 1 STG4B OP | Voltage differential element 1 operated in phase B of stage 4 |
| | VOLT DIF 1 STG4C OP | Voltage differential element 1 operated in phase C of stage 4 |
| FIXED OPERANDS | VOLT DIF 1 OP A | Voltage differential element 1 operated in phase A |
| | VOLT DIF 1 OP B | Voltage differential element 1 operated in phase B |
| FIXED OPERANDS | VOLT DIF 1 OP C | Voltage differential element 1 operated in phase C |
| | VOLT DIF 1 OP | Voltage differential element 1 operated |
| FIXED OPERANDS | VOLT DIF 2 to 3 | Same set of operands as shown for VOLT DIF 1 above |
| | Off | Logic = 0. Does nothing and may be used as a delimiter in an equation list; used as 'Disable' by other features. |
| FIXED OPERANDS | On | Logic = 1. Can be used as a test setting. |

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

| OPERAND TYPE | OPERAND SYNTAX | OPERAND DESCRIPTION |
|--|--|--|
| INPUTS/OUTPUTS: Contact inputs | Cont Ip 1 On Cont Ip 2 On ↓ Cont Ip 1 Off Cont Ip 2 Off | (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 ↓ Cont Op 1 IOff Cont Op 2 IOff | (will not appear unless ordered) (will not appear unless ordered) ↓ (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 ↓ Cont Op 1 VOff Cont Op 2 VOff | (will not appear unless ordered) (will not appear unless ordered) ↓ (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 inputs | REMOTE INPUT 1 On ↓ REMOTE INPUT 32 On | Flag is set, logic=1 ↓ Flag is set, logic=1 |
| INPUTS/OUTPUTS: Virtual inputs | Virt Ip 1 On ↓ Virt Ip 64 On | Flag is set, logic=1 ↓ Flag is set, logic=1 |
| INPUTS/OUTPUTS: Virtual outputs | Virt Op 1 On ↓ Virt Op 96 On | 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. |
| REMOTE DEVICES | REMOTE DEVICE 1 On ↓ REMOTE DEVICE 16 On | Flag is set, logic=1 ↓ Flag is set, logic=1 |
| | REMOTE DEVICE 1 Off ↓ REMOTE DEVICE 16 Off | 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 5–7: C70 FLEXLOGIC™ OPERANDS (Sheet 8 of 8)

| OPERAND TYPE | OPERAND SYNTAX | OPERAND DESCRIPTION |
|-------------------------------|--|--|
| SELF-DIAGNOSTICS | ANY MAJOR ERROR | Any of the major self-test errors generated (major error) |
| | ANY MINOR ERROR | Any of the minor self-test errors generated (minor error) |
| | ANY SELF-TESTS | Any self-test errors generated (generic, any error) |
| | BATTERY FAIL | See description in <i>Chapter 7: Commands and targets</i> |
| | DIRECT DEVICE OFF | See description in <i>Chapter 7: Commands and targets</i> |
| | DIRECT RING BREAK | See description in <i>Chapter 7: Commands and targets</i> |
| | DSP ERROR | See description in <i>Chapter 7: Commands and targets</i> |
| | EEPROM DATA ERROR | See description in <i>Chapter 7: Commands and targets</i> |
| | EQUIPMENT MISMATCH | See description in <i>Chapter 7: Commands and targets</i> |
| | ETHERNET SWITCH FAIL | See description in <i>Chapter 7: Commands and targets</i> |
| | FLEXLOGIC ERR TOKEN | See description in <i>Chapter 7: Commands and targets</i> |
| | IRIG-B FAILURE | See description in <i>Chapter 7: Commands and targets</i> |
| | LATCHING OUT ERROR | See description in <i>Chapter 7: Commands and targets</i> |
| | LOW ON MEMORY | See description in <i>Chapter 7: Commands and targets</i> |
| | NO DSP INTERRUPTS | See description in <i>Chapter 7: Commands and targets</i> |
| | PRI ETHERNET FAIL | See description in <i>Chapter 7: Commands and targets</i> |
| | PROGRAM MEMORY | See description in <i>Chapter 7: Commands and targets</i> |
| | PROTOTYPE FIRMWARE | See description in <i>Chapter 7: Commands and targets</i> |
| | REMOTE DEVICE OFF | See description in <i>Chapter 7: Commands and targets</i> |
| | SEC ETHERNET FAIL | See description in <i>Chapter 7: Commands and targets</i> |
| | SNTP FAILURE | See description in <i>Chapter 7: Commands and targets</i> |
| | SYSTEM EXCEPTION | See description in <i>Chapter 7: Commands and targets</i> |
| | UNIT NOT CALIBRATED | See description in <i>Chapter 7: Commands and targets</i> |
| | UNIT NOT PROGRAMMED | See description in <i>Chapter 7: Commands and targets</i> |
| | WATCHDOG ERROR | See description in <i>Chapter 7: Commands and targets</i> |
| UNAUTHORIZED ACCESS ALARM | UNAUTHORIZED ACCESS | Asserted when a password entry fails while accessing a password protected level of the relay. |
| 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 FlexLogic™ operators table.

Table 5–8: 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 5–9: FLEXLOGIC™ OPERATORS

| TYPE | SYNTAX | DESCRIPTION | NOTES |
|-----------------------|-------------------|--|---|
| Editor | INSERT | Insert a parameter in an equation list. | |
| | DELETE | Delete a parameter from an equation list. | |
| End | END | The first END encountered signifies the last entry in the list of processed FlexLogic™ parameters. | |
| One-shot | POSITIVE ONE SHOT | One shot that responds to a positive going edge. | A 'one shot' refers to a single input gate that generates a pulse in response to an edge on the input. The output from a 'one shot' is True (positive) for only one pass through the FlexLogic™ equation. There is a maximum of 64 'one shots'. |
| | NEGATIVE ONE SHOT | One shot that responds to a negative going edge. | |
| | DUAL ONE SHOT | One shot that responds to both the positive and negative going edges. | |
| Logic gate | NOT | Logical NOT | Operates on the previous parameter. |
| | OR(2) | 2 input OR gate | Operates on the 2 previous parameters. |
| | OR(16) | 16 input OR gate | Operates on the 16 previous parameters. |
| | AND(2) | 2 input AND gate | Operates on the 2 previous parameters. |
| | AND(16) | 16 input AND gate | Operates on the 16 previous parameters. |
| | NOR(2) | 2 input NOR gate | Operates on the 2 previous parameters. |
| | NOR(16) | 16 input NOR gate | Operates on the 16 previous parameters. |
| | NAND(2) | 2 input NAND gate | Operates on the 2 previous parameters. |
| | NAND(16) | 16 input NAND gate | Operates on the 16 previous parameters. |
| Timer | XOR(2) | 2 input Exclusive OR gate | Operates on the 2 previous parameters. |
| | LATCH (S,R) | Latch (set, reset): reset-dominant | The parameter preceding LATCH(S,R) is the reset input. The parameter preceding the reset input is the set input. |
| Timer | TIMER 1 | Timer set with FlexLogic™ timer 1 settings. | The timer is started by the preceding parameter. The output of the timer is TIMER #. |
| | TIMER 32 | Timer set with FlexLogic™ timer 32 settings. | |
| Assign virtual output | = Virt Op 1 | Assigns previous FlexLogic™ operand to virtual output 1. | The virtual output is set by the preceding parameter |
| | = Virt Op 96 | Assigns previous FlexLogic™ operand to virtual output 96. | |

5.4.2 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.

5.4.3 FLEXLOGIC™ EVALUATION

Each equation is evaluated in the order in which the parameters have been entered.



FlexLogic™ provides latches which by definition have a memory action, remaining in the set state after the set input has been asserted. However, they are *volatile*; that is, they reset on the re-application of control power.

When making changes to settings, all FlexLogic™ equations are re-compiled whenever any new setting value is entered, so all latches are automatically reset. If it is necessary to re-initialize FlexLogic™ during testing, for example, it is suggested to power the unit down and then back up.

5.4.4 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.

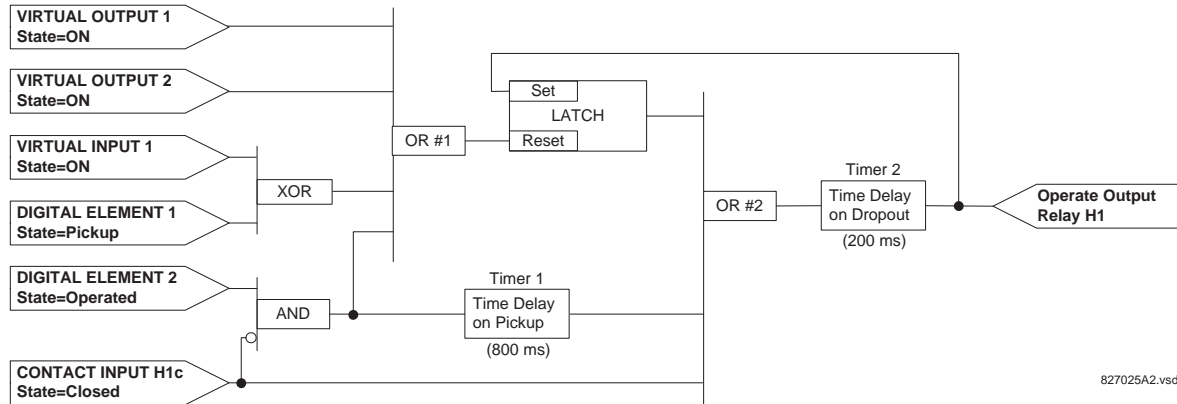


Figure 5-34: EXAMPLE LOGIC SCHEME

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.

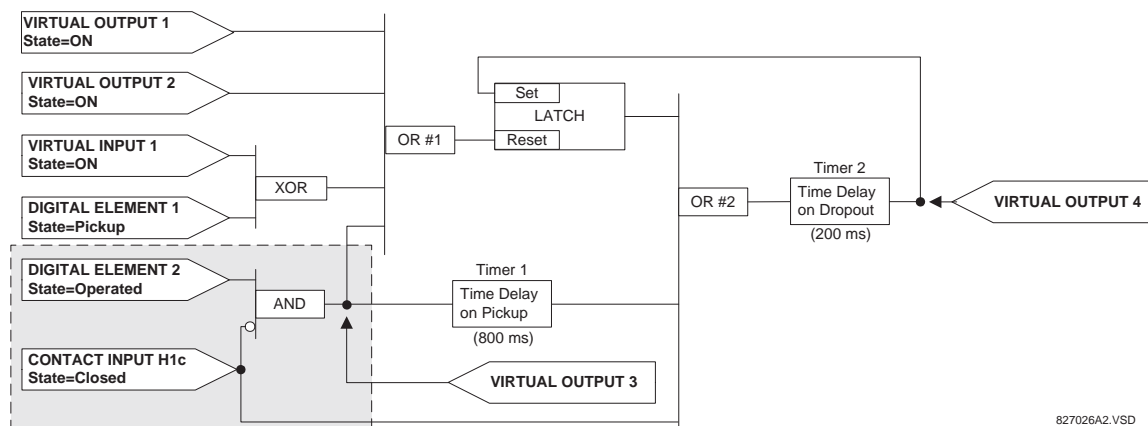


Figure 5-35: LOGIC EXAMPLE WITH VIRTUAL OUTPUTS

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.

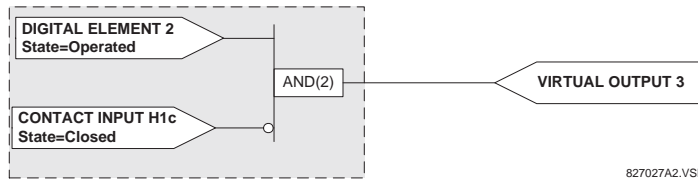


Figure 5–36: LOGIC FOR VIRTUAL OUTPUT 3

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.

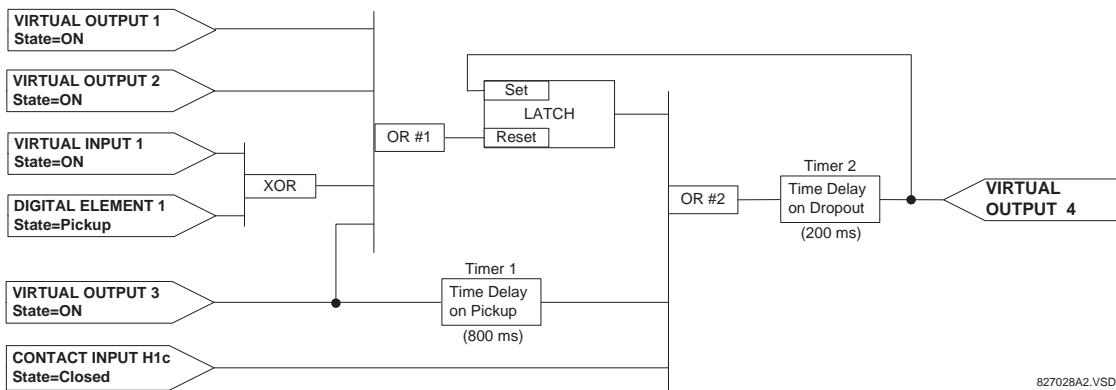


Figure 5–37: LOGIC FOR VIRTUAL OUTPUT 4

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.

| | |
|----|--|
| 01 | |
| 02 | |
| 03 | |
| 04 | |
| 05 | |
| ⋮ | |
| 97 | |
| 98 | |
| 99 | |

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Figure 5–38: 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.

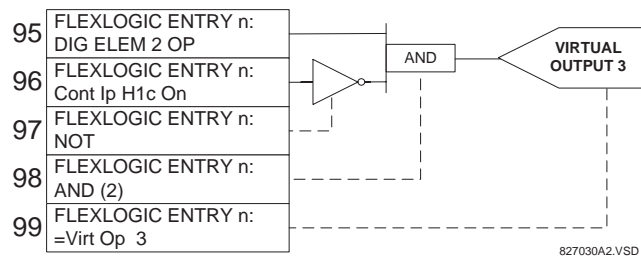


Figure 5–39: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 3

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.

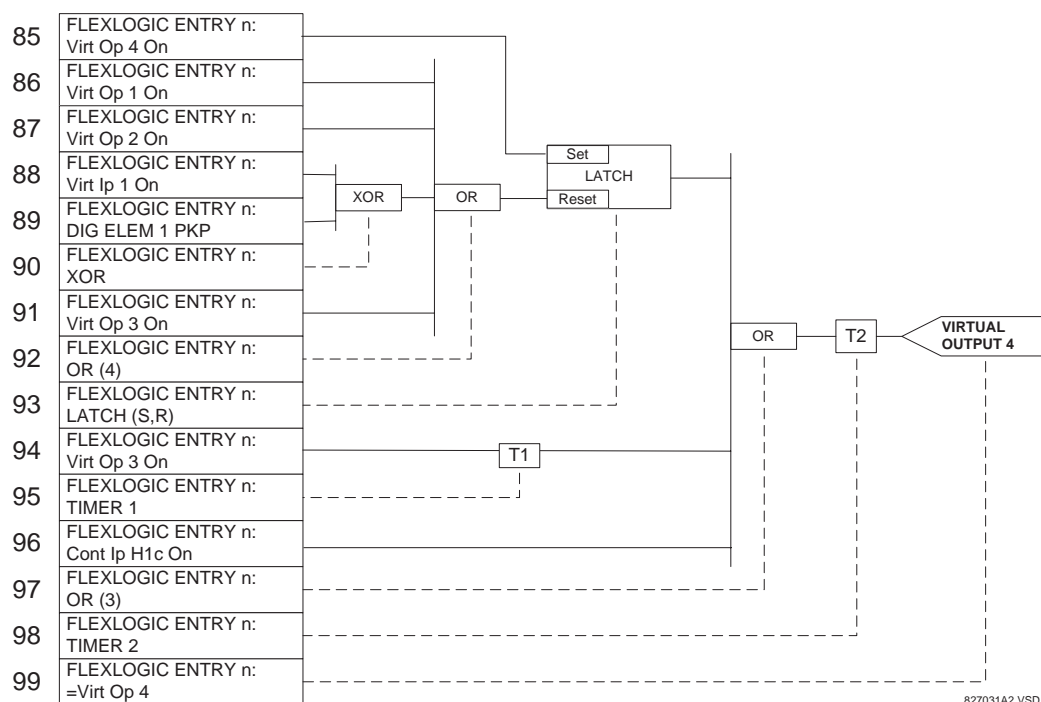


Figure 5–40: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 4

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

```

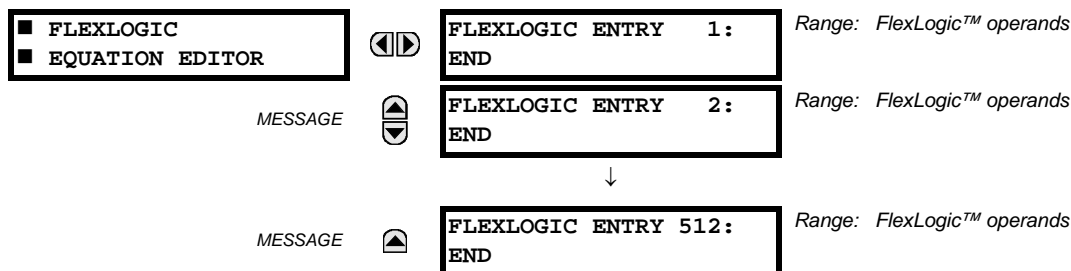
In the expression above, the virtual output 4 input to the four-input OR is listed before it is created. This is typical of a form of feedback, in this case, used to create a seal-in effect with the latch, and is correct.

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.

5.4.5 FLEXLOGIC™ EQUATION EDITOR

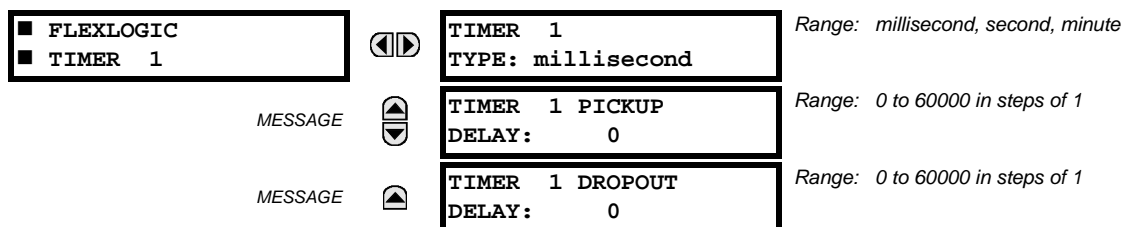
PATH: SETTINGS ⇒ FLEXLOGIC ⇒ FLEXLOGIC EQUATION EDITOR



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.

5.4.6 FLEXLOGIC™ TIMERS

PATH: SETTINGS ⇒ FLEXLOGIC ⇒ FLEXLOGIC TIMERS ⇒ FLEXLOGIC TIMER 1(32)



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".

5.4.7 FLEXELEMENTS™

PATH: SETTING ⇒ FLEXLOGIC ⇒ FLEXELEMENTS ⇒ FLEXELEMENT 1(16)

| | | | |
|-----------------|----|--|---|
| ■ FLEXELEMENT 1 | | FLEXELEMENT 1 | Range: Disabled, Enabled |
| | | FUNCTION: Disabled | |
| MESSAGE | ▲▼ | FLEXELEMENT 1 NAME: FxEl | Range: up to 6 alphanumeric characters |
| MESSAGE | ▲▼ | FLEXELEMENT 1 +IN: Off | Range: Off, any analog actual value parameter |
| MESSAGE | ▲▼ | FLEXELEMENT 1 -IN: Off | Range: Off, any analog actual value parameter |
| MESSAGE | ▲▼ | FLEXELEMENT 1 INPUT MODE: Signed | Range: Signed, Absolute |
| MESSAGE | ▲▼ | FLEXELEMENT 1 COMP MODE: Level | Range: Level, Delta |
| MESSAGE | ▲▼ | FLEXELEMENT 1 DIRECTION: Over | Range: Over, Under |
| MESSAGE | ▲▼ | FLEXELEMENT 1 PICKUP: 1.000 pu | Range: -90.000 to 90.000 pu in steps of 0.001 |
| MESSAGE | ▲▼ | FLEXELEMENT 1 HYSTERESIS: 3.0% | Range: 0.1 to 50.0% in steps of 0.1 |
| MESSAGE | ▲▼ | FLEXELEMENT 1 dt UNIT: milliseconds | Range: milliseconds, seconds, minutes |
| MESSAGE | ▲▼ | FLEXELEMENT 1 dt: 20 | Range: 20 to 86400 in steps of 1 |
| MESSAGE | ▲▼ | FLEXELEMENT 1 PKP DELAY: 0.000 s | Range: 0.000 to 65.535 s in steps of 0.001 |
| MESSAGE | ▲▼ | FLEXELEMENT 1 RST DELAY: 0.000 s | Range: 0.000 to 65.535 s in steps of 0.001 |
| MESSAGE | ▲▼ | FLEXELEMENT 1 BLK: Off | Range: FlexLogic™ operand |
| MESSAGE | ▲▼ | FLEXELEMENT 1 TARGET: Self-reset | Range: Self-reset, Latched, Disabled |
| MESSAGE | ▲ | FLEXELEMENT 1 EVENTS: Disabled | Range: Disabled, Enabled |

A FlexElement™ is a universal comparator that can be used to monitor any analog actual value calculated by the relay or a net difference of any two analog actual values of the same type. The effective operating signal could be treated as a signed number or its absolute value could be used as per user's choice.

The element can be programmed to respond either to a signal level or to a rate-of-change (delta) over a pre-defined period of time. The output operand is asserted when the operating signal is higher than a threshold or lower than a threshold as per user's choice.

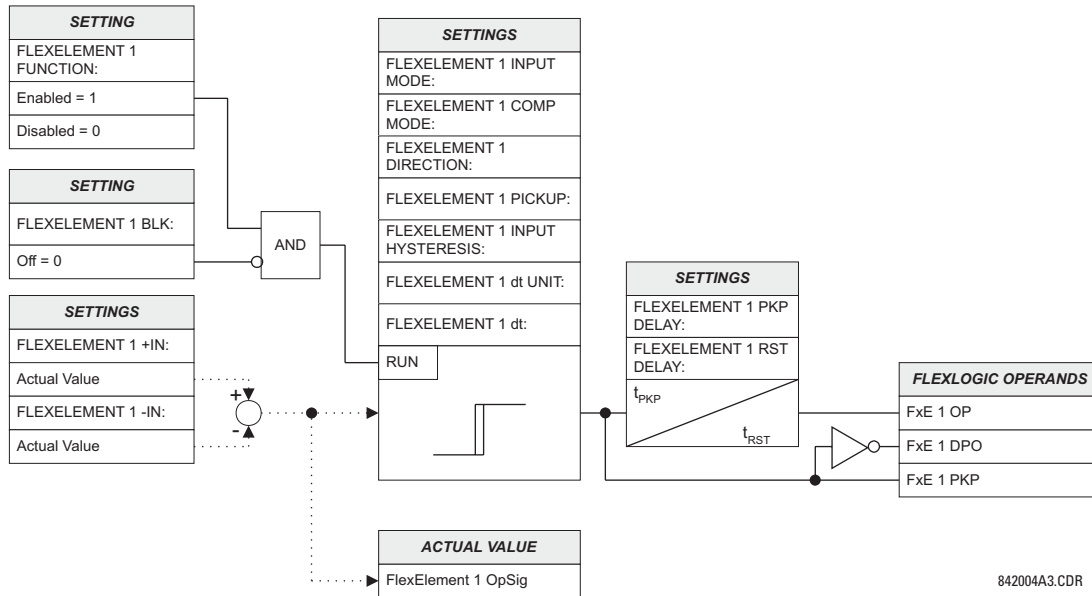


Figure 5-41: FLEXELEMENT™ SCHEME LOGIC

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 or 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.

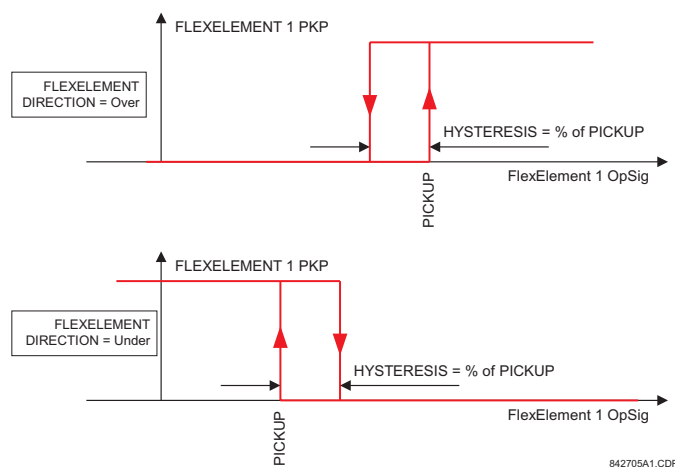


Figure 5-42: FLEXELEMENT™ DIRECTION, PICKUP, AND HYSTERESIS

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.

5

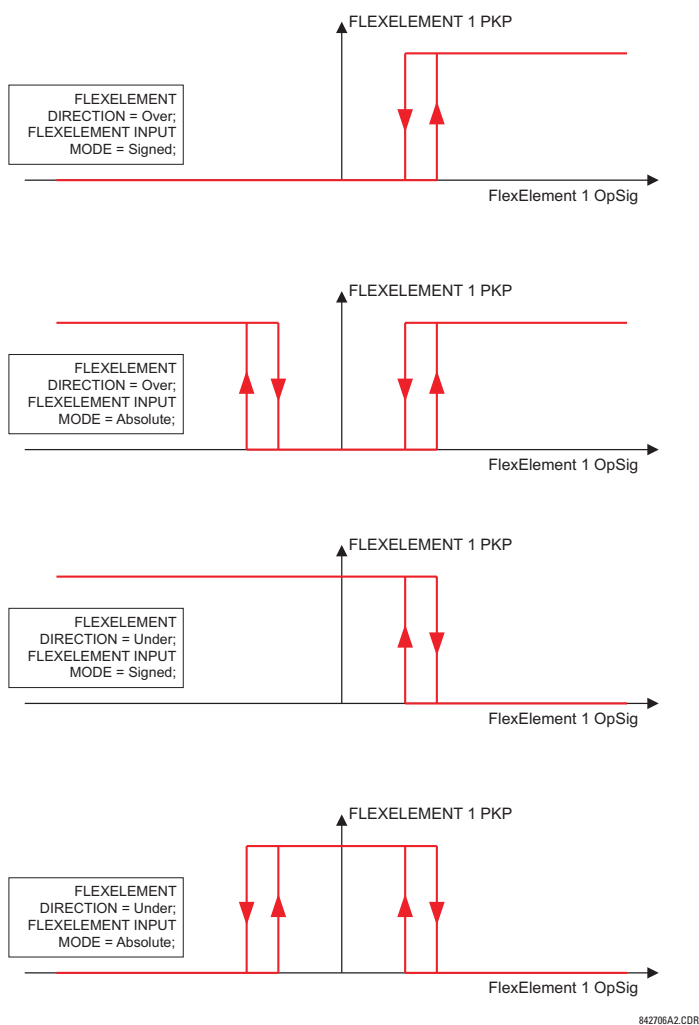


Figure 5-43: FLEXELEMENT™ INPUT MODE SETTING

The **FLEXELEMENT 1 PICKUP** setting specifies the operating threshold for the effective operating signal of the element. If set to “Over”, the element picks up when the operating signal exceeds the **FLEXELEMENT 1 PICKUP** value. If set to “Under”, the element picks up when the operating signal falls below the **FLEXELEMENT 1 PICKUP** value.

The **FLEXELEMENT 1 HYSTERESIS** setting controls the element dropout. It should be noticed that both the operating signal and the pickup threshold can be negative facilitating applications such as reverse power alarm protection. The FlexElement™ can be programmed to work with all analog actual values measured by the relay. The **FLEXELEMENT 1 PICKUP** setting is entered in per-unit values using the following definitions of the base units:

Table 5–10: 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 | $f_{\text{BASE}} = 1 \text{ Hz}$ |
| PHASE ANGLE | $\phi_{\text{BASE}} = 360 \text{ degrees}$ (see the UR angle referencing convention) |
| POWER FACTOR | $\text{PF}_{\text{BASE}} = 1.00$ |
| RTDs | BASE = 100°C |
| SOURCE CURRENT | $I_{\text{BASE}} = \text{maximum nominal primary RMS value of the +IN and –IN inputs}$ |
| SOURCE POWER | $P_{\text{BASE}} = \text{maximum value of } V_{\text{BASE}} \times I_{\text{BASE}} \text{ for the +IN and –IN inputs}$ |
| SOURCE THD & HARMONICS | BASE = 1% |
| SOURCE VOLTAGE | $V_{\text{BASE}} = \text{maximum nominal primary RMS value of the +IN and –IN inputs}$ |

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.

5.4.8 NON-VOLATILE LATCHES

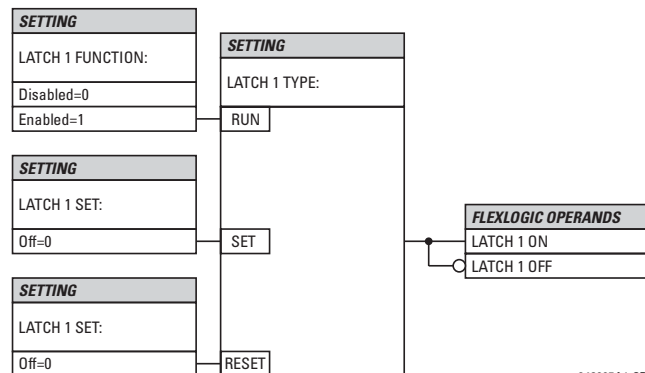
PATH: SETTINGS ⇒ FLEXLOGIC ⇒ NON-VOLATILE LATCHES ⇒ LATCH 1(16)

| | | |
|-----------|---------------------------------|--------------------------------------|
| ■ LATCH 1 | | Range: Disabled, Enabled |
| | LATCH 1 FUNCTION: Disabled | |
| 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 |



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Figure 5–44: NON-VOLATILE LATCH OPERATION TABLE (N = 1 to 16) AND LOGIC

5.5.1 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.

5.5.2 SETTING GROUP

PATH: SETTINGS ⇒ ↓ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6)

| | | | |
|-------------------|----|--------------------|-----------------|
| ■ SETTING GROUP 1 | ◀▶ | ■ BREAKER FAILURE | See page 5-102. |
| MESSAGE | ▲▼ | ■ PHASE CURRENT | See page 5-111. |
| MESSAGE | ▲▼ | ■ NEUTRAL CURRENT | See page 5-123. |
| MESSAGE | ▲▼ | ■ GROUND CURRENT | See page 5-130. |
| MESSAGE | ▲ | ■ VOLTAGE ELEMENTS | See page 5-133. |

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).

5.5.3 BREAKER FAILURE

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

| | | | | |
|---------------------|---------|--------------------------------------|----------|---|
| ■ 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, SRC 3, SRC 4, SRC 5, SRC 6 |
| | 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 ϕ A/3P: | Off | Range: FlexLogic™ operand |
| | MESSAGE | BF1 BKR POS2 ϕ A/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 ϕ B Off | Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes. |
| MESSAGE | | BF1 BKR POS1 ϕ C Off | Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes. |
| MESSAGE | | BF1 BKR POS2 ϕ B Off | Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes. |
| MESSAGE | | BF1 BKR POS2 ϕ C Off | Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes. |

In general, a breaker failure scheme determines that a breaker signaled to trip has not cleared a fault within a definite time, so further tripping action must be performed. Tripping from the breaker failure scheme should trip all breakers, both local and remote, that can supply current to the faulted zone. Usually operation of a breaker failure element will cause clearing of a larger section of the power system than the initial trip. Because breaker failure can result in tripping a large number of breakers and this affects system safety and stability, a very high level of security is required.

Two schemes are provided: one for three-pole tripping only (identified by the name “3BF”) and one for three pole plus single-pole operation (identified by the name “1BF”). The philosophy used in these schemes is identical. The operation of a breaker failure element includes three stages: initiation, determination of a breaker failure condition, and output.

INITIATION STAGE:

A FlexLogic™ operand representing the protection trip signal initially sent to the breaker must be selected to initiate the scheme. The initiating signal should be sealed-in if primary fault detection can reset before the breaker failure timers have finished timing. The seal-in is supervised by current level, so it is reset when the fault is cleared. If desired, an incomplete sequence seal-in reset can be implemented by using the initiating operand to also initiate a FlexLogic™ timer, set longer than any breaker failure timer, whose output operand is selected to block the breaker failure scheme.

Schemes can be initiated either directly or with current level supervision. It is particularly important in any application to decide if a current-supervised initiate is to be used. The use of a current-supervised initiate results in the breaker failure element not being initiated for a breaker that has very little or no current flowing through it, which may be the case for transformer faults. For those situations where it is required to maintain breaker fail coverage for fault levels below the **BF1 PH AMP SUPV PICKUP** or the **BF1 N AMP SUPV PICKUP** setting, a current supervised initiate should *not* be used. This feature should be utilized for those situations where coordinating margins may be reduced when high speed reclosing is used. Thus, if this choice is made, fault levels must always be above the supervision pickup levels for dependable operation of the breaker fail scheme. This can also occur in breaker-and-a-half or ring bus configurations where the first breaker closes into a fault; the protection trips and attempts to initiate breaker failure for the second breaker, which is in the process of closing, but does not yet have current flowing through it.

When the scheme is initiated, it immediately sends a trip signal to the breaker initially signaled to trip (this feature is usually described as re-trip). This reduces the possibility of widespread tripping that results from a declaration of a failed breaker.

DETERMINATION OF A BREAKER FAILURE CONDITION:

The schemes determine a breaker failure condition via three *paths*. Each of these paths is equipped with a time delay, after which a failed breaker is declared and trip signals are sent to all breakers required to clear the zone. The delayed paths are associated with breaker failure timers 1, 2, and 3, which are intended to have delays increasing with increasing timer numbers. These delayed paths are individually enabled to allow for maximum flexibility.

Timer 1 logic (early path) is supervised by a fast-operating breaker auxiliary contact. If the breaker is still closed (as indicated by the auxiliary contact) and fault current is detected after the delay interval, an output is issued. Operation of the breaker auxiliary switch indicates that the breaker has mechanically operated. The continued presence of current indicates that the breaker has failed to interrupt the circuit.

Timer 2 logic (main path) is not supervised by a breaker auxiliary contact. If fault current is detected after the delay interval, an output is issued. This path is intended to detect a breaker that opens mechanically but fails to interrupt fault current; the logic therefore does not use a breaker auxiliary contact.

The timer 1 and 2 paths provide two levels of current supervision, high-set and low-set, that allow the supervision level to change from a current which flows before a breaker inserts an opening resistor into the faulted circuit to a lower level after resistor insertion. The high-set detector is enabled after timeout of timer 1 or 2, along with a timer that will enable the low-set detector after its delay interval. The delay interval between high-set and low-set is the expected breaker opening time. Both current detectors provide a fast operating time for currents at small multiples of the pickup value. The overcurrent detectors are required to operate after the breaker failure delay interval to eliminate the need for very fast resetting overcurrent detectors.

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:

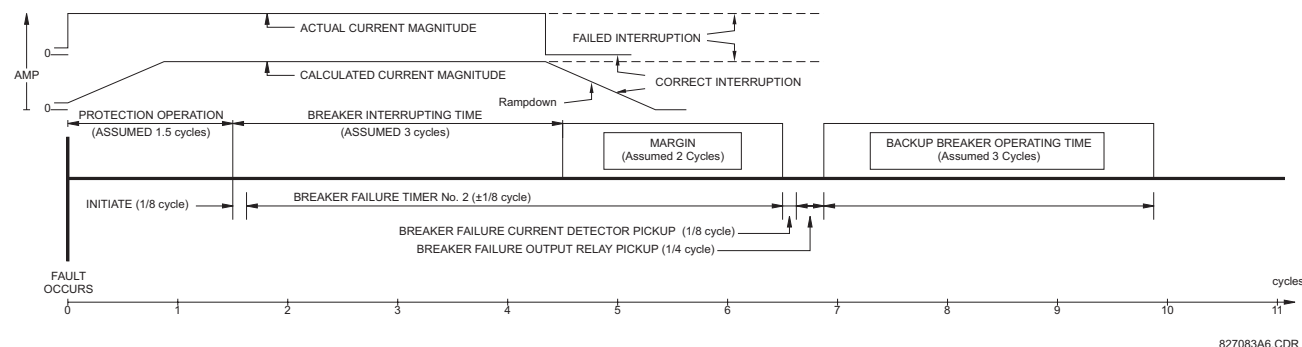


Figure 5-45: BREAKER FAILURE MAIN PATH SEQUENCE

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

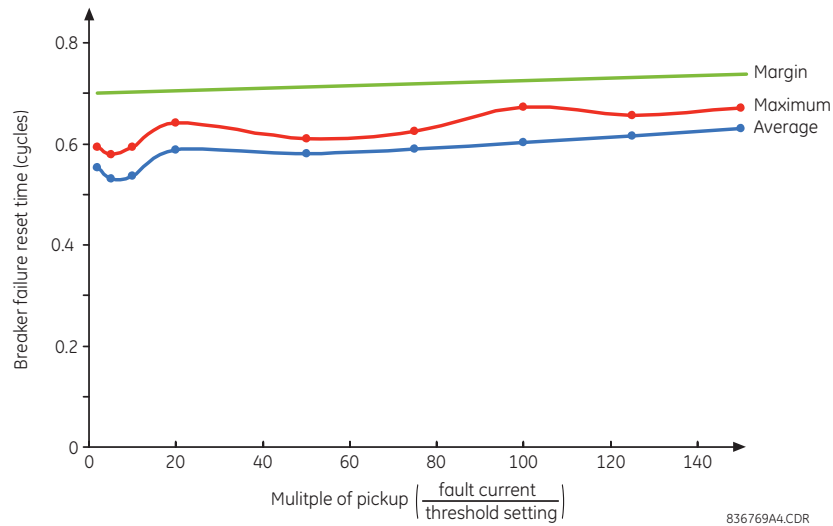


Figure 5-46: BREAKER FAILURE OVERCURRENT SUPERVISION RESET TIME

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 ϕ A/3P:** This setting selects the FlexLogic™ operand that represents the protected breaker early-type auxiliary switch contact (52/a). When using the single-pole breaker failure scheme, this operand represents the protected breaker early-type auxiliary switch contact on pole A. This is normally a non-multiplied form-A contact. The contact may even be adjusted to have the shortest possible operating time.
- **BF1 BKR POS2 ϕ A/3P:** This setting selects the FlexLogic™ operand that represents the breaker normal-type auxiliary switch contact (52/a). When using the single-pole breaker failure scheme, this operand represents the protected breaker auxiliary switch contact on pole A. This 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 ϕ B / BF1 BKR POS 1 ϕ C:** These settings select the FlexLogic™ operand to represents the protected breaker early-type auxiliary switch contact on poles B or C, accordingly. This contact is normally a non-multiplied Form-A contact. The contact 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 ϕ B:** 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 ϕ C:** 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.

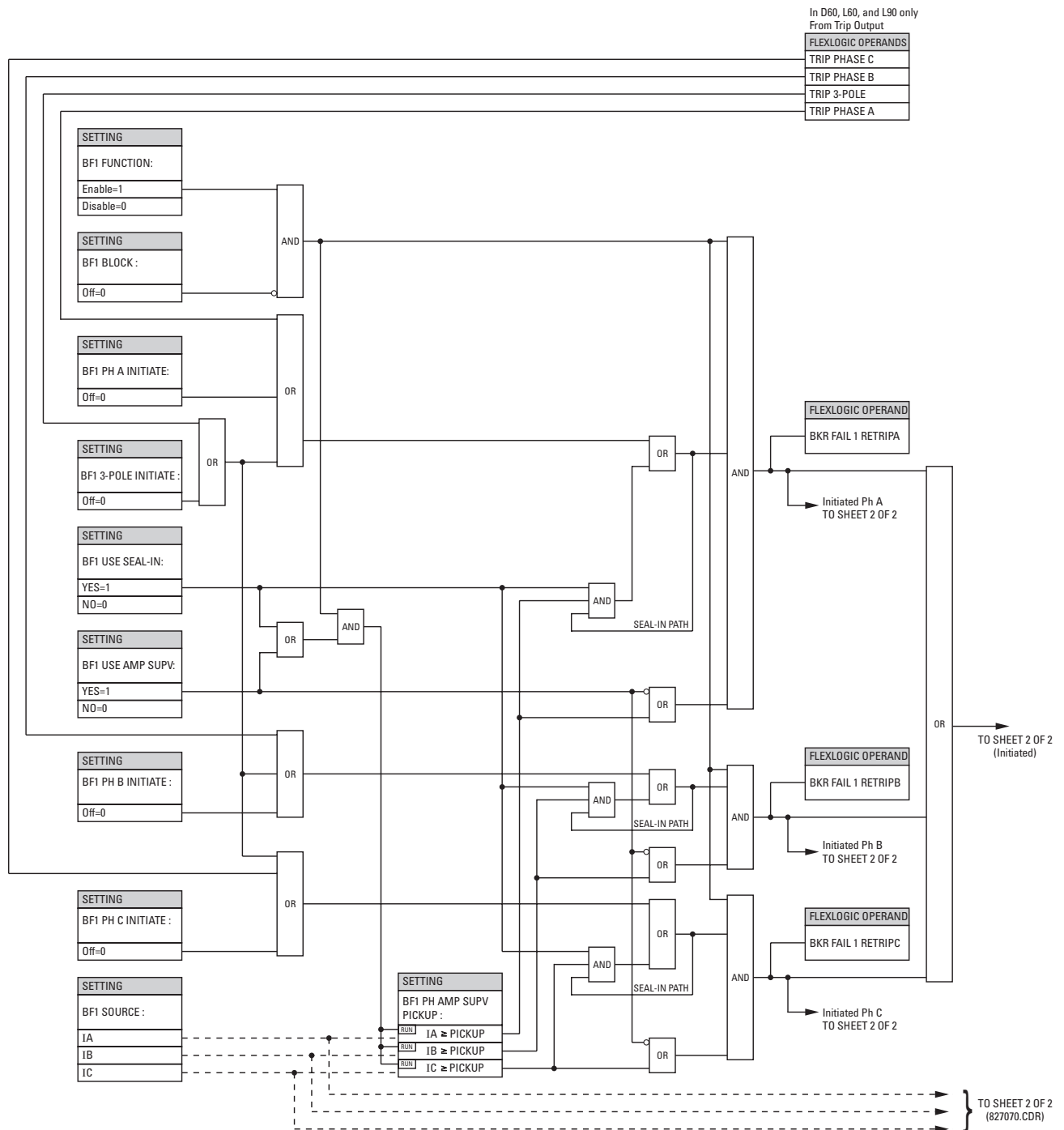
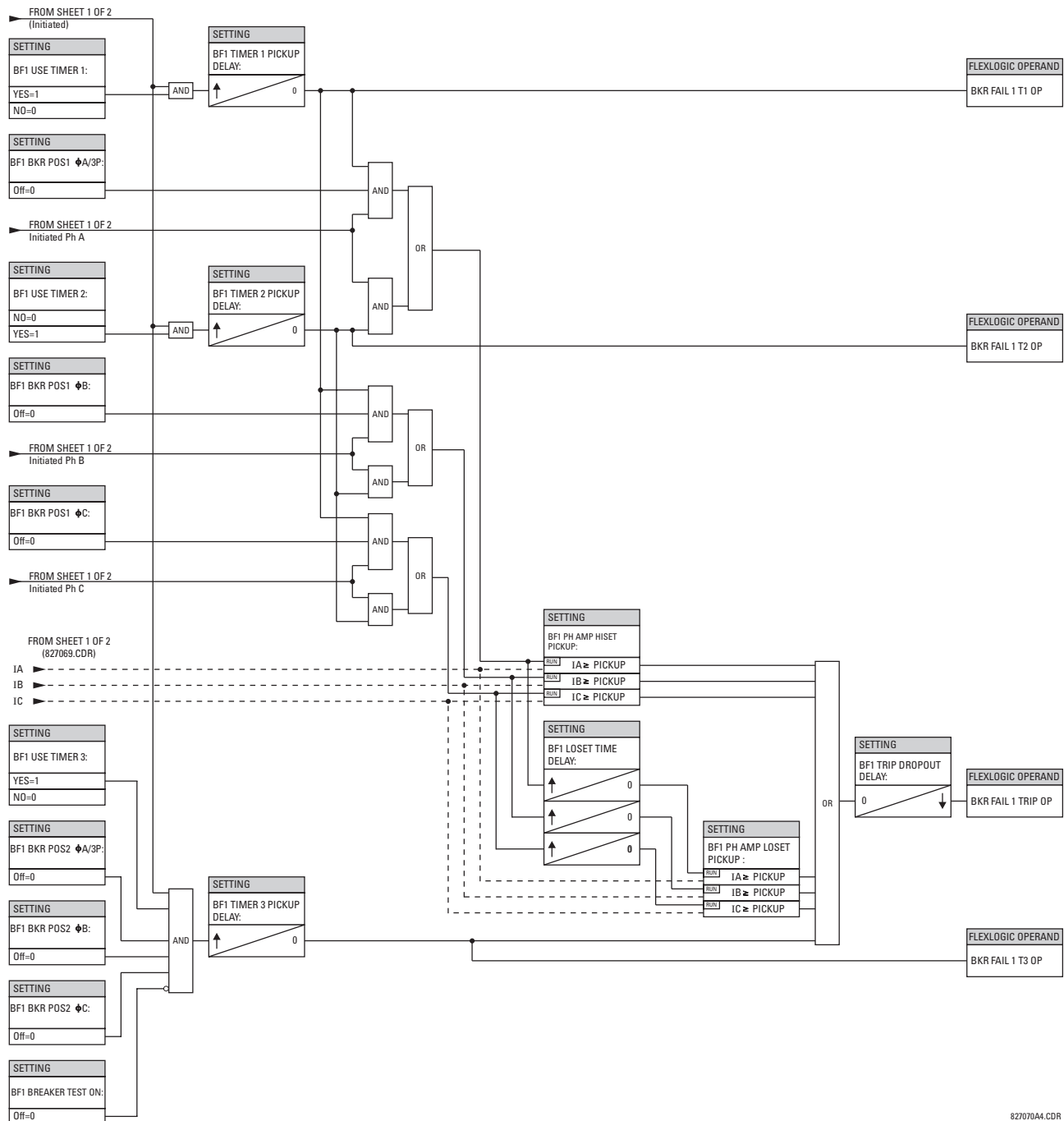


Figure 5–47: BREAKER FAILURE 1-POLE [INITIATE] (Sheet 1 of 2)

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Figure 5-48: BREAKER FAILURE 1-POLE [TIMERS] (Sheet 2 of 2)

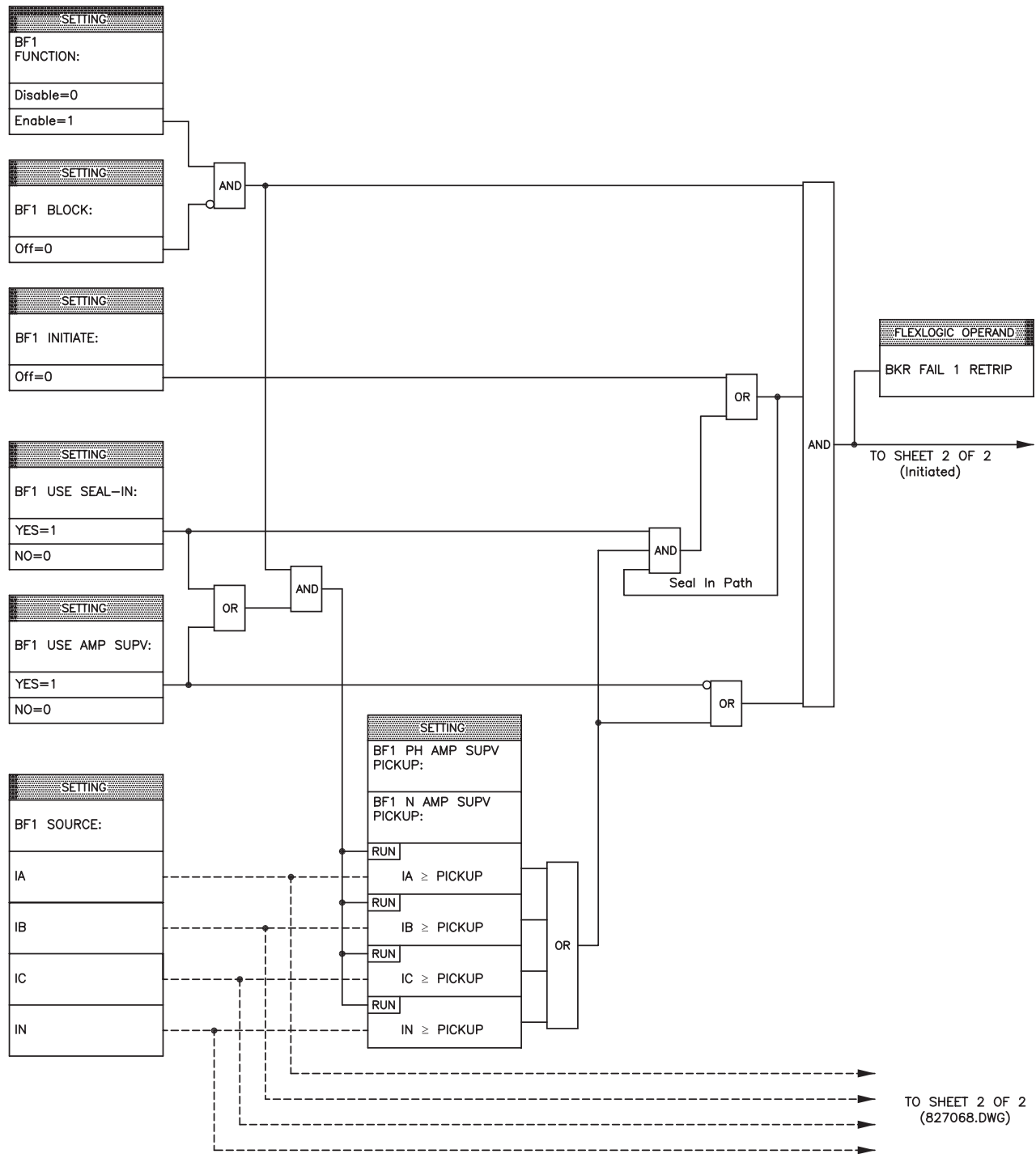


Figure 5-49: BREAKER FAILURE 3-POLE [INITIATE] (Sheet 1 of 2)

5

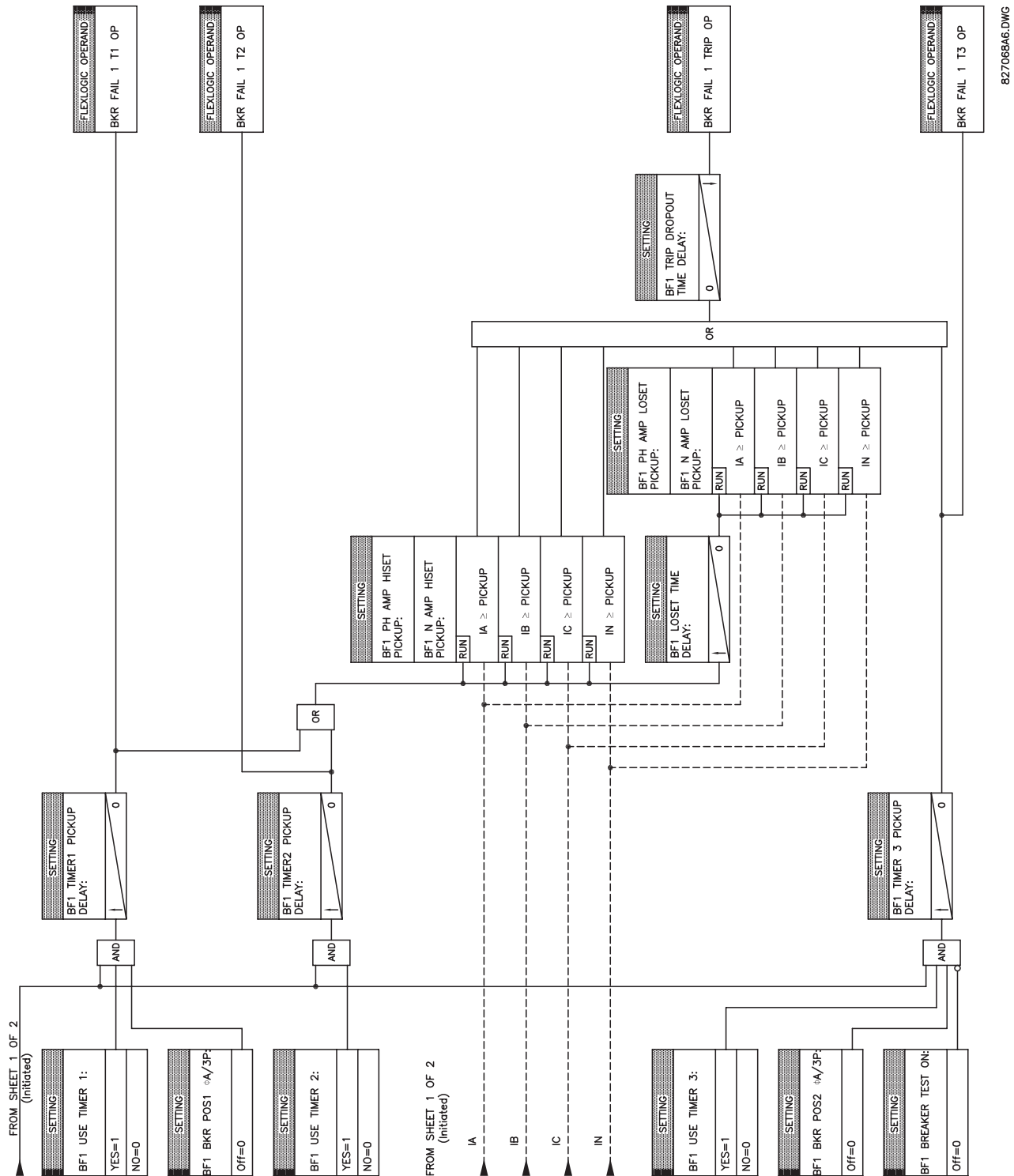


Figure 5-50: BREAKER FAILURE 3-POLE [TIMERS] (Sheet 2 of 2)

5.5.4 PHASE CURRENT

a) MAIN MENU

PATH: SETTINGS ⇒ ↓ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ ↓ PHASE CURRENT

| | | | |
|----------------------|----|----------------------------------|-----------------|
| ■ PHASE CURRENT ■ | ◀▶ | ■ PHASE TOC1 ■ | See page 5-117. |
| MESSAGE | ▲▼ | ■ PHASE TOC2 ■ | See page 5-117. |
| | | ↓ | |
| MESSAGE | ▲▼ | ■ PHASE TOC6 ■ | See page 5-117. |
| MESSAGE | ▲▼ | ■ PHASE IOC1 ■ | See page 5-119. |
| MESSAGE | ▲▼ | ■ PHASE IOC2 ■ | See page 5-119. |
| | | ↓ | |
| MESSAGE | ▲▼ | ■ PHASE IOC12 ■ | See page 5-119. |
| MESSAGE | ▲▼ | ■ PHASE CURRENT ■ UNBALANCE 1 | See page 5-120. |
| MESSAGE | ▲▼ | ■ PHASE CURRENT ■ UNBALANCE 2 | See page 5-120. |
| MESSAGE | ▲ | ■ PHASE CURRENT ■ UNBALANCE 3 | See page 5-120. |

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 5–11: 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:

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

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 5-12: 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 5-13: 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:

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

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 5-14: 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 5-15: 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:

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

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 5-16: 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 5-17: 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 I²t are derived from the formulae:

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

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 5–18: I²T 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:

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

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

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.

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

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

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.

c) PHASE TIME OVERCURRENT (ANSI 51P)

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

| | | | |
|--------------|----|---|---|
| ■ PHASE TOC1 | | PHASE TOC1 | Range: Disabled, Enabled |
| ■ | | FUNCTION: Disabled | |
| MESSAGE | ▲▼ | PHASE TOC1 SIGNAL SOURCE: SRC 1 | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| 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.

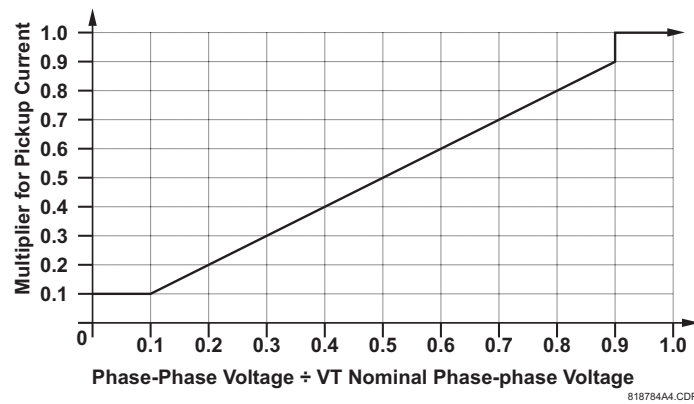


Figure 5-51: PHASE TIME OVERCURRENT VOLTAGE RESTRAINT CHARACTERISTIC

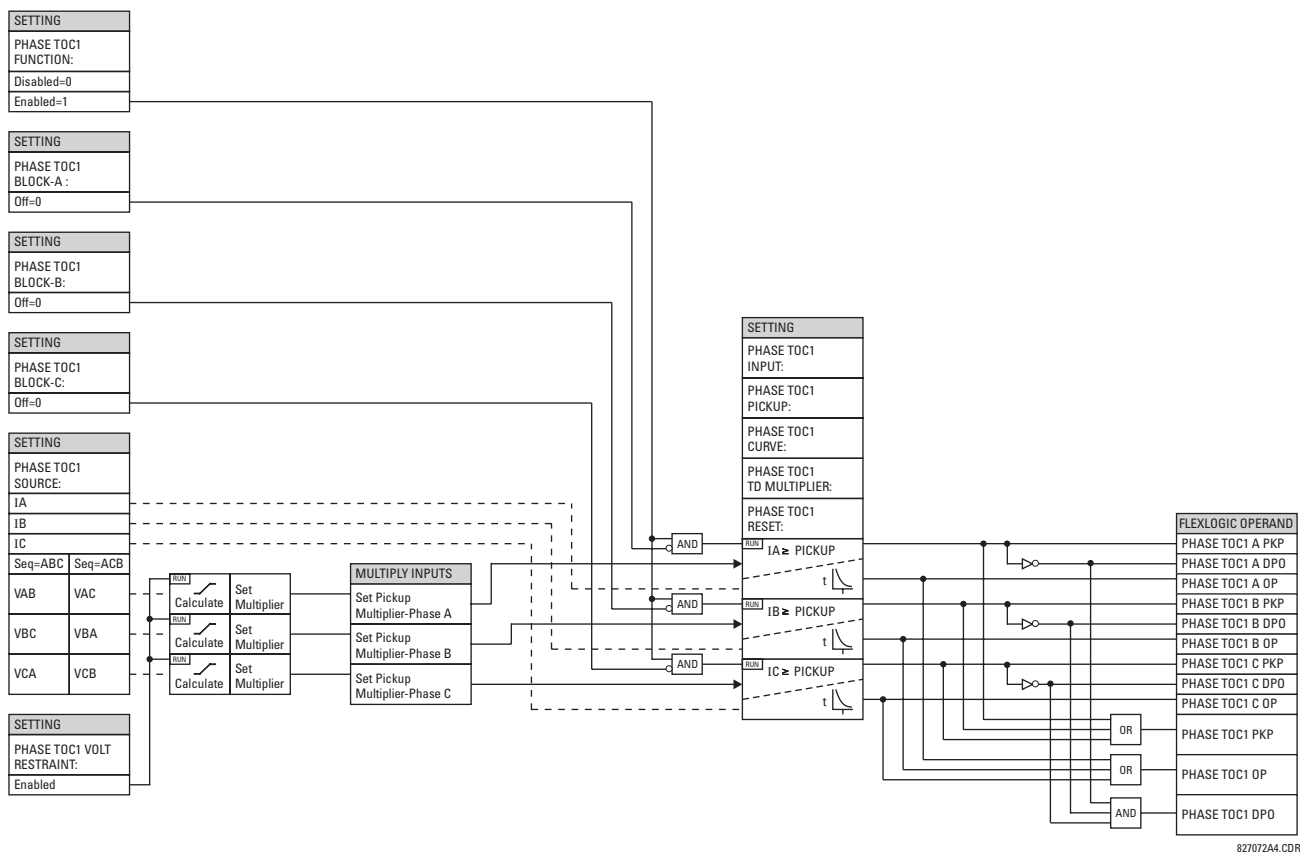


Figure 5-52: PHASE TIME OVERCURRENT 1 SCHEME LOGIC

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, SRC 3, SRC 4, SRC 5, SRC 6 |
| 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.

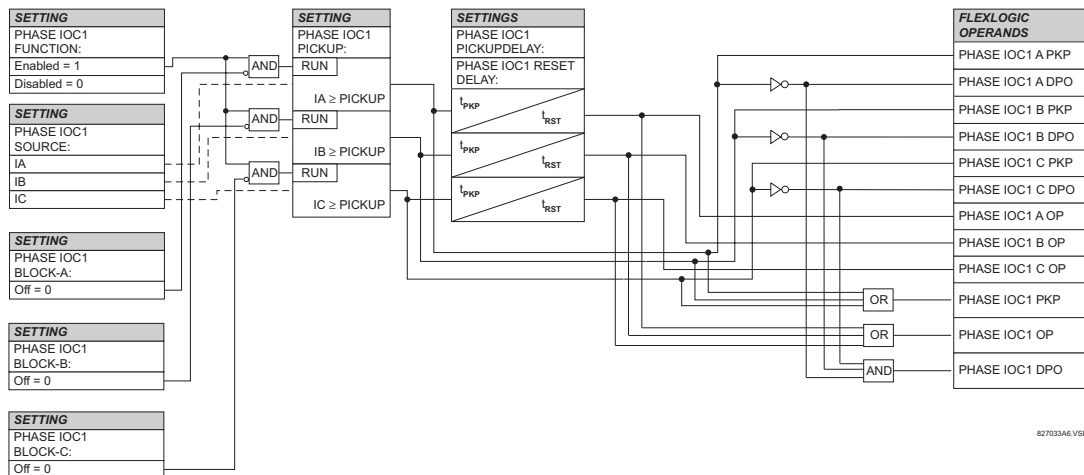


Figure 5-53: PHASE INSTANTANEOUS OVERCURRENT 1 SCHEME LOGIC

e) 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: 0.020 pu | Range: 0.001 to 5.000 pu in steps of 0.001 |
| | MESSAGE | CUR UNBALCE 1 STG 3A PICKUP: 0.020 pu | Range: 0.001 to 5.000 pu in steps of 0.001 |
| | MESSAGE | CUR UNBALCE 1 STG 4A PICKUP: 0.020 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: 0.020 pu | Range: 0.001 to 5.000 pu in steps of 0.001 |
| | MESSAGE | CUR UNBALCE 1 STG 3B PICKUP: 0.020 pu | Range: 0.001 to 5.000 pu in steps of 0.001 |
| | MESSAGE | CUR UNBALCE 1 STG 4B PICKUP: 0.020 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: 0.020 pu | Range: 0.001 to 5.000 pu in steps of 0.001 |
| | MESSAGE | CUR UNBALCE 1 STG 3C PICKUP: 0.020 pu | Range: 0.001 to 5.000 pu in steps of 0.001 |
| | MESSAGE | CUR UNBALCE 1 STG 4C PICKUP: 0.020 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 |

- **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.

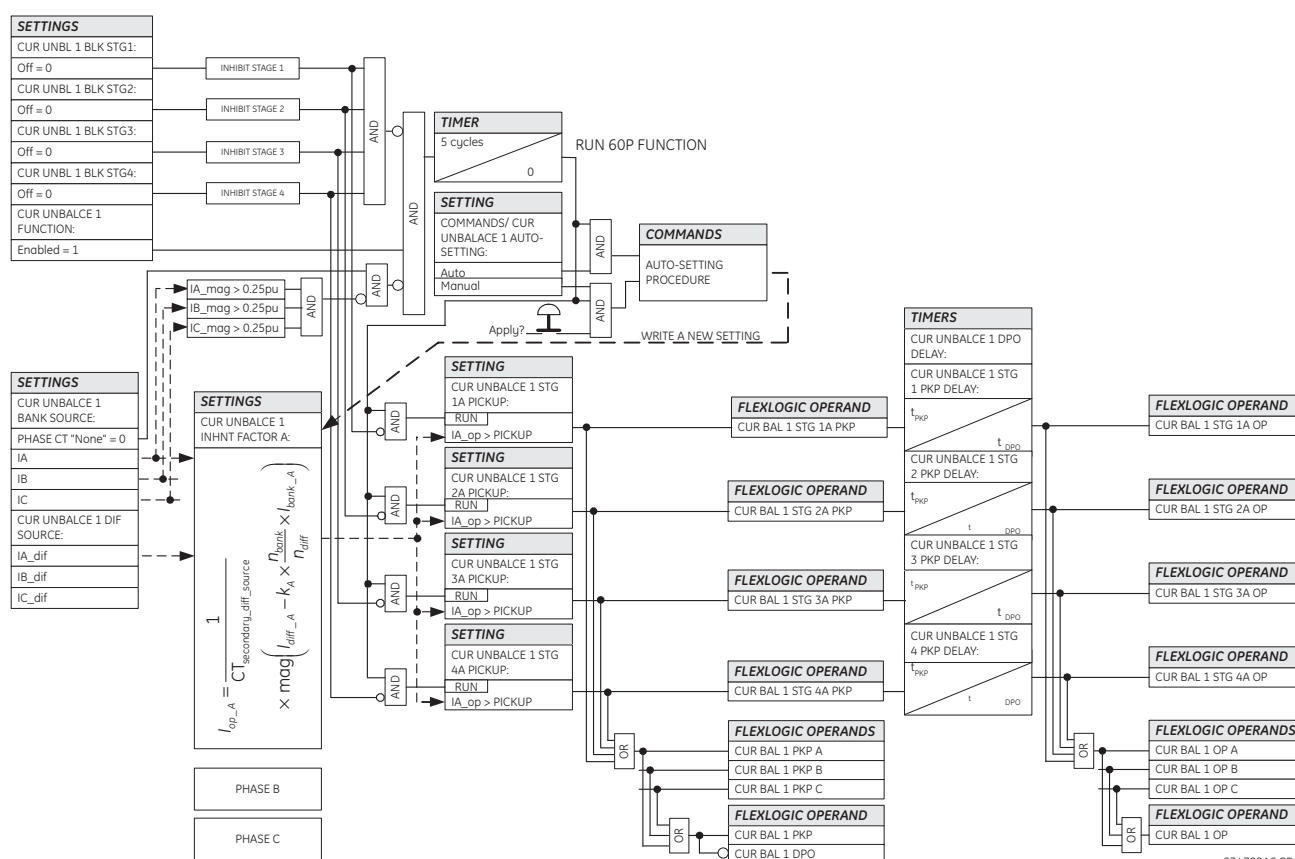
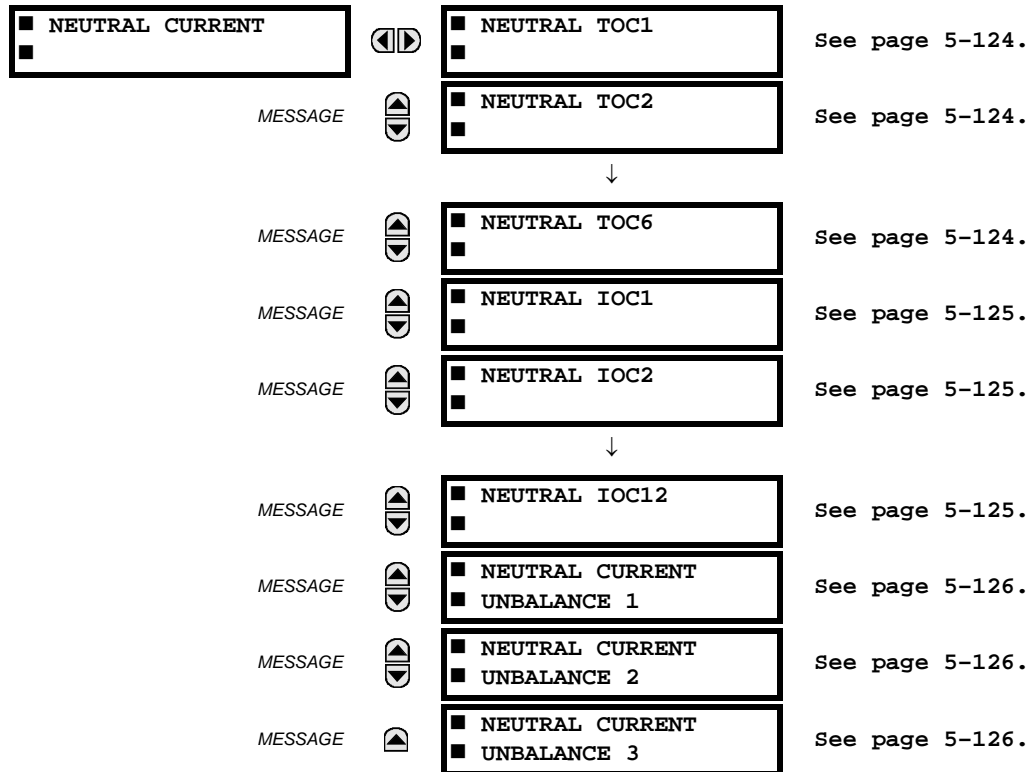


Figure 5-55: PHASE CURRENT UNBALANCE SCHEME LOGIC

5.5.5 NEUTRAL CURRENT

a) MAIN MENU

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



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)

| | | | |
|----------------|----|--------------------------------------|---|
| ■ NEUTRAL TOC1 | | NEUTRAL TOC1 FUNCTION: Disabled | Range: Disabled, Enabled |
| | | | |
| MESSAGE | ▲▼ | NEUTRAL TOC1 SIGNAL SOURCE: SRC 1 | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| MESSAGE | ▲▼ | NEUTRAL TOC1 INPUT: Phasor | Range: Phasor, RMS |
| MESSAGE | ▲▼ | NEUTRAL TOC1 PICKUP: 1.000 pu | Range: 0.000 to 30.000 pu in steps of 0.001 |
| MESSAGE | ▲▼ | NEUTRAL TOC1 CURVE: IEEE Mod Inv | Range: See OVERCURRENT CURVE TYPES table |
| MESSAGE | ▲▼ | NEUTRAL TOC1 TD MULTIPLIER: 1.00 | Range: 0.00 to 600.00 in steps of 0.01 |
| MESSAGE | ▲▼ | NEUTRAL TOC1 RESET: Instantaneous | Range: Instantaneous, Timed |
| MESSAGE | ▲▼ | NEUTRAL TOC1 BLOCK: Off | Range: FlexLogic™ operand |
| MESSAGE | ▲▼ | NEUTRAL TOC1 TARGET: Self-reset | Range: Self-reset, Latched, Disabled |
| MESSAGE | ▲ | NEUTRAL TOC1 EVENTS: Disabled | Range: Disabled, Enabled |

The neutral time overcurrent element can provide a desired time-delay operating characteristic versus the applied current or be used as a simple definite time element. The neutral current input value is a quantity calculated as $3I_0$ 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.

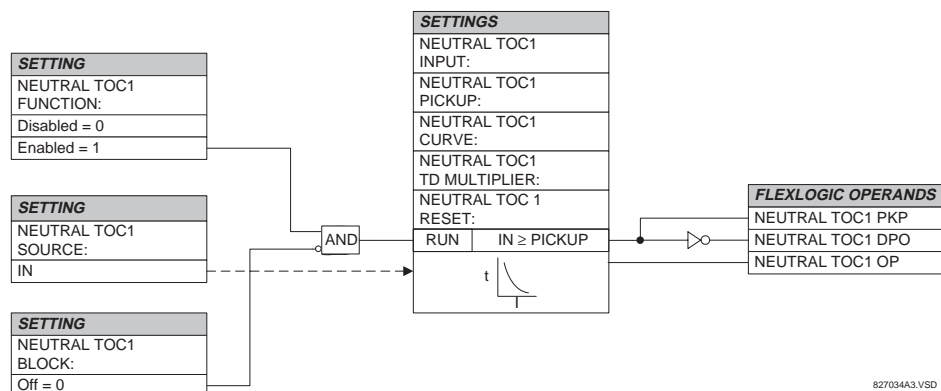


Figure 5-56: NEUTRAL TIME OVERCURRENT 1 SCHEME LOGIC

c) NEUTRAL INSTANTANEOUS OVERCURRENT (ANSI 50N)

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

| | | | |
|---|--|--|---|
| <div>■ NEUTRAL IOC1</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> | <div>⏮</div> <div>⏭</div> <div>⏭</div> <div>⏭</div> <div>⏭</div> <div>⏭</div> <div>⏭</div> | <div>NEUTRAL IOC1</div> <div>FUNCTION: Disabled</div> | Range: Disabled, Enabled |
| | | <div>NEUTRAL IOC1 SIGNAL</div> <div>SOURCE: SRC 1</div> | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| | | <div>NEUTRAL IOC1 PICKUP</div> <div>PICKUP: 1.000 pu</div> | Range: 0.000 to 30.000 pu in steps of 0.001 |
| | | <div>NEUTRAL IOC1 PICKUP</div> <div>DELAY: 0.00 s</div> | Range: 0.00 to 600.00 s in steps of 0.01 |
| | | <div>NEUTRAL IOC1 RESET</div> <div>DELAY: 0.00 s</div> | Range: 0.00 to 600.00 s in steps of 0.01 |
| | | <div>NEUTRAL IOC1 BLOCK:</div> <div>Off</div> | Range: FlexLogic™ operand |
| | | <div>NEUTRAL IOC1</div> <div>TARGET: Self-reset</div> | Range: Self-reset, Latched, Disabled |
| | | <div>NEUTRAL IOC1</div> <div>EVENTS: Disabled</div> | 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:

$$I_{op} = 3 \times (|I_0| - K \cdot |I_1|) \quad \text{where } K = 1/16 \quad (\text{EQ 5.15})$$

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

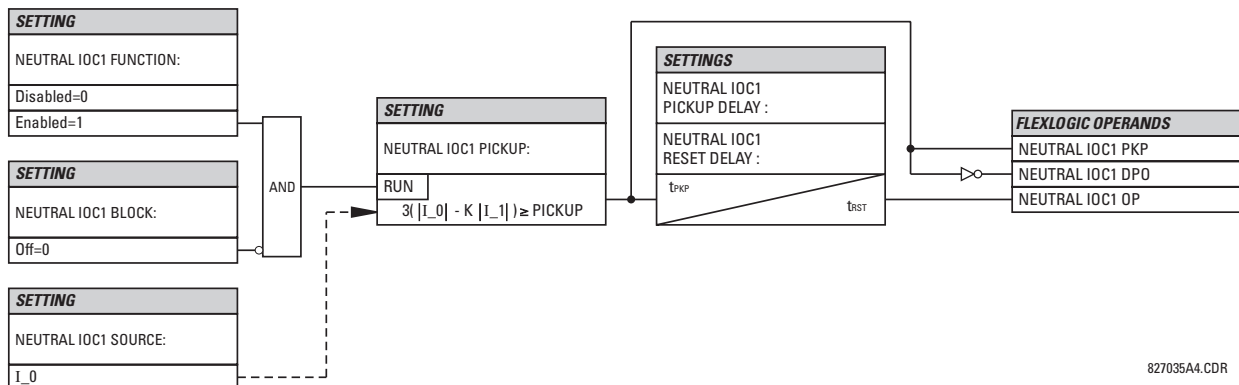


Figure 5-57: NEUTRAL IOC1 SCHEME LOGIC

d) 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 | Range: Disabled, Enabled |
| | | FUNCTION: Disabled | |
| 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 10.0% 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 10.0% 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 10.0% 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 10.0% 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

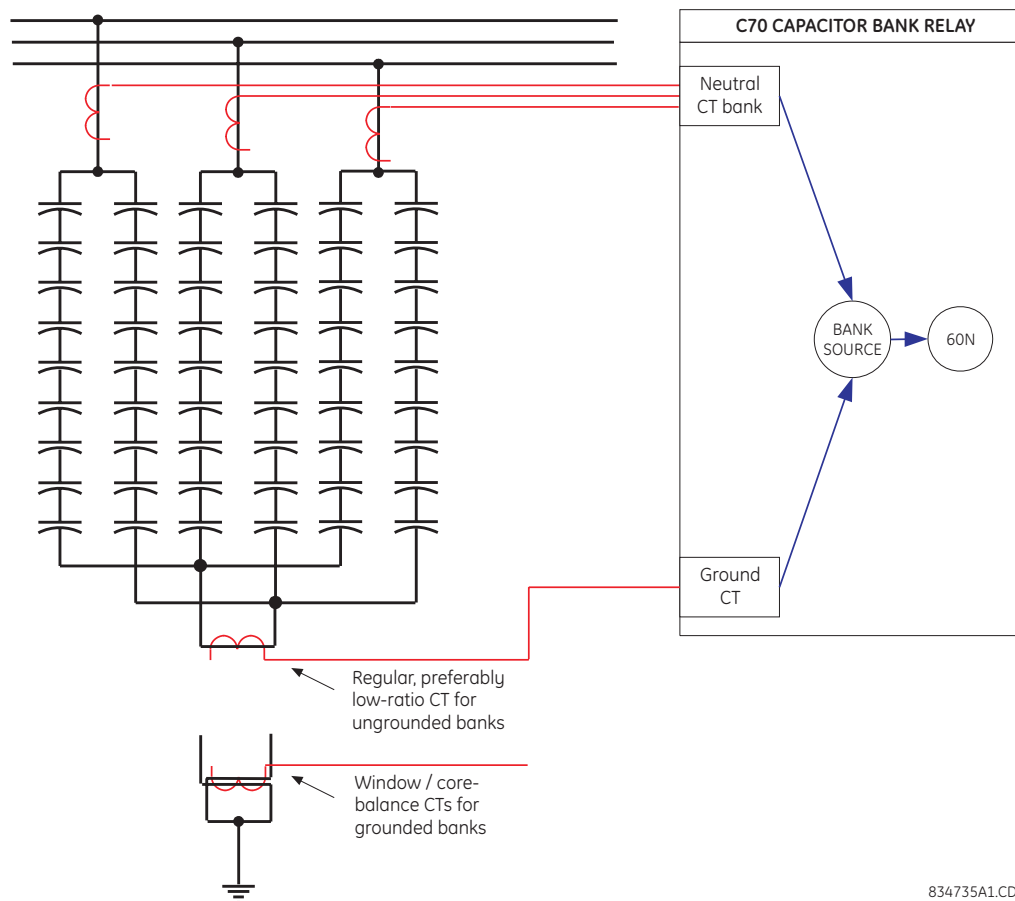
Up to three identical neutral current unbalance elements, one per each installed CT/VT module.

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.



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Figure 5-58: 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.

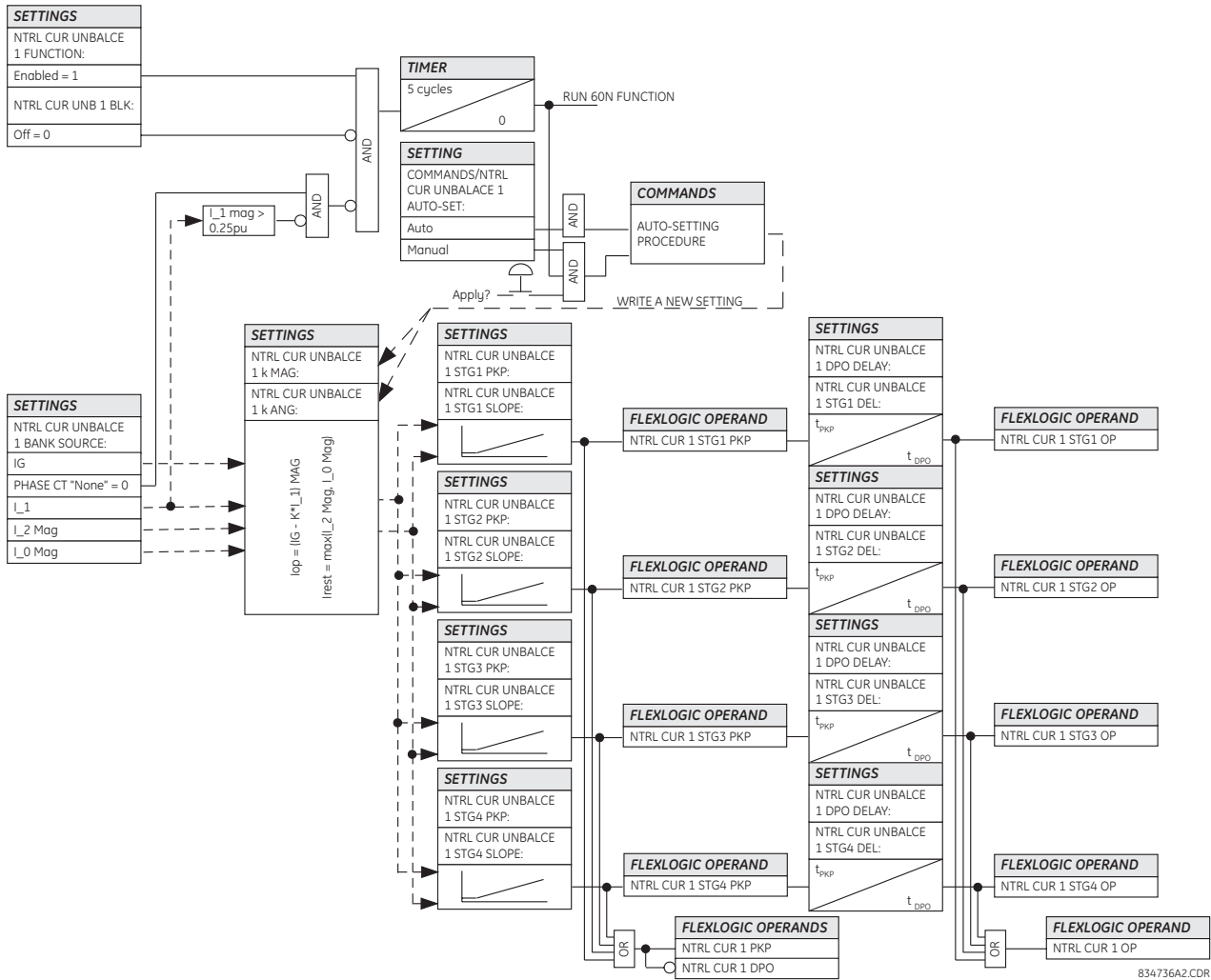
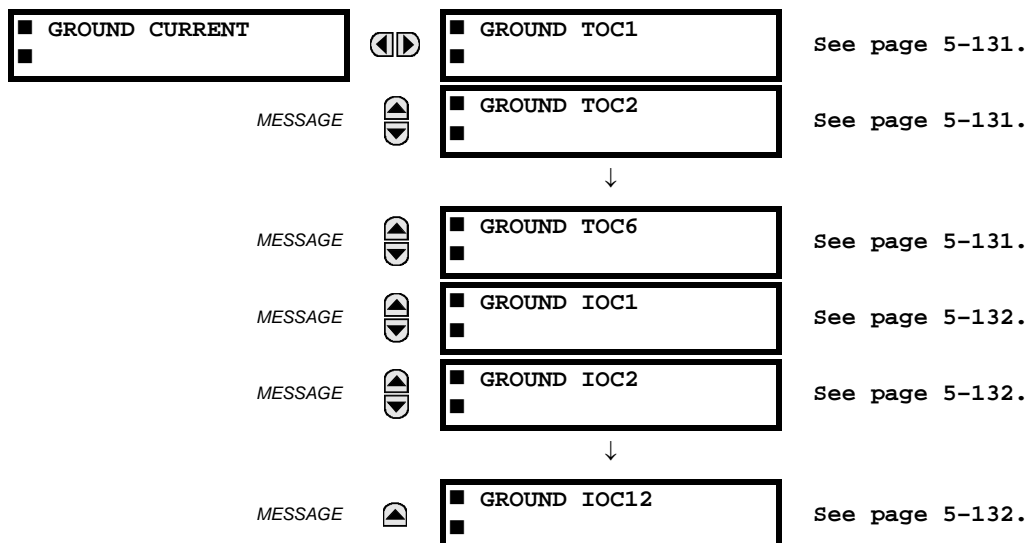


Figure 5-59: NEUTRAL CURRENT UNBALANCE SCHEME LOGIC

5.5.6 GROUND CURRENT

a) MAIN MENU

PATH: SETTINGS ⇒ ↓ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ ↓ GROUND CURRENT



5

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 |

b) GROUND TIME OVERCURRENT (ANSI 51G)

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

| | | | |
|---------------|----|-------------------------------------|---|
| ■ GROUND TOC1 | ◀▶ | GROUND TOC1 FUNCTION: Disabled | Range: Disabled, Enabled |
| MESSAGE | ▲▼ | GROUND TOC1 SIGNAL SOURCE: SRC 1 | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| 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.



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.

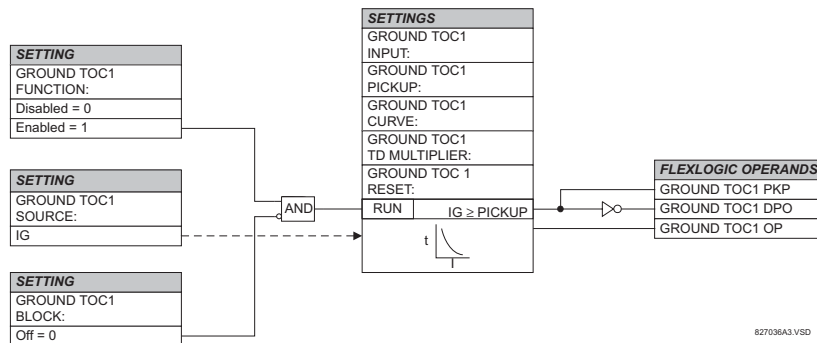


Figure 5-60: GROUND TOC1 SCHEME LOGIC

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, SRC 3, SRC 4, SRC 5, SRC 6 |
| 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 |

5

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.



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.

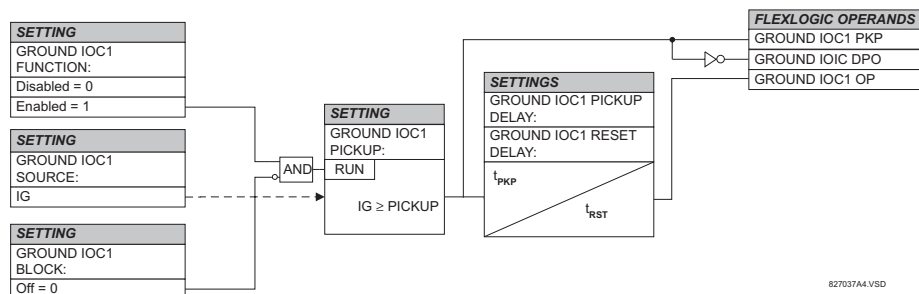


Figure 5-61: GROUND IOC1 SCHEME LOGIC

5.5.7 VOLTAGE ELEMENTS

a) MAIN MENU

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

| | | | |
|--------------------|----|------------------------------------|-----------------|
| ■ VOLTAGE ELEMENTS | ◀▶ | ■ PHASE ■ UNDERVOLTAGE1 | See page 5-135. |
| MESSAGE | ▲▼ | ■ PHASE ■ UNDERVOLTAGE2 | See page 5-135. |
| MESSAGE | ▲▼ | ■ PHASE ■ OVERVOLTAGE1 | See page 5-136. |
| MESSAGE | ▲▼ | ■ NEUTRAL OV1 | See page 5-137. |
| MESSAGE | ▲▼ | ■ NEUTRAL OV2 | See page 5-137. |
| MESSAGE | ▲▼ | ■ NEUTRAL OV3 | See page 5-137. |
| MESSAGE | ▲▼ | ■ NEG SEQ OV1 | See page 5-138. |
| MESSAGE | ▲▼ | ■ NEG SEQ OV2 | See page 5-138. |
| MESSAGE | ▲▼ | ■ NEG SEQ OV3 | See page 5-138. |
| MESSAGE | ▲▼ | ■ AUXILIARY OV1 | See page 5-139. |
| MESSAGE | ▲▼ | ■ AUXILIARY OV2 | See page 5-139. |
| MESSAGE | ▲▼ | ■ AUXILIARY OV3 | See page 5-139. |
| MESSAGE | ▲▼ | ■ VOLTAGE ■ DIFFERENTIAL 1 | See page 5-140. |
| MESSAGE | ▲▼ | ■ VOLTAGE ■ DIFFERENTIAL 2 | See page 5-140. |
| MESSAGE | ▲▼ | ■ VOLTAGE ■ DIFFERENTIAL 3 | See page 5-140. |
| MESSAGE | ▲▼ | ■ BANK ■ OVERVOLTAGE | See page 5-143. |
| MESSAGE | ▲▼ | ■ NEUTRAL VOLTAGE ■ UNBALANCE 1 | See page 5-147. |
| MESSAGE | ▲▼ | ■ NEUTRAL VOLTAGE ■ UNBALANCE 2 | See page 5-147. |
| MESSAGE | ▲▼ | ■ NEUTRAL VOLTAGE ■ UNBALANCE 3 | See page 5-147. |

These protection elements can be used for a variety of applications such as:

- **Undervoltage Protection:** For voltage sensitive loads, such as induction motors, a drop in voltage increases the drawn current which may cause dangerous overheating in the motor. The undervoltage protection feature can be used

to either cause a trip or generate an alarm when the voltage drops below a specified voltage setting for a specified time delay.

- **Permissive Functions:** The undervoltage feature may be used to block the functioning of external devices by operating an output relay when the voltage falls below the specified voltage setting. The undervoltage feature may also be used to block the functioning of other elements through the block feature of those elements.
- **Source Transfer Schemes:** In the event of an undervoltage, a transfer signal may be generated to transfer a load from its normal source to a standby or emergency power source.

The undervoltage elements can be programmed to have a definite time delay characteristic. The definite time curve operates when the voltage drops below the pickup level for a specified period of time. The time delay is adjustable from 0 to 600.00 seconds in steps of 0.01. The undervoltage elements can also be programmed to have an inverse time delay characteristic.

The undervoltage delay setting defines the family of curves shown below.

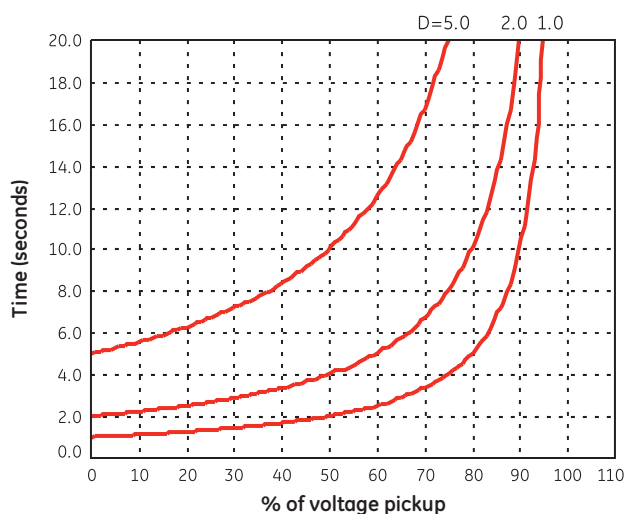
$$T = \frac{D}{\left(1 - \frac{V}{V_{pickup}}\right)} \quad (\text{EQ 5.16})$$

where: T = operating time

D = undervoltage delay setting ($D = 0.00$ operates instantaneously)

V = secondary voltage applied to the relay

V_{pickup} = pickup level



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Figure 5-62: INVERSE TIME UNDERVOLTAGE CURVES



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(2)

| | | | |
|-----------------|----|----------------------|---|
| ■ PHASE | ◀▶ | PHASE UV1 | Range: Disabled, Enabled |
| ■ UNDERVOLTAGE1 | | FUNCTION: Disabled | |
| MESSAGE | ▲▼ | PHASE UV1 SIGNAL | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| | | SOURCE: SRC 1 | |
| MESSAGE | ▲▼ | PHASE UV1 MODE: | Range: Phase to Ground, Phase to Phase |
| | | Phase to Ground | |
| MESSAGE | ▲▼ | PHASE UV1 | Range: 0.000 to 3.000 pu in steps of 0.001 |
| | | PICKUP: 1.000 pu | |
| MESSAGE | ▲▼ | PHASE UV1 | Range: Definite Time, Inverse Time |
| | | CURVE: Definite Time | |
| MESSAGE | ▲▼ | PHASE UV1 | Range: 0.00 to 600.00 s in steps of 0.01 |
| | | DELAY: 1.00 s | |
| MESSAGE | ▲▼ | PHASE UV1 MINIMUM | Range: 0.000 to 3.000 pu in steps of 0.001 |
| | | VOLTAGE: 0.100 pu | |
| MESSAGE | ▲▼ | PHASE UV1 BLOCK: | Range: FlexLogic™ operand |
| | | Off | |
| MESSAGE | ▲▼ | PHASE UV1 | Range: Self-reset, Latched, Disabled |
| | | TARGET: Self-reset | |
| MESSAGE | ▲▼ | PHASE UV1 | Range: Disabled, Enabled |
| | | EVENTS: Disabled | |

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).

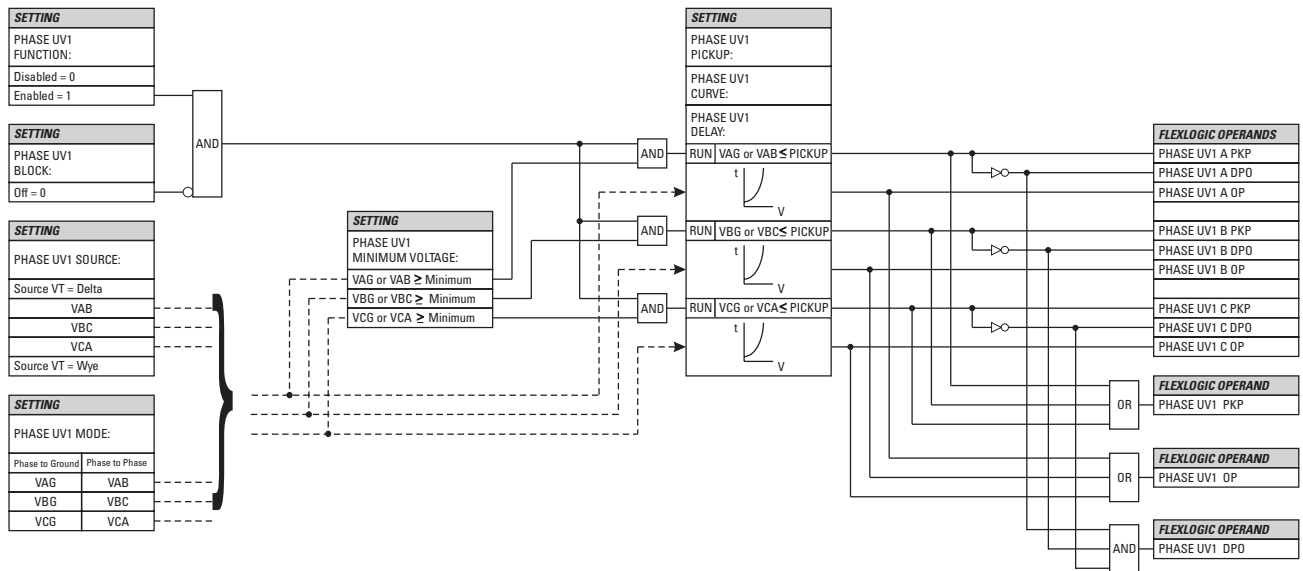


Figure 5-63: PHASE UNDERVOLTAGE1 SCHEME LOGIC

c) PHASE OVERVOLTAGE (ANSI 59P)

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

| | | | |
|---|---------|---|---|
| <div> <div>■ PHASE</div> <div>■ OVERVOLTAGE1</div> </div> | | <div> <div>◀▶</div> <div>PHASE OV1</div> <div>FUNCTION: Disabled</div> </div> | Range: Disabled, Enabled |
| | MESSAGE | <div> <div>▲▼</div> <div>PHASE OV1 SIGNAL</div> <div>SOURCE: SRC 1</div> </div> | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| | MESSAGE | <div> <div>▲▼</div> <div>PHASE OV1</div> <div>PICKUP: 1.000 pu</div> </div> | Range: 0.000 to 3.000 pu in steps of 0.001 |
| | MESSAGE | <div> <div>▲▼</div> <div>PHASE OV1 PICKUP</div> <div>DELAY: 1.00 s</div> </div> | Range: 0.00 to 600.00 s in steps of 0.01 |
| | MESSAGE | <div> <div>▲▼</div> <div>PHASE OV1 RESET</div> <div>DELAY: 1.00 s</div> </div> | Range: 0.00 to 600.00 s in steps of 0.01 |
| | MESSAGE | <div> <div>▲▼</div> <div>PHASE OV1 BLOCK:</div> <div>Off</div> </div> | Range: FlexLogic™ Operand |
| | MESSAGE | <div> <div>▲▼</div> <div>PHASE OV1</div> <div>TARGET: Self-reset</div> </div> | Range: Self-reset, Latched, Disabled |
| | MESSAGE | <div> <div>▲</div> <div>PHASE OV1</div> <div>EVENTS: Disabled</div> </div> | Range: Disabled, Enabled |

5

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.

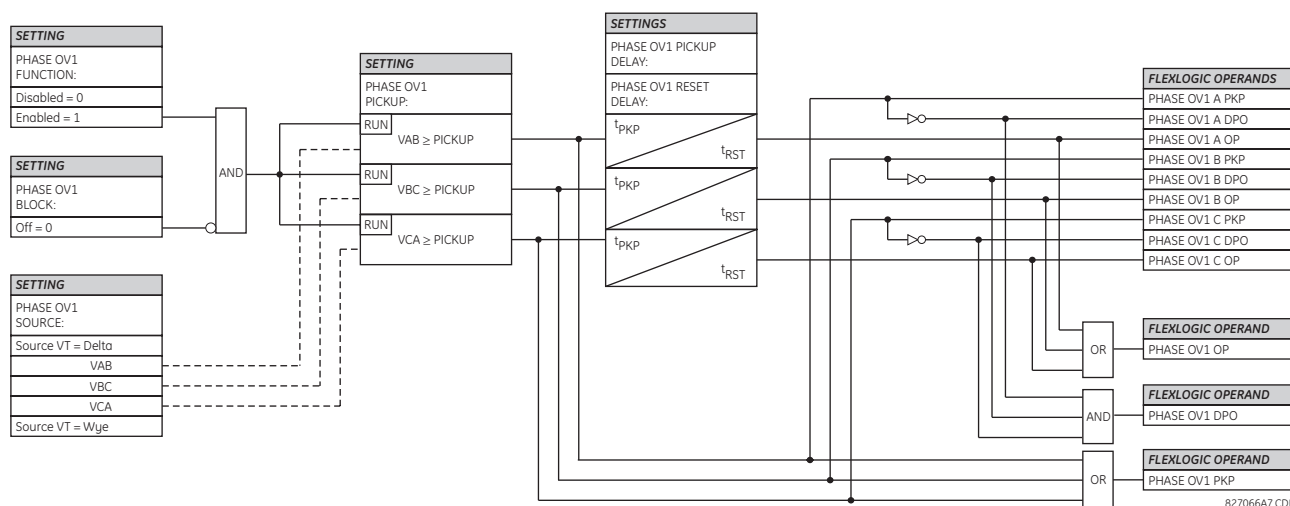


Figure 5-64: PHASE OVERVOLTAGE SCHEME LOGIC

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d) NEUTRAL OVERVOLTAGE (ANSI 59N)

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

| | | | |
|---------------|----|--------------------------------------|---|
| ■ NEUTRAL OV1 | | NEUTRAL OV1 | Range: Disabled, Enabled |
| ■ | | FUNCTION: Disabled | |
| MESSAGE | ▲▼ | NEUTRAL OV1 SIGNAL SOURCE: SRC 1 | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| 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.

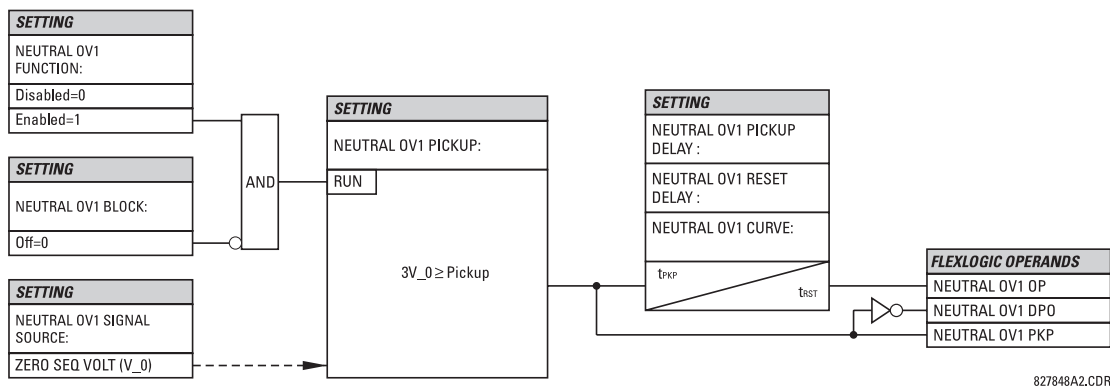


Figure 5-65: NEUTRAL OVERVOLTAGE1 SCHEME LOGIC

e) NEGATIVE-SEQUENCE OVERVOLTAGE(ANSI 59_2)

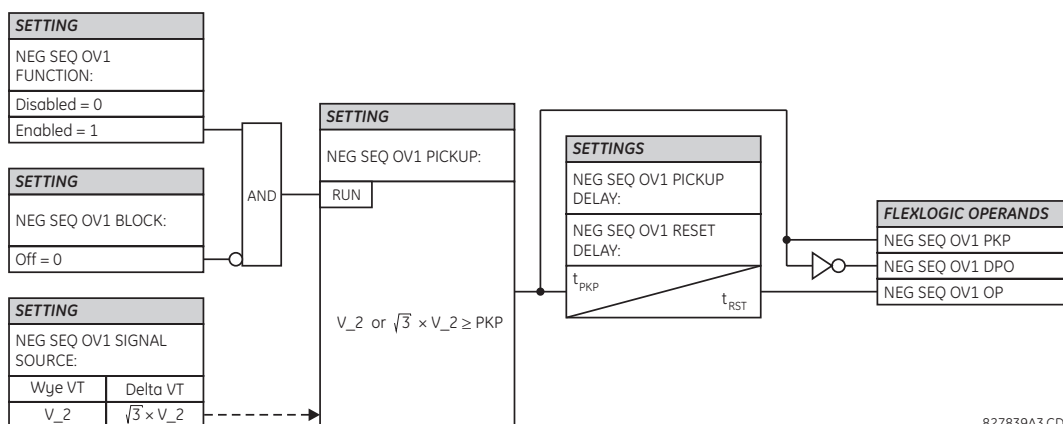
PATH: SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ VOLTAGE ELEMENTS ⇒ NEG SEQ OV1(3)

| | | | |
|---------------|----|-------------------------------------|---|
| ■ NEG SEQ OV1 | | NEG SEQ OV1 FUNCTION: Disabled | Range: Disabled, Enabled |
| MESSAGE | ▲▼ | NEG SEQ OV1 SIGNAL SOURCE: SRC 1 | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| 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 |

5

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.



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Figure 5-66: NEGATIVE-SEQUENCE OVERVOLTAGE SCHEME LOGIC

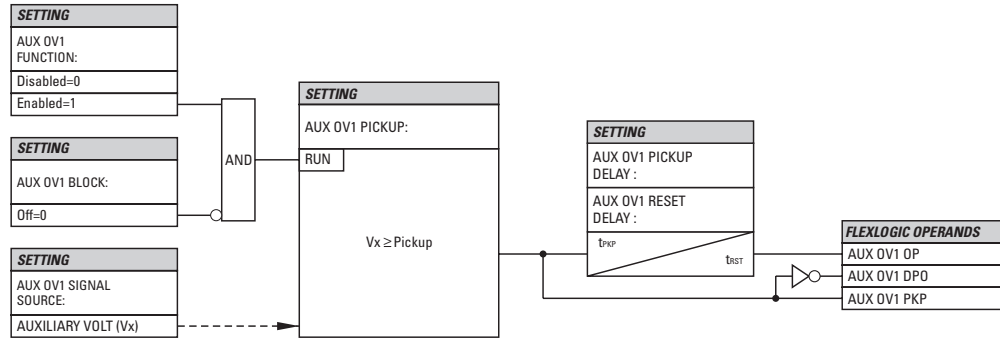
f) AUXILIARY OVERVOLTAGE (ANSI 59X)

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

| | | | |
|--|--|--|---|
| <div> <div>■ AUXILIARY OV1</div> <div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div> </div> | | <div> <div> <div>◀▶</div> <div>AUX OV1</div> <div>FUNCTION: Disabled</div> </div> <div> <div>▲▼</div> <div>AUX OV1 SIGNAL</div> <div>SOURCE: SRC 1</div> </div> <div> <div>▲▼</div> <div>AUX OV1 PICKUP:</div> <div>0.300 pu</div> </div> <div> <div>▲▼</div> <div>AUX OV1 PICKUP</div> <div>DELAY: 1.00 s</div> </div> <div> <div>▲▼</div> <div>AUX OV1 RESET</div> <div>DELAY: 1.00 s</div> </div> <div> <div>▲▼</div> <div>AUX OV1 BLOCK:</div> <div>Off</div> </div> <div> <div>▲▼</div> <div>AUX OV1 TARGET:</div> <div>Self-reset</div> </div> <div> <div>▲</div> <div>AUX OV1 EVENTS:</div> <div>Disabled</div> </div> </div> | <div>Range: Disabled, Enabled</div> <div>Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6</div> <div>Range: 0.000 to 3.000 pu in steps of 0.001</div> <div>Range: 0.00 to 600.00 s in steps of 0.01</div> <div>Range: 0.00 to 600.00 s in steps of 0.01</div> <div>Range: FlexLogic™ operand</div> <div>Range: Self-reset, Latched, Disabled</div> <div>Range: Disabled, Enabled</div> |
|--|--|--|---|

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.

5



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Figure 5-67: AUXILIARY OVERVOLTAGE SCHEME LOGIC

g) BANK VOLTAGE DIFFERENTIAL (ANSI 87V)

PATH: SETTINGS ⇒ ↓ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ ↓ VOLTAGE ⇒ ↓ 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 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 2A PICKUP: 0.020 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 3A PICKUP: 0.030 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 4A PICKUP: 0.040 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 1B PICKUP: 0.010 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 2B PICKUP: 0.020 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 3B PICKUP: 0.030 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 4B PICKUP: 0.040 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 1C PICKUP: 0.010 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 2C PICKUP: 0.020 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 3C PICKUP: 0.030 pu | Range: 0.001 to 0.250 pu in steps of 0.001 |
| | MESSAGE | VOLTAGE DIF 1 STG 4C PICKUP: 0.040 pu | Range: 0.001 to 0.250 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 |

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.

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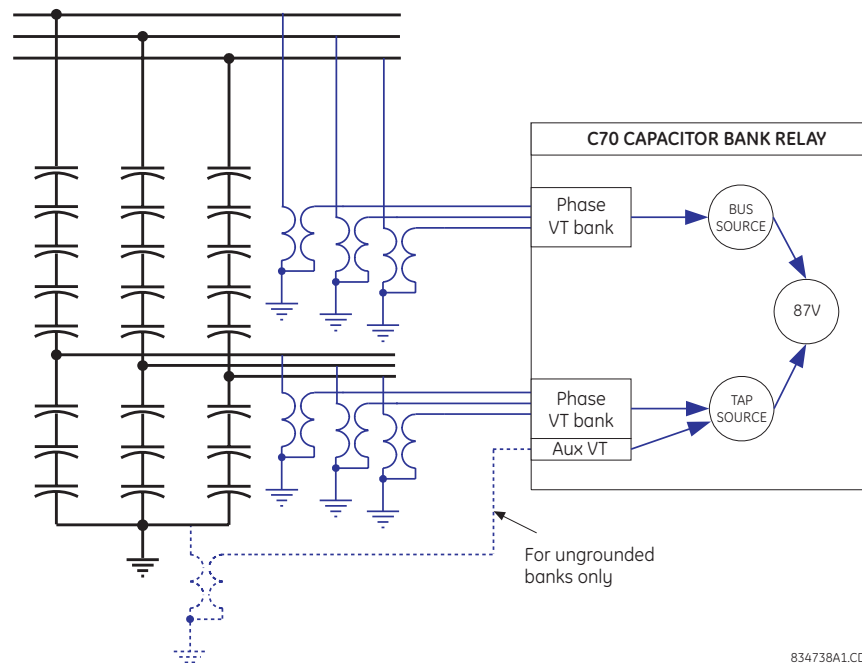


Figure 5-68: VOLTAGE DIFFERENTIAL BASIC CONNECTIONS

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.

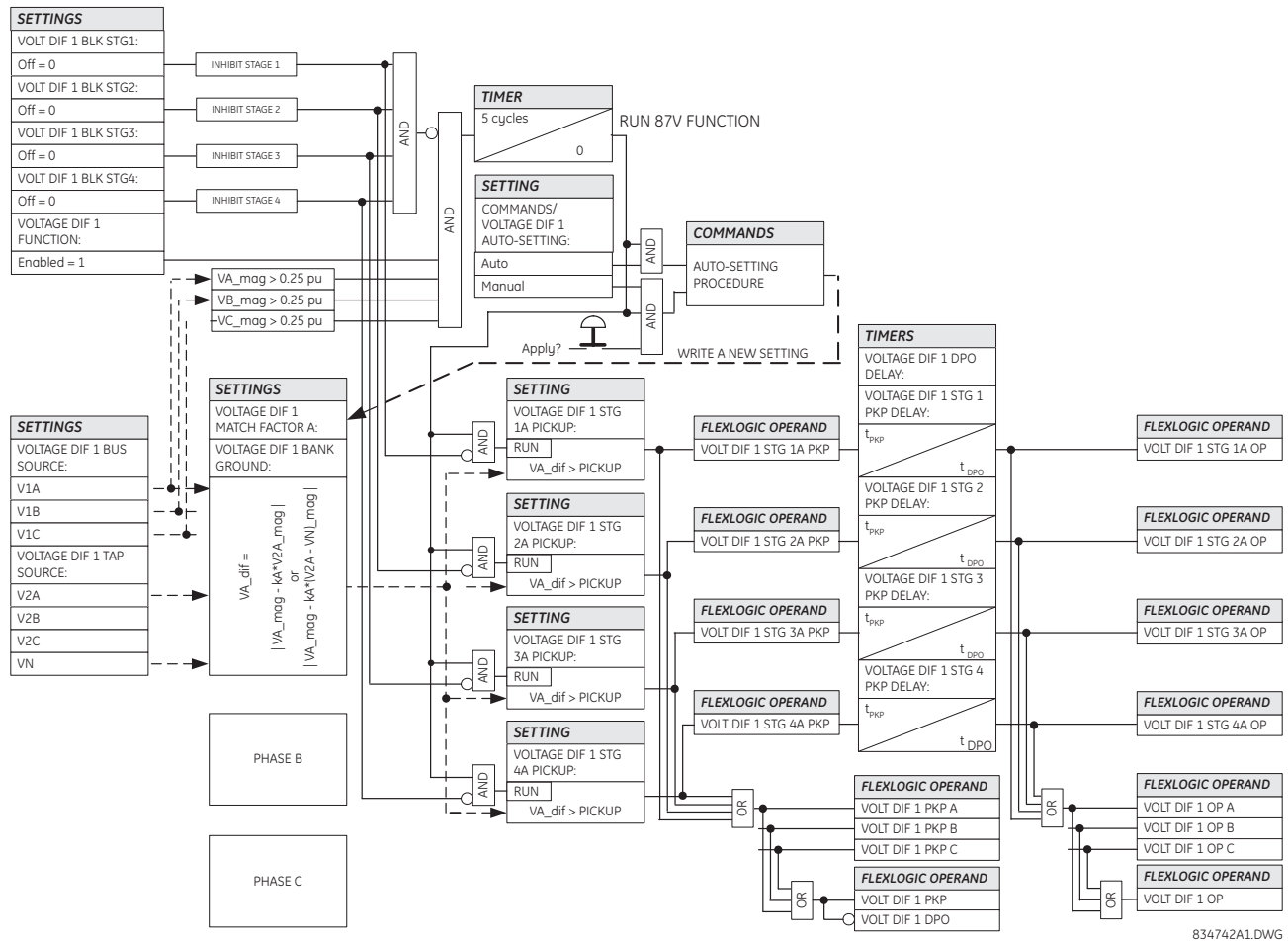


Figure 5-69: VOLTAGE DIFFERENTIAL SCHEME LOGIC

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 |

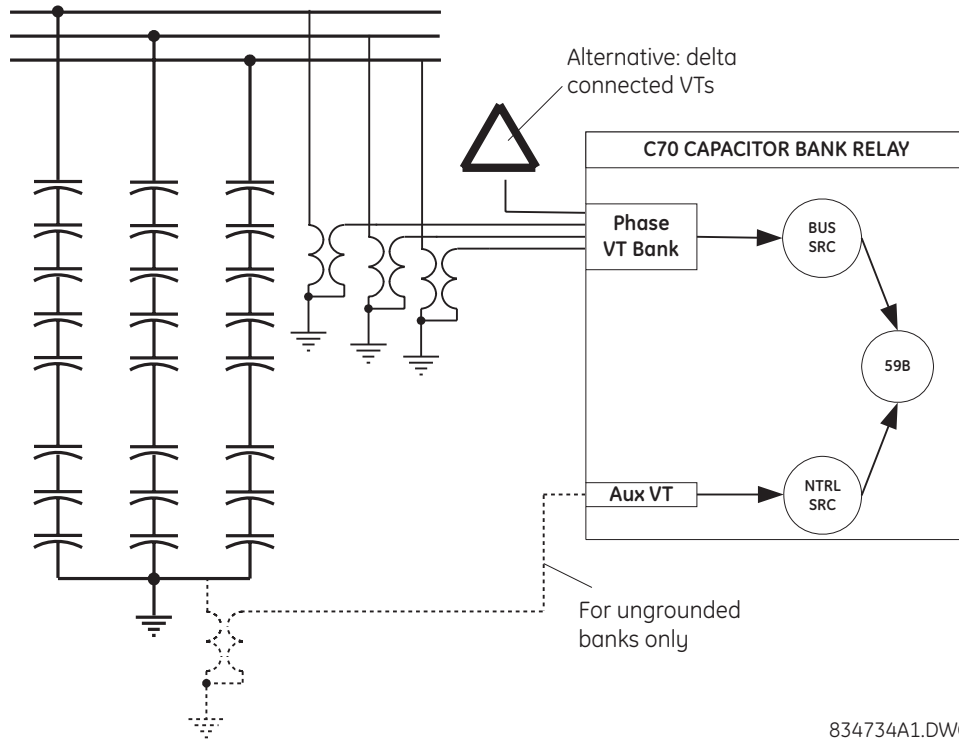
Up to three identical bank overvoltage elements, one per each VT bank configured in hardware, are provided.

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, this 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).



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Figure 5-70: 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 | | |
|---------------|---|---|---|
| | GROUNDING | UNGROUNDING | UNGROUNDING W/O VN |
| Wye | $V_{op_A} = V_A$ $V_{op_B} = V_B$ $V_{op_C} = V_C$ | $V_{op_A} = V_A - V_X$ $V_{op_B} = V_B - V_X$ $V_{op_C} = V_C - V_X$ | $V_{op_A} = (V_{CA} - V_{AB}) / 3$ $V_{op_B} = (V_{AB} - V_{BC}) / 3$ $V_{op_C} = (V_{BC} - V_{CA}) / 3$ |
| Delta | $V_{op_A} = (V_{CA} - V_{AB}) / 3$ $V_{op_B} = (V_{AB} - V_{BC}) / 3$ $V_{op_C} = (V_{BC} - V_{CA}) / 3$ | | |

- **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 wye 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.

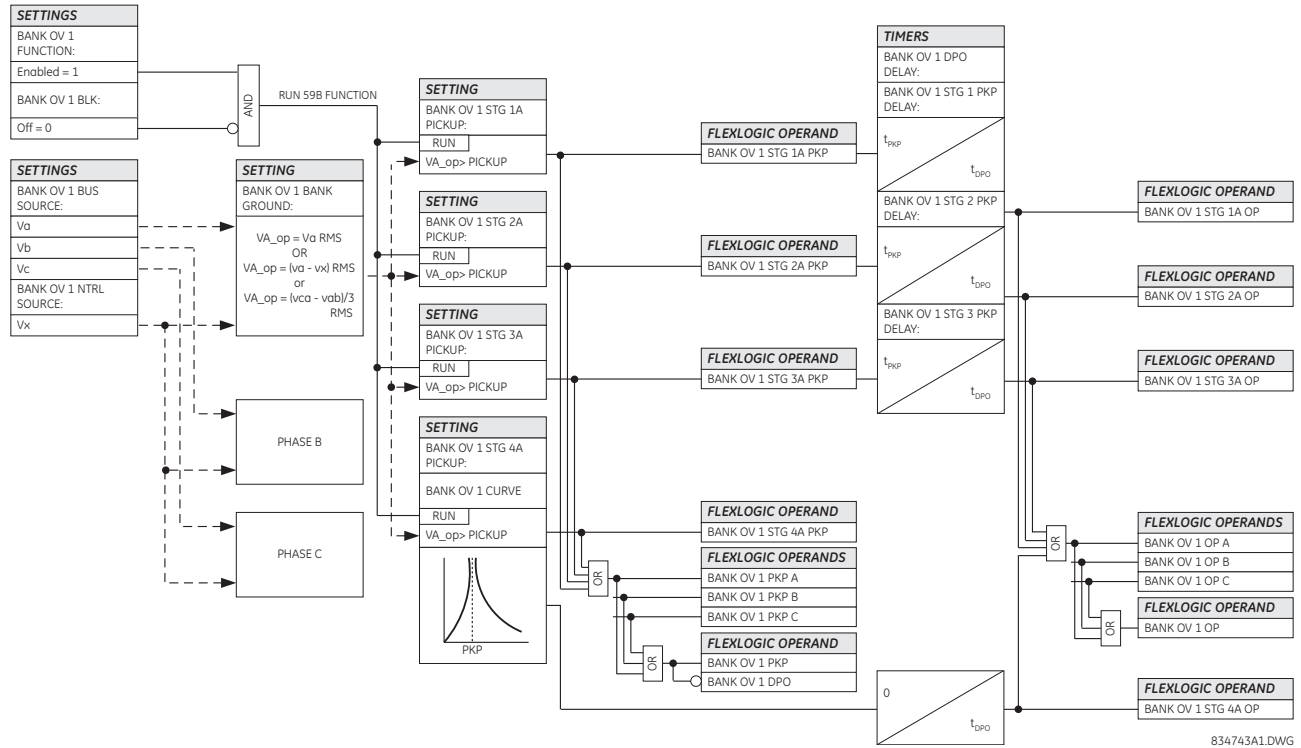


Figure 5-71: BANK PHASE OVERVOLTAGE SCHEME LOGIC

i) NEUTRAL VOLTAGE UNBALANCE (ANSI 59NU)

PATH: SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ VOLTAGE... ⇒ NEUTRAL VOLTAGE UNBALANCE 1(3)

| | | | |
|---|---------|---|---|
| <div> <div>NEUTRAL VOLTAGE UNBALANCE 1</div> </div> | MESSAGE | 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 0.250 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 0.250 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 0.250 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 0.250 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.

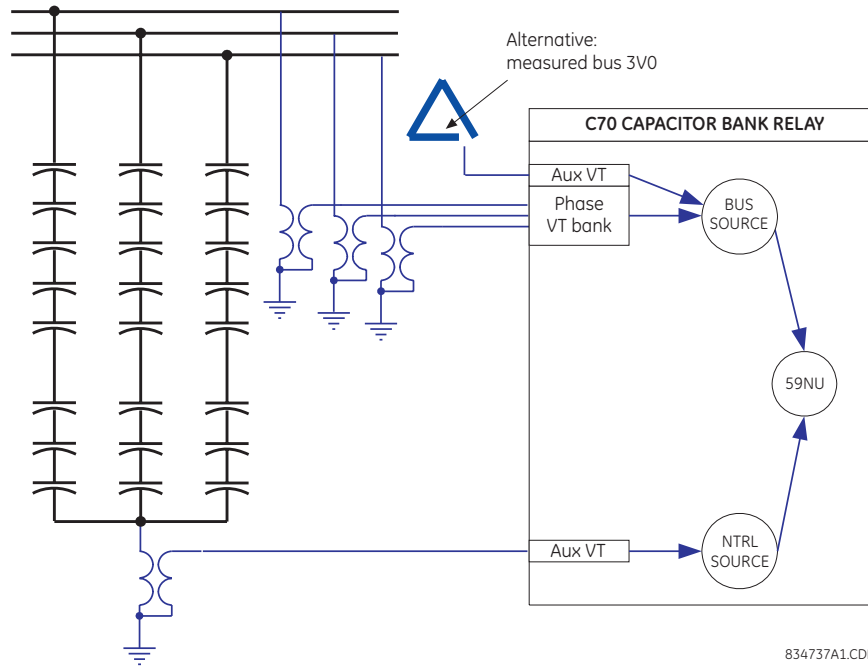


Figure 5-72: NEUTRAL VOLTAGE UNBALANCE BASIC CONNECTION

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. 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”.
- **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 3V0 during system faults (for example, an SLG fault at the bus). This is accomplished by the following condition:

$$\frac{3V0_{\text{BUS}}}{n_{\text{BUS_VT}}} - \frac{3I0_{\text{NTRL}} \times R}{n_{\text{NTRL_CT}} \times n_{\text{NTRL_VT}}} = 0 \quad (\text{EQ 5.17})$$

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

- $3V0_{\text{BUS}}$ is the bus voltage during system fault.

- $3I_{NTRL}$ is the primary current in the bank neutral during system fault.
- n_{BUS_VT} is the bus voltage VT ratio set in the source selected by the **NTRL VOL UNBAL 1 BUS SOURCE** setting.
- n_{NTRL_VT} is a neutral point voltage 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.
- **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.
- **NTRL VOL UNBAL 1 STG 1 PKP to NTRL VOL UNBAL 1 STG 4 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 under-current 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.

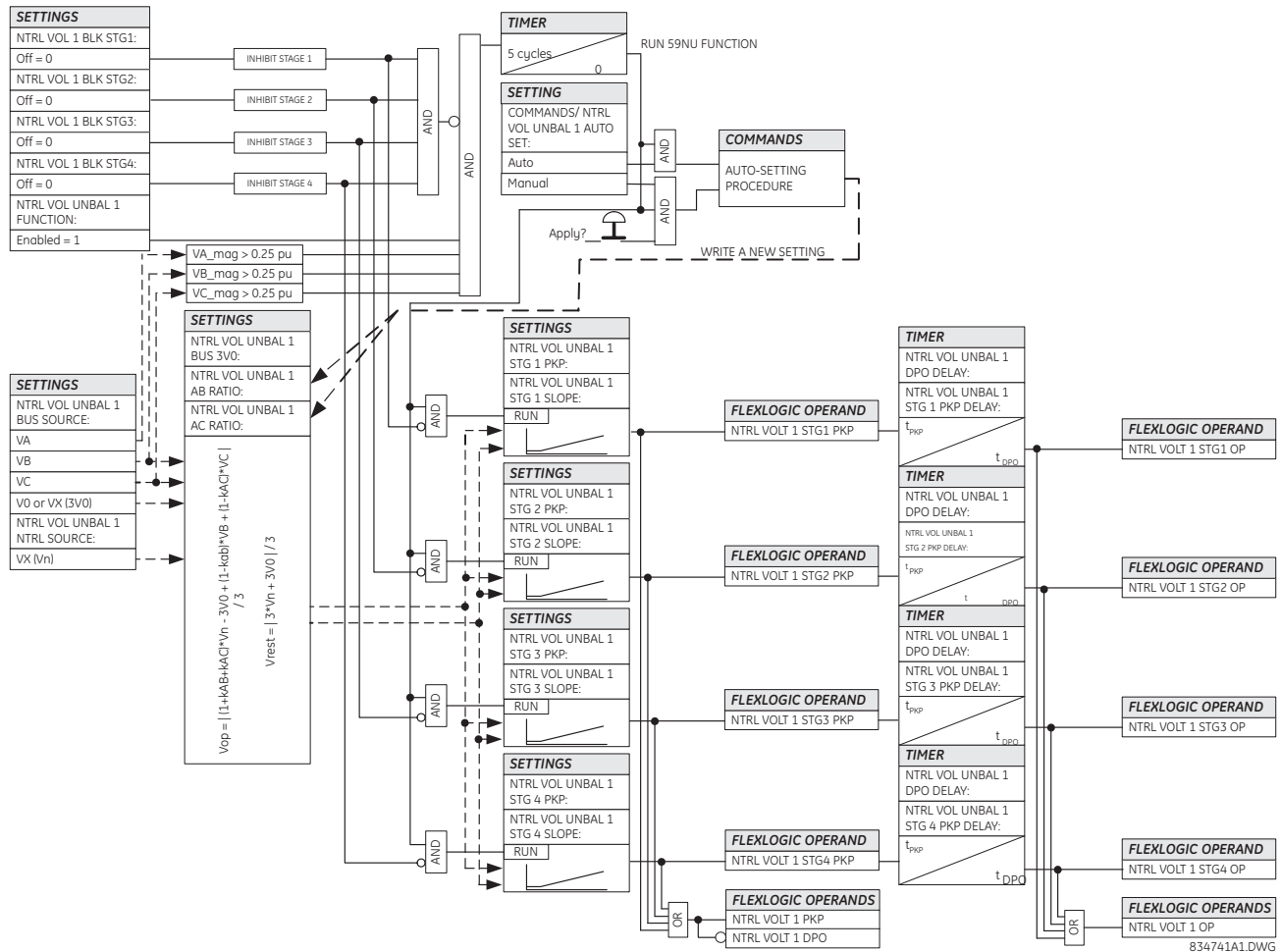


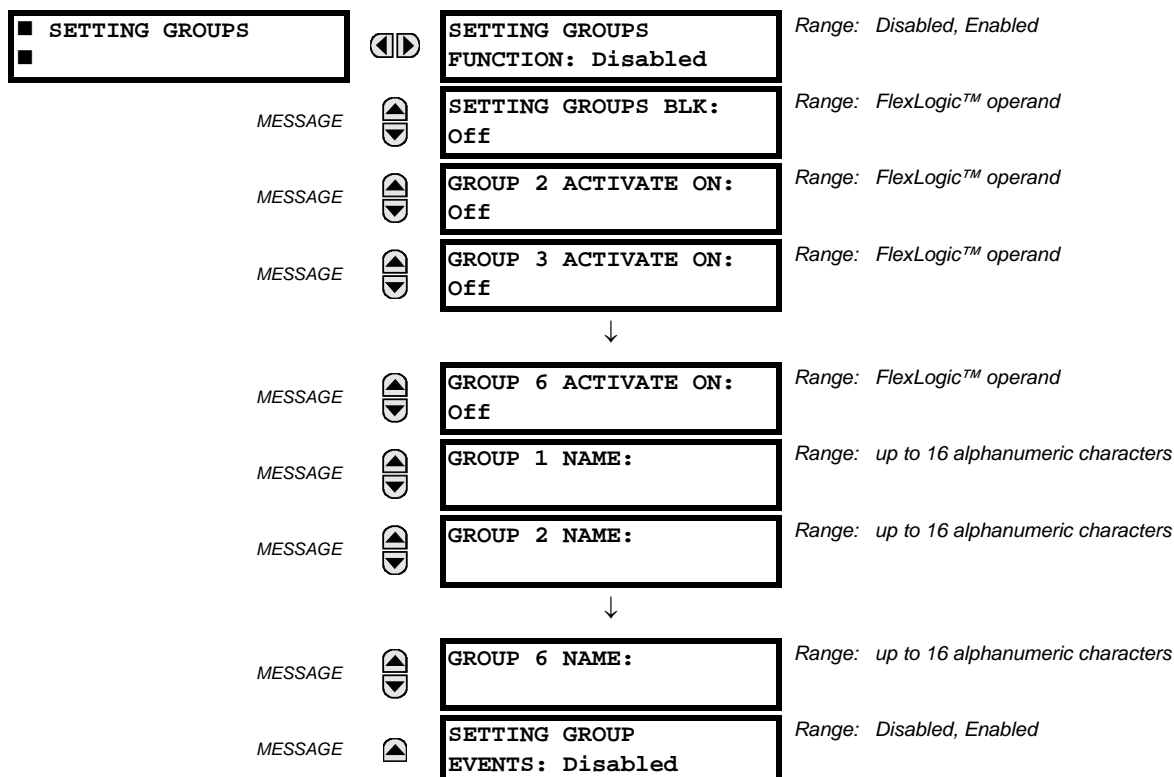
Figure 5–73: NEUTRAL VOLTAGE UNBALANCE LOGIC

5.6.1 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.

5.6.2 SETTING GROUPS

PATH: SETTINGS ⇌ CONTROL ELEMENTS ⇌ SETTINGS GROUPS



The setting groups menu controls the activation/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 the 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.

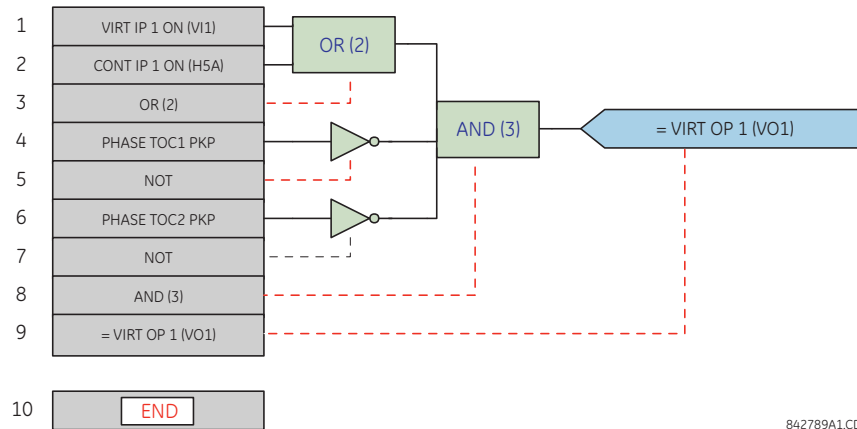


Figure 5-74: EXAMPLE FLEXLOGIC™ CONTROL OF A SETTINGS GROUP

5.6.3 SELECTOR SWITCH

PATH: SETTINGS ⇒ CONTROL ELEMENTS ⇒ SELECTOR SWITCH ⇒ SELECTOR SWITCH 1(2)

| | | |
|--|--|---|
| <div> <div>■ SELECTOR SWITCH 1</div> <div> <div>SELECTOR 1 FUNCTION:</div> <div>Disabled</div> </div> </div> | | Range: Disabled, Enabled |
| MESSAGE | <div> <div>SELECTOR 1 FULL RANGE:</div> <div>7</div> </div> | Range: 1 to 7 in steps of 1 |
| MESSAGE | <div> <div>SELECTOR 1 TIME-OUT:</div> <div>5.0 s</div> </div> | Range: 3.0 to 60.0 s in steps of 0.1 |
| MESSAGE | <div> <div>SELECTOR 1 STEP-UP:</div> <div>Off</div> </div> | Range: FlexLogic™ operand |
| MESSAGE | <div> <div>SELECTOR 1 STEP-UP MODE:</div> <div>Time-out</div> </div> | Range: Time-out, Acknowledge |
| MESSAGE | <div> <div>SELECTOR 1 ACK:</div> <div>Off</div> </div> | Range: FlexLogic™ operand |
| MESSAGE | <div> <div>SELECTOR 1 3BIT A0:</div> <div>Off</div> </div> | Range: FlexLogic™ operand |
| MESSAGE | <div> <div>SELECTOR 1 3BIT A1:</div> <div>Off</div> </div> | Range: FlexLogic™ operand |
| MESSAGE | <div> <div>SELECTOR 1 3BIT A2:</div> <div>Off</div> </div> | Range: FlexLogic™ operand |
| MESSAGE | <div> <div>SELECTOR 1 3BIT MODE:</div> <div>Time-out</div> </div> | Range: Time-out, Acknowledge |
| MESSAGE | <div> <div>SELECTOR 1 3BIT ACK:</div> <div>Off</div> </div> | Range: FlexLogic™ operand |
| MESSAGE | <div> <div>SELECTOR 1 POWER-UP MODE:</div> <div>Restore</div> </div> | Range: Restore, Synchronize, Sync/Restore |
| MESSAGE | <div> <div>SELECTOR 1 TARGETS:</div> <div>Self-reset</div> </div> | Range: Self-reset, Latched, Disabled |
| MESSAGE | <div> <div>SELECTOR 1 EVENTS:</div> <div>Disabled</div> </div> | Range: Disabled, Enabled |

The selector switch element is intended to replace a mechanical selector switch. Typical applications include setting group control or control of multiple logic sub-circuits in user-programmable logic.

The element provides for two control inputs. The step-up control allows stepping through selector position one step at a time with each pulse of the control input, such as a user-programmable pushbutton. The three-bit control input allows setting the selector to the position defined by a three-bit word.

The element allows pre-selecting a new position without applying it. The pre-selected position gets applied either after time-out or upon acknowledgement via separate inputs (user setting). The selector position is stored in non-volatile memory. Upon power-up, either the previous position is restored or the relay synchronizes to the current three-bit word (user setting). Basic alarm functionality alerts the user under abnormal conditions; for example, the three-bit control input being out of range.

- **SELECTOR 1 FULL RANGE:** This setting defines the upper position of the selector. When stepping up through available positions of the selector, the upper position wraps up to the lower position (position 1). When using a direct three-bit control word for programming the selector to a desired position, the change would take place only if the control word is within the range of 1 to the **SELECTOR FULL RANGE**. If the control word is outside the range, an alarm is established by setting the **SELECTOR ALARM** FlexLogic™ operand for 3 seconds.
- **SELECTOR 1 TIME-OUT:** This setting defines the time-out period for the selector. This value is used by the relay in the following two ways. When the **SELECTOR STEP-UP MODE** is “Time-out”, the setting specifies the required period of inactivity of the control input after which the pre-selected position is automatically applied. When the **SELECTOR STEP-UP MODE** is “Acknowledge”, the setting specifies the period of time for the acknowledging input to appear. The timer is re-started by any activity of the control input. The acknowledging input must come before the **SELECTOR 1 TIME-OUT** timer expires; otherwise, the change will not take place and an alarm will be set.
- **SELECTOR 1 STEP-UP:** This setting specifies a control input for the selector switch. The switch is shifted to a new position at each rising edge of this signal. The position changes incrementally, wrapping up from the last (**SELECTOR 1 FULL RANGE**) to the first (position 1). Consecutive pulses of this control operand must not occur faster than every 50 ms. After each rising edge of the assigned operand, the time-out timer is restarted and the **SELECTOR SWITCH 1: POS Z CHNG INITIATED** target message is displayed, where **Z** the pre-selected position. The message is displayed for the time specified by the **FLASH MESSAGE TIME** setting. The pre-selected position is applied after the selector times out (“Time-out” mode), or when the acknowledging signal appears before the element times out (“Acknowledge” mode). When the new position is applied, the relay displays the **SELECTOR SWITCH 1: POSITION Z IN USE** message. Typically, a user-programmable pushbutton is configured as the stepping up control input.
- **SELECTOR 1 STEP-UP MODE:** This setting defines the selector mode of operation. When set to “Time-out”, the selector will change its position after a pre-defined period of inactivity at the control input. The change is automatic and does not require any explicit confirmation of the intent to change the selector's position. When set to “Acknowledge”, the selector will change its position only after the intent is confirmed through a separate acknowledging signal. If the acknowledging signal does not appear within a pre-defined period of time, the selector does not accept the change and an alarm is established by setting the **SELECTOR STP ALARM** output FlexLogic™ operand for 3 seconds.
- **SELECTOR 1 ACK:** This setting specifies an acknowledging input for the stepping up control input. The pre-selected position is applied on the rising edge of the assigned operand. This setting is active only under “Acknowledge” mode of operation. The acknowledging signal must appear within the time defined by the **SELECTOR 1 TIME-OUT** setting after the last activity of the control input. A user-programmable pushbutton is typically configured as the acknowledging input.
- **SELECTOR 1 3BIT A0, A1, and A2:** These settings specify a three-bit control input of the selector. The three-bit control word pre-selects the position using the following encoding convention:

| A2 | A1 | A0 | POSITION |
|----|----|----|----------|
| 0 | 0 | 0 | rest |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 2 |
| 0 | 1 | 1 | 3 |
| 1 | 0 | 0 | 4 |
| 1 | 0 | 1 | 5 |
| 1 | 1 | 0 | 6 |
| 1 | 1 | 1 | 7 |

The “rest” position (0, 0, 0) does not generate an action and is intended for situations when the device generating the three-bit control word is having a problem. When **SELECTOR 1 3BIT MODE** is “Time-out”, the pre-selected position is applied in **SELECTOR 1 TIME-OUT** seconds after the last activity of the three-bit input. When **SELECTOR 1 3BIT MODE** is “Acknowledge”, the pre-selected position is applied on the rising edge of the **SELECTOR 1 3BIT ACK** acknowledging input.

The stepping up control input (**SELECTOR 1 STEP-UP**) and the three-bit control inputs (**SELECTOR 1 3BIT A0** through **A2**) lock-out mutually: once the stepping up sequence is initiated, the three-bit control input is inactive; once the three-bit control sequence is initiated, the stepping up input is inactive.

- **SELECTOR 1 3BIT MODE:** This setting defines the selector mode of operation. When set to “Time-out”, the selector changes its position after a pre-defined period of inactivity at the control input. The change is automatic and does not require explicit confirmation to change the selector position. When set to “Acknowledge”, the selector changes its position only after confirmation via a separate acknowledging signal. If the acknowledging signal does not appear within a pre-defined period of time, the selector rejects the change and an alarm established by invoking the **SELECTOR BIT ALARM** FlexLogic™ operand for 3 seconds.
- **SELECTOR 1 3BIT ACK:** This setting specifies an acknowledging input for the three-bit control input. The pre-selected position is applied on the rising edge of the assigned FlexLogic™ operand. This setting is active only under the “Acknowledge” mode of operation. The acknowledging signal must appear within the time defined by the **SELECTOR TIME-OUT** setting after the last activity of the three-bit control inputs. Note that the stepping up control input and three-bit control input have independent acknowledging signals (**SELECTOR 1 ACK** and **SELECTOR 1 3BIT ACK**, accordingly).
- **SELECTOR 1 POWER-UP MODE:** This setting specifies the element behavior on power up of the relay.

When set to “Restore”, the last position of the selector (stored in the non-volatile memory) is restored after powering up the relay. If the position restored from memory is out of range, position 0 (no output operand selected) is applied and an alarm is set (**SELECTOR 1 PWR ALARM**).

When set to “Synchronize” selector switch acts as follows. For two power cycles, the selector applies position 0 to the switch and activates **SELECTOR 1 PWR ALARM**. After two power cycles expire, the selector synchronizes to the position dictated by the three-bit control input. This operation does not wait for time-out or the acknowledging input. When the synchronization attempt is unsuccessful (that is, the three-bit input is not available (0,0,0) or out of range) then the selector switch output is set to position 0 (no output operand selected) and an alarm is established (**SELECTOR 1 PWR ALARM**).

The operation of “Synch/Restore” mode is similar to the “Synchronize” mode. The only difference is that after an unsuccessful synchronization attempt, the switch will attempt to restore the position stored in the relay memory. The “Synch/Restore” mode is useful for applications where the selector switch is employed to change the setting group in redundant (two relay) protection schemes.

- **SELECTOR 1 EVENTS:** If enabled, the following events are logged:

| EVENT NAME | DESCRIPTION |
|----------------------|--|
| SELECTOR 1 POS Z | Selector 1 changed its position to Z. |
| SELECTOR 1 STP ALARM | The selector position pre-selected via the stepping up control input has not been confirmed before the time out. |
| SELECTOR 1 BIT ALARM | The selector position pre-selected via the three-bit control input has not been confirmed before the time out. |

The following figures illustrate the operation of the selector switch. In these diagrams, "T" represents a time-out setting.

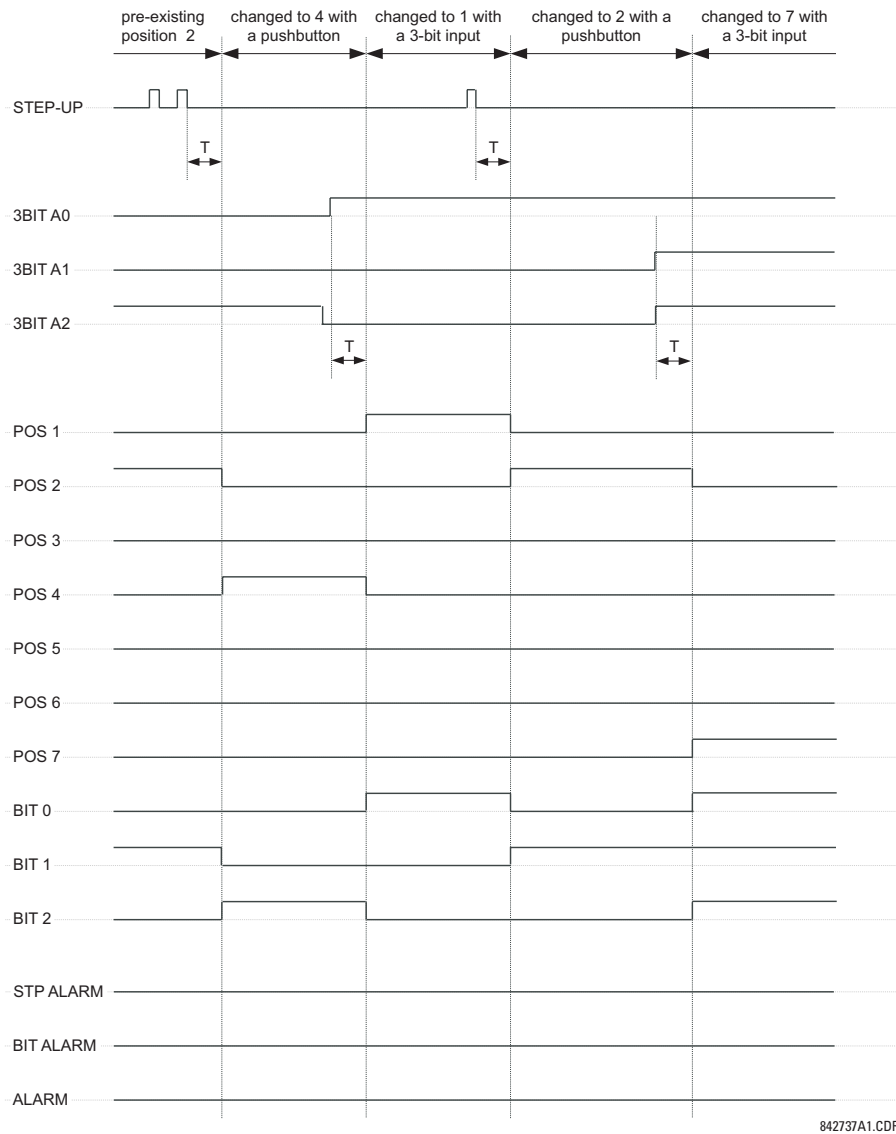
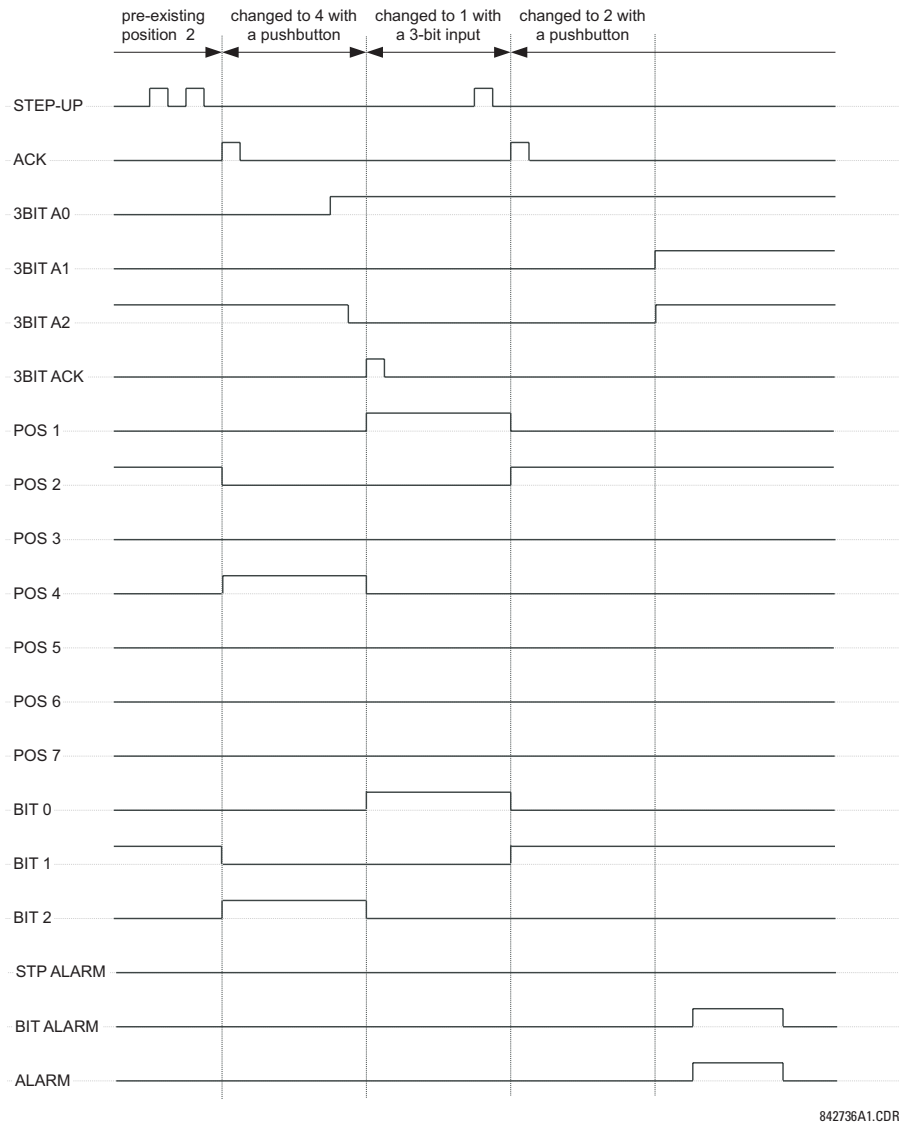


Figure 5-75: TIME-OUT MODE



842736A1.CDR

Figure 5-76: 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:

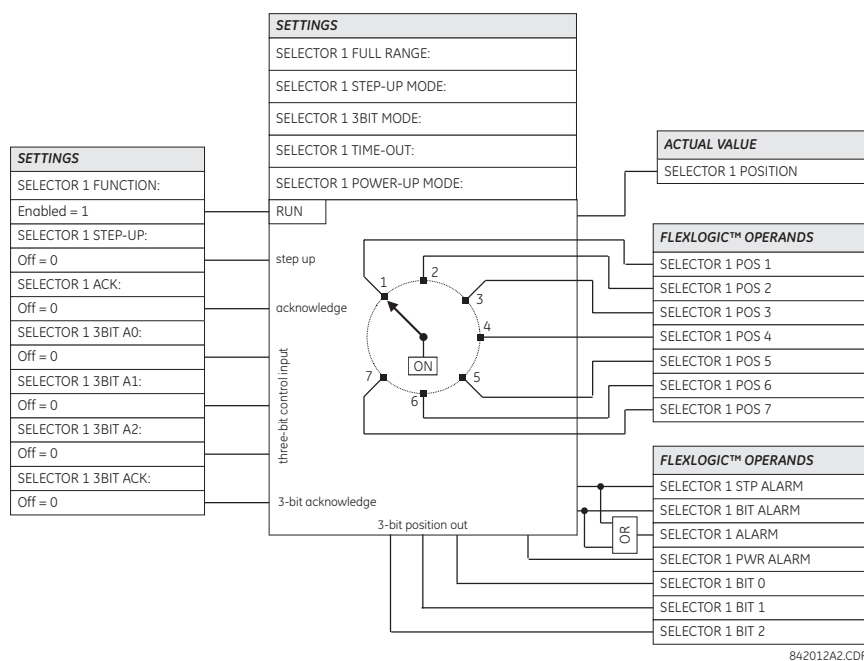


Figure 5-77: SELECTOR SWITCH LOGIC

5.6.4 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.

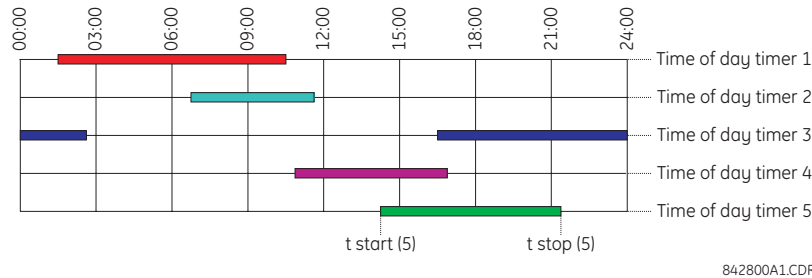


Figure 5-78: TIME OF DAY TIMER EXAMPLE

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 YEAR, DAYOFMONTH, and SECONDOFDAY FlexAnalog parameters to create virtually any time and date condition for custom time or season-based control actions.

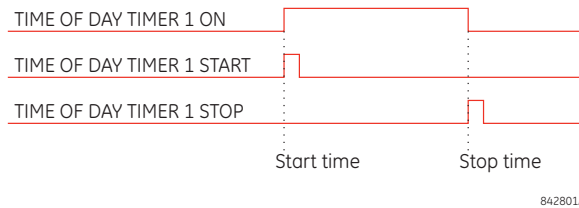


Figure 5-79: CLOSE/OPEN/MAINTAIN CONTROL VIA FLEXLOGIC™ OPERANDS

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.

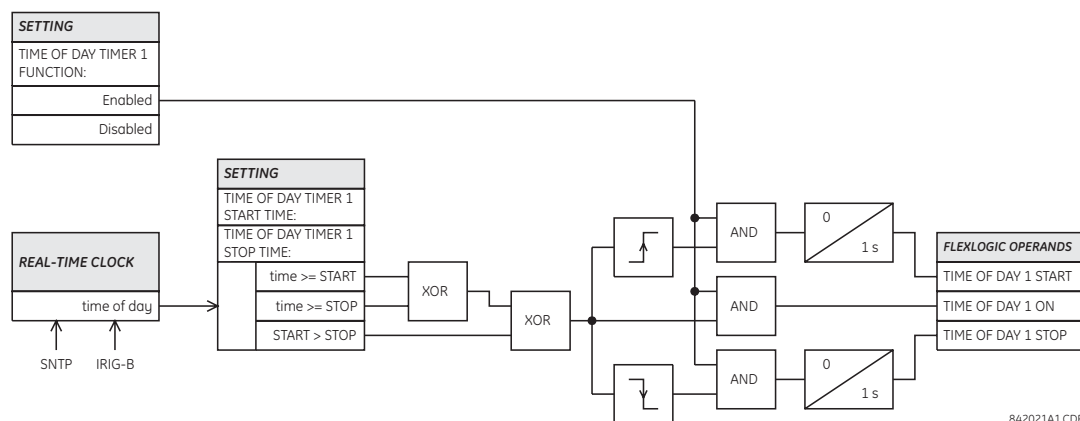























Figure 5-80: TIME OF DAY TIMER LOGIC

5.6.5 CAPACITOR CONTROL

PATH: SETTINGS ⇒ CONTROL ELEMENTS ⇒ CAPACITOR CONTROL ⇒ CAPACITOR CONTROL 1(4)

| | | | | |
|---|-----------------------|-----|----------------------------------|---------------------------|
| 5 | ■ 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.

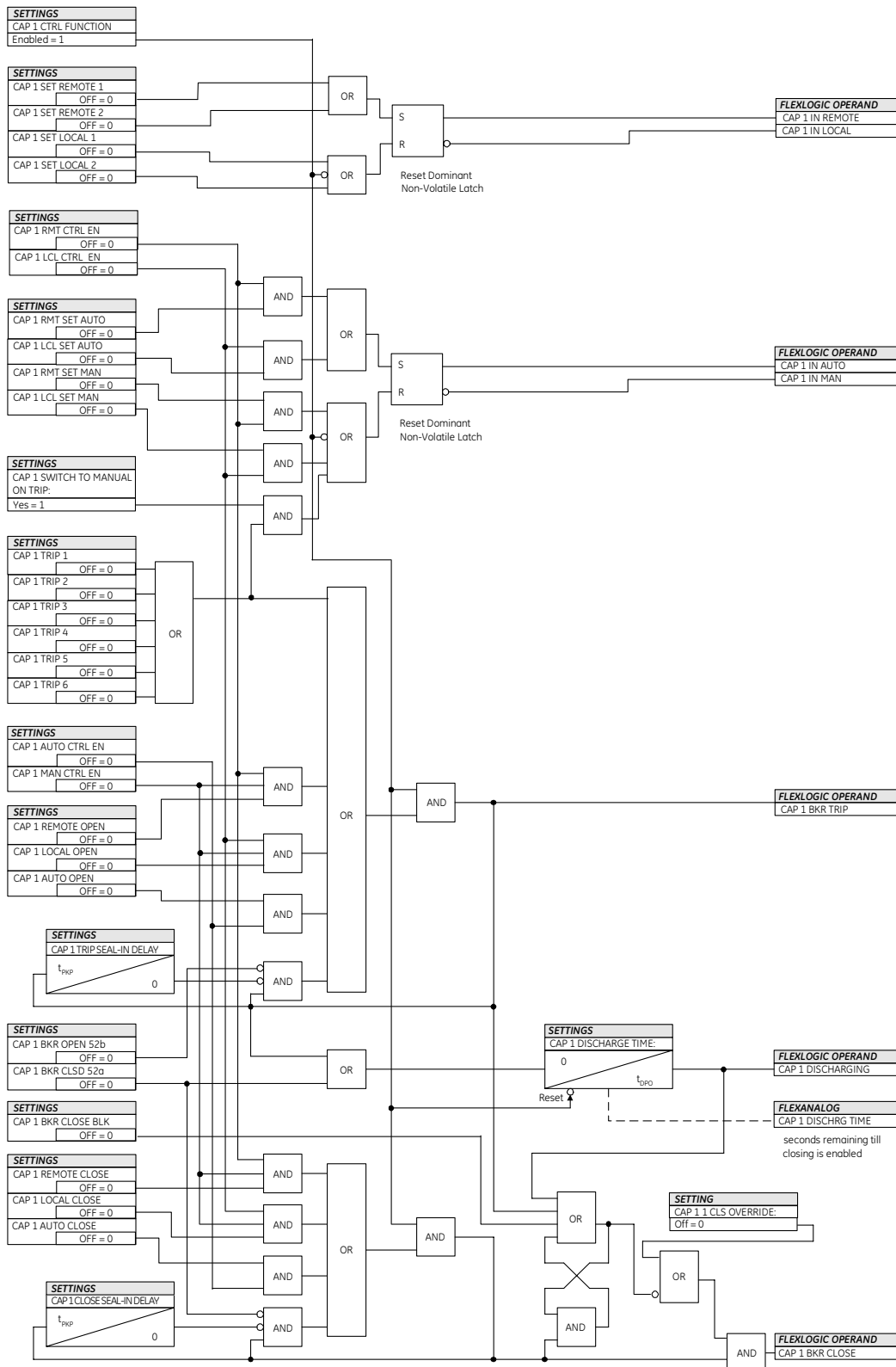
A provision is provided to force the auto/manual mode to manual on protection operation. This is to prevent the capacitor automatic switching scheme from attempting to close a faulted capacitor. A setting is used to control the automatic switch-over to manual upon the protection trip.

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.



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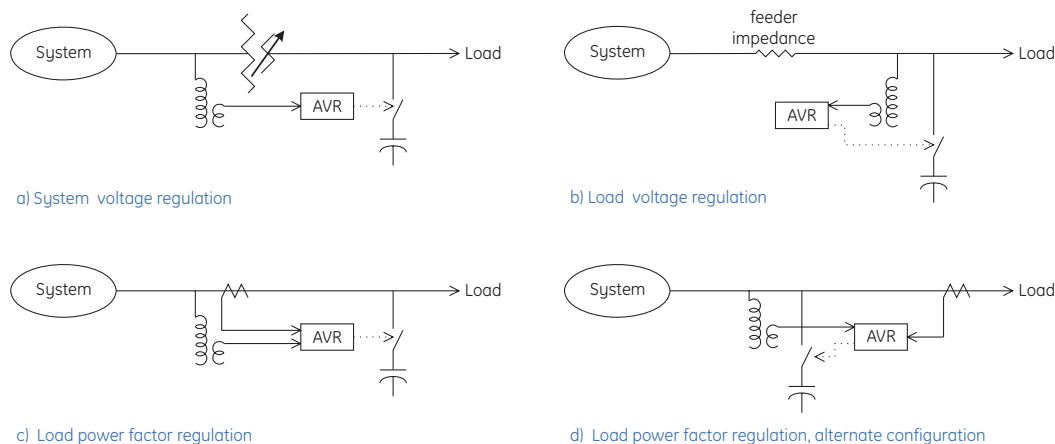
Figure 5-81: CAPACITOR BANK CONTROL SCHEME LOGIC

5.6.6 AUTOMATIC VOLTAGE REGULATOR

PATH: SETTINGS ⇒ CONTROL ELEMENTS ⇒ AUTOMATIC VOLTAGE REGULATOR ⇒ AUTOMATIC VOLTAGE REGULATOR 1(3)

| | | | |
|---|---------------|--|---|
| <div>■ AUTOMATIC VOLTAGE</div> <div>■ REGULATOR 1</div> | | <div>◀▶</div> <div>AVR 1 FUNCTION: Disabled</div> | Range: Disabled, Enabled |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 SOURCE: SRC 1</div> | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 MINIMUM VOLTAGE: 0.500 pu</div> | Range: 0.500 to 1.500 pu in steps of 0.001 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 CONTROL MODE: Voltage</div> | Range: Voltage, VAR |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 VOLT OPERATING SIGNAL: V1</div> | Range: Vab, Vbc, Vca, Vaver, V1, Vaux |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 VOLT LEVEL TO CLOSE: 0.950 pu</div> | Range: 0.750 to 1.500 pu in steps of 0.001 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 VOLT LEVEL TO OPEN: 1.050 pu</div> | Range: 0.750 to 1.500 pu in steps of 0.001 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 VOLT DROP COMPENS Z: 0.00 Ω</div> | Range: 0 to 250.00 ohms in steps of 0.01 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 VOLT DROP COMPENS RCA: 75°</div> | Range: 30 to 90° in steps of 1 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 VAR LEVEL TO CLOSE: 0.500 pu</div> | Range: -1.500 to 1.500 pu in steps of 0.001 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 VAR LEVEL TO OPEN: -0.500 pu</div> | Range: -1.500 to 1.500 pu in steps of 0.001 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 POWER FACTOR LIMIT: 1.00</div> | Range: 0.50 to 1.00 pu in steps of 0.01 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 VAR OPEN MODE: Minimize No. of Ops.</div> | Range: Minimize Uptime, Minimize No. of Ops. |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 DELAY BEFORE CLOSE: 1.000 s</div> | Range: 0.000 to 65.353 s in steps of 0.001 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 DELAY BEFORE OPEN: 1.000 s</div> | Range: 0.000 to 65.353 s in steps of 0.001 |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 BLOCK: Off</div> | Range: FlexLogic™ operand |
| MESSAGE | <div>▲▼</div> | <div>AVR 1 TARGET: Self-reset</div> | Range: Self-reset, Latched, Disabled |
| MESSAGE | <div>▲</div> | <div>AVR 1 EVENTS: Disabled</div> | 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.



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Figure 5–82: 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/power factor of a load to reduce transmission/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.

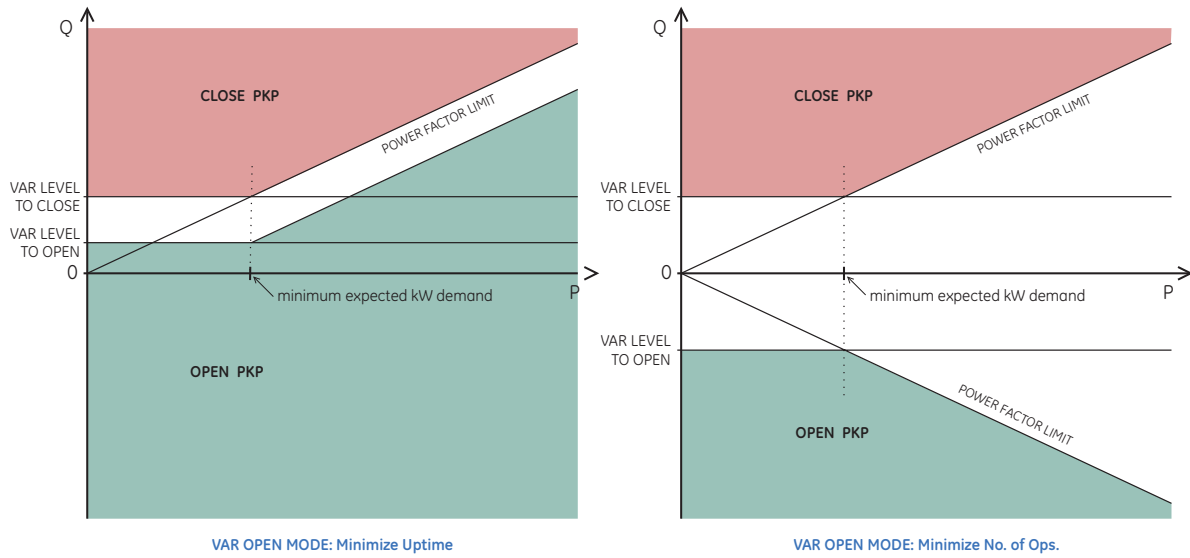


Figure 5-83: AUTOMATIC VOLTAGE REGULATOR PICKUP CHARACTERISTICS IN "VAR" MODE

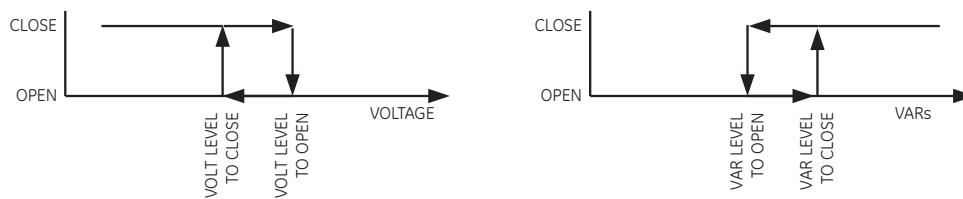
Care should be taken that the settings do not result in the capacitor being continuously cycled close and open. In the voltage mode the close voltage settings should be lower than the open voltage setting by more than the voltage change expected from capacitor switching, plus margin. Similarly in the "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, 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.



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Figure 5-84: 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.

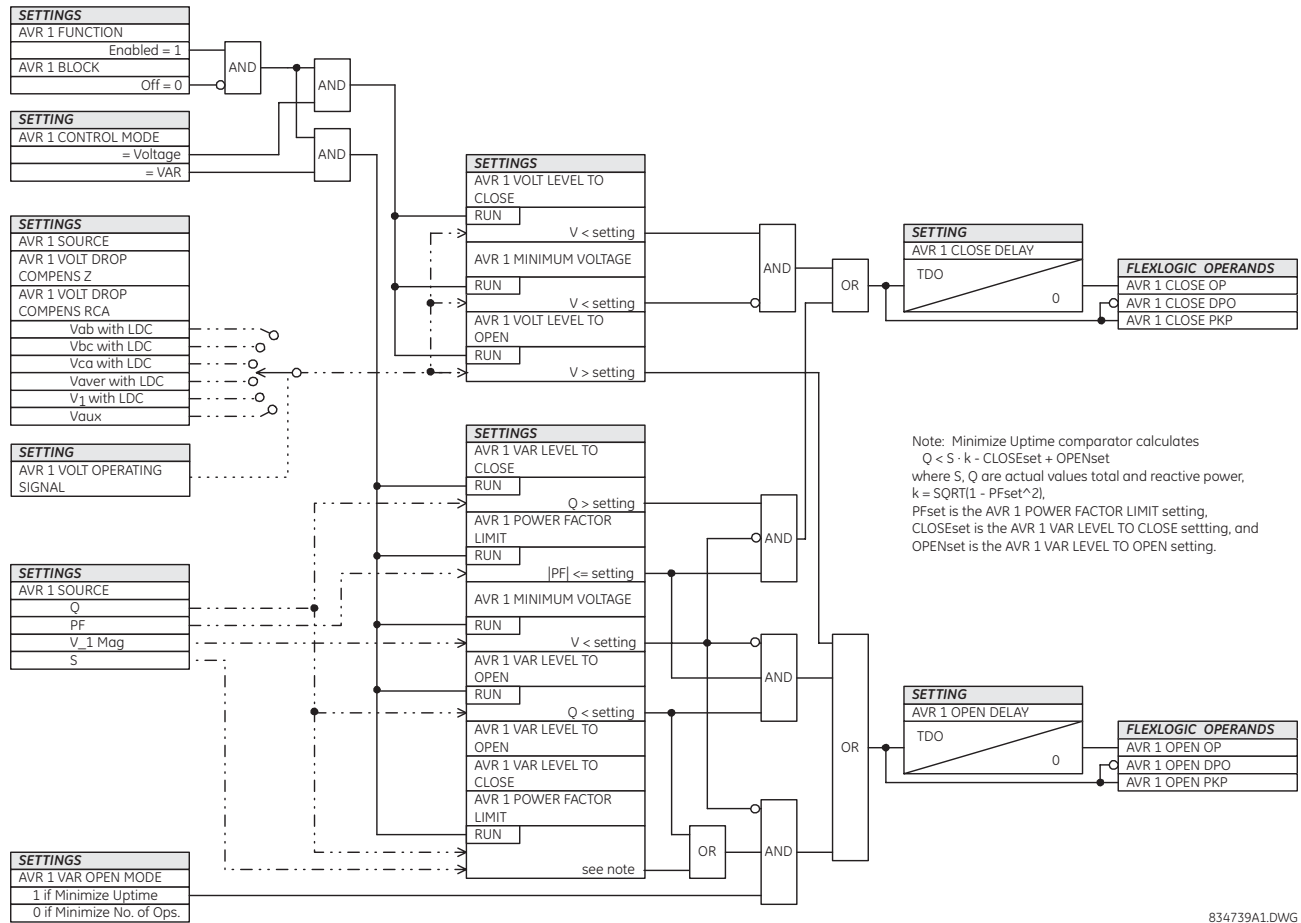


Figure 5-85: AUTOMATIC VOLTAGE REGULATOR SCHEME LOGIC

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5.6.7 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.

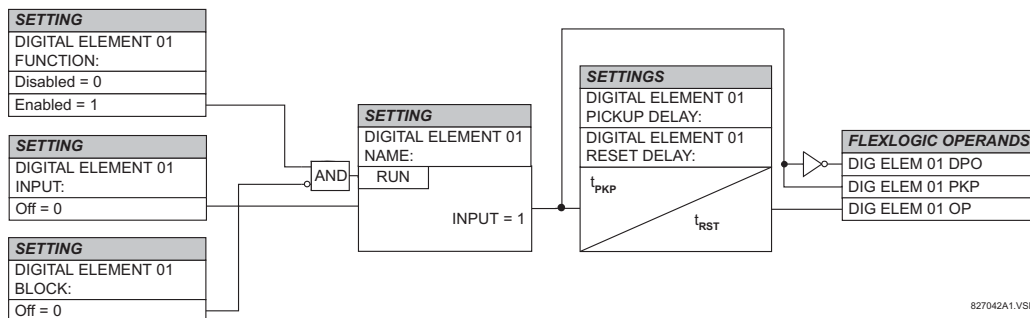


Figure 5-86: DIGITAL ELEMENT SCHEME LOGIC

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 FlexLogic™ operand “Cont Op # VOn” will be set (# represents the output contact number). If the output circuit has a high resistance or the DC current is interrupted, the trickle current will drop below the threshold and the FlexLogic™ operand “Cont Op # VOff” 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.

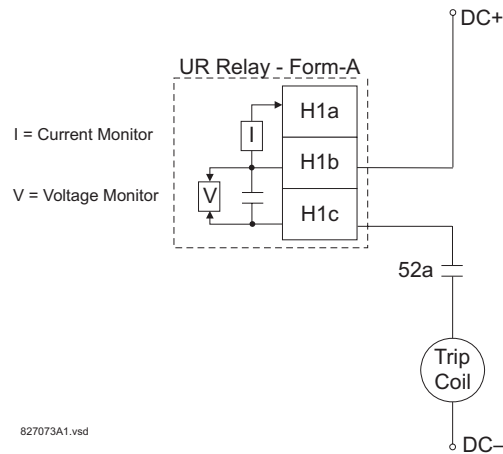
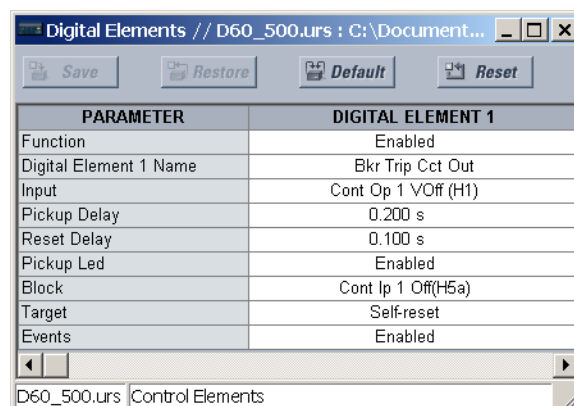


Figure 5–87: TRIP CIRCUIT EXAMPLE 1

Assume the output contact H1 is a trip contact. Using the contact output settings, this output will be given an ID name, e.g. “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, e.g. “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):

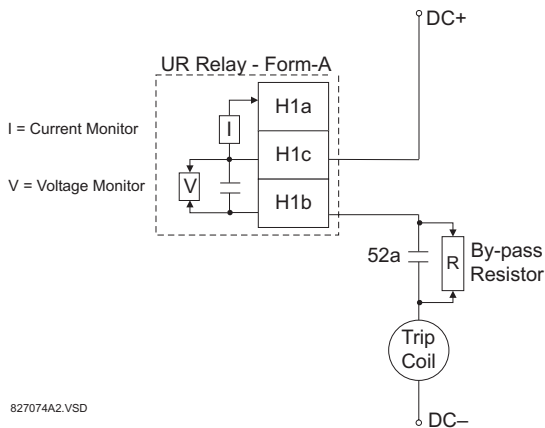


The PICKUP DELAY setting should be greater than the operating time of the breaker to avoid nuisance alarms.

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 |

**Table 5–19: VALUES OF RESISTOR ‘R’**

| POWER SUPPLY (V DC) | RESISTANCE (OHMS) | POWER (WATTS) |
|---------------------|-------------------|---------------|
| 24 | 1000 | 2 |
| 30 | 5000 | 2 |
| 48 | 10000 | 2 |
| 110 | 25000 | 5 |
| 125 | 25000 | 5 |
| 250 | 50000 | 5 |

Figure 5–88: TRIP CIRCUIT EXAMPLE 2

5.6.8 DIGITAL COUNTERS

PATH: SETTINGS ⇒ CONTROL ELEMENTS ⇒ DIGITAL COUNTERS ⇒ COUNTER 1(8)

| | | | |
|--|--|---|--------------------------|
| <div> <div>COUNTER 1</div> <div> <div>MESSAGE</div> <div> <div>▲</div> <div>▼</div> </div> </div> </div> | | <div> <div>COUNTER 1</div> <div>FUNCTION: Disabled</div> </div> | Range: Disabled, Enabled |
| <div> <div>COUNTER 1 NAME:</div> <div>Counter 1</div> </div> | | Range: 12 alphanumeric characters | |
| <div> <div>COUNTER 1 UNITS:</div> <div></div> </div> | | Range: 6 alphanumeric characters | |
| <div> <div>COUNTER 1 PRESET:</div> <div>0</div> </div> | | Range: -2,147,483,648 to +2,147,483,647 | |
| <div> <div>COUNTER 1 COMPARE:</div> <div>0</div> </div> | | Range: -2,147,483,648 to +2,147,483,647 | |
| <div> <div>COUNTER 1 UP:</div> <div>Off</div> </div> | | Range: FlexLogic™ operand | |
| <div> <div>COUNTER 1 DOWN:</div> <div>Off</div> </div> | | Range: FlexLogic™ operand | |
| <div> <div>COUNTER 1 BLOCK:</div> <div>Off</div> </div> | | Range: FlexLogic™ operand | |
| <div> <div>CNT1 SET TO PRESET:</div> <div>Off</div> </div> | | Range: FlexLogic™ operand | |
| <div> <div>COUNTER 1 RESET:</div> <div>Off</div> </div> | | Range: FlexLogic™ operand | |
| <div> <div>COUNT1 FREEZE/RESET:</div> <div>Off</div> </div> | | Range: FlexLogic™ operand | |
| <div> <div>COUNT1 FREEZE/COUNT:</div> <div>Off</div> </div> | | 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.

- **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.

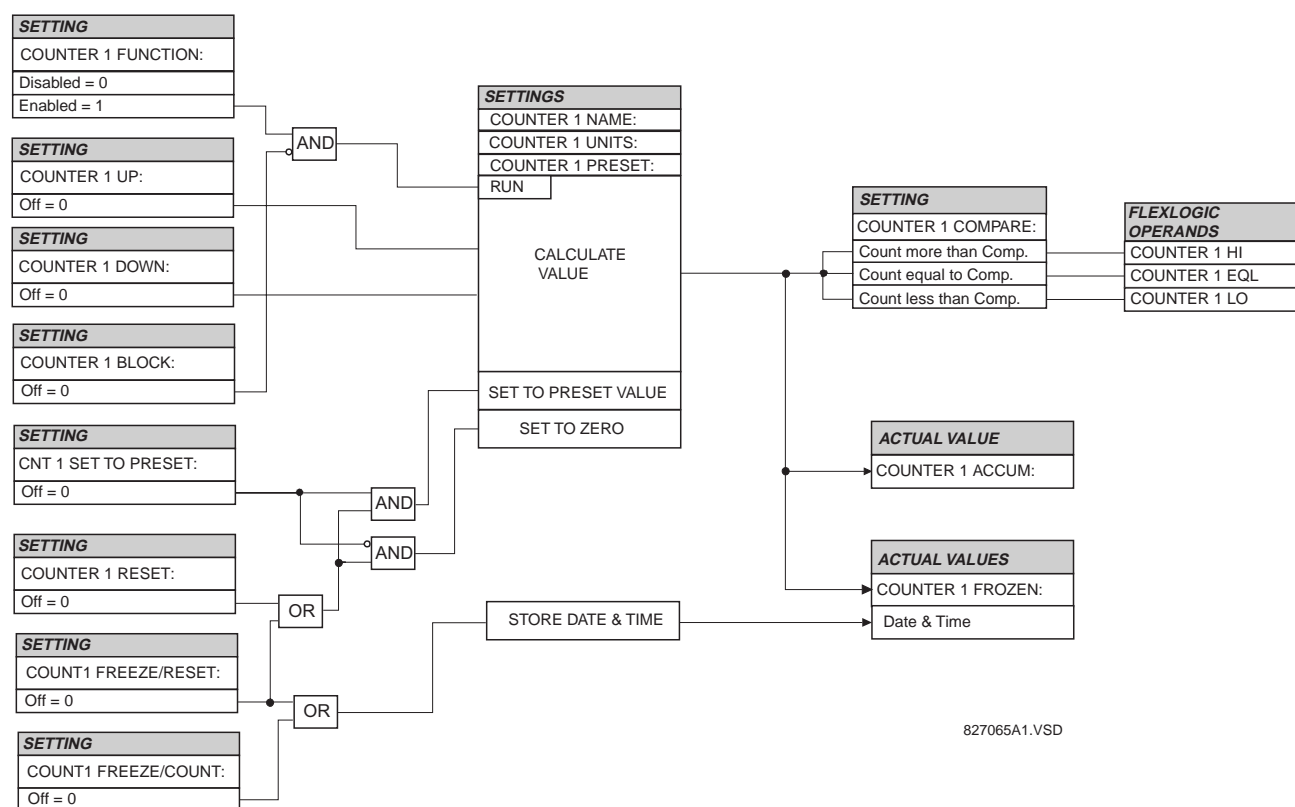


Figure 5-89: DIGITAL COUNTER SCHEME LOGIC

5.6.9 MONITORING ELEMENTS

a) MAIN MENU

PATH: SETTINGS ⇨ ⚙ CONTROL ELEMENTS ⇨ ⚙ MONITORING ELEMENTS

| | | | |
|----------------------------|----|----------------------------|-----------------|
| ■ MONITORING ■ ELEMENTS | ◀▶ | ■ BREAKER ■ FLASHOVER 1 | See page 5-176. |
| MESSAGE | ▲▼ | ■ BREAKER ■ FLASHOVER 2 | See page 5-176. |
| MESSAGE | ▲▼ | ■ BREAKER ■ FLASHOVER 3 | See page 5-176. |
| MESSAGE | ▲▼ | ■ BREAKER ■ FLASHOVER 4 | See page 5-176. |
| MESSAGE | ▲▼ | ■ BREAKER ■ FLASHOVER 5 | See page 5-176. |
| MESSAGE | ▲▼ | ■ BREAKER ■ FLASHOVER 6 | See page 5-176. |
| MESSAGE | ▲▼ | ■ BREAKER RESTRIKE 1 ■ | See page 5-180. |
| MESSAGE | ▲▼ | ■ BREAKER RESTRIKE 2 ■ | See page 5-180. |
| MESSAGE | ▲▼ | ■ BREAKER RESTRIKE 3 ■ | See page 5-180. |
| MESSAGE | ▲▼ | ■ VT FUSE FAILURE 1 ■ | See page 5-182. |
| MESSAGE | ▲▼ | ■ VT FUSE FAILURE 2 ■ | See page 5-182. |
| MESSAGE | ▲▼ | ■ VT FUSE FAILURE 3 ■ | See page 5-182. |
| MESSAGE | ▲▼ | ■ VT FUSE FAILURE 4 ■ | See page 5-182. |
| MESSAGE | ▲▼ | ■ VT FUSE FAILURE 5 ■ | See page 5-182. |
| MESSAGE | ▲ | ■ VT FUSE FAILURE 6 ■ | See page 5-182. |

b) BREAKER FLASHOVER

PATH: SETTINGS ⇒ CONTROL ELEMENTS ⇒ MONITORING ELEMENTS ⇒ BREAKER FLASHOVER 1(6)

| | | | |
|----------------------------|---------|-------------------------------------|---|
| ■ 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 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.

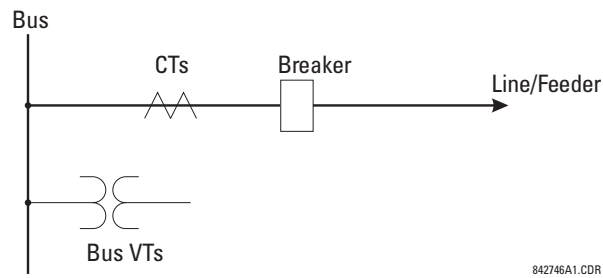


Voltages must be present prior to flashover conditions. If the three VTs are placed after the breaker on the line (or feeder), and the downstream breaker is open, the measured voltage would be zero and the flashover element will not be initiated.

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 FLSHOVR SPV** setting 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. ΔVA is greater than pickup (not applicable in this scheme)

The conditions at flashover detection are:

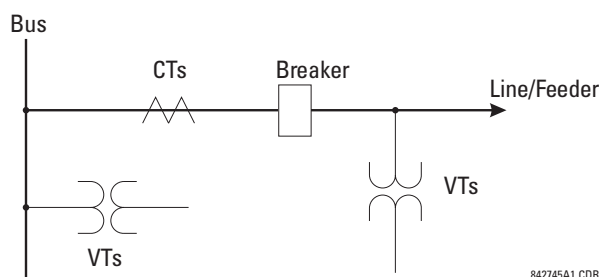
1. 52a status = 0
2. VAg, VBg, or VCg is lower than the pickup setting
3. IA, IB, or IC is greater than the pickup current flowing through the breaker
4. ΔVA is greater than pickup (not applicable in this scheme)

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(2) 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(2) 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(2) 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(2) 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(2) 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(2) 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. ΔVA 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. ΔVA 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)



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.

NOTE

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 specify 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 Flex-Logic™ operand resets.

- **BRK FLSHOVR PKP DELAY:** This setting specifies the time delay to operate after a pickup condition is detected.

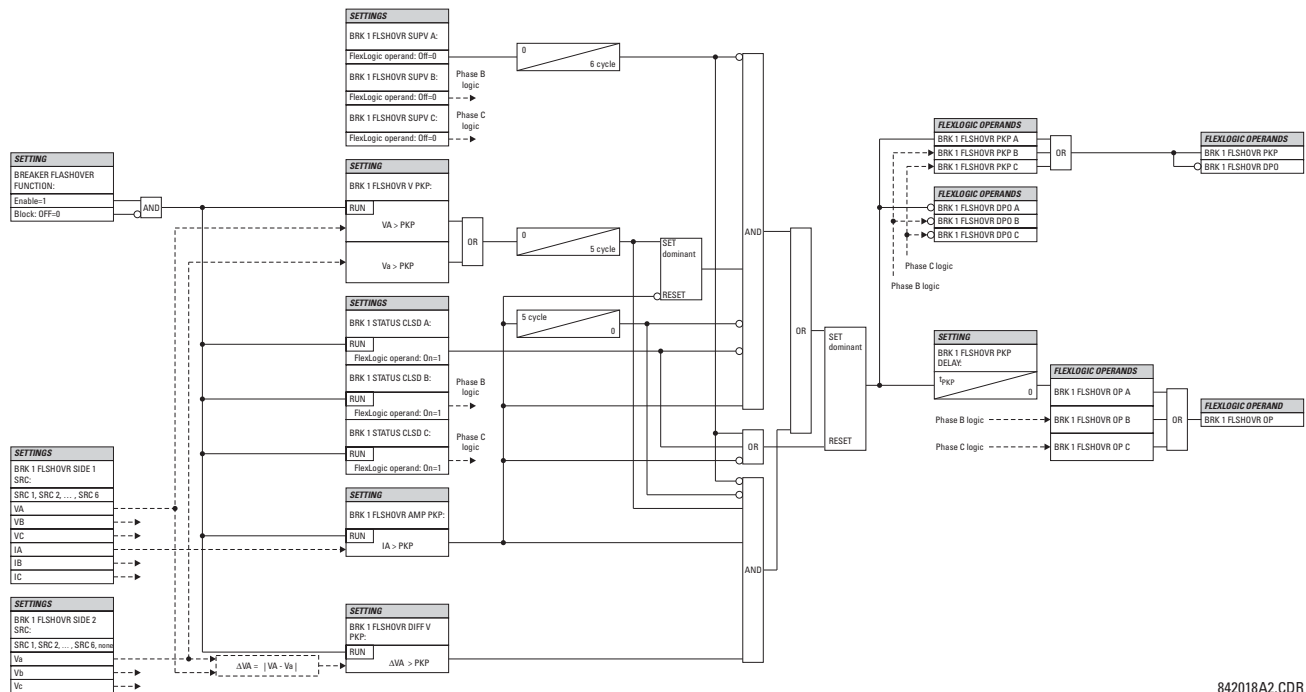


Figure 5-90: BREAKER FLASHOVER SCHEME LOGIC

c) BREAKER RESTRIKE

PATH: SETTINGS ⇨ CONTROL ELEMENTS ⇨ MONITORING ELEMENTS ⇨ BREAKER RESTRIKE 1(3)

| | | | |
|---|--|--|---|
| <div>■ BREAKER RESTRIKE 1</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> | | BREAKER RESTRIKE 1 | Range: Disabled, Enabled |
| | | FUNCTION: Disabled | |
| | | BKR RSTR 1 BLOCK: Off | Range: FlexLogic™ operand |
| | | BREAKER RESTRIKE 1 SOURCE: SRC 1 | Range: SRC 1, SRC 2, SRC 3, SRC 4, SRC 5, SRC 6 |
| | | BREAKER RESTRIKE 1 PICKUP: 0.500 pu | Range: 0.10 to 2.00 pu in steps of 0.01 |
| | | BREAKER RESTRIKE 1 RESET DELAY: 0.100 s | Range: 0.000 to 65.535 s in steps of 0.001 |
| | | BKR RSTR 1 BKR OPEN: Off | Range: FlexLogic™ operand |
| | | BKR RSTR 1 OPEN CMD: Off | Range: FlexLogic™ operand |
| | | BKR RSTR 1 CLS CMD: Off | Range: FlexLogic™ operand |
| | | BREAKER RESTRIKE 1 TARGET: Self-reset | Range: Self-reset, Latched, Disabled |
| | | 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”.

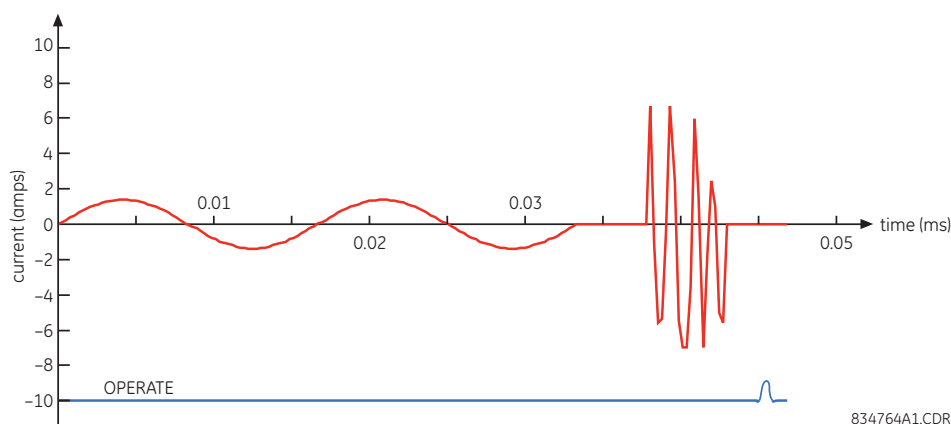


Figure 5-91: TYPICAL RESTRIKE WAVEFORM AND DETECTION FLAG

The breaker 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.

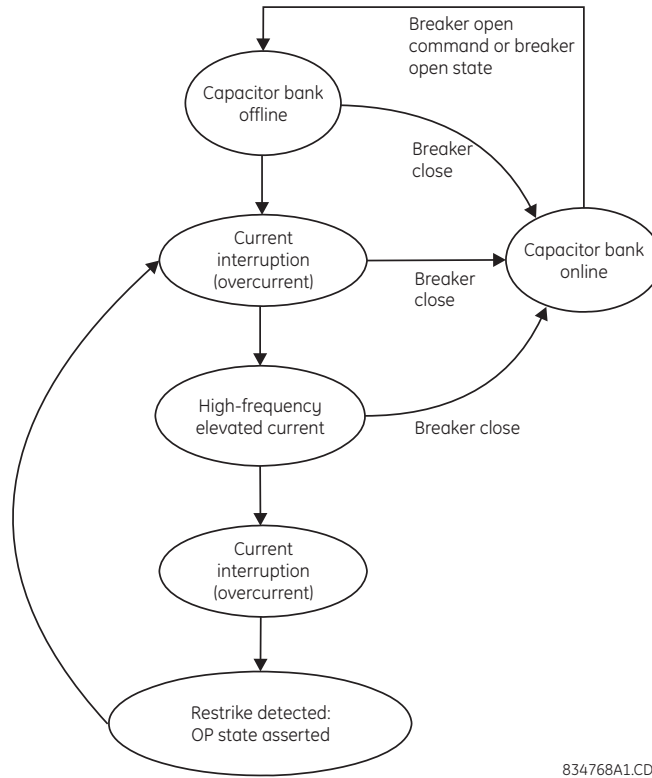
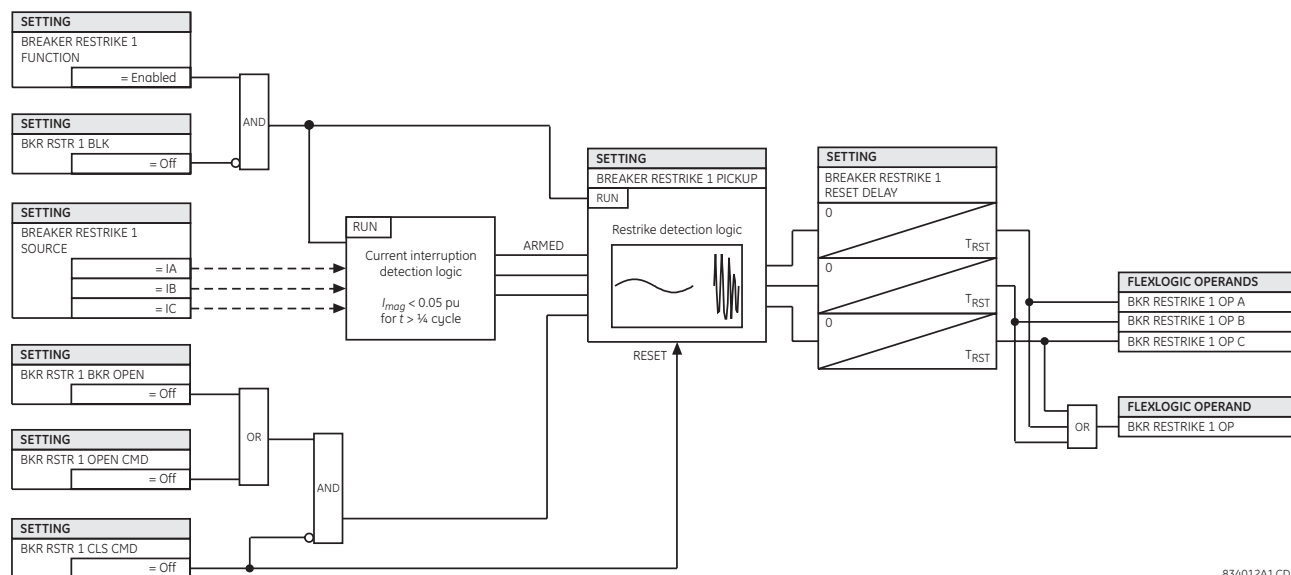


Figure 5–92: ALGORITHM ILLUSTRATION – STATE MACHINE TO DETECT RESTRIKE

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.

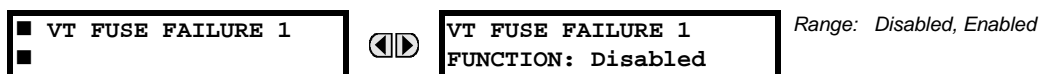


834012A1.CDR

Figure 5-93: BREAKER RESTRIKE SCHEME LOGIC

d) VT FUSE FAILURE

PATH: SETTINGS ⇨ CONTROL ELEMENTS ⇨ MONITORING ELEMENTS ⇨ VT FUSE FAILURE 1(6)



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.

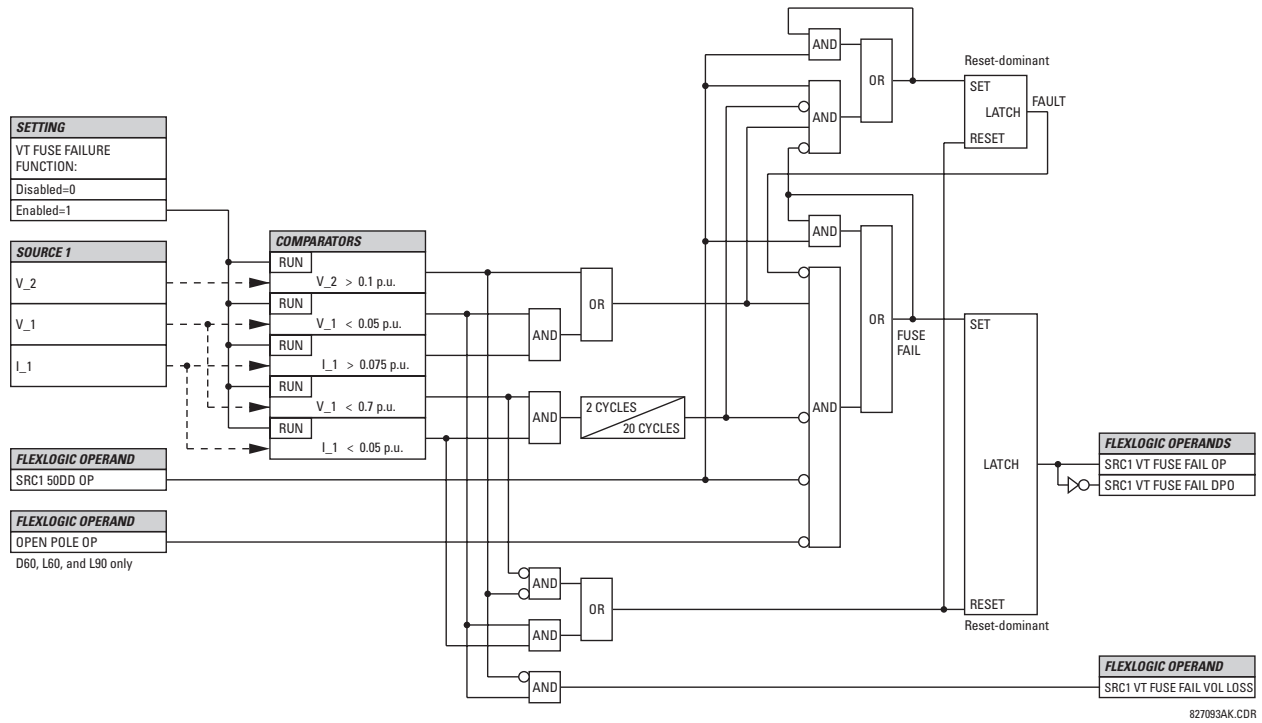


Figure 5-94: VT FUSE FAIL SCHEME LOGIC

5.6.10 TRIP BUS

PATH: SETTINGS ⇒ 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 | | | | | | | | | | | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|----------|----------|----------|----------|----------|
| <div> <div>Save</div> <div>Restore</div> <div>Default</div> <div>Reset</div> <div>VIEW ALL mode</div> </div> | | | | | | | | | | | |
| GROUPED ELEMENTS | TB1 | TB2 | TB3 | TB4 | TB5 | GROUP 1 | GROUP 2 | GROUP 3 | GROUP 4 | GROUP 5 | GROUP 6 |
| Current Differential | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Stub Bus | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Line Pickup | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Phase Distance Z 1 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Phase Distance Z 2 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Phase Distance Z 3 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Ground Distance Z 1 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Ground Distance Z 2 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Ground Distance Z 3 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Power Swing | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Load Encroachment | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Phase TOC 1 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Phase TOC 2 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Phase TOC 3 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |
| Phase TOC 4 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Disabled | Disabled | Disabled | Disabled | Disabled | Disabled |

Figure 5-95: 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.

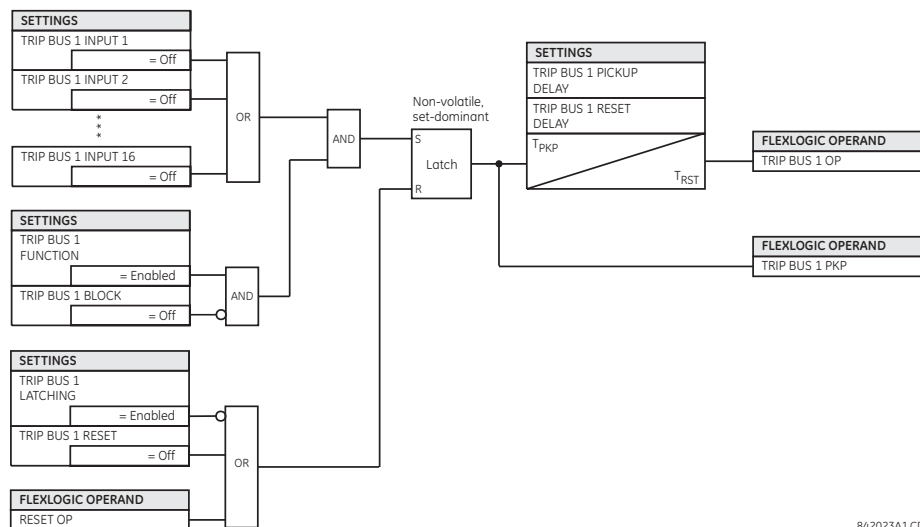
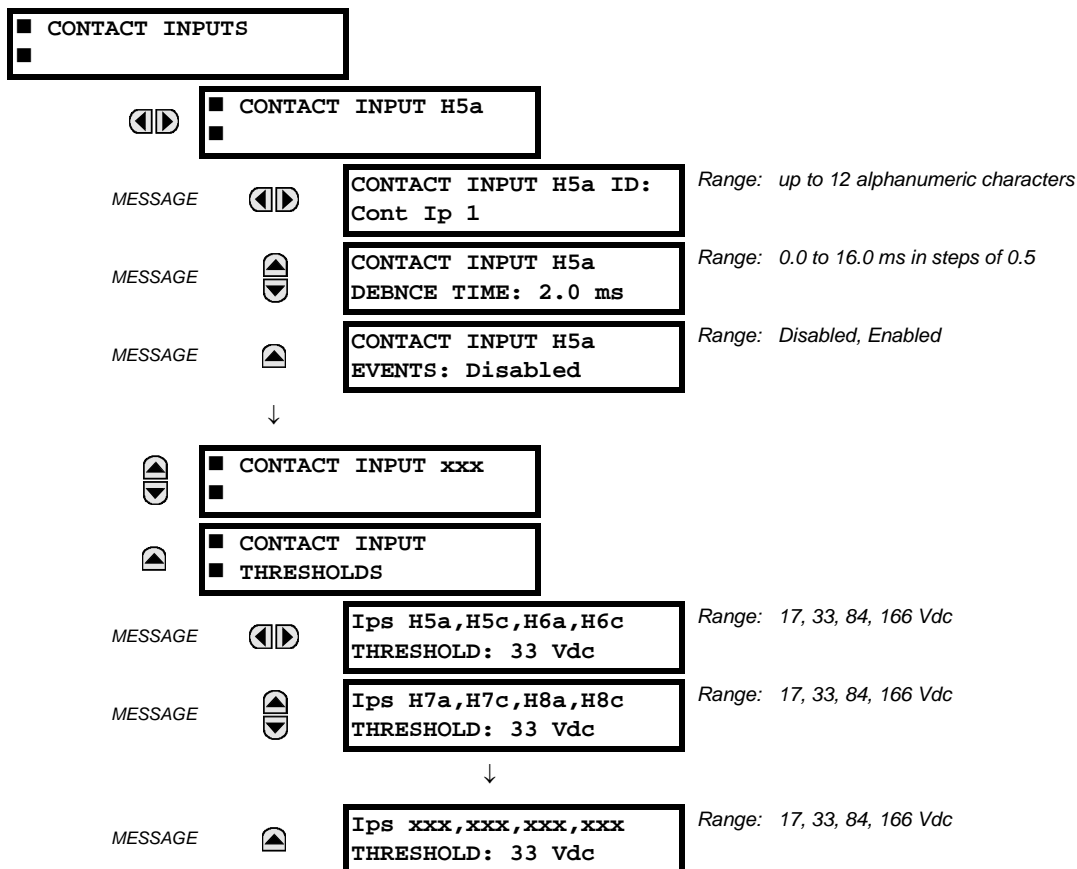


Figure 5-96: TRIP BUS LOGIC

5.7.1 CONTACT INPUTS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ CONTACT INPUTS



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.

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.

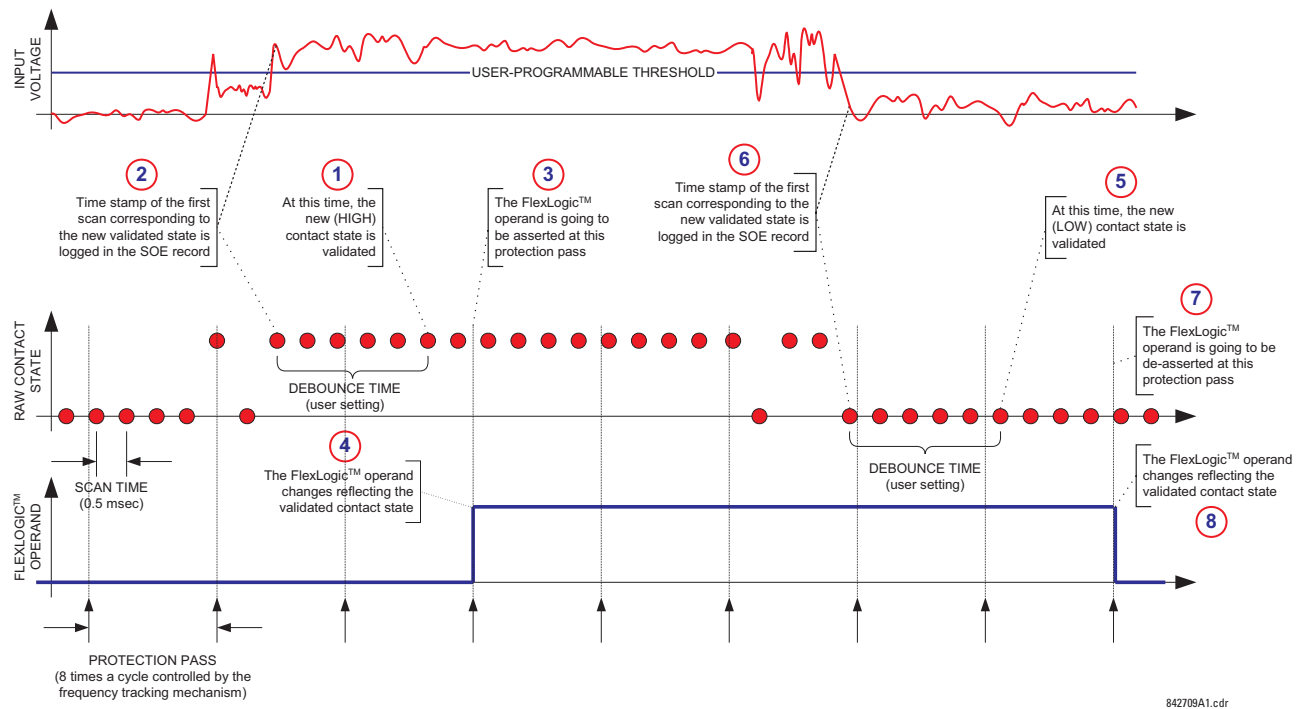


Figure 5-97: INPUT CONTACT DEBOUNCING MECHANISM AND TIME-STAMPING SAMPLE TIMING

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.

5.7.2 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.

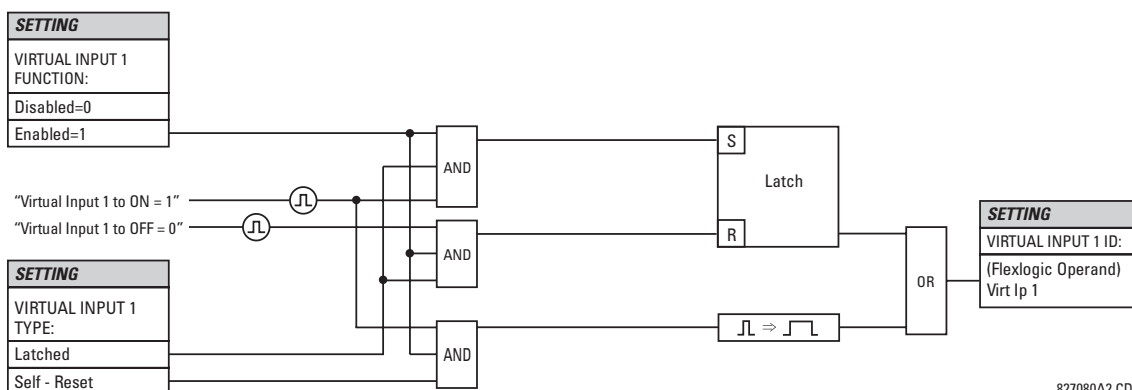
If the **VIRTUAL INPUT x FUNCTION** is to “Disabled”, the input will be forced to off (logic 0) regardless of any attempt to alter the input. If set to “Enabled”, the input operates as shown on the logic diagram and generates output FlexLogic™ operands in response to received input signals and the applied 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.

5



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.



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Figure 5-98: VIRTUAL INPUTS SCHEME LOGIC

5.7.3 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 or CONT OP 1 IOFF.

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".

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 | |

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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 | |

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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

5.7.4 VIRTUAL OUTPUTS

PATH: **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **VIRTUAL OUTPUTS** ⇒ **VIRTUAL OUTPUT 1(96)**

| | | | |
|---|----|--|---|
| <input checked="" type="checkbox"/> VIRTUAL OUTPUT 1 | ◀▶ | VIRTUAL OUTPUT 1 ID Virt Op 1 | Range: Up to 12 alphanumeric characters |
| <input type="checkbox"/> | | VIRTUAL OUTPUT 1 EVENTS: Disabled | Range: Disabled, Enabled |

MESSAGE ▲

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"

5.7.5 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.



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 ETypes APPID: 0 | Range: 0 to 16383 in steps of 1 |
| MESSAGE ▲▼ | | REMOTE DEVICE 1 DATASET: Fixed | Range: Fixed, GOOSE 1 through GOOSE 8 |

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 ETypes 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.

5.7.6 REMOTE INPUTS

5

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: 1 to 16 inclusive |
| MESSAGE ▲▼ | | REMOTE IN 1 ITEM: None | Range: None, DNA-1 to DNA-32, UserSt-1 to UserSt-32, Config Item 1 to Config Item 64 |
| 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 64 selections: DNA-1 through DNA-32 and UserSt-1 through UserSt-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 number (1 to 16) of the remote device which originates the required signal, as previously assigned to the remote device via the setting **REMOTE DEVICE 1(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.



For additional information on GSSE/GOOSE messaging, refer to the *Remote devices* section in this chapter.

5.7.7 REMOTE OUTPUTS

a) DNA BIT PAIRS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ REMOTE OUTPUTS DNA BIT PAIRS ⇒ REMOTE OUTPUTS DNA- 1(32) BIT PAIR

| | | | |
|---|--|----------------------------|---------------------------|
| <input checked="" type="checkbox"/> REMOTE OUTPUTS <input checked="" type="checkbox"/> DNA- 1 BIT PAIR | | DNA- 1 OPERAND: Off | Range: FlexLogic™ operand |
| | | DNA- 1 EVENTS: Disabled | Range: Disabled, Enabled |

MESSAGE

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 5–20: 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

| | | | |
|--|--|-------------------------------|---------------------------|
| <input checked="" type="checkbox"/> REMOTE OUTPUTS <input checked="" type="checkbox"/> UserSt- 1 BIT PAIR | | UserSt- 1 OPERAND: Off | Range: FlexLogic™ operand |
| | | UserSt- 1 EVENTS: Disabled | Range: Disabled, Enabled |

MESSAGE

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 UPDATE TIME: 60 s | Range: 1 to 60 s in steps of 1 |
|---|--------------------------------|



For more information on GSSE/GOOSE messaging, refer to *Remote Inputs/Outputs Overview* in the *Remote Devices* section.

5.7.8 RESETTING

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ RESETTING

| | | | |
|-------------|----|-----------------------|---------------------------|
| ■ RESETTING | ◀▶ | RESET OPERAND: Off | Range: FlexLogic™ operand |
|-------------|----|-----------------------|---------------------------|

Some events can be programmed to latch the faceplate LED event indicators and the target message on the display. Once set, the latching mechanism will hold all of the latched indicators or messages in the set state after the initiating condition has cleared until a RESET command is received to return these latches (not including FlexLogic™ latches) to the reset state. The RESET command can be sent from the faceplate Reset button, a remote device via a communications channel, or any programmed operand.

When the RESET command is received by the relay, two FlexLogic™ operands are created. These operands, which are stored as events, reset the latches if the initiating condition has cleared. The three sources of RESET commands each create the RESET OP FlexLogic™ operand. Each individual source of a RESET command also creates its individual operand RESET OP (PUSHBUTTON), RESET OP (COMMS) or RESET OP (OPERAND) to identify the source of the command. The setting shown above selects the operand that will create the RESET OP (OPERAND) operand.

5.7.9 DIRECT INPUTS/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)

| | | | |
|---|---|--|---|
| <div> <div>DIRECT OUTPUT 1</div> <div>MESSAGE</div> <div>MESSAGE</div> </div> | <div> <div>◀▶</div> <div>▲▼</div> <div>▲</div> </div> | <div>DIRECT OUT 1 NAME: Dir Out 1</div> <div>DIRECT OUT 1 OPERAND: Off</div> <div>DIRECT OUTPUT 1 EVENTS: Disabled</div> | <div>Range: up to 12 alphanumeric characters</div> <div>Range: FlexLogic™ operand</div> <div>Range: Enabled, Disabled</div> |
|---|---|--|---|

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.

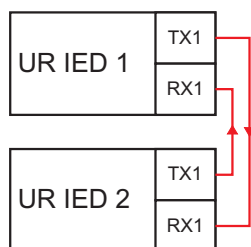


Figure 5–99: INPUT AND OUTPUT EXTENSION VIA DIRECT INPUTS AND OUTPUTS

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.

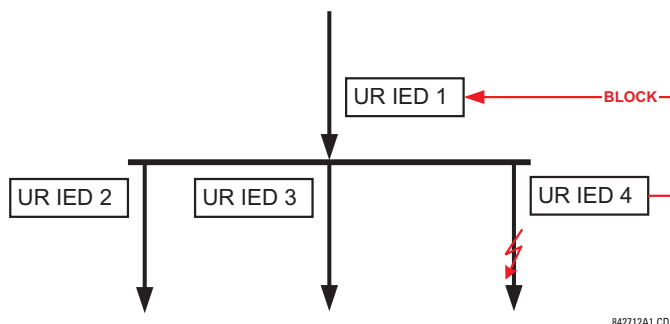


Figure 5–100: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME

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 send 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.

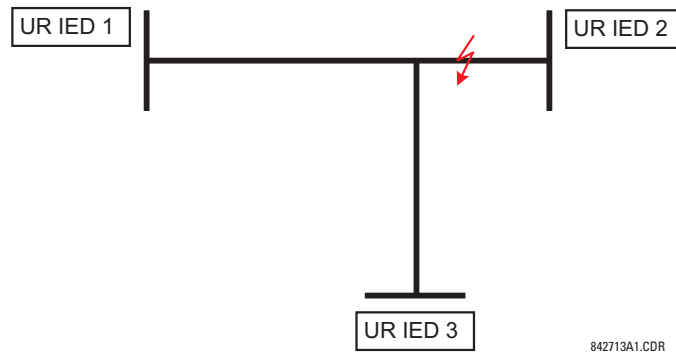


Figure 5-101: THREE-TERMINAL LINE APPLICATION

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.

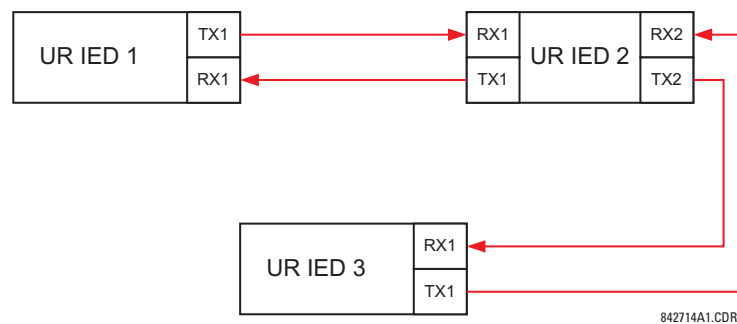


Figure 5-102: SINGLE-CHANNEL OPEN-LOOP CONFIGURATION

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"
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:

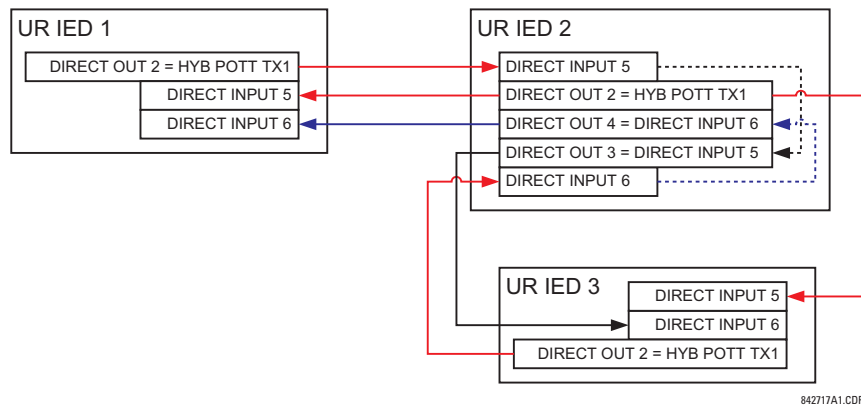


Figure 5–103: SIGNAL FLOW FOR DIRECT INPUT AND OUTPUT – EXAMPLE 3

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).

5.8.1 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: μ A | 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.

5.8.2 RTD INPUTS

PATH: SETTINGS ⇒ ⚙ TRANSDUCER I/O ⇒ ⚙ RTD INPUTS ⇒ RTD INPUT F1(U8)

RTD INPUT F1

MESSAGE

MESSAGE

RTD INPUT F1
FUNCTION: Disabled

RTD INPUT F1 ID:
RTD Ip 1

RTD INPUT F1 TYPE:
100Ω Nickel

Range: Disabled, Enabled

Range: Up to 20 alphanumeric characters

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.

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 5–21: RTD TEMPERATURE VS. RESISTANCE

| TEMPERATURE | | RESISTANCE (IN OHMS) | | | |
|-------------|-----|-------------------------|----------|----------|---------|
| °C | °F | 100 W PT (DIN 43760) | 120 W NI | 100 W NI | 10 W 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 |

5.8.3 DCMA OUTPUTS

PATH: SETTINGS ⇒ TRANSDUCER I/O ⇒ DCMA OUTPUTS ⇒ DCMA OUTPUT F1(U8)

■ DCMA OUTPUT F1

■

◀▶

MESSAGE ▲

MESSAGE ▲

MESSAGE ▲

DCMA OUTPUT F1

SOURCE: Off

Range: Off, any analog actual value parameter

DCMA OUTPUT F1

RANGE: –1 to 1 mA

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

DCMA OUTPUT F1

MIN VAL: 0.000 pu

Range: –90.000 to 90.000 pu in steps of 0.001

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).

The relay checks the driving signal (x in equations below) for the minimum and maximum limits, and subsequently re-scales so the limits defined as **MIN VAL** and **MAX VAL** match the output range of the hardware defined as **RANGE**. The following equation is applied:

$$I_{out} = \begin{cases} I_{min} & \text{if } x < \text{MIN VAL} \\ I_{max} & \text{if } x > \text{MAX VAL} \\ k(x - \text{MIN VAL}) + I_{min} & \text{otherwise} \end{cases} \quad (\text{EQ 5.18})$$

where: x is a driving signal specified by the **SOURCE** setting

I_{min} and I_{max} are defined by the **RANGE** setting

k is a scaling constant calculated as:

$$k = \frac{I_{max} - I_{min}}{\text{MAX VAL} - \text{MIN VAL}} \quad (\text{EQ 5.19})$$

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.

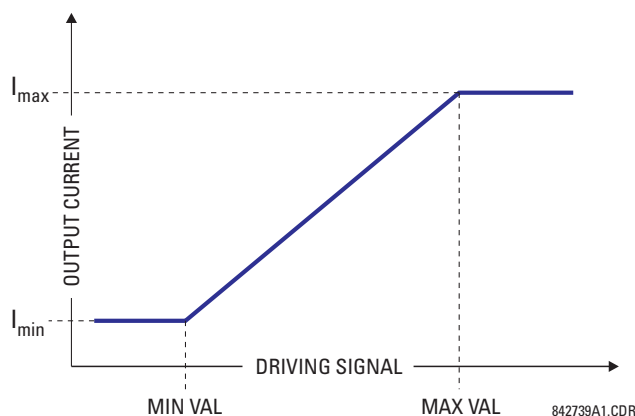


Figure 5-104: DCMA OUTPUT CHARACTERISTIC

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 (see the following examples). 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 (see the following

examples). The setting is entered in per-unit values. The base units are defined in the same manner as the FlexElement™ base units.



The **DCMA OUTPUT 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 1:

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:

$$P = \sqrt{3} \times 13.8 \text{ kV} \times 0.8 \text{ kA} \times 0.9 = 17.21 \text{ MW} \quad (\text{EQ 5.20})$$

The three-phase power with 20% overload margin is:

$$P_{max} = 1.2 \times 17.21 \text{ MW} = 20.65 \text{ MW} \quad (\text{EQ 5.21})$$

The base unit for power (refer to the FlexElements section in this chapter for additional details) is:

$$P_{BASE} = 115 \text{ V} \times 120 \times 1.2 \text{ kA} = 16.56 \text{ MW} \quad (\text{EQ 5.22})$$

The minimum and maximum power values to be monitored (in pu) are:

$$\text{minimum power} = \frac{-20.65 \text{ MW}}{16.56 \text{ MW}} = -1.247 \text{ pu}, \quad \text{maximum power} = \frac{20.65 \text{ MW}}{16.56 \text{ MW}} = 1.247 \text{ pu} \quad (\text{EQ 5.23})$$

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:

- $\pm 0.5\%$ of the full scale for the analog output module, or $\pm 0.005 \times (1 - (-1)) \times 20.65 \text{ MW} = \pm 0.207 \text{ MW}$
- $\pm 1\%$ 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 $0.01 \times 20 \text{ MW} + 0.207 \text{ MW} = 0.407 \text{ MW}$.

Example 2:

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:

$$I_{max} = 1.5 \times 4.2 \text{ kA} = 6.3 \text{ kA} \quad (\text{EQ 5.24})$$

The base unit for current (refer to the FlexElements section in this chapter for additional details) is:

$$I_{BASE} = 5 \text{ kA} \quad (\text{EQ 5.25})$$

The minimum and maximum power values to be monitored (in pu) are:

$$\text{minimum current} = \frac{0 \text{ kA}}{5 \text{ kA}} = 0 \text{ pu}, \quad \text{maximum current} = \frac{6.3 \text{ kA}}{5 \text{ kA}} = 1.26 \text{ pu} \quad (\text{EQ 5.26})$$

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:

- $\pm 0.5\%$ of the full scale for the analog output module, or $\pm 0.005 \times (20 - 4) \times 6.3 \text{ kA} = \pm 0.504 \text{ kA}$
- $\pm 0.25\%$ of reading or $\pm 0.1\%$ of rated (whichever is greater) for currents between 0.1 and 2.0 of nominal

For example, at the reading of 4.2 kA, the worst-case error is $\max(0.0025 \times 4.2 \text{ kA}, 0.001 \times 5 \text{ kA}) + 0.504 \text{ kA} = 0.515 \text{ kA}$.

Example 3:

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:

$$V_{min} = 0.7 \times \frac{400 \text{ kV}}{\sqrt{3}} = 161.66 \text{ kV}, \quad V_{max} = 1.1 \times \frac{400 \text{ kV}}{\sqrt{3}} = 254.03 \text{ kV} \quad (\text{EQ 5.27})$$

The base unit for voltage (refer to the FlexElements section in this chapter for additional details) is:

$$V_{BASE} = 0.0664 \text{ kV} \times 6024 = 400 \text{ kV} \quad (\text{EQ 5.28})$$

The minimum and maximum voltage values to be monitored (in pu) are:

$$\text{minimum voltage} = \frac{161.66 \text{ kV}}{400 \text{ kV}} = 0.404 \text{ pu}, \quad \text{maximum voltage} = \frac{254.03 \text{ kV}}{400 \text{ kV}} = 0.635 \text{ pu} \quad (\text{EQ 5.29})$$

The following settings should be entered:

DCMA OUTPUT H3 SOURCE: "SRC 2 V₁ 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 $\sqrt{3}$.

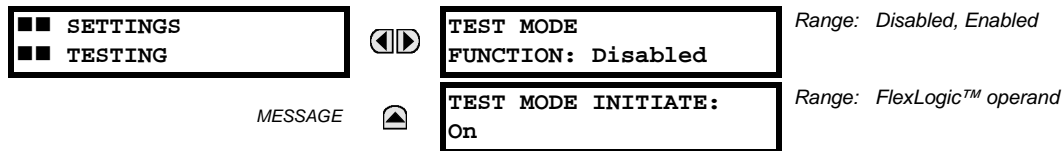
The worst-case error for this application could be calculated by superimposing the following two sources of error:

- $\pm 0.5\%$ of the full scale for the analog output module, or $\pm 0.005 \times (1 - 0) \times 254.03 \text{ kV} = \pm 1.27 \text{ kV}$
- $\pm 0.5\%$ of reading

For example, under nominal conditions, the positive-sequence reads 230.94 kV and the worst-case error is $0.005 \times 230.94 \text{ kV} + 1.27 \text{ kV} = 2.42 \text{ kV}$.

5.9.1 TEST MODE

PATH: SETTINGS ⇌ TESTING ⇌ TEST MODE



The relay provides test settings to verify that functionality using simulated conditions for contact inputs and outputs. The test mode is indicated on the relay faceplate by a flashing Test Mode LED indicator.

To initiate the Test mode, the **TEST MODE FUNCTION** setting must be “Enabled” and the **TEST MODE INITIATE** setting must be set to logic 1. In particular:

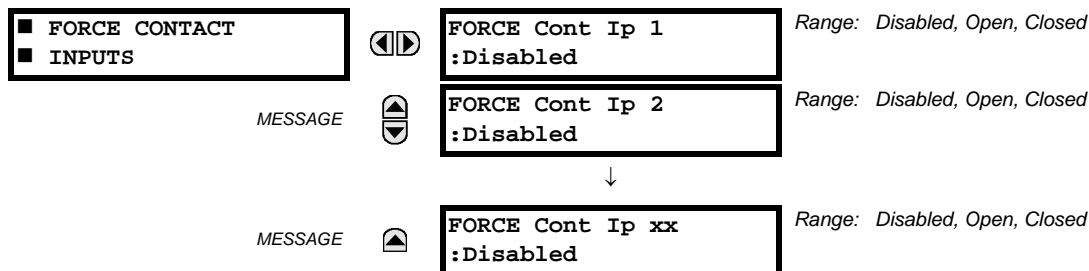
- To initiate Test Mode through relay settings, set **TEST MODE INITIATE** to “On”. The test mode starts when the **TEST MODE FUNCTION** setting is changed from “Disabled” to “Enabled”.
- To initiate test mode through a user-programmable condition, such as FlexLogic™ operand (pushbutton, digital input, communication-based input, or a combination of these), set **TEST MODE FUNCTION** to “Enabled” and set **TEST MODE INITIATE** to the desired operand. The test mode starts when the selected operand assumes a logic 1 state.

When in test mode, the C70 remains fully operational, 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 former can be forced to report as open or closed or remain fully operational; the latter 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.

5.9.2 FORCE CONTACT INPUTS

PATH: SETTINGS ⇌ TESTING ⇌ FORCE CONTACT INPUTS



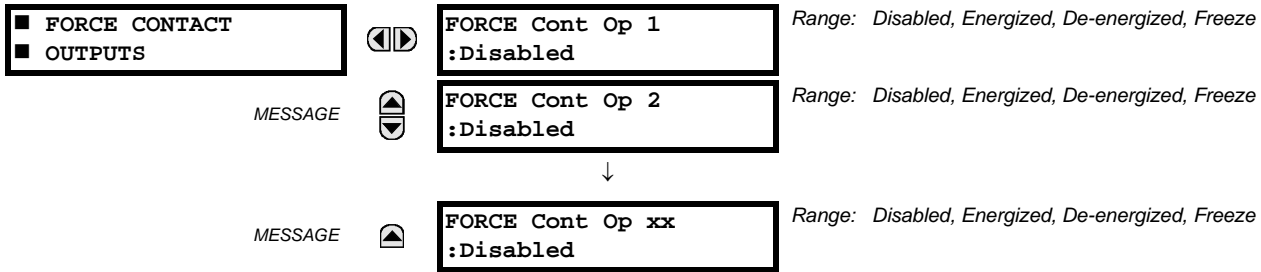
The relay digital inputs (contact inputs) could be pre-programmed to respond to the test mode in the following ways:

- 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.

5.9.3 FORCE CONTACT OUTPUTS

PATH: SETTINGS ⇒ TESTING ⇒ FORCE CONTACT OUTPUTS



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 | |

















D60_490.urs FlexLogic

Set the user-programmable pushbutton as latching by changing **SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE PUSHBUTTONS ⇒ USER PUSHBUTTON 1 ⇒ PUSHBUTTON 1 FUNCTION** to "Latched". To enable either pushbutton 1 or remote input 1 to initiate the Test mode, make the following changes in the **SETTINGS ⇒ TESTING ⇒ TEST MODE** menu:

TEST MODE FUNCTION: "Enabled" and **TEST MODE INITIATE**: "VO1"

6.1.1 ACTUAL VALUES MAIN MENU

| | | | |
|---|--|--|----------------|
| <div> <div>■ ■ ACTUAL VALUES</div> <div>■ ■ STATUS</div> </div> | | <div> <div>■ CONTACT INPUTS</div> <div>■</div> </div> | See page 6-3. |
| | | <div> <div>■ VIRTUAL INPUTS</div> <div>■</div> </div> | See page 6-3. |
| | | <div> <div>■ REMOTE INPUTS</div> <div>■</div> </div> | See page 6-3. |
| | | <div> <div>■ CONTACT OUTPUTS</div> <div>■</div> </div> | See page 6-4. |
| | | <div> <div>■ VIRTUAL OUTPUTS</div> <div>■</div> </div> | See page 6-4. |
| | | <div> <div>■ REMOTE DEVICES</div> <div>■ STATUS</div> </div> | See page 6-4. |
| | | <div> <div>■ REMOTE DEVICES</div> <div>■ STATISTICS</div> </div> | See page 6-5. |
| | | <div> <div>■ DIGITAL COUNTERS</div> <div>■</div> </div> | See page 6-5. |
| | | <div> <div>■ SELECTOR SWITCHES</div> <div>■</div> </div> | See page 6-5. |
| | | <div> <div>■ TIME OF DAY TIMERS</div> <div>■</div> </div> | See page 6-6. |
| | | <div> <div>■ FLEX STATES</div> <div>■</div> </div> | See page 6-6. |
| | | <div> <div>■ ETHERNET</div> <div>■</div> </div> | See page 6-6. |
| | | <div> <div>■ DIRECT INPUTS</div> <div>■</div> </div> | See page 6-7. |
| | | <div> <div>■ DIRECT DEVICES</div> <div>■ STATUS</div> </div> | See page 6-7. |
| | | <div> <div>■ ETHERNET SWITCH</div> <div>■</div> </div> | See page 6-8. |
| | | <div> <div>■ SOURCE SRC 1</div> <div>■</div> </div> | See page 6-12. |
| | | <div> <div>■ SOURCE SRC 2</div> <div>■</div> </div> | |
| | | <div> <div>■ SOURCE SRC 3</div> <div>■</div> </div> | |
| | | <div> <div>■ SOURCE SRC 4</div> <div>■</div> </div> | |
| | | <div> <div>■ SOURCE SRC 5</div> <div>■</div> </div> | |
| | | <div> <div>■ SOURCE SRC 6</div> <div>■</div> </div> | |

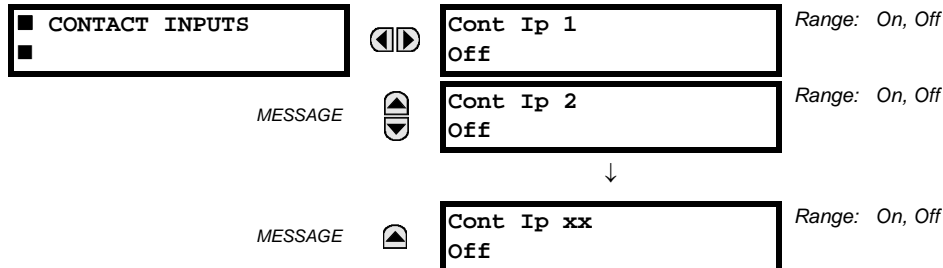
| | | | |
|---|---|---------------------------------------|----------------|
| |  | ■ CAPACITOR CONTROL ■ | See page 6-16. |
| |  | ■ CAPACITOR BANK ■ | See page 6-17. |
| |  | ■ TRACKING FREQUENCY ■ | See page 6-18. |
| |  | ■ FLEXELEMENTS ■ | See page 6-18. |
| |  | ■ IEC 61850 ■ GOOSE ANALOGS | See 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. |



For status reporting, 'On' represents Logic 1 and 'Off' represents Logic 0.

6.2.1 CONTACT INPUTS

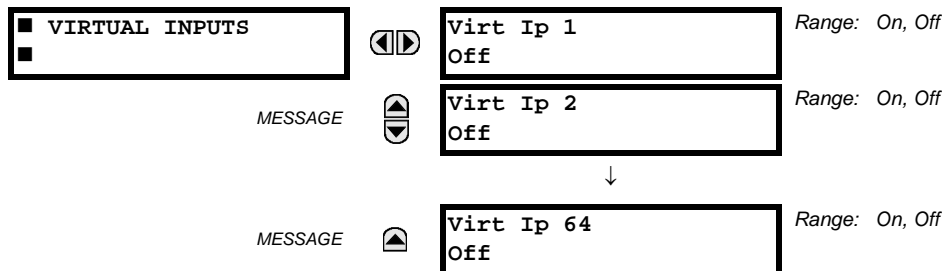
PATH: ACTUAL VALUES ⇒ STATUS ⇒ CONTACT INPUTS



The present status of the contact inputs is shown here. The first line of a message display indicates the ID of the contact input. For example, 'Cont Ip 1' refers to the contact input in terms of the default name-array index. The second line of the display indicates the logic state of the contact input.

6.2.2 VIRTUAL INPUTS

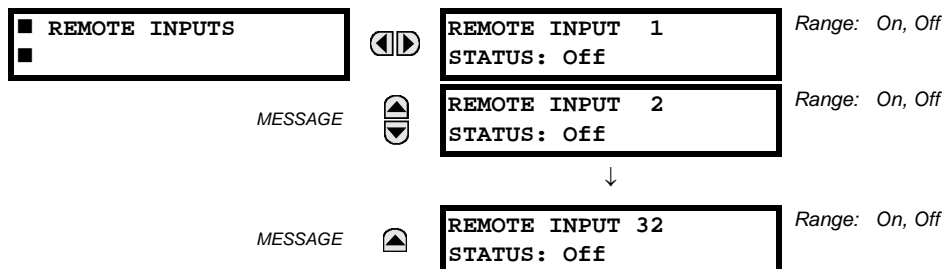
PATH: ACTUAL VALUES ⇒ STATUS ⇒ ↓ VIRTUAL INPUTS



The present status of the 64 virtual inputs is shown here. The first line of a message display indicates the ID of the virtual input. For example, 'Virt Ip 1' refers to the virtual input in terms of the default name. The second line of the display indicates the logic state of the virtual input.

6.2.3 REMOTE INPUTS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ ↓ REMOTE INPUTS

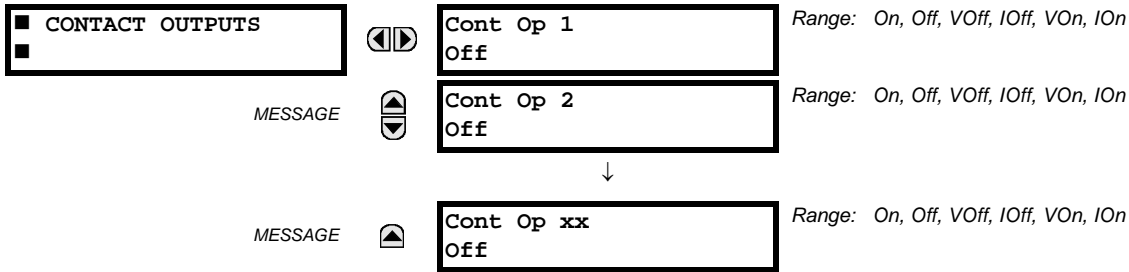


The present state of the 32 remote inputs is shown here.

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 CONTACT OUTPUTS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ CONTACT OUTPUTS



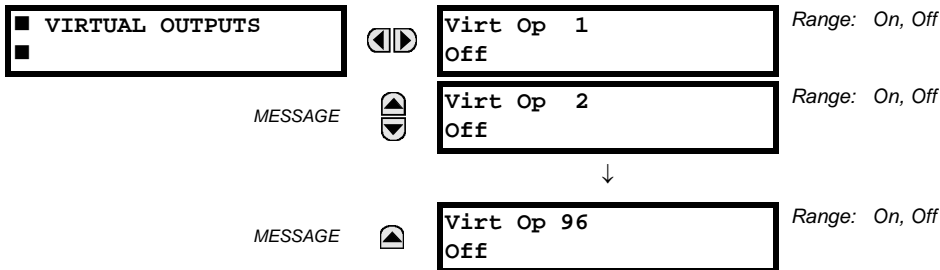
The present state of the contact outputs is shown here. The first line of a message display indicates the ID of the contact output. For example, 'Cont Op 1' refers to the contact output in terms of the default name-array index. The second line of the display indicates the logic state of the contact output.



For form-A contact outputs, the state of the voltage and current detectors is displayed as Off, VOff, IOff, VOn, IOn, and IOn. For form-C contact outputs, the state is displayed as Off or On.

6.2.5 VIRTUAL OUTPUTS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ VIRTUAL OUTPUTS

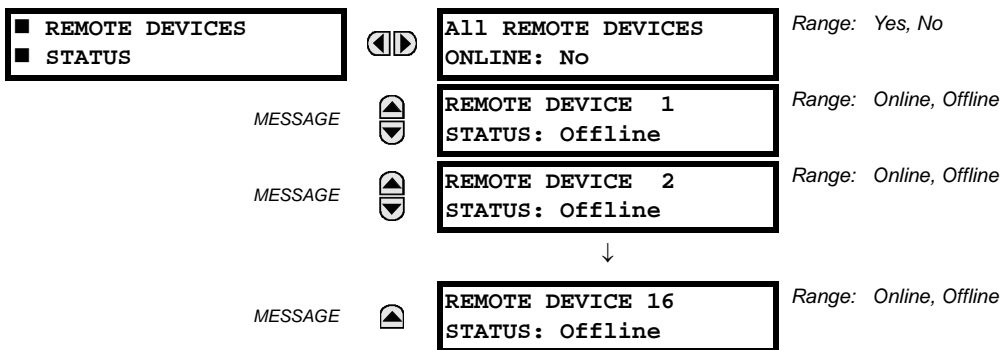


The present state of up to 96 virtual outputs is shown here. The first line of a message display indicates the ID of the virtual output. For example, 'Virt Op 1' refers to the virtual output in terms of the default name-array index. The second line of the display indicates the logic state of the virtual output, as calculated by the FlexLogic™ equation for that output.

6.2.6 REMOTE DEVICES

a) STATUS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ REMOTE DEVICES STATUS



The present state of up to 16 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 |
| ■ | ▲ | REMOTE DEVICE 1 SqNum: 0 |

MESSAGE

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.

6.2.7 DIGITAL COUNTERS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ DIGITAL COUNTERS ⇒ DIGITAL COUNTERS Counter 1(8)

| | | |
|--------------------|----|--|
| ■ DIGITAL COUNTERS | ◀▶ | Counter 1 ACCUM: 0 |
| ■ Counter 1 | ▲▼ | 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.

6.2.8 SELECTOR SWITCHES

PATH: ACTUAL VALUES ⇒ STATUS ⇒ SELECTOR SWITCHES

| | | | |
|---------------------|----|------------------------------------|-----------------------------|
| ■ SELECTOR SWITCHES | ◀▶ | SELECTOR SWITCH 1 POSITION: 0/7 | Range: Current Position / 7 |
| ■ | ▲ | SELECTOR SWITCH 2 POSITION: 0/7 | Range: Current Position / 7 |

MESSAGE

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.

6.2.9 TIME OF DAY TIMERS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ TIME OF DAY TIMERS

■ TIME OF DAY TIMERS

■

MESSAGE

TIME OF DAY TIMER 1:
Off

Range: On, Off

TIME OF DAY TIMER 2:
Off

Range: On, Off

TIME OF DAY TIMER 3:
Off

Range: On, Off

TIME OF DAY TIMER 4:
Off

Range: On, Off

TIME OF DAY TIMER 5:
Off

Range: On, Off

The current state of each time of day timer is displayed in this menu.

6.2.10 FLEX STATES

PATH: ACTUAL VALUES ⇒ STATUS ⇒ FLEX STATES

■ FLEX STATES

■

MESSAGE

PARAM 1: Off
Off

Range: Off, On

PARAM 2: Off
Off

Range: Off, On

↓

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.

6.2.11 ETHERNET

PATH: ACTUAL VALUES ⇒ STATUS ⇒ ETHERNET

■ ETHERNET

■

MESSAGE

ETHERNET PRI LINK
STATUS: OK

Range: Fail, OK

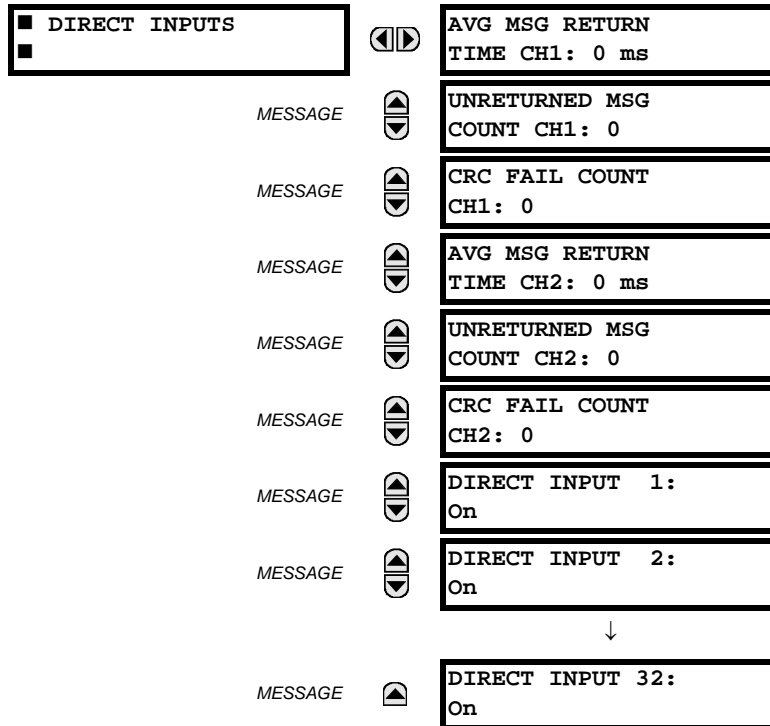
ETHERNET SEC LINK
STATUS: OK

Range: Fail, OK

These values indicate the status of the primary and secondary Ethernet links.

6.2.12 DIRECT INPUTS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ DIRECT INPUTS



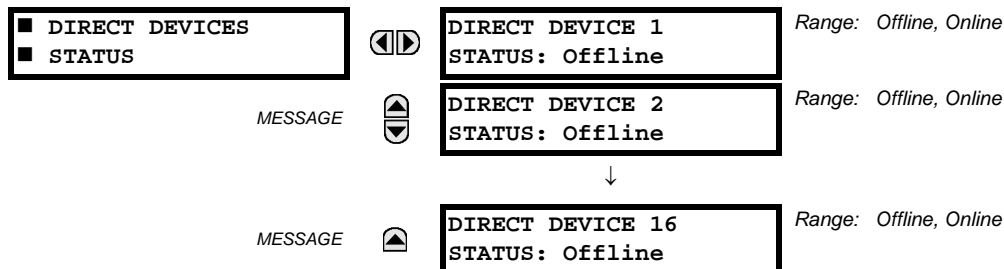
The **AVERAGE MSG RETURN TIME** is the time taken for direct output messages to return to the sender in a direct input/output ring configuration (this value is not applicable for non-ring configurations). This is a rolling average calculated for the last ten messages. There are two return times for dual-channel 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.

6.2.13 DIRECT DEVICES STATUS

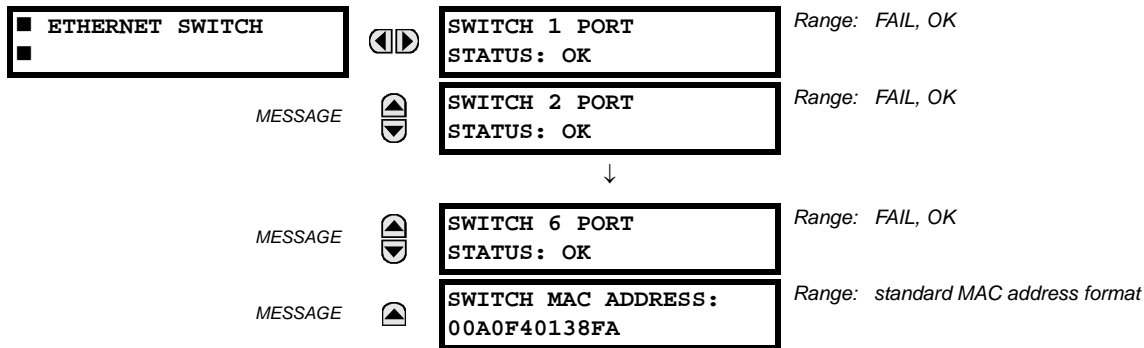
PATH: ACTUAL VALUES ⇒ STATUS ⇒ DIRECT DEVICES STATUS



These actual values represent the state of direct devices 1 through 16.

6.2.14 ETHERNET SWITCH

PATH: ACTUAL VALUES ⇒ STATUS ⇒ ⬇ ETHERNET SWITCH



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 represent 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.

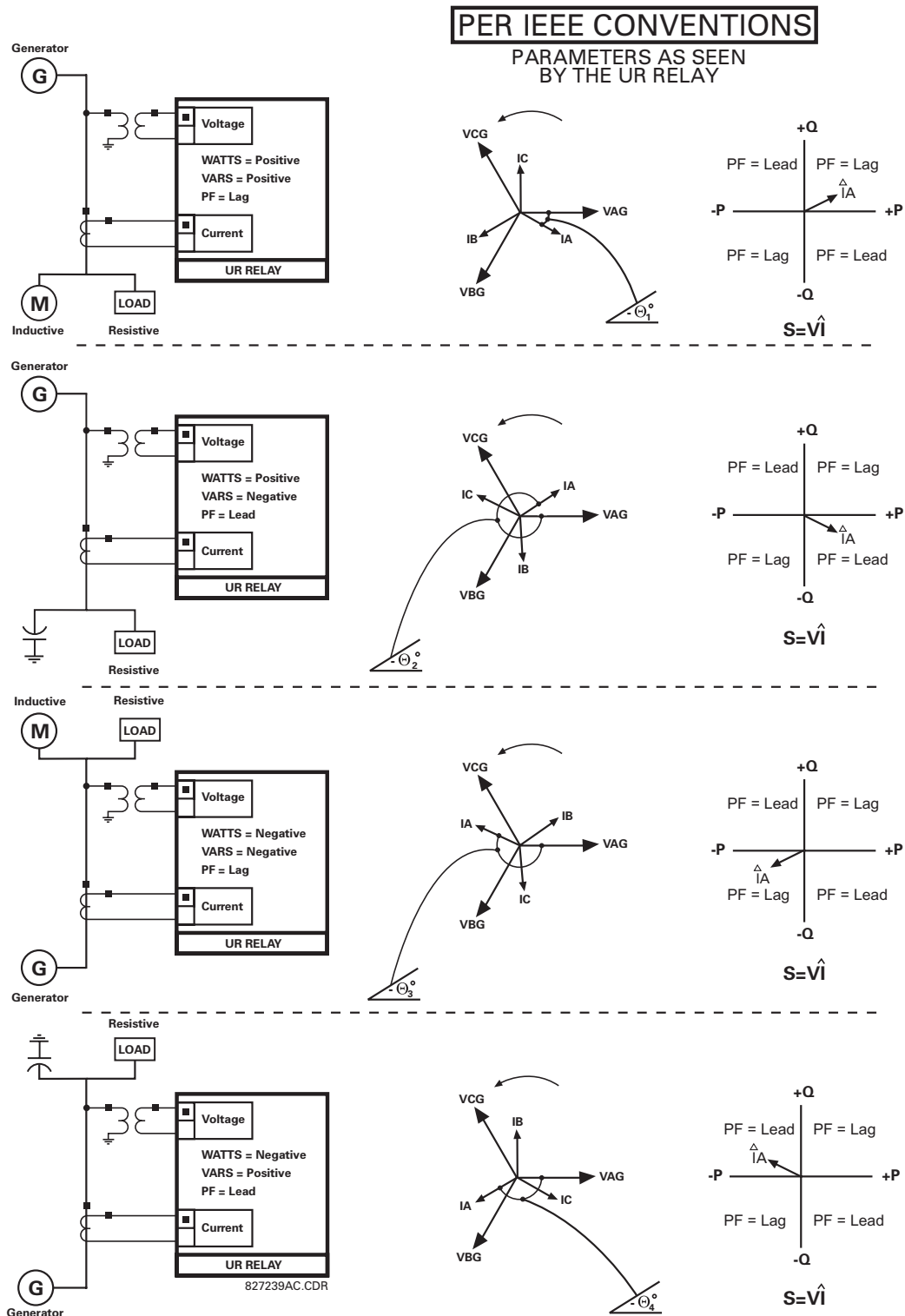


Figure 6-1: FLOW DIRECTION OF SIGNED VALUES FOR WATTS AND VARS

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.

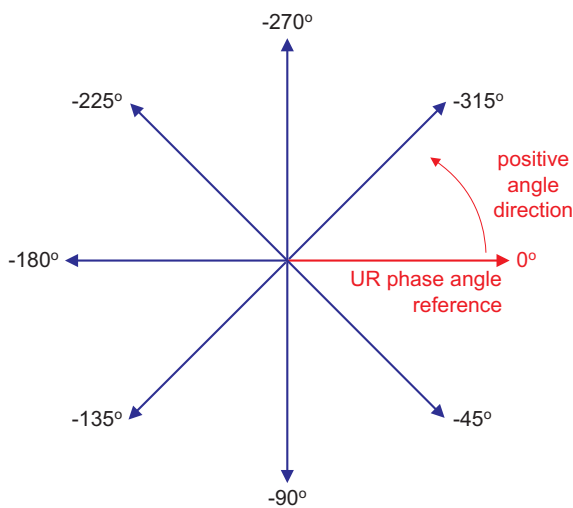


Figure 6-2: UR PHASE ANGLE MEASUREMENT CONVENTION

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:

$$V_0 = N/A$$

$$V_1 = \frac{1\angle-30^\circ}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$

$$V_2 = \frac{1\angle-30^\circ}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$

- ACB phase rotation:

$$V_0 = N/A$$

$$V_1 = \frac{1\angle30^\circ}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$

$$V_2 = \frac{1\angle-30^\circ}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$

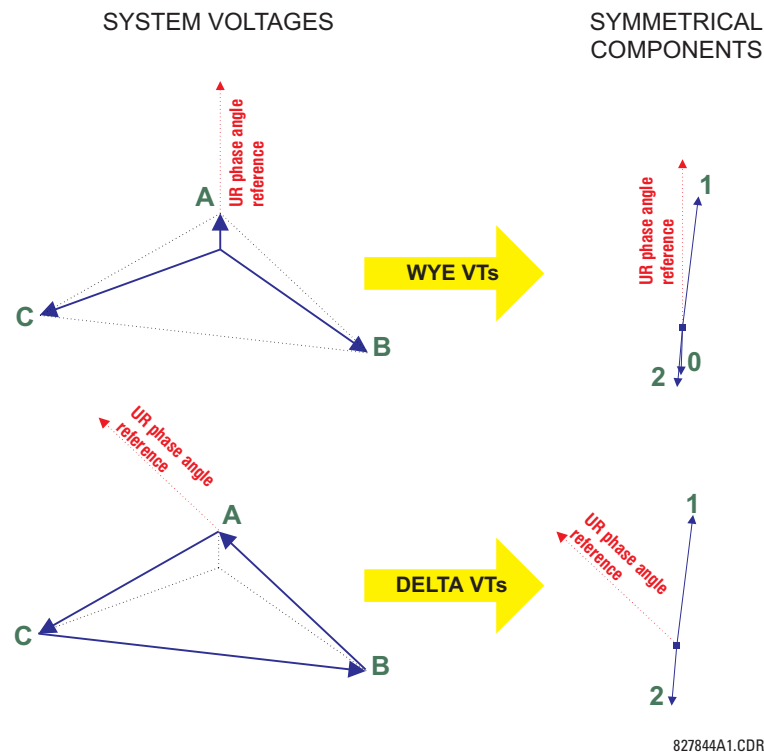
The zero-sequence voltage is not measurable under the Delta connection of instrument transformers and is defaulted to zero. The table below shows an example of symmetrical components calculations for the ABC phase rotation.

Table 6–1: SYMMETRICAL COMPONENTS CALCULATION EXAMPLE

| SYSTEM VOLTAGES, SEC. V * | | | | | | VT CONN. | RELAY INPUTS, SEC. V | | | SYMM. COMP, SEC. V | | |
|---|-----------------|-----------------|-----------------|-----------------|-----------------|-------------|----------------------|-----------------|----------------|--------------------|----------------|----------------|
| V _{AG} | V _{BG} | V _{CG} | V _{AB} | V _{BC} | V _{CA} | | F5AC | F6AC | F7AC | V ₀ | V ₁ | V ₂ |
| 13.9 ∠0° | 76.2 ∠-125° | 79.7 ∠-250° | 84.9 ∠-313° | 138.3 ∠-97° | 85.4 ∠-241° | WYE | 13.9 ∠0° | 76.2 ∠-125° | 79.7 ∠-250° | 19.5 ∠-192° | 56.5 ∠-7° | 23.3 ∠-187° |
| UNKNOWN (only V ₁ and V ₂ can be determined) | | | 84.9 ∠0° | 138.3 ∠-144° | 85.4 ∠-288° | DELTA | 84.9 ∠0° | 138.3 ∠-144° | 85.4 ∠-288° | N/A | 56.5 ∠-54° | 23.3 ∠-234° |

* The power system voltages are phase-referenced – for simplicity – to V_{AG} and V_{AB}, respectively. This, however, is a relative matter. It is important to remember that the 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**

6.3.2 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.

6

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: 0.00 V |
| ■ SRC 1 | | |
| 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 3φ: 0.000 W |
| ■ SRC 1 | | |
| MESSAGE | ▲▼ | SRC 1 REAL POWER φa: 0.000 W |
| MESSAGE | ▲▼ | SRC 1 REAL POWER φb: 0.000 W |
| MESSAGE | ▲▼ | SRC 1 REAL POWER φc: 0.000 W |
| MESSAGE | ▲▼ | SRC 1 REACTIVE PWR 3φ: 0.000 var |
| MESSAGE | ▲▼ | SRC 1 REACTIVE PWR φa: 0.000 var |
| MESSAGE | ▲▼ | SRC 1 REACTIVE PWR φb: 0.000 var |
| MESSAGE | ▲▼ | SRC 1 REACTIVE PWR φc: 0.000 var |
| MESSAGE | ▲▼ | SRC 1 APPARENT PWR 3φ: 0.000 VA |
| MESSAGE | ▲▼ | SRC 1 APPARENT PWR φa: 0.000 VA |
| MESSAGE | ▲▼ | SRC 1 APPARENT PWR φb: 0.000 VA |

| | | |
|---------|--|---|
| MESSAGE | | SRC 1 APPARENT PWR ϕc : 0.000 VA |
| MESSAGE | | SRC 1 POWER FACTOR 3 ϕ : 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** \Rightarrow **SYS-TEM SETUP** \Rightarrow **SIGNAL SOURCES**).

g) FREQUENCY METERING

PATH: ACTUAL VALUES \Rightarrow METERING \Rightarrow SOURCE SRC 1 \Rightarrow FREQUENCY

| | | |
|--|--|---|
| | <div> <div>FREQUENCY</div> <div>SRC 1</div> </div> | <div> <div>SRC 1 FREQUENCY:</div> <div>0.00 Hz</div> </div> |
|--|--|---|

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** \Rightarrow **SYSTEM SETUP** \Rightarrow **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** \Rightarrow **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 \Rightarrow METERING \Rightarrow SOURCE SRC 1 \Rightarrow CURRENT HARMONICS

| | | |
|---------|--|--|
| | <div> <div>CURRENT HARMONICS</div> <div>SRC 1</div> </div> | <div> <div>SRC 1 THD Ia: 0.0</div> <div>Ib: 0.0 Ic: 0.0%</div> </div> |
| MESSAGE | | <div> <div>SRC 1 2ND Ia: 0.0</div> <div>Ib: 0.0 Ic: 0.0%</div> </div> |
| MESSAGE | | <div> <div>SRC 1 3RD Ia: 0.0</div> <div>Ib: 0.0 Ic: 0.0%</div> </div> |
| | | ↓ |
| MESSAGE | | <div> <div>SRC 1 25TH Ia: 0.0</div> <div>Ib: 0.0 Ic: 0.0%</div> </div> |

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** \Rightarrow **SYSTEM SETUP** \Rightarrow **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

| | |
|--|---|
| <div> <div>VOLTAGE HARMONICS</div> <div>SRC 1</div> </div> | <div> <div>◀▶</div> <div>SRC 1 THD Va: 0.0</div> <div>Vb: 0.0 Vc: 0.0%</div> </div> |
| | <div> <div>MESSAGE</div> <div> <div>▲▼</div> <div>SRC 1 2ND Va: 0.0</div> <div>Vb: 0.0 Vc: 0.0%</div> </div> </div> |
| | <div> <div>MESSAGE</div> <div> <div>▲▼</div> <div>SRC 1 3RD Va: 0.0</div> <div>Vb: 0.0 Vc: 0.0%</div> </div> </div> |
| | <div> <div>MESSAGE</div> <div> <div>▲</div> <div>SRC 1 25TH Va: 0.0</div> <div>Vb: 0.0 Vc: 0.0%</div> </div> </div> |

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)

$k = 1, 2, \dots, N - 1$ is the index over one cycle for the Fast Fourier Transform (FFT)

m is the last sample number for the sliding window

$h = 1, 2, \dots, 25$ is the harmonic number

The short-time Fourier transform is applied to the unfiltered signal:

$$\begin{aligned}
 F_{\text{real}}(m, h) &= \frac{2}{N} \sum_k (f(m-k) \cdot \cos(h \cdot \omega_0 \cdot t(k))) \\
 F_{\text{imag}}(m, h) &= \frac{2}{N} \sum_k (f(m-k) \cdot \sin(h \cdot \omega_0 \cdot t(k))) \\
 F_{\text{ampl}}(m, h) &= \sqrt{F_{\text{real}}(m, h)^2 + F_{\text{imag}}(m, h)^2}
 \end{aligned}
 \tag{EQ 6.1}$$

The harmonics are a percentage of the fundamental signal obtained as a ratio of harmonic amplitude to fundamental amplitude multiplied by 100%. The total harmonic distortion (THD) is the ratio of the total harmonic content to the fundamental:

$$\text{THD} = \sqrt{F_2^2 + F_3^2 + \dots + F_{25}^2}
 \tag{EQ 6.2}$$



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

| | |
|---|--|
| <div> <div>CAPACITOR CONTROL</div> <div></div> </div> | <div> <div>◀▶</div> <div>CAP 1 DISCHARGE TIME:</div> <div>0 s</div> </div> |
| | <div> <div>MESSAGE</div> <div> <div>▲▼</div> <div>CAP 2 DISCHARGE TIME:</div> <div>0 s</div> </div> </div> |
| | <div> <div>MESSAGE</div> <div> <div>▲▼</div> <div>CAP 3 DISCHARGE TIME:</div> <div>0 s</div> </div> </div> |
| | <div> <div>MESSAGE</div> <div> <div>▲</div> <div>CAP 4 DISCHARGE TIME:</div> <div>0 s</div> </div> </div> |

These values indicate the time remaining before the next permissible close operation for each of the four capacitor banks.

6.3.4 CAPACITOR BANK

a) MAIN MENU

PATH: ACTUAL VALUES ⇒ METERING ⇒ CAPACITOR BANK

| | | | |
|------------------|----|-------------------|----------------|
| ■ CAPACITOR BANK | ◀▶ | ■ VOLTAGE | See page 6-3. |
| ■ | | ■ DIFFERENTIAL | |
| MESSAGE | ▲▼ | ■ NEUTRAL VOLTAGE | See page 6-17. |
| | | ■ UNBALANCE | |
| MESSAGE | ▲▼ | ■ PHASE CURRENT | See page 6-3. |
| | | ■ UNBALANCE | |
| MESSAGE | ▲ | ■ NEUTRAL CURRENT | See page 6-4. |
| | | ■ UNBALANCE | |

The capacitor bank menu contains the actual values for the voltage differential, 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)

| | | |
|------------------|----|-------------------|
| ■ VOLTAGE | ◀▶ | Bus Va: 0.0000 pu |
| ■ DIFFERENTIAL 1 | | 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)

| | | |
|-------------------|----|-------------------|
| ■ NEUTRAL VOLTAGE | ◀▶ | NEUTRAL-POINT Vx: |
| ■ UNBALANCE 1 | | 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)

| | | |
|-----------------|----|---------------------|
| ■ PHASE CURRENT | ◀▶ | Raw Id A: 0.0000 pu |
| ■ UNBALANCE 1 | | 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.

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 | $f_{BASE} = 1 \text{ Hz}$ |
| PHASE ANGLE | $\phi_{BASE} = 360 \text{ degrees}$ (see the UR angle referencing convention) |
| POWER FACTOR | $PF_{BASE} = 1.00$ |
| RTDs | BASE = 100°C |
| SOURCE CURRENT | $I_{BASE} = \text{maximum nominal primary RMS value of the +IN and –IN inputs}$ |
| SOURCE POWER | $P_{BASE} = \text{maximum value of } V_{BASE} \times I_{BASE} \text{ for the +IN and –IN inputs}$ |
| SOURCE THD & HARMONICS | BASE = 1% |
| SOURCE VOLTAGE | $V_{BASE} = \text{maximum nominal primary RMS value of the +IN and –IN inputs}$ |

6.3.7 IEC 61850 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 16 |
| | | 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

| | |
|---|--|
| <input type="checkbox"/> USER-PROGRAMMABLE <input type="checkbox"/> FAULT REPORT | <div>NEWEST RECORD NUMBER: 0</div> <div>MESSAGE <div>LAST CLEARED DATE: 2002/8/11 14:23:57</div></div> <div>MESSAGE <div>LAST REPORT DATE: 2002/10/09 08:25:27</div></div> |
|---|--|

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

| | | |
|--|---|---|
| <input type="checkbox"/> EVENT RECORDS | <div>EVENT: XXXX RESET OP(PUSHBUTTON)</div> <div>↓</div> <div>MESSAGE <div>EVENT: 3 POWER ON</div></div> <div>MESSAGE <div>EVENT: 2 POWER OFF</div></div> <div>MESSAGE <div>EVENT: 1 EVENTS CLEARED</div></div> | <div>EVENT 3 DATE: 2000/07/14</div> <div>EVENT 3 TIME: 14:53:00.03405</div> <div>Date and Time Stamps</div> |
|--|---|---|

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



| | | |
|--|---|----------------|
| <input type="checkbox"/> OSCILLOGRAPHY | <div>FORCE TRIGGER? No</div> <div>MESSAGE <div>NUMBER OF TRIGGERS: 0</div></div> <div>MESSAGE <div>AVAILABLE RECORDS: 0</div></div> <div>MESSAGE <div>CYCLES PER RECORD: 0.0</div></div> <div>MESSAGE <div>LAST CLEARED DATE: 2000/07/14 15:40:16</div></div> | Range: No, Yes |
|--|---|----------------|


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 |
| ■ | | NEWEST SAMPLE TIME: 2000/01/14 15:21:19 |

MESSAGE 

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

| | | | |
|---|---|---|--|
| <div> <div>MODEL INFORMATION</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div> | <div> <div>◀▶</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲</div> </div> | ORDER CODE LINE 1: C60-E00-HCH-F8F-H6A | Range: standard GE multilin order code format; example order code shown |
| | | ORDER CODE LINE 2: | Range: standard GE multilin order code format |
| | | ORDER CODE LINE 3: | Range: standard GE multilin order code format |
| | | ORDER CODE LINE 4: | Range: standard GE multilin order code format |
| | | SERIAL NUMBER: | Range: standard GE multilin serial number format |
| | | ETHERNET MAC ADDRESS 000000000000 | Range: standard Ethernet MAC address format |
| | | MANUFACTURING DATE: 0 | Range: YYYY/MM/DD HH:MM:SS |
| | | CT/ VT ADVANCED DIAG ACTIVE: No | Range: Yes, No |
| | | OPERATING TIME: 0:00:00 | Range: operating time in HH:MM:SS |
| | | 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.

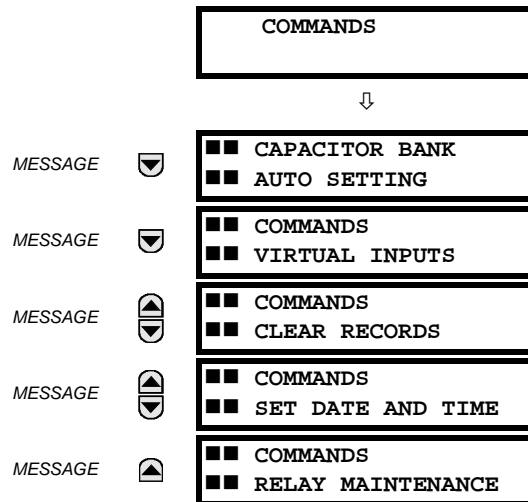
6.5.2 FIRMWARE REVISIONS

PATH: ACTUAL VALUES ⇒ ↓ PRODUCT INFO ⇒ ↓ FIRMWARE REVISIONS

| | | | |
|---|---|---------------------------------------|--|
| <div> <div>FIRMWARE REVISIONS</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div> | <div> <div>◀▶</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲</div> </div> | C60 Breaker Relay REVISION: 5.5x | Range: 0.00 to 655.35 Revision number of the application firmware. |
| | | MODIFICATION FILE NUMBER: 0 | Range: 0 to 65535 (ID of the MOD FILE) Value is 0 for each standard firmware release. |
| | | BOOT PROGRAM REVISION: 1.13 | Range: 0.00 to 655.35 Revision number of the boot program firmware. |
| | | FRONT PANEL PROGRAM REVISION: 0.08 | Range: 0.00 to 655.35 Revision number of faceplate program firmware. |
| | | COMPILE DATE: 2004/09/15 04:55:16 | Range: Any valid date and time. Date and time when product firmware was built. |
| | | 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



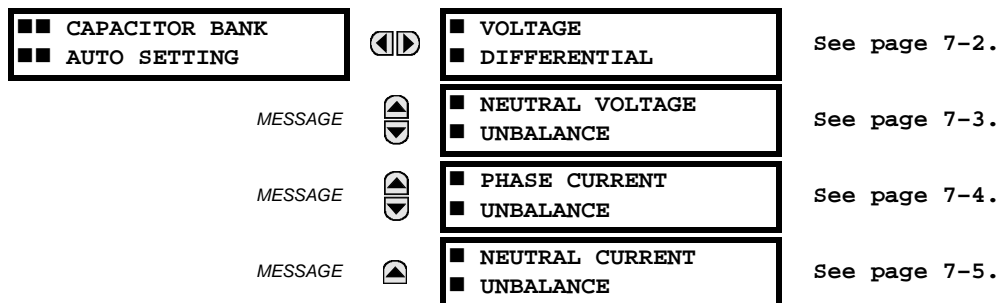
The commands menu contains relay directives intended for operations personnel. All commands can be protected from unauthorized access via the command password; see the *Security* section of chapter 5 for details. The following flash message appears after successfully command entry:

COMMAND
EXECUTED

7.1.2 CAPACITOR BANK AUTOMATIC SETTINGS

a) MAIN MENU

PATH: COMMANDS ⇒ CAPACITOR BANK AUTO SETTING



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)

| | | | |
|---|---|---|-------------------------------|
| <div> <div>VOLTAGE</div> <div>DIFFERENTIAL 1</div> </div> | <div> <div>◀▶</div> <div>▲▼</div> <div>▲▼</div> <div>▲</div> </div> | <div>VOLTAGE DIF 1 AUTO SETTING: Disabled</div> | Range: Disabled, Manual, Auto |
| | | <div>V DIF 1A k=####.####</div> <div>APPLY IN PHS A? No</div> | Range: Yes, No |
| | | <div>V DIF 1A k=####.####</div> <div>APPLY IN PHS B? No</div> | Range: Yes, No |
| | MESSAGE | <div>V DIF 1A k=####.####</div> <div>APPLY IN PHS C? No</div> | 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 is 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 frequency deviation from the nominal 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.

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 viewed under 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 | ◀ ▶ | NTRL VOL UNBAL 1 | Range: Disabled, Manual, Auto |
| ■ UNBALANCE 1 | | AUTO SET: Disabled | |
| MESSAGE | ▲ ▼ | XA/XB RATIO k=0.0000 | Range: Yes, No |
| | | APPLY? No | |
| MESSAGE | ▲ ▼ | XA/XC RATIO k=0.0000 | Range: Yes, No |
| | | APPLY? 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. 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 is 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. 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 **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. 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, 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 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)

| | | |
|--|--|-------------------------------|
| <div> <div>■ PHASE CURRENT</div> <div>■ UNBALANCE 1</div> </div> | <div>◀▶</div> <div>CUR UNBALANCE 1 AUTO SETTINGS: Disabled</div> | Range: Disabled, Manual, Auto |
| MESSAGE | <div>▲▼</div> <div>CUR UNB 1A k=0.0000</div> <div>APPLY IN PHS A? No</div> | Range: Yes, No |
| MESSAGE | <div>▲▼</div> <div>CUR UNB 1A k=0.0000</div> <div>APPLY IN PHS B? No</div> | Range: Yes, No |
| MESSAGE | <div>▲</div> <div>CUR UNB 1A k=0.0000</div> <div>APPLY IN PHS C? No</div> | 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 UNBALANCE 1 AUTO SETTINGS** command switched to “Manual”) or by automatic acceptance of the calculated factors (the **CUR UNBALANCE 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 UNBALANCE 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 UNBALANCE 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 UNBALANCE 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 UNBALANCE 1 AUTO-SET** command switched to “Manual”), or with automatic acceptance of the calculated factors (the **NTRL CUR UNBALANCE 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 UNBALANCE 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 is 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 UNBALANCE 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 back 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, 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

| | | | |
|--|----|-------------------|----------------|
| <div> <div>COMMANDS</div> <div>VIRTUAL INPUTS</div> </div> | ◀▶ | 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

| | | | |
|---|----|----------------------------------|---|
| <div> <div>COMMANDS</div> <div>CLEAR RECORDS</div> </div> | ◀▶ | 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

| | | | |
|---|----|---|-----------------------|
| <div> <div>COMMANDS</div> <div>SET DATE AND TIME</div> </div> | ◀▶ | 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

| | | | |
|--|-----------------------------|---|----------------|
| <div>■ ■ COMMANDS</div> <div>■ ■ RELAY MAINTENANCE</div> | <div>◀ ▶</div> <div>▲</div> | <div>PERFORM LAMPTTEST?</div> <div>No</div> | Range: No, Yes |
| | | <div>UPDATE ORDER CODE?</div> <div>No</div> | Range: No, Yes |

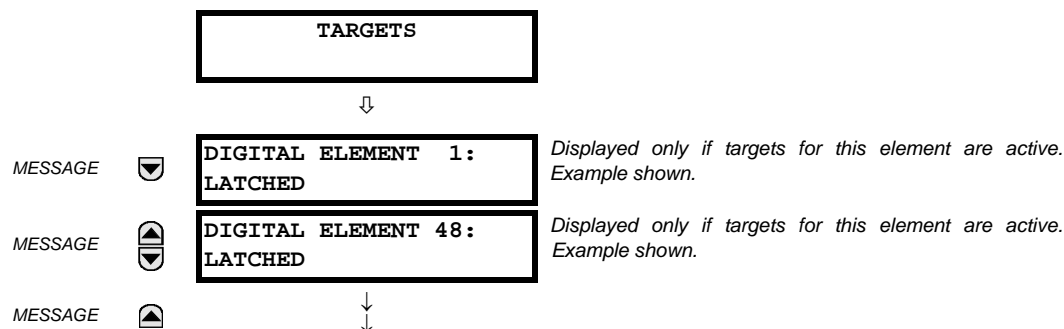
This menu contains commands for relay maintenance purposes. Commands are activated by changing a command setting to “Yes” and pressing the ENTER key. The command setting will then automatically revert to “No”.

The **PERFORM LAMPTTEST** 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.

7.2.1 TARGETS MENU



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”.

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 chapter 5 for additional details.

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).

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.

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 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.

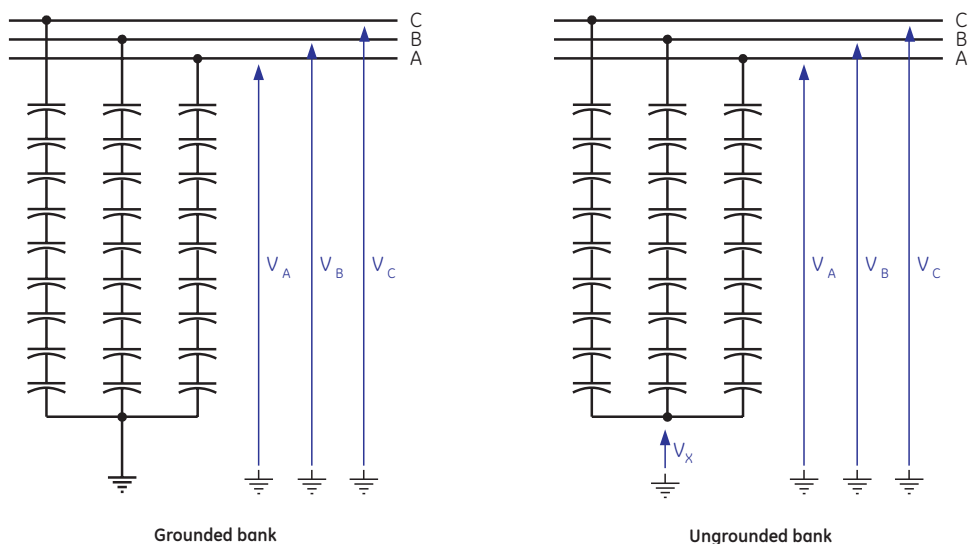
The purpose of capacitor unbalance protection is to detect unbalance caused by element failures as soon as practical, and to either alarm the condition so that repair can be scheduled for a convenient time, or to automatically remove the bank from service to prevent deterioration in the healthy elements 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.

8.1.2 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.



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Figure 8-1: 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.

$$|V_A - V_X|_{\text{RMS}}, |V_B - V_X|_{\text{RMS}}, \text{ or } |V_C - V_X|_{\text{RMS}} \quad (\text{EQ 8.1})$$

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:

$$V_X = \frac{1}{3}(V_A + V_B + V_C) \quad (\text{EQ 8.2})$$

As such, the A-string voltage is:

$$\begin{aligned} |V_A - V_X|_{\text{RMS}} &= \left| V_A - \frac{1}{3}(V_A + V_B + V_C) \right|_{\text{RMS}} \\ &= \frac{1}{3} |2V_A - V_B - V_C|_{\text{RMS}} \\ &= \frac{1}{3} |V_{AB} - V_{CA}|_{\text{RMS}} \end{aligned} \quad (\text{EQ 8.3})$$

Similarly, the B-string and C-string voltages are:

$$\frac{1}{3} |V_{BC} - V_{AB}|_{\text{RMS}} \quad \text{and} \quad \frac{1}{3} |V_{CA} - V_{BC}|_{\text{RMS}} \quad (\text{EQ 8.4})$$

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:

$$\begin{aligned}
 |V_A|_{\text{RMS}} &= \frac{1}{3} |3V_A + (V_B - V_B) + (V_C - V_C)|_{\text{RMS}} \\
 &= \frac{1}{3} |V_A - V_B - V_C + V_A + (V_A + V_B + V_C)|_{\text{RMS}} \\
 &= \frac{1}{3} |V_{AB} - V_{CA} + 3V_0|_{\text{RMS}}
 \end{aligned} \tag{EQ 8.5}$$

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:

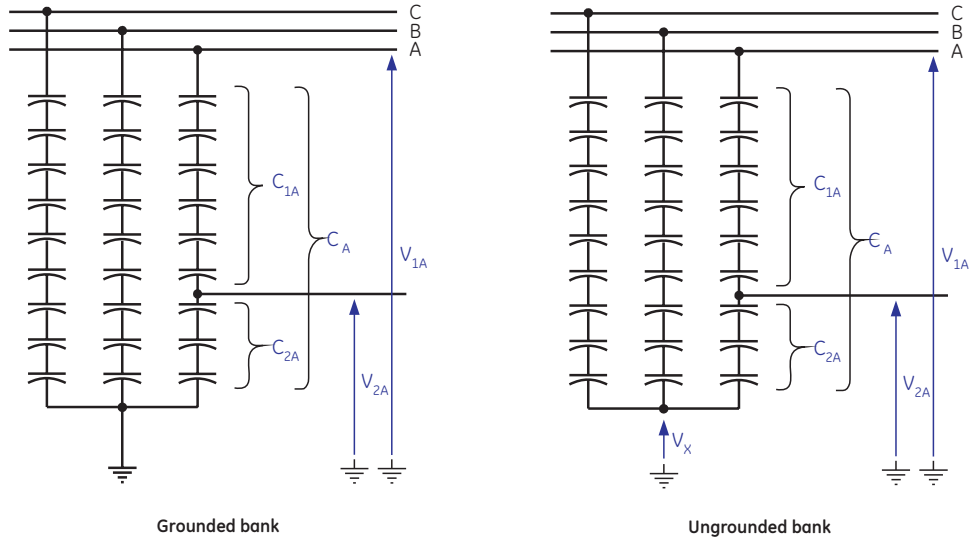
$$\frac{1}{3} |V_{AB} - V_{CA}|_{\text{RMS}}, \frac{1}{3} |V_{BC} - V_{AB}|_{\text{RMS}}, \text{ or } \frac{1}{3} |V_{CA} - V_{BC}|_{\text{RMS}} \tag{EQ 8.6}$$

These quantities are what the bank phase overvoltage protection measures whenever the bus source is set for delta VTs.

8.1.3 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.



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Figure 8-2: VOLTAGE DIFFERENTIAL APPLICATION TO GROUNDED AND UNGROUNDED BANKS

The voltage differential protection uses the following operating signal for grounded banks.

$$V_{OP(A)} = |V_{1A} - k_A V_{2A}| \tag{EQ 8.7}$$

The voltage differential protection uses the following operating signal for ungrounded banks.

$$V_{OP(A)} = |(V_{1A} - V_X) - k_A (V_{2A} - V_X)| \tag{EQ 8.8}$$

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.

$$V_{OP(A)} = |V_{1A} - k_A V_{2A}| \quad (\text{EQ 8.9})$$

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_{Spq} , then the string will form a voltage divider and the initial measured voltages are:

$$V_{1A} = V_{Spq} \quad (\text{EQ 8.10})$$

$$V_{2A} = V_{Spq} \times \frac{C_A}{C_{2A}} \quad (\text{EQ 8.11})$$

Substituting these results into equation 8.9, the initial operating signal is:

$$\begin{aligned} V_{OP(A)} &= |V_{1A} - k_A V_{2A}| \\ &= \left| V_{Spq} - k_A V_{Spq} \times \frac{C_A}{C_{2A}} \right| \\ &= V_{Spq} \times \left| 1 - k_A \times \frac{C_A}{C_{2A}} \right| \end{aligned} \quad (\text{EQ 8.12})$$

The match factor setting k_A is chosen as:

$$k_A = \frac{C_{2A}}{C_A} \quad (\text{EQ 8.13})$$

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:

$$\begin{aligned} \frac{d}{dC_A} V_{OP(1A)} &= V_{Spq} \times \left| \frac{d}{dC_A} \left(1 - k_A \frac{C_A}{C_{2A}} \right) \right| \\ &= V_{Spq} \times \left| -\frac{k_A}{C_{2A}} \right| \\ &= V_{Spq} \times \frac{k_A}{C_{2A}} \end{aligned} \quad (\text{EQ 8.14})$$

Substituting equation 8.13, we have:

$$\frac{d}{dC_A} V_{OP(1A)} = V_{Spq} \times \frac{1}{C_A} \quad \text{or} \quad dV_{OP(1A)} = V_{Spq} \times \frac{dC_A}{C_A} \quad (\text{EQ 8.15})$$

This can be written as:

$$V_{OP(1A)}(\text{pu}) = V_{Spq}(\text{pu}) \times \Delta C_A(\text{pu}) \quad (\text{EQ 8.16})$$

In the above equation, $\Delta C_A(\text{pu})$ is the capacitance change as a per-unit of the leg capacitance, V_{Spg} is the system phase-to-ground voltage, and $V_{OP(1A)}(\text{pu})$ 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:

$$C_A = \frac{C_{1A} C_{2A}}{C_{1A} + C_{2A}} \quad \text{or} \quad C_{2A} = \frac{C_A C_{1A}}{C_{1A} - C_A} \quad (\text{EQ 8.17})$$

In this case, we have:

$$\begin{aligned} V_{OP(A)} &= V_{Spg} \times \left| 1 - k_A \times \frac{C_A}{C_{2A}} \right| \\ &= V_{Spg} \times \left| 1 - k_A \times \frac{C_{1A} - C_A}{C_{1A}} \right| \end{aligned} \quad (\text{EQ 8.18})$$

The derivative is thus:

$$\begin{aligned} \frac{d}{dC_A} V_{OP(2A)} &= V_{Spg} \times \left| \frac{d}{dC_A} \left(1 - k_A \frac{C_{1A} - C_A}{C_{1A}} \right) \right| \\ &= V_{Spg} \times \left| \frac{k_A}{C_{1A}} \right| \\ &= V_{Spg} \times \frac{k_A}{C_{1A}} \end{aligned} \quad (\text{EQ 8.19})$$

Substituting equation 8.17 into equation 8.13, we have:

$$k_A = \frac{C_{2A}}{C_A} = \frac{C_{1A}}{C_{1A} - C_A} \quad \text{or} \quad C_{1A} = k_A C_{1A} - k_A C_A \quad (\text{EQ 8.20})$$

Therefore:

$$C_{1A} = \frac{k_A C_A}{k_A - 1} \quad (\text{EQ 8.21})$$

Substituting this value into equation 8.19, we get:

$$\begin{aligned} \frac{d}{dC_A} V_{OP(2A)} &= V_{Spg} \times \frac{k_A}{C_{1A}} \\ &= V_{Spg} \times \frac{k_A - 1}{C_A} \end{aligned} \quad (\text{EQ 8.22})$$

Or alternately,

$$dV_{OP(2A)} = V_{Spg} \times (k_A - 1) \times \frac{dC_A}{C_A} \quad (\text{EQ 8.23})$$

The value can be expressed as:

$$V_{OP(2A)}(\text{pu}) = V_{Spg}(\text{pu}) \times (k_A - 1) \times \Delta C_A(\text{pu}) \quad (\text{EQ 8.24})$$

In the above equation, $\Delta C_A(\text{pu})$ is the capacitance change as a per-unit of the leg capacitance, V_{Spg} is the system phase-to-ground voltage, and $V_{OP(2A)}(\text{pu})$ 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 $V_{OP(2A)}(\text{pu}) \geq V_{OP(1A)}(\text{pu})$, and thus that an element failure in the lower sub-string produces a operating signal no smaller than the same failure in the upper sub-string. Thus $V_{OP(1A)}(\text{pu})$ 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.

8.1.4 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:

$$V_{OP} = \frac{1}{3} |V_X(1 + k_{AB} + k_{AC}) - 3V_0 + V_B(1 - k_{AB}) + V_C(1 - k_{AC})| \quad (\text{EQ 8.25})$$

The restraint signal for the neutral voltage unbalance protection is:

$$V_{REST} = |V_X + V_0| \quad (\text{EQ 8.26})$$

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.

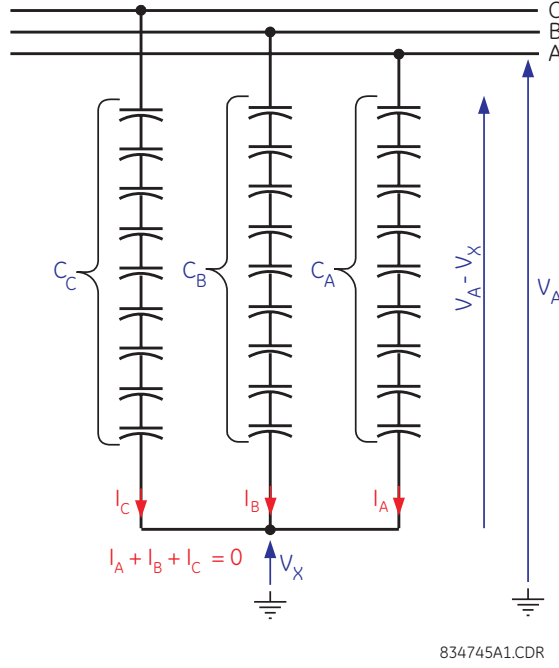


Figure 8–3: COMPENSATED BANK NEUTRAL OVERVOLTAGE APPLICATION

b) BALANCED CASE

To understand neutral voltage unbalance protection, we can start with Kirchhoff's current law for the neutral node of the bank:

$$I_A + I_B + I_C = j\omega C_A(V_A - V_X) + j\omega C_B(V_B - V_X) + j\omega C_C(V_C - V_X) = 0 \quad (\text{EQ 8.27})$$

This expression can be rearranged as follows.

$$\begin{aligned} & -V_X(C_A + C_B + C_C) + V_A C_A + V_B C_B + V_C C_C = 0 \\ \Rightarrow & -V_X(C_A + C_B + C_C) + V_A C_A + V_B C_A + V_C C_A + V_B C_B - V_B C_A + V_C C_C - V_C C_A = 0 \\ \Rightarrow & -V_X(C_A + C_B + C_C) + C_A(V_A + V_B + V_C) + V_B(C_B - C_A) + V_C(C_C - C_A) = 0 \end{aligned} \quad (\text{EQ 8.28})$$

Multiplying both sides by $-1 / C_A$ and substituting the sum of the phase voltages with $3V_0$ yields:

$$V_X \left(1 + \frac{C_B + C_C}{C_A}\right) - 3V_0 + V_B \left(1 - \frac{C_B}{C_A}\right) + V_C \left(1 - \frac{C_C}{C_A}\right) = 0 \quad (\text{EQ 8.29})$$

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:

$$\begin{aligned} V_{OP} &= \frac{1}{3} \left| V_X \left(1 + k_{AB} + k_{AC}\right) - 3V_0 + V_B \left(1 - k_{AB}\right) + V_C \left(1 - k_{AC}\right) - V_X \left(1 + \frac{C_B + C_C}{C_A}\right) + 3V_0 - V_B \left(1 - \frac{C_B}{C_A}\right) - V_C \left(1 - \frac{C_C}{C_A}\right) \right| \\ &= \frac{1}{3} \left| V_X \left(k_{AB} - \frac{C_B}{C_A} + k_{AC} - \frac{C_C}{C_A}\right) + V_B \left(\frac{C_B}{C_A} - k_{AB}\right) + V_C \left(\frac{C_C}{C_A} - k_{AC}\right) \right| \end{aligned} \quad (\text{EQ 8.30})$$

The unbalance ratio k -values that reflect the initial or inherent bank unbalance are chosen as:

$$k_{AB} = \frac{C_B}{C_A}, \quad k_{AC} = \frac{C_C}{C_A} \quad (\text{EQ 8.31})$$

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:

$$V_{OP} = |V_X - V_0| \quad (\text{EQ 8.32})$$

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:

$$\begin{aligned} \frac{d}{dC_C} V_{OP} &= \frac{1}{3} \frac{d}{dC_C} |(V_X(1 + k_{AB} + k_{AC}) - 3V_0 + V_B(1 - k_{AB}) + V_C(1 - k_{AC}))| \\ &= \frac{1}{3} \left| (1 + k_{AB} + k_{AC}) \frac{dV_X}{dC_C} \right| \end{aligned} \quad (\text{EQ 8.33})$$

Recall equation 8.29.

$$V_X \left(1 + \frac{C_B + C_C}{C_A} \right) - 3V_0 + V_B \left(1 - \frac{C_B}{C_A} \right) + V_C \left(1 - \frac{C_C}{C_A} \right) = 0 \quad (\text{EQ 8.34})$$

Differentiating this gives:

$$\begin{aligned} \frac{dV_X}{dC_C} \left(1 + \frac{C_B + C_C}{C_A} \right) + V_X \left(\frac{1}{C_A} \right) - V_C \left(\frac{1}{C_A} \right) &= 0 \\ \Rightarrow \frac{d}{dC_C} V_X &= - \frac{V_X - V_C}{C_A \left(1 + \frac{C_B + C_C}{C_A} \right)} \\ \Rightarrow \frac{d}{dC_C} V_X &= - \frac{V_X - V_C}{C_A (1 + k_{AB} + k_{AC})} \end{aligned} \quad (\text{EQ 8.35})$$

Substituting for V_X from equation 8.34 gives:

$$\frac{d}{dC_C} V_X = \frac{3V_0 - V_B(1 - k_{AB}) - V_C(2 + k_{AB})}{C_A(1 + k_{AB} + k_{AC})^2} \quad (\text{EQ 8.36})$$

This can be substituted into equation 8.33 to obtain:

$$\begin{aligned} \frac{d}{dC_C} V_{OP} &= \frac{1}{3} \left| (1 + k_{AB} + k_{AC}) \frac{dV_X}{dC_C} \right| \\ &= \frac{1}{3} \left| \frac{3V_0 - V_B(1 - k_{AB}) - V_C(2 + k_{AB})}{C_A(1 + k_{AB} + k_{AC})} \right| \end{aligned} \quad (\text{EQ 8.37})$$

For our purposes, $C_A \cong C_B \cong C_C$, so $k_{AB} \cong 1$ and $k_{AC} \cong 1$. This results in:

$$\begin{aligned} \frac{d}{dC_C} V_{OP} &\cong \frac{1}{3} \left| \frac{V_C - V_0}{C_C} \right| \\ &= \frac{1}{3} \times \frac{1}{C_C} \times |V_C - V_0| \end{aligned} \quad (\text{EQ 8.38})$$

Under normal system conditions (non-fault), $V_C \gg V_0$, and V_C is the system phase-to-ground voltage. The system voltage V_{Spq} , 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:

$$\frac{n_{bus_phs}}{n_{ntrl_aux}} \times V_{Spq} \quad (\text{EQ 8.39})$$

This gives:

$$\begin{aligned} \frac{d}{dC_C} V_{OP} &\cong \frac{1}{3} \times \frac{1}{C_C} \times \frac{n_{bus_phs}}{n_{ntrl_aux}} \times V_{Spq} \\ \Rightarrow dV_{OP} &\cong \frac{1}{3} \times \frac{n_{bus_phs}}{n_{ntrl_aux}} \times V_{Spq} \times \frac{dC_C}{C_C} \end{aligned} \quad (\text{EQ 8.40})$$

This can be written as:

$$V_{OP}(\text{pu}) \cong \frac{1}{3} \times \frac{n_{bus_phs}}{n_{ntrl_aux}} \times V_{Spq} \times \Delta C(\text{pu}) \quad (\text{EQ 8.41})$$

In the above equations, $\Delta C(\text{pu})$ is the capacitance change as a per-unit of the leg capacitance, and $V_{OP}(\text{pu})$ is the operating signal resulting from the failure in per-unit of the nominal value of the neutral-point VT. V_{Spq} 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_{bus_phs} and n_{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 from the non-fault sensitivity. To prevent misoperation, 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.

$$V_{REST} = |V_X + V_0| \quad (\text{EQ 8.42})$$

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.

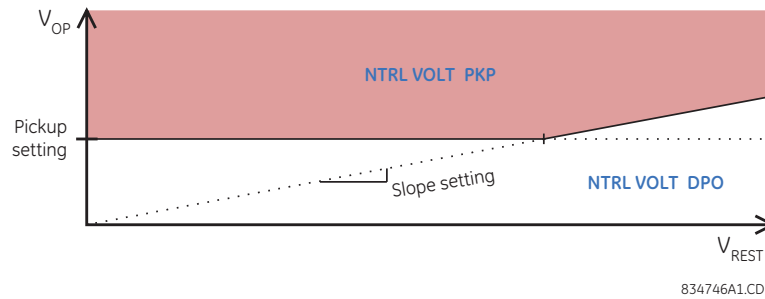


Figure 8-4: NEUTRAL OVERVOLTAGE RESTRAINT

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.

8.1.5 PHASE CURRENT UNBALANCE (ANSI 60P)

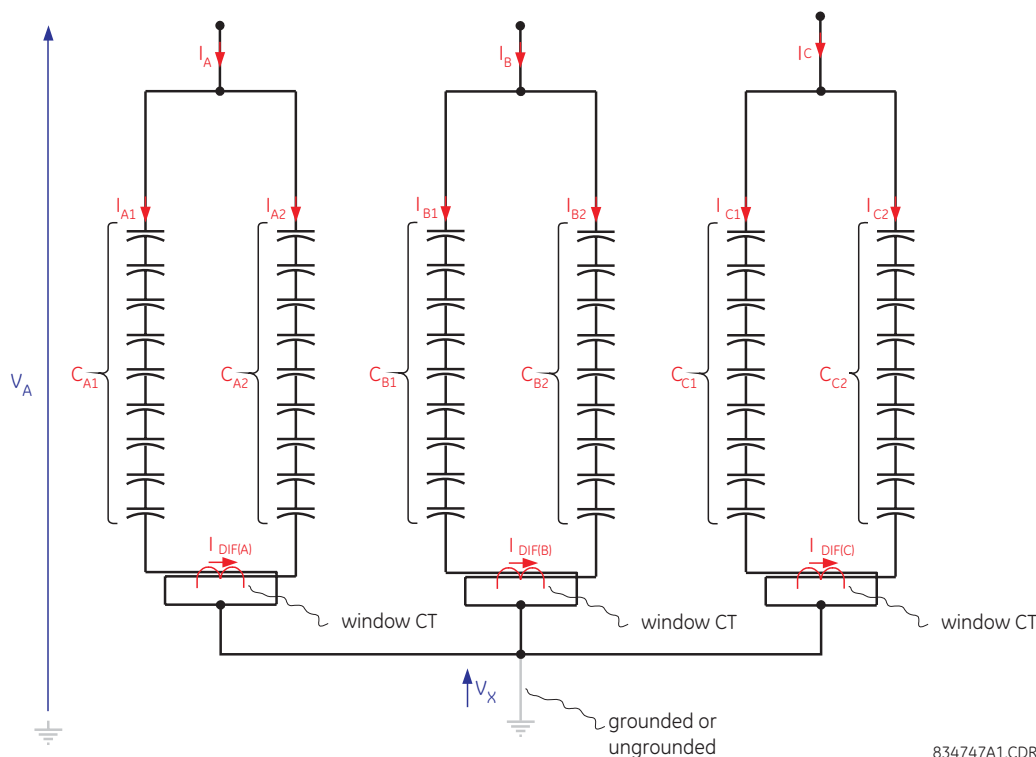
a) OPERATING PRINCIPLE

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.

$$I_{OP(A)} = |I_{DIF(A)} - k_A I_A| \quad (\text{EQ 8.43})$$

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.



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Figure 8–5: 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.

b) BALANCED CASE

To understand phase current unbalance protection, first note that the currents are driven by the individual admittances in each string:

$$I_{A1} = \frac{j\omega C_{A1}(V_A - V_X)}{I_{base}}; \quad I_{A2} = \frac{j\omega C_{A2}(V_A - V_X)}{I_{base}} \quad (\text{EQ 8.44})$$

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:

$$\begin{aligned} I_{DIF(A)} &= I_{A1} - I_{A2} \\ &= \frac{j\omega(V_A - V_X)(C_{A1} - C_{A2})}{I_{base}} \end{aligned} \quad (\text{EQ 8.45})$$

The total phase current is the vector sum of the two currents:

$$\begin{aligned} I_A &= I_{A1} + I_{A2} \\ &= \frac{j\omega(V_A - V_X)(C_{A1} + C_{A2})}{I_{base}} \end{aligned} \quad (\text{EQ 8.46})$$

Inserting equation 8.46 into equation 8.45, to eliminate the voltages, we get:

$$I_{DIF(A)} = I_A \times \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} \quad (\text{EQ 8.47})$$

Inserting this value into equation 8.43, we have:

$$\begin{aligned} I_{OP(A)} &= |I_{DIF(A)} - k_A I_A| \\ &= \left| I_A \times \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} - k_A I_A \right| \end{aligned} \quad (\text{EQ 8.48})$$

The capacitor bank leg-A inherent unbalance factor setting k_A is chosen to be:

$$k_A = \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} \quad (\text{EQ 8.49})$$

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:

$$\begin{aligned}
\frac{d}{dC_{A1}} I_{OP(A)} &= \left| \frac{d}{dC_{A1}} \left(I_A \times \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} - k_A I_A \right) \right| \\
&= \left| I_A \times \frac{(C_{A1} + C_{A2}) - (C_{A1} - C_{A2})}{(C_{A1} + C_{A2})^2} \right| \\
&= |I_A| \times \frac{2C_{A2}}{(C_{A1} + C_{A2})^2} \\
&\cong \frac{I_A}{2} \times \frac{1}{C_{A1}}
\end{aligned} \tag{EQ 8.50}$$

The last step assumes $C_{A1} \cong C_{A2}$, and replaces the phase current vector with its magnitude. This can be written as:

$$dI_{OP(A)} = \frac{I_A}{2} \times \frac{dC_{A1}}{C_{A1}} \tag{EQ 8.51}$$

Alternatively, we can say:

$$I_{OP(A)}(\text{pu}) = \frac{I_A}{2} \times \Delta C(\text{pu}) \tag{EQ 8.52}$$

In the above equation, $\Delta C(\text{pu})$ represents the capacitance change as a per-unit of the string capacitance, and $I_{OP(A)}(\text{pu})$ 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:

$$I_{OP(A)}(\text{pu}) = \frac{I_{rated}}{2I_{base}} \times \Delta C(\text{pu}) \tag{EQ 8.53}$$

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.

8.1.6 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.

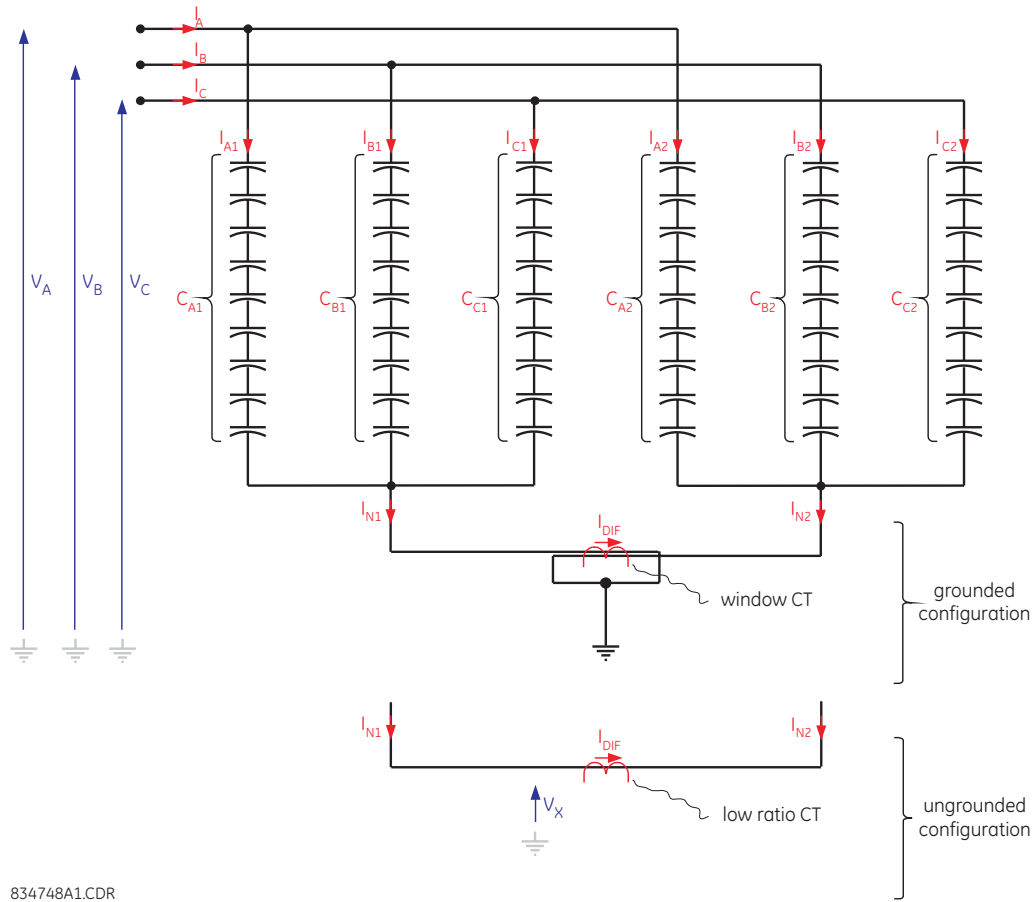


Figure 8-6: NEUTRAL CURRENT UNBALANCE APPLICATION

The neutral current unbalance protection uses the following operate signal.

$$I_{OP} = |I_{DIF} - k_1 I_1 - k_1^* I_2| \quad (\text{EQ 8.54})$$

The neutral current unbalance protection uses the following restraint signal.

$$I_{REST} = |I_0| \quad (\text{EQ 8.55})$$

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:

$$\begin{aligned}
I_{A1} &= \frac{V_A \times j\omega C_{A1}}{I_{base}}; & I_{A2} &= \frac{V_A \times j\omega C_{A2}}{I_{base}} \\
I_{B1} &= \frac{V_B \times j\omega C_{B1}}{I_{base}}; & I_{B2} &= \frac{V_B \times j\omega C_{B2}}{I_{base}} \\
I_{C1} &= \frac{V_C \times j\omega C_{C1}}{I_{base}}; & I_{C2} &= \frac{V_C \times j\omega C_{C2}}{I_{base}}
\end{aligned} \tag{EQ 8.56}$$

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:

$$\begin{aligned}
I_{N1} &= I_{A1} + I_{B1} + I_{C1} = \frac{j\omega C_{A1} V_A + j\omega C_{B1} V_B + j\omega C_{C1} V_C}{I_{base}} \\
I_{N2} &= I_{A2} + I_{B2} + I_{C2} = \frac{j\omega C_{A2} V_A + j\omega C_{B2} V_B + j\omega C_{C2} V_C}{I_{base}}
\end{aligned} \tag{EQ 8.57}$$

The differential current is the vector difference between the two currents. By subtracting I_{N2} from I_{N1} , one obtains:

$$\begin{aligned}
I_{DIF} &= I_{N1} - I_{N2} \\
&= \frac{j\omega [V_A(C_{A1} - C_{A2}) + V_B(C_{B1} - C_{B2}) + V_C(C_{C1} - C_{C2})]}{I_{base}}
\end{aligned} \tag{EQ 8.58}$$

At the same time the total currents in each phase are driven by the total admittance of the two banks in each phase:

$$\begin{aligned}
I_A &= I_{A1} + I_{A2} = \frac{j\omega V_A(C_{A1} + C_{A2})}{I_{base}} \\
I_B &= I_{B1} + I_{B2} = \frac{j\omega V_B(C_{B1} + C_{B2})}{I_{base}} \\
I_C &= I_{C1} + I_{C2} = \frac{j\omega V_C(C_{C1} + C_{C2})}{I_{base}}
\end{aligned} \tag{EQ 8.59}$$

Inserting the equations above into equation 8.58 so as to eliminate the voltages:

$$\begin{aligned}
I_{DIF} &= \frac{j\omega [V_A(C_{A1} - C_{A2}) + V_B(C_{B1} - C_{B2}) + V_C(C_{C1} - C_{C2})]}{I_{base}} \\
&= I_A \times \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} + I_B \times \frac{C_{B1} - C_{B2}}{C_{B1} + C_{B2}} + I_C \times \frac{C_{C1} - C_{C2}}{C_{C1} + C_{C2}}
\end{aligned} \tag{EQ 8.60}$$

Label k_A , k_B , and k_C as follows:

$$k_A = \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}}, \quad k_B = \frac{C_{B1} - C_{B2}}{C_{B1} + C_{B2}}, \quad k_C = \frac{C_{C1} - C_{C2}}{C_{C1} + C_{C2}} \tag{EQ 8.61}$$

Also, convert from phase coordinates into sequence components as follows, and equation 8.60 becomes:

$$\begin{aligned}
I_{DIF} &= k_A(I_1 + I_2 + I_0) + k_B(\hat{a}^2 I_1 + \hat{a} I_2 + I_0) + k_C(\hat{a} I_1 + \hat{a}^2 I_2 + I_0) \\
&= I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C) + I_2(k_A + \hat{a} k_B + \hat{a}^2 k_C) + I_0(k_A + k_B + k_C)
\end{aligned} \tag{EQ 8.62}$$

Substituting this into equation 8.54, we get:

$$\begin{aligned}
I_{OP} &= \left| I_{DIF} - (k_1 I_1 - k_1^* I_2) \right| \\
&= \left| I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C) + I_2(k_A + \hat{a} k_B + \hat{a}^2 k_C) + I_0(k_A + k_B + k_C) - k_1 I_1 - k_1^* I_2 \right| \\
&= \left| I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1) + I_2(k_A + \hat{a} k_B + \hat{a}^2 k_C - k_1^*) + I_0(k_A + k_B + k_C) \right| \\
&= \left| I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1) + I_2(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1)^* + I_0(k_A + k_B + k_C) \right|
\end{aligned} \tag{EQ 8.63}$$

The capacitor bank positive sequence inherent unbalance factor setting k_1 is chosen to be:

$$\begin{aligned}
k_1 &= k_A + \hat{a}^2 k_B + \hat{a} k_C \\
&= \frac{C_{A1} - C_{A2}}{C_{A1} + C_{A2}} + \hat{a}^2 \frac{C_{B1} - C_{B2}}{C_{B1} + C_{B2}} + \hat{a} \frac{C_{C1} - C_{C2}}{C_{C1} + C_{C2}}
\end{aligned} \tag{EQ 8.64}$$

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:

$$\begin{aligned}
\frac{d}{dC_{A1}} I_{OP} &= \left| \frac{d}{dC_{A1}} (I_1(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1) + I_2(k_A + \hat{a}^2 k_B + \hat{a} k_C - k_1)^* + I_0(k_A + k_B + k_C)) \right| \\
&= \left| \frac{dk_A}{dC_{A1}} I_1 + \frac{dk_A}{dC_{A1}} I_2 + \frac{dk_A}{dC_{A1}} I_0 \right| \\
&= \left| \frac{dk_A}{dC_{A1}} I_A \right| \\
&= \left| \frac{(C_{A1} + C_{A2}) - (C_{A1} - C_{A2})}{(C_{A1} + C_{A2})^2} I_A \right| \\
&= \frac{2C_{A2} I_A}{(C_{A1} + C_{A2})^2} \\
&\cong \frac{I_A}{2} \times \frac{1}{C_{A1}}
\end{aligned} \tag{EQ 8.65}$$

The final step assumes $C_{A1} \cong C_{A2}$, and replaces the phase current vector with its magnitude. This can be written as:

$$dI_{OP} = \frac{I_A}{2} \times \frac{dC_{A1}}{C_{A1}} \tag{EQ 8.66}$$

Alternately, we can say:

$$I_{OP}(\text{pu}) = \frac{I_A}{2} \times \Delta C(\text{pu}) \tag{EQ 8.67}$$

where $\Delta C(\text{pu})$ represents the capacitance change as a per-unit value of the string capacitance, and $I_{OP}(\text{pu})$ 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:

$$I_{OP}(\text{pu}) = \frac{I_{rated}}{2I_{base}} \times \Delta C(\text{pu}) \quad (\text{EQ 8.68})$$

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.

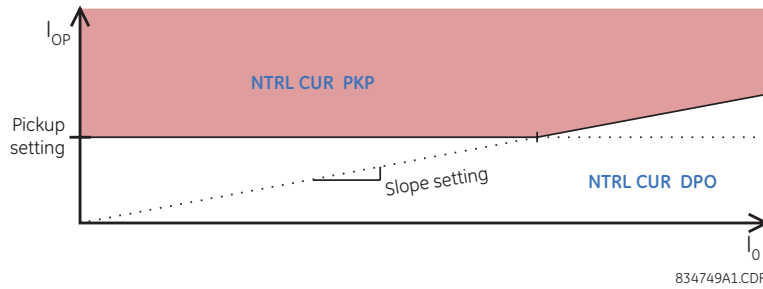


Figure 8-7: NEUTRAL CURRENT UNBALANCE RESTRAINT

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:

$$\begin{aligned} k_1 &= k_A + \hat{a}^2 k_B + \hat{a} k_C \\ &= \frac{C_{A1}}{C_{A1} + C_{A2}} + \hat{a}^2 \frac{C_{B1}}{C_{B1} + C_{B2}} + \hat{a} \frac{C_{C1}}{C_{C1} + C_{C2}} \end{aligned} \quad (\text{EQ 8.69})$$

Equation 8.65 becomes:

$$\begin{aligned}
 \frac{d}{dC_{A1}} I_{OP} &= \left| \frac{(C_{A1} + C_{A2}) - C_{A1}}{(C_{A1} + C_{A2})^2} I_A \right| \\
 &= \frac{C_{A2} I_A}{(C_{A1} + C_{A2})^2} \\
 &\cong \frac{I_A}{4} \times \frac{1}{C_{A1}}
 \end{aligned}
 \tag{EQ 8.70}$$

Equation 8.67 becomes:

$$I_{OP}(\text{pu}) = \frac{I_A}{4} \times \Delta C(\text{pu}) \tag{EQ 8.71}$$

Equation 8.68 becomes:

$$I_{OP}(\text{pu}) = \frac{I_{rated}}{4I_{base}} \times \Delta C(\text{pu}) \tag{EQ 8.72}$$

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 $\Delta C(\text{pu})$ is the capacitance of the string which has the element failure, so the larger bank will have a lower sensitivity than the smaller bank.

9.1.1 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.

9.1.2 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.

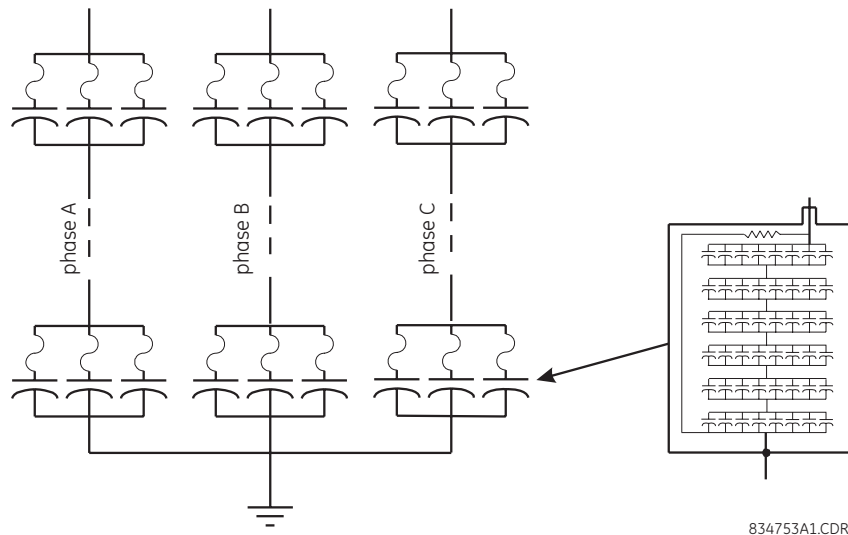
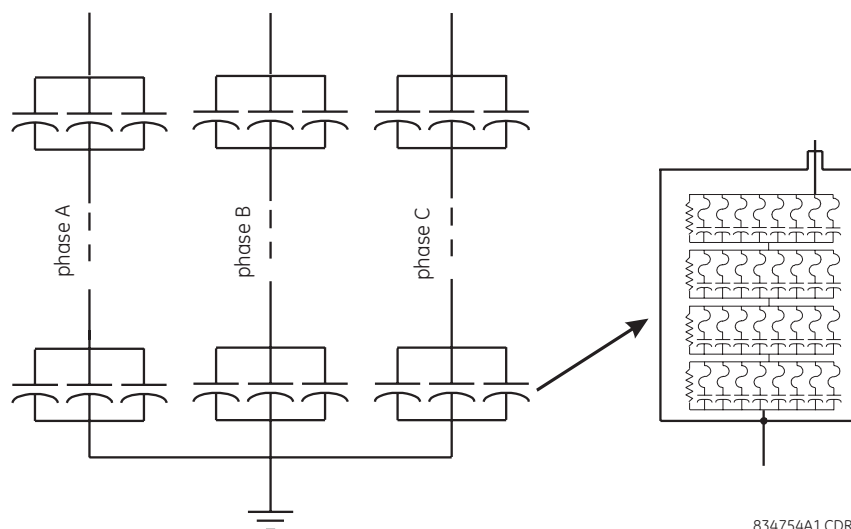


Figure 9-1: EXTERNALLY FUSED SHUNT CAPACITOR BANK AND CAPACITOR UNIT

9.1.3 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.



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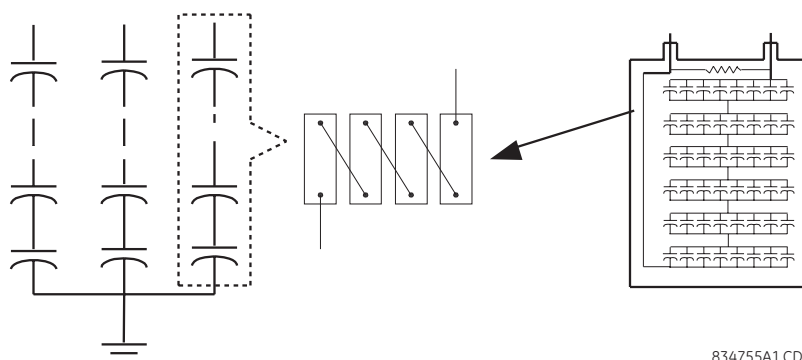
Figure 9-2: INTERNALLY FUSED SHUNT CAPACITOR BANK AND CAPACITOR UNIT

9.1.4 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.



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Figure 9-3: FUSELESS SHUNT CAPACITOR BANK AND SERIES STRING

9.1.5 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.

9.2.1 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).

9.2.2 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.

9.2.3 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.

9.2.4 H-CONFIGURATION

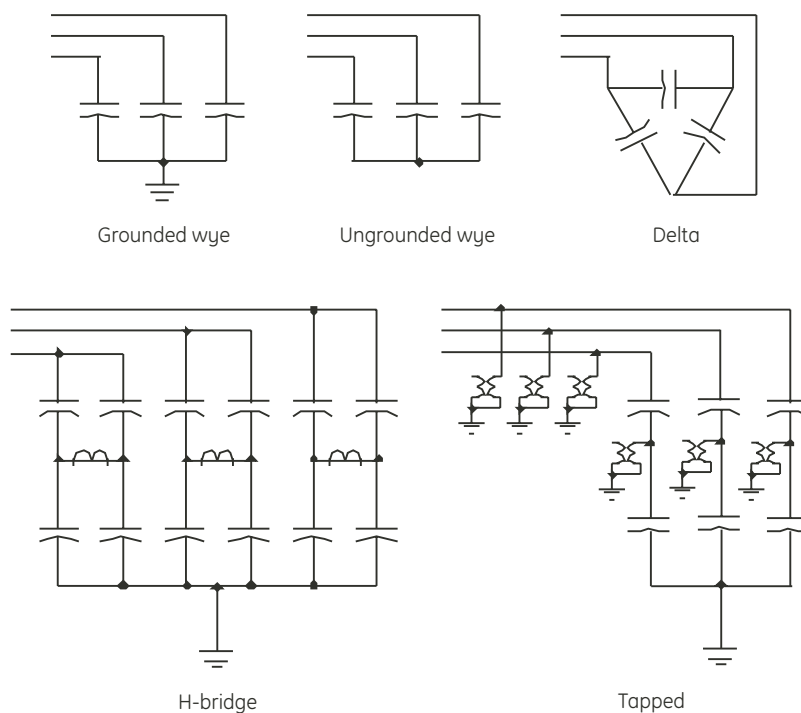
Some larger banks use an H-configuration in each phase with a current transformer connected between the two legs to compare the current down each leg. As long as all capacitors are balanced, no current will flow through the current transformer. If a capacitor fuse operates or an element shorts, some 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.

9.2.5 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.

9.2.6 SUMMARY

The following figure summarizes the grounded wye, ungrounded wye, delta, H-bridge, and tapped connection types for capacitor banks.



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Figure 9-4: CAPACITOR BANK CONNECTIONS

9.3.1 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.

9.3.2 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.

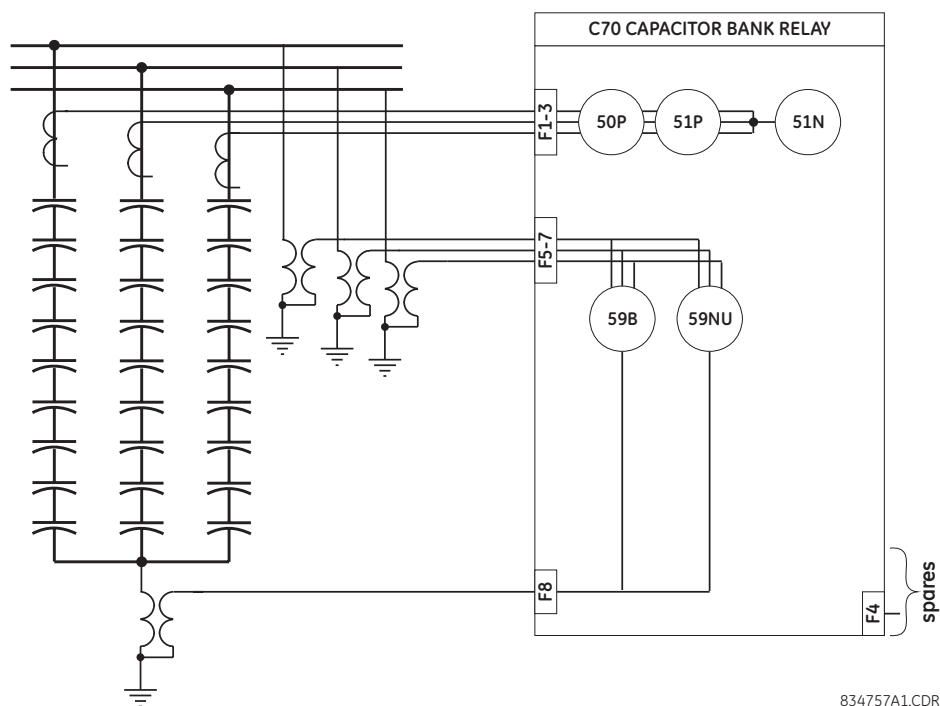


Figure 9-5: SINGLE BANK, UNGROUNDED, NO TAP AVAILABLE

The following figure illustrates a single capacitor bank, ungrounded, with a tap. In this case, two CT/VT modules are required.

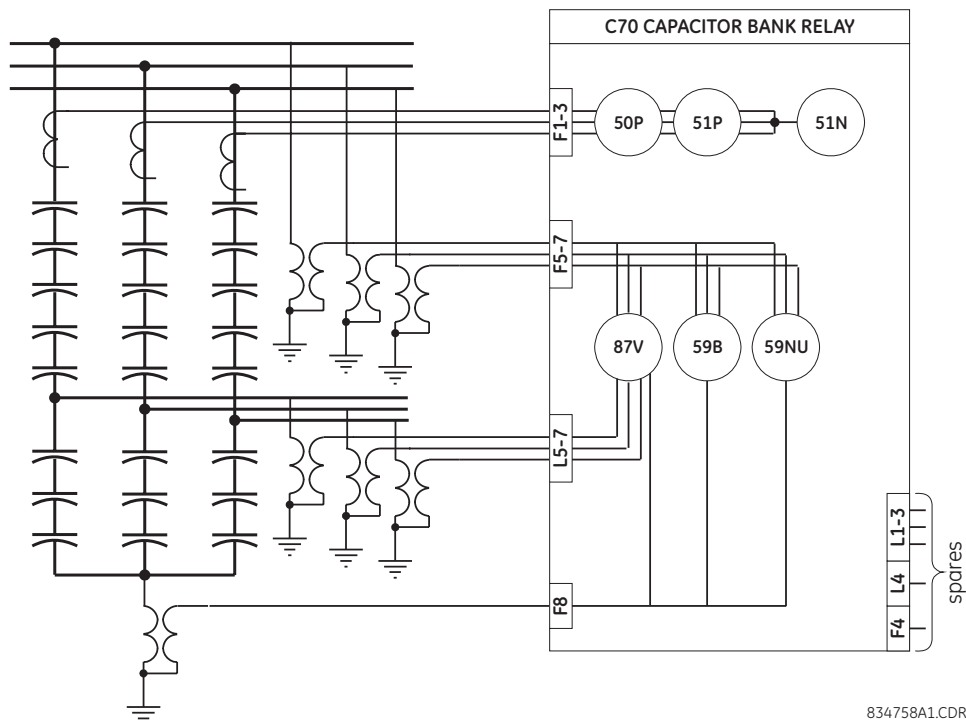


Figure 9-6: SINGLE BANK, UNGROUNDED, WITH A TAP

The following figure illustrates a single capacitor bank, grounded, with a tap. In this case, two CT/VT modules are required.

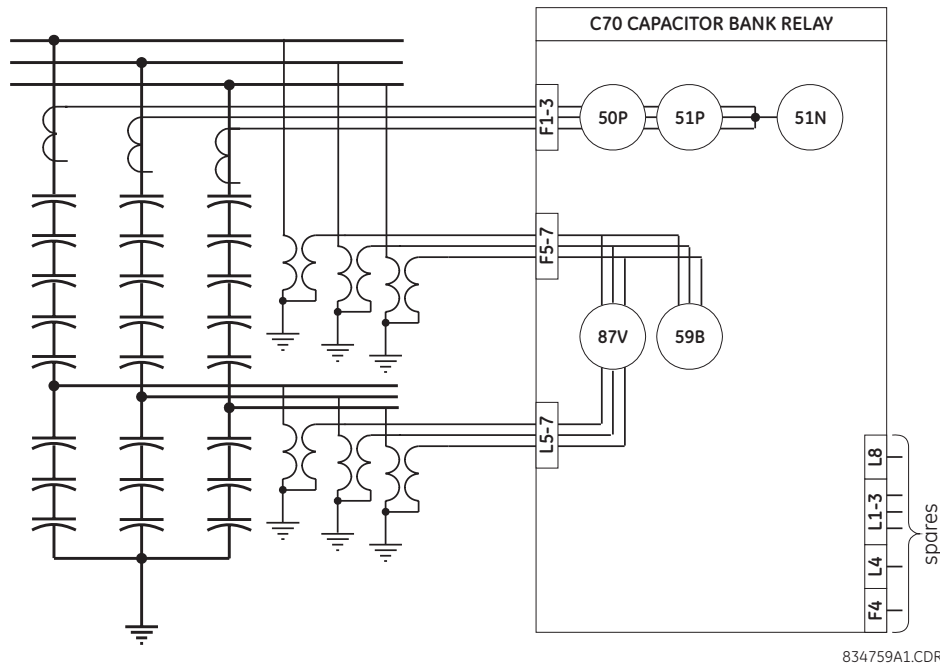


Figure 9-7: SINGLE BANK, GROUNDED, WITH A TAP

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.

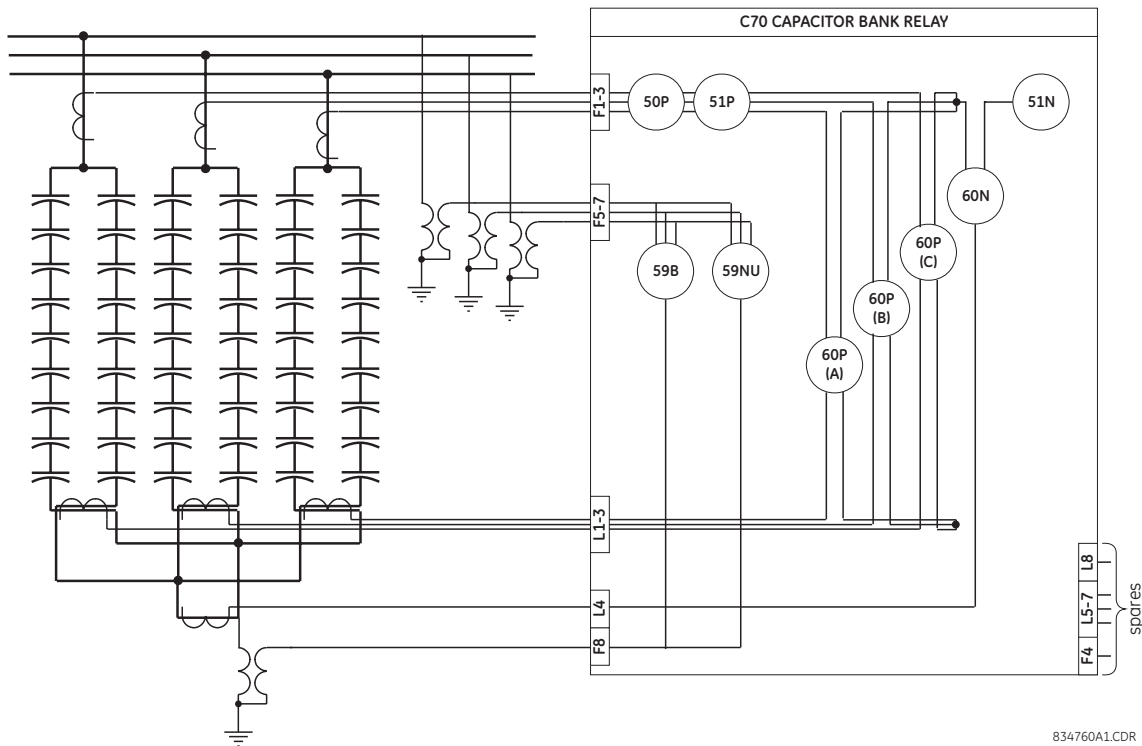
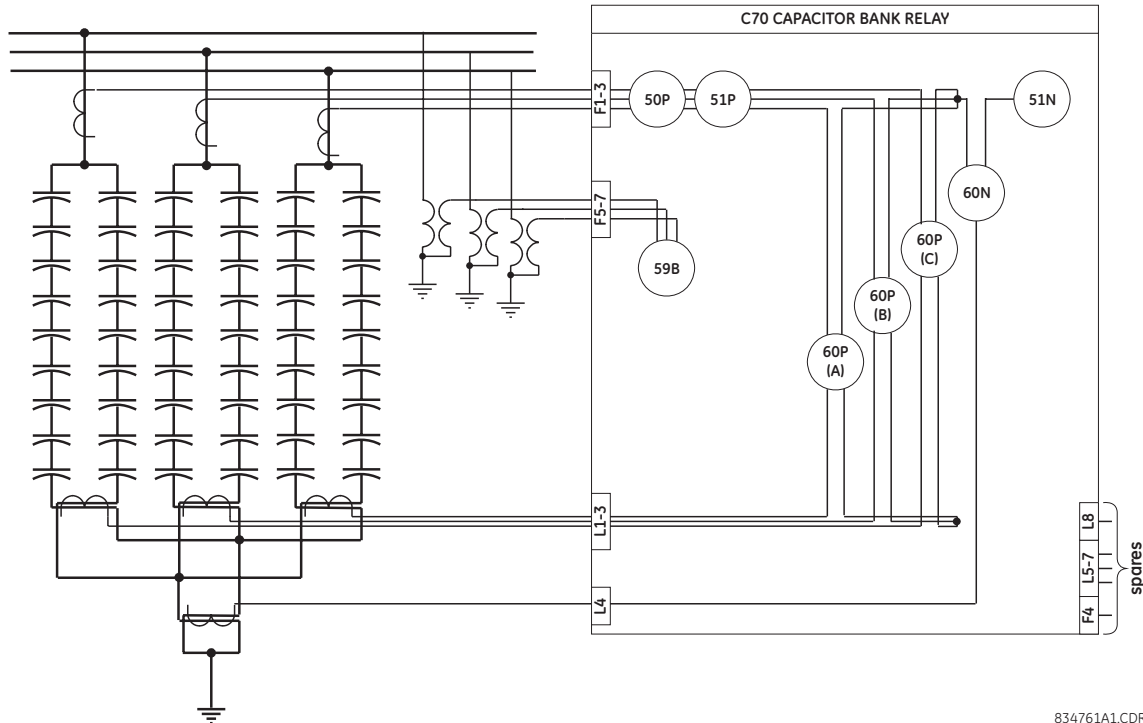


Figure 9-8: PARALLEL BANKS, UNGROUNDED, NO TAP AVAILABLE, CURRENT UNBALANCE PROTECTION

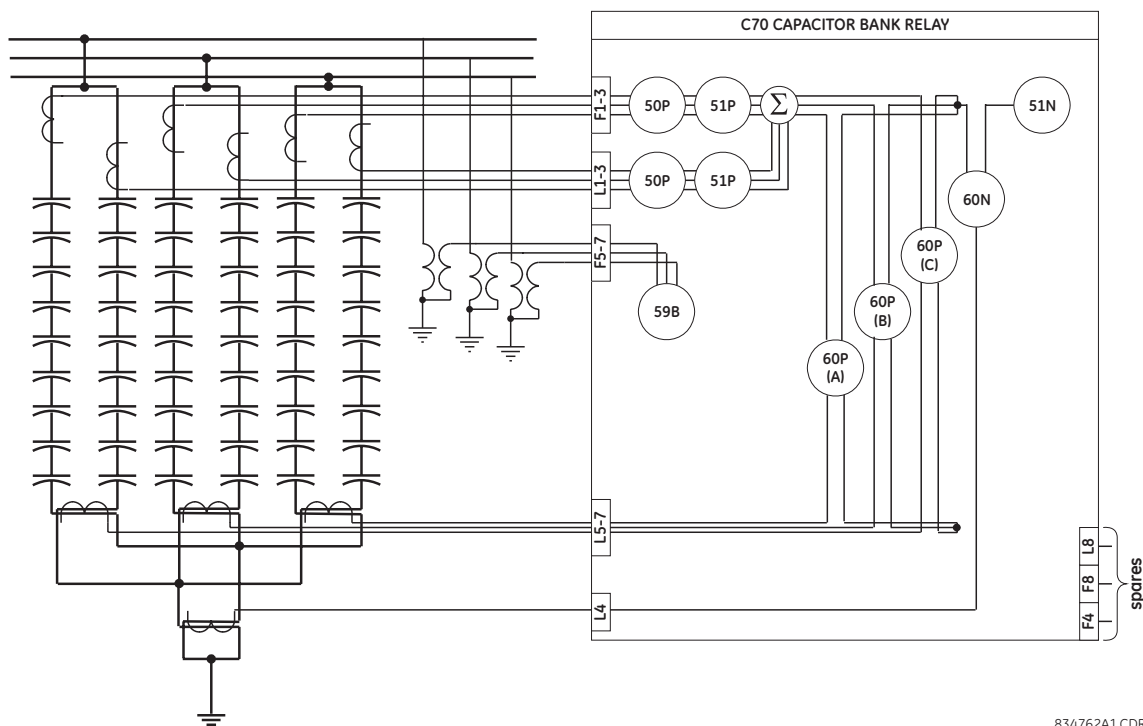
The following figure illustrates parallel capacitor banks, grounded, no tap available, and with current unbalance protection. In this case, two CT/VT modules are required.



834761A1.CDR

Figure 9-9: PARALLEL BANKS, GROUNDED, NO TAP AVAILABLE, CURRENT BALANCE PROTECTION

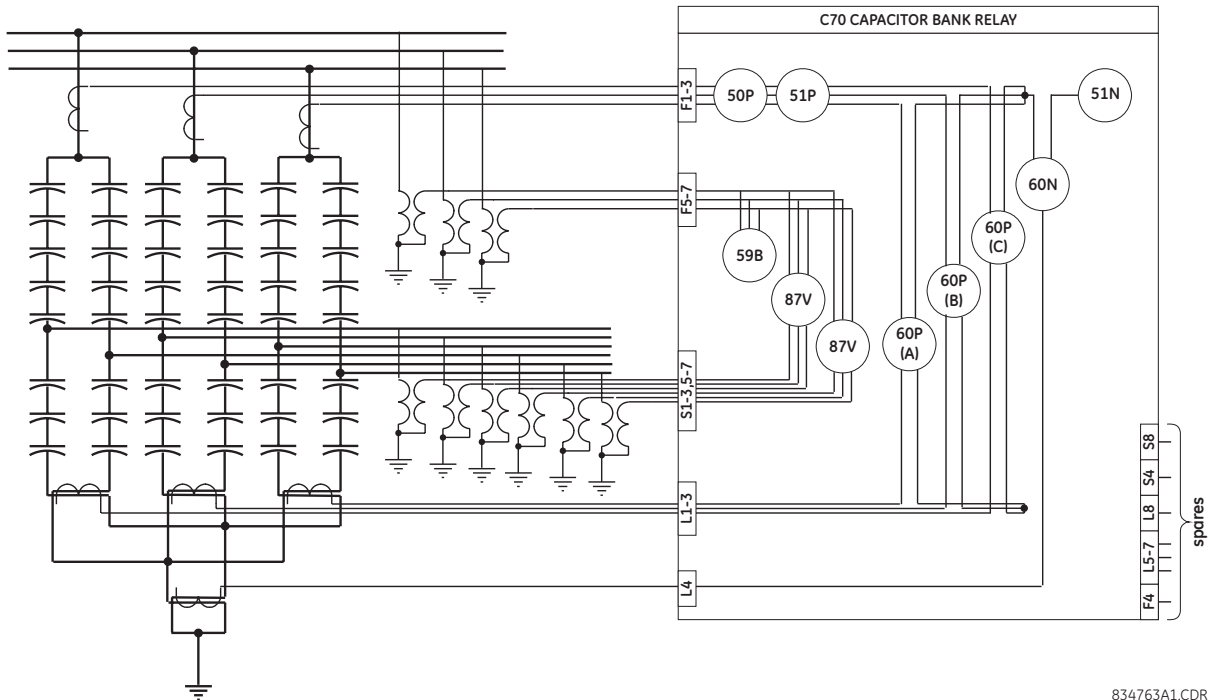
The following figure illustrates parallel capacitor banks, grounded, no tap available, with current unbalance protection and high-side CTs for each bank. In this case, two CT/VT modules are required.



834762A1.CDR

Figure 9-10: 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.



834763A1.CDR

Figure 9-11: PARALLEL BANKS, GROUNDED, WITH TAPS AND CURRENT BALANCE 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.

9.3.3 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.

9.3.4 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.

9.3.5 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.

9.3.6 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.

9.4.1 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.

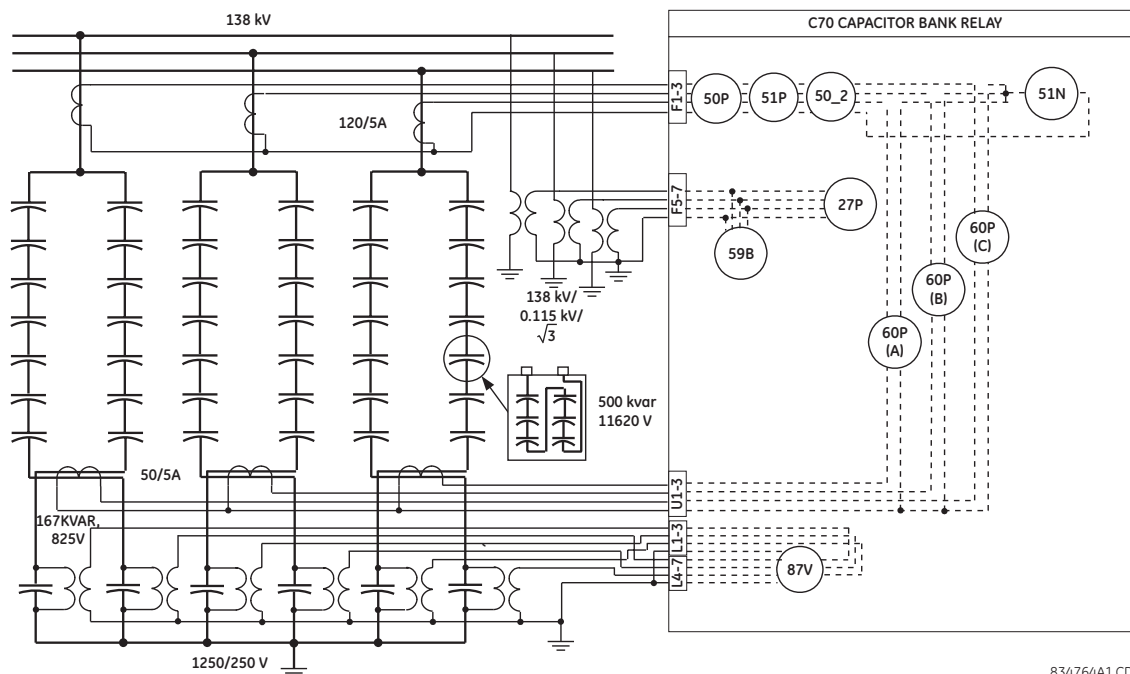


Figure 9-12: SAMPLE CAPACITOR BANK CONFIGURATION

Based on the bank configuration, CT connections, and VTs connections, a C70 model is chosen with three CT/VT modules: two type 8F modules (in slots F and U) and one type 8V module (in slot L) 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.

9.4.2 VT AND CT SETUP

The CT and VT connections are shown in the figure above. The CT channels are connected as follows.

- The type 8F 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 8F 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 8F 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 L1 to L3 and L5 to L7 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:

$$V_{tap(bus)} = \frac{13800}{\sqrt{3}} = 79674.34 \text{ V} \quad (\text{EQ 9.1})$$

The nominal tap VT voltage is:

$$V_{tap(nominal)} = \frac{138000 \times Z_C^b}{\sqrt{3} \times Z_C^t} = \frac{13800 \times 4.08}{\sqrt{3} \times 1894.42} = 171.41 \text{ V} \quad (\text{EQ 9.2})$$

Therefore, the tap VT secondary voltage is set as:

$$V_{tap(secondary)} = \frac{V_{tap(nominal)}}{N_{tap(VT)}} = \frac{171.41 \text{ V}}{5} = 34.28 \text{ V} \quad (\text{EQ 9.3})$$

Where the VT ratio $N_{tap(VT)}$ is calculated as:

$$N_{tap(VT)} = \frac{125 \text{ kV}}{0.25 \text{ kV}} = 5 \quad (\text{EQ 9.4})$$

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 |

9.4.3 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 |

At the bottom of the window, it says 'C70_520.urs System Setup'.

9.4.4 BANK UNBALANCE CALCULATIONS

The following values are used in unbalance calculations.

The impedance of one capacitor can:

$$Z_C^c = \frac{V_C^2}{Q_C} = \frac{(11.62 \text{ V})^2}{500 \times 10^{-3} \text{ vars}} = 270.05 \Omega \quad (\text{EQ 9.5})$$

The impedance of one capacitor element, with $n = 6$ capacitor elements per can:

$$Z_C^e = \frac{Z_C^c}{n} = \frac{270.05 \Omega}{6} = 45.01 \Omega \quad (\text{EQ 9.6})$$

The impedance of the top healthy capacitor string:

$$Z_C^s = Z_C^c \times N = 270.05 \Omega \times 7 = 1890.35 \Omega \quad (\text{EQ 9.7})$$

The impedance of the bottom capacitor can:

$$Z_C^b = \frac{V_{CN}^2}{Q_C} = \frac{(0.825 \text{ V})^2}{0.167 \text{ var}} = 4.08 \Omega \quad (\text{EQ 9.8})$$

The total impedance of the healthy capacitor string:

$$Z_C^t = Z_C^s + Z_C^b = 1890.35 \Omega + 4.08 \Omega = 1984.42 \Omega \quad (\text{EQ 9.9})$$

The maximum line-to-neutral system voltage:

$$V_{max} = V_C \times N + \frac{V_C \times N}{Z_C^s} \times Z_C^b = 11620 \text{ V} \times 7 + \frac{11620 \text{ V} \times 7}{1890.35 \Omega} \times 4.08 \Omega = 81515.37 \text{ V} \quad (\text{EQ 9.10})$$

The maximum phase current of the healthy bank:

$$I_{max} = \frac{V_{max}}{Z_C^t/2} = \frac{81515.37 \text{ V}}{1984.42 \Omega/2} = 86.06 \text{ A} \quad (\text{EQ 9.11})$$

The maximum voltage across the healthy top section:

$$V_{top} = \frac{V_{max} \times Z_C^s}{Z_C^t} = \frac{81515.37 \text{ V} \times 1890.35 \Omega}{1984.42 \Omega} = 81340.40 \text{ V} \quad (\text{EQ 9.12})$$

The maximum voltage across the healthy bottom section:

$$V_{bottom} = \frac{V_{max} \times Z_C^b}{Z_C^t} = \frac{81515.37 \text{ V} \times 4.08 \Omega}{1984.42 \Omega} = 175.37 \text{ V} \quad (\text{EQ 9.13})$$

The voltage distribution factor for the healthy perfectly balanced bank for the 87V-2 and 87V-3 elements:

$$K_{tap} = \frac{V_{top}}{V_{bottom}} = \frac{81340.40 \text{ V}}{175.37 \text{ V}} = 463.8194 \quad (\text{EQ 9.14})$$

The impedance of the string for the failed capacitors elements (for one failed element, $n_f = 1$):

$$Z_C^{sf} = Z_C^e(N \times n - n_f) + Z_C^b = 45.01 \Omega \times (7 \times 6 - 1) + 4.08 \Omega = 1849.41 \Omega \quad (\text{EQ 9.15})$$

The voltage at the tap in the section with one failed capacitor element in the string:

$$V_{tap2} = \frac{V_{max} \times Z_C^b}{Z_C^{sf}} = \frac{81515.37 \text{ V} \times 4.08 \Omega}{4.08 \Omega} = 179.64 \text{ V} \quad (\text{EQ 9.16})$$

The overvoltage at the affected capacitors with one capacitor element failed:

$$OV = \frac{V_{f(top)} \times N \times n}{V_{top} \times (N \times n - n_f)} = \frac{81335.74 \text{ V} \times 7 \times 6}{81340.40 \text{ V} \times (7 \times 6 - 1)} = 1.024 \text{ pu} \quad (\text{EQ 9.17})$$

The differential voltage between two taps with one failed capacitor element in the upper string, assuming $K = 1$, in per-unit values is:

$$V_{diff(tap)} = \left| \frac{V_{tap1} - K_{tap} \times V_{tap2}}{VT_{nom(tap)}} \right| = \left| \frac{175.374 \text{ V} - 1 \times 179.64 \text{ V}}{171.59 \text{ V}} \right| = 0.0249 \text{ pu} \quad (\text{EQ 9.18})$$

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:

$$V_{diff(string)} = \left| \frac{V_{f(top)} - K_{string} \times V_{tap2}}{VT_{nom(bus)}} \right| = \left| \frac{175.374 \text{ V} - 463.8194 \times 179.64 \text{ V}}{79674.34 \text{ V}} \right| = 0.0249 \text{ pu} \quad (\text{EQ 9.19})$$

The unbalance current in the window type CT between two strings with one failed capacitor element in the upper string:

$$I_{unbal} = \left| \frac{V_{max}}{Z_C^{sf} \times CT_{tap}} - \frac{V_{max}}{Z_C^s \times CT_{tapl}} \right| = \left| \frac{81515.37 \text{ V}}{1845.33 \Omega \times 50} - \frac{81515.37 \text{ V}}{1890.34 \Omega \times 50} \right| = 0.0209 \text{ pu} \quad (\text{EQ 9.20})$$

The following table summarizes the calculated values for the number of failed capacitors used to set the protection elements.

Table 9–1: 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:

$$V_{min} = \frac{0.85 \times V_{nom}}{\sqrt{3}} = \frac{0.85 \times 138000 \text{ V}}{\sqrt{3}} = 67723 \text{ V} \quad (\text{EQ 9.21})$$

The following table summarizes the unbalance values during minimum system conditions.

Table 9–2: 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.

9.4.5 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.

$$87V \text{ alarm} = 0.9 V_{diff(f1_max)} = 0.9 \times 0.0249 \text{ pu} = 0.0224 \text{ pu} \quad (\text{EQ 9.22})$$

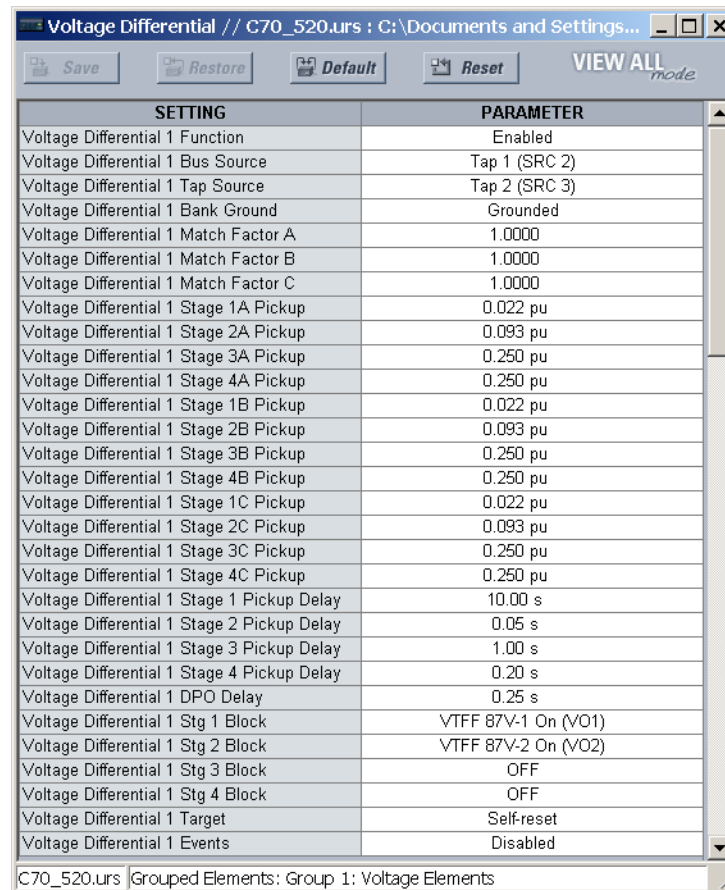
The alarm delay is set to 10 seconds to avoid alarming during transient conditions.

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.

$$87V \text{ trip} = \frac{V_{diff(f4_max)} + V_{diff(f3_max)}}{2} = \frac{0.1074 \text{ pu} + 0.0785 \text{ pu}}{2} = 0.093 \text{ pu} \quad (\text{EQ 9.23})$$

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 (V01) |
| Voltage Differential 1 Stg 2 Block | VTFF 87V-2 On (V02) |
| 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 |

C70_520.urs | Grouped Elements: Group 1: Voltage Elements

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™.

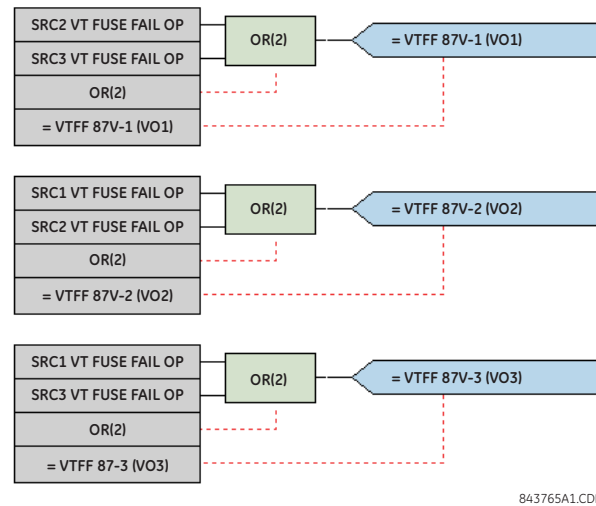


Figure 9–13: VOLTAGE DIFFERENTIAL BLOCKING DURING VT FUSE FAILURE

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.

9.4.6 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.

$$60P \text{ alarm} = 0.9 I_{unbal(f1_max)} = 0.9 \times 0.0209 \text{ pu} = 0.019 \text{ pu} \quad (\text{EQ 9.24})$$

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 |

C70_520.urs | Grouped Elements: Group 1: Phase Current

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.

$$60P \text{ trip} = \frac{I_{unbal}(f4_max) + I_{unbal}(f3_max)}{2} = \frac{0.0904 \text{ pu} + 0.0660 \text{ pu}}{2} = 0.078 \text{ pu} \quad (\text{EQ 9.25})$$

Therefore, the trip delay is chosen 50 ms.

9.4.7 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.

$$\begin{aligned} 59B \text{ pickup (stage 1)} &= 0.9 \times 1.25 = 1.125 \text{ pu} \\ 59B \text{ pickup (stage 2)} &= 0.9 \times 1.5 = 1.35 \text{ pu} \\ 59B \text{ pickup (stage 3)} &= 0.9 \times 2 = 1.80 \text{ pu} \end{aligned} \quad (\text{EQ 9.26})$$

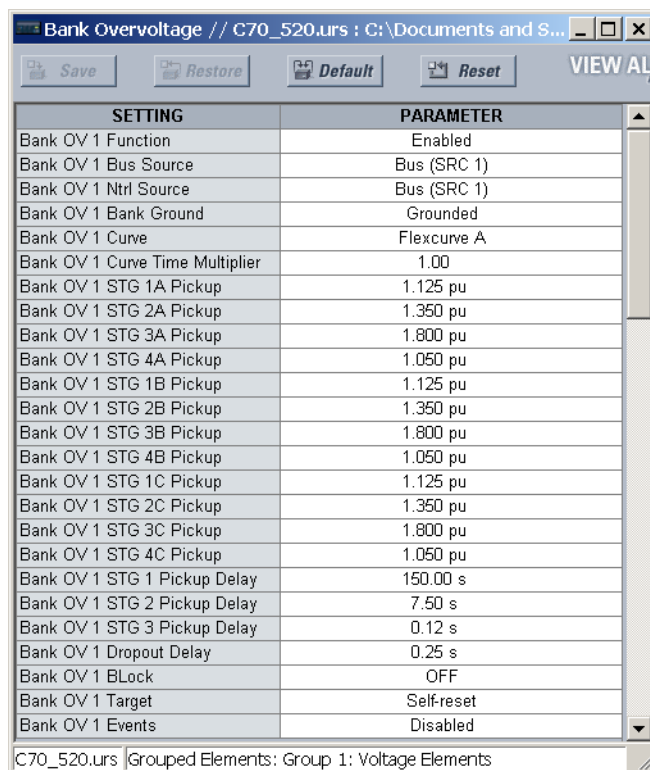
$$59B \text{ delay (stage 1)} = 0.5 \times 5 \times 60 = 150 \text{ seconds}$$

$$59B \text{ delay (stage 2)} = 0.5 \times 15 = 7.5 \text{ seconds}$$

(EQ 9.27)

$$59B \text{ delay (stage 3)} = 0.5 \times 0.25 = 0.125 \text{ seconds}$$

The following setting values are programmed in the EnerVista UR Setup software.



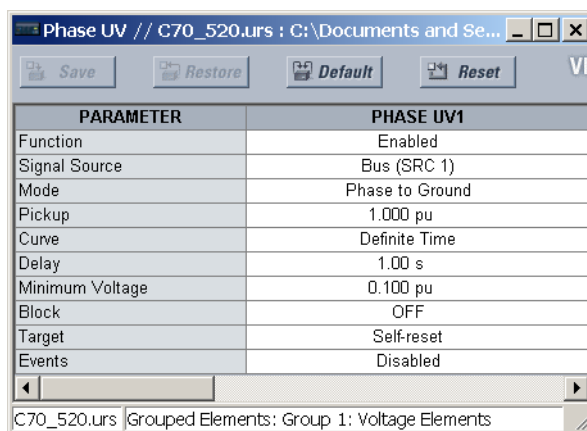
| SETTING | PARAMETER |
|---------------------------------|-------------|
| Bank OV 1 Function | Enabled |
| Bank OV 1 Bus Source | Bus (SRC 1) |
| Bank OV 1 Ntrl Source | Bus (SRC 1) |
| Bank OV 1 Bank Ground | Grounded |
| Bank OV 1 Curve | Flexcurve A |
| Bank OV 1 Curve Time Multiplier | 1.00 |
| 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 |

C70_520.urs | Grouped Elements: Group 1: Voltage Elements

9.4.8 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 |

C70_520.urs | Grouped Elements: Group 1: Voltage Elements

9.4.9 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 PARAMETERS

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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 |

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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 |

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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 |

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Table A-1: FLEXANALOG DATA ITEMS (Sheet 28 of 31)

| ADDRESS | FLEXANALOG NAME | UNITS | DESCRIPTION |
|---------|----------------------|-------|--|
| 10743 | SRC 6 lb Harm[14] | Amps | Source 6 phase B current sixteenth harmonic |
| 10744 | SRC 6 lb Harm[15] | Amps | Source 6 phase B current seventeenth harmonic |
| 10745 | SRC 6 lb Harm[16] | Amps | Source 6 phase B current eighteenth harmonic |
| 10746 | SRC 6 lb Harm[17] | Amps | Source 6 phase B current nineteenth harmonic |
| 10747 | SRC 6 lb Harm[18] | Amps | Source 6 phase B current twentieth harmonic |
| 10748 | SRC 6 lb Harm[19] | Amps | Source 6 phase B current twenty-first harmonic |
| 10749 | SRC 6 lb Harm[20] | Amps | Source 6 phase B current twenty-second harmonic |
| 10750 | SRC 6 lb Harm[21] | Amps | Source 6 phase B current twenty-third harmonic |
| 10751 | SRC 6 lb Harm[22] | Amps | Source 6 phase B current twenty-fourth harmonic |
| 10752 | SRC 6 lb Harm[23] | Amps | Source 6 phase B current twenty-fifth harmonic |
| 10753 | SRC 6 lc THD | --- | Source 6 phase C current total harmonic distortion |
| 10754 | SRC 6 lc Harm[0] | Amps | Source 6 phase C current second harmonic |
| 10755 | SRC 6 lc Harm[1] | Amps | Source 6 phase C current third harmonic |
| 10756 | SRC 6 lc Harm[2] | Amps | Source 6 phase C current fourth harmonic |
| 10757 | SRC 6 lc Harm[3] | Amps | Source 6 phase C current fifth harmonic |
| 10758 | SRC 6 lc Harm[4] | Amps | Source 6 phase C current sixth harmonic |
| 10759 | SRC 6 lc Harm[5] | Amps | Source 6 phase C current seventh harmonic |
| 10760 | SRC 6 lc Harm[6] | Amps | Source 6 phase C current eighth harmonic |
| 10761 | SRC 6 lc Harm[7] | Amps | Source 6 phase C current ninth harmonic |
| 10762 | SRC 6 lc Harm[8] | Amps | Source 6 phase C current tenth harmonic |
| 10763 | SRC 6 lc Harm[9] | Amps | Source 6 phase C current eleventh harmonic |
| 10764 | SRC 6 lc Harm[10] | Amps | Source 6 phase C current twelfth harmonic |
| 10765 | SRC 6 lc Harm[11] | Amps | Source 6 phase C current thirteenth harmonic |
| 10766 | SRC 6 lc Harm[12] | Amps | Source 6 phase C current fourteenth harmonic |
| 10767 | SRC 6 lc Harm[13] | Amps | Source 6 phase C current fifteenth harmonic |
| 10768 | SRC 6 lc Harm[14] | Amps | Source 6 phase C current sixteenth harmonic |
| 10769 | SRC 6 lc Harm[15] | Amps | Source 6 phase C current seventeenth harmonic |
| 10770 | SRC 6 lc Harm[16] | Amps | Source 6 phase C current eighteenth harmonic |
| 10771 | SRC 6 lc Harm[17] | Amps | Source 6 phase C current nineteenth harmonic |
| 10772 | SRC 6 lc Harm[18] | Amps | Source 6 phase C current twentieth harmonic |
| 10773 | SRC 6 lc Harm[19] | Amps | Source 6 phase C current twenty-first harmonic |
| 10774 | SRC 6 lc Harm[20] | Amps | Source 6 phase C current twenty-second harmonic |
| 10775 | SRC 6 lc Harm[21] | Amps | Source 6 phase C current twenty-third harmonic |
| 10776 | SRC 6 lc Harm[22] | Amps | Source 6 phase C current twenty-fourth harmonic |
| 10777 | SRC 6 lc Harm[23] | Amps | Source 6 phase C current twenty-fifth harmonic |
| 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 |
| 13526 | DCMA Inputs 12 Value | mA | dcmA input 12 actual value |

Table A-1: FLEXANALOG DATA ITEMS (Sheet 29 of 31)

| ADDRESS | FLEXANALOG NAME | UNITS | DESCRIPTION |
|---------|----------------------|-------|----------------------------|
| 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 |
| 13586 | RTD Inputs 35 Value | --- | RTD input 35 actual value |

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Table A-1: FLEXANALOG DATA ITEMS (Sheet 30 of 31)

| ADDRESS | FLEXANALOG NAME | UNITS | DESCRIPTION |
|---------|----------------------|---------|--|
| 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 lop A | Amps | Phase current balance composite phase A operating current actual value |
| 13832 | 60P 1 Comp lop B | Amps | Phase current balance composite phase B operating current actual value |
| 13834 | 60P 1 Comp lop 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 lop | Amps | Neutral current unbalance lop 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 |
| 39431 | FlexElement 4 Value | --- | FlexElement™ 4 actual value |

Table A–1: FLEXANALOG DATA ITEMS (Sheet 31 of 31)

| ADDRESS | FLEXANALOG NAME | UNITS | DESCRIPTION |
|---------|----------------------|-------|---------------------------------|
| 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 |
| 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 |

A

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 | <i>N</i> 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 μ s 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 | | |
| | A _{low} | low order byte of A | | |
| | A _{high} | 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 | | |
| | D _i | 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. | D _i (+) A _{low} --> A _{low} | | |
| | 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 | | SLAVE RESPONSE | |
|------------------------------|---------------|----------------|---------------|
| PACKET FORMAT | EXAMPLE (HEX) | PACKET FORMAT | EXAMPLE (HEX) |
| SLAVE ADDRESS | 11 | SLAVE ADDRESS | 11 |
| FUNCTION CODE | 04 | FUNCTION CODE | 04 |
| DATA STARTING ADDRESS - high | 40 | BYTE COUNT | 06 |
| DATA STARTING ADDRESS - low | 50 | DATA #1 - high | 00 |
| NUMBER OF REGISTERS - high | 00 | DATA #1 - low | 28 |
| NUMBER OF REGISTERS - low | 03 | DATA #2 - high | 01 |
| CRC - low | A7 | DATA #2 - low | 2C |
| CRC - high | 4A | DATA #3 - high | 00 |
| | | DATA #3 - low | 00 |
| | | CRC - low | 0D |
| | | CRC - high | 60 |

B.2.3 EXECUTE OPERATION (FUNCTION CODE 05H)

This function code allows the master to perform various operations in the relay. Available operations are shown in the *Summary of operation codes* table below.

The following table shows the format of the master and slave packets. The example shows a master device requesting the slave device 11h (17 decimal) to perform a reset. The high and low code value bytes always have the values “FF” and “00” respectively and are a remnant of the original Modbus definition of this function code.

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 | | SLAVE RESPONSE | |
|----------------------------|---------------|----------------------------|---------------|
| PACKET FORMAT | EXAMPLE (HEX) | PACKET FORMAT | EXAMPLE (HEX) |
| SLAVE ADDRESS | 11 | SLAVE ADDRESS | 11 |
| FUNCTION CODE | 10 | FUNCTION CODE | 10 |
| DATA STARTING ADDRESS - hi | 40 | DATA STARTING ADDRESS - hi | 40 |
| DATA STARTING ADDRESS - lo | 51 | DATA STARTING ADDRESS - lo | 51 |
| NUMBER OF SETTINGS - hi | 00 | NUMBER OF SETTINGS - hi | 00 |
| NUMBER OF SETTINGS - lo | 02 | NUMBER OF SETTINGS - lo | 02 |
| BYTE COUNT | 04 | CRC - lo | 07 |
| DATA #1 - high order byte | 00 | CRC - hi | 64 |
| 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 | | |

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 | | SLAVE RESPONSE | |
|-----------------------|---------------|-----------------------|---------------|
| PACKET FORMAT | EXAMPLE (HEX) | PACKET FORMAT | EXAMPLE (HEX) |
| SLAVE ADDRESS | 11 | SLAVE ADDRESS | 11 |
| FUNCTION CODE | 39 | FUNCTION CODE | B9 |
| CRC - low order byte | CD | ERROR CODE | 01 |
| CRC - high order byte | F2 | 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:

OSCnnnnn.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 yyyyyy` (replace `xxxxx` with the starting record number and `yyyyyy` 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.

B.4.1 MODBUS MEMORY MAP

Table B–9: MODBUS MEMORY MAP (Sheet 1 of 51)

| 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 51)

| 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 |

Table B–9: MODBUS MEMORY MAP (Sheet 3 of 51)

| 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) |
| 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 |
| 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 |

Table B-9: MODBUS MEMORY MAP (Sheet 4 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|--|---------------------------------|---------|-------|--------|---------|
| 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 | | | | | |
| 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 |

Table B–9: MODBUS MEMORY MAP (Sheet 5 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|--|---------------------------------|-------|-------|--------|--------------|
| 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) |
| 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 |

Table B-9: MODBUS MEMORY MAP (Sheet 6 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---|-----------------|----------------------|-------|--------|----------------|
| 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) |
| 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) |
| 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) |

Table B–9: MODBUS MEMORY MAP (Sheet 7 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|---------------------|-------|--------|--------|--------------|
| 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 | | | | | |
| 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 |

Table B-9: MODBUS MEMORY MAP (Sheet 8 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|----------------------|---------------------|-------|------|--------|---------|
| 34C2 | DCMA Inputs 2 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34C4 | DCMA Inputs 3 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34C6 | DCMA Inputs 4 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34C8 | DCMA Inputs 5 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34CA | DCMA Inputs 6 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34CC | DCMA Inputs 7 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34CE | DCMA Inputs 8 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34D0 | DCMA Inputs 9 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34D2 | DCMA Inputs 10 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34D4 | DCMA Inputs 11 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34D6 | DCMA Inputs 12 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34D8 | DCMA Inputs 13 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34DA | DCMA Inputs 14 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34DC | DCMA Inputs 15 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34DE | DCMA Inputs 16 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34E0 | DCMA Inputs 17 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34E2 | DCMA Inputs 18 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34E4 | DCMA Inputs 19 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34E6 | DCMA Inputs 20 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34E8 | DCMA Inputs 21 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34EA | DCMA Inputs 22 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34EC | DCMA Inputs 23 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| 34EE | DCMA Inputs 24 Value | -9999999 to 9999999 | --- | 1 | F004 | 0 |
| RTD Input Values (Read Only) (48 modules) | | | | | | |
| 34F0 | RTD Input 1 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F1 | RTD Input 2 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F2 | RTD Input 3 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F3 | RTD Input 4 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F4 | RTD Input 5 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F5 | RTD Input 6 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F6 | RTD Input 7 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F7 | RTD Input 8 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F8 | RTD Input 9 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F9 | RTD Input 10 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34FA | RTD Input 11 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34FB | RTD Input 12 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34FC | RTD Input 13 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34FD | RTD Input 14 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34FE | RTD Input 15 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34FF | RTD Input 16 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 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 |

Table B-9: MODBUS MEMORY MAP (Sheet 9 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|--|-----------------|-------|--------|--------|-------------|
| 350E | RTD Input 31 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 350F | RTD Input 32 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3510 | RTD Input 33 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3511 | RTD Input 34 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3512 | RTD Input 35 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3513 | RTD Input 36 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3514 | RTD Input 37 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3515 | RTD Input 38 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3516 | RTD Input 39 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3517 | RTD Input 40 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3518 | RTD Input 41 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 3519 | RTD Input 42 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 351A | RTD Input 43 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 351B | RTD Input 44 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 351C | RTD Input 45 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 351D | RTD Input 46 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 351E | RTD Input 47 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 351F | RTD Input 48 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 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 lop A | 0 to 99.9999 | pu | 0.0001 | F004 | 0 |
| 3608 | Phase current unbalance 1 comp lop B | 0 to 99.9999 | pu | 0.0001 | F004 | 0 |
| 360A | Phase current unbalance 1 comp lop 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 lop | 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 10 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---|-----------------|-------|-------|--------|--------------|
| 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 |
| 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 | min. | 1 | F001 | 5 |
| 4013 | Setting password access timeout | 5 to 480 | min. | 1 | F001 | 30 |
| 4014 | Invalid password attempts | 2 to 5 | --- | 1 | F001 | 3 |
| 4015 | Password lockout duration | 5 to 60 | min. | 1 | F001 | 5 |
| 4016 | Password access events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 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 |

Table B–9: MODBUS MEMORY MAP (Sheet 11 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---|-----------------|-------|------|--------|-----------------|
| 4089 | IP Subnet Mask | 0 to 4294967295 | --- | 1 | F003 | 4294966272 |
| 408B | Gateway IP Address | 0 to 4294967295 | --- | 1 | F003 | 56554497 |
| 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 16 | --- | 1 | F001 | 0 |
| 40C9 | DNP TCP connection timeout | 0 to 16 | --- | 1 | F001 | 0 |
| 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 |
| 40FD | Reserved (60 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) |

Table B-9: MODBUS MEMORY MAP (Sheet 12 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---|-----------------|-------|------|--------|---------------------|
| 4144 | DNP object 22 default variation | 0 to 3 | --- | 1 | F523 | 0 (1) |
| 4145 | DNP object 23 default variation | 0 to 3 | --- | 1 | F523 | 0 (1) |
| 4146 | DNP object 30 default variation | 1 to 5 | --- | 1 | F001 | 1 |
| 4147 | DNP object 32 default variation | 0 to 5 | --- | 1 | F525 | 0 (1) |
| 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) |
| 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 13 of 51)

| 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 <i>n</i> (16 items) | 0 to 65535 | --- | 1 | F600 | 0 |
| 4200 | Oscillography Digital Channel <i>n</i> (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 |
| Breaker restrike (read/write settings) | | | | | | |
| 4262 | Breaker restrike 1 function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 4263 | Breaker restrike 1 block | 0 to 65535 | --- | 1 | F300 | 0 |
| 4264 | Breaker restrike 1 signal source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 4265 | Breaker restrike 1 pickup | 0.1 to 2 | pu | 0.01 | F001 | 500 |
| 4266 | Breaker restrike 1 reset delay | 0 to 65.535 | s | 0.001 | F001 | 100 |
| 4267 | Breaker restrike 1 breaker open | 0 to 65535 | --- | 1 | F300 | 0 |
| 4268 | Breaker restrike 1 open command | 0 to 65535 | --- | 1 | F300 | 0 |
| 4269 | Breaker restrike 1 close command | 0 to 65535 | --- | 1 | F300 | 0 |
| 426A | Breaker restrike 1 target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 426B | Breaker restrike 1 events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 426C | ...Repeated for breaker restrike 2 | | | | | |
| 4276 | ...Repeated for breaker restrike 3 | | | | | |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 14 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|------------|-------|------|--------|--------------------|
| 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 | | | | | |
| 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 IRI-G-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 | | | | | |

Table B–9: MODBUS MEMORY MAP (Sheet 15 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|--|--------------|-------|-------|--------|--------------|
| 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) |
| 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 1000000 | 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 1000000 | 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 2 | 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 16 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---|------------|-------|------|--------|----------------------|
| 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 |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 17 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|-------------------------------------|------------|-------|------|--------|-----------------|
| 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 | | | | | |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 18 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|------------|-------|-------|--------|-------------------|
| 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 | | | | | |
| 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 | | | | | |

Table B–9: MODBUS MEMORY MAP (Sheet 19 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|------------|-------|-------|--------|-------------------|
| 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) |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 20 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|------------|-------|-------|--------|-------------------|
| 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 |
| 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) |
| 5494 | 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) |

Table B-9: MODBUS MEMORY MAP (Sheet 21 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|--|----------------|-------|-------|--------|-----------------|
| 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 |
| 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 |

Table B-9: MODBUS MEMORY MAP (Sheet 22 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---------------------------------------|-----------------------|-------|-------|--------|---------------------|
| 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 |
| 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 |
| 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 | | | | | |

Table B–9: MODBUS MEMORY MAP (Sheet 23 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---|--------------|-------|-------|--------|--------------|
| 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 2 | s | 0.001 | F001 | 70 |
| 7550 | Disconnect switch 1 alarm delay | 0 to 1000000 | 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 | | | | | |
| 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) |

Table B-9: MODBUS MEMORY MAP (Sheet 24 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|------------|-------|-------|--------|-------------------|
| 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 |
| 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 | | | | | |
| 7B8C | ...Repeated for User Programmable Pushbutton 3 | | | | | |
| 7B8D | ...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 |

Table B–9: MODBUS MEMORY MAP (Sheet 25 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|-----------------|-------|-------|--------|-----------------|
| 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 |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 26 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--------------------------------------|------------------------------------|------------|-------|------|--------|--------------|
| 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 | | | | | |
| 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 |

Table B-9: MODBUS MEMORY MAP (Sheet 27 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---------------------------------|-------------|-------|-------|--------|------------------|
| 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 |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 28 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|------------|-------|-------|--------|----------------|
| 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 | | | | | |
| 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 | | | | | |

Table B–9: MODBUS MEMORY MAP (Sheet 29 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|--|-----------------------------|-------|-------|--------|--------------|
| 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 | | | | | |
| 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 |
| 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 |
| 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 |

Table B-9: MODBUS MEMORY MAP (Sheet 30 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|--|-----------------|-------|--------|--------|--------------------------|
| 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) |
| 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 |

Table B–9: MODBUS MEMORY MAP (Sheet 31 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|--|-------------------|-------|--------|--------|-----------------|
| 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 0.250 | 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 0.250 | 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 0.250 | 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 0.250 | 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 |
| 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 |

Table B–9: MODBUS MEMORY MAP (Sheet 32 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|---------------------|-------|--------|--------|----------------|
| 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 0.2500 | pu | 0.001 | F001 | 10 |
| 9E4B | Voltage differential 1 stage 2A pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 20 |
| 9E4C | Voltage differential 1 stage 3A pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 30 |
| 9E4D | Voltage differential 1 stage 4A pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 40 |
| 9E4E | Voltage differential 1 stage 1B pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 10 |
| 9E5F | Voltage differential 1 stage 2B pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 20 |
| 9E50 | Voltage differential 1 stage 3B pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 30 |
| 9E51 | Voltage differential 1 stage 4B pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 40 |
| 9E52 | Voltage differential 1 stage 1C pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 10 |
| 9E53 | Voltage differential 1 stage 2C pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 20 |
| 9E54 | Voltage differential 1 stage 3C pickup | 0.001 to 0.2500 | pu | 0.001 | F001 | 30 |
| 9E55 | Voltage differential 1 stage 4C pickup | 0.001 to 0.2500 | 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) | | | | | | |
| A040 | VT Fuse Failure Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 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 | | | | | |
| 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 |

Table B–9: MODBUS MEMORY MAP (Sheet 33 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|------------|-------|------|--------|--------------------|
| 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) |
| 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 |

Table B–9: MODBUS MEMORY MAP (Sheet 34 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|---------------------------|-------|-------|--------|-------------------|
| 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 | | | | | |
| 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 GOOSE/GSSE Configuration (Read/Write Setting) | | | | | | |
| AA80 | Default GOOSE/GSSE Update Time | 1 to 60 | s | 1 | F001 | 60 |
| AA81 | IEC 61850 GSSE Function (GsEna) | 0 to 1 | --- | 1 | F102 | 1 (Enabled) |
| AA82 | IEC 61850 GSSE ID | --- | --- | --- | F209 | "GSSEOut" |
| AAA3 | IEC 61850 GOOSE Function (GoEna) | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| AAA4 | IEC 61850 GSSE Destination MAC Address | --- | --- | --- | F072 | 0 |
| AAA7 | IEC 61850 Standard GOOSE ID | --- | --- | --- | F209 | "GOOSEOut" |
| AAC8 | IEC 61850 Standard GOOSE Destination MAC Address | --- | --- | --- | F072 | 0 |
| AACB | IEC 61850 GOOSE VLAN Transmit Priority | 0 to 7 | --- | 1 | F001 | 4 |
| AACC | IEC 61850 GOOSE VLAN ID | 0 to 4095 | --- | 1 | F001 | 0 |
| AACD | IEC 61850 GOOSE ETYPE APPID | 0 to 16383 | --- | 1 | F001 | 0 |
| AACE | Reserved (2 items) | 0 to 1 | --- | 1 | F001 | 0 |
| IEC 61850 Server Configuration (Read/Write Settings/Commands) | | | | | | |
| AAD0 | TCP Port Number for the IEC 61850 / MMS Protocol | 1 to 65535 | --- | 1 | F001 | 102 |
| AAD1 | IEC 61850 Logical Device Name | --- | --- | --- | F213 | "IECName" |
| AAE1 | IEC 61850 Logical Device Instance | --- | --- | --- | F213 | "LDInst" |
| AAF1 | IEC 61850 LPHD Location | --- | --- | --- | F204 | "Location" |
| AB19 | Include non-IEC 61850 Data | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| AB1A | IEC 61850 Server Data Scanning Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |

Table B–9: MODBUS MEMORY MAP (Sheet 35 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---|---------------------------------|-------|-------|--------|---------|
| AB1B | Reserved (15 items) | | | | | |
| 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 RRExCx 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 (4 items) | 0 to 65534 | --- | 1 | F206 | (none) |
| AD31 | IEC 61850 logical node RFLOx name prefix (5 items) | 0 to 65534 | --- | 1 | F206 | (none) |
| AD40 | IEC 61850 logical node XCBRx name prefix (6 items) | 0 to 65534 | --- | 1 | F206 | (none) |
| AD52 | IEC 61850 logical node PTRCx name prefix (6 items) | 0 to 65534 | --- | 1 | F206 | (none) |
| AD64 | IEC 61850 logical node PDIFx name prefix (6 items) | 0 to 65534 | --- | 1 | F206 | (none) |
| AD70 | IEC 61850 logical node MMXNx name prefix (6 items) | 0 to 65534 | --- | 1 | F206 | (none) |
| IEC 61850 GGIO4 general analog configuration settings (read/write) | | | | | | |
| AF00 | Number of analog points in GGIO4 | 4 to 32 | --- | 4 | F001 | 4 |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 36 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---|--------------|-------|-------|--------|---------|
| 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) |
| 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 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.phsADeaband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0D2 | IEC 61850 MMXU PhV.phsB Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0D4 | IEC 61850 MMXU PhV.phsC Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0D6 | IEC 61850 MMXU A.phsA Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0D8 | IEC 61850 MMXU A.phsB Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0DA | IEC 61850 MMXU A.phsC Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0DC | IEC 61850 MMXU A.neut Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0DE | IEC 61850 MMXU W.phsA Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0E0 | IEC 61850 MMXU W.phsB Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0E2 | IEC 61850 MMXU W.phsC Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0E4 | IEC 61850 MMXU VAr.phsA Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |
| B0E6 | IEC 61850 MMXU VAr.phsB Deadband 1 | 0.001 to 100 | % | 0.001 | F003 | 10000 |

Table B-9: MODBUS MEMORY MAP (Sheet 37 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|--------------|-------|-------|--------|---------|
| B0E8 | IEC 61850 MMXU VA.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 GGIO2 Control Configuration (Read/Write Setting) (64 modules) | | | | | | |
| B240 | IEC 61850 GGIO2.CF.SPCSO1.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B241 | IEC 61850 GGIO2.CF.SPCSO2.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B242 | IEC 61850 GGIO2.CF.SPCSO3.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B243 | IEC 61850 GGIO2.CF.SPCSO4.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B244 | IEC 61850 GGIO2.CF.SPCSO5.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B245 | IEC 61850 GGIO2.CF.SPCSO6.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B246 | IEC 61850 GGIO2.CF.SPCSO7.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B247 | IEC 61850 GGIO2.CF.SPCSO8.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B248 | IEC 61850 GGIO2.CF.SPCSO9.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B249 | IEC 61850 GGIO2.CF.SPCSO10.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B24A | IEC 61850 GGIO2.CF.SPCSO11.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B24B | IEC 61850 GGIO2.CF.SPCSO12.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B24C | IEC 61850 GGIO2.CF.SPCSO13.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B24D | IEC 61850 GGIO2.CF.SPCSO14.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B24E | IEC 61850 GGIO2.CF.SPCSO15.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B24F | IEC 61850 GGIO2.CF.SPCSO16.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B250 | IEC 61850 GGIO2.CF.SPCSO17.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B251 | IEC 61850 GGIO2.CF.SPCSO18.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B252 | IEC 61850 GGIO2.CF.SPCSO19.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B253 | IEC 61850 GGIO2.CF.SPCSO20.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B254 | IEC 61850 GGIO2.CF.SPCSO21.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B255 | IEC 61850 GGIO2.CF.SPCSO22.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B256 | IEC 61850 GGIO2.CF.SPCSO23.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B257 | IEC 61850 GGIO2.CF.SPCSO24.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B258 | IEC 61850 GGIO2.CF.SPCSO25.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B259 | IEC 61850 GGIO2.CF.SPCSO26.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B25A | IEC 61850 GGIO2.CF.SPCSO27.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B25B | IEC 61850 GGIO2.CF.SPCSO28.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B25C | IEC 61850 GGIO2.CF.SPCSO29.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B25D | IEC 61850 GGIO2.CF.SPCSO30.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B25E | IEC 61850 GGIO2.CF.SPCSO31.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B25F | IEC 61850 GGIO2.CF.SPCSO32.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B260 | IEC 61850 GGIO2.CF.SPCSO33.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B261 | IEC 61850 GGIO2.CF.SPCSO34.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B262 | IEC 61850 GGIO2.CF.SPCSO35.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B263 | IEC 61850 GGIO2.CF.SPCSO36.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B264 | IEC 61850 GGIO2.CF.SPCSO37.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B265 | IEC 61850 GGIO2.CF.SPCSO38.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B266 | IEC 61850 GGIO2.CF.SPCSO39.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B267 | IEC 61850 GGIO2.CF.SPCSO40.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B268 | IEC 61850 GGIO2.CF.SPCSO41.ctilModel Value | 0 to 2 | --- | 1 | F001 | 2 |

Table B-9: MODBUS MEMORY MAP (Sheet 38 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|-----------------|-------|------|--------|---------------|
| B269 | IEC 61850 GGIO2.CF.SPCSO42.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B26A | IEC 61850 GGIO2.CF.SPCSO43.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B26B | IEC 61850 GGIO2.CF.SPCSO44.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B26C | IEC 61850 GGIO2.CF.SPCSO45.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B26D | IEC 61850 GGIO2.CF.SPCSO46.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B26E | IEC 61850 GGIO2.CF.SPCSO47.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B26F | IEC 61850 GGIO2.CF.SPCSO48.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B270 | IEC 61850 GGIO2.CF.SPCSO49.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B271 | IEC 61850 GGIO2.CF.SPCSO50.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B272 | IEC 61850 GGIO2.CF.SPCSO51.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B273 | IEC 61850 GGIO2.CF.SPCSO52.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B274 | IEC 61850 GGIO2.CF.SPCSO53.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B275 | IEC 61850 GGIO2.CF.SPCSO54.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B276 | IEC 61850 GGIO2.CF.SPCSO55.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B277 | IEC 61850 GGIO2.CF.SPCSO56.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B278 | IEC 61850 GGIO2.CF.SPCSO57.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B279 | IEC 61850 GGIO2.CF.SPCSO58.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B27A | IEC 61850 GGIO2.CF.SPCSO59.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B27B | IEC 61850 GGIO2.CF.SPCSO60.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B27C | IEC 61850 GGIO2.CF.SPCSO61.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B27D | IEC 61850 GGIO2.CF.SPCSO62.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| B27E | IEC 61850 GGIO2.CF.SPCSO63.cttlModel Value | 0 to 2 | --- | 1 | F001 | 2 |
| IEC 61850 Report Settings (Read/Write Setting) (14 modules) | | | | | | |
| B280 | IEC 61850 Report Control 1 RptID | --- | --- | --- | F209 | |
| B2A1 | IEC 61850 Report Control 1 OptFlds | 0 to 65535 | --- | 1 | F001 | 0 |
| B2A2 | IEC 61850 Report Control 1 BufTrm | 0 to 4294967295 | --- | 1 | F003 | 0 |
| B2A4 | IEC 61850 Report Control 1 TrgOps | 0 to 65535 | --- | 1 | F001 | 0 |
| B2A5 | IEC 61850 Report Control 1 IntgPd | 0 to 4294967295 | --- | 1 | F003 | 0 |
| B2A7 | ...Repeated for Report 2 | | | | | |
| B2CE | ...Repeated for Report 3 | | | | | |
| B2F5 | ...Repeated for Report 4 | | | | | |
| B31C | ...Repeated for Report 5 | | | | | |
| B343 | ...Repeated for Report 6 | | | | | |
| B36A | ...Repeated for Report 7 | | | | | |
| B391 | ...Repeated for Report 8 | | | | | |
| B3B8 | ...Repeated for Report 9 | | | | | |
| B3DF | ...Repeated for Report 10 | | | | | |
| B406 | ...Repeated for Report 11 | | | | | |
| B42D | ...Repeated for Report 12 | | | | | |
| B454 | ...Repeated for Report 13 | | | | | |
| B47B | ...Repeated for Report 14 | | | | | |
| B4A2 | ...Repeated for Report 15 | | | | | |
| B4C9 | ...Repeated for Report 16 | | | | | |
| 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 |

Table B-9: MODBUS MEMORY MAP (Sheet 39 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---|----------|-------|------|--------|--------------|
| B5CA | Configurable GOOSE Dataset Items for Transmission | 0 to 256 | --- | 1 | F232 | 0 (None) |
| B60A | ...Repeated for Module 2 | | | | | |
| B674 | ...Repeated for Module 3 | | | | | |
| B6DE | ...Repeated for Module 4 | | | | | |
| B748 | ...Repeated for Module 5 | | | | | |
| B7B2 | ...Repeated for Module 6 | | | | | |
| B81C | ...Repeated for Module 7 | | | | | |
| B886 | ...Repeated for Module 8 | | | | | |
| IEC 61850 Configurable GOOSE Reception (Read/Write Setting) (8 modules) | | | | | | |
| B900 | Configurable GOOSE Dataset Items for Transmission | 0 to 128 | --- | 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 | | | | | |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 40 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|----------------------------------|-------|-------|------|--------|---------|
| BC10 | ...Repeated for Contact Input 35 | | | | | |
| BC18 | ...Repeated for Contact Input 36 | | | | | |
| BC20 | ...Repeated for Contact Input 37 | | | | | |
| BC28 | ...Repeated for Contact Input 38 | | | | | |
| BC30 | ...Repeated for Contact Input 39 | | | | | |
| BC38 | ...Repeated for Contact Input 40 | | | | | |
| BC40 | ...Repeated for Contact Input 41 | | | | | |
| BC48 | ...Repeated for Contact Input 42 | | | | | |
| BC50 | ...Repeated for Contact Input 43 | | | | | |
| BC58 | ...Repeated for Contact Input 44 | | | | | |
| BC60 | ...Repeated for Contact Input 45 | | | | | |
| BC68 | ...Repeated for Contact Input 46 | | | | | |
| BC70 | ...Repeated for Contact Input 47 | | | | | |
| BC78 | ...Repeated for Contact Input 48 | | | | | |
| BC80 | ...Repeated for Contact Input 49 | | | | | |
| BC88 | ...Repeated for Contact Input 50 | | | | | |
| BC90 | ...Repeated for Contact Input 51 | | | | | |
| BC98 | ...Repeated for Contact Input 52 | | | | | |
| BCA0 | ...Repeated for Contact Input 53 | | | | | |
| BCA8 | ...Repeated for Contact Input 54 | | | | | |
| BCB0 | ...Repeated for Contact Input 55 | | | | | |
| BCB8 | ...Repeated for Contact Input 56 | | | | | |
| BCC0 | ...Repeated for Contact Input 57 | | | | | |
| BCC8 | ...Repeated for Contact Input 58 | | | | | |
| BCD0 | ...Repeated for Contact Input 59 | | | | | |
| BCD8 | ...Repeated for Contact Input 60 | | | | | |
| BCE0 | ...Repeated for Contact Input 61 | | | | | |
| BCE8 | ...Repeated for Contact Input 62 | | | | | |
| BCF0 | ...Repeated for Contact Input 63 | | | | | |
| BCF8 | ...Repeated for Contact Input 64 | | | | | |
| BD00 | ...Repeated for Contact Input 65 | | | | | |
| BD08 | ...Repeated for Contact Input 66 | | | | | |
| BD10 | ...Repeated for Contact Input 67 | | | | | |
| BD18 | ...Repeated for Contact Input 68 | | | | | |
| BD20 | ...Repeated for Contact Input 69 | | | | | |
| BD28 | ...Repeated for Contact Input 70 | | | | | |
| BD30 | ...Repeated for Contact Input 71 | | | | | |
| BD38 | ...Repeated for Contact Input 72 | | | | | |
| BD40 | ...Repeated for Contact Input 73 | | | | | |
| BD48 | ...Repeated for Contact Input 74 | | | | | |
| BD50 | ...Repeated for Contact Input 75 | | | | | |
| BD58 | ...Repeated for Contact Input 76 | | | | | |
| BD60 | ...Repeated for Contact Input 77 | | | | | |
| BD68 | ...Repeated for Contact Input 78 | | | | | |
| BD70 | ...Repeated for Contact Input 79 | | | | | |
| BD78 | ...Repeated for Contact Input 80 | | | | | |
| BD80 | ...Repeated for Contact Input 81 | | | | | |
| BD88 | ...Repeated for Contact Input 82 | | | | | |
| BD90 | ...Repeated for Contact Input 83 | | | | | |
| BD98 | ...Repeated for Contact Input 84 | | | | | |
| BDA0 | ...Repeated for Contact Input 85 | | | | | |
| BDA8 | ...Repeated for Contact Input 86 | | | | | |
| BDB0 | ...Repeated for Contact Input 87 | | | | | |
| BDB8 | ...Repeated for Contact Input 88 | | | | | |

Table B–9: MODBUS MEMORY MAP (Sheet 41 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|--------|-------|------|--------|--------------|
| 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 | | | | | |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 42 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|-----------------------------------|--------|-------|------|--------|--------------|
| C004 | ...Repeated for Virtual Input 40 | | | | | |
| C010 | ...Repeated for Virtual Input 41 | | | | | |
| C01C | ...Repeated for Virtual Input 42 | | | | | |
| C028 | ...Repeated for Virtual Input 43 | | | | | |
| C034 | ...Repeated for Virtual Input 44 | | | | | |
| C040 | ...Repeated for Virtual Input 45 | | | | | |
| C04C | ...Repeated for Virtual Input 46 | | | | | |
| C058 | ...Repeated for Virtual Input 47 | | | | | |
| C064 | ...Repeated for Virtual Input 48 | | | | | |
| C070 | ...Repeated for Virtual Input 49 | | | | | |
| C07C | ...Repeated for Virtual Input 50 | | | | | |
| C088 | ...Repeated for Virtual Input 51 | | | | | |
| C094 | ...Repeated for Virtual Input 52 | | | | | |
| C0A0 | ...Repeated for Virtual Input 53 | | | | | |
| C0AC | ...Repeated for Virtual Input 54 | | | | | |
| C0B8 | ...Repeated for Virtual Input 55 | | | | | |
| C0C4 | ...Repeated for Virtual Input 56 | | | | | |
| C0D0 | ...Repeated for Virtual Input 57 | | | | | |
| C0DC | ...Repeated for Virtual Input 58 | | | | | |
| C0E8 | ...Repeated for Virtual Input 59 | | | | | |
| C0F4 | ...Repeated for Virtual Input 60 | | | | | |
| C100 | ...Repeated for Virtual Input 61 | | | | | |
| C10C | ...Repeated for Virtual Input 62 | | | | | |
| C118 | ...Repeated for Virtual Input 63 | | | | | |
| C124 | ...Repeated for Virtual Input 64 | | | | | |
| Virtual Outputs (Read/Write Setting) (96 modules) | | | | | | |
| C130 | Virtual Output 1 Name | --- | --- | --- | F205 | "Virt Op 1 " |
| C136 | Virtual Output 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| C137 | Reserved | --- | --- | --- | F001 | 0 |
| C138 | ...Repeated for Virtual Output 2 | | | | | |
| C140 | ...Repeated for Virtual Output 3 | | | | | |
| C148 | ...Repeated for Virtual Output 4 | | | | | |
| C150 | ...Repeated for Virtual Output 5 | | | | | |
| C158 | ...Repeated for Virtual Output 6 | | | | | |
| C160 | ...Repeated for Virtual Output 7 | | | | | |
| C168 | ...Repeated for Virtual Output 8 | | | | | |
| C170 | ...Repeated for Virtual Output 9 | | | | | |
| C178 | ...Repeated for Virtual Output 10 | | | | | |
| C180 | ...Repeated for Virtual Output 11 | | | | | |
| C188 | ...Repeated for Virtual Output 12 | | | | | |
| C190 | ...Repeated for Virtual Output 13 | | | | | |
| C198 | ...Repeated for Virtual Output 14 | | | | | |
| C1A0 | ...Repeated for Virtual Output 15 | | | | | |
| C1A8 | ...Repeated for Virtual Output 16 | | | | | |
| C1B0 | ...Repeated for Virtual Output 17 | | | | | |
| C1B8 | ...Repeated for Virtual Output 18 | | | | | |
| C1C0 | ...Repeated for Virtual Output 19 | | | | | |
| C1C8 | ...Repeated for Virtual Output 20 | | | | | |
| C1D0 | ...Repeated for Virtual Output 21 | | | | | |
| C1D8 | ...Repeated for Virtual Output 22 | | | | | |
| C1E0 | ...Repeated for Virtual Output 23 | | | | | |
| C1E8 | ...Repeated for Virtual Output 24 | | | | | |
| C1F0 | ...Repeated for Virtual Output 25 | | | | | |
| C1F8 | ...Repeated for Virtual Output 26 | | | | | |

Table B–9: MODBUS MEMORY MAP (Sheet 43 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|-----------------------------------|-------|-------|------|--------|---------|
| C200 | ...Repeated for Virtual Output 27 | | | | | |
| C208 | ...Repeated for Virtual Output 28 | | | | | |
| C210 | ...Repeated for Virtual Output 29 | | | | | |
| C218 | ...Repeated for Virtual Output 30 | | | | | |
| C220 | ...Repeated for Virtual Output 31 | | | | | |
| C228 | ...Repeated for Virtual Output 32 | | | | | |
| C230 | ...Repeated for Virtual Output 33 | | | | | |
| C238 | ...Repeated for Virtual Output 34 | | | | | |
| C240 | ...Repeated for Virtual Output 35 | | | | | |
| C248 | ...Repeated for Virtual Output 36 | | | | | |
| C250 | ...Repeated for Virtual Output 37 | | | | | |
| C258 | ...Repeated for Virtual Output 38 | | | | | |
| C260 | ...Repeated for Virtual Output 39 | | | | | |
| C268 | ...Repeated for Virtual Output 40 | | | | | |
| C270 | ...Repeated for Virtual Output 41 | | | | | |
| C278 | ...Repeated for Virtual Output 42 | | | | | |
| C280 | ...Repeated for Virtual Output 43 | | | | | |
| C288 | ...Repeated for Virtual Output 44 | | | | | |
| C290 | ...Repeated for Virtual Output 45 | | | | | |
| C298 | ...Repeated for Virtual Output 46 | | | | | |
| C2A0 | ...Repeated for Virtual Output 47 | | | | | |
| C2A8 | ...Repeated for Virtual Output 48 | | | | | |
| C2B0 | ...Repeated for Virtual Output 49 | | | | | |
| C2B8 | ...Repeated for Virtual Output 50 | | | | | |
| C2C0 | ...Repeated for Virtual Output 51 | | | | | |
| C2C8 | ...Repeated for Virtual Output 52 | | | | | |
| C2D0 | ...Repeated for Virtual Output 53 | | | | | |
| C2D8 | ...Repeated for Virtual Output 54 | | | | | |
| C2E0 | ...Repeated for Virtual Output 55 | | | | | |
| C2E8 | ...Repeated for Virtual Output 56 | | | | | |
| C2F0 | ...Repeated for Virtual Output 57 | | | | | |
| C2F8 | ...Repeated for Virtual Output 58 | | | | | |
| C300 | ...Repeated for Virtual Output 59 | | | | | |
| C308 | ...Repeated for Virtual Output 60 | | | | | |
| C310 | ...Repeated for Virtual Output 61 | | | | | |
| C318 | ...Repeated for Virtual Output 62 | | | | | |
| C320 | ...Repeated for Virtual Output 63 | | | | | |
| C328 | ...Repeated for Virtual Output 64 | | | | | |
| C330 | ...Repeated for Virtual Output 65 | | | | | |
| C338 | ...Repeated for Virtual Output 66 | | | | | |
| C340 | ...Repeated for Virtual Output 67 | | | | | |
| C348 | ...Repeated for Virtual Output 68 | | | | | |
| C350 | ...Repeated for Virtual Output 69 | | | | | |
| C358 | ...Repeated for Virtual Output 70 | | | | | |
| C360 | ...Repeated for Virtual Output 71 | | | | | |
| C368 | ...Repeated for Virtual Output 72 | | | | | |
| C370 | ...Repeated for Virtual Output 73 | | | | | |
| C378 | ...Repeated for Virtual Output 74 | | | | | |
| C380 | ...Repeated for Virtual Output 75 | | | | | |
| C388 | ...Repeated for Virtual Output 76 | | | | | |
| C390 | ...Repeated for Virtual Output 77 | | | | | |
| C398 | ...Repeated for Virtual Output 78 | | | | | |
| C3A0 | ...Repeated for Virtual Output 79 | | | | | |
| C3A8 | ...Repeated for Virtual Output 80 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 44 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|--|------------|-------|------|--------|----------------------|
| 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 | F102 | 0 (Disabled) |
| C431 | Force VFD and LED | 0 to 1 | --- | 1 | F126 | 0 (No) |
| C432 | Test Mode Initiate | 0 to 65535 | --- | 1 | F300 | 1 |
| 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) |
| 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 | | | | | |

Table B–9: MODBUS MEMORY MAP (Sheet 45 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|--|------------|-------|------|--------|--------------|
| 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 | | | | | |
| 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 |

Table B-9: MODBUS MEMORY MAP (Sheet 46 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|------------|-------|------|--------|--------------|
| 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 | | | | | |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 47 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|---|--------------|-------|------|--------|--------------|
| 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 | | | | | |
| 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) |

Table B-9: MODBUS MEMORY MAP (Sheet 48 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|------------|-------|------|--------|-------------------|
| 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 8 | --- | 1 | F184 | 0 (Fixed) |
| CB23 | ...Repeated for Device 2 | | | | | |
| CB46 | ...Repeated for Device 3 | | | | | |
| CB69 | ...Repeated for Device 4 | | | | | |
| CB8C | ...Repeated for Device 5 | | | | | |
| CBAF | ...Repeated for Device 6 | | | | | |
| CBD2 | ...Repeated for Device 7 | | | | | |
| CBF5 | ...Repeated for Device 8 | | | | | |
| CC18 | ...Repeated for Device 9 | | | | | |
| CC3B | ...Repeated for Device 10 | | | | | |
| CC5E | ...Repeated for Device 11 | | | | | |
| CC81 | ...Repeated for Device 12 | | | | | |
| CCA4 | ...Repeated for Device 13 | | | | | |
| CCC7 | ...Repeated for Device 14 | | | | | |
| CCEA | ...Repeated for Device 15 | | | | | |
| CD0D | ...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) |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 49 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|----------------------------------|------------|-------|------|--------|--------------|
| 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 | | | | | |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 50 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|--|----------------------------------|-----------------|-------|------|--------|---------|
| 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 | | | | | |
| 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 | | | | | |

Table B-9: MODBUS MEMORY MAP (Sheet 51 of 51)

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|------------------------------|-----------------|-------|------|--------|-------------|
| 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 | bitmask | value | bitmask | value |
|---------|-------|---------|-------|---------|--------|
| 0 | 300 | 4 | 9600 | 8 | 115200 |
| 1 | 1200 | 5 | 19200 | 9 | 14400 |
| 2 | 2400 | 6 | 38400 | 10 | 28800 |
| 3 | 4800 | 7 | 57600 | 11 | 33600 |

F113**ENUMERATION: PARITY**

0 = None, 1 = Odd, 2 = Even

F114**ENUMERATION: IRIG-B SIGNAL TYPE**

0 = None, 1 = DC Shift, 2 = Amplitude Modulated

F115**ENUMERATION: BREAKER STATUS**

0 = Auxiliary A, 1 = Auxiliary B

F116**ENUMERATION: NEUTRAL OVERVOLTAGE CURVES**

0 = Definite Time, 1 = FlexCurve™ A, 2 = FlexCurve™ B, 3 = FlexCurve™ C

F117**ENUMERATION: NUMBER OF OSCILLOGRAPHY RECORDS**

0 = 1×72 cycles, 1 = 3×36 cycles, 2 = 7×18 cycles, 3 = 15×9 cycles

F118**ENUMERATION: OSCILLOGRAPHY MODE**

0 = Automatic Overwrite, 1 = Protected

F119**ENUMERATION: FLEXCURVE™ PICKUP RATIOS**

| mask | value | mask | value | mask | value | mask | value |
|------|-------|------|-------|------|-------|------|-------|
| 0 | 0.00 | 30 | 0.88 | 60 | 2.90 | 90 | 5.90 |
| 1 | 0.05 | 31 | 0.90 | 61 | 3.00 | 91 | 6.00 |
| 2 | 0.10 | 32 | 0.91 | 62 | 3.10 | 92 | 6.50 |
| 3 | 0.15 | 33 | 0.92 | 63 | 3.20 | 93 | 7.00 |
| 4 | 0.20 | 34 | 0.93 | 64 | 3.30 | 94 | 7.50 |
| 5 | 0.25 | 35 | 0.94 | 65 | 3.40 | 95 | 8.00 |
| 6 | 0.30 | 36 | 0.95 | 66 | 3.50 | 96 | 8.50 |
| 7 | 0.35 | 37 | 0.96 | 67 | 3.60 | 97 | 9.00 |
| 8 | 0.40 | 38 | 0.97 | 68 | 3.70 | 98 | 9.50 |
| 9 | 0.45 | 39 | 0.98 | 69 | 3.80 | 99 | 10.00 |
| 10 | 0.48 | 40 | 1.03 | 70 | 3.90 | 100 | 10.50 |
| 11 | 0.50 | 41 | 1.05 | 71 | 4.00 | 101 | 11.00 |
| 12 | 0.52 | 42 | 1.10 | 72 | 4.10 | 102 | 11.50 |
| 13 | 0.54 | 43 | 1.20 | 73 | 4.20 | 103 | 12.00 |
| 14 | 0.56 | 44 | 1.30 | 74 | 4.30 | 104 | 12.50 |
| 15 | 0.58 | 45 | 1.40 | 75 | 4.40 | 105 | 13.00 |
| 16 | 0.60 | 46 | 1.50 | 76 | 4.50 | 106 | 13.50 |
| 17 | 0.62 | 47 | 1.60 | 77 | 4.60 | 107 | 14.00 |
| 18 | 0.64 | 48 | 1.70 | 78 | 4.70 | 108 | 14.50 |
| 19 | 0.66 | 49 | 1.80 | 79 | 4.80 | 109 | 15.00 |
| 20 | 0.68 | 50 | 1.90 | 80 | 4.90 | 110 | 15.50 |
| 21 | 0.70 | 51 | 2.00 | 81 | 5.00 | 111 | 16.00 |
| 22 | 0.72 | 52 | 2.10 | 82 | 5.10 | 112 | 16.50 |
| 23 | 0.74 | 53 | 2.20 | 83 | 5.20 | 113 | 17.00 |
| 24 | 0.76 | 54 | 2.30 | 84 | 5.30 | 114 | 17.50 |
| 25 | 0.78 | 55 | 2.40 | 85 | 5.40 | 115 | 18.00 |
| 26 | 0.80 | 56 | 2.50 | 86 | 5.50 | 116 | 18.50 |
| 27 | 0.82 | 57 | 2.60 | 87 | 5.60 | 117 | 19.00 |
| 28 | 0.84 | 58 | 2.70 | 88 | 5.70 | 118 | 19.50 |
| 29 | 0.86 | 59 | 2.80 | 89 | 5.80 | 119 | 20.00 |

F122**ENUMERATION: ELEMENT INPUT SIGNAL TYPE**

0 = Phasor, 1 = RMS

F123**ENUMERATION: CT SECONDARY**

0 = 1 A, 1 = 5 A

F124**ENUMERATION: LIST OF ELEMENTS**

| bitmask | element |
|---------|-----------------------------------|
| 0 | Phase Instantaneous Overcurrent 1 |
| 1 | Phase Instantaneous Overcurrent 2 |
| 2 | Phase Instantaneous Overcurrent 3 |
| 3 | Phase Instantaneous Overcurrent 4 |
| 4 | Phase Instantaneous Overcurrent 5 |

| bitmask | element |
|---------|---|
| 5 | Phase Instantaneous Overcurrent 6 |
| 6 | Phase Instantaneous Overcurrent 7 |
| 7 | Phase Instantaneous Overcurrent 8 |
| 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 |
| 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 |
| 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 |
| 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 |

| bitmask | element |
|---------|-----------------------------------|
| 120 | Negative Sequence Overvoltage |
| 144 | Phase Undervoltage 1 |
| 145 | Phase Undervoltage 2 |
| 148 | Auxiliary Overvoltage 1 |
| 152 | Phase 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 |
| 407 | FlexElement™ 8 |
| 408 | FlexElement™ 9 |
| 409 | FlexElement™ 10 |
| 410 | FlexElement™ 11 |
| 411 | FlexElement™ 12 |
| 412 | FlexElement™ 13 |

B

| bitmask | element |
|---------|-----------------------|
| 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 |
| 712 | Digital Element 21 |
| 713 | Digital Element 22 |
| 714 | Digital Element 23 |
| 715 | Digital Element 24 |
| 716 | Digital Element 25 |
| 717 | Digital Element 26 |

| bitmask | element |
|---------|-----------------------------------|
| 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 |
| 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 |

| bitmask | element |
|---------|----------------------------------|
| 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 |
| 882 | RTD Input 34 |
| 883 | RTD Input 35 |
| 884 | RTD Input 36 |
| 885 | RTD Input 37 |
| 886 | RTD Input 38 |
| 887 | RTD Input 39 |

| bitmask | element |
|---------|---------------------------------|
| 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 |
| 942 | Disconnect switch 23 |
| 943 | Disconnect switch 24 |
| 968 | Breaker 1 |
| 969 | Breaker 2 |
| 970 | Breaker 3 |
| 971 | Breaker 4 |

| bitmask | element |
|---------|--------------------|
| 972 | Breaker 5 |
| 973 | Breaker 6 |
| 980 | Breaker restrike 1 |
| 981 | Breaker restrike 2 |
| 982 | Breaker restrike 3 |

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 | Maintenance Alert |
| 10 | FlexLogic Error Token |
| 11 | Equipment Mismatch |
| 13 | Unit Not Programmed |
| 14 | System Exception |
| 15 | Maintenance Alert |
| 16 | Ethernet Switch Failure |
| 17 | Maintenance Alert |
| 18 | Maintenance Alert |
| 19 | Maintenance Alert |
| 20 | Maintenance Alert |
| 21 | Maintenance Alert |
| 27 | Remote Device Off |
| 28 | Direct Device Off |
| 29 | Maintenance Alert |
| 30 | Any Minor Error |
| 31 | Any Major Error |
| 32 | DSP Error |
| 33 | No DSP Interrupts |
| 34 | Unit Not Calibrated |
| 35 | EEPROM Data Error |
| 36 | SRAM Data Error |
| 37 | Program Memory |
| 38 | Watchdog Error |
| 39 | Low On Memory |
| 40 | Prototype Firmware |

| bitmask | error |
|---------|-------------------|
| 41 | Module Failure 01 |
| 42 | Module Failure 02 |
| 43 | Module Failure 03 |
| 44 | Module Failure 04 |
| 45 | Module Failure 05 |
| 46 | Module Failure 06 |
| 47 | Module Failure 07 |
| 48 | Module Failure 08 |
| 49 | Module Failure 09 |
| 50 | Incompatible H/W |
| 51 | Maintenance Alert |
| 52 | Maintenance Alert |
| 53 | Maintenance Alert |
| 54 | Maintenance Alert |
| 55 | Maintenance Alert |
| 56 | Maintenance Alert |

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 On |
| 5 | Test Mode 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 | Corrupt DSP Program |
| 18 | Reload DSP Settings |
| 19 | DSP Hardware Error |
| 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 |

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 | 128 | Dataset Item 64 |

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

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

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

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 |

F185**ENUMERATION: PHASE A,B,C, GROUND SELECTOR**

0 = A, 1 = B, 2 = C, 3 = G

F186**ENUMERATION: MEASUREMENT MODE**

0 = Phase to Ground, 1 = Phase to Phase

F190**ENUMERATION: SIMULATED KEYPRESS**

| bitmsk | keypress | bitmsk | keypress |
|--------|------------------------------|--------|-----------------------------|
| 0 | --- use between real keys | 23 | Reset |
| 1 | 1 | 24 | User 1 |
| 2 | 2 | 25 | User 2 |
| 3 | 3 | 26 | User 3 |
| 4 | 4 | 27 | User-programmable key 1 |
| 5 | 5 | 28 | User-programmable key 2 |
| 6 | 6 | 29 | User-programmable key 3 |
| 7 | 7 | 30 | User-programmable key 4 |
| 8 | 8 | 31 | User-programmable key 5 |
| 9 | 9 | 32 | User-programmable key 6 |
| 10 | 0 | 33 | User-programmable key 7 |
| 11 | Decimal Pt | 34 | User-programmable key 8 |
| 12 | Plus/Minus | 35 | User-programmable key 9 |
| 13 | Value Up | 36 | User-programmable key 10 |
| 14 | Value Down | 37 | User-programmable key 11 |
| 15 | Message Up | 38 | User-programmable key 12 |
| 16 | Message Down | 43 | User-programmable key 13 |
| 17 | Message Left | 44 | User-programmable key 14 |
| 18 | Message Right | 45 | User-programmable key 15 |
| 19 | Menu | 46 | User-programmable key 16 |
| 20 | Help | 47 | User 4 (control pushbutton) |
| 21 | Escape | 48 | User 5 (control pushbutton) |
| 22 | Enter | 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

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

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

F232

ENUMERATION: CONFIGURABLE GOOSE DATASET ITEMS FOR TRANSMISSION

| value | GOOSE dataset item |
|-------|-------------------------------|
| 0 | None |
| 1 | GGIO1.ST.Ind1.q |
| 2 | GGIO1.ST.Ind1.stVal |
| 3 | GGIO1.ST.Ind2.q |
| 4 | GGIO1.ST.Ind2.stVal |
| ↓ | ↓ |
| 255 | GGIO1.ST.Ind128.q |
| 256 | GGIO1.ST.Ind128.stVal |
| 257 | MMXU1.MX.TotW.mag.f |
| 258 | MMXU1.MX.TotVAr.mag.f |
| 259 | MMXU1.MX.TotVA.mag.f |
| 260 | MMXU1.MX.TotPF.mag.f |
| 261 | MMXU1.MX.Hz.mag.f |
| 262 | MMXU1.MX.PPV.phsAB.cVal.mag.f |
| 263 | MMXU1.MX.PPV.phsAB.cVal.ang.f |
| 264 | MMXU1.MX.PPV.phsBC.cVal.mag.f |
| 265 | MMXU1.MX.PPV.phsBC.cVal.ang.f |
| 266 | MMXU1.MX.PPV.phsCA.cVal.mag.f |
| 267 | MMXU1.MX.PPV.phsCA.cVal.ang.f |
| 268 | MMXU1.MX.PhV.phsA.cVal.mag.f |
| 269 | MMXU1.MX.PhV.phsA.cVal.ang.f |
| 270 | MMXU1.MX.PhV.phsB.cVal.mag.f |
| 271 | MMXU1.MX.PhV.phsB.cVal.ang.f |
| 272 | MMXU1.MX.PhV.phsC.cVal.mag.f |
| 273 | MMXU1.MX.PhV.phsC.cVal.ang.f |
| 274 | MMXU1.MX.A.phsA.cVal.mag.f |
| 275 | MMXU1.MX.A.phsA.cVal.ang.f |
| 276 | MMXU1.MX.A.phsB.cVal.mag.f |
| 277 | MMXU1.MX.A.phsB.cVal.ang.f |
| 278 | MMXU1.MX.A.phsC.cVal.mag.f |
| 279 | MMXU1.MX.A.phsC.cVal.ang.f |
| 280 | MMXU1.MX.A.neut.cVal.mag.f |
| 281 | MMXU1.MX.A.neut.cVal.ang.f |
| 282 | MMXU1.MX.W.phsA.cVal.mag.f |
| 283 | MMXU1.MX.W.phsB.cVal.mag.f |
| 284 | MMXU1.MX.W.phsC.cVal.mag.f |
| 285 | MMXU1.MX.VAr.phsA.cVal.mag.f |
| 286 | MMXU1.MX.VAr.phsB.cVal.mag.f |
| 287 | MMXU1.MX.VAr.phsC.cVal.mag.f |
| 288 | MMXU1.MX.VA.phsA.cVal.mag.f |
| 289 | MMXU1.MX.VA.phsB.cVal.mag.f |
| 290 | MMXU1.MX.VA.phsC.cVal.mag.f |
| 291 | MMXU1.MX.PF.phsA.cVal.mag.f |
| 292 | MMXU1.MX.PF.phsB.cVal.mag.f |
| 293 | MMXU1.MX.PF.phsC.cVal.mag.f |
| 294 | MMXU2.MX.TotW.mag.f |
| 295 | MMXU2.MX.TotVAr.mag.f |
| 296 | MMXU2.MX.TotVA.mag.f |
| 297 | MMXU2.MX.TotPF.mag.f |

| value | GOOSE dataset item |
|-------|-------------------------------|
| 298 | MMXU2.MX.Hz.mag.f |
| 299 | MMXU2.MX.PPV.phsAB.cVal.mag.f |
| 300 | MMXU2.MX.PPV.phsAB.cVal.ang.f |
| 301 | MMXU2.MX.PPV.phsBC.cVal.mag.f |
| 302 | MMXU2.MX.PPV.phsBC.cVal.ang.f |
| 303 | MMXU2.MX.PPV.phsCA.cVal.mag.f |
| 304 | MMXU2.MX.PPV.phsCA.cVal.ang.f |
| 305 | MMXU2.MX.PhV.phsA.cVal.mag.f |
| 306 | MMXU2.MX.PhV.phsA.cVal.ang.f |
| 307 | MMXU2.MX.PhV.phsB.cVal.mag.f |
| 308 | MMXU2.MX.PhV.phsB.cVal.ang.f |
| 309 | MMXU2.MX.PhV.phsC.cVal.mag.f |
| 310 | MMXU2.MX.PhV.phsC.cVal.ang.f |
| 311 | MMXU2.MX.A.phsA.cVal.mag.f |
| 312 | MMXU2.MX.A.phsA.cVal.ang.f |
| 313 | MMXU2.MX.A.phsB.cVal.mag.f |
| 314 | MMXU2.MX.A.phsB.cVal.ang.f |
| 315 | MMXU2.MX.A.phsC.cVal.mag.f |
| 316 | MMXU2.MX.A.phsC.cVal.ang.f |
| 317 | MMXU2.MX.A.neut.cVal.mag.f |
| 318 | MMXU2.MX.A.neut.cVal.ang.f |
| 319 | MMXU2.MX.W.phsA.cVal.mag.f |
| 320 | MMXU2.MX.W.phsB.cVal.mag.f |
| 321 | MMXU2.MX.W.phsC.cVal.mag.f |
| 322 | MMXU2.MX.VAr.phsA.cVal.mag.f |
| 323 | MMXU2.MX.VAr.phsB.cVal.mag.f |
| 324 | MMXU2.MX.VAr.phsC.cVal.mag.f |
| 325 | MMXU2.MX.VA.phsA.cVal.mag.f |
| 326 | MMXU2.MX.VA.phsB.cVal.mag.f |
| 327 | MMXU2.MX.VA.phsC.cVal.mag.f |
| 328 | MMXU2.MX.PF.phsA.cVal.mag.f |
| 329 | MMXU2.MX.PF.phsB.cVal.mag.f |
| 330 | MMXU2.MX.PF.phsC.cVal.mag.f |
| 331 | MMXU3.MX.TotW.mag.f |
| 332 | MMXU3.MX.TotVAr.mag.f |
| 333 | MMXU3.MX.TotVA.mag.f |
| 334 | MMXU3.MX.TotPF.mag.f |
| 335 | MMXU3.MX.Hz.mag.f |
| 336 | MMXU3.MX.PPV.phsAB.cVal.mag.f |
| 337 | MMXU3.MX.PPV.phsAB.cVal.ang.f |
| 338 | MMXU3.MX.PPV.phsBC.cVal.mag.f |
| 339 | MMXU3.MX.PPV.phsBC.cVal.ang.f |
| 340 | MMXU3.MX.PPV.phsCA.cVal.mag.f |
| 341 | MMXU3.MX.PPV.phsCA.cVal.ang.f |
| 342 | MMXU3.MX.PhV.phsA.cVal.mag.f |
| 343 | MMXU3.MX.PhV.phsA.cVal.ang.f |
| 344 | MMXU3.MX.PhV.phsB.cVal.mag.f |
| 345 | MMXU3.MX.PhV.phsB.cVal.ang.f |
| 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 |

| value | GOOSE dataset item |
|-------|-------------------------------|
| 351 | MMXU3.MX.A.phsB.cVal.mag.f |
| 352 | MMXU3.MX.A.phsC.cVal.mag.f |
| 353 | MMXU3.MX.A.phsC.cVal.mag.f |
| 354 | MMXU3.MX.A.neut.cVal.mag.f |
| 355 | MMXU3.MX.A.neut.cVal.mag.f |
| 356 | MMXU3.MX.W.phsA.cVal.mag.f |
| 357 | MMXU3.MX.W.phsB.cVal.mag.f |
| 358 | MMXU3.MX.W.phsC.cVal.mag.f |
| 359 | MMXU3.MX.VAr.phsA.cVal.mag.f |
| 360 | MMXU3.MX.VAr.phsB.cVal.mag.f |
| 361 | MMXU3.MX.VAr.phsC.cVal.mag.f |
| 362 | MMXU3.MX.VA.phsA.cVal.mag.f |
| 363 | MMXU3.MX.VA.phsB.cVal.mag.f |
| 364 | MMXU3.MX.VA.phsC.cVal.mag.f |
| 365 | MMXU3.MX.PF.phsA.cVal.mag.f |
| 366 | MMXU3.MX.PF.phsB.cVal.mag.f |
| 367 | MMXU3.MX.PF.phsC.cVal.mag.f |
| 368 | MMXU4.MX.TotW.mag.f |
| 369 | MMXU4.MX.TotVAr.mag.f |
| 370 | MMXU4.MX.TotVA.mag.f |
| 371 | MMXU4.MX.TotPF.mag.f |
| 372 | MMXU4.MX.Hz.mag.f |
| 373 | MMXU4.MX.PPV.phsAB.cVal.mag.f |
| 374 | MMXU4.MX.PPV.phsAB.cVal.mag.f |
| 375 | MMXU4.MX.PPV.phsBC.cVal.mag.f |
| 376 | MMXU4.MX.PPV.phsBC.cVal.mag.f |
| 377 | MMXU4.MX.PPV.phsCA.cVal.mag.f |
| 378 | MMXU4.MX.PPV.phsCA.cVal.mag.f |
| 379 | MMXU4.MX.PhV.phsA.cVal.mag.f |
| 380 | MMXU4.MX.PhV.phsA.cVal.mag.f |
| 381 | MMXU4.MX.PhV.phsB.cVal.mag.f |
| 382 | MMXU4.MX.PhV.phsB.cVal.mag.f |
| 383 | MMXU4.MX.PhV.phsC.cVal.mag.f |
| 384 | MMXU4.MX.PhV.phsC.cVal.mag.f |
| 385 | MMXU4.MX.A.phsA.cVal.mag.f |
| 386 | MMXU4.MX.A.phsA.cVal.mag.f |
| 387 | MMXU4.MX.A.phsB.cVal.mag.f |
| 388 | MMXU4.MX.A.phsB.cVal.mag.f |
| 389 | MMXU4.MX.A.phsC.cVal.mag.f |
| 390 | MMXU4.MX.A.phsC.cVal.mag.f |
| 391 | MMXU4.MX.A.neut.cVal.mag.f |
| 392 | MMXU4.MX.A.neut.cVal.mag.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 |

| value | GOOSE dataset item |
|-------|-------------------------------|
| 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.mag.f |
| 412 | MMXU5.MX.PPV.phsBC.cVal.mag.f |
| 413 | MMXU5.MX.PPV.phsBC.cVal.mag.f |
| 414 | MMXU5.MX.PPV.phsCA.cVal.mag.f |
| 415 | MMXU5.MX.PPV.phsCA.cVal.mag.f |
| 416 | MMXU5.MX.PhV.phsA.cVal.mag.f |
| 417 | MMXU5.MX.PhV.phsA.cVal.mag.f |
| 418 | MMXU5.MX.PhV.phsB.cVal.mag.f |
| 419 | MMXU5.MX.PhV.phsB.cVal.mag.f |
| 420 | MMXU5.MX.PhV.phsC.cVal.mag.f |
| 421 | MMXU5.MX.PhV.phsC.cVal.mag.f |
| 422 | MMXU5.MX.A.phsA.cVal.mag.f |
| 423 | MMXU5.MX.A.phsA.cVal.mag.f |
| 424 | MMXU5.MX.A.phsB.cVal.mag.f |
| 425 | MMXU5.MX.A.phsB.cVal.mag.f |
| 426 | MMXU5.MX.A.phsC.cVal.mag.f |
| 427 | MMXU5.MX.A.phsC.cVal.mag.f |
| 428 | MMXU5.MX.A.neut.cVal.mag.f |
| 429 | MMXU5.MX.A.neut.cVal.mag.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.mag.f |
| 449 | MMXU6.MX.PPV.phsBC.cVal.mag.f |
| 450 | MMXU6.MX.PPV.phsBC.cVal.mag.f |
| 451 | MMXU6.MX.PPV.phsCA.cVal.mag.f |
| 452 | MMXU6.MX.PPV.phsCA.cVal.mag.f |
| 453 | MMXU6.MX.PhV.phsA.cVal.mag.f |
| 454 | MMXU6.MX.PhV.phsA.cVal.mag.f |
| 455 | MMXU6.MX.PhV.phsB.cVal.mag.f |
| 456 | MMXU6.MX.PhV.phsB.cVal.mag.f |

| value | GOOSE dataset item |
|-------|------------------------------|
| 457 | MMXU6.MX.PhV.phsC.cVal.mag.f |
| 458 | MMXU6.MX.PhV.phsC.cVal.ang.f |
| 459 | MMXU6.MX.A.phsA.cVal.mag.f |
| 460 | MMXU6.MX.A.phsA.cVal.ang.f |
| 461 | MMXU6.MX.A.phsB.cVal.mag.f |
| 462 | MMXU6.MX.A.phsB.cVal.ang.f |
| 463 | MMXU6.MX.A.phsC.cVal.mag.f |
| 464 | MMXU6.MX.A.phsC.cVal.ang.f |
| 465 | MMXU6.MX.A.neut.cVal.mag.f |
| 466 | MMXU6.MX.A.neut.cVal.ang.f |
| 467 | MMXU6.MX.W.phsA.cVal.mag.f |
| 468 | MMXU6.MX.W.phsB.cVal.mag.f |
| 469 | MMXU6.MX.W.phsC.cVal.mag.f |
| 470 | MMXU6.MX.VAr.phsA.cVal.mag.f |
| 471 | MMXU6.MX.VAr.phsB.cVal.mag.f |
| 472 | MMXU6.MX.VAr.phsC.cVal.mag.f |
| 473 | MMXU6.MX.VA.phsA.cVal.mag.f |
| 474 | MMXU6.MX.VA.phsB.cVal.mag.f |
| 475 | MMXU6.MX.VA.phsC.cVal.mag.f |
| 476 | MMXU6.MX.PF.phsA.cVal.mag.f |
| 477 | MMXU6.MX.PF.phsB.cVal.mag.f |
| 478 | MMXU6.MX.PF.phsC.cVal.mag.f |
| 479 | GGIO4.MX.AnIn1.mag.f |
| 480 | GGIO4.MX.AnIn2.mag.f |
| 481 | GGIO4.MX.AnIn3.mag.f |
| 482 | GGIO4.MX.AnIn4.mag.f |
| 483 | GGIO4.MX.AnIn5.mag.f |
| 484 | GGIO4.MX.AnIn6.mag.f |
| 485 | GGIO4.MX.AnIn7.mag.f |
| 486 | GGIO4.MX.AnIn8.mag.f |
| 487 | GGIO4.MX.AnIn9.mag.f |
| 488 | GGIO4.MX.AnIn10.mag.f |
| 489 | GGIO4.MX.AnIn11.mag.f |
| 490 | GGIO4.MX.AnIn12.mag.f |
| 491 | GGIO4.MX.AnIn13.mag.f |
| 492 | GGIO4.MX.AnIn14.mag.f |
| 493 | GGIO4.MX.AnIn15.mag.f |
| 494 | GGIO4.MX.AnIn16.mag.f |
| 495 | GGIO4.MX.AnIn17.mag.f |
| 496 | GGIO4.MX.AnIn18.mag.f |
| 497 | GGIO4.MX.AnIn19.mag.f |
| 498 | GGIO4.MX.AnIn20.mag.f |
| 499 | GGIO4.MX.AnIn21.mag.f |
| 500 | GGIO4.MX.AnIn22.mag.f |
| 501 | GGIO4.MX.AnIn23.mag.f |
| 502 | GGIO4.MX.AnIn24.mag.f |
| 503 | GGIO4.MX.AnIn25.mag.f |
| 504 | GGIO4.MX.AnIn26.mag.f |
| 505 | GGIO4.MX.AnIn27.mag.f |
| 506 | GGIO4.MX.AnIn28.mag.f |
| 507 | GGIO4.MX.AnIn29.mag.f |

| value | GOOSE dataset item |
|-------|-----------------------|
| 508 | GGIO4.MX.AnIn30.mag.f |
| 509 | GGIO4.MX.AnIn31.mag.f |
| 510 | GGIO4.MX.AnIn32.mag.f |

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 |

F237**ENUMERATION: REAL TIME CLOCK MONTH**

| value | month |
|-------|-----------|
| 0 | January |
| 1 | February |
| 2 | March |
| 3 | April |
| 4 | May |
| 5 | June |
| 6 | July |
| 7 | August |
| 8 | September |
| 9 | October |
| 10 | November |
| 11 | December |

F238**ENUMERATION: REAL TIME CLOCK DAY**

| value | day |
|-------|-----------|
| 0 | Sunday |
| 1 | Monday |
| 2 | Tuesday |
| 3 | Wednesday |
| 4 | Thursday |
| 5 | Friday |
| 6 | Saturday |

F239**ENUMERATION: REAL TIME CLOCK DAYLIGHT SAVINGS TIME START DAY INSTANCE**

| value | instance |
|-------|----------|
| 0 | First |
| 1 | Second |
| 2 | Third |
| 3 | Fourth |
| 4 | Last |

F241**ENUMERATION: NEUTRAL VOLTAGE UNBALANCE BUS 3V0**

0 = Calculated, 1 = Measured

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: PTTTTTDDDDDDDDDD, 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 |

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).

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 multi-drop 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

- 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

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.

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 “IED-Name” 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 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 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 2 through 8 will have changes in their status transmitted at a maximum rate of every 100 ms. Datasets 2 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

C

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.

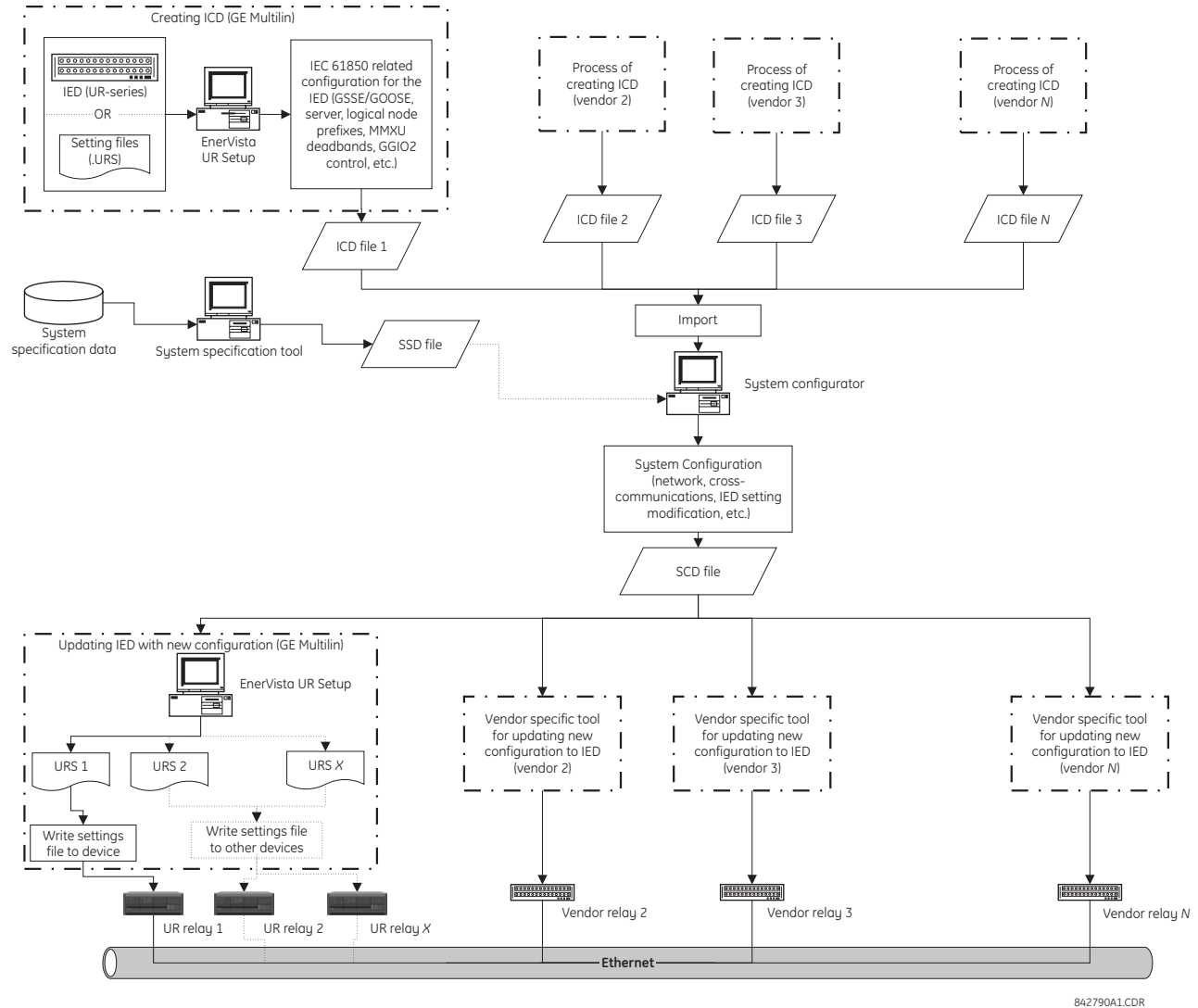


Figure 0-1: IED CONFIGURATION PROCESS

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 the 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 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 5.5x, 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.

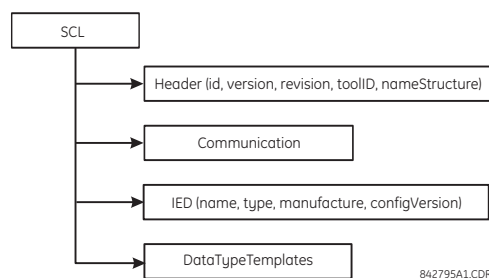


Figure 0-2: ICD FILE STRUCTURE, SCL (ROOT) NODE

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.

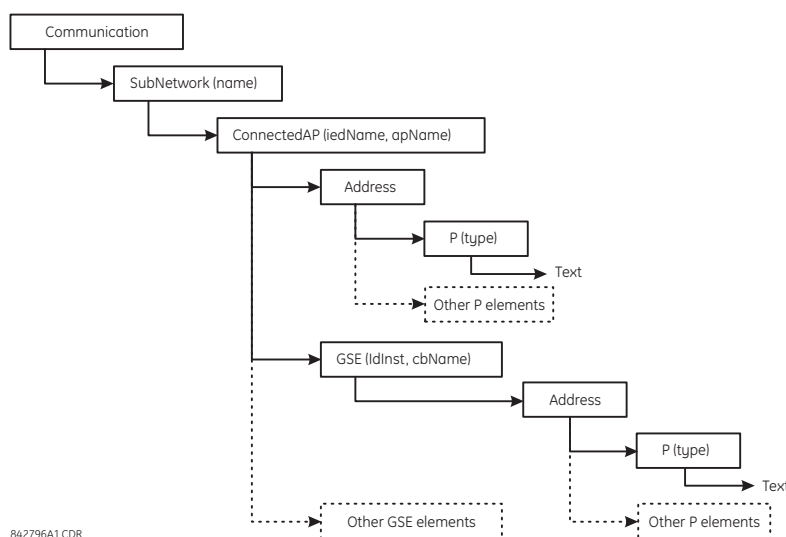


Figure 0-3: ICD FILE STRUCTURE, COMMUNICATIONS NODE

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 **LNTType**, 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.

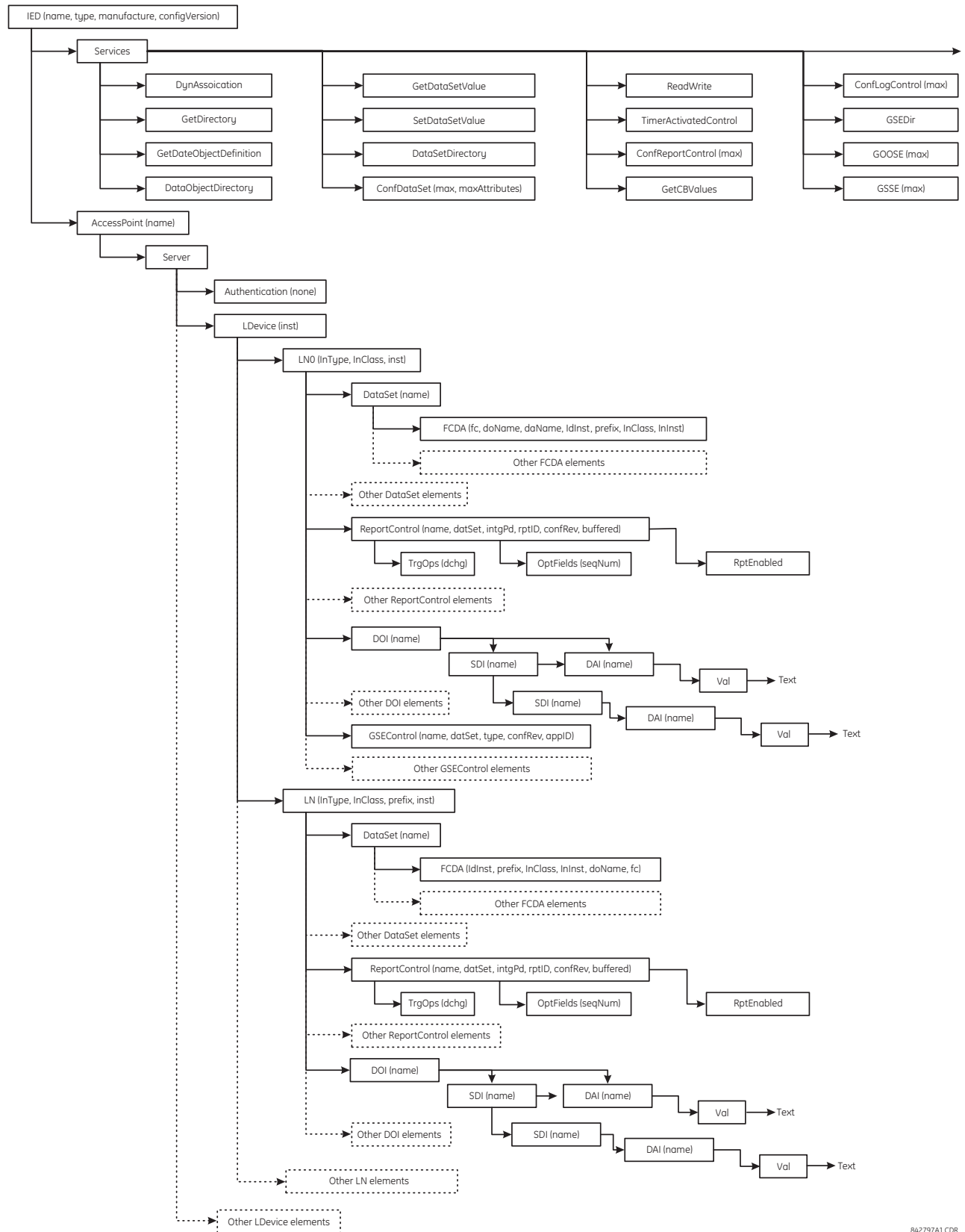
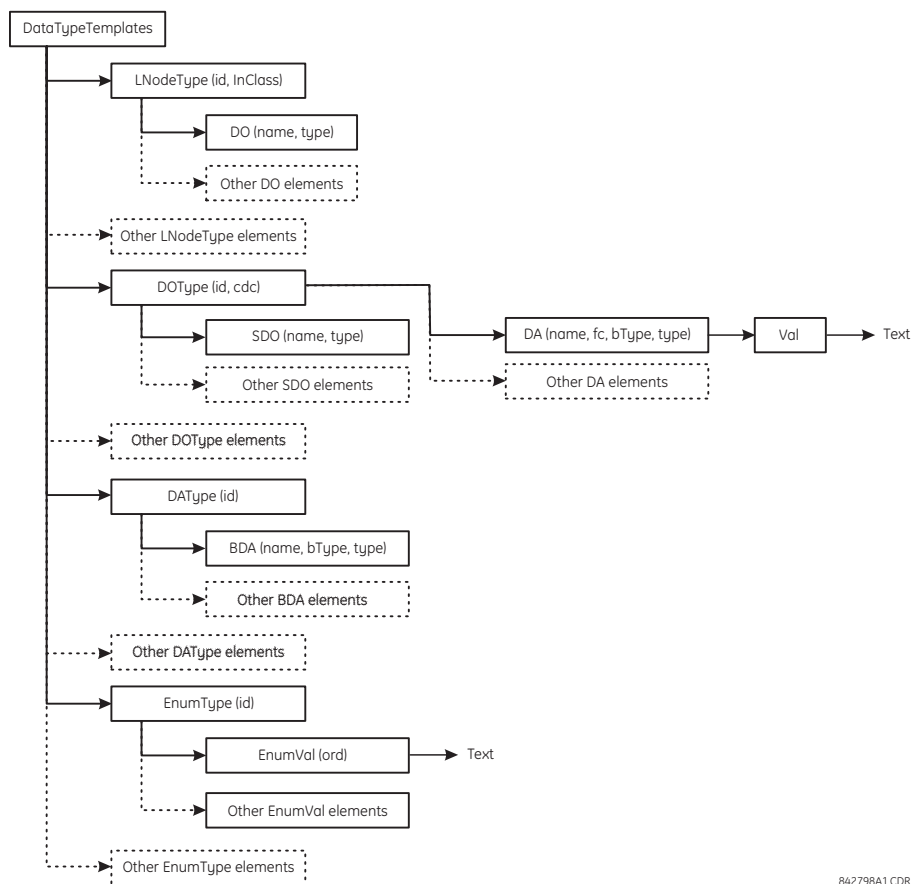


Figure 0-4: ICD FILE STRUCTURE, IED NODE

842797A1.CDR

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 or have a base type such as DA.



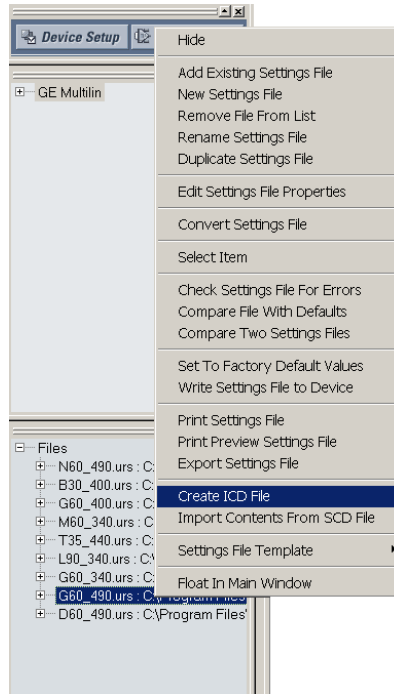
842798A1.CDR

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:

- Header
- Substation
- Communication
- IED section (one or more)
- DataTypeTemplates

The root file structure of an SCD file is illustrated below.

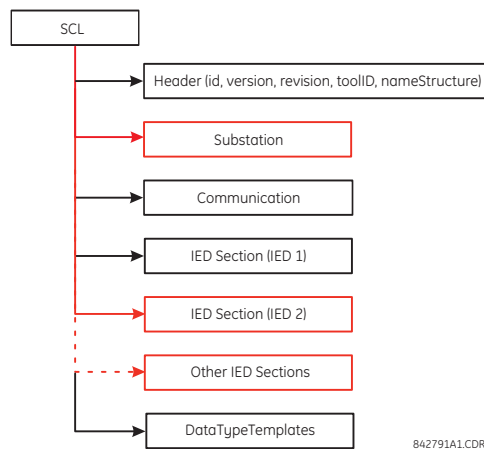


Figure 0-6: SCD FILE STRUCTURE, SCL (ROOT) NODE

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:

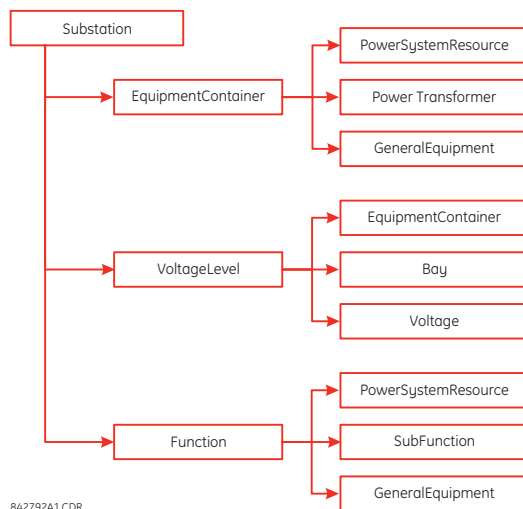


Figure 0-7: SCD FILE STRUCTURE, SUBSTATION NODE

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.

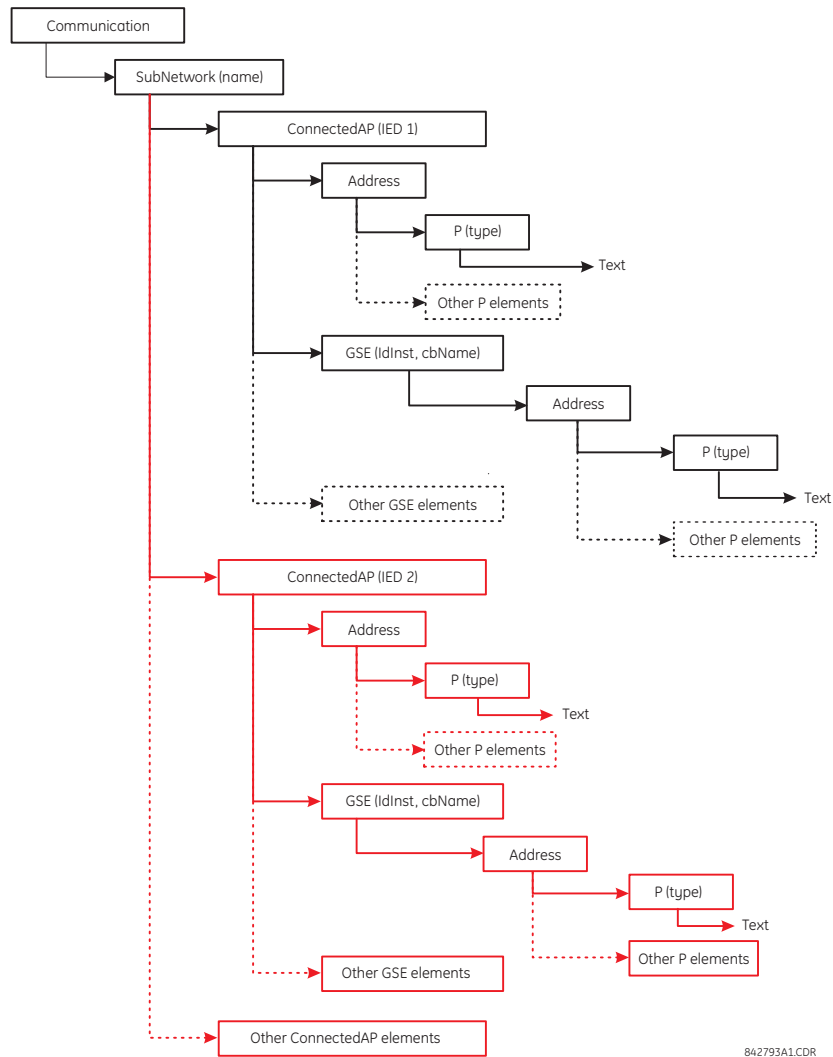


Figure 0–8: SCD FILE STRUCTURE, COMMUNICATIONS NODE

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.

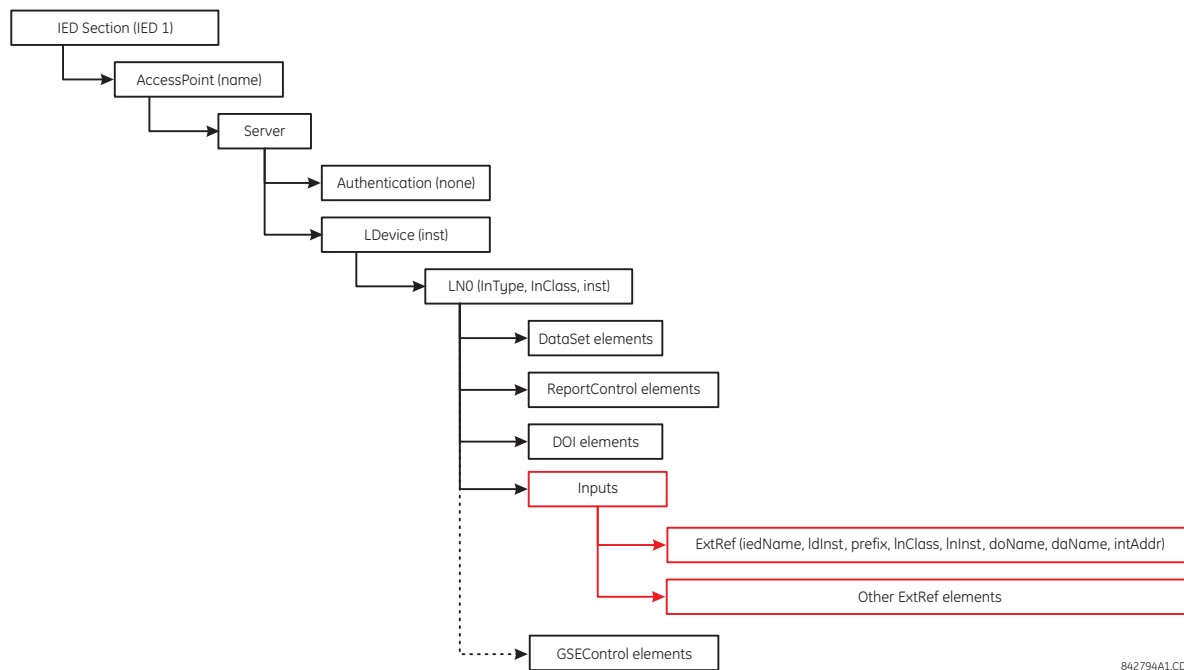
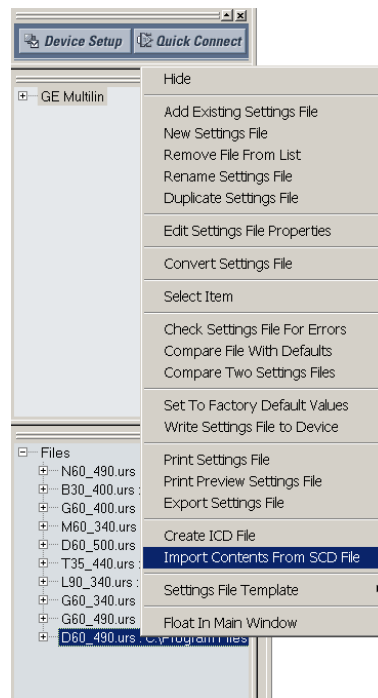


Figure 0-9: SCD FILE STRUCTURE, IED NODE

C.5.6 IMPORTING AN SCD FILE WITH ENERVISTA UR SETUP

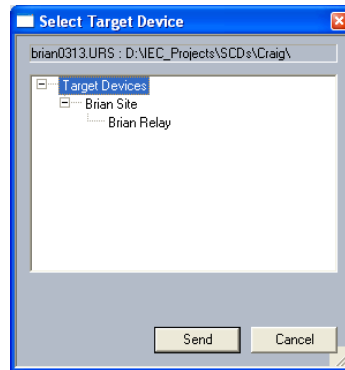
The following procedure describes how to update the C70 with the new configuration from an SCD file with the EnerVista UR Setup software.

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 | --- | |



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 |



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, according to 5.5.3.7.3.3) | | | 20 |



- c6:** shall declare support for at least one (BRCB or URCB)
c7: shall declare support for at least one (QueryLogByTime or QueryLogAfter)
c8: shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage)
c9: shall declare support if TP association is available
c10: shall declare support for at least one (SendMSVMessage or SendUSVMessage)

C.7.1 LOGICAL NODES TABLE

The UR-series of relays supports IEC 61850 logical nodes as indicated in the following table. Note that the actual instantiation of each logical node is determined by the product order code. For example, the logical node “PDIS” (distance protection) is available only in the D60 Line Distance Relay.

Table 0–1: 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 | --- |
| RBDRE: 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 0–1: 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 | --- |
| 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 | --- |
| 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 | --- |

Table 0–1: 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 this section the boxes indicate the following: ☒ – used in standard direction; ☐ – not used; ☐ – cannot be selected in IEC 60870-5-104 standard.

1. SYSTEM OR DEVICE:

- ☐ System Definition
☐ Controlling Station Definition (Master)
☒ **Controlled Station Definition (Slave)**

2. NETWORK CONFIGURATION:

- ☐ Point-to-Point ☐ Multipoint
☐ Multiple Point-to-Point ☐ Multipoint Star

3. PHYSICAL LAYER

Transmission Speed (control direction):

| Unbalanced Interchange Circuit V.24/V.28 Standard: | Unbalanced Interchange Circuit V.24/V.28 Recommended if >1200 bits/s: | Balanced Interchange Circuit X.24/X.27: |
|---|---|---|
| <input type="checkbox"/> 400 bits/sec. <input type="checkbox"/> 200 bits/sec. <input type="checkbox"/> 300 bits/sec. <input type="checkbox"/> 600 bits/sec. <input type="checkbox"/> 1200 bits/sec. | <input type="checkbox"/> 2400 bits/sec. <input type="checkbox"/> 4800 bits/sec. <input type="checkbox"/> 9600 bits/sec. | <input type="checkbox"/> 2400 bits/sec. <input type="checkbox"/> 4800 bits/sec. <input type="checkbox"/> 9600 bits/sec. <input type="checkbox"/> 19200 bits/sec. <input type="checkbox"/> 38400 bits/sec. <input type="checkbox"/> 56000 bits/sec. <input type="checkbox"/> 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: |
|---|---|---|
| <input type="checkbox"/> 400 bits/sec. <input type="checkbox"/> 200 bits/sec. <input type="checkbox"/> 300 bits/sec. <input type="checkbox"/> 600 bits/sec. <input type="checkbox"/> 1200 bits/sec. | <input type="checkbox"/> 2400 bits/sec. <input type="checkbox"/> 4800 bits/sec. <input type="checkbox"/> 9600 bits/sec. | <input type="checkbox"/> 2400 bits/sec. <input type="checkbox"/> 4800 bits/sec. <input type="checkbox"/> 9600 bits/sec. <input type="checkbox"/> 19200 bits/sec. <input type="checkbox"/> 38400 bits/sec. <input type="checkbox"/> 56000 bits/sec. <input type="checkbox"/> 64000 bits/sec. |

4. LINK LAYER

| Link Transmission Procedure: | Address Field of the Link: |
|---|--|
| <input type="checkbox"/> Balanced Transmission <input type="checkbox"/> Unbalanced Transmission | <input type="checkbox"/> Not Present (Balanced Transmission Only) <input type="checkbox"/> One Octet <input type="checkbox"/> Two Octets <input type="checkbox"/> Structured <input type="checkbox"/> 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 standard.

Common Address of ADSU:

- ~~One Octet~~
- ☒ Two Octets

Information Object Address:

- ~~One Octet~~ ☒ Structured
- ~~Two Octets~~ ☒ Unstructured
- ☒ Three Octets

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

| | |
|---|----------------------|
| <input checked="" type="checkbox"/> <1> := Single-point information | M_SP_NA_1 |
| ■ <2> := Single-point information with time tag | M_SP_TA_1 |
| <input type="checkbox"/> <3> := Double-point information | M_DP_NA_1 |
| ■ <4> := Double-point information with time tag | M_DP_TA_1 |
| <input type="checkbox"/> <5> := Step position information | M_ST_NA_1 |
| ■ <6> := Step position information with time tag | M_ST_TA_1 |
| <input type="checkbox"/> <7> := Bitstring of 32 bits | M_BO_NA_1 |
| ■ <8> := Bitstring of 32 bits with time tag | M_BO_TA_1 |
| <input type="checkbox"/> <9> := Measured value, normalized value | M_ME_NA_1 |
| ■ <10> := Measured value, normalized value with time tag | M_ME_TA_1 |
| <input type="checkbox"/> <11> := Measured value, scaled value | M_ME_NB_1 |
| ■ <12> := Measured value, scaled value with time tag | M_ME_TB_1 |
| <input checked="" type="checkbox"/> <13> := Measured value, short floating point value | M_ME_NC_1 |
| ■ <14> := Measured value, short floating point value with time tag | M_ME_TC_1 |
| <input checked="" type="checkbox"/> <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 |
| <input type="checkbox"/> <20> := Packed single-point information with status change detection | M_SP_NA_1 |

| | |
|---|-----------|
| <input type="checkbox"/> <21> := Measured value, normalized value without quantity descriptor | M_ME_ND_1 |
| <input checked="" type="checkbox"/> <30> := Single-point information with time tag CP56Time2a | M_SP_TB_1 |
| <input type="checkbox"/> <31> := Double-point information with time tag CP56Time2a | M_DP_TB_1 |
| <input type="checkbox"/> <32> := Step position information with time tag CP56Time2a | M_ST_TB_1 |
| <input type="checkbox"/> <33> := Bitstring of 32 bits with time tag CP56Time2a | M_BO_TB_1 |
| <input type="checkbox"/> <34> := Measured value, normalized value with time tag CP56Time2a | M_ME_TD_1 |
| <input type="checkbox"/> <35> := Measured value, scaled value with time tag CP56Time2a | M_ME_TE_1 |
| <input type="checkbox"/> <36> := Measured value, short floating point value with time tag CP56Time2a | M_ME_TF_1 |
| <input checked="" type="checkbox"/> <37> := Integrated totals with time tag CP56Time2a | M_IT_TB_1 |
| <input type="checkbox"/> <38> := Event of protection equipment with time tag CP56Time2a | M_EP_TD_1 |
| <input type="checkbox"/> <39> := Packed start events of protection equipment with time tag CP56Time2a | M_EP_TE_1 |
| <input type="checkbox"/> <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

| | |
|---|-----------|
| <input checked="" type="checkbox"/> <45> := Single command | C_SC_NA_1 |
| <input type="checkbox"/> <46> := Double command | C_DC_NA_1 |
| <input type="checkbox"/> <47> := Regulating step command | C_RC_NA_1 |
| <input type="checkbox"/> <48> := Set point command, normalized value | C_SE_NA_1 |
| <input type="checkbox"/> <49> := Set point command, scaled value | C_SE_NB_1 |
| <input type="checkbox"/> <50> := Set point command, short floating point value | C_SE_NC_1 |
| <input type="checkbox"/> <51> := Bitstring of 32 bits | C_BO_NA_1 |
| <input checked="" type="checkbox"/> <58> := Single command with time tag CP56Time2a | C_SC_TA_1 |
| <input type="checkbox"/> <59> := Double command with time tag CP56Time2a | C_DC_TA_1 |
| <input type="checkbox"/> <60> := Regulating step command with time tag CP56Time2a | C_RC_TA_1 |
| <input type="checkbox"/> <61> := Set point command, normalized value with time tag CP56Time2a | C_SE_TA_1 |
| <input type="checkbox"/> <62> := Set point command, scaled value with time tag CP56Time2a | C_SE_TB_1 |
| <input type="checkbox"/> <63> := Set point command, short floating point value with time tag CP56Time2a | C_SE_TC_1 |
| <input type="checkbox"/> <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

| | |
|---|-----------|
| <input checked="" type="checkbox"/> <70> := End of initialization | M_EI_NA_1 |
|---|-----------|

System information in control direction

| | |
|---|-----------|
| <input checked="" type="checkbox"/> <100> := Interrogation command | C_IC_NA_1 |
| <input checked="" type="checkbox"/> <101> := Counter interrogation command | C_CI_NA_1 |
| <input checked="" type="checkbox"/> <102> := Read command | C_RD_NA_1 |
| <input checked="" type="checkbox"/> <103> := Clock synchronization command (see Clause 7.6 in standard) | C_CS_NA_1 |
| <input checked="" type="checkbox"/> <104> := Test command | C_TS_NA_1 |
| <input checked="" type="checkbox"/> <105> := Reset process command | C_RP_NA_1 |
| <input checked="" type="checkbox"/> <106> := Delay acquisition command | C_CD_NA_1 |
| <input checked="" type="checkbox"/> <107> := Test command with time tag CP56Time2a | C_TS_TA_1 |

Parameter in control direction

| | |
|--|------------|
| <input type="checkbox"/> <110> := Parameter of measured value, normalized value | PE_ME_NA_1 |
| <input type="checkbox"/> <111> := Parameter of measured value, scaled value | PE_ME_NB_1 |
| <input checked="" type="checkbox"/> <112> := Parameter of measured value, short floating point value | PE_ME_NC_1 |
| <input type="checkbox"/> <113> := Parameter activation | PE_AC_NA_1 |

File transfer

| | |
|--|-----------|
| <input type="checkbox"/> <120> := File Ready | F_FR_NA_1 |
| <input type="checkbox"/> <121> := Section Ready | F_SR_NA_1 |
| <input type="checkbox"/> <122> := Call directory, select file, call file, call section | F_SC_NA_1 |
| <input type="checkbox"/> <123> := Last section, last segment | F_LS_NA_1 |
| <input type="checkbox"/> <124> := Ack file, ack section | F_AF_NA_1 |
| <input type="checkbox"/> <125> := Segment | F_SG_NA_1 |
| <input type="checkbox"/> <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 |
| NO. | MNEMONIC | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 20 to 36 | 37 to 41 | 44 |
| <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 | | | | | | | | | | | | | | | | |

| TYPE IDENTIFICATION | | CAUSE OF TRANSMISSION | | | | | | | | | | | | | | | |
|---------------------|-------------|-----------------------|-----------------|-------------|-------------|----------------------|------------|-------------------------|--------------|---------------------------|------------------------|---------------------------------|---------------|--------------------------------|----------------------------------|-----------------------------|-------------------------------|
| NO. | MNEMONIC | 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 |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 20 to 36 | 37 to 41 | 44 |
| <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 | | | | | | X | X | | | | | | | | | |
| <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:

- | | | | |
|---|---|--|--|
| <input checked="" type="checkbox"/> Global | | | |
| <input checked="" type="checkbox"/> Group 1 | <input checked="" type="checkbox"/> Group 5 | <input checked="" type="checkbox"/> Group 9 | <input checked="" type="checkbox"/> Group 13 |
| <input checked="" type="checkbox"/> Group 2 | <input checked="" type="checkbox"/> Group 6 | <input checked="" type="checkbox"/> Group 10 | <input checked="" type="checkbox"/> Group 14 |
| <input checked="" type="checkbox"/> Group 3 | <input checked="" type="checkbox"/> Group 7 | <input checked="" type="checkbox"/> Group 11 | <input checked="" type="checkbox"/> Group 15 |
| <input checked="" type="checkbox"/> Group 4 | <input checked="" type="checkbox"/> Group 8 | <input checked="" type="checkbox"/> Group 12 | <input checked="" type="checkbox"/> 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 acknowledgements in case of no data messages $t_2 < t_1$ | 10 s |
| t_3 | 20 s | Timeout for sending test frames in case of a long idle state | 20 s |

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

Maximum number of outstanding I-format APDUs k and latest acknowledge APDUs (w):

| PARAMETER | DEFAULT VALUE | REMARKS | SELECTED VALUE |
|-----------|---------------|---|----------------|
| k | 12 APDUs | Maximum difference receive sequence number to send state variable | 12 APDUs |
| w | 8 APDUs | Latest acknowledge after receiving w I-format APDUs | 8 APDUs |

Maximum range of values k : 1 to 32767 ($2^{15} - 1$) APDUs, accuracy 1 APDU

Maximum range of values w : 1 to 32767 APDUs, accuracy 1 APDU
 Recommendation: w should not exceed two-thirds of k .

Portnumber:

| PARAMETER | VALUE | REMARKS |
|------------|-------|--------------|
| Portnumber | 2404 | In all cases |

RFC 2200 suite:

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

- ☒ Ethernet 802.3
- ☐ Serial X.21 interface
- ☐ Other selection(s) from RFC 2200 (list below if selected)

D.1.2 POINT LIST

D

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: <input type="checkbox"/> Master <input checked="" type="checkbox"/> 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: <input checked="" type="checkbox"/> None <input type="checkbox"/> Fixed at 3 <input type="checkbox"/> Configurable | Maximum Application Layer Re-tries: <input checked="" type="checkbox"/> None <input type="checkbox"/> Configurable |
| Requires Data Link Layer Confirmation: <input checked="" type="checkbox"/> Never <input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable | |

Table E-1: DNP V3.00 DEVICE PROFILE (Sheet 2 of 3)

| | | | | |
|---|--|--|--|---------------------------------------|
| Requires Application Layer Confirmation: | | | | |
| <input type="checkbox"/> Never <input type="checkbox"/> Always <input checked="" type="checkbox"/> When reporting Event Data <input checked="" type="checkbox"/> When sending multi-fragment responses <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable | | | | |
| Timeouts while waiting for: | | | | |
| Data Link Confirm: | <input checked="" type="checkbox"/> None | <input type="checkbox"/> Fixed at ____ | <input type="checkbox"/> Variable | <input type="checkbox"/> Configurable |
| Complete Appl. Fragment: | <input checked="" type="checkbox"/> None | <input type="checkbox"/> Fixed at ____ | <input type="checkbox"/> Variable | <input type="checkbox"/> Configurable |
| Application Confirm: | <input type="checkbox"/> None | <input checked="" type="checkbox"/> Fixed at 10 s | <input type="checkbox"/> Variable | <input type="checkbox"/> Configurable |
| Complete Appl. Response: | <input checked="" type="checkbox"/> None | <input type="checkbox"/> Fixed at ____ | <input type="checkbox"/> Variable | <input type="checkbox"/> 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 | <input checked="" type="checkbox"/> Never | <input type="checkbox"/> Always | <input type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| SELECT/OPERATE | <input type="checkbox"/> Never | <input checked="" type="checkbox"/> Always | <input type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| DIRECT OPERATE | <input type="checkbox"/> Never | <input checked="" type="checkbox"/> Always | <input type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| DIRECT OPERATE – NO ACK | <input type="checkbox"/> Never | <input checked="" type="checkbox"/> Always | <input type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| Count > 1 | <input checked="" type="checkbox"/> Never | <input type="checkbox"/> Always | <input type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| Pulse On | <input type="checkbox"/> Never | <input type="checkbox"/> Always | <input checked="" type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| Pulse Off | <input type="checkbox"/> Never | <input type="checkbox"/> Always | <input checked="" type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| Latch On | <input type="checkbox"/> Never | <input type="checkbox"/> Always | <input checked="" type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| Latch Off | <input type="checkbox"/> Never | <input type="checkbox"/> Always | <input checked="" type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| Queue | <input checked="" type="checkbox"/> Never | <input type="checkbox"/> Always | <input type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| Clear Queue | <input checked="" type="checkbox"/> Never | <input type="checkbox"/> Always | <input type="checkbox"/> Sometimes | <input type="checkbox"/> Configurable |
| Explanation of 'Sometimes': Object 12 points are mapped to UR Virtual Inputs. The persistence of Virtual Inputs is determined by the VIRTUAL INPUT X TYPE settings. Both "Pulse On" and "Latch On" operations perform the same function in the UR; that is, the appropriate Virtual Input is put into the "On" state. If the Virtual Input is set to "Self-Reset", it will reset after one pass of FlexLogic™. The On/Off times and Count value are ignored. "Pulse Off" and "Latch Off" operations put the appropriate Virtual Input into the "Off" state. "Trip" and "Close" operations both put the appropriate Virtual Input into the "On" state. | | | | |

Table E-1: DNP V3.00 DEVICE PROFILE (Sheet 3 of 3)

| | |
|--|--|
| Reports Binary Input Change Events when no specific variation requested: <ul style="list-style-type: none"> <input type="checkbox"/> Never <input checked="" type="checkbox"/> Only time-tagged <input type="checkbox"/> Only non-time-tagged <input type="checkbox"/> Configurable | Reports time-tagged Binary Input Change Events when no specific variation requested: <ul style="list-style-type: none"> <input type="checkbox"/> Never <input checked="" type="checkbox"/> Binary Input Change With Time <input type="checkbox"/> Binary Input Change With Relative Time <input type="checkbox"/> Configurable (attach explanation) |
| Sends Unsolicited Responses: <ul style="list-style-type: none"> <input type="checkbox"/> Never <input checked="" type="checkbox"/> Configurable <input type="checkbox"/> Only certain objects <input type="checkbox"/> Sometimes (attach explanation) <input checked="" type="checkbox"/> ENABLE/DISABLE unsolicited Function codes supported | Sends Static Data in Unsolicited Responses: <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Never <input type="checkbox"/> When Device Restarts <input type="checkbox"/> When Status Flags Change <p>No other options are permitted.</p> |
| Default Counter Object/Variation: <ul style="list-style-type: none"> <input type="checkbox"/> No Counters Reported <input type="checkbox"/> Configurable (attach explanation) <input checked="" type="checkbox"/> Default Object: 20 Default Variation: 1 <input checked="" type="checkbox"/> Point-by-point list attached | Counters Roll Over at: <ul style="list-style-type: none"> <input type="checkbox"/> No Counters Reported <input type="checkbox"/> Configurable (attach explanation) <input checked="" type="checkbox"/> 16 Bits (Counter 8) <input checked="" type="checkbox"/> 32 Bits (Counters 0 to 7, 9) <input type="checkbox"/> Other Value: _____ <input checked="" type="checkbox"/> Point-by-point list attached |
| Sends Multi-Fragment Responses: <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Yes <input type="checkbox"/> 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.

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) | 06 (no range, or all) | | |
| | 3 | Class 2 Data | 20 (enable unsol) | 07, 08 (limited quantity) | | |
| | 4 | Class 3 Data | 21 (disable unsol) 22 (assign class) | | | |
| 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**

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 |

F.1.2 CHANGES TO THE C70 MANUAL

Table F-2: 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-3: 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-4: 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 |
| 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 |

Table F–4: MAJOR UPDATES FOR C70 MANUAL REVISION S1 (Sheet 2 of 2)

| PAGE (R3) | PAGE (S1) | CHANGE | DESCRIPTION |
|-----------|-----------|--------|---|
| --- | 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–5: 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–6: 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–7: 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 CUTOFF 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 |
| 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 |

Table F-7: MAJOR UPDATES FOR C70 MANUAL REVISION R1 (Sheet 2 of 2)

| PAGE (P2) | PAGE (R1) | CHANGE | DESCRIPTION |
|-----------|-----------|--------|---|
| 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-8: 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.2.1 STANDARD ABBREVIATIONS

| | | | |
|----------------|---|----------------------|--|
| A..... | Ampere | FREQ..... | Frequency |
| AC..... | Alternating Current | FSK..... | Frequency-Shift Keying |
| A/D..... | Analog to Digital | FTP..... | File Transfer Protocol |
| AE..... | Accidental Energization, Application Entity | FxE..... | FlexElement™ |
| AMP..... | Ampere | FWD..... | Forward |
| ANG..... | Angle | | |
| ANSI..... | American National Standards Institute | G..... | Generator |
| AR..... | Automatic Reclosure | GE..... | General Electric |
| ASDU..... | Application-layer Service Data Unit | GND..... | Ground |
| ASYM..... | Asymmetry | GNTR..... | Generator |
| AUTO..... | Automatic | GOOSE..... | General Object Oriented Substation Event |
| AUX..... | Auxiliary | GPS..... | Global Positioning System |
| AVG..... | Average | | |
| | | HARM..... | Harmonic / Harmonics |
| BER..... | Bit Error Rate | HCT..... | High Current Time |
| BF..... | Breaker Fail | HGF..... | High-Impedance Ground Fault (CT) |
| BFI..... | Breaker Failure Initiate | HIZ..... | High-Impedance and Arcing Ground |
| BKR..... | Breaker | HMI..... | Human-Machine Interface |
| BLK..... | Block | HTTP..... | Hyper Text Transfer Protocol |
| BLKG..... | Blocking | HYB..... | Hybrid |
| BPNT..... | Breakpoint of a characteristic | | |
| BRKR..... | Breaker | I..... | Instantaneous |
| | | I ₀ | Zero Sequence current |
| CAP..... | Capacitor | I ₁ | Positive Sequence current |
| CC..... | Coupling Capacitor | I ₂ | Negative Sequence current |
| CCVT..... | Coupling Capacitor Voltage Transformer | IA..... | Phase A current |
| CFG..... | Configure / Configurable | IAB..... | Phase A minus B current |
| .CFG..... | Filename extension for oscillography files | IB..... | Phase B current |
| CHK..... | Check | IBC..... | Phase B minus C current |
| CHNL..... | Channel | IC..... | Phase C current |
| CLS..... | Close | ICA..... | Phase C minus A current |
| CLSD..... | Closed | ID..... | Identification |
| CMND..... | Command | IED..... | Intelligent Electronic Device |
| CMPSRN..... | Comparison | IEC..... | International Electrotechnical Commission |
| CO..... | Contact Output | IEEE..... | Institute of Electrical and Electronic Engineers |
| COM..... | Communication | IG..... | Ground (not residual) current |
| COMM..... | Communications | Igd..... | Differential Ground current |
| COMP..... | Compensated, Comparison | IN..... | CT Residual Current (3Io) or Input |
| CONN..... | Connection | INC SEQ..... | Incomplete Sequence |
| CONT..... | Continuous, Contact | INIT..... | Initiate |
| CO-ORD..... | Coordination | INST..... | Instantaneous |
| CPU..... | Central Processing Unit | INV..... | Inverse |
| CRC..... | Cyclic Redundancy Code | I/O..... | Input/Output |
| CRT, CRNT..... | Current | IOC..... | Instantaneous Overcurrent |
| CSA..... | Canadian Standards Association | IOV..... | Instantaneous Overvoltage |
| CT..... | Current Transformer | IRIG..... | Inter-Range Instrumentation Group |
| CVT..... | Capacitive Voltage Transformer | ISO..... | International Standards Organization |
| | | IUV..... | Instantaneous Undervoltage |
| D/A..... | Digital to Analog | | |
| DC (dc)..... | Direct Current | K0..... | Zero Sequence Current Compensation |
| DD..... | Disturbance Detector | kA..... | kiloAmpere |
| DFLT..... | Default | kV..... | kiloVolt |
| DGNST..... | Diagnostics | | |
| DI..... | Digital Input | LED..... | Light Emitting Diode |
| DIFF..... | Differential | LEO..... | Line End Open |
| DIR..... | Directional | LFT BLD..... | Left Blinder |
| DISCREP..... | Discrepancy | LOOP..... | Loopback |
| DIST..... | Distance | LPU..... | Line Pickup |
| DMD..... | Demand | LRA..... | Locked-Rotor Current |
| DNP..... | Distributed Network Protocol | LTC..... | Load Tap-Changer |
| DPO..... | Dropout | | |
| DSP..... | Digital Signal Processor | M..... | Machine |
| dt..... | Rate of Change | mA..... | MilliAmpere |
| DTT..... | Direct Transfer Trip | MAG..... | Magnitude |
| DUTT..... | Direct Under-reaching Transfer Trip | MAN..... | Manual / Manually |
| | | MAX..... | Maximum |
| ENCRMNT..... | Encroachment | MIC..... | Model Implementation Conformance |
| EPRI..... | Electric Power Research Institute | MIN..... | Minimum, Minutes |
| .EVT..... | Filename extension for event recorder files | MMI..... | Man Machine Interface |
| EXT..... | Extension, External | MMS..... | Manufacturing Message Specification |
| | | MRT..... | Minimum Response Time |
| F..... | Field | MSG..... | Message |
| FAIL..... | Failure | MTA..... | Maximum Torque Angle |
| FD..... | Fault Detector | MTR..... | Motor |
| FDH..... | Fault Detector high-set | MVA..... | MegaVolt-Ampere (total 3-phase) |
| FDL..... | Fault Detector low-set | MVA_A..... | MegaVolt-Ampere (phase A) |
| FLA..... | Full Load Current | MVA_B..... | MegaVolt-Ampere (phase B) |
| FO..... | Fiber Optic | MVA_C..... | MegaVolt-Ampere (phase C) |

| | | | |
|----------------|---|----------------|--|
| MVAR | MegaVar (total 3-phase) | SAT | CT Saturation |
| MVAR_A | MegaVar (phase A) | SBO | Select Before Operate |
| MVAR_B | MegaVar (phase B) | SCADA | Supervisory Control and Data Acquisition |
| MVAR_C | MegaVar (phase C) | SEC | Secondary |
| MVARH | MegaVar-Hour | SEL | Select / Selector / Selection |
| MW | MegaWatt (total 3-phase) | SENS | Sensitive |
| MW_A | MegaWatt (phase A) | SEQ | Sequence |
| MW_B | MegaWatt (phase B) | SIR | Source Impedance Ratio |
| MW_C | MegaWatt (phase C) | SNTP | Simple Network Time Protocol |
| MWH | MegaWatt-Hour | SRC | Source |
| N | Neutral | SSB | Single Side Band |
| N/A, n/a | Not Applicable | SSEL | Session Selector |
| NEG | Negative | STATS | Statistics |
| NMPLT | Nameplate | SUPN | Supervision |
| NOM | Nominal | SUPV | Supervise / Supervision |
| NSAP | Network Service Access Protocol | SV | Supervision, Service |
| NTR | Neutral | SYNC | Synchrocheck |
| | | SYNCHCHK | Synchrocheck |
| O | Over | T | Time, transformer |
| OC, O/C | Overcurrent | TC | Thermal Capacity |
| O/P, Op | Output | TCP | Transmission Control Protocol |
| OP | Operate | TCU | Thermal Capacity Used |
| OPER | Operate | TD MULT | Time Dial Multiplier |
| OPERATG | Operating | TEMP | Temperature |
| O/S | Operating System | TFTP | Trivial File Transfer Protocol |
| OSI | Open Systems Interconnect | THD | Total Harmonic Distortion |
| OSB | Out-of-Step Blocking | TMR | Timer |
| OUT | Output | TOC | Time Overcurrent |
| OV | Overvoltage | TOV | Time Overvoltage |
| OVERFREQ | Overfrequency | TRANS | Transient |
| OVLDT | Overload | TRANSF | Transfer |
| P | Phase | TSEL | Transport Selector |
| PC | Phase Comparison, Personal Computer | TUC | Time Undercurrent |
| PCNT | Percent | TUV | Time Undervoltage |
| PF | Power Factor (total 3-phase) | TX (Tx) | Transmit, Transmitter |
| PF_A | Power Factor (phase A) | U | Under |
| PF_B | Power Factor (phase B) | UC | Undercurrent |
| PF_C | Power Factor (phase C) | UCA | Utility Communications Architecture |
| PFL | Phase and Frequency Lock Loop | UDP | User Datagram Protocol |
| PHS | Phase | UL | Underwriters Laboratories |
| PICS | Protocol Implementation & Conformance Statement | UNBAL | Unbalance |
| PKP | Pickup | UR | Universal Relay |
| PLC | Power Line Carrier | URC | Universal Recloser Control |
| POS | Positive | .URS | Filename extension for settings files |
| POTT | Permissive Over-reaching Transfer Trip | UV | Undervoltage |
| PRESS | Pressure | V/Hz | Volts per Hertz |
| PRI | Primary | V_0 | Zero Sequence voltage |
| PROT | Protection | V_1 | Positive Sequence voltage |
| PSEL | Presentation Selector | V_2 | Negative Sequence voltage |
| pu | Per Unit | VA | Phase A voltage |
| PUIB | Pickup Current Block | VAB | Phase A to B voltage |
| PUIT | Pickup Current Trip | VAG | Phase A to Ground voltage |
| PUSHBTN | Pushbutton | VARH | Var-hour voltage |
| PUTT | Permissive Under-reaching Transfer Trip | VB | Phase B voltage |
| PWM | Pulse Width Modulated | VBA | Phase B to A voltage |
| PWR | Power | VBG | Phase B to Ground voltage |
| QUAD | Quadrilateral | VC | Phase C voltage |
| R | Rate, Reverse | VCA | Phase C to A voltage |
| RCA | Reach Characteristic Angle | VCG | Phase C to Ground voltage |
| REF | Reference | VF | Variable Frequency |
| REM | Remote | VIBR | Vibration |
| REV | Reverse | VT | Voltage Transformer |
| RI | Reclose Initiate | VTFF | Voltage Transformer Fuse Failure |
| RIP | Reclose In Progress | VTLOS | Voltage Transformer Loss Of Signal |
| RGT BLD | Right Blinder | WDG | Winding |
| ROD | Remote Open Detector | WH | Watt-hour |
| RST | Reset | w/ opt | With Option |
| RSTR | Restrained | WRT | With Respect To |
| RTD | Resistance Temperature Detector | X | Reactance |
| RTU | Remote Terminal Unit | XDUCER | Transducer |
| RX (Rx) | Receive, Receiver | XFMR | Transformer |
| s | second | Z | Impedance, Zone |
| S | Sensitive | | |

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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